

Abstracts

GENERAL

Tess Maching and Roland Williamson. ‘Damn clever metal bashers’: The thoughts and insights of 21st century goldsmiths, silversmiths and jewellers regarding Iron Age gold torus torcs. In C Nimura, H Chittock, P Hommel and C Gosden (eds), *Art in the Eurasian Iron Age: context, connections and scale*. Oxford: Oxbow, 2019, 179-196.

The craftspeople chosen are from a number of different gold-working traditions and trained in a range of techniques, with differing levels of age and experience. The paper derives from discussions with them regarding the manufacture, possible techniques used, the difficulties of creation and the practicalities involved in gold torus torc production. As experienced gold-workers, their comments provide an insight into the complexity of these items and the skills needed to create them. They offer differences and similarities in response, leading to a better understanding of the objects in question. This approach is valuable, as all too often these objects are examined with an archaeological or scientifically analytical eye; aspects that only a worker in gold might notice can sometimes be overlooked.

BRITISH ISLES

A Boucher. *Worcester Magistrates Court: Excavation of Romano-British homes and industry at Castle Street*. Oxford: BAR BS658, 2020, 240pp, many figures and tables. ISBN: 9781407357041. £54.

In 2000 archaeological excavations on the periphery of the Roman ‘small town’ at Worcester revealed extensive evidence for timber-framed buildings. Major changes during the later Roman period led to much of the site being levelled when a series of gravel and cobbled surfaces were laid out. Several new structures were then built, together defining a courtyard associated with a number of hearths, thought to be part of a smithy complex. It may even have formed one element of a wider ‘light industrial’ zone of the settlement, with evidence for pottery production and other metalworking in the vicinity.

J Zant and C Howard-Davies. *Roman and medieval Carlisle: The Northern Lanes, Excavations 1978-82, Appendix 6: The fired clay*. Lancaster: Oxford Archaeology, 2019. (https://library.oxfordarchaeology.com/4716/16/Appendix_06.pdf).

Contains a brief report (J Bayley, p.451) on three Roman and post-Roman crucible sherds, one used for melting a copper alloy.

EUROPE

F Albarède, J Blichert-Toft, F de Callataÿ, G Davis, P Debernardi, L Gentili, H Gitler, F Kemmers, S Klein, C Malod-Dognin, J Milot, P Télouk, M Vaxevanopoulos and K Westner. *From commodity to money: the rise of silver coinage around the ancient Mediterranean (6th-1st century BCE)*. *Archaeometry*, 2020. DOI: 10.1111/arcm.12615.

The reasons why the Western Mediterranean, especially Carthage and Rome, resisted monetization relative to the Eastern Mediterranean are still unclear. Here, we address this question by combining lead and silver isotope abundances in silver coinage from the Aegean, Magna Graecia, Carthage, and the Roman Republic. The relationships between $^{109}\text{Ag}/^{107}\text{Ag}$ and $^{208}\text{Pb}/^{206}\text{Pb}$ reflect mixing of silver ores or objects with lead metal used for cupellation, revealing important information about the technology of smelting. The Greek world extracted Ag and Pb from associated ores, whereas on the Iberian Peninsula, Carthaginians and Republican era Romans applied Phoenician cupellation techniques and added exotic Pb to Pb-poor Ag ores. Massive silver re-cupellation is observed in Rome during the Second Punic War. After defeating the Carthaginians and the Macedonians in the late 2nd century BCE, the Romans brought together the efficient, millennium-old techniques of silver extraction of the Phoenicians, who considered this metal a simple commodity, with the monetization of economy introduced by the Greeks.

T Birch, F Kemmers, S Klein, H-M Seitz and H E Höfer. *Silver for the Greek colonies: issues, analysis and preliminary results from a large-scale coin sampling project*. In K A Sheedy and G Davis (eds), 2020, *Mines, Metals, and Money: Ancient World Studies in Science, Archaeology and History*. London: Royal Numismatic Society (Metallurgy in Numismatics 6), 101-148.

This paper introduces the large-scale coin sampling project, Coinage and the dynamics of power: the Western Mediterranean 500-100 BC, along with the results for the archaic coins analysed which demonstrate that multiple silver sources were accessible for minting archaic coinage, mostly confined to the Aegean. In formulating a research design, it became apparent that long-standing and problematic issues remain with the archaeometric study of coinage (i.e. surface analyses, reference materials, data comparability). The principal purpose of this paper is to highlight the importance of a sound sampling protocol and analytical strategy for studying ancient coinage, to ensure the quality, reliability and comparability of future coin data. The paper also introduces a set of three new archaeological silver-alloy standards that can be used for studying coinage.

T Birch, K J Westner, F Kemmers, S Klein, H E Höfer and H-M Seitz. Retracing Magna Graecia's silver coupling lead isotopes with a multi-standard trace element procedure. *Archaeometry* 62(1), 2020, 81-108.

This study presents the results of compositional and lead isotopic analysis of coinage issued by the Greek colonies of Syracuse, Metapontum, Taras and Thurium in the 5th to 3rd centuries BCE. The data suggest that each colony in Magna Graecia, regardless of its motherland roots and despite ongoing conflicts between the cities, had access to the same silver, and that this supply was stable overall throughout their period of minting and issuing coinage. The paper retraces the silver sources of the colonies and points out a potential supply route for the metal. It includes a method development for a multi-standard quantification approach for laser ablation-inductively coupled-mass spectrometry (LA-ICP-MS) analysis of silver.

A Dolfini, I Angelini and G Artioli. Copper to Tuscany – Coals to Newcastle? The dynamics of metalwork exchange in early Italy. *PLoS ONE* 15(1), 2020. DOI: 10.1371/journal.pone.0227259.

The paper integrates lead isotope, chemical, and archaeological analysis of objects from central Italy. The aim was to develop robust provenance hypotheses for 4th and 3rd millennia BC metals from an important metallurgical district in prehistoric Europe, displaying precocious copper mining and smelting, as well as socially significant uses of metals in 'Rinaldone-style' burials. All major (and most minor) ore bodies from Tuscany and neighbouring regions were characterised chemically and isotopically, and 20 Copper Age axe-heads, daggers and halberds were sampled and analysed, and were also reassessed archaeologically. This approach has allowed us to challenge received wisdom concerning the local character of early metal production and exchange in the region. The research has shown that most objects were likely manufactured in west-central Italy using copper from Southern Tuscany and, quite possibly, the Apuanian Alps. A few objects, however, display isotopic and chemical signatures compatible with the Western Alpine and, in one case, French ore deposits. This shows that the Copper Age communities of west-central Italy participated in superregional exchange networks tying together the middle/upper Tyrrhenian region, the western Alps, and perhaps the French Midi. These networks were largely independent from others at the time, which embraced the north-Alpine region and the south-eastern Alps, respectively.

H Gandois, L Rousseau, B Gehres, C Le Carlier, G Querré, B Poissonnier and J-M Gilbert. New hints of metallurgical activity on the Atlantic coast of France in the mid third millennium BC: Overview and perspectives on Beaker metallurgy in Western Europe. *Antiquaries Journal* 100, 2020, 1-32.

The site of L'anse de la République, belonging to the Beaker culture, was discovered in the 1960s. It was investigated during the late 1980s and in 2014. Several items excavated are clearly linked to metallurgy. This article assesses the results of new analyses (XRF, microscopy, SEM and EDS) undertaken on copper residue, slags, and smelting-crucible sherds which allow the authors to assert that copper ore was smelted on the site.

Radiocarbon dating confirms the site belongs to the earliest phase of the Beaker culture (2500 BC). The metallic copper produced here has two main impurities: arsenic and nickel. The extremely rare vestiges of Beaker metallurgy in France, which contrast with the numerous metal objects recovered, are reviewed. Also considered is the use of domestic smelting vessels for smelting ore; this may have been more widespread than previously thought in the Beaker culture on the Atlantic coast of Europe.

J Istenič. Roman military equipment from the River Ljubljana: Typology, chronology and technology. 2019, Ljubljana: Narodni muzej Slovenije (Catalogi et monographiae 43). €58.

Chapter 16 (pp.145-189, by J Istenič and Ž Šmit) gives a full data set of PIXE analyses of non-ferrous metals, and PIGE analyses of enamels on 79 pieces of Roman military equipment, mostly from the Middle and Late Augustan periods (15 BC to AD 14). Annotated photos of the swords, daggers, sheaths, helmets, buckles and other fittings show exactly where the analyses were made.

N Laskaris, I Varalis, C Tsodoulos and C Dolmas. Evidence of Au-Hg gilding process in post Byzantine ecclesiastical silver-ware (chalices) of eastern Thessaly by pXRF. *Mediterranean Archaeology and Archaeometry* 20(1), 2020, 189-203.

Silver and gold alloys were widely used for making objects during the Byzantine and post-Byzantine eras. A major category is ecclesiastical silver, used in the celebration of the liturgy. This study focuses on post-Byzantine ecclesiastical silver chalices, kept in parish churches and monasteries of eastern Thessaly. They were studied with non-destructive analysis (XRF) for clarification of the role of gold in the silver-copper-gold alloy. The main question answered in this work is whether gold was part of the alloy or applied as an amalgam (Au-Hg alloy). By using XRF and mathematical procedures it was proved that in all cases the gold was fire gilding.

M Mödlinger, E Godfrey, H Postma, P Schillebeeckx and W Kockelmann. Neutron analyses of eight Bronze Age swords from Austria: The question of 'stabbing' or 'cut-and-thrust' weapons. *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102521.

Neutron diffraction (ND) and neutron resonance capture analyses (NRCA) of eight Bronze Age metal-hilted swords of various types from three Austrian museums are presented. ND was carried out on all eight swords, giving information about crystallographic microstructure, and major metal alloy and mineral compound proportions. NRCA was carried out on four of the swords to determine the elemental compositions at various regions of them because no invasive sampling was permitted. XRF was used to measure the elemental compositions of one sample cut from each of four swords. The tin contents of the swords determined by NRCA, XRF and ND data are in good agreement; some small differences could be well understood. The use of these swords as primarily either 'stabbing', or 'cut-and-thrust' weapons were addressed based on the ND results and provide information relevant for experimental archaeology and use-wear analysis.

M Mödler and P Trebsche. Archaeometallurgical investigation of a Late Bronze Age hoard from Mahersdorf in Lower Austria. *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102476

Chemical and lead isotope analyses show that the 13 objects from this hoard (Ha B1; 11th century BCE) were primarily made from two distinct copper alloys that derived from fahllore. The hoard contains end-winged and socketed axes, made in the central and SE European traditions, respectively; typology and composition correlate. A single object, a median-winged axe, was made from recycled Ösenring copper and deposited c.150–200 years after its manufacture. At the time, the region was surrounded by several competing copper mines located in SE Lower Austria, the Slovak Ore Mountains, and the Kőszeg-Güns-Mountains; other than some deposits in the Slovak Ore Mountains, the ores in these mines lack chemical and lead isotopic characterizations, which precludes their direct use in provenancing. Metallographic analyses showed the bronze objects represent four different stages in the production process: ingots, cast objects without edge hardening, finished objects with edge hardening and one recycled object. Three socketed axes with T-decoration were cast in the same mould.

B Molloy and M Mödler. The organisation and practice of metal smithing in Later Bronze Age Europe. *Journal of World Prehistory* (2020). DOI: 10.1007/s10963-020-09141-5

During the later Bronze Age in Europe (c. 1500–800 BC) the archaeological visibility of the production and consumption of bronze increases substantially, yet there remains a significant imbalance between the vast number of finished artefacts that survive and the evidence for where, how, and by whom they were produced. At the centre of these questions is the metal smith, who has been variously regarded in scholarship as nomadic, a reviled outsider, elite in status, a mediator of wealth, a shaman or a proto-scientist. In most cases, however, the social role of the smith is seen as central to the functioning of Bronze Age societies. This paper provides a new cross-regional study that evaluates current theoretical paradigms in the light of empirical evidence. It does this through contextual analyses of metalworking traces, focussing on case studies primarily from Atlantic, Nordic, Urnfield and Balkan regions of Europe. Our work breaks down the production cycle into practical steps, and the material evidence for each step is evaluated. This enables similarities and differences on the broader European scale to be identified and discussed, allowing better characterisation of the modes of participation in smithing and the identities of those involved. This consequently improves our understanding of the archaeological material patterns related to smithing, ranging from discard or deposition at settlements, the construction of identity in mortuary practice, technological choices in alloy design and treatment, and the quality of finished metalwork objects. It is argued that the material evidence in many regions indicates that metalworking was more broadly embedded in society; this might be through cross-craft interaction, the location of metalworking activities, and the reuse of casting debris and moulds. Crafting metal was a commonplace and socially visible activity, which in many regions enhanced social integration and stability.

P Valério, R J C Silva, A M Monge Soares, M Fátima Araújo and J Luís Cardoso. Compositional and microstructural outlook of grave goods from Anta do Malhão and Soalheironas (Portugal): The diachronic use of arsenical copper in southwestern Iberian Peninsula. *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102527.

This work presents the technological study of artefacts from these necropolises in the Algarve region. Typologies of metalwork and pottery date the single inhumation at Anta do Malhão to a late phase of the ‘Ferradeira Horizon’ (last quarter of the 3rd millennium BC) while assigning the necropolis at Soalheironas to an earlier phase of the Middle Bronze Age (1st half of the 2nd millennium BC). Micro-EDXRF, optical microscopy and SEM-EDX show artefacts were made of arsenical copper alloys (2.01–3.40% As, with <0.05% Fe). The deformed equiaxed grains with annealing twins and slip bands show cycles of hammering and annealing, followed by a finishing hammering operation. The integration of results in the prehistoric metallurgy of SW Iberian Peninsula suggests a shared technological tradition, while discussion discloses important developments involving the increased production of strain-hardened tools and weapons, together with a rising substitution of copper metal by arsenical copper alloys from 3rd to 2nd millennium BC.

K J Westner, T Birch, F Kemmers, S Klein, H E Höfer and H-M Seitz. Rome’s rise to power. Geochemical analysis of silver coinage from the Western Mediterranean (4th to 2nd centuries BCE). *Archaeometry* 62(3), 2020, 577–592.

We present the results of geochemical analysis of silver coinage issued by Rome and dated between the fourth and second century BCE, which are complemented by data of coinage issued by Carthage, the Brettii, and the Greek colony of Emporion. Each of these minting authorities represents one of the major parties involved in the struggle for hegemony in the fourth to second centuries BCE Western Mediterranean region. This study retraces how the metal supply shifts in response to the transforming power relations and how this change is related to Rome’s rise to the virtually uncontested ruler of the region.

NEAR EAST

D Ackerfeld, Y Abadi-Reiss, O Yagel, Y Harlavan, T Abulafia, D Yegorov and E Ben-Yosef. Firing up the furnace: New insights on metallurgical practices in the Chalcolithic Southern Levant from a recently discovered copper-smelting workshop at Horvat Beter (Israel). *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102578.

Recent discoveries shed new light on the earliest phase of southern Levantine metallurgy (second half of the 5th millennium BCE). Multiple fragments of furnaces, crucibles and slag were excavated, and found to represent an extensive copper smelting workshop located within a distinct quarter of a settlement. Typological and chemical analyses revealed a two-stage technology (furnace-based primary smelting followed by melting/refining in crucibles), and lead isotope analysis indicated that the ore originated exclusively from Wadi Faynan (MBS Formation), more than 100km away. These observations

strengthen previous suggestions that metallurgy in this region started with furnace-based technology (possibly not locally invented). Furthermore, the absence of any artefact related to the contemporary industry of copper-based alloys indicates a high degree of craft specialization, and together with other regional observations testifies to the important role of metallurgy in the society of the Beer-sheba Valley during this formative time.

R Alipour, T Rehren and M Martinon-Torres. Chromium crucible steel was first made in Persia. *Journal of Archaeological Science*, 2020. DOI: 10.1016/j.jas.2020.105224

Chromium-alloyed stainless steel was developed in the early 20th century, building on 19th century experiments with low chromium steel. The intentional addition of chromium to steel nearly a millennium earlier, as part of the Persian crucible steel (*pulad*) tradition including the production of low-chromium crucible steel in early 2nd millennium CE Persia is presented. Archaeological finds from the 11th century CE site of Chahak in Iran show the intentional and regular addition of chromium mineral to the crucible charge, resulting in steel containing around 1wt% chromium. A contemporaneous crucible steel flint striker held in the Tanavoli Collection is reported to also contain chromium, suggesting its origin from Chahak. We argue that the mysterious compound '*rusakhtaj*' from Biruni's (10th–11th century CE) recipe for crucible steel making refers to the mineral chromite. Additional historical sources up to the mid-2nd millennium CE refer to crucible steel from Chahak as being particularly brittle, consistent with its increased phosphorus content.

V Orfanou, T Birch, A Lichtenberger, R Raja, G H Barfod, C E Leshner and C Eger. Copper-based metalwork in Roman to early Islamic Jerash (Jordan): Insights into production and recycling through alloy compositions and lead isotopes. *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102519.

We examined 49 copper-based artefacts using reflected light microscopy and micro-XRF. A subset was analysed by electron microprobe for major and minor elements at higher spatial resolution, and by multi-collector ICP-MS for lead isotopes. Results provide new information on the civic life and material culture from a key urban site in the Roman Empire's eastern provinces and imply that binary bronze dominated the Roman period, (leaded) brass characterised the Byzantine period, while tin-containing alloys were prevalent during the Islamic period. Lead isotopes suggest that during the Roman and Byzantine periods some of the metal in Jerash came from European and/or Mediterranean sources, while copper used during the Islamic period may have been sourced more locally from Timna. The changes in alloy types and lead isotopes suggest that recycling of metals took place in Jerash possibly as early as the Roman period and more frequent from the Byzantine period onwards.

B Redon and T Faucher (eds). Samut Nord. L'exploitation de l'or du désert Oriental à l'époque ptolémaïque. Institut français d'archéologie orientale (Fouilles de l'Ifao 83), 2020.

This publication includes an introduction to the work carried out in 2013–16, geological data and ore characterization of Samut Nord, and accounts of the excavations of the Ptolemaic mines, mineral processing facilities including sorting, crushing

and grinding areas, and associated features. It also includes two chapters on the Pharonic and medieval occupation of the mining district.

I S Stepanova, L Weeks, K A Franke, B Overlaet, O Alard, C M Cable, Y Yousif Al Aali, M Boraike, H Zein and P Grave. The provenance of early Iron Age ferrous remains from southeastern Arabia. *Journal of Archaeological Science* 120, 2020. DOI: 10.1016/j.jas.2020.105192.

This study of material from Saruq al-Hadid and the contemporary site of Muweilah (early Iron Age, c1250–800 BCE) explores the provenance of the earliest iron from SE Arabia. It summarizes the evidence for iron resources and technology in the region and adjacent areas and analyses iron ores, slags and slag inclusions in artefacts from these sites, alongside Iron Age ferrous artefacts from Iran, using OM, SEM-EDS, XRF, ICP-MS and LA-ICP-MS. Multivariate statistical analyses are used to explore these geochemical data, alongside a large dataset of ores and artefacts from existing publications. The slag samples from Muweilah originated from iron smithing, providing the first evidence for iron working of any kind in SE Arabia. Differences in the geochemical compositions of the material from Saruq al-Hadid and Muweilah and iron ores from the UAE and Oman – particularly the distribution of rare earth elements – suggest that Iron Age ferrous artefacts from SE Arabia were not smelted from locally-available iron ores. Rather, the study demonstrates geochemical similarities between SE Arabian iron objects, typological parallels from Luristan and ores of the Sanandaj-Sirjan metallogenic belt of Iran, suggesting that iron may have been imported, at least partially as complete objects, from this region. Multiple source deposits are indicated, however, and the possible contribution of iron from other regions of ancient Western Asia and neighbouring regions remains to be further explored. The research provides new information regarding the long-distance exchange contacts of SE Arabia during the early Iron Age.

ASIA

Siran Liu, He Xiaolin, Jianli Chen, Guisen Zou, Shijia Guo, Xicheng Gong and T Rehren. Micro-slag and “invisible” copper processing activities at a Middle-Shang period (14th–13th century BC) bronze casting workshop. *Journal of Archaeological Science* 122, 2020. DOI: 10.1016/j.jas.2020.105222

Micro-slag artefacts from ancient bronze casting workshops were largely ignored in previous research despite their rich information potential. Current research demonstrates they could significantly enhance our understanding of past metallurgical activities but their identification requires careful in-situ analysis and a well-designed sampling strategy. Here we present an innovative methodology combining in-situ geochemical survey, wet-sieving of soil samples and detailed microscopic study, employed to investigate an important Middle-Shang site, Taijiashi, in the Huaihe River valley. The micro-slugs from this site revealed that in addition to bronze alloying and casting, raw copper refining was also practiced. Material evidence for the refining process was not immediately visible in the archaeological excavation since most slag was mechanically crushed to retrieve any copper

trapped in them, leaving only micro-slag fragments typically smaller than 3mm. The fact that most micro-slag was recovered from one sector of a small building located on the same platform as the elites' long houses suggests that mechanical processing of refining slag was conducted in a confined area and closely supervised. It might reflect people at this site valuing copper as a highly precious material and making efforts to recover copper otherwise lost in slag. This find will potentially shed new light on a range of important issues of Shang archaeology, including the regional variation of Shang metallurgical styles and the provenance of copper in the Shang period. This research also encourages researchers to look into archaeological soil samples with abnormally high copper contents and understand the particles in them causing these high readings.

FanYang, T Rehren, Ping Kang, Siran Liu and Kunlong Chen. On the soldering techniques of gold objects from the Boma site, Xinjiang, China. *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102572

The soldering techniques of the 3rd to 5th century CE gold artefacts from the Boma site in Xinjiang are investigated, based on micro-analysis of cross-section samples. The results show that Au-Ag-Cu ternary alloy with high silver and copper content was used as solder material for connecting gold wire onto the arm armour, while copper salt bonding was used for the granulation of the finger ring and scabbard. The unusually slight compositional differences in the joining areas of the Boma granulation samples remind us of their complicated heat treatment, a crucial aspect for the understanding of ancient goldsmithing to which more attention needs to be paid.

Yiu-Kang Hsu and B J Sabatini. A geochemical characterization of lead ores in China: An isotope database for provenancing archaeological materials. *PLoS ONE* 14(4), 2019. DOI: 10.1371/journal.pone.0215973

A lead isotope-driven provenance study lies in concert with a comprehensively evaluated database of geological ore sources and accompanying archaeological and contextual information. This paper compiles and evaluates all currently available lead isotope data for galena and K-feldspars in China, and provided geological interpretations for how their ore-forming substances evolved across relevant tectonic terrains. Particular attention is paid to the geological settings of host ore deposits that were likely exploited in ancient and historic China, detailing the heterogeneity and homogeneity of their ore formation across different metallogenic provinces and belts. Using the isotope database, and supportive geological and archaeological background information, three case studies are presented that detail the provenancing of Chinese cultural materials. The isotope data themselves are presented in ternary diagrams that allow for their concise and accurate comparison.

AFRICA

T P Thondhlana, M Martín-Torres and S Chirikure. The archaeometallurgical reconstruction of early second-millennium AD metal production activities at Shankare Hill, northern Lowveld, South Africa. *Azania* 51(3), 327-61. DOI:

10.1080/0067270X.2016.1173309.

Archaeologists have previously documented more than 50 2nd-millennium AD settlements, associated with extensive evidence of metal production, around Phalaborwa in the northern Lowveld of South Africa. Archaeometallurgical research was carried out at Shankare Hill, one of these Iron Age settlements, in order to reconstruct the extractive metallurgical activities represented at the site. To achieve this standard archaeological fieldwork together with laboratory studies were employed. This paper presents both the archaeological and archaeometric results that enabled the reconstruction, in great detail, of the various metal production activities from ore beneficiation to primary smelting and subsequent metal refining processes that took place at Shankare. Iron smelting debris, which significantly differed both microscopically and chemically from copper smelting slags, was documented at middens with exclusive metal production debris, whilst copper production debris, which included mostly crushed furnace slag and secondary refining ceramic crucible fragments, was confined to low density scatters and domestic middens. The Palabora Igneous Complex, whose unique ore signature is well documented in the geological literature, was identified as the source of both the copper and iron ores smelted at Shankare. Beyond the technological reconstruction, the results are used to discuss the role of metal production and exchange within the wider southern African archaeological context.

AMERICAS

F Garrido and M T Plaza. Provincial Inca metallurgy in northern Chile: New data for the Viña del Cerro smelting site. *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102556.

Inca provincial expansion in the Collasuyu has largely been explained by the need to intensify mining to satisfy their metallurgical demand. Despite the evidence for many mines and metallurgical activities during the Late Horizon in the southern Andes, it is still not clear how their production was organized and articulated. At Viña del Cerro the metal obtained was unalloyed copper. There is no evidence for the manufacturing of artefacts at the site, or at any of the major Inca settlements in the Copiapó valley. We argue that tin bronze artefacts in Copiapó were likely imported from abroad and that the local copper production was probably taken elsewhere for processing and final manufacture. New radiocarbon dates indicate that Inca metallurgical activities in Copiapó valley reused a local site and technology, though the Incas did not establish an intense occupation there. This site demonstrates the logistics and challenges of developing a political economy based on wealth finance in the far corners of the Inca Empire, where decentralizing the *chaîne opératoire* seemed to be the chosen strategy for economic control.

R Gil Montero and F Téreygeol. Ore dressing technics in the Andes during the seventeenth century: The case of San Antonio del Nuevo Mundo, Lípez, present-day Bolivia. *International Journal of Historical Archaeology*, 2020. DOI: 10.1007/s10761-020-00547-7.

This article analyses the ore dressing techniques present during the peak production period of a silver mine in the 17th-century

Andes, from an archaeological and historical perspective. It is not focused on the silver refinery constructions, or their description and social relationships, which are presented in the specialized literature, but rather on attention to the objects that were necessary for the silver production and to their location. We redefined those constructions, identified their social relations through historical sources and their characteristics regarding this particular period, type of mining camp, stage of the mines' silver production, and the power and labour relations.

S A Kennedy and S J Kelloway. Identifying metallurgical practices at a colonial silver refinery in Puno, Peru, using portable X-ray fluorescence spectroscopy (pXRF). *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102568.

This study presents the results of in situ pXRF analyses of surface soils at the site of Trapiche Itapalluni, a Spanish colonial silver refinery located 15km SW of Puno, Peru in the western Lake Titicaca Basin (4000m asl). Although the benefits of pXRF analysis are well known, such as its wide availability and rapid, non-destructive nature, there has been little application of this technique at colonial metallurgical sites in the high-altitude Andes. The results of our analysis confirmed the introduction of the patio process of silver refining from Mexico to the Puno Bay, and further clarified areas of intense metallurgical production, including local Andean adaptations. This study highlights the advantages of in situ pXRF analysis of surface soils at industrial archaeology sites, especially in marginal and high-altitude environments such as the southern Andes.

M M Morita, L Zilio and G M Bilmes. Composition and possible provenance of metallic archaeological objects found in Patagonia Argentina. *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102575.

The composition of eight metal objects found in various archaeological sites of hunter-gatherers was determined by using a simple qualitative analysis by laser induced breakdown

spectroscopy (LIBS) and the depth profiling advantage of this technique. We found that the objects are made of copper (native copper, brass and bronze). The determination of the material composition of the artefacts enables us to propose hypotheses about the manufacture of the pieces as well as, together with other indicators, discussing their possible origin. These artefacts could either have been produced locally by mobile hunter-gatherer societies that inhabited Patagonia, or acquired through contacts with other non-Patagonian groups or European travellers.

F Téreygeol, P Cruz and J-C Méaudre. The reverberatory furnace for ore smelting: An experiment on a South American innovation. *JAS: Reports* 33, 2020. DOI: 10.1016/j.jasrep.2020.102580.

Research in both South America and Europe brought together a series of examples relating to the use of a reverberatory furnace for smelting non-ferrous ores. Although the invention of this process may have occurred in multiple places, the main region of innovation is incontestably the Andes. To approach this dynamic process of innovation, we decided to use an experimental approach. Over 6 years and 14 tests, a total of 165 hours of firings were conducted on the experimental platform at Melle, France. The tests carried out with galena (PbS) allowed us to understand the operating mode and the possible yields of this type of furnace. By analogy, this provides information for the better identification of archaeological remains.

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