



**Knowledge Sharing Webinar Organized by
Metallurgical Engineering & Material Science Technical Division of Fed. MES**

Archeometallurgical Research in Myanmar

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**Federation of Myanmar Engineering Societies
(Hlaing Universities' Campus)**

ARCHAEOMETALLURGICAL RESEARCH IN MYANMAR

- Archaeology aims to reconstruct past cultures, practices, and human behaviors through material remains. Among the transformative milestones in prehistoric societies, the invention and utilization of metals played a crucial role in shaping prehistory, especially in the Bronze Age, and Iron Age. Archaeometallurgy, a vital component of material culture studies, investigates ancient metallurgical production technologies and the provenance of materials. This field provides profound insights into ancient crafts, industries, economies, cultural interactions, innovations, and social structures. Originating in the mid-18th century with compositional analyses of artifacts, archaeometallurgy has since evolved, employing advanced methods to trace historical practices and trade networks. In Myanmar, archaeometallurgical research remains in its nascent stage. Initial studies focused on compositional analyses of metal artifacts, later transitioning to microstructural analysis by both foreign and local scholars after 2000. Recent advancements include French-led isotopic provenance studies. Despite these efforts, the field faces significant challenges, including limited funding, equipment, and expertise. Overcoming these obstacles requires interdisciplinary collaboration between archaeologists and scientists to advance research and enhance the understanding of Myanmar's rich cultural heritage.

OVERVIEW

- **Archaeology**
- **Archaeology and Material Science**
- **Archaeometallurgical Research in Myanmar**
- **Conclusion**

ARCHAEOLOGY

- The study of the human past through its material remains.
- Reconstruct past cultures, practices, and human behaviors through material remains.



HISTORY AND ARCHAEOLOGY

- History and archaeology are closely related fields, but they differ in their methods and focus:
- Archaeology: the study of the past using objects and other excavated evidences as the main sources of data.
- History: the study of the past using documents and inscriptions as evidences

THE BACKGROUND OF ARCHAEOLOGY

- **The Speculative Phase** (14th to the early 19th C.)

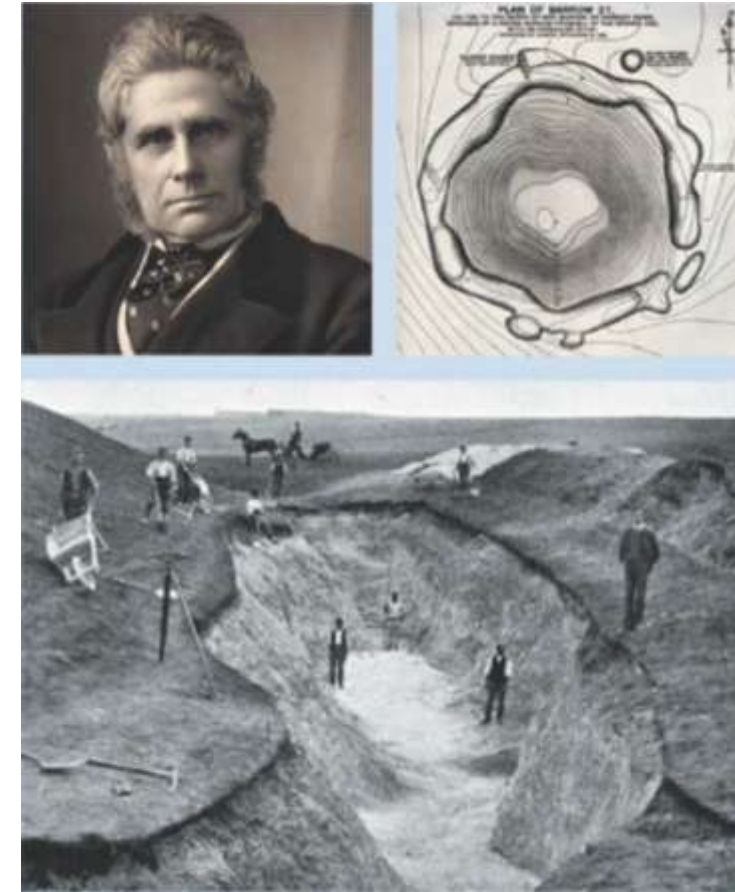
Focused on collecting artifacts and speculating about the past

- **The First Excavation** (18th C.)

Thomas Jefferson dug a trench or section across a burial mound in 1784. His works mark the beginning of the end of the Speculative Phase.

- **The Beginnings of Modern Archaeology** (the mid-19th C.)

The newly developed science of geology: the earth was older than just a few thousand years, and the stratification of rocks (the arrangement in superimposed layers or strata) established principles to be the basis of archaeological excavation.



THE PROCESS OF ARCHAEOLOGY

- Exploration/ Survey
- Excavation
- Post Excavation Analysis
- Publication

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Archaeological and Geological Evidence from the Southernmost Region of Myanmar

Kalayar Myat Myat Htwe ^{*1}, Day Wa Aung², Ye Tun¹, Win Pa Pa Lwin¹

Abstract

The Tanintharyi coast, encompassing the regions of Dawei, Myeik, and Kawthaung in southernmost Myanmar, emerged as a significant cultural hub around the fourth century BCE. Systematic archaeological excavations were not conducted in this area until 2018. Recent excavation at Maliwan in Kawthaung Division, carried out by the French-Myanmar Mission, have uncovered numerous artifacts, including local and Indian-related ceramic shards, stone and glass beads, and metal objects. Despite extensive research by regional and international archaeologists over the past two decades, considerable gaps remain. This study addresses these gaps by integrating geological formations with archaeological evidence and conducting a comparative study, typology, and elemental analysis using the available samples. Diverse-coloured glass beads, raw glass and copper-based objects were analysed using an optical microscope for microstructures and SEM-EDS for elemental analysis. This paper contributes a novel perspective on the socio-economic cultural and material technology diffusion to hybridity in the ancient southernmost region of Myanmar.

Keywords: Southernmost Region of Myanmar, Diffusion, Hybridity, Ancient Maritime Trade Network

1. Introduction

The Isthmus of Kra, situated in the southernmost region of Myanmar, has been of geographically strategic importance since ancient times, yielding significant archaeological evidence. This region is notable for its abundant natural resources until now, including forestry and geological resources: minerals such as tin, gold and lead. Additionally, it serves as a crucial

ARCHAEOLOGICAL FINDINGS

Artifacts (Portable objects shaped, modified or created by people)

- Ceramic
- Metal
- Glass



Ecofacts (Unmodified, natural items found in archaeological contexts)

- Animal Remains
- Plant Remains and etc.

ARCHAEOLOGY AND MATERIAL SCIENCE

- **The analysis of ancient coins, glass, glazes, and pigments** (Eminent scientists, primarily chemists) in the late 18th century
 - ❖ **The composition and manufacture of ancient artefacts**
- **The official combination of archaeology with the sciences** as a career path in 1955
 - ❖ **The opening of the earliest university laboratory** dedicated to the development and application of scientific methods to the study of the past **at Oxford.**

Artefacts:

- Elemental or molecular chemistry
- Microstructure and texture,
- Isotopic composition



The technology of their manufacture or
The provenance of the raw materials used.

In archaeological materials science

- The study of production technologies and the provenance of materials.



The study of past human practices

- **Ancient technologies** are embedded in social structures and develop over time.

- Reconstruction and understanding

 - ❖ Ancient crafts and industries

 - (History of Technology)

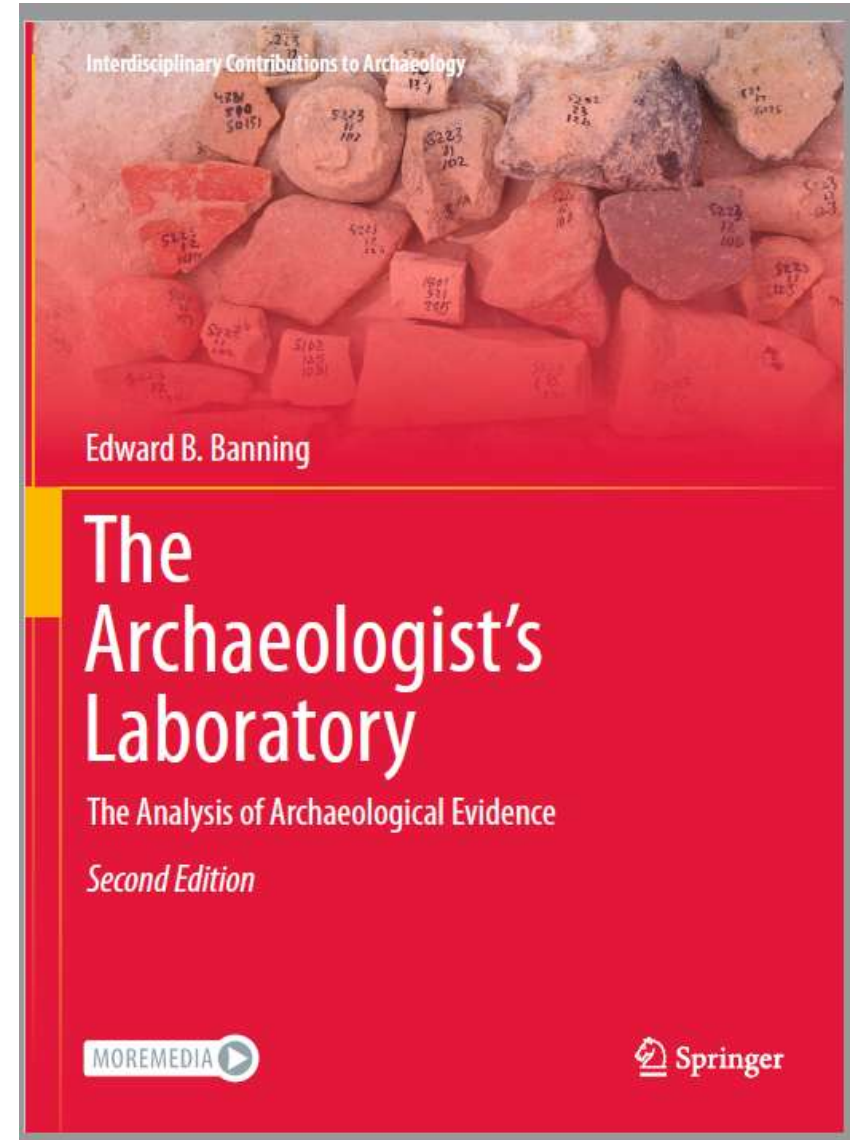
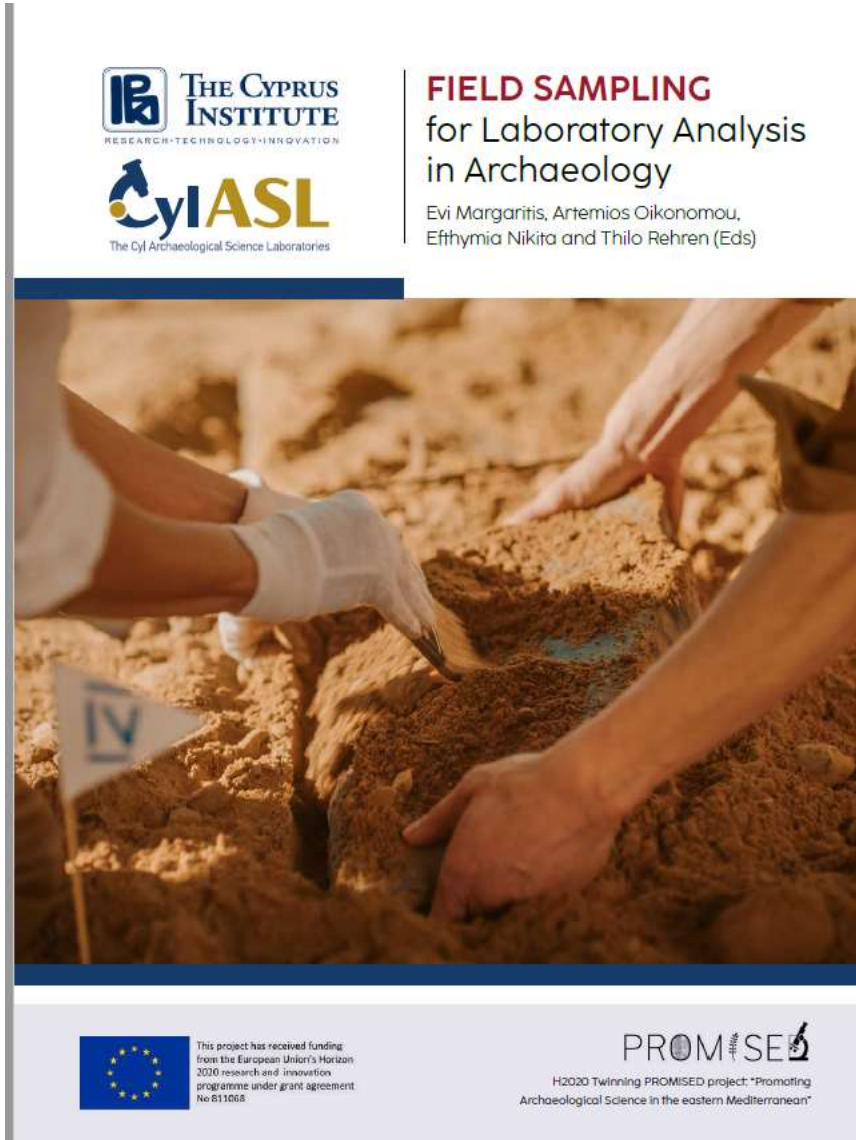
 - ❖ Ancient economies, innovations, cultural contacts and social organisation

 - (Technology in Society)

Tracking the provenance of materials  Cultural connections and trade routes

ARCHAEOLOGY AND MATERIAL SCIENCE

- Ceramic
- Metal
- Glass
- Pigments
- Stone
- Human remains
- Animal Remains
- Plant Remains and etc.



METHODOLOGY

- Destructive analysis
- Non-destructive analysis

- **Analysis**
- Microscopic analysis
- Compositional analysis
- Isotopic analysis

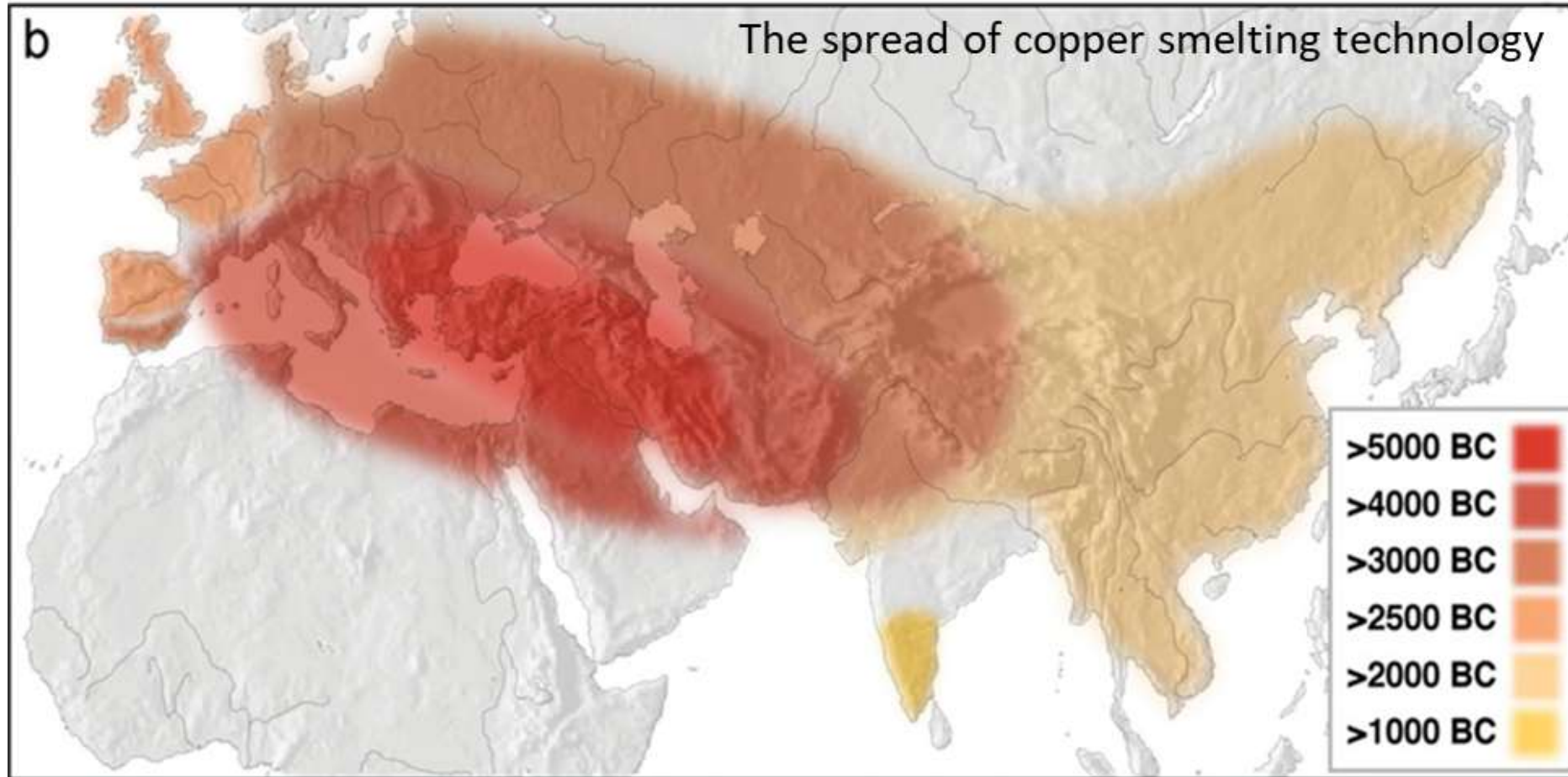
- **Instrument**
- Microscope
- XRF
- pXRF
- SEM-EDS
- ICP-MS

- ❖ Very rare or valuable artifacts and materials should be **avoided from damaging analytical methods.**
- ❖ **Minimize the destruction** of priceless artifacts and archaeological materials.
- ❖ Samples should be **as small as possible.**

ARCHAEOLOGY

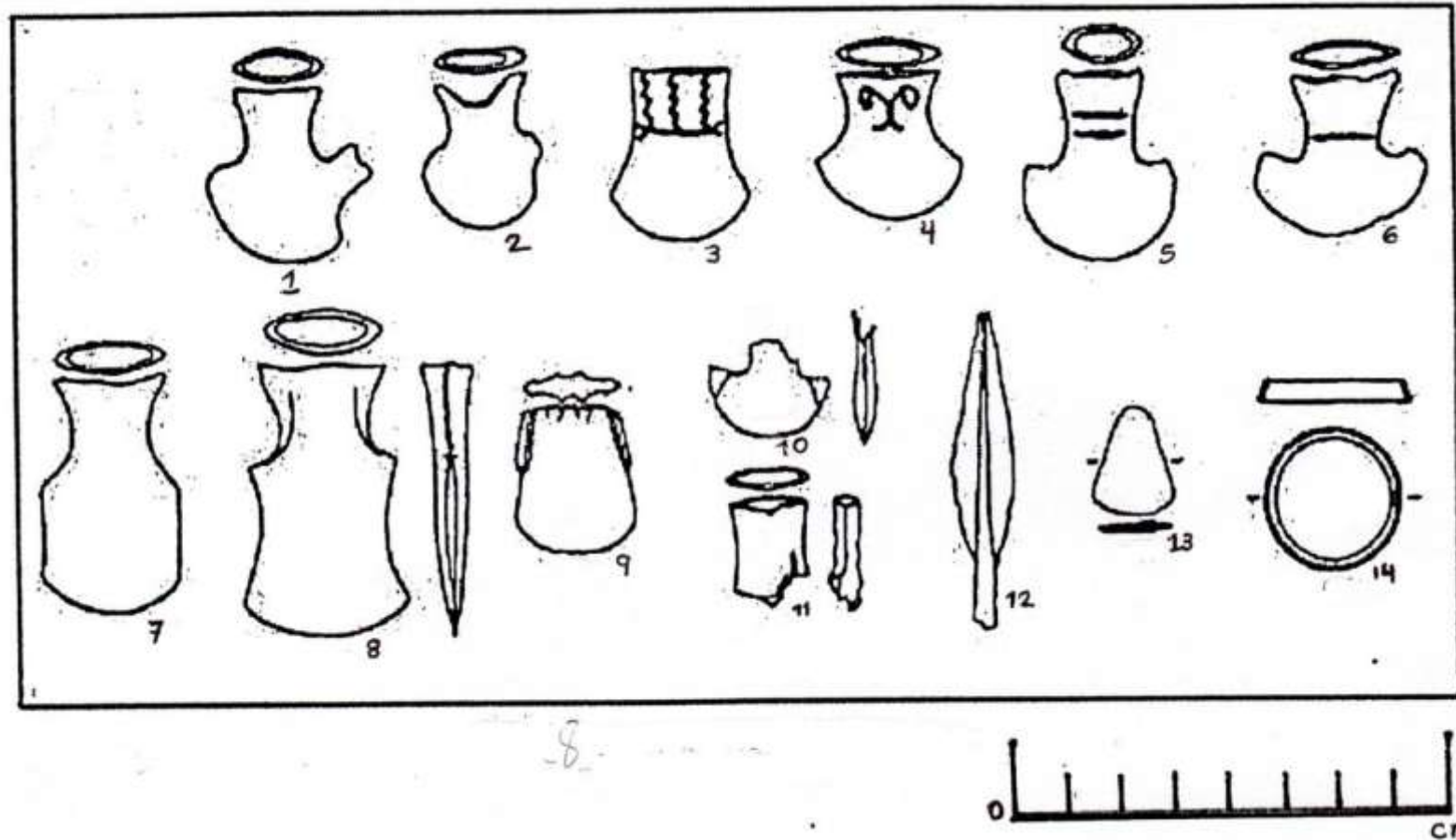
- **Prehistory:** **Stone Age:** Palaeolithic Period (Anyarthian Culture)
Mesolithic Period
Neolithic Period (Oakaie, Halin)
Bronze Age (Nyaunggan Burial site)
Iron Age (Thaungthaman Site and Samon Vally Sites)
- **Protohistory:** **Pyu ancient cites:** Beikthano, Halin and Srikhitra (World Heritage Sites)
Maimaw and etc
- **History:** From Bagan to the recent past.

ARCHAEOMETALLURGICAL RESEARCH IN MYANMAR

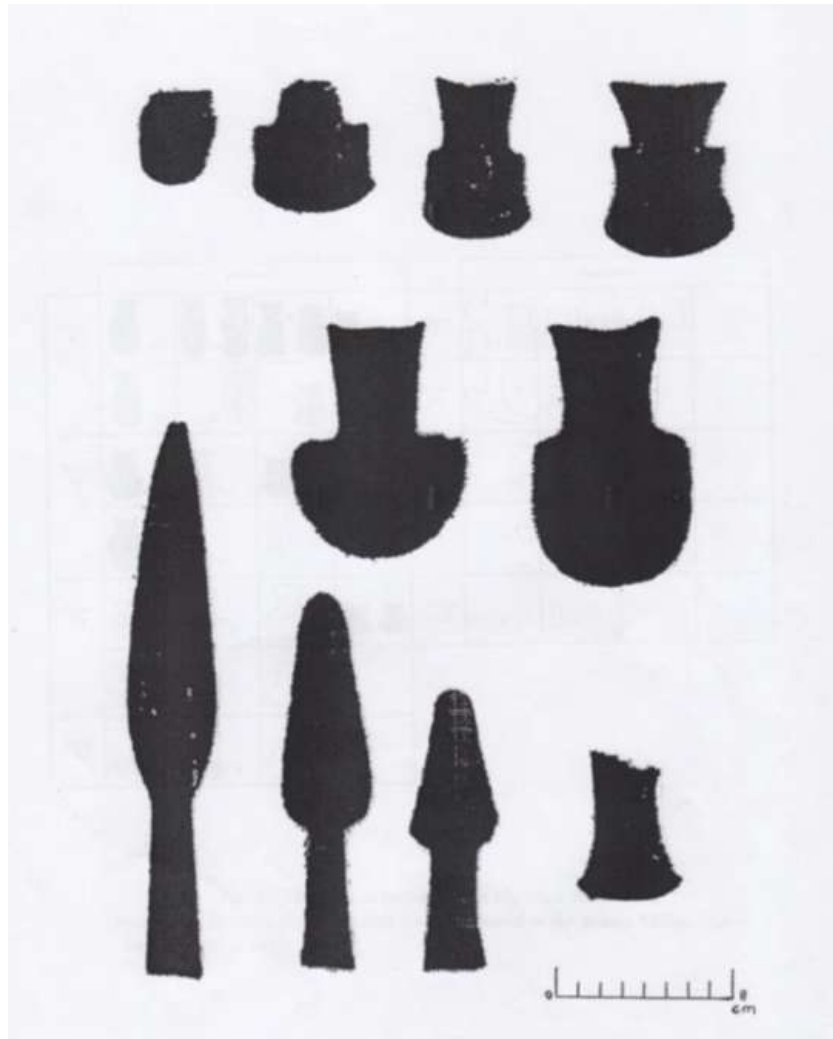


Source: Benjamin W. Roberts, Christopher P. Thornton & Vincent C. Pigott, "Development of metallurgy in Eurasia", *Antiquity*, 83,2009, p-1014.

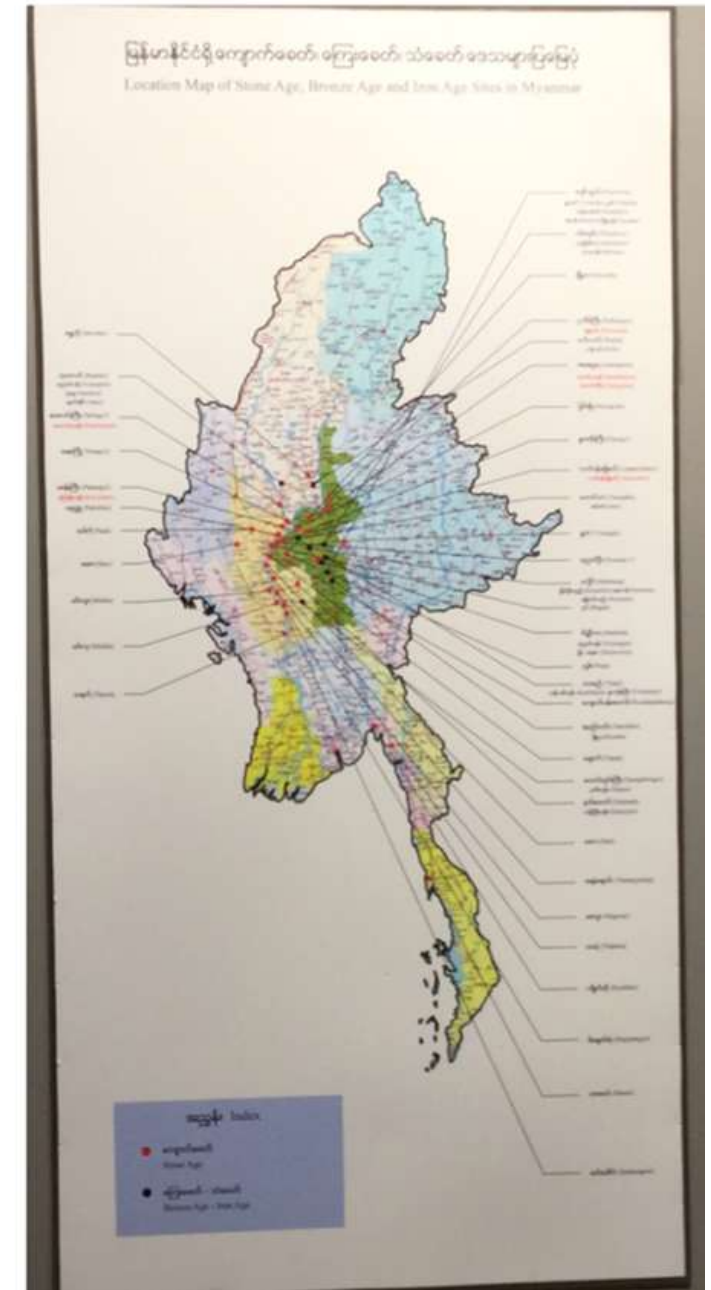
ARCHAEOMETALLURGICAL RESEARCH IN MYANMAR



T.O Morris, "Copper and Bronze Antiquities from Burma", *JBRS*, Vol XXIII, II, Rangoon, Burma Research Society, 1938, pp. 95-100.



Myint Aung, “More Evidence of Myanmar Bronze Age”, *Revealing Myanmar's past: A Anthology of Archaeological Articles*, 2012



NYAUNGGAN BRONZE AGE



REPORT ON THE INVESTIGATION OF METALLIC IMPLEMENTS FOUND IN NYAUNGGAN VILLAGE, BUDALIN TOWNSHIP

U Nyunt Htay*, Dr. Khin Maung Win**

This report attempts to cover the two main functions. The first one deals with the various field trips undertaken by specialists groups and some relevant observations made by the members. The second function is to interpret those observations and also the analytical results obtained by X-ray fluorescence analysis of the metallic implements collected from the excavated sites. The University Research Centre (URC) is responsible for the X-ray fluorescence (XRF) analysis.

Field Trips

The first field trip started in January 1998 and lasted for about ten days. The team consisted of representatives from the Ministry of Culture, the Ministry of Education and the Ministry of Defence respectively. Excavation activities, carried out during that trip, revealed the presence of some bronze implements along with metal rolls, human skeletons and pottery.¹

The second trip was in May 1998. Since the second trip was undertaken as a follow-up study, the group consisted of scholars from the Department of Archaeology of the Ministry of Culture, the Department of Anthropology of the University of Yangon and from the Universities Historical Research Centre. During this nearly two-week trip some evidences of copper smelting were observed.

The third field study which took place in December 1998 was led by Professor U San Nyein of the Department of Archaeology and

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** Retired Director General, Department of Technical and Vocational Education. Former Head of Metallurgical Engineering Department.

¹ Report on Recent Archaeological Finds in Budalin Township, Sagaing Division by Daw Ni Ni Myint, Director, Universities Historical Research Centre.

UNIVERSITIES' RESEARCH CENTRE UNIVERSITY OF YANGON

Mention U Htun Aung Chain UHRC Report
Nyaunggan Project Lab File XRF 10327 to 10330
Your Ref Memo dated 30-12-98 Date 1-1-99
Details of Samples Copper alloy samples & Slag

RESULTS OF X-RAY FLUORESCENCE ANALYSIS

Qualitative analysis for heavy elements only (z = 20 and above)

Sample mark	Description
SLAG	Major elements: Fe, Mn Minor element: Ca Trace elements: Zn, Cu, Ti, Zr, Sr, Cr
NG-CU1	Major element: Cu Minor element: Sn Trace element: Fe
NG-CU2	Major element: Cu Minor elements: Sn, Fe

Operated by

Sd/-

Daw Ohnmar Win
Lecturer

Sd/-

U Ye Myint Swe
Assistant Lecturer

YWA HTIN

Iron Age burials
in the Samon Valley, Upper Burma



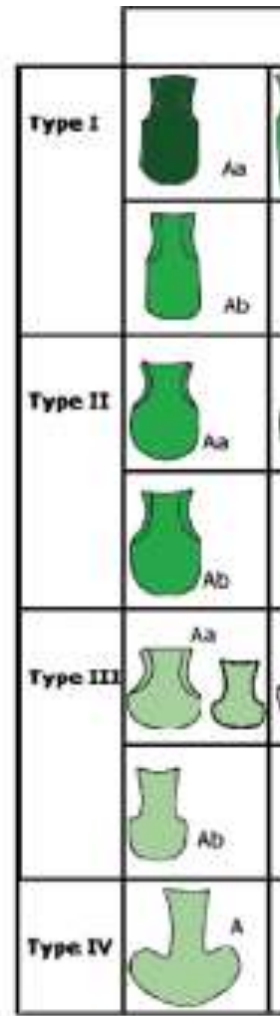
Preface by JEAN-FRANÇOIS JARRIGE

Member of the Institute
President of the Musée Guimet

under the direction of
JEAN-PIERRE PAUTREAU

Director of Research at the CNRS
Head of the French Archaeological Mission in Myanmar

MISSION ARCHEOLOGIQUE FRANCAISE AU MYANMAR



The types of a

ANALYSES OF BRONZE VASES FROM THE SAMON VALLEY

Fragments of the cylindrical vase MH1 (fig. 95) found in grave 32 on the Myo Hla site (Yamethin township) were analysed with the use of an electron microscope coupled with microanalysis X*. These methods permit the detection of the nature of a metal or an alloy and to eventually highlight the heterogeneity of its composition and its structure, and therefore technological

Fig. 96: General view of a vase's fragment (MH1) obtained with electron microscope (scale 100 µm) / Vue générale d'un fragment de vase (MH1) au MEB (échelle 100 µm, électronique rétro-diffusée), photo J.-Ch. Le Roussel

ANALYSIS POINTS	1	2	3	4	5
O	8.4	15.7	15	17.4	8.5
Al	ud/nd	ud/nd	ud/nd	ud/nd	ud/nd
Si	0.1	0.9	0.4	0.4	0.5
S	ud/nd	ud/nd	ud/nd	ud/nd	ud/nd
Cl	0.6	ud/nd	5	ud/nd	0.3
C	3.2	1.5	3.4	3.9	2.4
Sn	13.1	66.3	30.9	26.2	19.4
Cu	74.4	15.6	45.1	51.9	68.9
total	99.8	99.4	99.8	99.8	100

Fig. 96: Chemical composition expressed in elementary percentage obtained by X micro-analysis on different parts of the vase (nd: undetermined) / Composition chimique exprimée en pourcentage élémentaire obtenue par micro-analyse X en différents points du fragment de vase (nd: non déterminé), table J.-Ch. Le Roussel

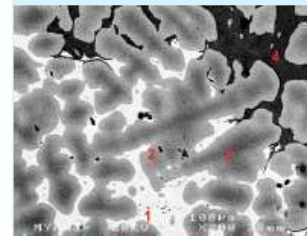


Fig. 100: Section detail obtained with electron microscope (scale 100 µm) / Détail de la section au MEB (échelle 100 µm, électronique rétro-diffusée), photo J.-Ch. Le Roussel

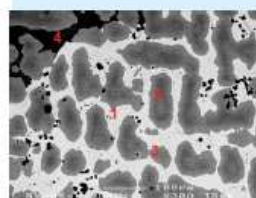


Fig. 102: Detail of a vase's fragment obtained with electron microscope (scale 100 µm, 100x) / Détail d'un fragment de vase au MEB (échelle 100 µm, électronique rétro-diffusée), photo J.-Ch. Le Roussel



Fig. 95: Myo Hla Yamethin township. The bronze cylindrical vase from 32 burial / Le vase cylindrique en bronze de la sépulture 32, photo J.-Ch. Pautreau, MAFM

data concerning the way it was manufactured. To facilitate the task, a fragment of the vase was placed in resin and worked in such a way as to obtain a polished section.

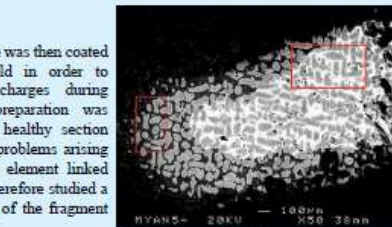


Fig. 96: General view of a vase's fragment obtained with electron microscope (scale 100 µm) / Vue générale d'un fragment de vase au MEB (échelle 100 µm, électronique rétro-diffusée), photo J.-Ch. Le Roussel

ANALYSIS POINTS	1	2	3	4
O	ud/nd	ud/nd	ud/nd	5.5
Al	ud/nd	0.2	ud/nd	ud/nd
Si	0.1	ud/nd	0.1	ud/nd
S	ud/nd	ud/nd	ud/nd	ud/nd
Cl	ud/nd	ud/nd	ud/nd	ud/nd
Zn	ud/nd	ud/nd	ud/nd	ud/nd
Pb	ud/nd	ud/nd	ud/nd	ud/nd
C	3.9	4.7	4.3	2.9
Sn	23.9	5.8	12.5	15
Cu	71.7	89.1	82.8	78.8
total	99.6	99.8	99.7	100

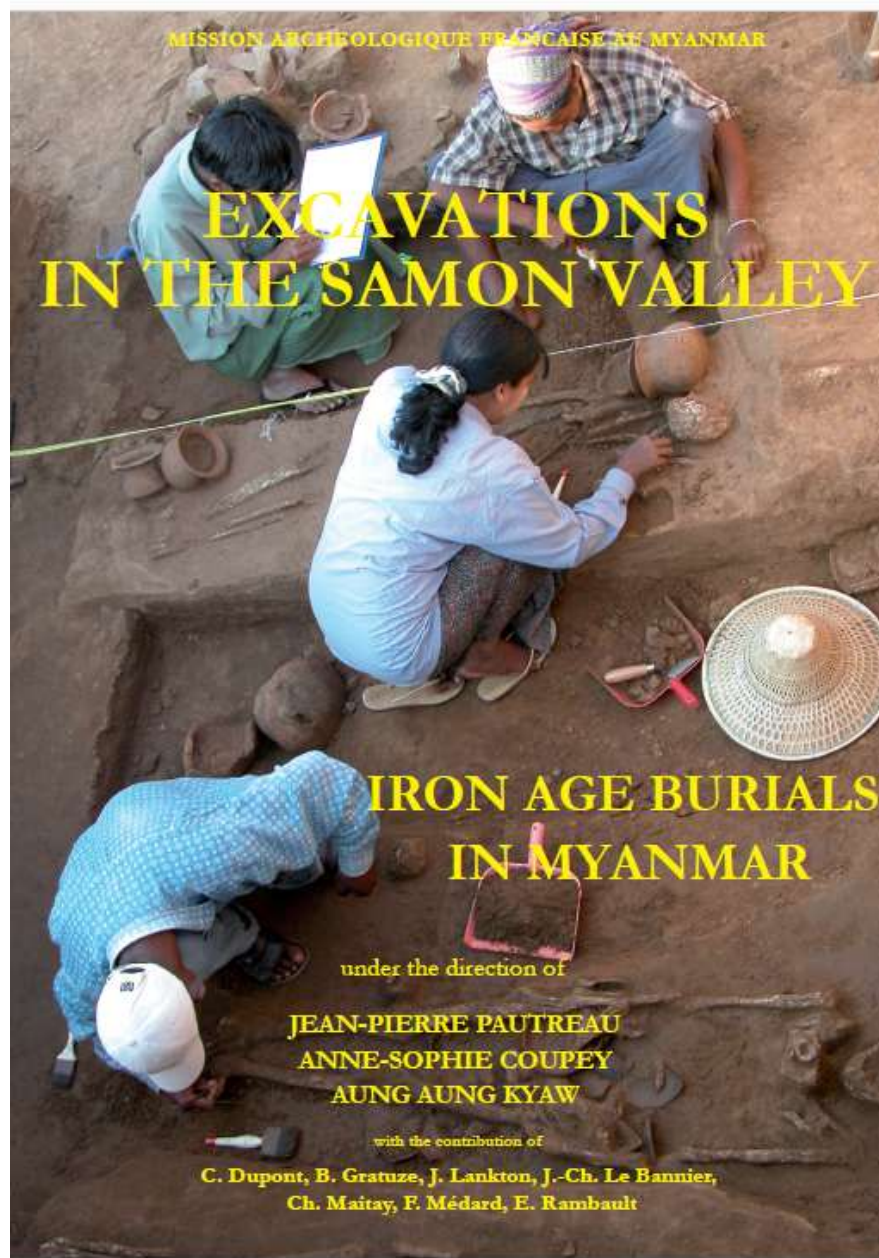
Fig. 101: Chemical composition expressed in elementary percentage obtained by X micro-analysis on different parts of the object (nd: undetermined) / Composition chimique exprimée en pourcentage élémentaire obtenue par micro-analyse X en différents points du fragment de l'objet (nd: non déterminé), table J.-Ch. Le Roussel



1 type

between 12 and 9

bault, MAFM)



NOTES CONCERNING A FEW COPPER-BASE ALLOY OBJECTS FROM THE SAMON VALLEY

Emma Rambault



Fig. 940: Bronze axes, current types in the Samon valley/baches en bronze, types usuels dans la vallée de la Samon (photo and CAD E. Rambault, M4FM).



Fig. 941: Bronze adze, current type in the Samon valley/herminette en bronze, typique dans la vallée de la Samon (photo and CAD E. Rambault, M4FM).

Metal grave goods made from copper-base alloy found in the Samon valley are quite varied. Tools (axes) have been found, as well as weapons (spearheads, sword blades), also jewellery or body ornaments (ankle rings and bracelets), receptacles (vases), coffin ornamentation, bundles of copper wire and diverse exotic objects. Whilst some of these objects are the result of archaeological digs, most are the result of grave looting.

Socketted axes and adzes.

Socketted axes were found in a dig at Ywa Htin. Whilst the bones are well conserved, one notes that the axe (blade and handle) had been placed between the forearms (Pantreau *et al.* 2007). Socketted axes were amongst the most common objects discovered. Intensive pillaging in the region brought to light more than 200 such items.

It was noted that their shapes were quite regular (Rambault in Pantreau *et al.* 2007, pp. 54-55 ; Rambault 2008). In the majority, they were socketted axes with a thickened shoulder (fig. 940) and adzes (fig. 941). An analysis of the composition of the alloy was carried out on one axe from the Kyut Kan site (Pantreau *et al.* 2007) and this proved to be binary bronze with 8.91% of tin.

Spearheads.

Several spearheads were discovered in graves at Ywa Htin. Grave S5/10 contained two, placed to the right, alongside the body of the deceased (Pantreau *et al.* 2007). The proximal

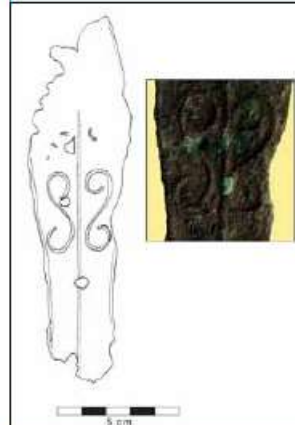


Fig. 942: Bronze spearhead decorated with an "S" in relief/poignée de lance en bronze ornée d'un "S" en relief (photo and CAD E. Rambault, M4FM).



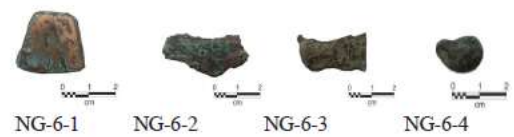
Fig. 943: Bronze socketted spearheads from the Samon valley/poignées de lance en bronze de la vallée de la Samon (photo and CAD E. Rambault, M4FM).

part had a socket. The sharpened head, larger than the socket frequently has a foliated shape. A central rib is often seen on both side of the sharpened head and also a small ridge around the circumference. The spear-



NG-1

NG-3



NG-6-1

NG-6-2

NG-6-3

NG-6-4



MH-1

MH-2 and MH-3



MOH-S

MOH-B

KKH-B



KKH-W

MT



SP

Photo by researcher



KKH-S



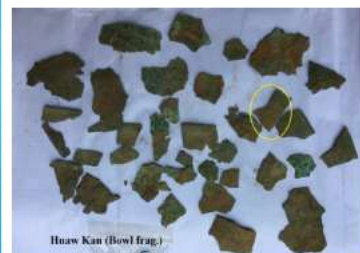
KTG



HTP



HK-1

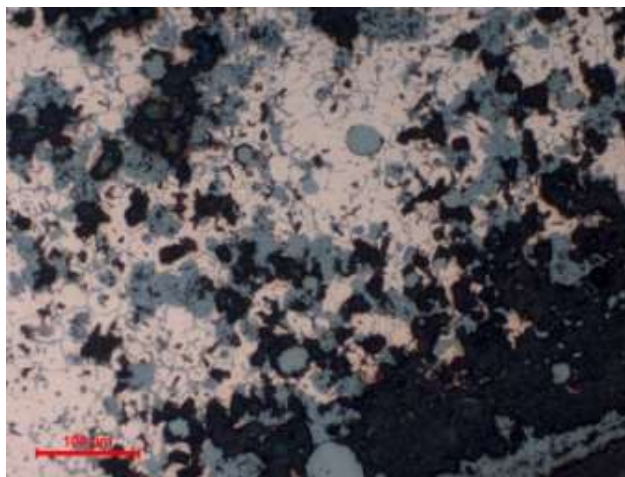


HK-2

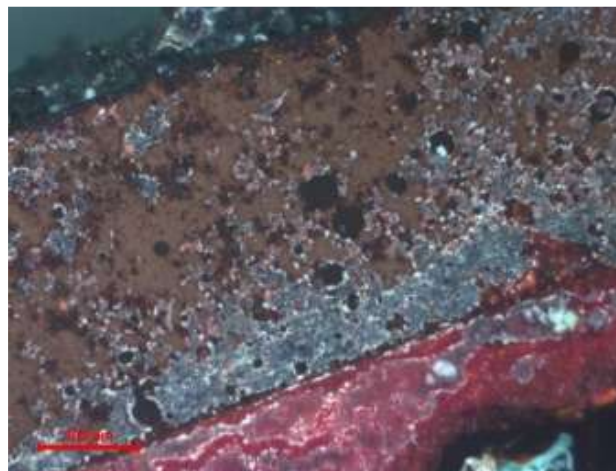


YH

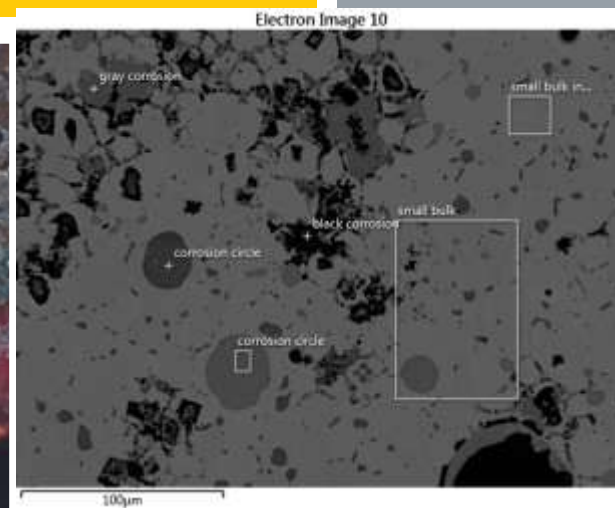
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MOH-S 100 PPL

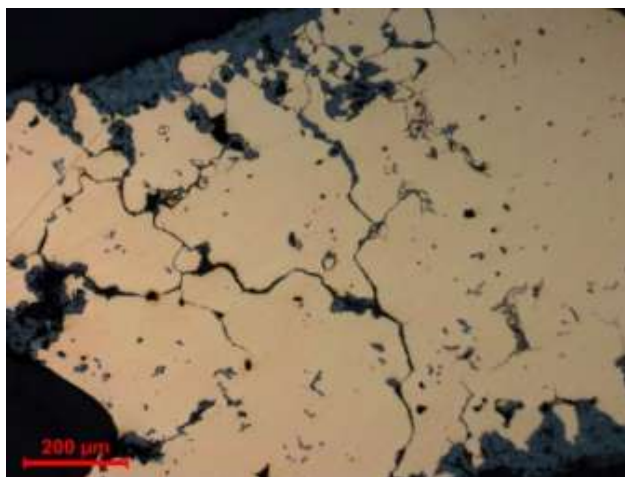


MOH-S 100 XPL

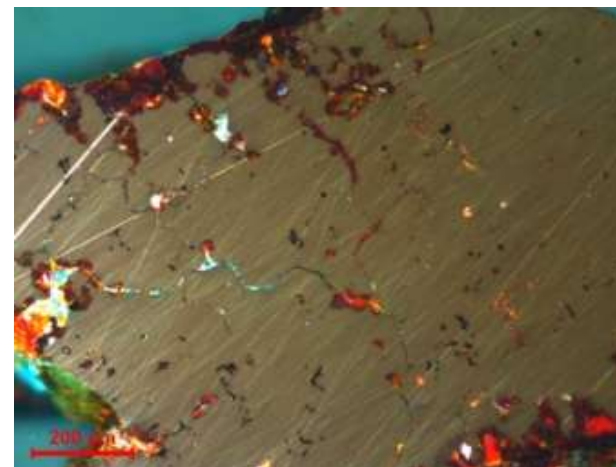


MOH-S (SEM)

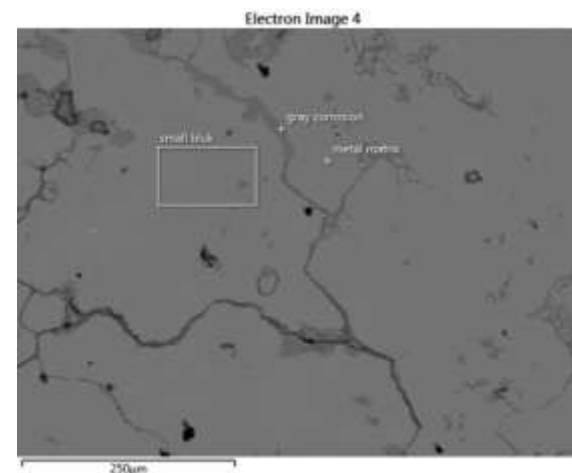
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MOH-B 100 PPL



MOH-B 100 XPL

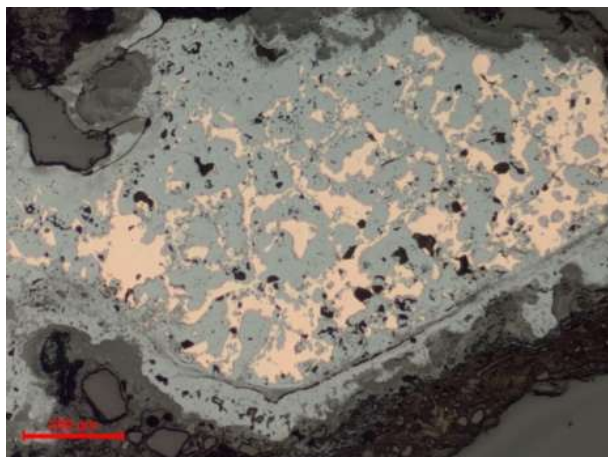


MOH-B (SEM)

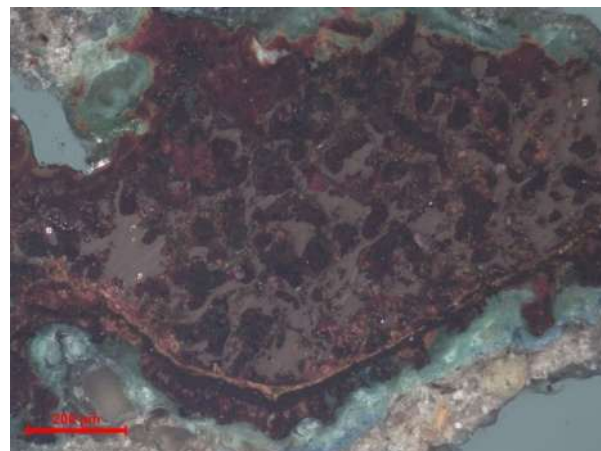


MOH-S (Spear), (80.9 Cu, 1.9 Fe, 1.9 S)

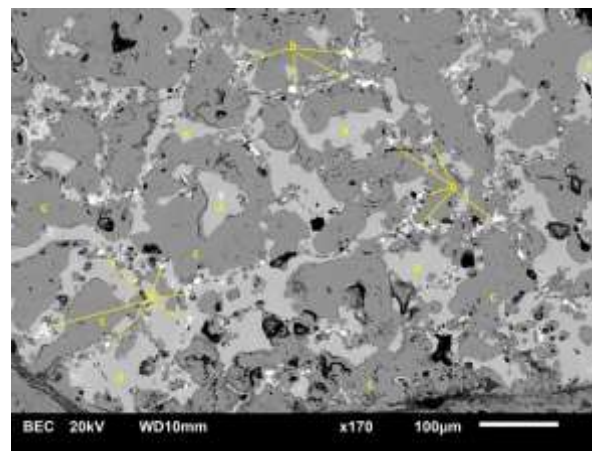
(low tin bronze, from 1-18% tin)



KKH-B 100 PPL



KKH-B 100 XPL

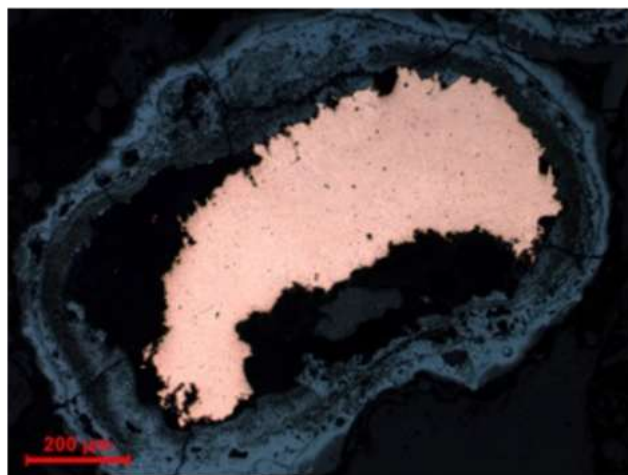


KKH-B (SEM)

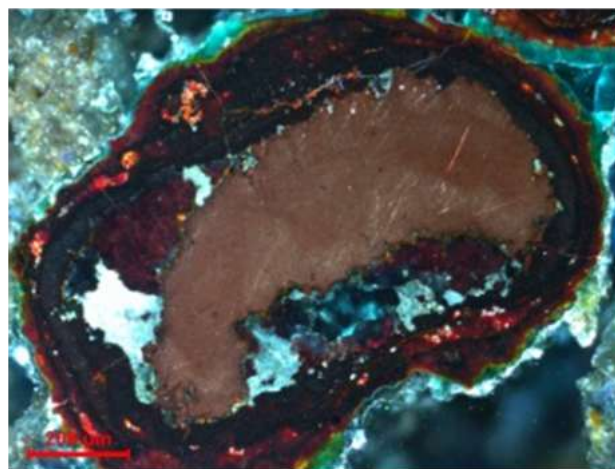


KKH-B (Bangle), (82.7 Cu, 3.5 As, 0.4 Sn, 0.3 Ag)

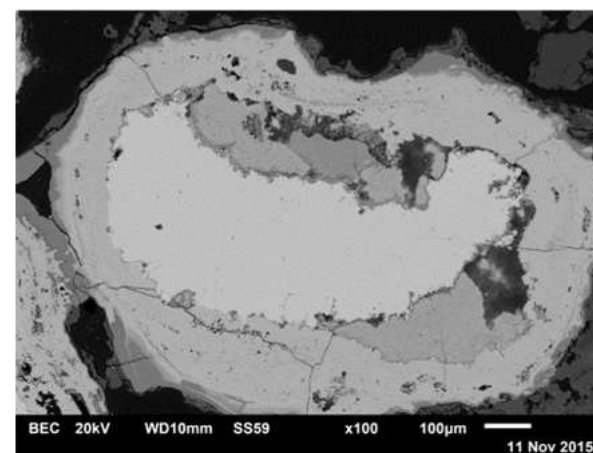
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KKH-W 100 PPL



KKH-W 100 XPL



KKH-W (SEM)

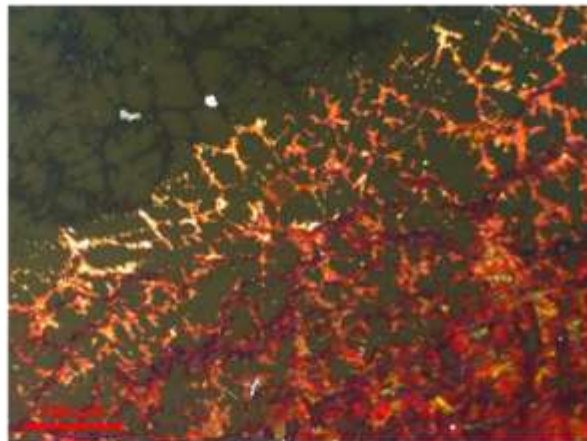


KKH-W (Bronze Wrie bundles), (98.1 Cu, 1.1 S)

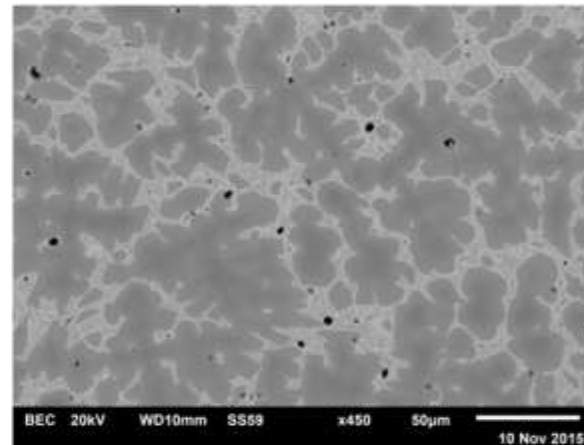
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NG-6-2 200 PPL



NG-6-2 200 XPL

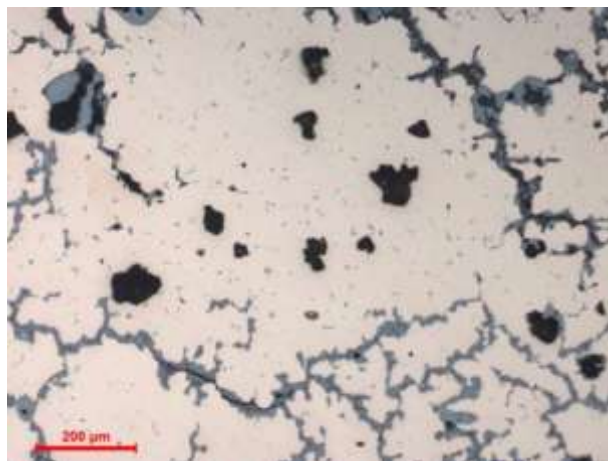


NG-6-2 (SEM)

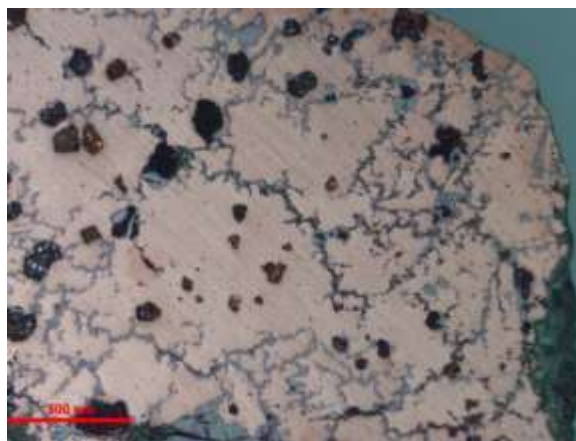
(Photo by researcher)



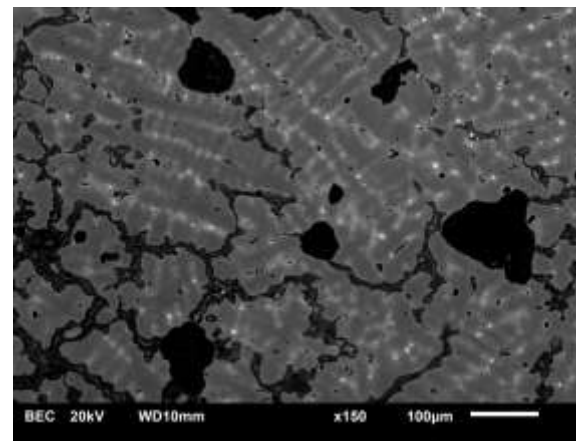
NG-6-2 (Ingot), (82.8 Cu, 17.1 Sn , 0.1 S)



NG_ 6-3 100 PPL



NG_ 6-3 100 XPL

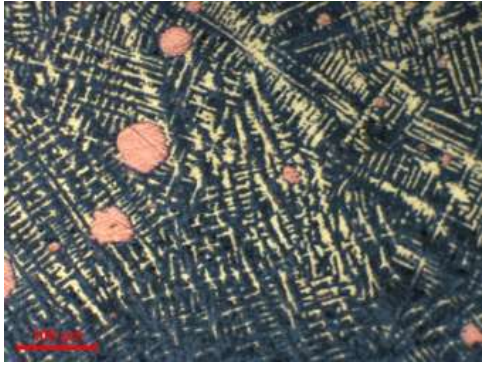


NG_ 6-3 (SEM)

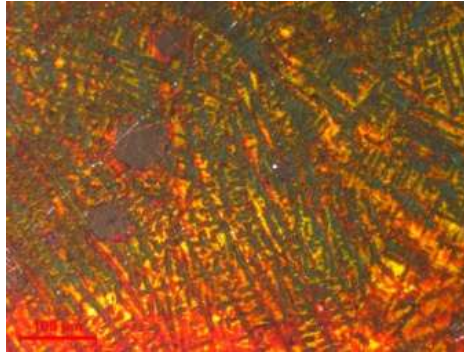
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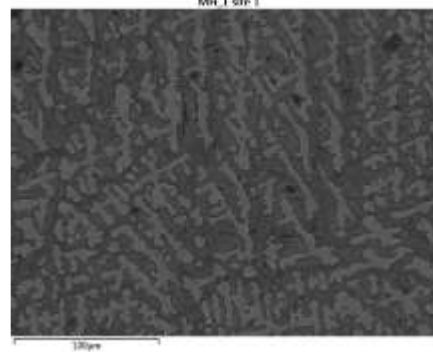
NG-6-2 (Ingot), (94.9 Cu, 5.1 Sn , 0.3 S, 0.5 Pb)



MH-1 200 PPL

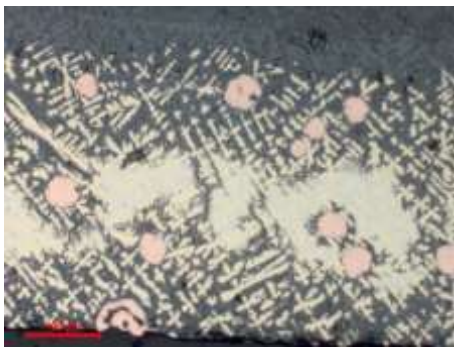


MH-1 200 XPL

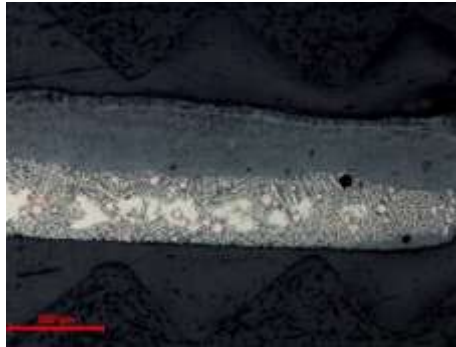


MH-1 (SEM)

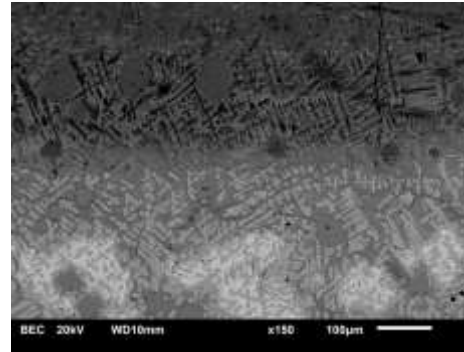
High tin bronze, from 18-30% tin samples



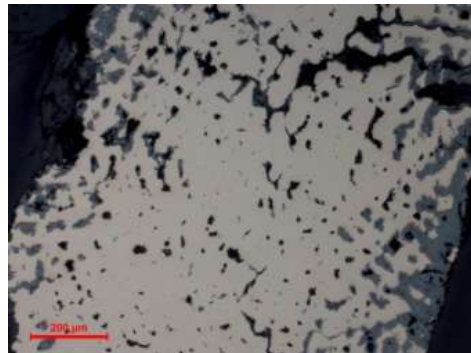
MH-2 100 PPL



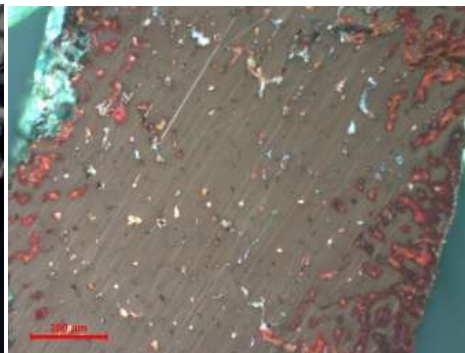
MH-2 50 XPL



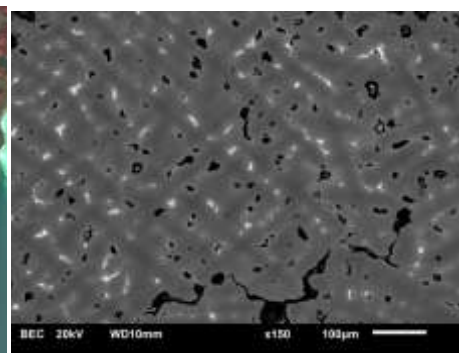
MH-2 (SEM)



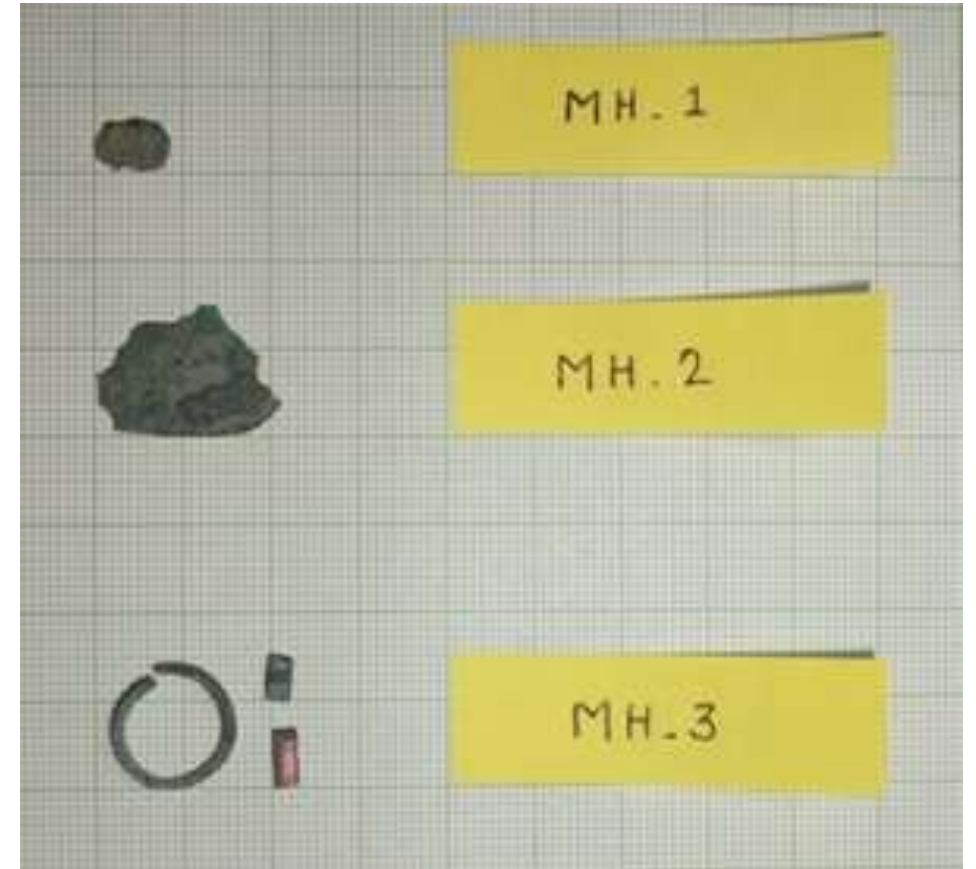
MH-3 100 PPL

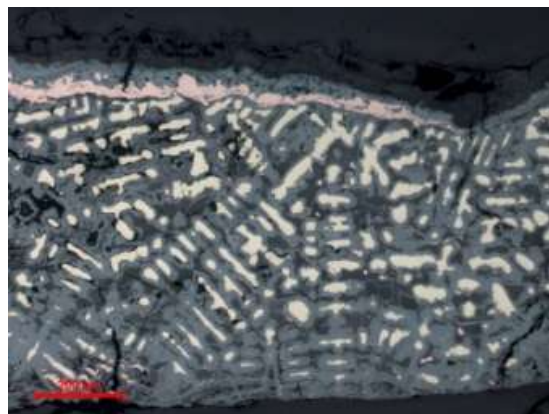


MH-3 100 XPL

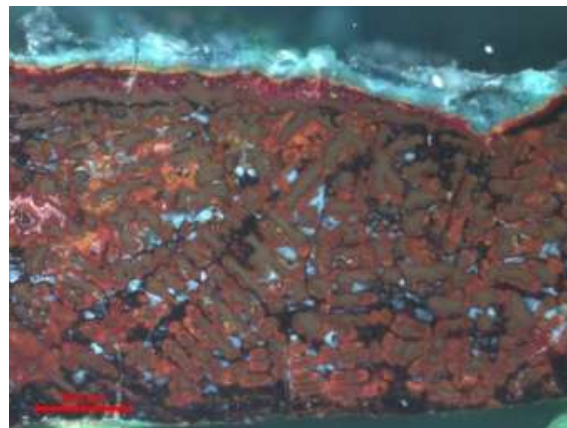


MH-3 (SEM)

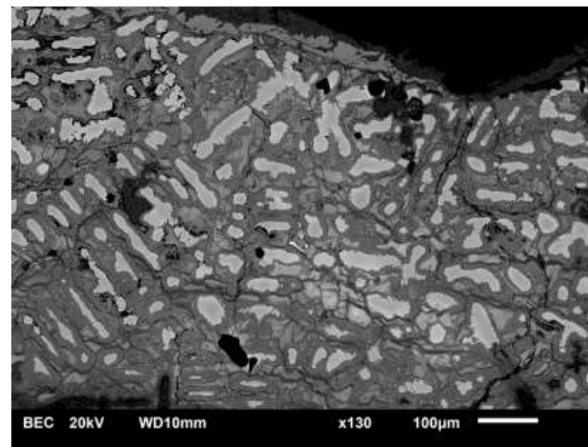




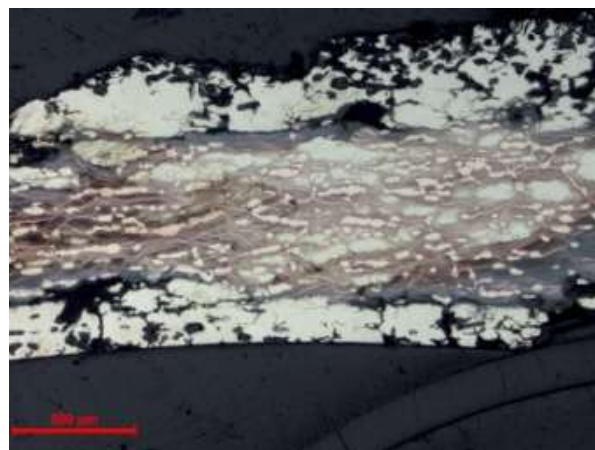
KKH-S 100 PPL



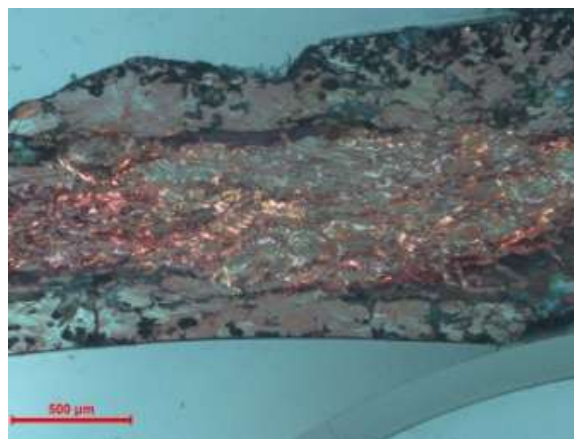
KKH-S 100 XPL



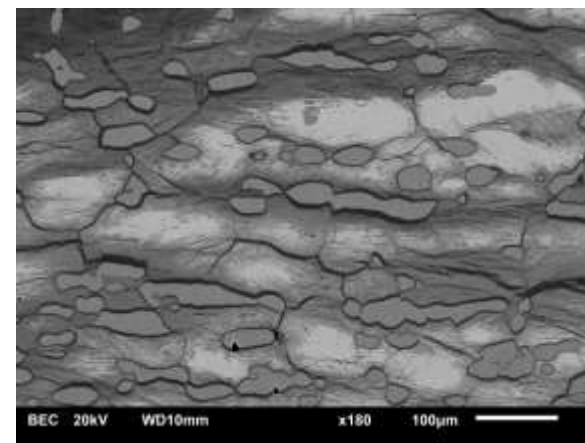
KKH-S (SEM)
(Photo by researcher)



SP 50 PPL

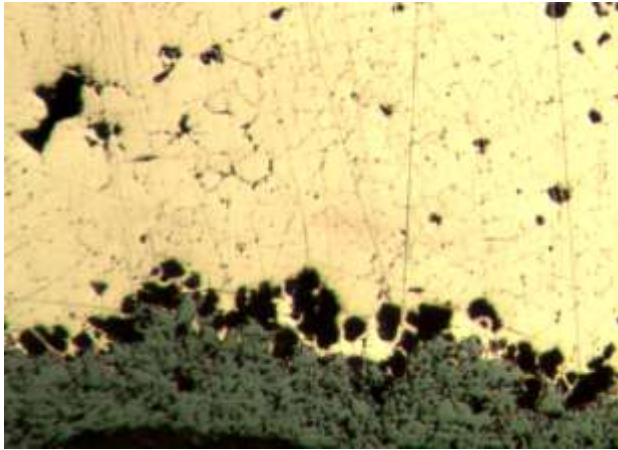


SP 50 XPL

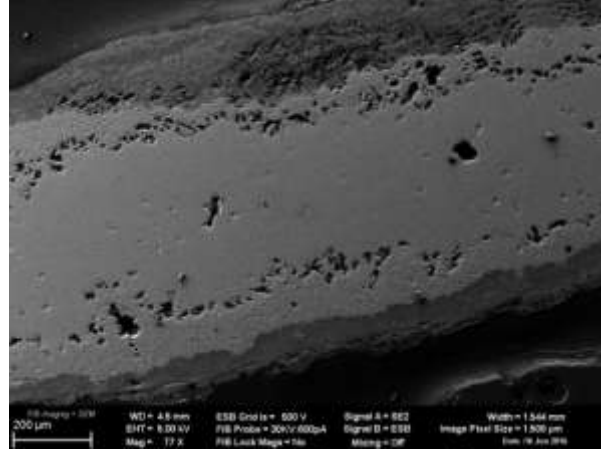


SP (SEM)





YH 100 PPL



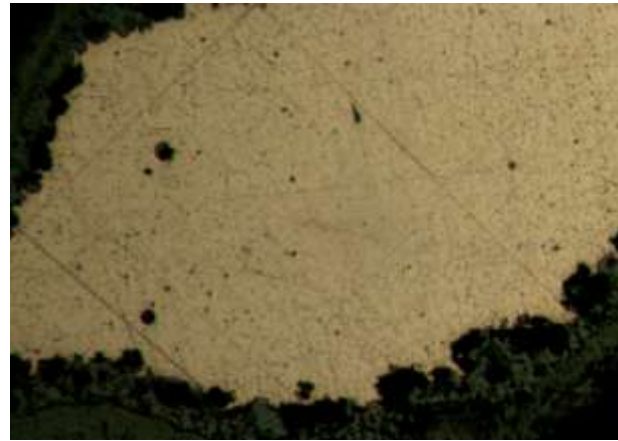
YH (SEM)



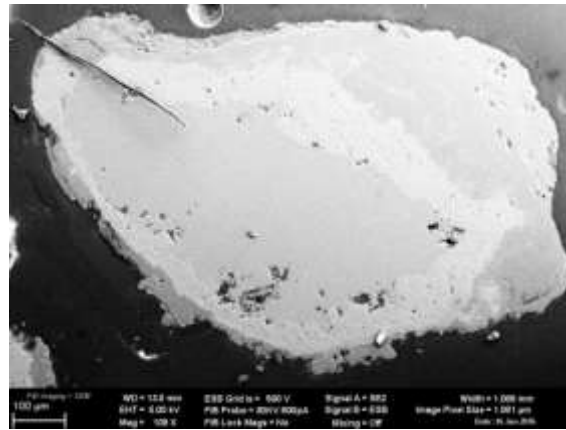
HK-1



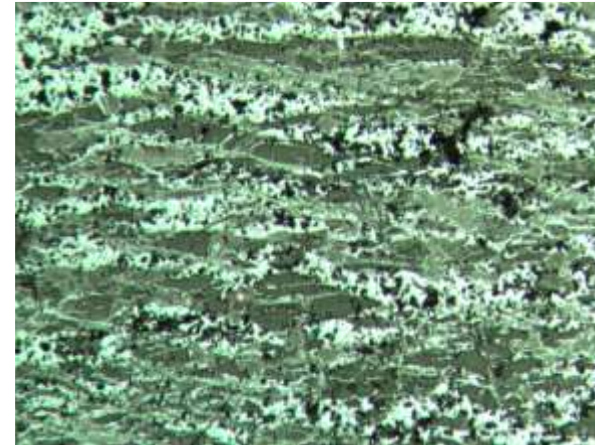
HK-2



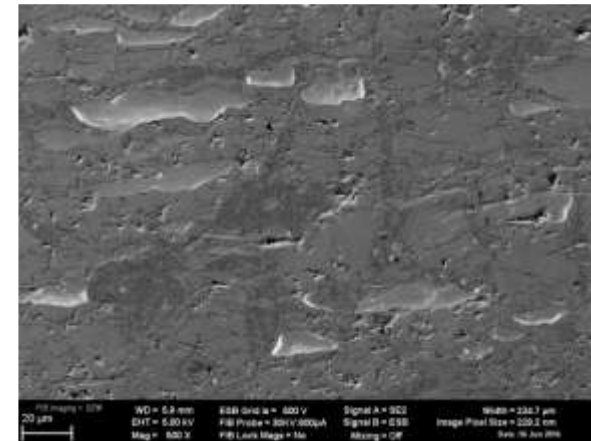
HK 100 PPL



HK (SEM)



HK-2 100 PPL



HK-2 (SEM)

HK (Wire bundle)

HK-2 (Bowl)

Metallurgical traditions and metal e prehistoric central Myanmar, c. 100

Thomas Oliver Pryce^{1,2} · Kalayar Myat Myat Htwe³ · Myrto C Tiffany Martin⁴ · Enrique Vega² · Thilo Rehren^{4,5} · Tin Tin W Peter Petchey⁷ · Jitlada Innanchai⁸ · Baptiste Pradier¹

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Abstract Myanmar has been notably underrepresented in recent studies of archaeometallurgy in Southeast Asia, despite its richness in both mineral and cultural resources and its potentially central role in long-distance exchange networks linking India, China and peninsular neighbours. Here, we present original analytical data on copper-base artefacts from several Bronze Age and Iron Age sites in Myanmar. Observed microstructures range from as-cast, worked, to fully annealed; compositions include leaded copper, low-tin to high-tin bronzes, and arsenical copper/bronze. Lead isotope analyses indicate that the metal originates from different geological sources, including several that match the lead isotope signatures of known prehistoric coppermines in Thailand and Laos. These archaeometallurgical data, including evidence for secondary copper-base production, more than double those

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⁶ Ministry of Religious Affairs and Culture, Mandalay, Myanmar

⁷ Department of Anthropology and Archaeology, University of Otago, Dunedin, New Zealand

⁸ Independent Scholar, Lampang, Thailand

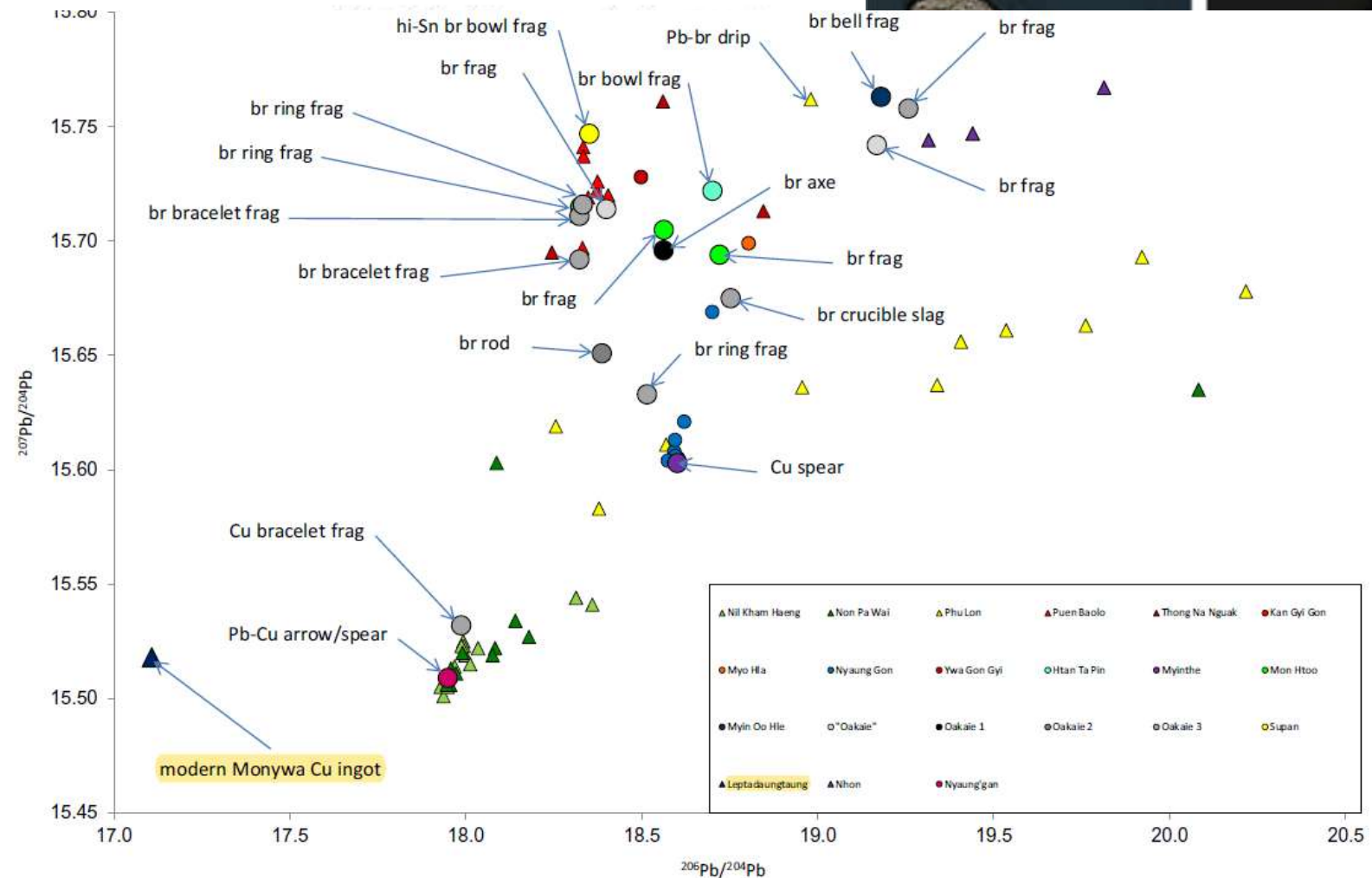


Fig. 22 Bi-plot of lead isotope values. Previously published regional primary copper production systems are represented by *triangles*: *green* for Nil Kham Haeng and Non Pa Wai (Khao Wong Prachan Valley, central Thailand), *yellow* for Phu Lon (northern Thailand) and *red* for Puen Baolo and Thong Na Nguak (Sepon, central Laos), from Pryce

et al. (2011b). Previously published data from Myanmar (Kan Gyi Gon, Myo Hla, Nyaung Gon and Ywa Gon Gyi) are represented by *small circles*, from Pryce et al. (2014) and Dussubieux and Pryce (2016). New data are represented by *large circles* and artefact types are labelled. Symbols are larger than error bars

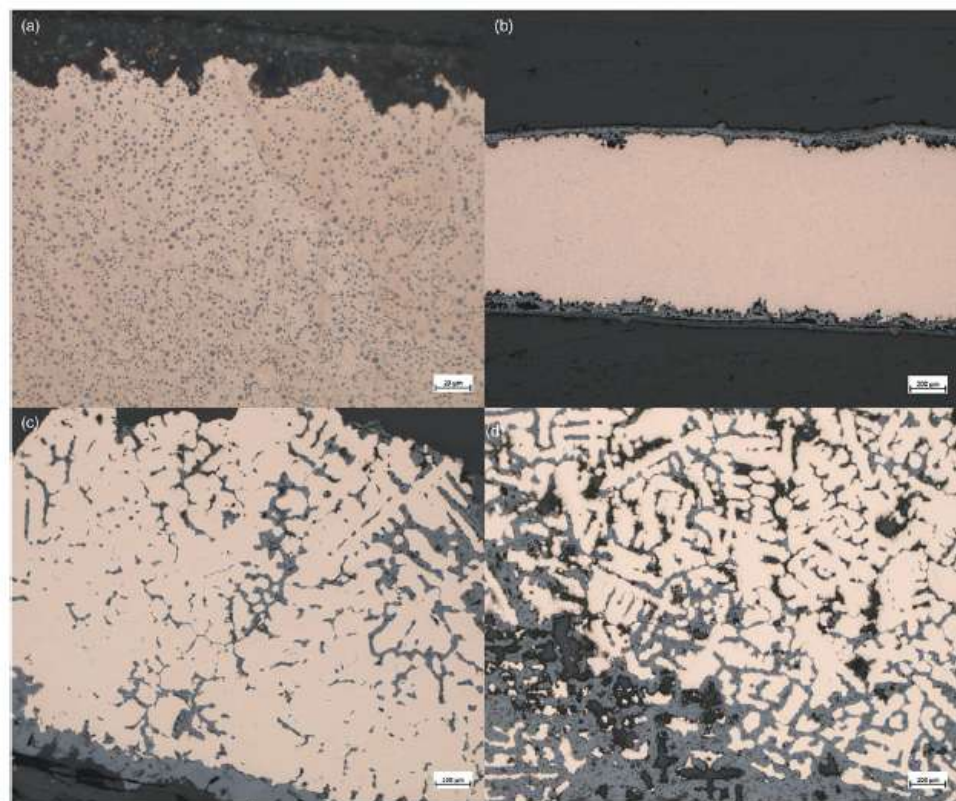


Figure 6. Optical micrographs. Top left: as-cast wire bundle (HL28/2) with round copper sulphide inclusions; top right: wire bundle (HL28/5); below left: bronze cast bell/rattle (HL28/12); below right: bronze as-cast bangle (HL29-1/1); bottom: a bronze ring with an as-cast microstructure (HL29-1/7).

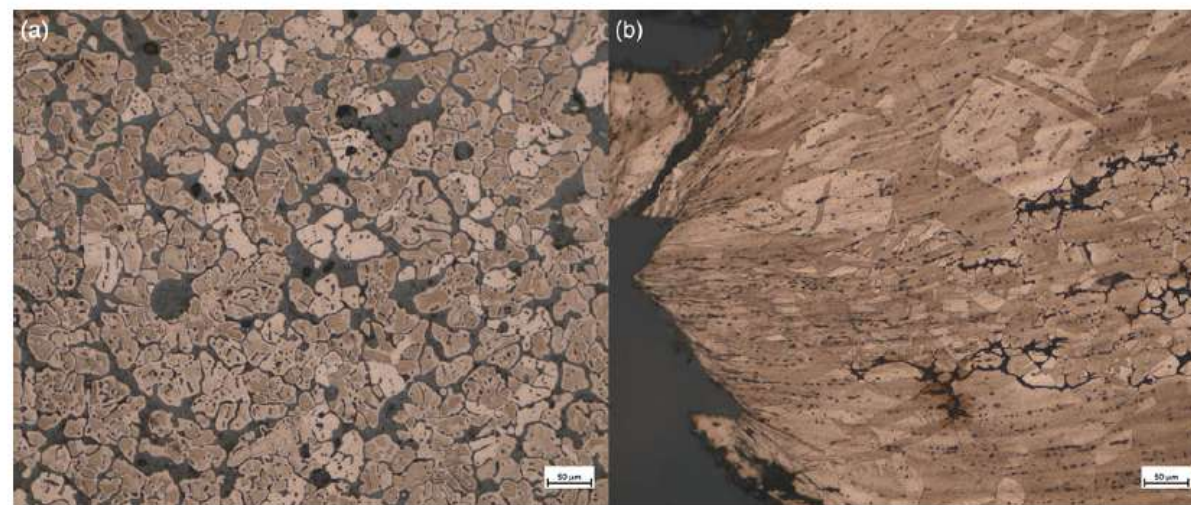


Figure 7. Optical micrographs, after etching. Left: a leaded copper sample (NYG3/1) with an as-cast structure; right: a copper ring sample (HL29-1/8) which has been hammered and annealed.

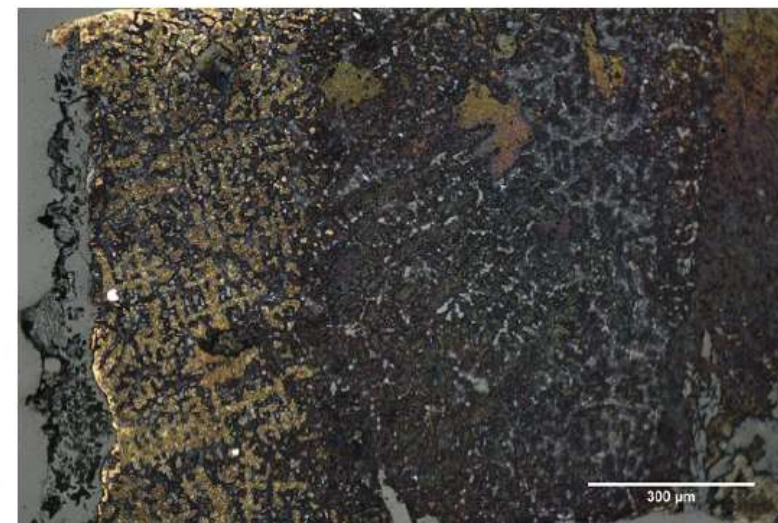


Figure 8. HL28/18 almost entirely composed of corrosion products but with an identifiably as-cast structure.

rcles represent the documented prehistoric copper-producing centres with lead isotope characterizations.

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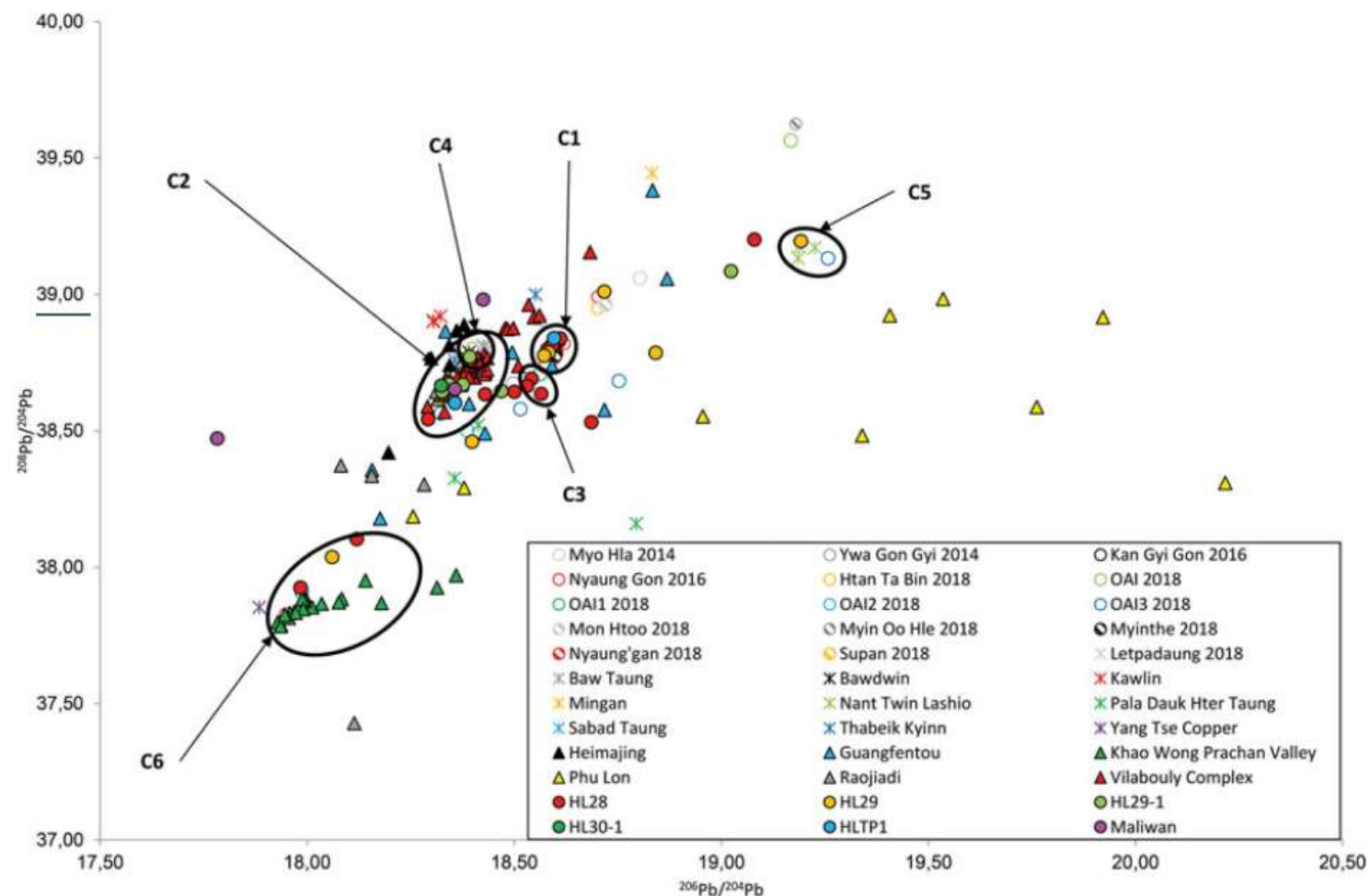


Figure 12. All Myanmar artefact plus mineral LI data deemed potentially relevant in the previous section, representing all four stable isotope ratios, plotted against published copper production systems in Thailand (Khao Wong Prachan Valley and Phu Lon), Laos (Vilabouly Complex), Yunnan (Guangfentou) and Sichuan (Raojiadi) (Chen et al. 2020; Pryce et al. 2022b; Zou et al. 2019). C6 is a cluster we consider identifiable once regional copper production data are included. Error bars are smaller than symbols.

Archaeological and Geological Evidence from the Southernmost Region of Myanmar

Kalayar Myat Myat Htwe^{*1}, Day Wa Aung², Ye Tun¹, Win Pa Pa Lwin¹

Abstract

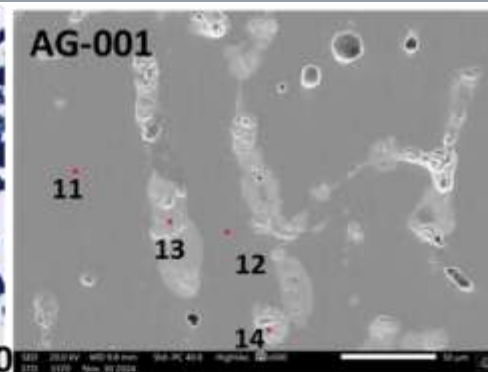
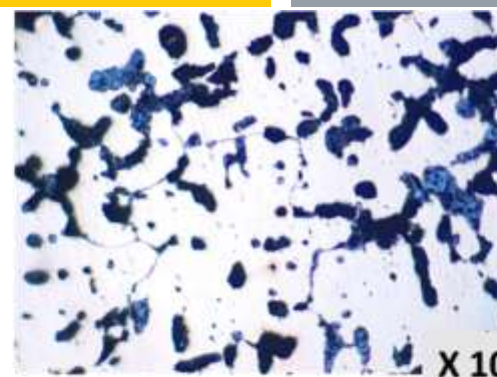
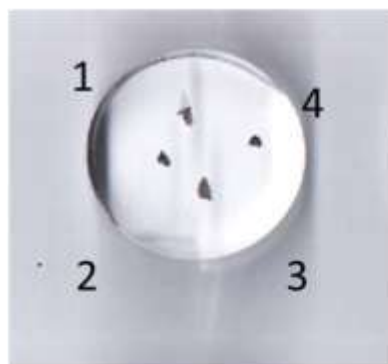
The Tanintharyi coast, encompassing the regions of Dawei, Myeik, and Kawthaung in southernmost Myanmar, emerged as a significant cultural hub around the fourth century BCE. Systematic archaeological excavations were not conducted in this area until 2018. Recent excavation at Maliwan in Kawthaung Division, carried out by the French-Myanmar Mission, have uncovered numerous artifacts, including local and Indian-related ceramic shards, stone and glass beads, and metal objects. Despite extensive research by regional and international archaeologists over the past two decades, considerable gaps remain. This study addresses these gaps by integrating geological formations with archaeological evidence and conducting a comparative study, typology, and elemental analysis using the available samples. Diverse-coloured glass beads, raw glass and copper-based objects were analysed using an optical microscope for microstructures and SEM-EDS for elemental analysis. This paper contributes a novel perspective on the socio-economic cultural and material technology diffusion to hybridity in the ancient southernmost region of Myanmar.

Keywords: Southernmost Region of Myanmar, Diffusion, Hybridity, Ancient Maritime Trade Network

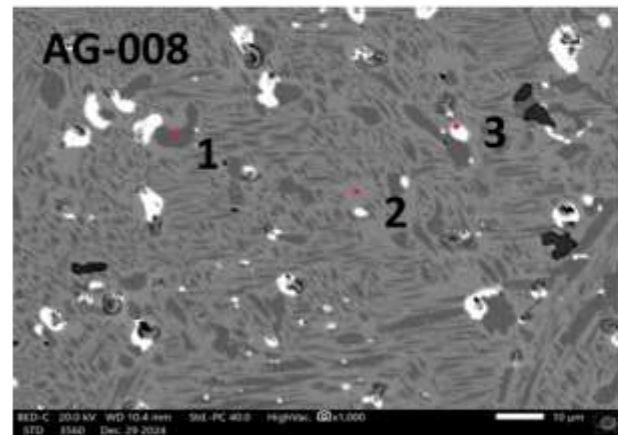
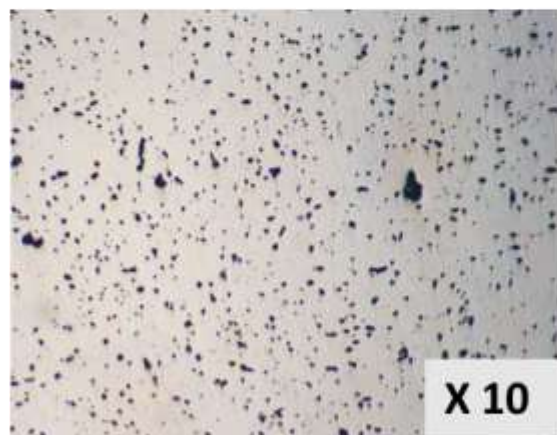
1. Introduction

The Isthmus of Kra, situated in the southernmost region of Myanmar, has been of geographically strategic importance since ancient times, yielding significant archaeological evidence. This region is notable for its abundant natural resources until now, including forestry and geological resources: minerals such as tin, gold and lead. Additionally, it serves as a crucial

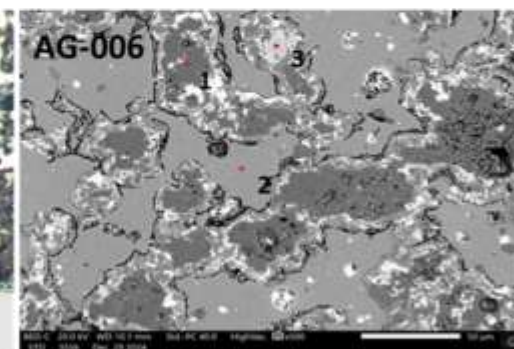
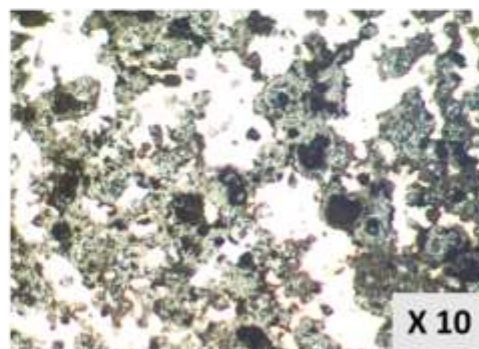




Sample ID	Site	SEM-EDS Point	Point Description	S	Fe	CU	Sn	Pb	As	Total
AG-001	Aw Gyi	Spc- 011	gray	0	0.65	95.7	3.66	0	0	100
		Spc- 012	gray	0	0.68	96.1	3.19	0	0	100
		Spc- 013	bright granule	12.6	0	1.94	0	85.5	0	100
		Spc- 014	bright granule	12	0	5.9	0	81.1	0	99



Sample ID	Site	SEM-EDS Point	Point Description	S	Fe	CU	Sn	Pb	As	Total
AG-008	Aw Gyi	Spc- 001	dark gray area	0	0	85.9	14.1	0	0	100
		Spc- 002	gray area	0	0	66.3	33.7	0	0	100
		Spc- 003	white area	0	0	12	4.47	83.5	0	100

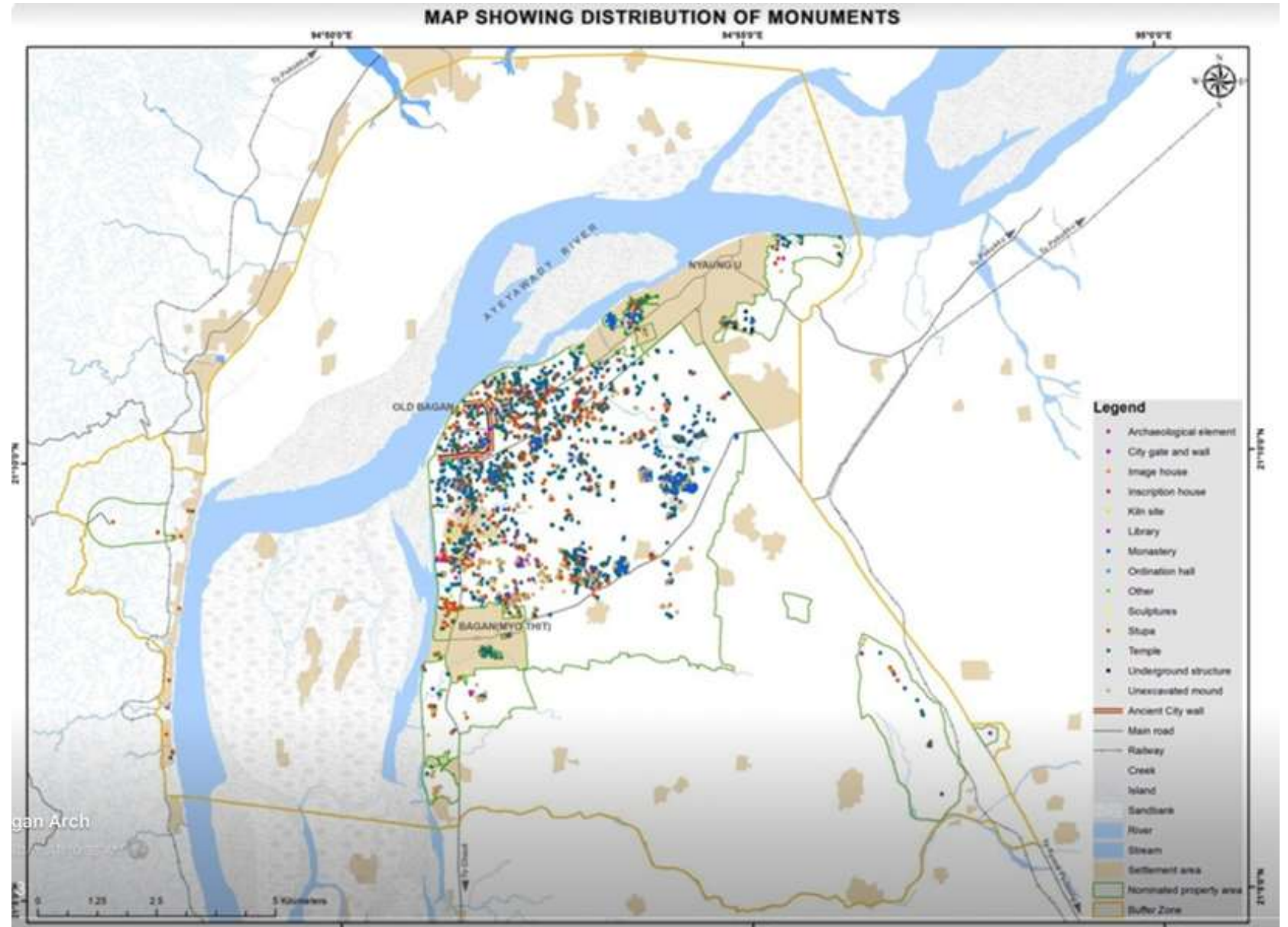


Sample ID	Site	SEM-EDS Point	Point Description	S	Fe	CU	Sn	Pb	As	Total
AG-006	Aw Gyi	Spc- 001	dark gray area	0	0	100	0	0	0	100
		Spc- 002	gray area	0	0	88	9.88	0	2.11	100
		Spc- 003	white area	0	0	61.2	38.1	0	0	99.3



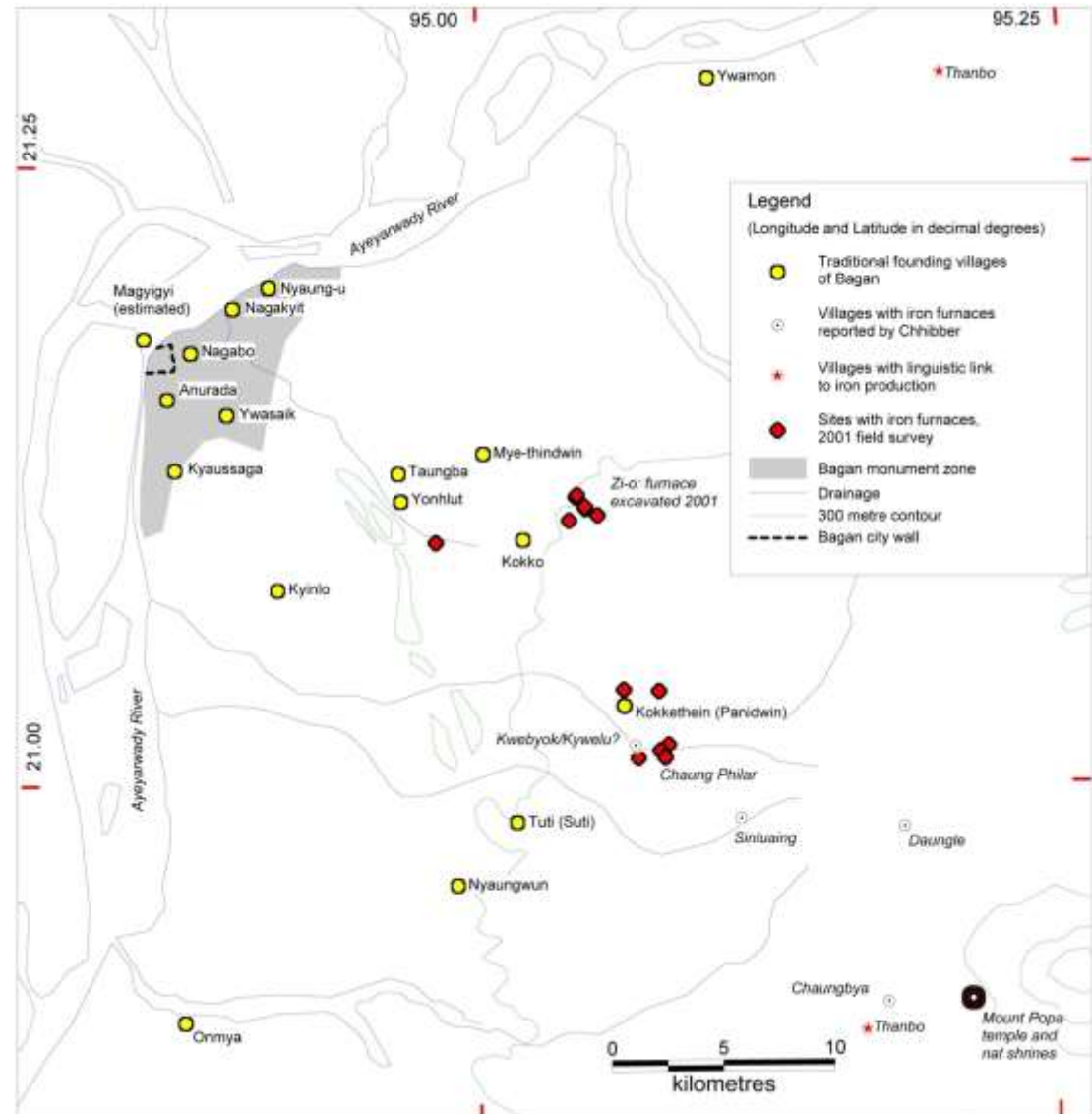
THE BAGAN IRON PROJECT

- Dr. Kalayar Myat Myat Htwe (University of Yangon, Myanmar)
- Dr. Pira Venunan (Silpakorn University, Thailand),
- Dr. Mitch Hendrickson (University of Illinois, USA),
- Dr. Stéphanie Leroy (UMR5060 IRAMAT , CNRS, France),
- Dr. Bob Hudson (University of Sydney, Australia),
- Dr. T.O. Pryce (UMR 7055, CNRS, France) – Mission Archéologique Française au Myanmar Director



LOCATION OF THE IRON PRODUCTIONS SITES

How to explain lots of iron production sites
to be found between Bagan and Mount Popa?



BAGAN'S ECONOMY

Rice

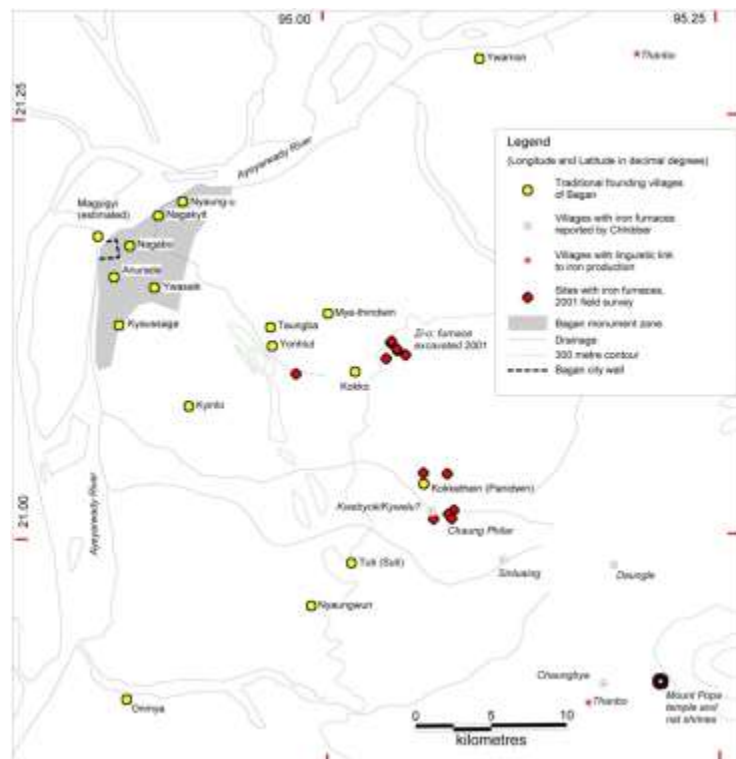
Trade

Conquest

The quality iron was essential requirement

- agricultural and craft tools,
- billets for exchange, and
- weapons for combat.





KPC

2017 SURVEY



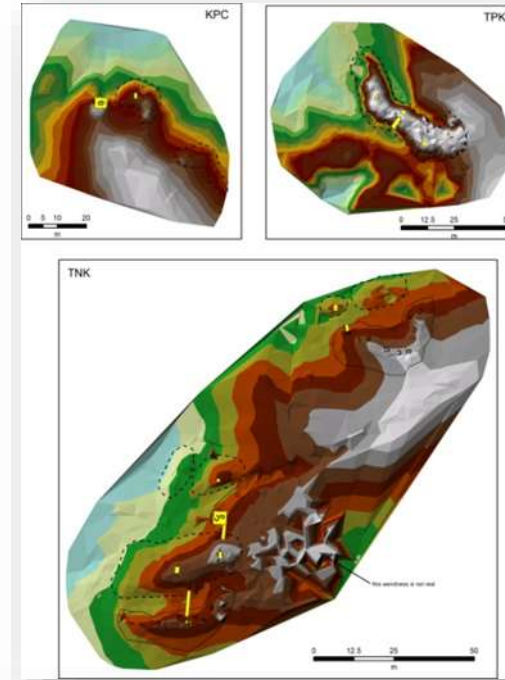
TPK





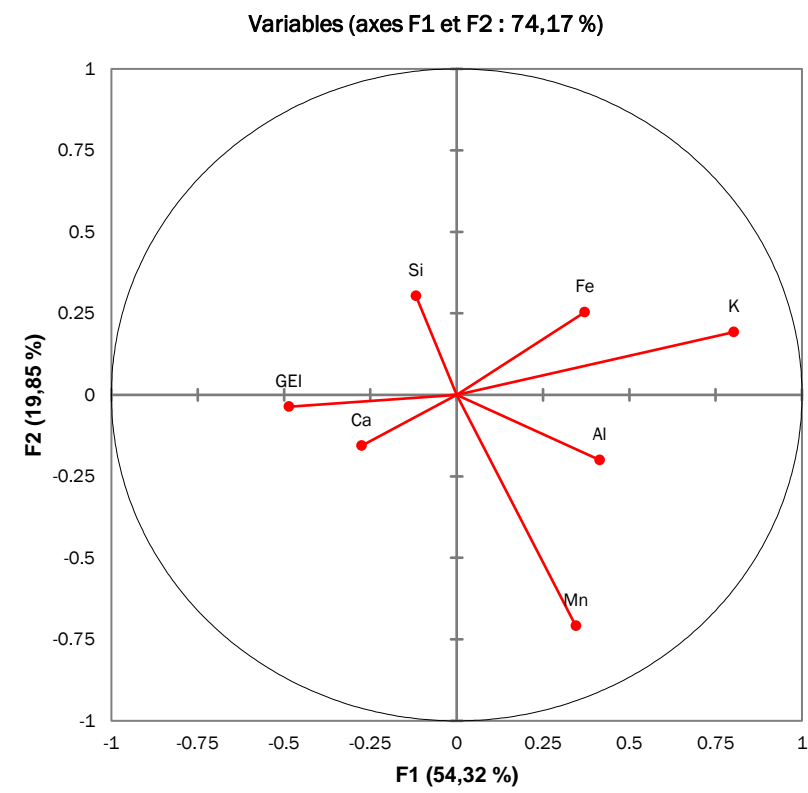
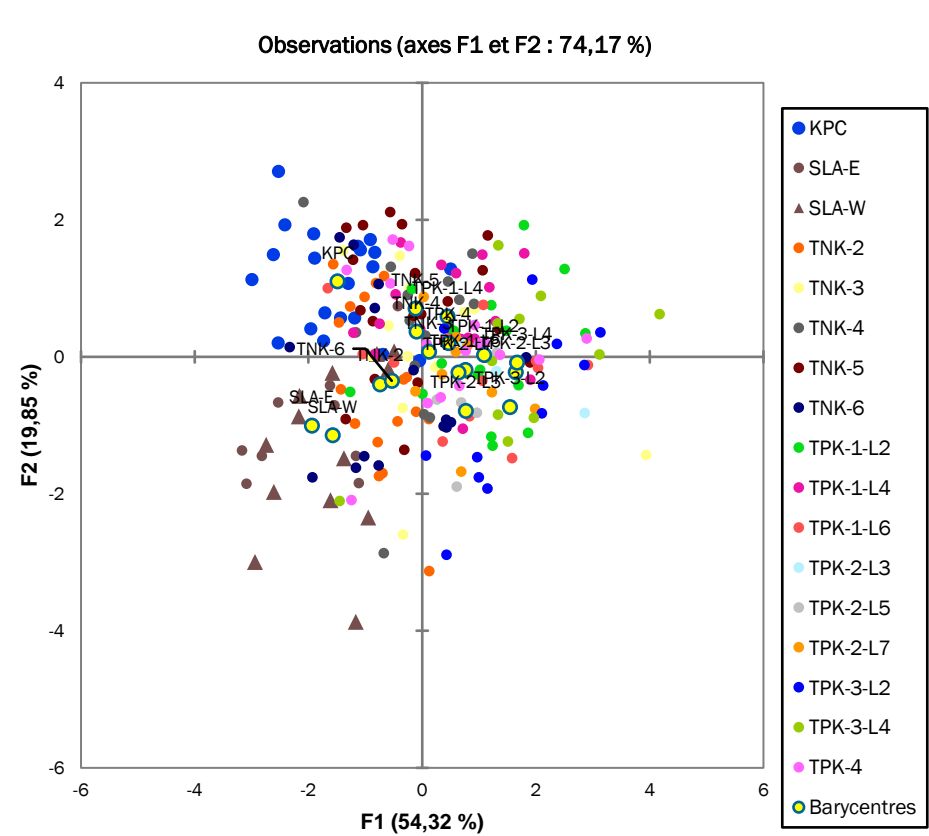








PLOT OF THE CHEMICAL SIGNATURES BY USING MULTIVARIATE ANALYSIS



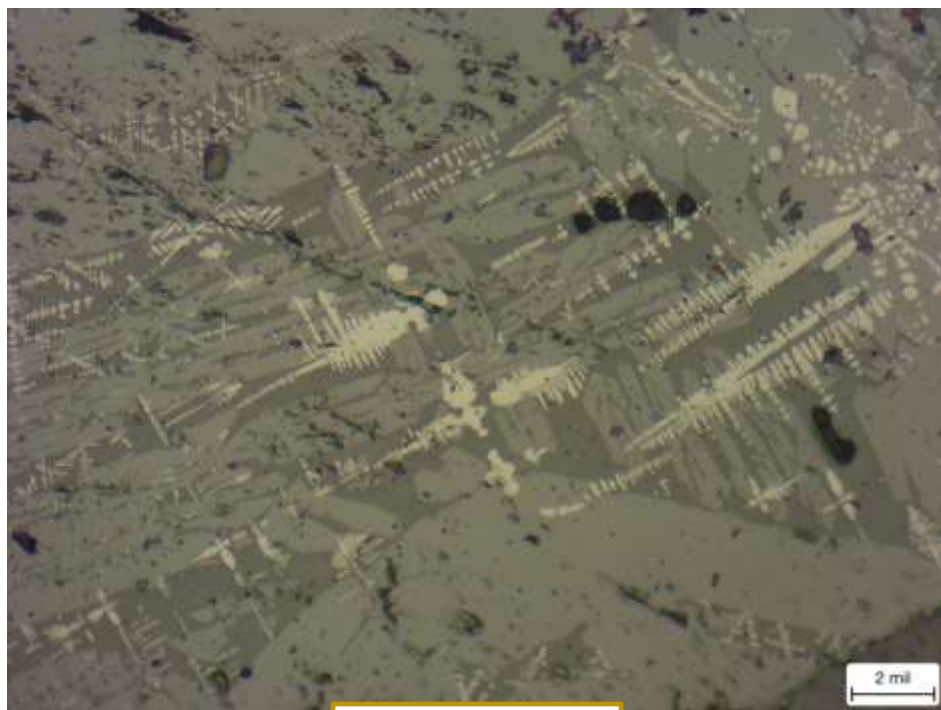
Produced by Dr. Leroy

LABORATORY ANALYSIS

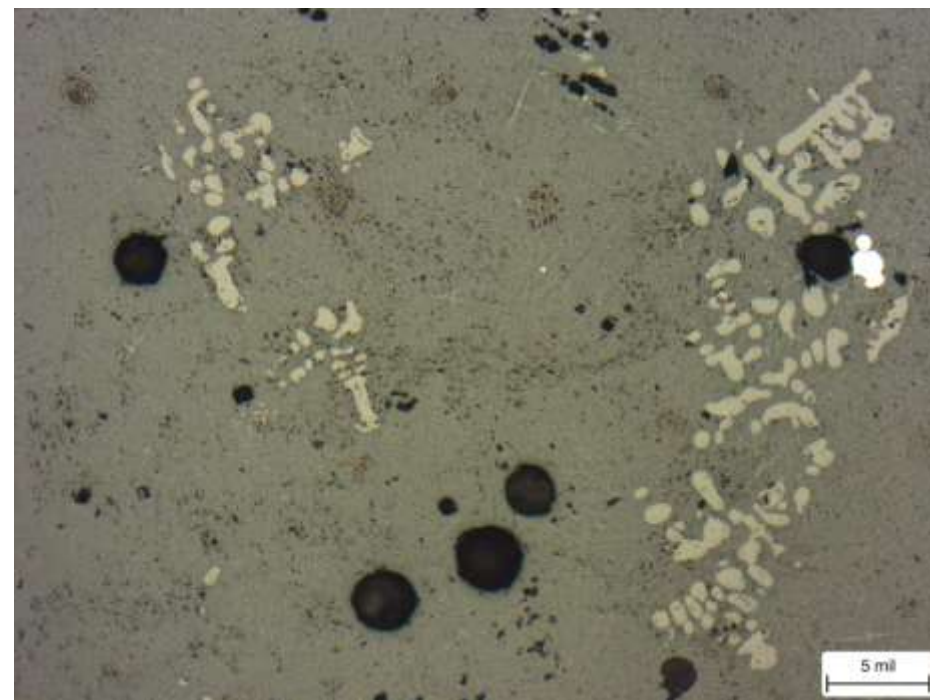
- **Optical microscopic analysis**

(Silpakorn University Archaeometallurgical Laboratory in Thailand)

- **SEM-EDS analysis**

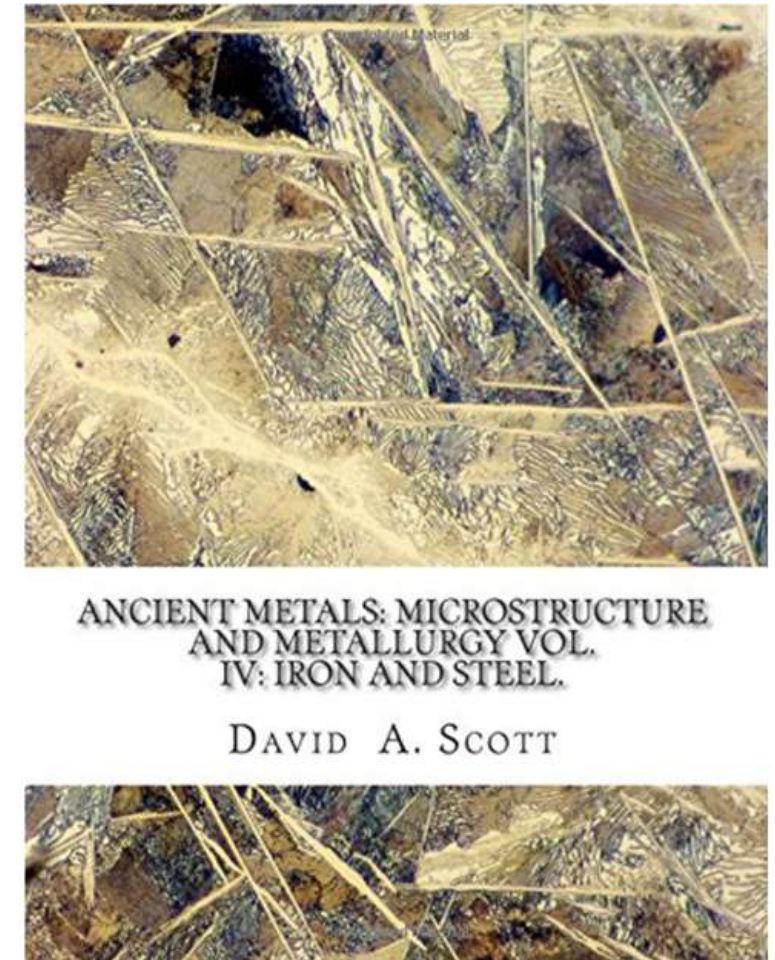
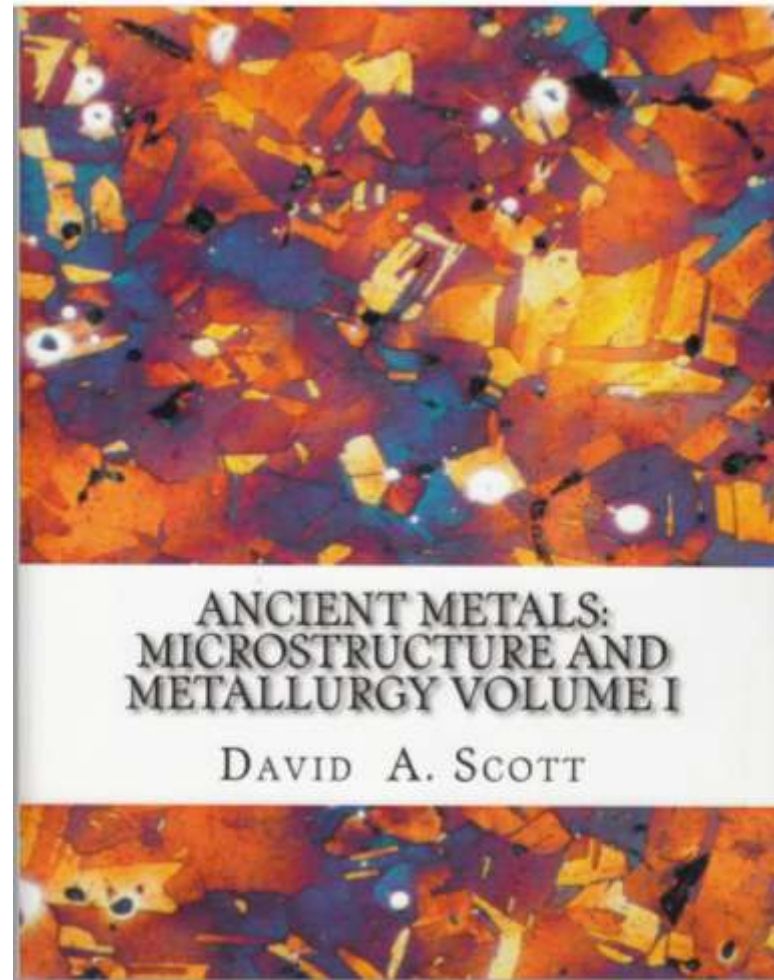
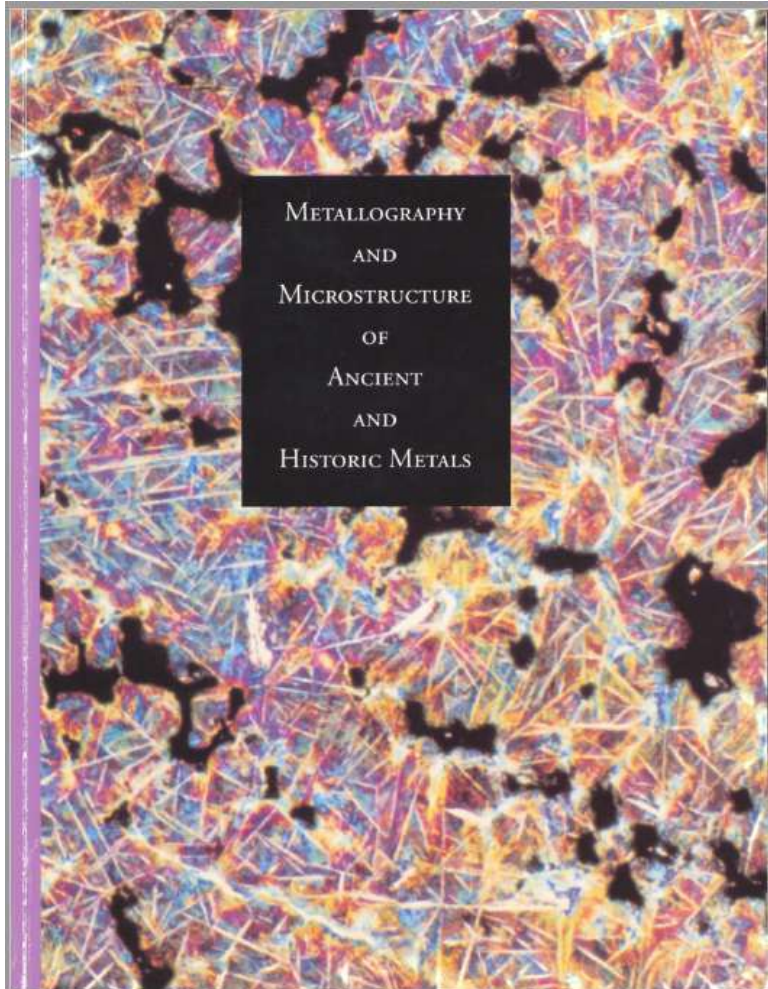


TPK-1-L6



TPK-2 -L7

SOME REFERENCE TEXT BOOKS FOR STUDIES



CONCLUSION

- Connections with China and other Southeast Asia
- Cultural and Material technology Diffusion and Hybridity
- Challenges and Future Outlook in Archaeometallurgy
 - ❖ Current Challenges: Limited funding, insufficient equipment, lack of expertise
- Path Forward
 - ❖ Foster interdisciplinary collaboration between archaeologists and scientists.
 - ❖ Strengthen research efforts to uncover and preserve Myanmar's cultural heritage.

***THANK YOU for
your attention***

