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ORIGINAL PAPER

Identification of woods from museum archaeological collections: use of local and non-local wood in pre-Columbian societies from northwestern Argentina

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Abstract
Archaeological finds of uncharred wooden artefacts are particularly rare in Northwestern Argentina. In this respect, the museum collections from the sites of La Paya and El Churcal, in the Calchaquí Valley (Northwestern Argentina), are significant owing to their excellent conservation and diversity of their uncharred wooden artifacts. However, due to necessary current conservation policy in Argentina, researchers may have limited access to artifacts and sampling possibilities. We carried out the identification of woods used to manufacture artifacts from La Paya and El Churcal collections as part of our ongoing studies on the processes of production, circulation, and consumption of raw materials and goods in societies inhabiting the Calchaquí Valley during the late pre-Columbian period (ninth to sixteenth centuries). As a result, we acquired previously unknown information on woods used to manufacture artifacts in the Calchaquí Valley. Despite working with two museum collections that offered different possibilities for intervention and different levels of accuracy of identification, we were able to obtain successful results that show similar trends between the collections.

Keywords Wood identification · Archaeological collections · Late pre-Columbian period · Northwestern Argentina

Introduction

During the early stages of archaeological research in Northwestern Argentina (NWA), at the beginning of the twentieth century, important archaeological explorations were carried out in order to recover material relevant to the study of regional pre-Columbian history and to obtain collections of archaeological objects. These objects made up the heritage of the first national museums and are of great value due to their significance and integrity; however, their study poses difficulties derived from the methods of recovery, processing, and recording used at the time. Moreover, current conservation policies restrict intervention on these materials for their study.

In this frame, the museum collections from the archaeological sites of La Paya and El Churcal in the Calchaquí Valley (Salta Province, NWA) become all the more significant due to the good state of preservation of their uncharred wooden objects, most unusual in NWA, and the great number and range of artifacts, as well as the degree of contextualization of their materials. We analyzed these collections with the aim of increasing our knowledge of practices of interregional circulation and consumption of goods in the Calchaquí societies between the ninth and sixteenth centuries, which have been investigated for some time (Sprovieri 2013). Through xylological analyses, it was possible to establish that different woods, both of local and non-local origin, were used in the manufacturing of Calchaquí objects.

The Calchaquí Valley: environmental and sociohistorical background

In NWA, it is possible to observe a succession of natural regions from east to west with distinctive features of topography, climate, and resources. The Calchaquí Valley (CV) is located in the Salta-Jujuy area, with mountain blocks running

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from north to south and deep and narrow valleys (Cabrera 1971; Serrano 1963) (Fig. 1). Its phytogeographic features correspond to those of the Monte Region, a semiarid area with low forest cover and large steppes with about 40 species of xerophile shrubs and trees. Predominant vegetation includes *Bulnesia retama*, *Larrea nítida* and *Larrea divaricata*, *Cercidium australe*, and *Cortaderia rudiuscula* and *Cortaderia argentea.* It is also possible to observe trees such as *Schinus molle*, *Geoffroea decorticans*, forests of *Prosopis nigra* and *Prosopis alba*, and, in some areas, columnar cacti species can be identified (*Trichocereus pasacana*) (Serrano 1963; Cabrera 1971; Pol et al. 2006).

To the west of the CV, we find the Puna Region, a high desert *altiplano* with cold and dry climate and marked temperature variations during the day. These conditions account for the steppe vegetation, which includes only about 20 species, of which hard grasses and shrubs such as *Paraestrephia* sp. and *Azorella yareta* are predominant. Larger trees such as *Polylepis ferox* and *Prosopis ferox* are very scarce (Serrano 1963; Cabrera 1971; Reboratti 2006). To the east of the CV, we find the lowest and most humid lands of the Subandean Region (the eastern slope of the Andes mountain range), with cloud forests and mountain forests known as Yungas. This region is covered in dense vegetation and is home to about 170 tree species throughout its area. The climate is hot and humid with abundant rainfall, and vegetation is organized in three different floors according to altitude. In the highest of these floors (3000–1500 m amsl), we find the Upper Temperate Montane Forest, with common forests of a single tree species such as *Podocarpus parlatorei* or *Alnus acuminata*, below which there are shrubs, herbaceous plants, and moss (Serrano 1963; Corcuera 1997; Brown et al. 2006).

The next floor has the highest precipitation of the region and gives way for the development of the Montane Subtropical Forest, with dense vegetation, high trees, and lianas and climbing plants growing through the trees. Between 1500 and 1000 m amsl, where fog is more frequent, we find the Myrtaceae Forest, with vegetation such as *Blepharocalyx salicifolius*, *Juglans australis*, and *Cedrela lilo* and *Cedrela angustifolia*. Below that, between 1000 and 700 m amsl, we can observe the Montane Forest, with a predominance of *Tipuana tipu*, *Pterogyne nitens*, *Cinnamomum porphyrium*, *Nectandra pichurim*, and *Ocotea puberula* and the presence of epiphytes, shrubs, and ferns (Serrano 1963; Cabrera 1971; Corcuera 1997; Brown et al. 2006). The lowest level (700–400 m amsl), where topography is gentler, belongs to the Premontane Lowland Seasonal Forest. Predominant species include *Tabebuia impetiginosa*, *Anadenanthera colubrina*, *Myroxylon peruiferum*, *Cordia trichotoma*, *Patagonula americana*, and *Astronium urundeuva*, as well as a

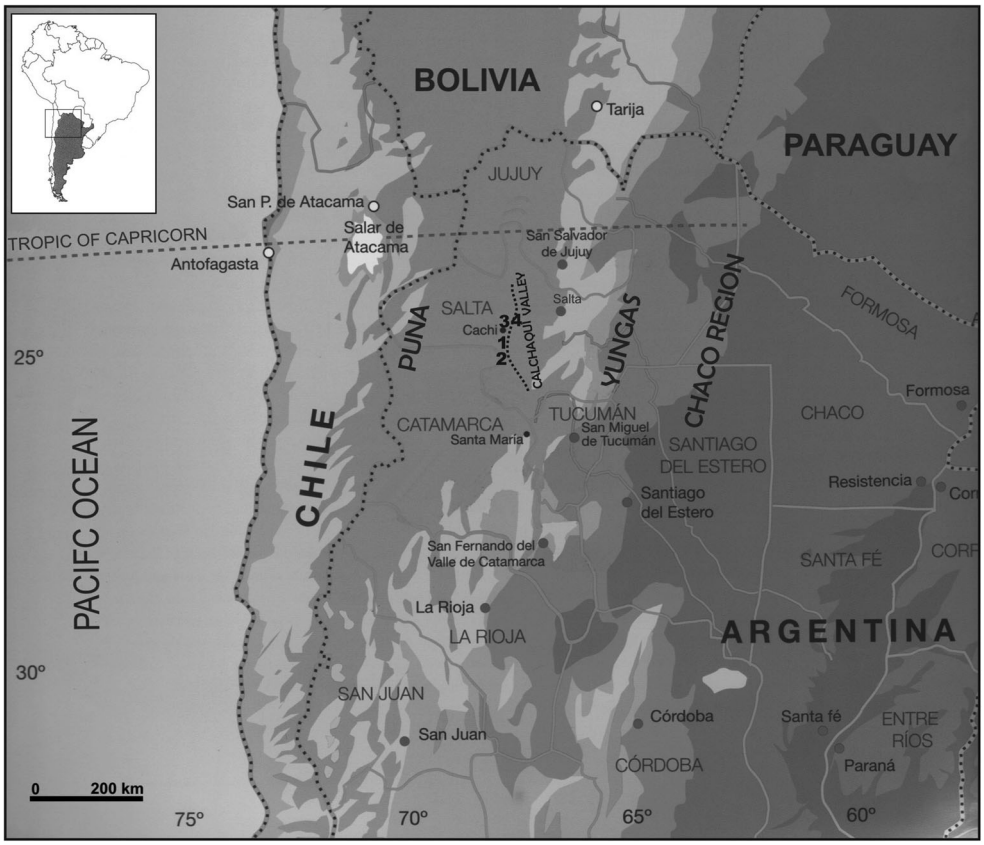


Fig. 1 Physical map of Northwestern Argentina with the location of environmental regions, the Calchaquí Valley and the study sites (modified from Goretti 2006). References: (1) La Paya, (2) El Churcal, (3) Tero, and (4) Kipón

considerable amount of herbaceous plants and lianas (Cabrera 1971; Corcuera 1997; Brown et al. 2006). Finally, to the east of the Yungas lies the Chaco Region, a sedimentary plain dominated by the Chaco Forest, of xerophytes and semideciduous vegetation, with a predominance of *Schinopsis quebracho-colorado* and *Aspidosperma quebracho-blanco*, *Astronium balansae*, smaller trees such as *Ziziphus mistol*, *Tabebuia nodosa*, and a great variety of trees and shrubs (over 50 species approximately) (Cabrera 1971, Torrella and Adámoni 2006).

Because of its particular geographical situation and its 200-km north-south extension, the CV constitutes a link between different areas and environments; it connects to the Puna Region from its western springs and basins and opens communications from north to south and with eastern crossings (Ardissone 1940; Tarragó 1970; Baldini 2003).

The environmental diversity of the Andean Region brought about the development of caravan networks that linked stable communities by transporting resources from different areas, such as minerals, wood, hallucinogens, and feathers, thus creating a regional short- and long-distance trade system (Dillehay and Núñez 1988; Aschero 2000; Nielsen 2009).

It is possible to recognize, in the CV and NWA in general, between the 9th and the 15th century AD, the Regional Development Period (RDP) (900–1430/70 AD), characterized by a growth in population and increasing complexity in society, with a more intensified exploitation, management, and control of natural resources, roads, and areas of economic significance. These features related to, on the one hand, subsistence based on intensive agriculture with an irrigation system and terraces and platforms on the hillsides and, on the other hand, camelid herding with access to high pasturelands and alluvial plains at the valley bottom. Towards the middle of the 15th century, the Inca Empire spread into NWA (AD 1470–1530). Local communities were then incorporated to a network of relations linking them to the Empire and its center through policies under military control, with political negotiation strategies, population resettlement, intensification of production, attached craft specialists, and a financial system based on corvée labor (González 1980; Hyslop 1984; Williams and D'Altroy 1998; Raffino and Stehberg 1999; Acuto et al. 2012; D'Altroy et al. 2000; Gheggi y Williams 2013).

Within this spatial and sociohistorical frame, we addressed the study of the processes of circulation and consumption of resources and goods, an issue that has been systematically unexplored in the CV area. To this end, the origin of ceramic, metal, wood, lithic, and bone artifacts was established through a stylistic approach that considered morphological, decorative, and technological traits in the objects examined (Sprovieri 2008–2009, 2013; Baldini and Sprovieri 2009). These were then matched, by comparison, to styles and varieties already described for the Calchaquí Valley, for the rest of Northwestern Argentina, and for the Southern Andes, with chronological value and a particular spatial distribution. Moreover, the origin of obsidian and wood was determined through provenance analysis (Sprovieri 2013); the last one being a relevant and particularly novel line, which had never been the focus of study in the region. This paper shows the results of the identification of uncharred wood used for the manufacture of artifacts, from two relevant collections discovered in the CV. The results, obtained through the analysis of the macroscopic and microscopic features of the artifacts, suggest the consumption of non-local woods, thus contributing to our knowledge of the processes of interregional circulation of resources and goods in the CV.

Archaeological collections from the Calchaquí Valley

La Paya

The archaeological site of La Paya is a residential settlement occupied during the periods of Regional Development (900–1430/70 AD) through the Inca expansion (1430/70–1536 AD) (Figs. 1 and 2). Located on a terrace next to the valley bottom, it consists of over 550 subrectangular structures, 250 circular stone-walled graves, and a structure of Inca architectural features known as *Casa Morada*. The settlement is crisscrossed by trails and surrounded by a perimeter wall mostly belonging to the Inca period. Outside the wall, towards the west, there is a concentration of graves similar to the ones mentioned above (Ambrosetti 1907; Alfaro de Lanzone 1985; González and Díaz 1992).

In the early 20th century, Ambrosetti (1907) excavated 203 contexts, most of them burials. The materials recovered from these excavations, along with other objects purchased by Ambrosetti (1902) and Boman (1908), composed a wide collection of 1699 pieces, the majority of which are stored in the J. B. Ambrosetti Museum of Ethnography (ME) (Sprovieri 2010). The collection includes complete and partially complete uncharred pieces, in a good state of preservation, most of which were grave goods.

After reviewing the ME collection and respective publications, it was possible to observe the existence of a great diversity of artifacts and raw materials from the RDP and Inca period. The largest assemblage was ceramics, mainly whole and fragmentary vessels, and some potsherds. Stylistic analysis of the vessels assigned them mostly to the Santa María-Calchaquí variety and to other RDP local pottery styles (black polished and ordinary).

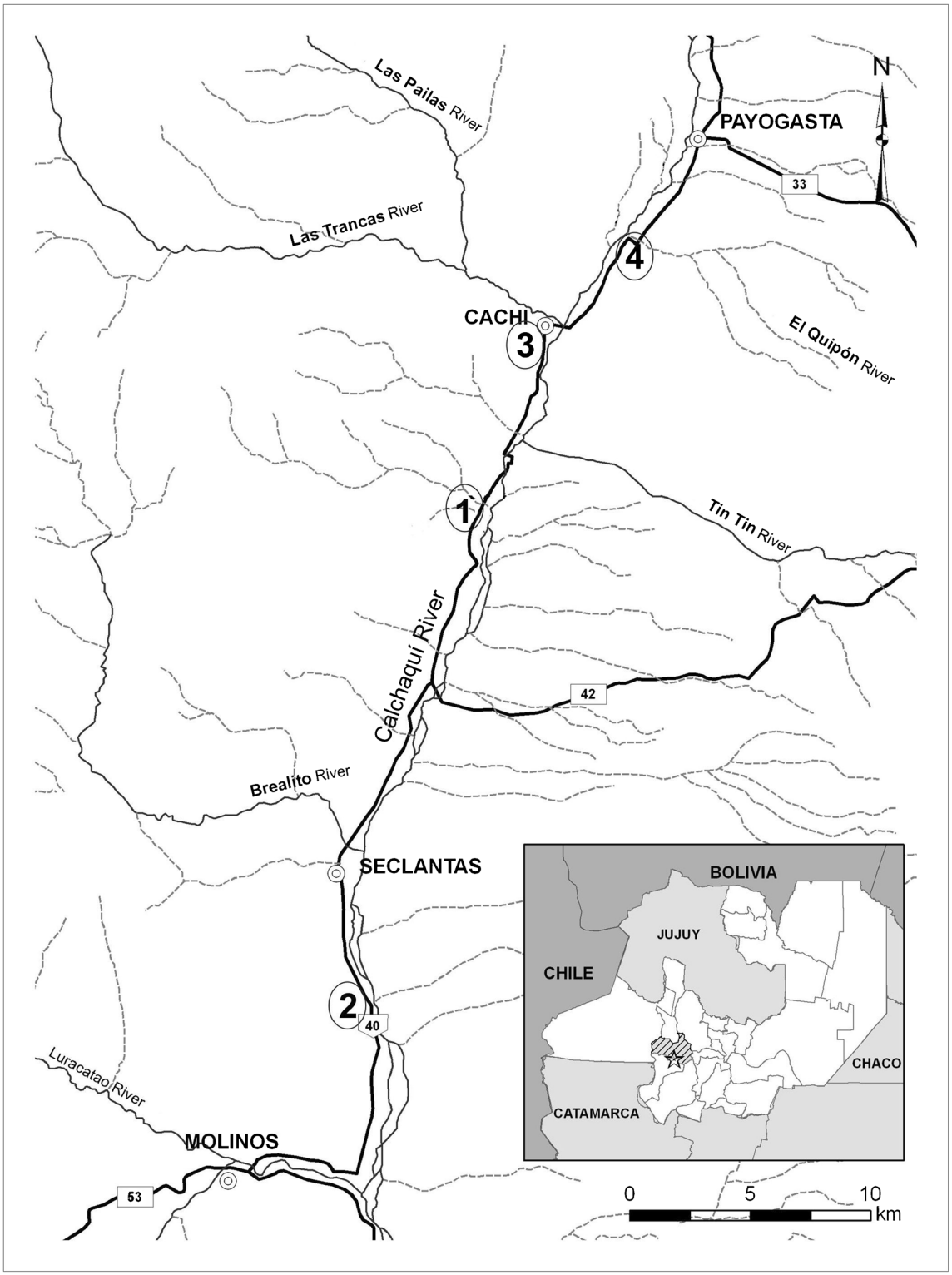
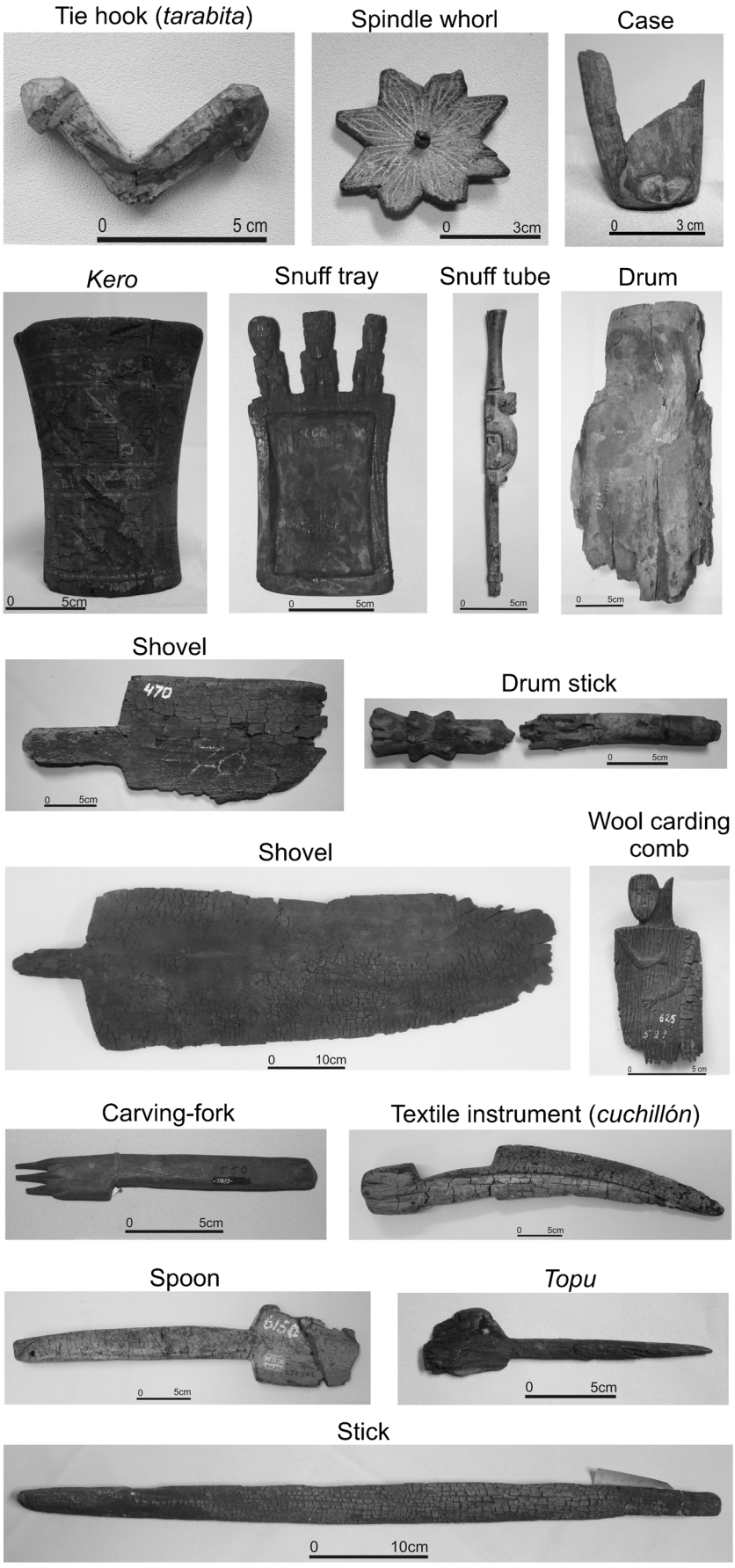


Fig. 2 Map of the middle section of the Calchaquí Valley with the location of the study sites. References: (1) La Paya, (2) El Churcal, (3) Tero, and (4) Kipón

Furthermore, several types of Inca pottery and other vessels showing features of the ceramics from other regions of NWA and northern Chile were identified (Sprovieri 2008–2009, 2010, 2013).

The wooden object collection is the second largest, followed by the metal objects, which include utilitarian items, such as pliers, chisels, awls, small axes, or knives, and objects of personal adornment and ostentation, like breastplates, rings, *tumi* knives, and discs.


Tie hook (*tarabita*)
0 5 cm
Spindle whorl
0 3cm
Case
0 3 cm
Kero
0 5cm
Snuff tray
0 5cm
Snuff tube
0 5cm
Drum
0 5cm
Shovel
470
0 5cm
Drum stick
0 5cm
Shovel
0 10cm
Wool carding comb
0 5 cm
Carving-fork
0 5cm
Textile instrument (*cuchillón*)
0 5cm
Spoon
0 5cm
Topu
0 5cm
Stick
0 10cm

◀ **Fig. 3** Wooden artifacts at La Paya

Finally, there is a smaller and less diverse assemblage of stone artifacts, mainly grinding tools, arrowheads, and some necklaces, and one of bone artifacts, chiefly including *topus*, spatulas, and spindle whorls (Sprovieri 2008–2009, 2010, 2013).

Wooden objects from graves at La Paya

As regards the wood collection, in particular, according to our most recent review, 395 wooden objects were originally recovered in La Paya, specifically from 102 funerary contexts, from *Casa Morada* and 4 other contexts. The current collection in ME consists of 170 of these objects (Fig. 3, Table 1), which are representative of the variety in the original collection. The objects were analyzed according to their morphological, technological, and decorative features. They are uncharred pieces in a good state of preservation and integrity. They include artifacts used for inhaling hallucinogenic substances (snuff trays and tubes), with particular morphological and iconographic features (anthropomorphic and zoomorphic figures) (Sprovieri 2008–2009). There are also objects related to daily activities (farming, weaving, cooking, load carrying, etc.), such as shovels, *tarabitas* (tie hooks), spindle whorls, *cuchillones* (textile instruments), and wool carding combs. Finally, we find certain objects used in special situations, probably ritual, such as musical instruments, carved anthropomorphic figures, and Inca *keros* (ceremonial drinking cups).

Table 1 Type and number of wooden artifacts from La Paya at ME

Type of artifact	Number
Spindle whorl	77
Tarabita (tie hook)	11
Shovel	10
Cuchillón (textile instrument)	9
Snuff tray	8
Stick	7
Snuff tube	4
Case	3
Spoon	2
Topu (pin)	2
Kero (ceremonial drinking cup)	2
Drum	1
Drum stick	1
Wool carding comb	1
Undefined	32
Total	170

El Churcal

The archaeological site of El Churcal stands 25 km south of La Paya (Figs. 1 and 2) and it is 30 ha in area, with 700 structures (houses, graves, etc.) and a public space (Baldini 2010). Raffino et al. (1976) and Raffino (1984) estimated that it was occupied during RDP according to type of settlement, its associated remains, the absence of indicators related to Inca occupation, and wood dating at 740 ± 50 BP (there is no available information regarding genus or species of the wood dated, and it was not possible to determine whether it belonged to a young branch or an older trunk.) During the 1970s, 20 adult and 33 sub-adult graves were excavated, from which it was possible to obtain a large collection of materials with highly variable information. The collection includes 48 wooden objects of different types from eight graves (Table 2).

We analyzed objects from graves 14 and 138, deposited in La Plata Museum of Natural Sciences along with its original provenance and association data, and one object from grave 110, sampled in the modern-day village of Molinos. Grave 14, marked on the surface with a circle of stones and its roof is supported by *Prosopis* sp. braces, contained seven adults and one sub-adult inside a black polished bowl. The grave goods consisted of 40 objects of different type and material, 22 of which were made of wood. The wood dating mentioned above was performed on this grave. Grave 138 contained four adults and one sub-adult in an ordinary urn below, covered with an ordinary pot. The grave goods included four wooden objects. Finally, grave 110 contained one adult accompanied of three vessels and two wooden objects (Table 2).

Wooden objects from graves at El Churcal

Analyzed materials from graves 14 and 138 are mostly fragmentary and required careful examination and classification; some objects could be assimilated in shape to those identified at La Paya, such as spindle whorls, *tarabitas*, and wool carding combs.

The pieces were analyzed macroscopically and microscopically (using a stereoscopic microscope) in order to identify morphological features, decorative features, and traces of its manufacturing process. Several artifacts were partially restored.

One of the groups consists of a large amount of fragments of small sticks whose diameters range between 20.5 and 3 mm, with no apparent shaping. A second group gathers incomplete pieces from different types of formatized objects or artifacts, including long fragments with a flat-convex cross section and diameters between 15 and 22 mm (Fig. 4) whose size and characteristics match up with complete or semi-complete bows found in other regions of NWA and northern Chile (Lehmann-Nitsche 1904; Latcham 1938; Krapovickas 1958–59; Cigliano 1973).

Table 2 Number and type of wooden artifacts in the graves at El Churcal

Type of artifact	Graves							
	14	101	110	137	138	143	144	146
Spindle whorl	6			1			12	
Tarabitas (tie hook)	4	Several				1	1	
Spoon	1							
Needle	1							
Graver	1							
Carving-fork	1				1			
Bow	2				1			
Small stick	Several				Several			Several
Shaft					Several			
Cuchillón (textile instrument)	3	1	1				2	
Board	Several							
Comb			1					
Undefined	1							
Total	22	2	2	1	4	1	15	1

There is another set of artifacts made up of long and thin fragments with a diameter of 6/6.5 mm and a groove of 2.5 to 3 mm in depth, at one end (Fig. 4), which resemble the shafts found in a contemporary settlement in NWA (Cigliano 1973) and northern Chile (Latcham 1938). Identification of these fragments as arrow shafts was confirmed once we considered the arrow shafts reported by Raffino (1984) next to the bows in the graves at El Churcal. Also recovered at El Churcal were star-shaped and flat-rectangular spindle whorls (Fig. 4), similar to those found at La Paya, Tero, and Kipón (Debenedetti 1908; Tarragó et al. 1979; Sprovieri 2013) (Figs. 1 and 2), as well as remains of a small carved anthropomorphic figure, several small sharpened sticks of various diameters, an incomplete artifact, possibly a *tarabita*, and a stick with a hole in one end, possibly a needle (Fig. 4).

The piece from grave 110 has a rectangular section, with fragmented prongs in one end and a carved anthropomorphic figure in the opposite (Fig. 4). Similar objects found at La Paya and Kipón were identified as "wool carding combs" (Ambrosetti 1907; Debenedetti 1908).

Identification of woods from museum archaeological collections

Wood identification is performed through xylology, the study of wood macro- and microscopic structures and its anatomical, chemical, physical, and mechanical properties (Pearsall 1989; Wheeler and Baas 1998; Tortorelli 2009), which allows us to identify its genus and/or species and determine its habitat.

The procedure consists in observing the diagnostic anatomical features in the study object: vessel grouping and arrangement, porosity, axial parenchyma type and arrangement, ray size, presence of growth rings, deposits in different structures, etc. (IAWA Committee 1989) in the three sections commonly studied: transverse section (TS), tangential longitudinal section (TLS), and radial longitudinal section (RLS). Observation may occur at different magnifications: macroscopically, using a stereoscopic microscope or a scanning electron microscope (SEM); the latter process requires objects to be sampled. As our study material belongs to museum collections, sampling was not a possibility in all cases.

Our analysis began with the La Paya collection, where intervention on the objects was restricted and no samples were taken. The diagnostic features were identified by macroscopic observation and using a stereoscopic microscope (between ×10 and ×40) on sections obtained through scalpel scraping on the surface of the objects; however, not all of the sections were obtained due to the morphology of the pieces, their degree of conservation, or the limited possibilities for scraping on certain well-preserved parts of the pieces. Therefore, we often worked with TS and, in some cases, with TLS. We registered as many diagnostic features from each piece as possible, most frequently vessel grouping and arrangement, porosity, axial parenchyma type and arrangement, and ray size.

The anatomical features from the samples were compared to current reference data available at the Xylotheque in the Dendrology Department at the Faculty of Agrarian and Forest Sciences (National University of La Plata). Further information was provided by atlas and reference manuals on the

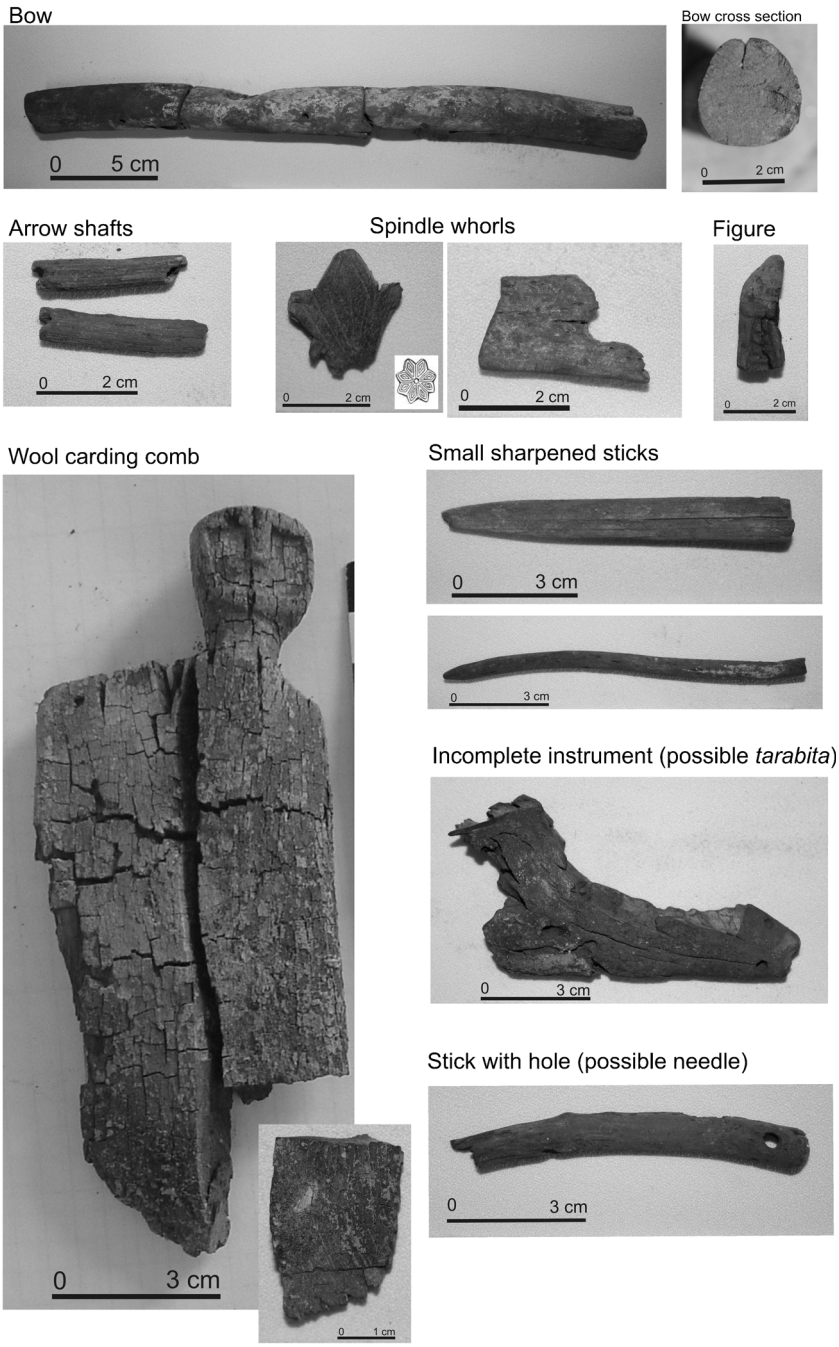


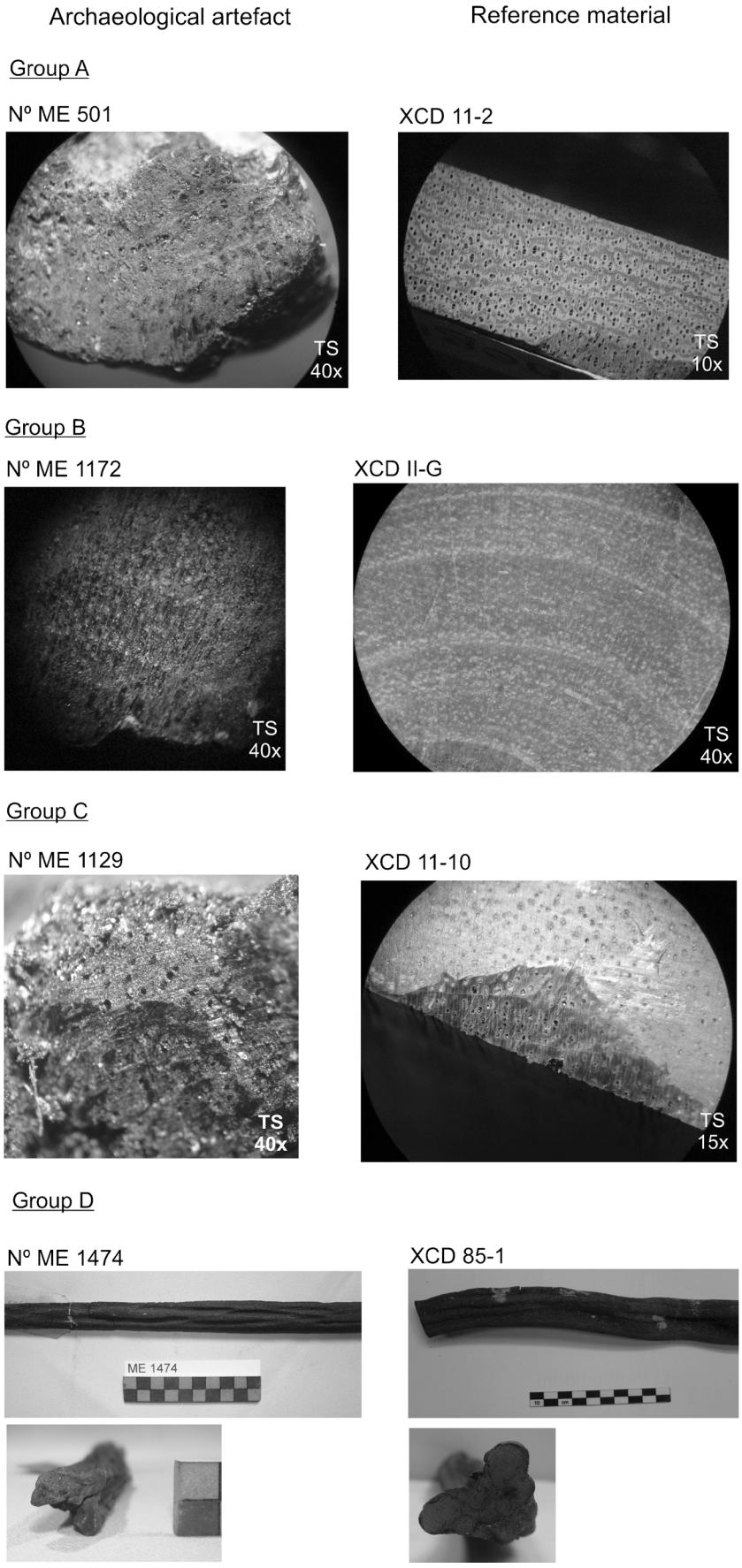
Fig. 4 Wooden artifacts at El Churcal

anatomy of native Argentine wood (Cozzo 1948, 1951; Cristiani 1978; Tortorelli 2009; Catálogo de las Plantas Vasculares del Conosur n.d., etc.). With the aid of these procedures, it was possible to make a first approach to the identification of wood, enabling a tentative determination of genus/species. Pieces were divided in groups according to their anatomical features and then matched up to similar species of native wood.

Afterwards, we analyzed the collection from El Churcal. The greater possibility of intervention on these pieces due to their fragmented state provided a deeper and more comprehensive approach on the matter. It was possible to make final determinations that show analogous results to those obtained at La Paya. The analysis of diagnostic anatomical features was performed at different levels: firstly, following the process carried out in La Paya, we obtained sections from the surface of the pieces, which were observed macroscopically and using a stereoscopic microscope. Small samples from each piece were later macerated and observed with an optical microscope

Table 3 Groups of related wood identified at La Paya

Group	Type and number of artifacts	Observed characteristics	Related wood		Reference material and bibliography
			Scientific name	Common name	
A	Case: 3 Shovel: 2 Snuff tray: 2 Spindle whorl: 2 *Topu*: 2 Carving-fork: 1 Snuff tube: 1 Spoon: 1 Stick: 1 *Tarabita*: 1	TS (Fig. 5): wood diffuse-porous; big solitary vessels and radial multiple of 2 or 3, paratracheal axial parenchyma, vasicentric, tending to aliform and in narrow bands TLS: Non-storied structure	*Prosopis* sp.	*Algarrobo*	XCD 11-2 Cristiani (1978), Castro (1994), Tortorelli (2009)
B	*Tarabita*: 4 Spindle whorl: 3 Snuff tube: 2 Spoon: 1	Physical features: homogeneous texture TS (Fig. 5): wood diffuse-porous, tending to ring-porous; very small vessels with dark inclusions; visible rays	B*ulnesia* sp./*Larrea* sp.	*Retama*, *palo santo*/-*jarillas*	XCD II-G Cozzo (1948)
C	Shovel: 3 Stick: 1 Snuff tray: 1 Spindle whorl: 1 Snuff tube: 1	Physical features: fine homogeneous texture TS (Fig. 5): wood diffuse-porous; small solitary vessels and radial multiple of 2 or 3; abundant axial parenchyma, in cases vasicentric; visible rays TLS: non-storied structure	*Acacia* sp.	*Churqui*, *arca*, *tusca*	XCD 11-10 Cozzo (1951), Tortorelli (2009)
D	Stick: 4	Physical features (Fig. 5): extremely hard wood (impossibility of obtaining wood sections), external morphology of a rope or cable-like appearance, forming short longitudinal grooves in the surface	Lianas		XCD 85-1 a 5
E	*Kero*: 2 Drum: 1	Physical features: very light weight wood TS (Fig. 6): big solitary vessels and small clusters; visible rays and lighter in color; non-visible parenchyma	*Erythrina falcata* Benth. or *Erythrina crista-galli* L. *crista-galli*	*Seibo jujeño* or *seibo*	XCD 11-12 Tortorelli (2009)
F	Snuff tray: 2	Light red wood TS (Fig. 6): wood diffuse-porous; numerous very small solitary vessels; non-visible rays	*Anadenanthera colubrina* (Vell.) Brenan *cebil* (Griseb.) Altschul	*Cebil*	XCD 11-20 Cozzo (1951), Tortorelli (2009)
G	Stick: 1	Physical features: soft and very light weight wood, heartwood color yellow TS (Fig. 6): wood diffuse-porous; small vessels; pith observed at the center TLS (Fig. 6): short axial tubes (laticifers) next to the bark	*Sapium haematospermum* Müll. Arg.	*Curupí*	XCD 15-2 Roth and Giménez de Bolzón (1997), Tortorelli (2009)
H	Shovel: 1	Physical features: semi-heavy wood TS (Fig. 6): wood semi-ring porous; growth ring boundaries distinct; visible rays; apotracheal axial parenchyma in tangential narrow bands	*Juglans australis* Griseb.	*Nogal criollo*	XCD 2-1 Tortorelli (2009)
I	Drum stick: 1	Physical features: soft and light weight wood TS (Fig. 6): wood diffuse-porous; small vessels arranged in tangential bands (ulmiform), very wide rays	*Cordia trichotoma* (Vell.) Arráb. ex Steud.	*Peteribí*	XCD 30-2 Tortorelli (2009)


Archaeological artefact
Reference material
Group A
Nº ME 501
TS
40x
XCD 11-2
TS
10x
Group B
Nº ME 1172
TS
40x
XCD II-G
TS
40x
Group C
Nº ME 1129
TS
40x
XCD 11-10
TS
15x
Group D
Nº ME 1474
ME 1474
XCD 85-1

◀ **Fig. 5** Groups A to D of wood from La Paya

with different magnifications (×100 to ×400). Finally, new samples were observed with a SEM.

Having obtained the diagnostic features of the samples through different procedures, they were compared to the same reference data and atlas used at La Paya.

Woods from La Paya

Xylological studies were performed on 40% ($n = 68/170$) of the wooden pieces from the La Paya collection at ME and on two snuff trays, artifacts rarely discovered, from the area surrounding Cachi (Fig. 2). Twenty-five of the pieces provided no relevant information on anatomical features after attempts to obtain sections for observation were unsuccessful or after finding alterations on the wood, possibly due to restoration and conservation techniques (lacquers and adhesive products) applied when they were discovered or stored.

The analysis of both physical and anatomical properties of the 45 remaining pieces yielded nine different groups of related wood (A–I), which were matched up to similar species of native wood (Table 3 and Figs. 5 and 6). This enabled a preliminary identification of woods on the basis of firm analytical grounds. The results show that woods from three of the nine groups identified at La Paya (A–C) have similar features to wood species found at the Calchaquí Valley, while the six remaining groups (D–I) present anatomical features which resemble those of wood species in the Yungas Region, to the east of the CV. Further information and examples from each group were introduced in Sprovieri (2010, 2013), Sprovieri and Rivera (2014), and Rivera and Sprovieri (2015).

Woods from El Churcal

As mentioned above, according to original data, wooden artifacts from graves 14, 110, and 138 of El Churcal added a total of 28. To date, our ongoing studies have reached identification of the wood type used (family/genus/species or parts of the plant) in almost 30% of them. All of the pieces were observed macroscopically with a stereoscopic microscope, later macerated and observed using a microscope, and analyzed with the SEM.

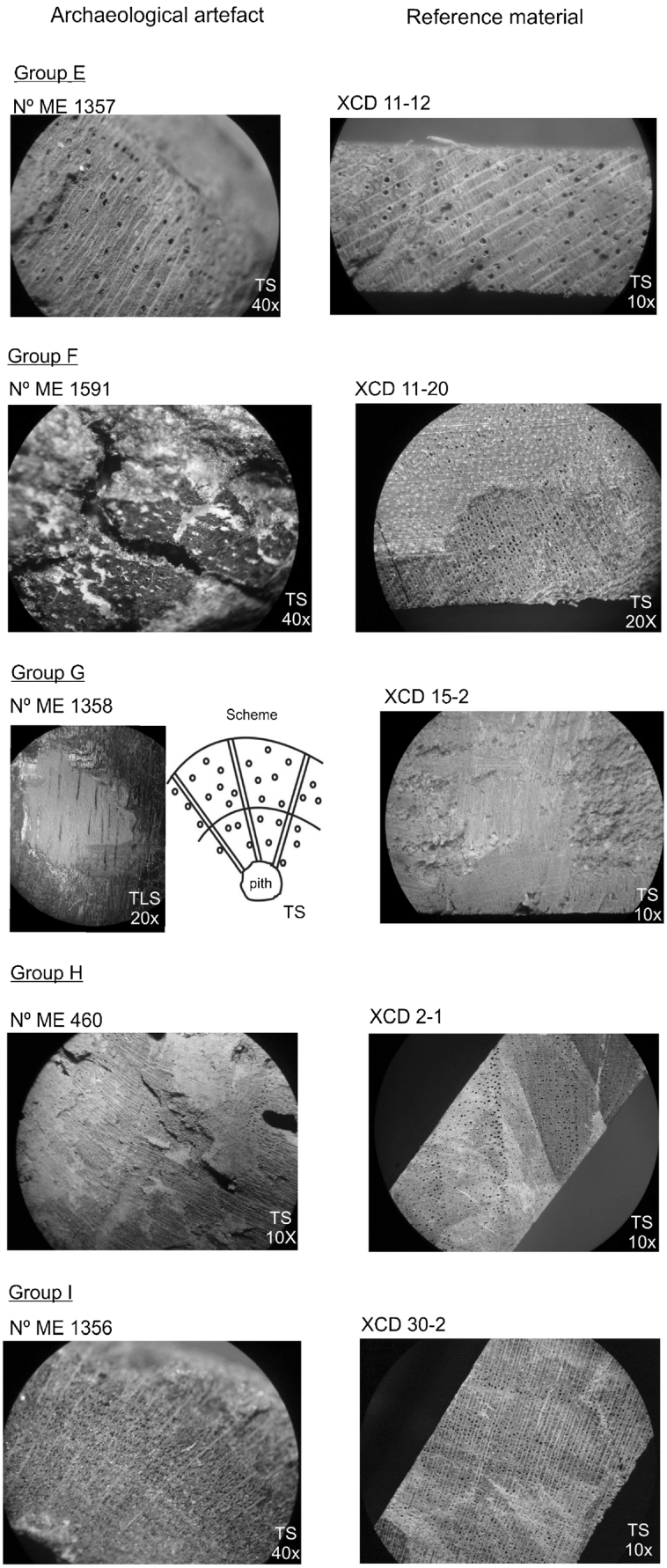
Four groups have been identified so far (Table 4 and Figs. 7, 8, 9, and 10). Group I consists of a single object, whose wood was identified as *Astronium urundeuva* (Allemão) Engl. (*urundel*) or *Astronium balansae* Engl. (*urunday*). The number of similar features between these species has made it difficult to distinguish them. Furthermore, these species are themselves similar to *Schinopsis balansae* Engl. or *Schinopsis lorentzii* (Griseb.) Engl. (*quebrachos colorados*). These four species are large trees up to 25/30 m high, long-lived, and slow-growing. They require mild conditions of humidity and full sunlight for their development. Their wood is hard and heavy with densities between 1150 and 1250 kg/m^3. Anatomically, these species exhibit diffuse porosity, oval vessel outline, scanty paratracheal parenchyma, abundant thick- to very thick-walled fibers, intercellular radial canals, and similar ray height ranges. Of particular note is the presence of abundant tyloses in the vessels in all four species. No other species in NWA presents this feature together with the rest of the features mentioned (Tortorelli 2009).

Among the species of *Astronium*, small differences can be observed: *A. urundeuva* shows a greater predominance of homogeneous uniseriate rays and wider vessel diameters. For their part, *Schinopsis* spp. differ from *Astronium* spp. in that in the former vessels in radial multiples of two or three reach about 50%, have wider diameters, and are more numerous per square millimeter. Furthermore, in *Schinopsis* spp., the parenchyma is scanty paratracheal to vasicentric and in marginal narrow bands. In particular, *S. balansae* differs from the species of *Astronium* in having wider rays, 80% of which are multiseriate, while *S. lorentzii* is different from them by such features as vessel tangential walls horizontal to oblique and thin- to thick-walled fibers (Tortorelli 2009).

At the moment, we cannot rule out completely the possibility that the wood might belong to one of the *Schinopsis* species; however, taking into account features like vessel diameter, presence of solitary vessels, number of vessels per square millimeter, type of parenchyma, and ray width in cell numbers, the sample is more closely related to the *Astronium* species mentioned above and between them to *A. balansae*. Nevertheless, none of these species develop in the CV. They all do in phytogeographical regions to the east of the CV: the *urundel* grows in the Premontane Lowland Seasonal Forest, the lowest floor of the Yungas; the *urunday*, in the eastern wet region of the Chaco Forest; and the *quebracho colorados*, typically, in the Chaco Region.

Group II consists of a bow fragment made of a type of wood related to the Myrtaceae family, regularly found in the Myrtaceae Forest of the Yungas in NWA. Frequently observed in this family is the presence of vasicentric tracheids (Ragonese 1977; Castro and Luna 1993; Tortorelli 2009), also observed in the bow fragment used for analysis.

In the Yungas Region, there are about 18 species from the Myrtaceae family. Among native species, the most frequent are *Blepharocalyx salicifolius* (Kunth) O. Berg (*horco molle*), *Eugenia hyemalis* Camb., *Eugenia uniflora* L. (*arrayán*, *ñangapirí*), *Myrcianthes pungens* (Berg) Legrand (*guabiyú*), and *Myrrhinium loranthoides* (Hook. Et Arn.) Burr. (*maitín*) (Morales et al. 1995, Atencia 2003, Grau et al. 2016). Among these species, it is the *B. salicifolius* that shares most of the anatomical characteristics observed in the sample from


Archaeological artefact
Reference material
Group E
Nº ME 1357
TS
40x
XCD 11-12
TS
10x
Group F
Nº ME 1591
TS
40x
XCD 11-20
TS
20X
Group G
Nº ME 1358
TLS
20x
Scheme
pith
TS
XCD 15-2
TS
10x
Group H
Nº ME 460
TS
10X
XCD 2-1
TS
10x
Group I
Nº ME 1356
TS
40x
XCD 30-2
TS
10x

◀ **Fig. 6** Groups E to I of wood from La Paya

El Churcal. For their part, the two *Eugenia* species differ from the sample analyzed in presenting vessels exclusively solitary (no vessels in radial multiples are observed), more vessels per square millimeter (double in *E. hyemalis* and almost three times more *E. uniflora*), axial parenchyma in bands and apotracheal diffuse and diffuse-in-aggregates, higher rays, and thick- to very thick-walled fibers (Rodrigues dos Santos et al. 2014, Rodrigues dos Santos and Cardoso Marchiori 2009). *M. pungens* differs from our sample in having more numerous vessels (more than 100 per mm^2), vessels exclusively solitary, and axial parenchyma in bands and apotracheal diffuse and diffuse-in-aggregates (Richter and Dallwitz 2000), while *M. loranthoides* is different in having more numerous vessels per square millimeter (more than twice its number), higher rays, and apotracheal axial parenchyma diffuse-in-aggregates (Cardoso Marchiori 1984). All this leads us to put forward the possibility that the bow fragment from El Churcal might have been manufactured with wood from *horco molle*, which must be confirmed by further observations.

Furthermore, according to ethnographic data from the Chaco Region, what is most frequently used in the making of bows is heavy and hard wood species such as *Mimozyganthus carinatus* (Griseb.) Burkart, *Celtis ehrenbergiana* (Klotzsch) Liebm. *ehrenbergiana*, *Prosopis kuntzei* Harms, *Bauhinia forficata* Link (Vogel) Fortunato & Wunderlin Phil., *Casearia sylvestris* Sw. *sylvestris*, or *Cordia americana* (L.) Gottschling & J.S. Mill. (Arenas 2003; Scarpa 2007; Kamienkowski and Arenas 2012; Martínez Crovetto 2012). These are heavy and hardwood species, with densities over 800 kg/m^3 (Tortorelli 2009), which resemble the characteristics of the Myrtaceae species previously considered. This information also contributes to a positive association of the bow found at El Churcal with the Myrtaceae family.

Finally, groups III and IV include artifacts whose wood was found to be of young branches and bark, respectively,, showing that all parts of plants were utilized, a practice never before recognized in the region. On the other hand, these parts of plants do not exhibit the necessary anatomical features to produce an accurate taxonomic identification.

Circulation and consumption of wood in the Calchaquí Valley during the late pre-Columbian period

The analysis carried out revealed the fact that Calchaquí societies made a comprehensive use of wood resources by exploiting different parts of the plant. Not only did they use parts of the log to make single-piece objects—some of considerable size, such as shovels or *keros*—but also parts of the bark (*tarabita*) and young branches to produce artifacts of different kinds (shafts, spindle whorls, small sharpened sticks).

As regards the kind of wood, information provided by the analyses points to the use of different genera and species and of both trees (*Prosopis* sp., *J. australis* Griseb., etc.) and shrubs or smaller specimens (*Bulnesia* sp., *Larrea* sp.).

Part of these species was available locally, while others came from the east of the Calchaquí Valley. As regards the latter, the analyses performed at La Paya yielded six types of wood from the Yunga Region; El Churcal provided two more from the same region, with one of them possibly originating further east, in the Chaco Region.

These results confirm the supply and use of non-local wood in the production of Calchaquí artifacts, a fact that shows late societies in the CV were part of specific interregional interaction networks which brought about the arrival of these resources to the region.

Evidence of involvement in these networks is supported further by the presence of rattles made with the fruit of *J. australis* Griseb., which grows in the Yungas, in funerary contexts at La Paya and El Churcal. Furthermore, snuff trays and tubes recovered from some of those graves stand as indirect evidence of the consumption of psychoactive substances produced from species typically found in the Yungas (Sprovieri 2013; Sprovieri and Rivera 2014). The circulation of woods between the CV and the Yungas had not been confirmed for any period of the regional pre-Columbian history, which means the evidence emerging from this study proves the existence of circuits connecting these culturally and ecologically diverse areas during the last pre-Columbian centuries.

So far, it was known that during the RDP, before the Inca Empire arrived in the Valley, Calchaquí populations took part in different circuits of interregional interaction which caused the entry and exit of different materials. On the one hand, resources and raw materials were from the Puna (obsidian, tin, etc.) and apparently from the Pacific Ocean (shells). On the other hand, goods or decorative styles (pottery, snuff trays and tubes, spindle whorls, rock art) which were moved through spheres of circulation covering other areas of NWA, such as the Yocavil Valley (Catamarca), the Quebrada del Toro (Salta), and the south of the Quebrada de Humahuaca (Jujuy), or northern Chile, especially the Loa river area (Sprovieri 2010, 2013) (Fig. 1).

During the Inca period, interregional circulation of goods, resources, and ideas showed continuity and change, although apparently no interruptions, but rather the intensification and expansion of previous spheres of circulation, like the one covering the Quebrada de Humahuaca or the Pacific Coast, and the appearance of other spheres which would cover new areas like Yavi (Jujuy), the Bolivian altiplano, northern Chile, especially San Pedro de Atacama, and central areas of the Empire (Sprovieri 2010, 2013).

Table 4 Groups of wood identified at El Churcal

Group	Number, type of artifact and origin	Observed characteristics	Identified wood species		Bibliography
			Scientific name	Common name	
I	Object no. 21: "wool carding comb" (grave 110)	TS (Fig. 7a, b): wood diffuse-porous; solitary vessels and radial multiple of 2 with abundant deposits (tyloses); oval vessel: diameter 73–96 μm; 19–20 vessels per mm^2; axial parenchyma scanty paratracheal; crystals present; fibers very thick--walled, abundant. TLS (Fig. 7c): ray width 1–3 cells; ray height 135–216 μm, ray width 26–6 μm; vessel length 143–200 μm; oblique tangential walls; intercellular canal in ray RLS: heterogeneous rays with procumbent cells and square marginal cells	*Astronium urundeuva* (Allemão) Engl. or *Astronium balansae* Engl. Possible: *Schinopsis balansae* Engl. or *Schinopsis lorentzii* (Griseb.) Engl.	*urundel* or *urunday quebrachos colorad-os*	Giménez and López (2000, 2002), Tortorelli (2009)
II	Object no. 7: bow (grave 14)	TS (Fig. 8a, b): wood diffuse-porous; radial solitary and clustered vessels; circular vessel diameter 30–46 μm; 28 vessels per mm^2; thin-to thick-walled fibers; axial parenchyma scanty paratracheal and apotracheal reticulate RLS (Fig. 8c, d): heterogeneous rays with procumbent cells and upright and square marginal cells; aerolar pits of angular outline and wide circular opening; possible vasicentric tracheids; tangential walls horizontal to oblique TLS (Fig. 8c): uniseriate and biseriate rays; ray height 102–260 μm (mean 182 μm); rays 4–10 cells high (mean 8 cells); non-storied structure	Myrtaceae	–	Ragonese (1977), Castro and Luna (1993), Tortorelli (2009)
III	Object no. 5b: spindle whorl (grave 14) Object no. 9: small sharpened stick (grave 14) Object nos. 12 and 17: small sharpened sticks (grave 138) Object no. 19: arrow shaft (grave 138)	TS (Fig. 9): pith observed at the center; mostly parenchyma; vessels and rays identified, but growth ring boundaries indistinct or absent; primary wood structure	–	Young branches	
IV	Object no. 30: incomplete instrument (possibly a *tarabita*) (grave 14)	TS (Fig. 10a): vessels and rays from conductive system; homogeneous structure associated with bark. Confirmed in RLS (Fig. 10b)	–	Bark	

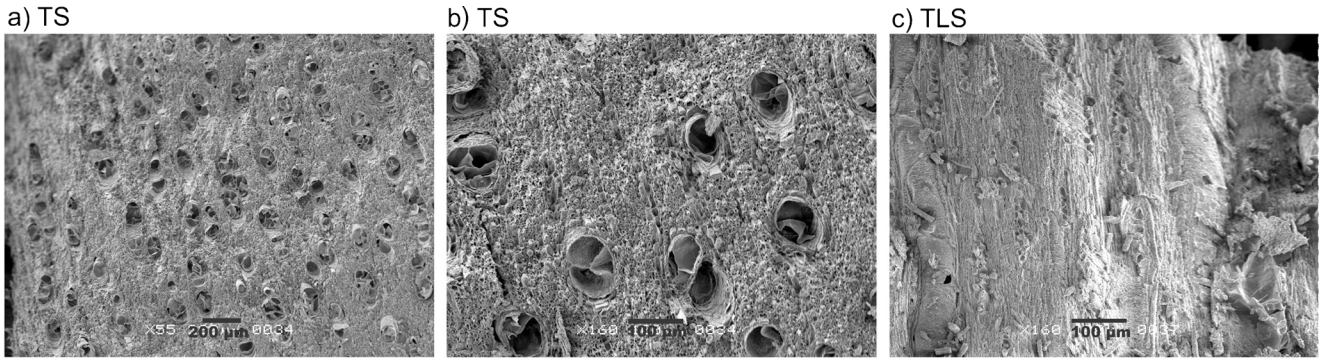


Fig. 7 Group I of woods from El Churcal

In this context, the connections between the CV and the Yungas, supported by the study of woods presented in this article, prove the areas east of the CV were somehow integrated to the circuits that allowed for supply and circulation of resources and goods by the Calchaquí populations. Such integration persisted as from the RDP until the Inca Period.

Such persistence could suggest that the circuits connecting the Calchaquí populations and the eastern region continued to develop without imperial intervention or at least of relevant nature. If we consider that east-to-west connections, or vice versa, must have been essential to Calchaquí populations, insofar as they may have allowed them to secure goods and

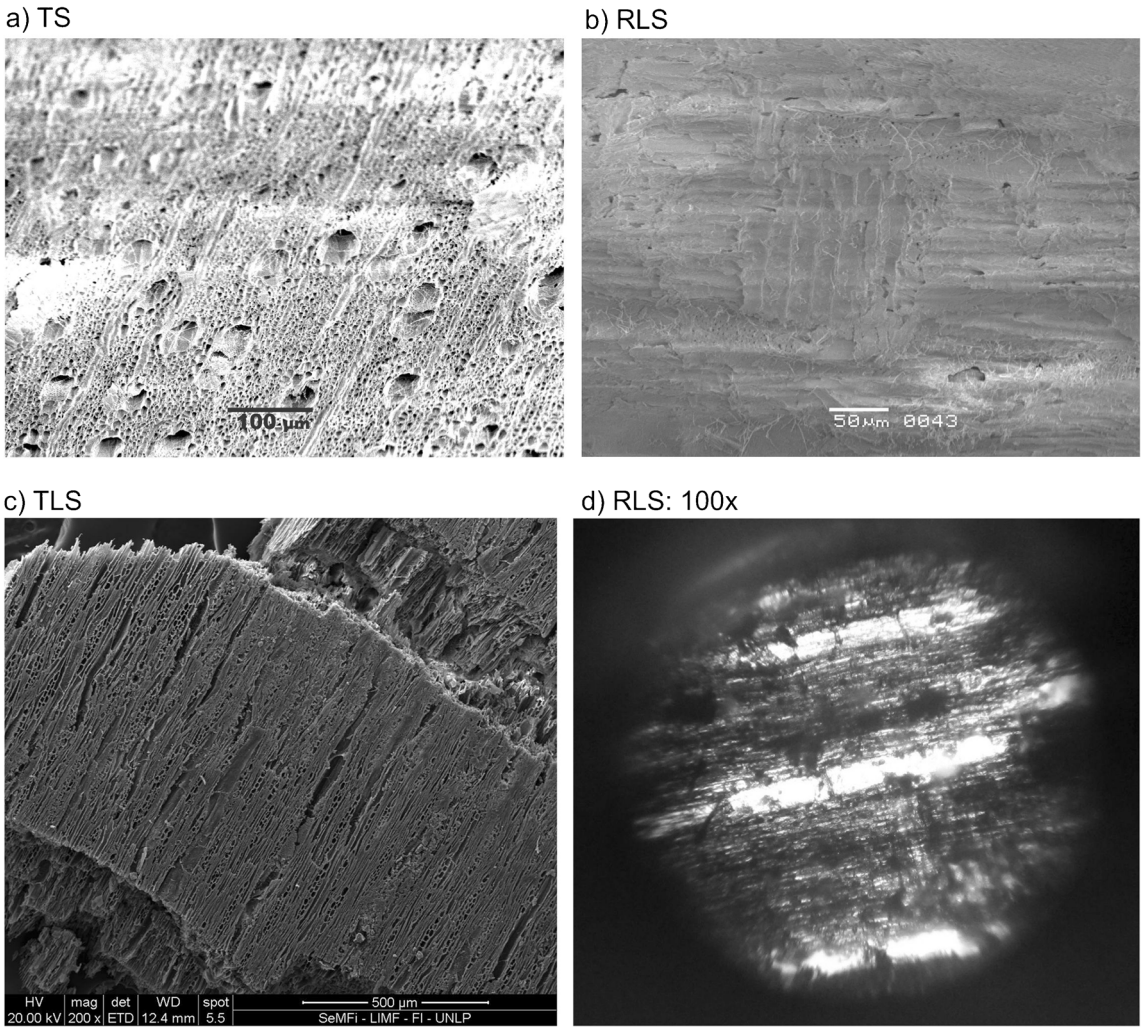


Fig. 8 Group II of woods from El Churcal

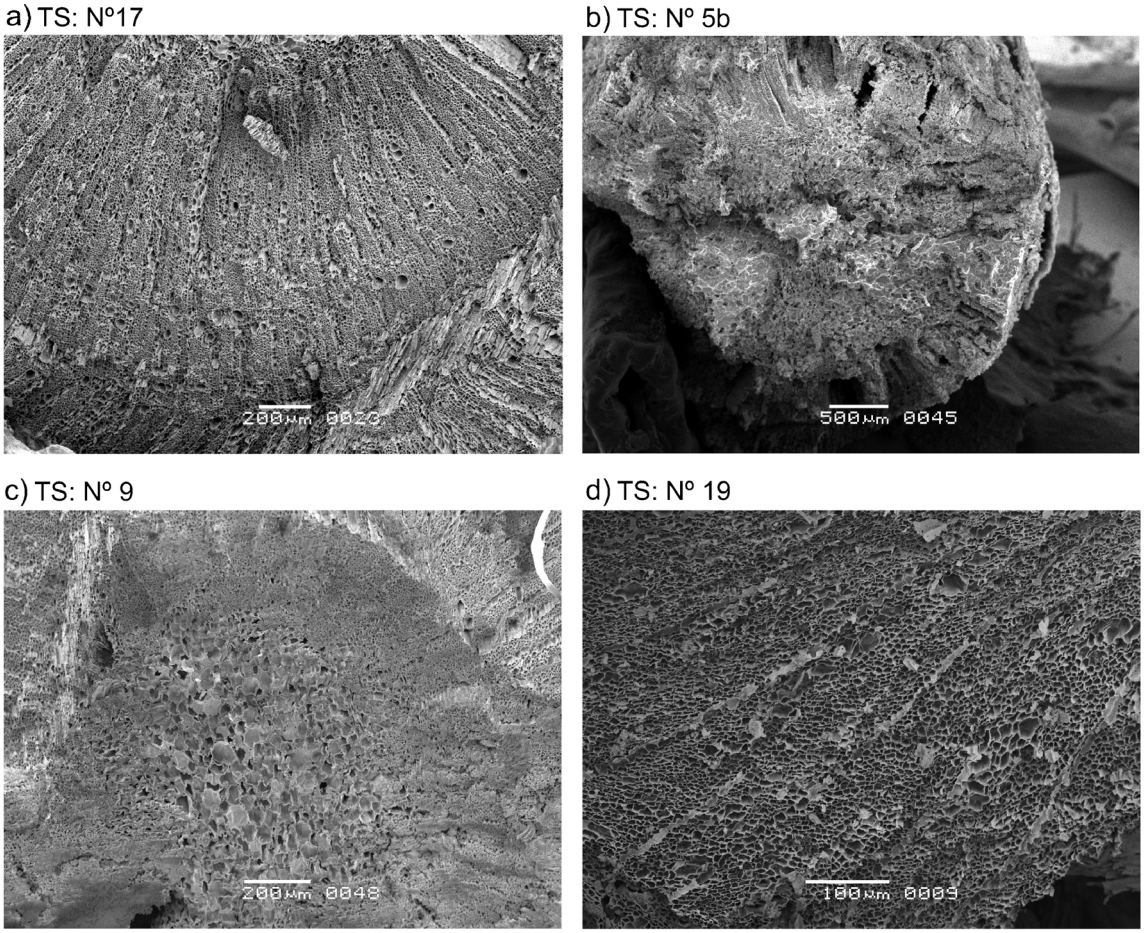


Fig. 9 Group III of woods from El Churcal

resources from other ecological regions, then it is possible to suggest the Empire had no intervention in the local networks of circulation of certain materials that would guarantee the subsistence and social reproduction of the local communities.

After all, integral use of several parts of the plant and of local and non-local varieties of wood species by late Calchaquí societies is indicative of the deep knowledge they had of resources, their characteristics and availability, and of the kind of informed decisions they made regarding their use. Furthermore, it suggests levels of organization that ensured the supply of wood to several communities in the CV and signals the existence of widely shared knowledge about its use and exploitation. The collections studied, along with the results obtained, suggest the importance wood had for these

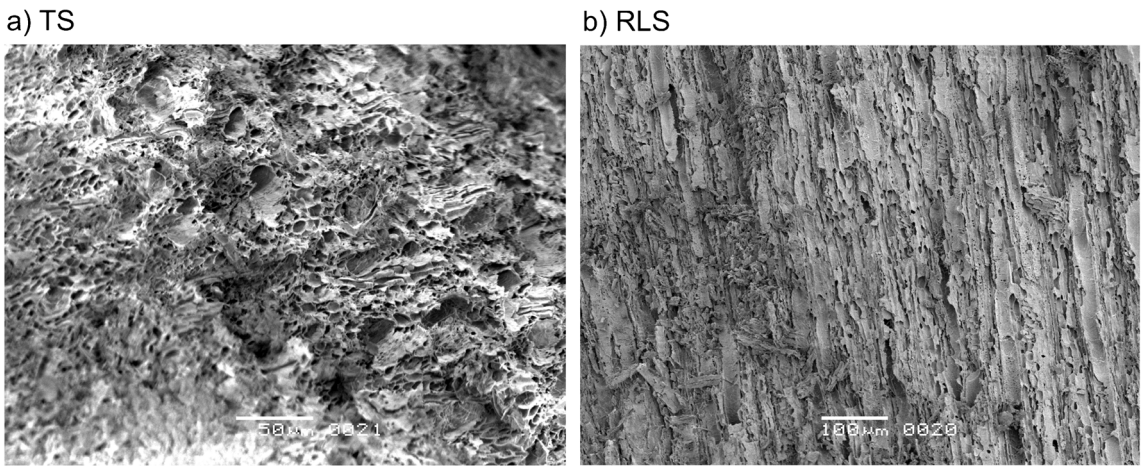


Fig. 10 Group IV of woods from El Churcal

societies, which is usually difficult to assess due to its poor conservation.

In addition, our study shows that, despite the availability and effective use of local wood in the manufacturing of a large number of Calchaquí artifacts, non-local woods were also used. This implied not only a degree of knowledge regarding the specific features and local environment of each species but also the effective handling of the social relationships and mechanisms that enabled interactions with populations inhabiting areas separated from the CV. Our analysis so far indicates that non-local woods tended to be used for the manufacture of artifacts that were not, for the most part, involved in daily domestic activities. Rather, these artifacts seemed to be associated with more specific social practices, as is the case with musical instruments, snuff trays and tubes, ceremonial *keros*, and bows. One object departs from this trend: a long shovel from the La Paya collection, an object related to textile and agricultural activities. As yet, there is not enough information regarding the function and context of use of other artifacts, such as "sticks" and wool carding combs (so labeled by Ambrosetti over a century ago), to interpret them within this trend. This is also the case with arrow shafts made of wood from young branches and a *tarabita* made of parts of the bark. Although we have more information about the uses given to these objects, it has not been possible to determine the species of the wood used. This is an aspect that emerges from our analyses and which we will continue to examine and specify in future studies.

Conclusions

While archaeological studies in the Calchaquí Valley have provided data about the processes of late interregional circulation, with various degrees of depth (Tarragó and De Lorenzi 1976; Calderari 1991a and b; González and Díaz 1992; Gifford 2003; Baldini et al. 2004; Williams 2004; Yacobaccio et al. 2004), a comprehensive study of the issue has developed only recently (Sprovieri 2010, 2013).

This research introduces the study of woods, which had never been the focus of investigation in the archaeology of the region. This provides highly relevant data about the specificity of the circulation and consumption of goods in the Calchaquí Valley during the last pre-Columbian centuries, which suggests an effective integration of Calchaquí populations in contexts of interregional interaction of diverse scope and singularity.

For our research, the museum collections from La Paya and El Churcal were of great value owing to their good state of preservation, which allowed the study of the artifacts despite the limited possibilities for intervention they offered. The analyses performed enabled a preliminary identification of woods recovered at La Paya on the basis of firm analytical grounds. Deeper analyses carried out on the wooden objects from El Churcal made it possible to make final determinations showing similar trends to the results obtained from La Paya. These include the use of several wood species, the use of both local and non-local woods, and wood supply from the Yungas Region. The identification of wood from museum archaeological collections has allowed us to obtain previously unknown information about a scarcely studied material in the region, which contributes to the knowledge of circulation and consumption of wood in late pre-Columbian societies from the Calchaquí Valley, a topic we will continue to analyze in depth in future contributions.

Furthermore, this work seeks to contribute to the development of the studies on wood in the archaeology of Northwestern Argentina, which has so far focused more on other kinds of materials and crafts, such as ceramics, architecture, and metallurgy, despite the ancestral significance attached to wood as a resource by past societies. The interest in its study has traditionally been directed at its charred condition, mainly because of its suitability for radiocarbon dating. However, there has been a significant development of anthracological studies in NWA over the last decades, and today, it is possible to mention a number of experienced specialists undertaking this kind of studies (Marconetto, 1999, 2008, Capparelli 2004, Capparelli and Raffino 1997, Rodríguez 1996–97, 2000, etc.).

Still, studies on archaeological uncharred wood in NWA have been by far more limited and sporadic. Given that uncharred wood does not preserve well, especially in the valleys and forests that cover the region, it has been difficult to establish it as a sustained line of analysis in modern researches. For this reason, the value of museum collections should not be disregarded. Many of these were assembled during the first decades of the 20th century and, despite presenting certain difficulties for their analysis, they constitute the largest sets of remains from pre-Columbian wooden objects, and they hold the potential value of analyzing this material and its manufacturing, circulation, and consumption processes in the past. It is our intention to continue working on this process of appreciation.

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