Abstracts

GENERAL

P T Craddock. Brass, zinc and the beginning of chemical industry. *Indian Journal of History of Science* 53(2), 2018, 148-181**.**

There have recently been a few major publications on the early history of brass and zinc. These have presented major new information on the history, technology and economic impact of the new metal, zinc. Based on these papers an effort is made here to provide an overview of the principal developments from the earliest times up until the rise of the European industry in the early 19th century. In both India and in China a striking feature of the production of zinc was the rise of a real chemical industry based on scientific laboratory practice, long before such developments began in Europe.

M Mödlinger, M H G Kuijpers, D Braekmans and D Berger. Quantitative comparisons of the color of CuAs, CuSn, CuNi, and CuSb alloys. *Journal of Archaeological Science* 88, 2017, 14-23.

The colours of copper alloys are of particular interest in archaeology and can be characterised quantitatively and systematically. The CIELAB colour system can determine different colour parameters by means of a spectrophotometer that describes the surface colour. Additional information can be calculated from these parameters which allows a set of colour composition diagrams connecting chromaticity and alloy composition to built. With such data it is possible to estimate the colour of prehistoric metal artefacts with similar chemical compositions. A better understanding of the association between metallurgical composition and colour will aid the research of prehistoric metalwork because choices in production and use of metal were likely influenced by this particular quality of metal.

BRITAIN AND IRELAND

J Czierpka. Nägel, Kohle und Eisen: Der Industrialisierungsprozess im Black Country [Nails, coal and iron: industrialisation in the Black Country]. *Der Anschnitt* 69(1), 2017, 2-9.

Industrialisation is strongly influenced by where it takes place. Thus the location (the sum of the prevailing geographical and geological factors), has to be incorporated into every analysis. In the Black Country, one of the leading British iron-producing areas in the 19th century, the path to industrialisation was laid out in the 16th century, when hand-made nail making was drawn to the area by the newly-established slitting mills and local coal. The nail trade demanded huge amounts of iron but the local iron industry was unable to increase its production until water power was rendered obsolete by the introduction of the steam engine. The use of coal laid the basis for the industry's enormous growth, accompanied by an increase in coal production and the development of a dense canal system.

T Havard, T Darvill and M Alexander. A Bronze Age round barrow cemetery, pit alignments, Iron Age burials, Iron Age copper working, and later activity at Four Crosses, Llandysilio, Powys. *Archaeological Journal* 174(1), 2017, 1-67**.**

The evidence for Middle Iron Age copper working includes the remains of three furnaces, reduced-fired furnace lining fragments, a fragment of block tuyère and small quantities of slag, ore and copper prills.

EUROPE

R Bendikiene, M Bertasius, A Ciuplys, J Navasaitis and G Zaldarys. Excavations of ironware of the third–fifth century from Marvele necropolis (Lithuania). *Archaeological and Anthropological Sciences* 10(6), 2018, 1503-1523.

In 2006, three axes, four spearheads, two knives and a clasp were excavated in demolished 3rd–5th century tombs at the Marvele necropolis in Lithuania. Metallographic and chemical analysis as well as mechanical properties of the artefacts followed. Metallurgical slag, clinkers and iron concretions found in the surroundings of tombs were also tested and are presented. Metallographic analysis and hardness tests' results revealed that axes were forged from two separate billets of iron, whilst spearheads and knives were made from a single billet. The results of chemical analysis have confirmed earlier results from other Lithuanian archaeological sites. Some differences in chemical composition were observed, which might suggest some ironware was possibly not of local origin.

M Georgakopoulou. Metal production, working and consumption across the sites at Dhaskalio and Kavos, in C Renfrew, O Philaniotou, N Brodie, G Gavalas and M J Boyd (eds), *The Marble Finds from Kavos and the Archaeology of Ritual.* 2018. Cambridge: McDonald Institute for Archaeological Research, 501–32.

On the Kavos Promontory (outside the main settlement area on Dhaskalio) there is evidence for the smelting of pure copper and arsenical copper with lead. Within the main settlement secondary metalworking activities, such as refining, casting and probably hammering into shape were carried out. The main alloy worked was a leaded arsenical copper. The evidence for lead and silver working is scarcer though two litharge fragments were identified.

H Lettany. *The Zeebrugge Shipwreck: A forgotten early sixteenth-century merchantman discovered off the Belgian coast.* Oxford: BAR (S2898), 2018, 118pp.

The wreck was found in 1990 and the excavation team appeared to have focussed mainly on the excavation of its cargo. This included a range of domestic objects as well as a large collection of candlesticks. Recent work includes semi-quantitative pXRF analysis of 80 of these objects.

T Parjanadze and M Bode. Roman Silver Objects from the ancient kingdom of Kartli (Caucasian Iberia) in Georgia (Mtskheta, Dedoplis Gora [Kareli district]) – a lead isotope investigation. *Metalla* 23(2), 2017, 39-50.

Seven silver objects from antique Georgia have been investigated. Six are strongly affected by a fire and were found in a palace at Dedoplis Gora, burnt down after an earthquake in 80 AD. Another object is a fragmented silver box of the 3rd century AD, from Mtskheta, the old capital of the Kingdom of Kartli. All objects come from a time of great political influence from Rome. The lead isotope analysis points to three sources in the Roman Empire: the Central Balkans, the Cevennes (Massif Central) in France and the Pangeon Mountains in northern Greece, but also to lead-silver mines in Iran.

R Saage and S K T S Wärmländer. Metal residues in 5th c. BC–13th c. AD Estonian tools for non-ferrous metal casting. *Journal of Archaeological Science: Reports* 19, 2018, 35–51.

The elemental analysis included qualitative pXRF analysis of 175 artefacts and detailed residue analysis using SEM-EDS of thirteen selected artefacts. This analysis identified for the first time Estonian Iron Age crucibles used for casting gold and silver. Most of the investigated crucibles were used for casting various copper alloys, while the casting ladles and most of the stone moulds were used for casting pewter. Casting of pewter and precious metals only occurred in regional centres such as hill forts and strongholds, while copper alloys were cast in all parts of Estonia.

J Vogl, M Rosner, J Curbera, U Peltz and B Peplinski. Lead isotope analysis in magic artefacts from the Berlin museums. *Archaeological and Anthropological Sciences* 10(5), 2018, 1111–1127.

The lead isotope compositions of 59 curse tablets were determined; these covered the whole range of Mediterranean ore deposits. The majority were made of lead matching the narrow range of the Laurion ore deposits with only eight of the 59 artefacts made of recycled lead or lead from other sources. All but two were approximately dated by their inscriptions. The lead isotopic composition together with information obtained from the inscriptions, the resulting dating, the context of the find and its history provided information about the origins of these artefacts, which points to Laurion as the major and dominant lead source in the Aegean, at least during the 4th-3rd century BC.

NEAR EAST

E Ben-Yosef (ed). *Mining for ancient copper: Essays in memory of Beno Rothenberg***.** Tel Aviv: Tel Aviv University, Institute of Archaeology Monograph 37, 2018, 584pp.

This book contains 37 chapters, organized in five sections: Timna Valley, Nahal 'Amram, Faynan and the Negev, Cyprus, Oman, Greece and Britain, and Metalworking. It celebrates Rothenberg's approach, based on the study of the people and societies behind the artefacts and technologies. It includes, in addition to contributions on technologies, results of research on various aspects of the production and use of copper in ancient societies from the geological settings of copper mines to the diet of metalworkers and the characteristics of metal trade systems. The studies range from Oman to the British Isles, with a special emphasis on the southern Levant and the Arabah Valley. The introduction and table of contents can be downloaded from: https://www.academia.edu/35902000/.

M Jansen, A Hauptmann, S Klein and H-M Seitz. The potential of stable Cu isotopes for the identification of Bronze Age ore mineral sources from Cyprus and Faynan: results from Uluburun and Khirbat Hamra Ifdan. *Archaeological and Anthropological Sciences* 10(6), 2018, 1485–1502.

Cu isotope signatures are specific to the types of ore minerals. Two case studies are presented: at Faynan, mainly oxidized copper ores occur and the Cu isotope signature of ingots from the EBA metal workshop from Khirbat Hamra Ifdan indicates the production of copper came from Faynan's ores. The Cu isotope composition of Timna ores is different so origins of copper artefacts can be determined by combining trace elements, Pb isotopes and Cu isotopes. Oxhide ingots from the Uluburun shipwreck have previously been assigned to Cypriot deposits based on Pb isotopes. They show a Cu isotope signature which matches oxidized copper ores from Cyprus, while later oxhide ingots (and slag from the Cypriot settlements Kition and Enkomi) show a different signature which might be due to the use of sulfidic ore sources. There could be a chronological shift from oxidized to sulfidic ore sources for Cypriot copper production, requiring different technologies. Therefore, Cu isotopes can be used as a proxy to reconstruct mining and smelting activities.

F W Rademakers, T Rehren and M M Voigt. Bronze metallurgy in the Late Phrygian settlement of Gordion, Turkey. *Archaeological and Anthropological Sciences* 10(7), 2018, 1645–1672.

A discussion of bronze production from Late Phrygian/Achaemenid Gordion: crucibles, moulds, casting waste and their find contexts. Microscopic analysis and chemical characterisation of the crucible ceramic and slags allow discussion of their technical performance. Given the lack of contemporary parallels, reference is made to the Egyptian crucibles from Pi-Ramesse. The crucible analyses are then connected to the other production remains to obtain a more holistic understanding of the metallurgical process. The technical observations are interpreted in their archaeological context. The results offer the first detailed overview of bronze production for ancient Phrygia. Online supplementary data offers a technical overview of ancient (bronze) crucible analysis.

ASIA

Y-K Hsu, J Rawson, A M Pollard, Q Ma, F Luo, P-H Yao and C C Shen. Application of kernel density estimates to lead isotope compositions of bronzes from Ningxia, north-west China: Application of KDEs to lead isotope compositions. *Archaeometry* 60(1), 2018, 128-143.

The aim of this paper is to apply kernel density estimates (KDEs) to the visualization and interpretation of lead isotope data from bronze assemblages found along the northern border of central China, here designated as the Arc. New lead isotope analyses of 30 leaded tin–bronze artefacts from the Wangdahu cemetery (c500-300 BC) in the Ningxia Hui autonomous region, north-west China, provide the basis for the discussion. Their characteristic isotope signature is fundamentally different from that of Dajing ores in north-east China, as well from that of early Qin bronzes in Shaanxi and Gansu provinces. This suggests that a variety of metal resources were utilized by peoples living in the Arc. The KDE approach thus proves effective at presenting and comparing lead isotope data.

N O Kozhevnikov, A V Kharinsky and S V Snopkov. Geophysical prospection and archaeological excavation of ancient iron smelting sites in the Barun-Khal valley on the western shore of Lake Baikal (Olkhon region, Siberia). *Archaeological Prospection* 26(2), 2018, 1–17.

In 1997, an ancient iron production site, Barun-Khal 2, was discovered in the Barun-Khal valley (Olkhon region, near the west shore of Lake Baikal). Archaeometallurgical investigations followed, including magnetometry, resistivity, self-potential (SP) and radiometric surveys, archaeological excavation, analysis of chemical composition and magnetism of slag and other residuals, and radiocarbon dating of charcoal samples. The magnetometer survey discovered another iron production site, Barun-Khal 3. Excavations have found well preserved slag tapping bloomery furnaces built into the sides of a large pit (Barun-Khal 2) or a trench (Barun-Khal 3). According to radiocarbon dating, iron production began here within the 2nd and 3rd centuries BC and lasted until the 7th to 11th centuries AD. The importance of these works is because there are significant gaps in the coverage of Russia (including Siberia) with archaeometallurgical studies.

O Oudbashi and A Hasanpour. Bronze alloy production during the Iron Age of Luristan: a multianalytical study on recently discovered bronze objects. *Archaeological and Anthropological Sciences* 10(6), 2018, 1443–1458.

Application of bronze alloys to produce artistic and religious artefacts was commonplace during the Iron Age in western Iran (1500–550 BC). The alloy composition and manufacturing processes of some recently excavated objects from the Iron Age cemetery of Baba Jilan, northern Luristan, were analysed by ICP-MS as well as microscopic studies by SEM-EDS and metallography. Comparisons were made between Baba Jilan objects and other analysed bronzes from Luristan. The results showed that all Baba Jilan samples are made of binary copper-tin alloys but the tin contents were variable, proving that alloying to produce bronze was not a well-controlled process. The microscopic studies also showed that the manufacturing operations are similar in the Luristan bronzes.

Lu Wang, Fan Chen, Yongqiang Wang, Wei Qian, Jianjun Mei, M Martinon-Torres, Kunlong Chen. Copper metallurgy in prehistoric upper Ili Valley, Xinjiang, China. *Archaeological and Anthropological Sciences,* 2018, 1-11.

The upper Ili Valley in northwest Xinjiang is a crucial place for the study of early interactions between the Eurasian Steppe and northern China. This paper presents scientific analytical results and examines the use and production of copper alloys in the region with regard to the transregional exchange of materials and technology. The substantial proportion of unalloyed copper and the clear drop in tin concentrations in the bronze samples from the Iron Age indicates the decrease of tin usage compared with the Bronze Age. The shift between the Bronze and Iron Ages can also be seen from the lead isotope results. The changes of the material (alloys) and metal source(s) between the Bronze and Iron Ages in the upper Ili Valley imply movements of objects, raw materials and related technical practises.

AFRICA

J Humphris, R Bussert F Alshishani and T Scheibner. The ancient iron mines of Meroe. *Azania* 53(3), 2018, 291-311.

Ongoing research at the Royal City of Meroe and the nearby Meroitic town of Hamadab in Sudan has established the presence of a Kushite iron production tradition spanning over 1000 years. Potentially from as early as the 7th century BC to as late as the 6th century AD, a significant quantity of iron was produced at Meroe, while Hamadab appears to have started producing iron during the latter stages of this time-frame. This paper presents the results of archaeological and geological research that has identified ancient iron mining activity in the area. Insights into aspects of the ore procurement stage of the chaîne opératoire of Meroitic iron production, including the nature of the mined ores and the manner in which this activity was conducted, are presented. Indications as to the organisation of mining activities are also provided. The potential of this research is highlighted and future research questions are posed.

F Rademakers, N Nikis, T De Putter and P Degryse. Copper production and trade in the Niari Basin (Republic of Congo) during the 13th to 19th centuries AD: Chemical and lead isotope characterization. *Archaeometry* 60(6), 2018, 1251–1270.

In central Africa copper ore occurs in only a few locations and copper appears to have been scarce in the past, unlike iron, which is attested more widely and earlier in the archaeological record. This paper presents the first detailed characterization of an early copper-working region in Central Africa. Located along the southern border of the Republic of the Congo, the Niari Basin has revealed several copper production sites ranging from the 13th to 19th century AD. The evidence, specifically in the Mindouli, Mfouati and Boko-Songho areas, includes production remains as well as copper ingots and artefacts. The chemical and lead isotope analyses of this material are interpreted against geological background data, with an emphasis on copper provenance. Combining these results with archaeological and historical

evidence for regional metallurgical activity, insights on the production of copper in the Niari Basin emphasize the potential of this research for forthcoming work on copper use and trade in a wider central African context.

AMERICAS

N H Thomas. *Seventeenth-century metallurgy on the Spanish colonial frontier: Pueblo and Spanish interactions***.** Tucson: University of Arizona Press (Anthropological Papers 79). 2018. 124pp.

The excavation and analysis of a smelting precinct is described. It was used between 1620 and 1650, within a Pueblo IV town (Pa'ako) in New Spain (now New Mexico), founded by the expedition of Juan Oñate in 1598. This is one of the few known colonial metal production sites in the Southwest. There was no smelting of metals in North America before European invasions, but the excavations uncovered evidence of both copper and lead smelting within the pueblo. Hardly any lead metal was recovered from the site – it was probably taken away to Santa Fe to be assayed for its silver content. Much of the copper seems have been given to the inhabitants of the pueblo, who hammered it into sheet and cut it up to form pendants. There are a few micrographs of the ores, metals and slags. A critical analysis of archaeological features and materials related to metal production during the early colonial period (AD 1598–1680) is provided. Using the ethnography of Pueblo peoples and 17th-century European manuals of metallurgy and the evidence Thomas builds a social and historical context within which to understand the decisions made at the time.

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