

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/283334641>

RADIOCARBON DATING OF ATACAMA (CHILE) SNUFF TRAYS: AN UPDATE ON STYLISTIC AND CHRONOLOGICAL CORRELATIONS

Article in Radiocarbon · October 2015

CITATIONS

9

READS

383

5 authors, including:



Catherine Lavier

Ministère de la culture et de la communication

44 PUBLICATIONS 202 CITATIONS

SEE PROFILE



Helena Horta Tricallotis

Universidad Católica del Norte (Chile)

28 PUBLICATIONS 201 CITATIONS

SEE PROFILE



Valentina Figueroa

Universidad Católica del Norte (Chile)

54 PUBLICATIONS 509 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



FONDECYT 1160849: Estudio multidisciplinario del sistema religioso atacameño: Parafernalia alucinógena, cronología y diferenciación social (500-1500 d.c.). [View project](#)



Poblados Maiceros y Arquitectura funeraria en el valle del Lluta [View project](#)

RADIOCARBON DATING OF ATACAMA (CHILE) SNUFF TRAYS: AN UPDATE ON STYLISTIC AND CHRONOLOGICAL CORRELATIONS

Pascale Richardin¹ • Catherine Lavier² • Helena Horta³ • Valentina Figueroa³ • Nicolás Lira⁴

ABSTRACT. The Atacama region of Chile has the highest concentration of hallucinogenic paraphernalia from prehistoric cemeteries on the planet. These artifacts have been studied since the late 19th century, primarily from the perspective of stylistic classification, which has been used to infer their temporal assignment. However, direct chronological dating of the snuff trays has not been addressed until now, through an interdisciplinary study conducted in San Pedro de Atacama on the psychotropic paraphernalia collection of the Instituto de Investigaciones Arqueológicas y Museo R.P. Gustavo Le Paige S.J. (IIAM), part of the Universidad Católica del Norte. In this study, samples were taken from eight snuff trays for radiocarbon dating and to develop a suitable procedure and protocol for sample extraction and handling of wooden archaeological pieces. This article provides the results of these activities by establishing the existence of a sequence of styles in the hallucinogenic paraphernalia that goes from the Middle to Late Intermediate period (about AD 300 to 1400), which shows that in this time-span there were two styles (Tiwanaku and local), and then both were replaced by a macroregional style.

INTRODUCTION

According to archaeological investigations conducted to date, and thanks to the extraordinary climatic conditions of the Atacama Desert, which enable the conservation of organic materials, we know that in this South Andean region the inhalation of powder obtained from plants with alkaloid components that alter the state of consciousness of those who consume them was practiced for a long period of time (e.g. Uhle 1898, 1913, 1915; Núñez 1962, 1963, 1967, 1994; Tarragó 1968, 1989; Thomas and Benavente 1984; Torres 1984a,b, 1986, 1987a,b, 1998, 2001a,b, 2004; Torres et al. 1991; Torres and Conklin 1995; Chacama 2001; Hermosilla 2001; Torres and Repke 2006). This practice and the instruments associated with it—snuff trays and tubes, large and small spoons, dispensers, stone and wood mortars, spatulas, pouches to hold the pulverized seeds, woven bags, cane and wooden recipients—have been collectively called the “hallucinogenic complex” in the specialized literature. The grave goods of hundreds of tombs dating from the Late Formative period to the arrival of the Spanish conquistadors bear witness to this deep-rooted custom and in turn have enabled the preservation of a variety of snuff paraphernalia, most of it made of wood, some of it stone. Notable among those instruments are the snuff trays, which were used to hold the powder from the cebil seeds (*Anadenanthera colubrina* var. *Cebil*) (Reis Altschul 1964, 1972; Torres et al. 1991; Torres 1998) so they could be snuffed through tubes. Investigation of the hallucinogenic complex began more than a century ago, but to date none of the psychotropic paraphernalia mentioned have been subjected to radiocarbon dating. An interdisciplinary team composed of French researchers from the Centre de Recherche et de Restauration des Musées de France and CNRS, and Chilean researchers from the Department of Anthropology of the Universidad de Chile and from the Instituto de Investigaciones Arqueológicas y Museo R.P. Gustavo Le Paige S.J. (IIAM), of the Universidad Católica del Norte, performed the aforementioned dating in 2012. Given that the idea was to employ for the first time on these objects a procedure to extract samples from archaeological material, among other precautions the team decided to subject a smaller number of trays to analysis, focusing especially on those that were already showing signs of deterioration, as can be observed in the photograph of the samples studied.

Traditionally, the paraphernalia studied has been chronologically assigned on the basis of (1) its association with other materials found among the same set of grave goods (essentially ceramics,

1. Centre de Recherche et de Restauration des Musées de France, Palais du Louvre, Porte des Lions, 14 quai François Mitterrand, F-75001 Paris, France. Corresponding author. Email: pascale.richardin@culture.gouv.fr.

2. Université Pierre et Marie Curie, UPMC Paris 06, UMR 8220, Laboratoire d'Archéologie Moléculaire et Structurale, LAMS, Paris, France.

3. Instituto de Investigaciones Arqueológicas y Museo R.P. Gustavo Le Paige S.J., Universidad Católica del Norte, Chile.

4. Université Panthéon-Sorbonne, Paris 01, UMR 8096, Paris, France.

charcoal and bones), which could be dated by thermoluminescence or ^{14}C ; and (2) its stylistic and iconographic correspondence. Our goal has thus been to develop a more accurate methodology for dating these materials.

SAN PEDRO DE ATACAMA IN THE MIDDLE PERIOD

During the period traditionally considered the rise of Tiwanaku influence (about AD 400–1000), San Pedro society had a tremendous cultural vitality owing to its unique geographic location at the heart of a group of oases in the middle of the Atacama Salt Plateau (2450 m asl) and the fact that it was situated at the halfway point on the route stretching from the Pacific coast through the Atacama Desert and the eastern watershed of the Andes Mountains (Figure 1). The Atacameño people took full advantage of these conditions. From early on, they became skillful at benefiting from an extensive network of kinship-based political alliances that were built not only with Altiplano societies but also with others adjoining that region, such as the peoples of what is now northwest Argentina and those that lived in the Southern Altiplano of what is today Bolivia. The cultural richness that resulted from those alliances is more than evident in a variety of local traditions ranging from the textile traditions displayed in their clothing and identifying headwear (Agüero 2000, 2004) to the Black Polished ceramics (Stovel 2005, 2008) and the manufacturing of copper ore beads and psychotropic paraphernalia (Salazar et al. 2014), all of which were clearly configured in the Atacameño style.

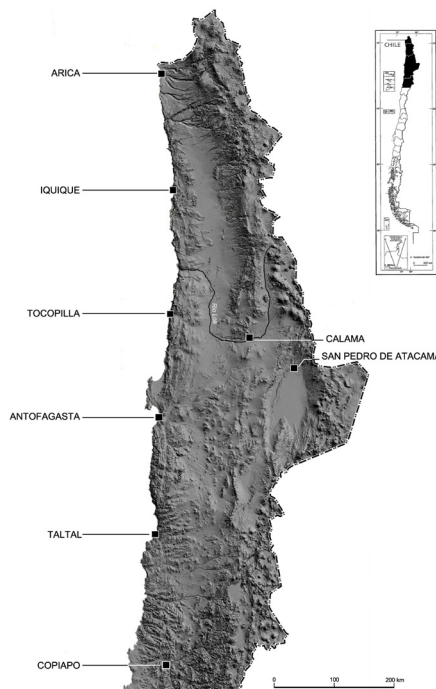


Figure 1 Map of San Pedro de Atacama

In connection with the hallucinogenic complex, interest initially focused on snuff trays and other psychotropic elements of Tiwanaku style, but has now spread to the definition of other styles, including a so-called Atacamenian local style (Llagostera et al. 1988; Llagostera 2001, 2006) or “local production” (Núñez 1963), or San Pedro style (Horta 2014), and one macroregional style (Circumpuneño). The latter has been described as a post-Tiwanaku style frequently represented in the basin of the Loa River, the Puna de Jujuy, and northwestern Argentina, and infrequently represented in the oasis of San Pedro de Atacama (Horta 2012).

SNUFFING PRACTICE AND STYLES

In this macroregional context, San Pedro de Atacama was a pole of attraction for different pre-Hispanic societies that wished to exchange different products for the copper ore found in the area. Exchange was practiced intensely at this time, and the products traded were not limited to domestic and other everyday goods but also included ritual and symbolic items associated with the religious sphere. Thus, during the Middle period, snuff trays and other paraphernalia made their way to San Pedro from different places, such as the Southern Altiplano of Bolivia and northwestern Argentina; nevertheless, about 25% of the IIAM registered paraphernalia was manufactured locally (Horta 2014).

Regarding stylistic diversity, early investigations of the hallucinogenic complex focused on a limited number of items displaying Tiwanaku iconography and formats and ignored those that did not correspond to that style. Torres was the first researcher to attempt to define the Tiwanaku style based on the collection of trays and tubes preserved by IIAM, using a sample of around 500 items for his analysis⁵ (Torres 1984a). It should be noted here that formal iconographic analysis of hallucinogenic paraphernalia has generated a prolific body of literature by researchers of different nationalities. Figure 2 shows the eight snuff trays from the archaeological Museum of San Pedro de Atacama, selected for this study.



Figure 2 Studied snuff trays from the Archaeological Museum of San Pedro de Atacama: (1) IIAM 351, Tiwanaku style, Quitor 6 grave 2509, snuff tray 9076; (2) IIAM 024, San Pedro style, Quitor 5 grave 2077-2089, snuff tray 9148; (3) IIAM 340, San Pedro style, Sequitor Alabrado grave 5203-5205, snuff tray 9065; (4) IIAM 393, Tiwanaku style, Sequitor Alabrado grave 1702, snuff tray 9079; (5) IIAM 275, Tiwanaku style, Catarpe 5 grave 2351, snuff tray 9075; (6) IIAM 205, San Pedro style, Quitor 5 grave 2163, snuff tray 9149; (7) IIAM 038, Circumpuneño style, Quitor 1 grave 1178, snuff tray 8890; (8) IIAM 387, Circumpuneño style, Pucara de Quitor without context, snuff tray 9055.

5. Currently, the IIAM has a records database that includes digital images of these objects, which has greatly facilitated their study and enabled registration of nearly 700 pieces.

MATERIAL AND METHODS

Sampling

Sampling of the wooden objects in this study is very delicate because it raises several problems based on their fragility and conservation, and on their representativity and significance. The preservation of these snuff trays is particular because of the very low humidity contained in the fibers. This is due to the cutting and the wood work used in the past, but also due to the conditions of discoveries and conservation in the region and the museum. The free water is completely evaporated,⁶ the saturation level is overtaken⁷, and the bound water in cellular membranes falls below the limit of the natural drying⁸, reaching an almost “oven-dried” state. During this phase, the wood can undergo structural modifications and can deform (and/or during and after excavation), as far as, once dried, it is capable of absorbing the humidity of the air (hygroscopy). Fortunately, the environmental conditions in the Atacama region are constant and without abrupt variations.⁹ The water rate in the wood reaches a low level of hygroscopic balance¹⁰ and it stabilizes, thus avoiding any change, and explaining the generally very good conservation of the tablets.

However, the difficulties of the wood sampling is due to the tablets’ rather small size, their whole aspect, and their hardness, which can make visible and invasive any taking of matter. Using methods developed at the C2RMF (Richardin and Gandolfo 2013a,b), microsampling is performed in order to keep the integrity of the object, while gathering sufficient quantity (between 2–10 mg) for ¹⁴C measurement (Figure 3).

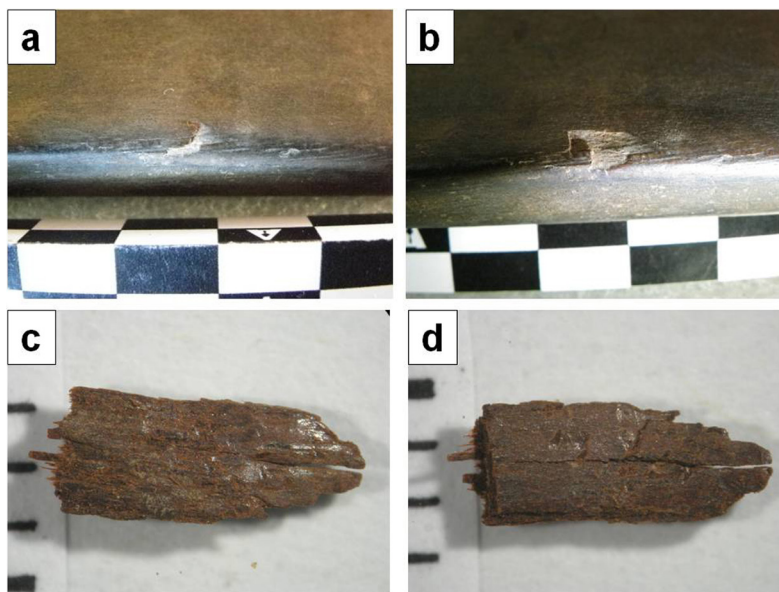


Figure 3 Location the sample taken from the snuff tray IIAM 351 (a) before and (b) after sampling. Binocular picture of the collected sample (3.93 mg): (c) recto and (d) verso.

6. Water situated in the space of the wood (fibers, vessels, tracheids, etc.).

7. Over the fibers saturation point (PSF) at around 30% depending of the wood species, their age, their volumetric mass, their percentages of components (e.g. cellulose, hemicelluloses, lignin, and extractives) and the climatic conditions (temperature, hygrometric degree, atmospheric pressure, etc.).

8. Depending also of those same factors, below 18/15%.

9. From 15/20% during the “wet” season and some 5% in the dried areas.

10. Probably around 5% for the tablets.

Moreover, analyzing wood with a dendrometrical approach also generates usable information and data for the next steps of the snuff trays' analysis. At the moment, certain information like the number of tree rings and their growth, does not interfere in the interpretation of the ¹⁴C dates. The number of snuff trays is limited due to current restrictions to preserve the integrity and preservation of such artifacts; however, from the tray sample some degree of categorization was able to be made according to style: Tiwanaku (samples 351, 393, and 275), San Pedro (024, 340, and 205), and Circumpuneño (038 and 387) style. Thus, the selection criterion was the feasibility of sampling and then the assignment to a particular style.

Next, the question arose as to whether the tables could be ordered chronologically. This dendro-data can be used to date a large lot of tablets and to classify them in contemporary groups: wood series will be correlated between them and the styles will benefit from an higher chronological fineness. It will then be possible to better specify information such as circulation axis, speed of propagation, arrival and term, acculturation, and adaptation.

Sample Preparation

Three steps for the sample preparation for ¹⁴C dating are necessary: a chemical pretreatment (cleaning or extraction of the carbonaceous matter), a combustion (or extraction of CO₂), and a graphitization (transformation of CO₂ into graphite). Only the two first steps are performed at the C2RMF while the graphitization step is done at the Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) of Saclay, France (Cottureau et al. 2007; Moreau et al. 2013).

Chemical Pretreatment

In order to eliminate all insoluble impurities (e.g. dust or textile fibers due to the manipulation of museum objects), samples are initially washed in an ultrasonic bath with ultrapure water (Direct-Q system, Millipore). Then, because they can be polluted by varnishes, waxes, and other organic compounds or even by oils and resins from within the wood itself, the samples are also washed with a mixture of dichloromethane/methanol (1/1) and then with acetone (AnalaR Normapur, VWR International). Between each cleaning, 3–4 rinses with ultrapure water are performed. This is the routine solvent extraction sequence for samples collected from museum objects and treated at C2RMF (Richardin and Gandolfo 2013a).

The wood samples were then subjected to a routine acid-base-acid method (Richardin et al. 2010). This consists of sequential washes (80°C, 1 hr) with 0.5M HCl, 0.05M NaOH, and once again with 0.5M HCl. After each step, the supernatant was removed and the remaining sample rinsed with ultrapure water until neutrality of the washing water was achieved.

Combustion

Finally, the clean samples were dried overnight in a low-vacuum (100 mbar) oven at 60°C. The dried samples were then combusted to CO₂ at high temperature (5 hr at 850°C) under high vacuum (at 10⁻⁶ Torr) using a homemade combustion bench. To control the sample preparation, we used a standard: a calibration sample (FIRI H) or a charcoal from South Africa, with an infinite age (CB-AFS). Yields are between 30 and 55% and the CO₂ amounts (between 0.1 and 0.9 mg) are sufficient for ¹⁴C measurement.

Graphitization

CO₂ samples were reduced to graphite at 600°C using Fe powder as catalyst prior to accelerator mass spectrometry (AMS) ¹⁴C dating.

Radiocarbon Measurements

Measurements were conducted at the AMS facility of the CEA of Saclay (Moreau et al. 2013). The ^{14}C activity is calculated by comparing the measured intensities of the ^{14}C , ^{13}C , and ^{12}C beams from each sample with those of CO_2 standards, prepared with HOx (I) oxalic acid reference, normalized with a $\delta^{13}\text{C}$ value of -25‰ . The ^{14}C ages (in yr BP = years before 1950) are calculated by correcting the isotope fractionation $\delta^{13}\text{C}$, measured by AMS with the $^{13}\text{C}/^{12}\text{C}$ ratio. Calendar ages are determined using the OxCal v 4.2.3 program (Bronk Ramsey 1995; Bronk Ramsey and Lee 2013) and the most recent calibration curve data for the Southern Hemisphere, SHCal13 (Hogg et al. 2013). Calibrated age ranges correspond to 95.4% probability (2σ) and are expressed in years cal BC.

RESULTS AND DISCUSSION

The ^{14}C ages (in yr BP), and calibrated calendar age ranges of the individual samples are given in Table 1 and compared in Figure 4.

Table 1 Radiocarbon ages (BP) and calibrated ages of samples.

Inventory nr	Lab code	^{14}C age (yr BP)	95.4 % (2σ) calibrated age ranges (relative area under distribution)	Style
IIAM 351	SacA-33697	1845 ± 30	AD 125 (83.4%) 254 AD 294 (12.0%) 335	Tiwanaku, “Sacrificer,” reused sample
IIAM 024	SacA-33785	1635 ± 30	AD 390 (95.4%) 543	San Pedro
IIAM 340	SacA-33292	1590 ± 30	AD 426 (95.4%) 584	San Pedro
IIAM 393	SacA-33686	1525 ± 30	AD 534 (95.4%) 643	Tiwanaku, volumetric
IIAM 275	SacA-33291	1340 ± 30	AD 655 (93.9%) 774 AD 820 (1.5%) 832	Tiwanaku, “Sacrificer,” reused sample
IIAM 205	SacA-33696	1150 ± 30	AD 885 (93.8%) 996 AD 1005 (1.6%) 1013	San Pedro
IIAM 038	SacA-33290	1135 ± 30	AD 892 (95.4%) 1016	Circumpuneño
IIAM 387	SacA-33685	660 ± 30	AD 1299 (95.4%) 1399	Circumpuneño

According to the calibrated dates, the Tiwanaku and San Pedro styles are contemporary, and were clearly in effect during the Middle period, about AD 300–1000, while the Circumpuneño style was present during the period AD 900–1400, and thus is an expression of the Late Intermediate period. The date obtained for snuff tray IIAM 351 (Figure 2.1) corroborates the early chronological placement of the Tiwanaku Sacrificer,¹¹ a figure depicted in profile with the head front-facing or turned upwards, visual attributes related to decapitation (a human head and ax), feline features (teeth and ears), and occasionally, wings. According to observations made by Torres (2001a), this is the most frequently found icon on Tiwanaku snuff trays discovered in San Pedro de Atacama, and according to our records it is found on 24% (15/62) of the imported paraphernalia in the collection of Horta (2014). Additionally, snuff tray IIAM 275 (Figure 2.5) demonstrates that the icon in question was used for an extended period that lasted at least until AD 700–800, with the additional information obtained from the Solcor 3 snuff tray (AD 500–1000; see Note 11).

11. This refers to thermoluminescence (TL) dates obtained previously for trays 8844 from Toconao Oriente, tomb 4229-4230 (AD 190 ± 140 ; Berenguer et al. 1986; Torres 2001a) and 9106 from Quito 8, tomb 3229-3230 (AD 180; Berenguer et al. 1986; Tarragó 1989; Torres 2001a). For tomb 107 of Solcor 3, which includes a beautiful tray with the Tiwanaku Sacrificer, three ^{14}C dates were also obtained: AD 490 ± 100 ; AD 730 ± 60 ; AD 930 ± 120 (Llagostera et al. 1988). These demonstrate the extensive period during which this important icon was in use.

Furthermore, the date for snuff tray IIAM 393 (Figure 2.4) is consistent with the classical Tiwanaku period and establishes a more precise temporal range for this singular representation, which depicts a human figure reclining backwards, an image seldom found in the snuff trays identified to date from the south-central Andean region¹² (Llagostera 2006:Figure 6c).

Also worth mentioning are the dates obtained for snuff trays IIAM 024, 340, and 205, in the San Pedro style (Figures 2.2 and 2.3). This style, which features human figures and images of shamans and their alter egos on rectangular trays, is only found in the central oases of the Atacama Salt Plateau (present-day San Pedro de Atacama), and as such it can be considered a local style. The range of dates obtained from these three snuff trays indicates that the San Pedro style was contemporary with that of Tiwanaku (about AD 400–1000), which contradicts the idea put forward by other researchers that the Atacameño people had begun to practice snuffing and developed their own unique style before the influence of that Altiplano state took hold (Llagostera et al. 1988).

The results of the ¹⁴C dating obtained for snuff trays IIAM 038 and 387 (Figures 2.7 and 2.8) are fully coherent with the proposal that the Circumpuneño style was in effect in post-Tiwanaku times (Horta 2012). The tray IIAM 038 is fractured today, but the notes left by Le Paige (1964, 1965) tell us that the upper middle section originally bore the figure of a bird that is now missing (“beautiful snuff tray with a condor with outspread wings”). This description and the general format of the piece allow us to assign it to the Circumpuneño style.

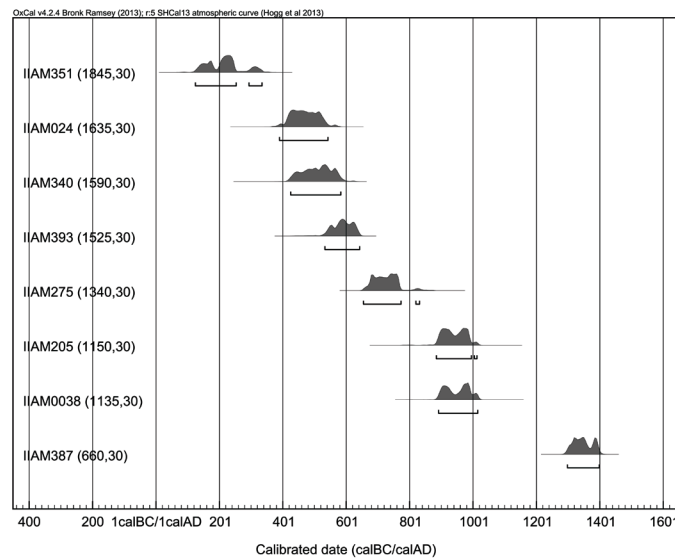


Figure 4 Calibration plots of the calibrated dates of the samples

CONCLUSIONS

As discussed in the Introduction, for the first time samples have been obtained directly from Chilean snuff trays for ¹⁴C analysis, with the double aim of developing a procedure and protocol for studying wooden archaeological material and to test ¹⁴C and thermoluminescence (TL) dates obtained

12. In the IIAM collection only two other examples are known: IIAM 403, tray 9071, no tomb, from Solor Túmulo Sur, and the other from Solor 3, also without context. The most spectacular of this series—for its degree of integrity and the preservation of iconographic detail—is tray N°41.0.8911, from San Pedro de Atacama, which today is housed in the American Museum of Natural History in New York (Torres 1987b:Plate 97).

over the past 30 yr for a variety of grave goods including snuff trays. Thus, the indirect dating by association with ceramics or bone (conducted in 16 different contexts) can now be complemented by direct dating of the material performed by our team on the aforementioned snuff trays. Indeed, the results presented do not invalidate the time ranges that were previously established by TL dating (6 tombs) and ^{14}C (10 tombs) dating. [Recently, Torres-Rouff and Hubbe (2013) ^{14}C dated a large sample of osteological material with interesting facts about the prolonged duration in time of several cemeteries of the Salar de Atacama.] On the contrary, our results reinforce the previous ones and even expand the period during which snuffing was practiced in the Atacama region up to Inca times.

As indicated above, up to now the usual archaeological practice in relation to the hallucinogenic complex has been to date a piece of ceramic, charcoal, or bone from a certain tomb and then extend the date obtained to the paraphernalia found in the same tomb. Using this method, researchers have found most of the paraphernalia in association with Polished Black and Almost-Polished Black ceramics, giving a date range of approximately AD 100–700 (Tarragó 1989; Torres 1998). Nevertheless, the direct ^{14}C dates obtained for these eight snuff trays enable us to both expand the dates previously assigned and establish the time ranges for each style defined to date, namely Tiwanaku, San Pedro, and Circumpuneño. In effect, the first two styles were found to be contemporary, falling into the Middle period, while the third was confirmed to have been in effect during the Late Intermediate period. Thus, the variations in stylistic and iconographic attributes established for each style have chronological significance, and when conducted on a broad sample, stylistic and iconographic analysis as a method in itself can indeed provide independent verification through the use of ^{14}C dating.

ACKNOWLEDGMENTS

This paper was financed under the Proyecto de Investigación Asociativa Conicyt Anillo ACT-96. We want to thank Bernard Berthier and his team from the Laboratory of Measurement of Carbon 14 (LMC14 - UMS2572) for the graphitization step of the gas samples and the ^{14}C measurements, and Nathalie Gandolfo from the C2RMF for the sample preparation.

REFERENCES

- Agüero C. 2000. Fragmentos para armar un territorio. La textilera en Atacama durante los períodos Intermedio Tardío y Tardío. *Estudios Atacameños* 20:7–28.
- Agüero C. 2004. Componente Tiwanaku vs. componente local en los oasis de San Pedro de Atacama. Tejidosueños en el Cono sur. Textiles andinos: pasado, presente y futuro. In: *Actas del 51º Congreso Internacional de Americanistas*. Barcelona: Departamento de Artes, Universidad de Barcelona, Grup d'Estudis Precolombins. p 180–98.
- Berenguer J, Deza A, Román A, Llagostera A. 1986. La secuencia de Myriam Tarragó para San Pedro de Atacama: un test portermo luminiscencia. *Revista Chilena de Antropología* 5:17–54.
- Bronk Ramsey C. 1995. Radiocarbon calibration and analysis of stratigraphy: the OxCal program. *Radiocarbon* 37(2):425–30.
- Bronk Ramsey C, Lee S. 2013. Recent and planned developments of the program OxCal. *Radiocarbon* 55(2–3):720–30.
- Chacama J. 2001. Tabletillas, tubos y espátulas. Aproximación a un complejo alucinógeno en el área de Arica, extremo norte de Chile. *Eleusis* 5:85–100.
- Cottureau E, Arnold M, Moreau C, Baqué D, Bavay D, Caffy I, Comby C, Dumoulin J-P, Hain S, Peron M, Salomon J, Setti V. 2007. Artemis, the new ^{14}C AMS at LMC14 in Saclay, France. *Radiocarbon* 49(2):291–9.
- Hermosilla N. 2001. The people of the Tumi, the Condor and the Jaguar. Psychoactive plant use in the Loa River Basin, Atacama Desert. *Eleusis* 5:123–36.
- Hogg A, Hua Q, Blackwell P, Niu M, Buck C, Guilderson TP, Heaton T, Palmer J, Reimer P, Reimer R, Turney C, Zimmerman S. 2013. SHCal13 Southern Hemisphere calibration, 0–50,000 years cal BP. *Radiocarbon* 55(4):1889–903.
- Horta H. 2012. El estilo Circumpuneño en el arte de la parafernalia alucinógena prehispánica (Atacama y noroeste argentino). *Estudios Atacameños* 43:5–34.
- Horta H. 2014. Lo propio y lo ajeno. Definición del estilo San Pedro en la parafernalia alucinógena de los oasis del salar de Atacama. *Chungara, Revista de Antropología Chilena* 46(4):559–83.
- Latham R. 1938. *Arqueología de la región Atacameña*. Santiago: Prensas de la Universidad de Chile.
- Le Paige G. 1964. El Prececerámico en la cordillera Atacameña y los cementerios del Período Agroalfarero

- de San Pedro de Atacama. *Anales de la Universidad del Norte* 3, Chile.
- Le Paige G. 1965. San Pedro de Atacama y su zona (14 temas). *Anales de la Universidad del Norte* 4, Chile.
- Llagostera A. 2001. Archaeology of hallucinogens in San Pedro de Atacama (north Chile). *Eleusis* 5:101–21.
- Llagostera A. 2006. Contextualización e iconografía de las tabletas psicotrópicas Tiwanaku de San Pedro de Atacama. *Chungara* 38(1):83–111.
- Llagostera A, Torres C, Costa MA. 1988. El complejo psicotrópico en Solcor-3 (San Pedro de Atacama). *Estudios Atacameños* 9:61–98.
- Moreau C, Caffy I, Comby C, Delqué-Kolic E, Dumoulin J-P, Hain S, Quiles A, Setti V, Souprayen C, Thellier B, Vincent J. 2013. Research and development of the Artemis ¹⁴C AMS Facility: status report. *Radiocarbon* 55(2–3):331–7.
- Núñez L. 1962. Tallas prehispánicas en madera. Contribución a la arqueología del norte de Chile [unpublished thesis]. Santiago: Instituto Pedagógico, Facultad Filosofía y Educación, Universidad de Chile.
- Núñez L. 1963. Problemas en torno a la tableta de rapé. In: *Anales de la Universidad del Norte 2, Congreso Internacional Arqueología de San Pedro de Atacama*. p 149–68.
- Núñez L. 1967. Informe arqueológico sobre una muestra de posible narcótico del sitio Patillos-1 (Provincia de Tarapacá, Norte de Chile). *Arstryck* 1967–1968: 83–90.
- Núñez L. 1994. Cruzando la cordillera por el norte: señorías, caravanas y alianzas. In: Francisco Mena, editor. *La Cordillera de los Andes: Ruta de encuentros*. Santiago: Exhibition Catalogue Museo Chileno de Arte Precolombino. p 9–21.
- Reis Altschul S. 1964. A taxonomic study of the genus *Anadenanthera*. In: *Contributions from the Gray Herbarium of Harvard University N°CVCIII*. Cambridge, Massachusetts p 3–65.
- Reis Altschul S. 1972. *The Genus Anadenanthera in Amerindian Cultures*. Cambridge: Botanical Museum, Harvard University.
- Richardin P, Gandolfo N. 2013a. Datation et authentification des œuvres de musée - Apports de la datation par le carbone 14. *Spectra Analyse* 292:55–60.
- Richardin P, Gandolfo N. 2013b. Radiocarbon dating and authentication of objects from ethnographic museums. *Radiocarbon* 55(3–4):1810–8.
- Richardin P, Cuisance F, Buisson N, Asensi-Amoros V, Lavier C. 2010. AMS radiocarbon dating and scientific examination of high historical value manuscripts: application to two Chinese manuscripts from Dunhuang. *Journal of Cultural Heritage* 11:398–403.
- Salazar D, Niemeyer HN, Horta H, Figueroa V, Manríquez G. 2014. Interaction, social identity, agency and change during Middle Horizon San Pedro de Atacama (northern Chile): a multidimensional and interdisciplinary perspective. *Journal of Anthropological Archaeology* 35:135–52.
- Stovel E. 2005. The archaeology of identity construction: ceramic evidence from northern Chile. In: Funari PP, Zarankin E, Stovel E, editors. *Global Archaeological Theory. Contextual Voices and Contemporary Thoughts*. New York: Kluwer Academic.
- Stovel E. 2008. Interaction and social fields in San Pedro de Atacama, northern Chile. In: Silverman H, Isbell WH, editors. *The Handbook of South American Archaeology*. Berlin: Springer. p 979–1002.
- Tarragó M. 1968. Secuencias culturales en la etapa agroalfarera de San Pedro de Atacama (Chile). In: *Actas del XXXVII Congreso Internacional de Americanistas*. Volume II. Buenos Aires. p 119–44.
- Tarragó M. 1989. Contribución al conocimiento arqueológico de las poblaciones de los oasis de San Pedro de Atacama en relación con los otros pueblos puneños, en especial, el sector septentrional del valle Calchaquí [unpublished PhD thesis]. Facultad de Humanidades y Artes, Universidad Nacional de Rosario, Argentina.
- Thomas C, Benavente MA. 1984. Reflexiones metodológicas acerca de las creencias en la cultura San Pedro a través del análisis de correspondencia de las tabletas de rapé. In: *Simposio Culturas Atacameñas*. 44º Congreso Internacional de Americanistas, Manchester, UK. p 157–74.
- Torres C. 1984a. Tabletillas para alucinógenos de San Pedro de Atacama: estilo e iconografía. In: *Tesoros de San Pedro de Atacama*. Santiago: Exhibition Catalogue Museo Chileno de Arte Precolombino. p 23–36.
- Torres C. 1984b. Iconografía de las tabletas para inhalar sustancias psicoactivas de la zona de San Pedro de Atacama, norte de Chile. *Estudios Atacameños* 7:178–96.
- Torres C. 1986. Tabletillas para alucinógenos en Sudamérica: tipología, distribución y rutas de difusión. *Boletín del Museo Chileno de Arte Precolombino* 1:37–53.
- Torres C. 1987a. *The Iconography of South American snuff trays and Related Paraphernalia*. Göteborg: Etnologiska Studier 37, Etnografiska Museet.
- Torres C. 1987b. The iconography of the Prehispanic snuff trays from San Pedro de Atacama, northern Chile. *Andean Past* 1:191–254.
- Torres C. 1998. Psychoactive substances in the archaeology of northern Chile and NW Argentina. *Chungara* 30:49–63.
- Torres C. 2001a. Iconografía Tiwanaku en la parafernalia inhalatoria. In: Kaulicke P, Isbell WH, editors. *Huari y Tiwanaku: Modelos versus evidencias. Second Part*. Boletín PUCP, Departamento Humanidades, Pontificia Universidad Católica del Perú. p 247–54.
- Torres C. 2001b. Shamanic inebriants in South America archaeology: recent investigations. *Eleusis* 5:3–12.
- Torres C. 2004. Imágenes legibles: la iconografía Tiwanaku como significativa. *Boletín del Museo Chileno de Arte Precolombino* 9:55–73.
- Torres C, Conklin W. 1995. Exploring the San Pedro de Atacama/Tiwanaku relationship. In: Dransart P, editor. *Andean Art: Visual Expression and Its Relation*

- to *Andean Beliefs and Values*. Avebury: Worldwide Archaeology Series, Volume 13. p 79–108.
- Torres CM, Repke DB. 2006. *Anadenanthera*. *Visionary Plant of Ancient South America*. New York: Hawthorth Herbal Press.
- Torres C, Repke DB, Chan K, Mackenna D, Llagostera A, Schultes RE. 1991. Snuff powders from Pre-Hispanic San Pedro de Atacama: chemical and contextual analysis. *Current Anthropology* 32:640–9.
- Torres-Rouff C, Hubbe M. 2013. The sequence of human occupation in the Atacama oases, Chile: a radiocarbon chronology bases on human skeletal remains. *Latin American Antiquity* 24(3):330–44.
- Uhle M. 1898. A snuffing-tube from Tiahuanaco. *Bulletin of the Free Museum of Science and Art*. Philadelphia: University of Pennsylvania. Volume 1(4).
- Uhle M. 1913. Tabletas de Chiu Chiu. *Revista Chilena de Historia y Geografía* 8:454–7.
- Uhle M. 1915. Los tubos y tabletas para rapé de Chile. *Revista Chilena de Historia y Geografía* XVI:114–36.