University of Miskolc
Faculty of Materials and Chemical Engineering

Antal Kerpely Doctoral School of Materials Science and Technology

Archaeometallurgy

Dr. Béla Török

COURSE DESCRIPTION

2025.
Dr. Béla Török

Archaeometallurgy

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Lecturer

Dr. Béla Török, professor, Institute of Chemical Metallurgy and Foundry Engineering

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Recommended for

Course is recommended for all students of the Antal Kerpely Doctoral School, especially for the ones working in the field of Chemical metallurgy; Foundry engineering; Plastic deformation of metals; Physical metallurgy and heat treatment; Materials informatics; Ceramics and their technologies; Chemical processes and technologies.

Language

English or Hungarian

Aim

The fundamental aim of the course is to provide specialised, interdisciplinary knowledge and scientific background in relation to the chemical and physical metallurgical characteristics of historical metal technologies (copper and its alloys, precious metals, iron) and the material analysis of related archaeological finds and reconstruction products.

Methodology

The course material is divided into four topics. In case of 1-3 students, it is taught in four meetings with personalized, individual consultations. At the end of the course, there is a fifth meeting to clarify any remaining questions. In addition to the basic knowledge of the topics, the consultations focus on case studies and literature related to individual research topics and interests. In respect of the latter, I also assign individual tasks which I check at the next meeting, when we also discuss any questions that may arise on the part of the student. In the event of a larger number of students, the course material will be taught in weekly contact hours.

Thematics

Topic 1: The archaeometallurgy of copper and its alloys, bronzes, and precious metals:

- Technologies used in copper production from the beginning of Metal Ages to the end of the Middle Ages (processing of native copper, copper metallurgy, related objects, tools)

- Early technologies of the production of tin, lead, and zinc.

- Technologies related to the production, casting and shaping of copper-based alloys (alloying processes, the role of alloying materials, casting processes, cold and hot forming methods)

- Prehistoric, ancient and medieval metallurgical processes related to precious metals (silver metallurgy, cupellation, separation of gold and silver, various gilding technologies, inlaying, niello)

Topic 2: Archaeometallurgy of iron

- Bloomery smelting process of iron (physical and chemical characteristics, technologies from the beginning of the Iron Age to the end of the Middle Ages, basic materials and additives)

- Types of bloomery furnaces and medieval workshops, their metallurgical characteristics.

- Concepts of operational steps (chaîne opératoire) from ore preparation and bloomery process to the forging of finished objects.

- Various historical metalforming techniques ("bulk" forging, folding and layering techniques, diffusion annealing, forge welding).

Topic 3: Archeometry of metal technologies – archaeological finds to be examined, the role of chemical and mineral analysis

- Types and characteristics of ores, fuels, and additives

- Examination of the remains of contemporary metallurgical objects (furnace heads, blowers, molds, etc.)

- Examination of primary, intermediate, and finished products, the properties of different types of slag, and their metallurgical role.

- Usability and effectiveness of methods used in the chemical composition and mineralogical examination of archaeometallurgical archaeological finds (ED-XRF, AAS, ICP-OES, PGAA, TOF-ND, EDS, XRD). Slag and alloy compositions, enrichments of various elements.

Topic 4: Archeometry of metal technologies – products of reconstruction experiments, the role of microstructure analysis in archeometallurgy

- Experiments related to the production, casting, and shaping of historical copper-based alloys.

- Reconstructions of ancient processes related to precious metals (cupellation, separation, inlaying, gilding, etc.).

- Experiments related to the archaeometallurgy of iron (bloomery process, re-heating, compacting purification, various forging techniques).

- Usability and effectiveness of microscopic methods (OM, SEM) used in microstructural examinations of metallurgical archaeological finds. Special sample preparation, phase definition and distribution, inclusion examination of metal objects.

Recommended literature

1. Roberts, B.W. – Thornton, C.P. (eds.): Archaeometallurgy in Global Perspectives. Methods and Syntheses. Springer 2014. ISBN 978-1-4614-9017-3
2. Hauptmann, A.: Archaeometallurgy – Materials Science Aspects. Springer 2021. ISBN 978-3-030-50367-3
3. Tylecote, R.F.: A History of Metallurgy. The Institute of Materials. London. The Bath Press, Avon. 1992.
4. Hauptmann, A.: The Archaeometallurgy of Copper. Springer 2007. ISBN 978-3-540-72237-3

5. Buchwald V.F.: Iron and steel in ancient times. Historisk-filosofiske Skrifter 29, The Royal Danish Academy of Sciences and Letters, Copenhagen, 2005.
6. Pleiner, R.: Iron In Archaeology – The European Bloomery Smelters. Archeologickỳ ústav AV ČR, Praha, 2000. ISBN 80-86124-26-6
7. Pleiner, R.: Iron In Archaeology – Early European Blacksmith. Archeologickỳ ústav AV ČR, Praha, 2006. ISBN 80-86124-62-2
8. Török, B. – Giumlia-Mair, A. (eds.): Proceedings of the 5th International Conference „Archaeometallurgy in Europe". Monographies Instrumentum, Edition Mergoil 73. Drémil-Lafage 2021. ISBN 978-2-35518-121-4

Completion, Grading

Oral exam after evaluation of individual tasks.

Complex Exam Questions

1. The role of tin, lead, zinc, and arsenic in the quality of ancient and medieval copper alloys, and their impact on contemporary bronze technologies.
2. Physical and chemical characteristics of cupellation and historical separation techniques.
3. Ancient and medieval fundamental bronze casting methods and technologies.
4. Surface element enrichment phenomena and their effects on the chemical composition of ancient bronze objects.
5. The metallurgical and energetic characteristics of the bloomery process and the factors influencing them.
6. Types of slag, their characteristics and metallurgical role in the archaeometallurgy of iron.
7. Microstructures characteristics of different medieval iron forging techniques.
8. Classification of inclusions in archaeological iron objects according to their origin and technological role, based on their chemical composition and microstructure.
9. Comparison of the parameters and effectiveness of destructive and non-destructive testing methods in the same analysis focus on identical finds.