Metallurgical Traditions Under Inka Rule

A technological study of metals and technical ceramics from the Aconcagua Valley, Central Chile (South America)

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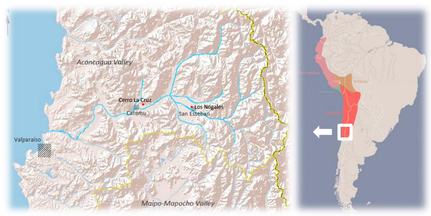
Introduction

During the Inka expansion (AD 1400-1540), the **Aconcagua valley** in central Chile experienced a series of changes, among which stands an increase in metallic objects. With the Inka arrival, the number of metallic artefacts soars from very few artefacts to nearly 60 pieces distributed in 10 sites. The following research is the first study characterising the area's metallurgical technology within its social context.

The technical analyses of metallic artefacts and technical ceramics from the sites **Cerro La Cruz** and **Los Nogales** suggest the presence of at least two metallurgical traditions present in the valley:

- At **Cerro La Cruz** the scarcity of bronze, the typologies and techniques suggest a tradition rooted in the indigenous Diaguita Culture.
- At **Los Nogales** the presence of typical Inka crucibles lined with bone ash and the use of bronze point to a tradition closely related to the Inka expansion, also documented in north-western Argentina.



Location of the sites, the Aconcagua valley and the Inka Empire.

Sites & Materials

***Cerro La Cruz** (M1, M2, M3, M4, M5, M6, M8, M9)*

- An Inka ritual centre where the Inka gathered local groups under a reciprocity and redistribution system for control and to formalise social and power relationships
- Pottery: Diaguita-Inka, Local-Inka, Aconcagua Salmon
- 44 metallic artefacts: copper-based (n=35) and white metals (n=9)
- Ornaments (earrings, pendants, bells) and tools (chisels, bars, axes)
- Radiocarbon dates: AD 1285-1430

***Los Nogales** (M7, R1, R2, R3, R4)*

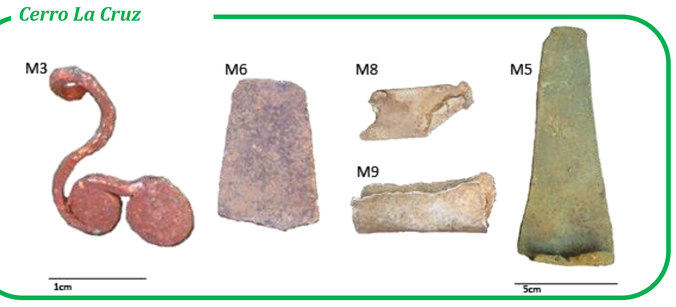
- An indigenous occupation site composed of a domestic area and a burial ground
- Pottery: local ceramic of Inka period, Aconcagua Salmon
- 2 metallic artefacts: semi-lunar plate (M7) and a pair of tweezers
- 12 technical ceramics with a white coating: 7 moulds and 5 crucibles
- Radiocarbon dates: AD 1420-1640

Methods

- ***Metallic Artefacts:** metallography, SEM-EDS*
- ***Technical Ceramics:** petrography, SEM-EDS*
- ***White lining on technical ceramics:** FTIR, XRD, SEM-EDS*

The analyses were carried out at the UCL Institute of Archaeology and the UCL Earth's Science Department.

Cerro La Cruz



Los Nogales

Results

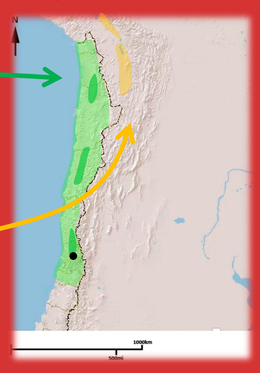
Metals

Composition and raw materials

In **Cerro La Cruz (CLC)**, pure copper and copper with arsenic and silver impurities were used. Ores with these elements are found in the Chilean territory, indicating the use of local raw materials. Silver ores are probably silver chlorides or sulphides. The 0.6% Sn in one object suggests some use of imported low-tin bronze.

In **Los Nogales (LN)** a high-tin bronze was used. However, cassiterite (tin oxide) is found only in NW Argentina and the altiplano. The presence of bronze artefacts in northern and central Chile suggests imported materials, as bronze was distributed into Chile by the Inka.

	Artefact	S	Cu	As	Ag	Sn	*Total**
CLC	M1	-	100	-	-	-	97.2
	M2	-	100	-	-	-	97.1
	M4	-	100	-	-	-	99.3
	M5	-	97.4	1.2	1.4	-	99.8
	M6	-	99.4	-	0.6	-	*101.5*
	M8	-	9.7	-	89.9	-	*101.4*
	M9	-	2.8	-	96.8	-	*100*
	M3	-	99.4	-	-	0.6	*104.1*
LN	M7	0.5	88.6	-	-	10.9	104.9

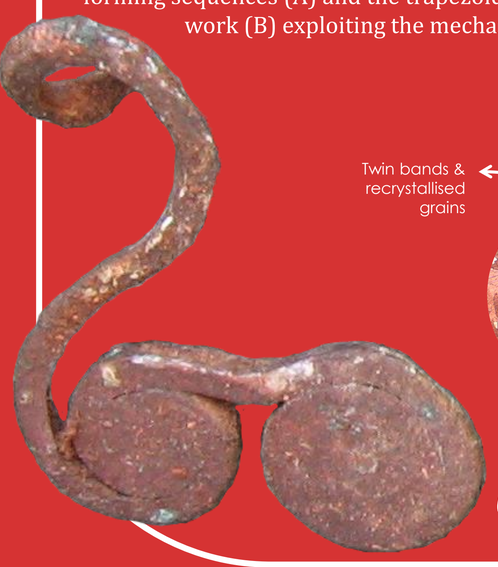


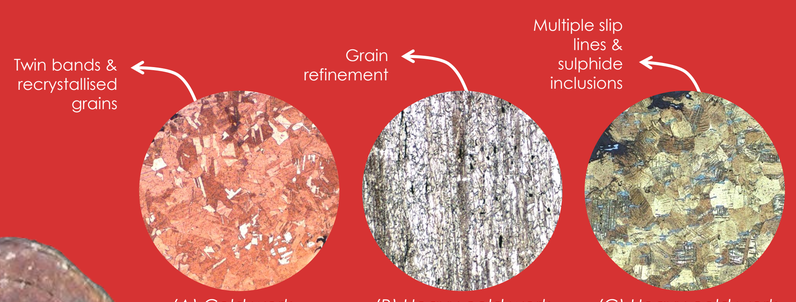
(Table) Bulk chemical composition of metallic artefacts by SEM-EDS (wt%). (*) Analytical totals. (Map) Distribution of copper (green), arsenic (dark green) and tin (yellow) ores. Cassiterite (SnO_2) is found only in the altiplano and NW Argentina. Sites are in black.

Manufacturing techniques

In **Cerro La Cruz**, manufacturing techniques are consistent between the copper samples, indicating expertise in the work of relatively pure copper. Earrings and the small sheet (M1-M4, M6) show the same forming sequences (A) and the trapezoidal plate (M5) shows heavier work (B) exploiting the mechanical properties of the alloy with As and Ag.

The semi-lunar plate M7 at **Los Nogales** was heavily worked (C) leaving multiple slip lines, suggesting specialised knowledge working bronze. The artisan was able to avoid brittleness.





(A) Cold work Annealing Mild cold work

(B) Heavy cold work Annealing Cold work

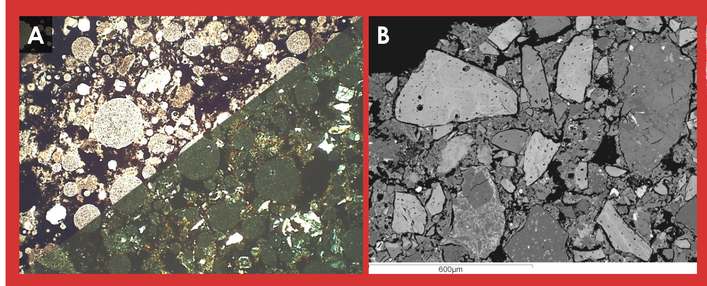
(C) Heavy cold work Annealing cold work

(A) and (B) metallography of relative pure copper samples (M1 & M5) from Cerro La Cruz. (C) High-tin bronze (M7) from Los Nogales.

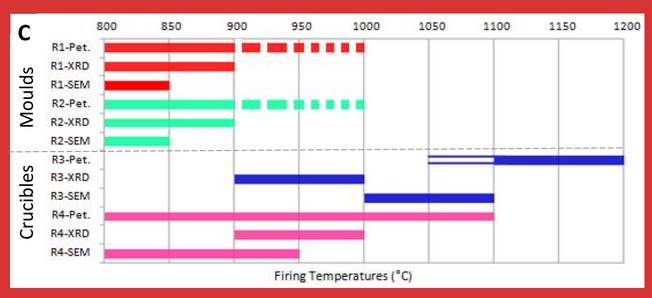
Refractories

The fabric

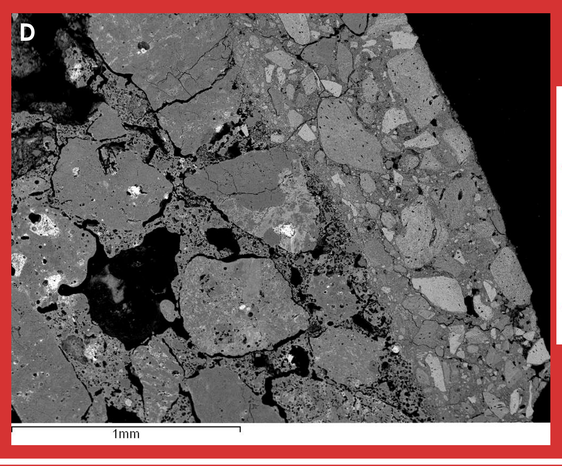
The **fabric** contained large amounts of inclusions (45-50%) in a porous matrix of montmorillonite clay (A). Inclusions were intermediate volcanic rocks, locally available. Bone ash temper was added to moulds (B). Firing temperatures were estimated at 800°-850°C for moulds and 900°-1050°C for crucibles (C). The technical ceramics studied were unused.



(A) Thin section image of crucibles and (B) SEM image of bone temper in moulds fabric . Samples R2 and R3.



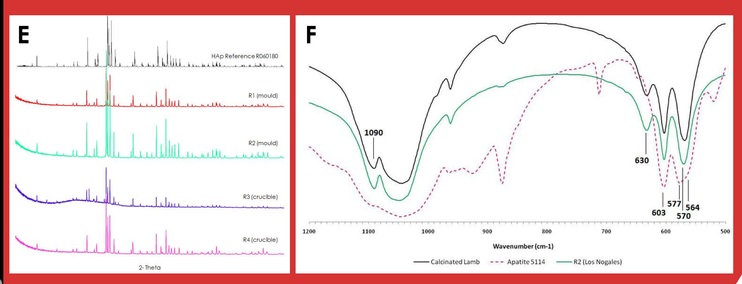
(C) Comparative table with firing temperature estimates of the ceramic bodies based on petrography, SEM and XRD.



Perforated crucibles were used to receive and distribute the molten metal more efficiently. They were blocked with a plug to control the pouring of metal into the moulds. The system allowed metalworkers to fill several moulds successively and to avoid slag to be dragged into the mould.

The coating

The coating covering the technical ceramics was identified as biogenic thermally altered hydroxylapatite; this is **ground bone ash**. The very pure paste was applied before the ceramics were fired. It contributed to thermal and chemical refractoriness.



(D) SEM image of the bone lining. (E) XRD pattern of an hydroxylpatite reference (black) and the archaeological samples. (F) FTIR spectra of the experimental calcined bone, geological apatite and archaeological sample (R2).

Conclusions

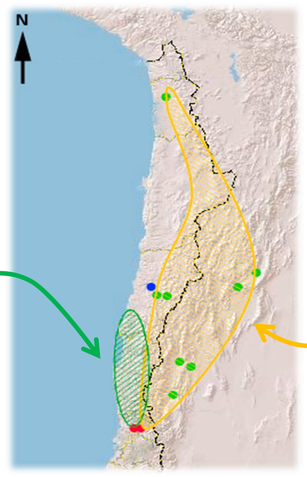
- Both sites showed different technological traditions:

Cerro La Cruz

- ✓ Use of relatively pure copper
- ✓ Copper ores available along the Chilean territory
- ✓ Tin and silver acquired by exchange
- ✓ Predominance of Diaguita-Inka designs
- ✓ Similar Diaguita forming techniques

Technological tradition based on the Diaguita metallurgy, originated at Animas since AD 700

Local communities with Diaguita substrate were **more conservative** with their metallurgical tradition, rejecting and modifying certain aspects of the dominant technology, such as the use of bronze, gold and classic Inka designs.



Distribution of the two metallurgical traditions. Blue and green dots: sites with perforated crucibles and bronze evidence, their area of influence is showed in yellow. The green area shows the territory of the Diaguita culture, with their own technological tradition.

Los Nogales

- ✓ Use of high-tin bronze and foreign design → imported artefact
- ✓ Tin available just in the altiplano and NW Argentina → bronze was introduced and widely distributed in Chile by the Inkas
- ✓ Presence of perforated crucibles of coarse fabric and bone ash coating → technology originated in the NW Argentina and introduced in Chile by the Inkas
- ✓ Local features in the refractories: a) bone temper in moulds, b) inclusions locally available

Technological tradition based on the metallurgy of NW Argentina, introduced by the Inkas

Local communities without a Diaguita substrate were **more receptive** to new technologies imported by Inkas, related in this case to a NW Argentinean tradition.

- For the first time is possible to identify metallurgical traditions in central Chile.
- This diversity in traditions agrees with the assumption that the Inka domain in the Aconcagua Valley was culturally mediated.
- The conservatism of the Diaguita-Inka groups from **Cerro La Cruz** is consistent with a non-coercive scheme proposed for the Inka domination.
- Inka materials are not usually found in local sites. Therefore, the evidence of **Los Nogales** suggests that some of the inkanised ideas were accepted by local groups without Diaguita background.
- The distribution of the metallurgical traditions presented here reveal the complex and extended networks present during the Late Period in central Chile.

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