PROGRAMME

9.30 WELCOME (Dr. Peter Hambro Mikkelsen, Dept. for Conservation and Archaeological Science, Moesgaard Museum)

9.35 **Lead Circulation in Northeast Asia: The Provenance of Lead in the Qi State Bronzes**
Chen Wang

10:00 **Not so dull after all? A reassessment of the lead vessel rims from the Mycenae Shaft Graves**
Stephanie Aulsebrook

10:25 **Archaeometallurgical investigations in Notre-Dame de Paris: research in progress on construction iron and lead after the fire**
Maxime L'Héritier, Aurélia Azéma, Delphine Syvilay, Emmanuelle Delque-Kolic, Ivan Guillot, Guillaume Sarah, Sandrine Baron, Delphine Neff, Philippe Dillmann

10:50 **Geochemical and isotopic characterisation of the coin metal of Roman denarii - A multifactorial application tool for numismatic, political, strategic and logistic contexts in the Republic and the Imperial Era.** (Poster Presentation)
Tim Greifelt, Sabine Klein, David Wigg-Wolf

11:00 COFFEE BREAK

11:20 **The early history of Bradley Ironworks**
Peter King

11:45 **Roffey – a Medieval centre of iron production?**
Jack Cranfield

12:05 **Archaeometric dating of smithing slag (Media digest)**
Patrice de Rijk

12:15 **Feeling the Peat: an investigation into an alternative metalworking fuel for the Scottish Iron Age**
Paul M Jack

12:35 LUNCH

13:30 **From OXALID to GlobaLID: A substantial upgrade of a well-known data pool of lead isotopes for metal provenancing using R and Shiny App**
Sabine Klein, Thomas Rose, Katrin J. Westner, Yiu-Kang Hsu

13:55 **Innovations in the Development of Tin Bronze Metallurgy in the Bronze Age of Iran (ca. 3000 -1500 BCE) – A Multidisciplinary Research**
Omid Oudbashi, Mathias Mehofer

14:15 **Bronze Age machine production? An assessment of the minimum variation in bronze artefact reproduction using clay and soapstone moulds.**
Bart Cornelis, Jakob Thæsing Hviid, Christian Steven Hoggard, Thomas Birch

14:35 **Investigation of ancient iron and copper production remains from Irtyash Lake (middle Trans-Urals, Russia)**
Ivan S. Stepanov, Dmitry A. Artemyev, Anton M. Naumov, Ivan A. Blinov, Maxim N. Ankushev

14:55 **Attempts to repoduce graphite morphology in ancient Chinese malleable cast iron**
Donald Wagner

15:15 COFFEE BREAK

15:30 **A Chaîne Opératoire Approach to Copper Production in the Niari Basin, Republic of the Congo, 15th-17th c. CE**
Braden Cordivari

15:50 **Fe-P prills in wootz crucibles from Telangana, India**
Meghna Desai, Thilo Rehren, S Jaikishan

16:10 ***CUPRUM, QUO VADIS*: "Sheikh-Ali" copper mine, new insights for Cu-As metallurgy in 3rd Millennium BC, Iran**
Mohammadamin Emami, Christopher P Thornton

16:30 **The Damhus Hoard – Chemical and isotopic results of early Viking silver coinage**
Thomas Birch, Helle Horsnæs, Rasmus Andreasen, Claus Feveile, Mahir Hrnjíc, Jens Christiansen Moesgaard

16:50 DISCUSSION? (Student prize to be announced)

17:30 CLOSE

Date: 13th November, 2021
Location: Online Zoom Event hosted by Moesgaard Museum, Denmark
Time: 9.30 – 17:30 (GMT)

Conference Attendence: Free
Registration Link (Eventbrite):
https://hms_rip_2021.eventbrite.com

ABSTRACTS

Lead Circulation in Northeast Asia: The Provenance of Lead in the Qi State Bronzes

Chen Wang (UCL, London)

Linzi city of the Qi State was the largest city in Northeast Asia of the Warring States Period of Ancient China (475 BC-221 BC), with a prominent bronze making industry. However, the provenance of ores used for metal production in Linzi still remains unclear. In this study, the slags from the coin workshop and the bronzes from the cemetery No. 2 of Fenzhuang site, both in Linzi, were analyzed for the lead isotope ratio. The chemical composition analysis shows that the lead concentration of most bronzes and slags was higher than 2 wt%, which implies that lead was added artificially. Our analyses show that the lead isotope data could be divided into three distinctive fields (A, B, C), which indicate that there were at least three different sources of the lead ores for the Linzi metal production. We infer that these three fields are most likely with the ores in Shandong Peninsula, the middle and lower reaches of Yangtze River and Liaoning Province respectively. The result suggested that the lead ores used in the bronze industry of the Qi State were mostly imported from other vassal states, which indicates the high volume of the trading activity in the Qi State during the Warring State Period. Furthermore, some evidences indicated that there was a circulation system among Shandong Peninsula, Liaodong Peninsula, Korean Peninsula and Japan Islands.

Not so dull after all? A reassessment of the lead vessel rims from the Mycenae Shaft Graves

Stephanie Aulsebrook (Dept. of Aegean and Textile Archaeology, University of Warsaw)

Grave Circle A at Late Bronze Age Mycenae, excavated in 1876, is famous for containing many unique metal artefacts that exhibit highly sophisticated craftsmanship, such as weapons, vessels and jewellery, as well as copious quantities of gold. Given the astounding array of objects available for study, it is understandable that certain less eye-catching finds from the same context have been overlooked. However mundane, such objects still have interesting stories to tell us if their biographies can be reconstructed. This is one of the aims of the ongoing 'Forging Society at Late Bronze Age Mycenae' project. A recent restudy of a group of four solid lead vessel rims clad in bronze, currently located in the storerooms of the National Archaeological Museum at Athens, has confirmed the overturning of the first and best-known interpretation of these artefacts as well as revealing the crafting connections between these rims that indicate a common workshop origin. Reconstruction of their complete chaîne opératoire, however, remains challenging. Presented here are these new findings and their implications for our understanding of the metal vessel assemblage at the dawn of the Mycenaean Period.

Archaeometallurgical investigations in Notre-Dame de Paris: research in progress on construction iron and lead after the fire

Maxime L'Héritier, Aurélia Azéma, Delphine Syvilay, Emmanuelle Delque-Kolic, Ivan Guillot, Guillaume Sarah, Sandrine Baron, Delphine Neff, Philippe Dillmann (Université de Paris)

Metallic structures are omnipresent in medieval great stone monuments. The newly opened restoration yard in Notre-Dame de Paris following the 15th April 2019 fire gives a unique opportunity to question the evolution of practices related to these metals over the centuries: quality and use for construction, provenance, recycling... This contribution aims to present the research themes and first results of the "Metal workgroup" of Notre-Dame's scientific program coordinated by French National Research Centre and Ministry of Culture.

The restoration works reveal various iron cramps, chains and series of hitherto unknown iron armatures. Their archaeometallurgical study enables to clarify their role in the building's structure, their chronology, but also their quality and origin, enlightening the builders' choices and the ancient supply circuits. More than 30 iron cramps and pins coming from diverse parts of the masonry or collected in the burnt framework archaeological remains were sampled and analysed by metallography, SEM-EDS to study the production processes and LA-ICP-MS to look for iron provenance. Eight samples were also submitted to tensile tests to determine their mechanical behaviour and ten artefacts were radiocarbon dated. Structural µ-Raman analyses were performed on corrosion layers to study the fire's range of temperature.

Besides, the research focuses on the different uses of lead (covering, decoration, sealing ...) and on the practices of craftsmen according to the period. The identification of the different sources of lead and recycling practices is conducted by means of elemental (LA-ICP-MS) and isotopic analyses (MC-ICP-MS) of more than 300 lead samples coming from lead joints still in place and from the remains of the spire and roof.

Geochemical and isotopic characterisation of the coin metal of Roman denarii - A multifactorial application tool for numismatic, political, strategic and logistic contexts in the Republic and the Imperial Era. (Poster Presentation)

Tim Greifelt[1], Sabine Klein[1], David Wigg-Wolf[2]

[1]Deutsches Bergbau-Museum Bochum
[2]Römisch-Germanische Kommission des Deutschen Archäologischen Instituts Frankfurt

The metallurgical and especially the isotopic composition of silver in the coin metal of Roman republical and Roman Imperial denarii has been more and more intensively investigated in recent years. Only a small number of lead isotope analyses have been included in the analyses of the fineness (Butcher & Ponting 2014), with the help of which further well-founded statements about the origin ofthe metal raw material can be made beyond the chemical fingerprinting.

To complement the investigations of Butcher and Ponting, more than 200 additional coins from the period 50 BCE to 240 CE have already been sampled (Historisches Museum Hanau Schloss Philippsruhe; Historisches Museum Regensburg; LWL Museum für Kunst und Kultur Münster; Varusschlacht – Museum und Park Kalkriese). These were examined for their chemical composition and lead isotope ratios; in addition, the copper isotopy of selected coins was measured.

The question arises to what extent the reduction in silver content is due to possible raw material crisesor economic policy decisions? The answer to this question is of central importance for our understanding of Roman economic policy and the economic policy options of ancient states.

Reference:
K. Butcher, M. Ponting (2014). *The metallurgy of Roman silver coinage: From the Reform of Nero to theReform of Trajan*. Cambridge.

The early history of Bradley Ironworks
Peter King (Independent, UK)

Bradley Furnace was the first coke furnace in the Black Country of the industrial revolution, though it had precursors. This was built in 1757 by John Wilkinson, but in recent times a date of 1768 has been quoted, which is actually that of Wilkinson's second furnace there. This results from the work of W.A. Smith in the 1960s, who identified the site of Hallfields Furnace at Bradley and assumed it was his original one. The paper will explore the early history of the furnace.

Roffey – a Medieval centre of iron production?
Jack Cranfield (Dept. of Archaeology, University of Exeter)

While it has been suggested that the Weald of Kent, Sussex and Surrey was a significant centre for making iron during the medieval period, documentary evidence to support this is highly limited and restricted to small numbers of sources. However, an account from Roffey, near Horsham in West Sussex, forms a rare reference to this industry in the 14th century, documenting that in 1327 1000 horseshoes were purchased from a forge at Roffey and sent to the port at Shoreham to supply the Scottish War. While Roffey's ability to supply such a substantial order could suggest an extensive iron industry was present at this date, the absence of further detailed records raises questions on the true extent of iron making and blacksmithing there, and whether Roffey can be seen as a centre for iron production. This paper will consider how a non-invasive archaeological approach, using a combination of geophysical surveying, fieldwalking, artefactual analysis and a broader landscape investigation, can further our understanding medieval ironworking at Roffey and determine the scale of industry at the site.

Archaeometric dating of smithing slag (Media digest)
Patrice de Rijk (Bad Bayersoien, Germany)

Usually, three types of smithing slag can be recognized: the well-known iron-rich smithing hearth bottom (SHB) or parts thereof, silica-rich slag pieces and parts of the hearth lining. The boundaries between those three types are fluid. Generally, iron-rich smithing slag has a specific weight over 2 g/cm³, whereas the silicate rich smithing slag and hearth lining have a lower specific weight.

Smithing slag is usually dated by context and accompanying datable finds. However, this is not always possible and therefore smithing slag from many sites is only roughly dated in the period Iron Age up to Modern times. To refine such rough dating, smithing slag from 177 sites, mainly from the Netherlands, have been studied. By comparing several different parameters in a trial-and-error method, it now has become possible to differentiate between smithing slag from the Roman period (c. 0-500 AD), the Early Middle Ages (c. 500-1000 AD) and the Late Middle Ages (c. 1000-1500 AD) by using slag weight and magnetism only.

By plotting the ratios between iron-rich slag and silicate-rich slag/hearth lining and magnetic and non-magnetic slag, slag from Roman period sites tend to cluster in the higher silicate-rich and non-magnetic part of the diagram, whereas slag from late medieval sites clusters in the iron-rich magnetic part. The reason for this is not quite understood yet but might relate to the quality of the iron used.

Feeling the Peat: an investigation into an alternative metalworking fuel for the Scottish Iron Age
Paul M Jack (University of Sheffield)

The limited woodland resources that have characterised the Northern Isles of Scotland for millennia pose serious questions when attempting to understand how prehistoric communities fuelled their iron smelting endeavours. The economics of wood charcoal may have served as an impetus for Iron Age metalworkers to have experimented with other fuel sources. The archaeological evidence from the Northern Isles, and ethnographic studies from the 19th and 20th centuries, tentatively suggests that peat could have been used for such activities. This research aimed to determine if peat charcoal could function as an iron smelting fuel via an experimental campaign. Thermal data recovered from experimental charcoaling and smelting attempts, as well as a metallographic study of the smelting products, has suggested that peat, once charcoaled, may be capable of producing a good quality iron bloom. Moreover, a means of identifying the use of charcoal for smelting archaeologically has been developed using pXRF. These results stimulate questions pertaining to Iron Age resource use and management. The use of peat charcoal would also have strengthened the link between metalworking and watery places, as observed by the use of bog ore in smelting, and the watery deposition contexts of many metalwork hoards. Alternatively, the use of wood charcoal may have been important for performing and upholding status due to its comparative scarcity. The success of statistical analysis to differentiate between the elemental composition of furnace linings exposed to wood charcoal and peat charcoal opens a new avenue for identifying Iron Age fuel use.

From OXALID to GlobaLID: A substantial upgrade of a well-known data pool of lead isotopes for metal provenancing using R and Shiny App

Sabine Klein [1,2,], Thomas Rose [3,4], Katrin J. Westner [5], Yiu-Kang Hsu [6]*

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[6]Forschungsbereich Archäometallurgie, Leibniz-Forschungsmuseum für Georessourcen/Deutsches Bergbau-Museum Bochum, Am Bergbaumuseum 28, 44791 Bochum, Germany, yiu-kang.hsu@bergbaumuseum.de

Lead (Pb) isotope geochemistry is an approved key method in archaeological sciences to reconstruct the resource provenance of metals. Comparing the Pb isotopic "fingerprints" of objects with ores allows the reconstruction of trade networks of past civilisations, enabling insights into economic, societal, and cultural developments of the ancient world. Successful interpretation of Pb isotopes of metal artefacts rely crucially on the published ore data, which are partly only available from pre- or re-digitised publications. Access to non-digitised data can be difficult, because not all institutions can provide equal access to all relevant publications to their researchers. Pb isotope reference data collections were compiled by individual working groups, usually focussing on regions of interest. Hence many blank regions exist, but it remains unearthed whether they occur due to missing research interest or rather due to lacking research infrastructure of the investigating researchers. A great step towards a larger-scale Pb isotope collection came with the OXALID database in the early 2000s. Still up today, OXALID is the most used and cited source for reference data, but the limitation of OXALID and other currently available Pb isotope data collections is that they cannot be easily edited, modified, and verified in accordance with the rapid increase in newly published Pb isotope data. Additionally, the majority of data are focussed on Europe and particularly the Mediterranean region, and therefore are of little use to researchers from other parts of world. Integrated meta-information still lacks severely. Riding the wave of open science and new data infrastructures, the authors are endeavouring to digitalise and construct a global Pb isotope database. Coupled with an interactive web application based on R and ShinyApps that offers its users many statistical and graphical data tools, GlobaLID is a highly promising approach for the modernisation of archaeometry as an applied geoscience discipline.

Innovations in the Development of Tin Bronze Metallurgy in the Bronze Age of Iran (ca. 3000 - 1500 BCE) – A Multidisciplinary Research

Omid Oudbashi[1], *Mathias Mehofer*[2]

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Within an ongoing cooperation project between the Art University of Isfahan and the Vienna Institute for Archaeological Science, University of Vienna, the emergence and spread of tin bronze metallurgy in the Iranian Plateau during the Bronze Age (3rd – 2nd millennium BCE) is investigated. Despite of the importance of the copper alloys metallurgy during the Bronze Age, there is limited systematic scientific data about the copper base metallurgy and alloying processes in this period. Nevertheless, it is obvious that the tin bronze technology occurred widely through the Middle and Late Bronze Age (ca. 2500 to 1500 BC). It is also very interesting to note that the application of tin bronze emerged during the Early Bronze Age in western Iran, where previously copper and arsenical copper were used. In this paper, the analytical results of some copper based artefacts and metallurgical materials are presented and analysed based on the multianalytical methods to show the emergence and development of tin bronze during the Bronze Age. The results showed that tin bronze occurred during the EBA in the western Iran while arsenical copper was the main metallic material used in other parts of Iran, especially central and eastern Iran. Furthermore, it is worth noting that the spread of tin bronze metallurgy occurred more during the MBA and LBA. Accordingly, it can be concluded that although tin bronze metallurgy started already during the EBA in the western Iranian Plateau, it became a commonplace during the second millennium BC as a dominant material in the archaeometallurgy of the prehistoric Iranian Plateau.

Bronze Age machine production? An assessment of the minimum variation in bronze artefact reproduction using clay and soapstone moulds.

Bart Cornelis[1], *Jakob Thøsing Hviid*[2], *Christian Steven Hoggard*[3], *Thomas Birch*[4].

[1] University of Groningen – MA student
[2] Aarhus University
[3] University of Southampton
[4] Moesgaard Museum

The Bronze Age introduced a new manufacturing technology by using bivalve moulds to cast copper-alloy objects. Moulds offer the potential of reproducing existing artefacts by replicating them in clay by using a positive, or by reuse of the mould proper[1]. The reproductive fidelity of moulds facilitates a means of standardisation which is increasingly measured with the coefficient of variation (CV). The output of a CV is a percentage with a low percentage representing a higher degree of standardisation. However, a CV is highly dependent on the material and production technology. Therefore, an empirically derived CV is required to measure the minimum variation attainable to assess what could be regarded as 'standardised' for copper-alloy casting technology. In so doing, experimental archaeology was used to produce one soapstone and eight clay bivalve moulds in

order to cast ten palstaves per mould type. The resulting CV's indicate that soapstone moulds can reproduce objects more accurately than clay moulds as a single stone mould can be reused multiple times, whereas clay moulds seldom survive a single use. The outcome provides a CV that can benefit future Bronze Age research by acquiring a baseline CV for each mould type, which can be used to assess standardisation within typologies or hoards. Furthermore, the CV could aid in assessing craftsmanship, identifying workshops or typological fidelity towards the shape of an artefact.

Reference:
[1] Flohr Sørensen, T., 2012. Original copies: seriality, similarity and the simulacrum in the Early Bronze Age. Danish Journal of Archaeology, 1(1), pp.45-61.

Investigation of ancient iron and copper production remains from Irtyash Lake (middle Trans-Urals, Russia)

Ivan S. Stepanov[1*], *Dmitry A. Artemyev*[1], *Anton M. Naumov*[2], *Ivan A. Blinov*[1], *Maxim N. Ankushev*[1]

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[2]Municipal government institution of the Ozersk urban district of the Chelyabinsk region "City Museum"

In the mountain-forest zone of the middle Trans-Urals, iron technology is conventionally thought to have been adopted during the local early Iron Age (EIA, 7th-3rd c. BCE) by the skilled bronze-working population of the Itkul culture. However, these claims remain unresolved at present. We analyse via SEM-EDS iron-metallurgical slags, iron ores, technical ceramics, iron object and copper slags from one of the key clusters of Itkul sites, Irtyash Lake, in order to provide first insight into past metal production practices, exploited ore sources and the possible link between copper and iron metallurgy in this part of the Urals. The results confirm bloomery smelting of local ironstone ores in Irtyash area, at least during the early medieval period. Beyond that, the analyses provide the first evidence for small-scale iron-smithing at the EIA sites of Irtyash-1 and Shatanov-5, alongside secondary copper-working activities. The compositional similarity observed between iron- and copper-working slags from Irtyash-1 indicates the deliberate use of steatite-bearing clay mixtures for iron and copper-metallurgical ceramics, which is likely related to their refractory properties. The iron-working slags from the EIA sites suggest the use of iron ores associated with copper deposits, although primary slags formed during the smelting of these iron ores were not identified. It is possible that the early trials iron metallurgy in the middle Trans-Urals, during the EIA, were stimulated by the rich experience of the Itkul population with copper metallurgy and their deep knowledge of the diverse mineral resource base of the Urals.

Attempts to repoduce graphite morphology in ancient Chinese malleable cast iron

Donald Wagner (Independent, Denmark)

I suppose it is well known by now that iron casting and malleablizing annealing were practised in China by 300 BCE, probably earlier. The graphite morphology in some of the artefacts is unexpected, with spherulitic graphite where more nest-like nodules would be expected, given the very low sulphur content.

Some thirty years ago I did some experiments which gave a partial explanation, showing that the phenomenon appears in thin-sectioned castings with very low silicon. I have no chance to continue this work, but perhaps I can persuade others to look into it.

A Chaîne Opératoire Approach to Copper Production in the Niari Basin, Republic of the Congo, 15th-17th c. CE

Braden Cordivari (Institute for the Study of the Ancient World, New York University)

Copper has been exploited in Central Africa since at least the mid-1st millennium CE. Prior to the widespread introduction of European brass in the course of the 19th century, unalloyed copper was the main prestige metal in the region, used for status items, ornaments and currencies. Copper ingots also played an important role in long distance trade throughout Central Africa. The Niari Basin, South Republic of the Congo, was the primary copper deposit exploited in West Central Africa that supplied the main polities of the area during the second millennium CE. This project considers copper production in the Niari Basin during a period dated to the mid-15th/mid-17th centuries CE. Reconstructed technical parameters inform an understanding of social and economic dynamics within the Niari and articulate with discussions of the broader regional exchange of copper.

Using a combination of pXRF, OM, SEM-EDS, and FTIR, the project assesses the structure and composition of slags and technical ceramics from sites associated with two different regional productions: Moubiri-type at the site of Kingoyi near Mindouli and Kindangakanzi-type at Kindangakanzi near Boko-Songho. Similarities in chaînes opératoires suggest sharing of metallurgical knowledge at mining and smelting sites. Both sites are characterised by crucible smelting and the reuse of refractory domestic pottery as crucibles. Moubiri-type pottery is alumina-rich, while Kindangakanzi-type pottery is formed from a magnesia-rich clay, a refractory crucible type unique in sub-Saharan Africa. The interactions between these two types of regional production are considered through the theoretical lens of communities and constellations of practice.

Fe-P prills in wootz crucibles from Telangana, India

Meghna Desai, Thilo Rehren, S Jaikishan

Telangana was a pre-modern wootz steel production center in south-central India. The refractory crucible fragments from various sites in Telangana consist of three distinct layers: the vitrified inner crucible slag layer, the tempered main body of the crucible, and a heavily vitrified outer fuel ash glaze layer. Iron prills, formed as a result of the strongly reducing environment during the use of the crucibles, are found across all the layers of the crucible fabric. Particularly in the vitrified fuel ash glaze layer large Fe-P prills very rich in phosphorus were identified using SEM-EDS, with Fe3P, Fe2P and α-Fe. The co-existence of the three phases in the prills was determined using the EDS values and Fe-P phase diagram. This presentation discusses the conditions under which these Fe-P prills formed, on the basis of interaction of iron with phosphorus, conditions of phosphorus enrichment and the prill solidification temperature. In addition, we explore to which extent the study of these prills furthers our knowledge on fuel ash interaction with the external crucible fabric, and whether it contributes substantially to the study of crucible steel production.

***CUPRUM, QUO VADIS*: "Sheikh-Ali" copper mine, new insights for Cu-As metallurgy in 3rd Millennium BC, Iran**

Mohammadamin Emami[1,2], Christopher P. Thornton[3]

[1]Art University of Isfahan, Department of Conservation and Archaeometry, Isfana, Iran
[2]Institut de Recherche sur les Archéomatériaux-Centre de Recherche en Physique Appliquée à l'Archéologie, Université Bordeaux Montaigne, France
[3]University of Pennsylvania Museum

Scientific and especially archaeometallurgical investigations on ancient mining operations and metallic ore sources in Iran have significantly increased over the past few decades. Statements confirm that the primary metal extraction and ore processing were undertaken from the 3th millennium was practiced in south east of Iran by innovative arsenic Bronzes. However, the first evidence of metal extraction in Iran also goes back to 6500 BC from Tappeh Ali-Kosh, located in the Dehloran Province wets of Iran.

The most important archaeometallurgical finds from Kerman on the processing of native copper are from 3200 until 3600 BC and belong to Tappeh Yahya, Shahdad and Jiroft area; where native copper have been melted. Kerman Province in southern Iran has always been considered regarding the mining and ore processing, due to enrichment of this region by means of polymélange metals outcrops.

The area of "Sheikh-Ali" is introducing in this research as one of the significant sites for various metallic components and polymetallic ores which were probably explored in the Antiquity. The "Sheikh Ali" copper deposit is located in a geological corridor called Hajiabad-Kahnoudj and between Kerman and Bandar Abbas. The deposit is about 270 km south of Kerman and geologically belongs to "Ophiolithic Mélange" formation in the south of the Zagros metalogeny zone. The type of deposit in this area will be interpreted known as Cyprus type ore deposits. The copper ore carriers in the area are chalcopyrite, chalcocite and chromite. Accompanying minerals are hematite and titan-spineles in dike forms orogeny. The metallogeny consist arsenide, tin and antimony in many different amounts. Due to the mineralogical geological investigations on slag and ores, Sheikh Ali can be possibly mentioned as one of the significant raw material sources for arsenic bronze as well as tin bronze.

The Damhus Hoard – Chemical and isotopic results of early Viking silver coinage

Thomas Birch[1], *Helle Horsnæs*[2], *Rasmus Andreasen*[3], *Claus Feveile*[4], *Mahir Hrnjíc*[3], *Jens Christiansen Moesgaard*[5]

[1]Moesgaard Museum
[2]Nationalmuseet
[3]Aarhus Universitet
[4]Sydvestjyske Museer
[5]Stockholm Universitet

Up until August 2018, only 13 examples of the so-called KG4 ('kombinationsgruppe' = combination group) type Viking silver coins known, showing a face on one side and a forward facing deer motif on the other (Moesgaard 2018). The discovery of the Damhus hoard, with 262 coins, is a significant addition to the previously known KG4 type (Feveile og Moesgaard 2018). In a joint collaboration between the National Museum, Southwest Jutland Museums, Moesgaard Museum, Stockholm University and Aarhus University, 25 coins have were selected for analysis of the metal and lead isotope compositions. The results provide an insight into the minting technology and the origins of the silver that was used to mint the Damhus coins.

References:
Moesgaard JC (2018). Den fremadskuende hjort – en hidtil uerkendt fase i Ribes udmøntning i 800-tallet? *By, marsk og geest* (30), 17-27
Feveile C og Moesgaard JC (2018). Appendiks: Damhus-skatten – et fantastisk indspark til den tidlige mønthistorie. *By, marsk og geest* (30), 28-30