Institute of archaeology

Institut za arheologiju

7th International Conference on Mediaeval Archaeology

7. međunarodni znanstveni skup srednjovjekovne arheologije

Secrets of iron - from raw material to an iron object

Tajne željeza - od sirovine do željeznog predmeta

Book of Abstracts / Knjiga sažetaka

Zagreb, 10th – 11th September 2020
Zagreb, 10. – 11. rujna 2020

7th International Conference on Mediaeval Archaeology
7. međunarodni znanstveni skup srednjovjekovne arheologije

SECRETS OF IRON - FROM RAW MATERIAL TO AN IRON OBJECT

TAJNE ŽELJEZA - OD SIROVINE DO ŽELJEZNOG PREDMETA

Programme and the Book of Abstracts
Program i knjiga sažetaka

Institute of Archaeology / Institut za arheologiju

Zagreb, 10th - 11th September 2020
Zagreb, 10. – 11. rujna 2020

IMPRESSUM

Nakladnik/Publisher
INSTITUT ZA ARHEOLOGIJU

Glavni i odgovorni urednik/Editor-in-chief
dr. sc. Tajana Sekelj Ivančan

Prijevod/Translation
Autori/Authors
Barbara Smith Demo

Korektura/Proofreading
Barbara Smith Demo, Katarina Botić

Grafičko oblikovanje/Graphic design
Računalni slog/Layout
Hrvoje Jambrek

Tisak/Printed by
Tiskara Zelina d.d., Sv. I. Zelina

Naklada/Issued
100 primjeraka/100 copies

ISBN 978-953-6064-57-1
CIP zapis dostupan u računalnome katalogu Nacionalne i sveučilišne knjižnice u Zagrebu pod brojem 001071865.

Uz pomoć Ministarstva znanosti i obrazovanja Republike Hrvatske i Hrvatske zaklada za znanost.
With help of Croatian Ministry of Sciense and Education and Croatian Science foundation.

7th International Conference of Mediaeval Archaeology

7. međunarodni znanstveni skup srednjovjekovne arheologije

Institute of Archaeology

Institut za arheologiju

Zagreb, 10th – 11th September 2020
Zagreb, 10. – 11. rujna 2020

Organizator skupa/Conference organized by:
INSTITUT ZA ARHEOLOGIJU
Ulica Ljudevita Gaja 32
HR-10000 Zagreb

Suorganizator/Co-organizer:
ARHEOLOŠKI MUZEJ U ZAGREBU
Trg Nikole Šubića Zrinskog 19
HR-10000 Zagreb

Znanstveno pokroviteljstvo/Scientific patronage:
Nacionalni odbor INQUA - Međunarodna unija za istraživanje kvartara, Hrvatska akademija znanosti i umjetnosti /Croatian National INQUA Committee – International Union for Quaternary Research, Croatian Academy of Sciences and Arts

Za organizatora/Conference organizer:
dr. sc. Tajana Sekelj Ivančan

Znanstveni odbor/Scientific Committee:
dr. sc. Tajana Sekelj Ivančan
dr. sc. Siniša Krznar
dr. sc. Tatjana Tkalčec
dr. sc. Juraj Belaj

Organizacijski odbor/Organizational Committee:
dr. sc. Tajana Sekelj Ivančan
Tena Karavidović
dr. sc. Siniša Krznar
dr. sc. Tatjana Tkalčec
dr. sc. Juraj Belaj

Koordinatorice (AMZ)/Coordinators (AMZ):
Maja Bunčić, Dora Kušan Špalj

Pomoć u realizaciji skupa/With the help of:
Katarina Botić, Kristina Turkalj

Mjesto održavanja/Address of the Conference:
GALERIJA ARHEOLOŠKOG MUZEJA U ZAGREBU
Pavla Hatza 6
HR-10000 Zagreb

Thursday, 10th September 2020	
08:30-09:00	Registration // online greenroom– speakers for the First Morning session
09:00-09:15	**Opening of the conference, welcome speeches:** **T. Sekelj Ivančan** **M. Dizdar,** director of the Institute of Archeology **S. Mihelić,** director of the Archaeological Museum in Zagreb
First Morning Session (09:15-11:20) *Session Chair:* ***Tena Karavidović***	
09:20-09:40	**Gömöri János:** Bloomery iron smelting in Hungary
09:40-10:00	**Brigitte Cech:** The production of ferrum Noricum in Hüttenberg, Austria
10:00-10:20	**Vladimir Zavyalov, Nataliya Terekhova:** Ironmaking in Rural Settlements of Ancient Rus
10:20-10:40	**Szilvia Gyöngyösi, Zsuzsa Bánóczy, Péter Barkóczy, Géza Szabó:** Specialized iron production in Roman period
10:40-11:00	**Evgeny Vodyasov, Olga Zaitceva:** Recent research on iron-smelting sites in the Altai Mountains (South Siberia)
11:00-11:20	Discussion // online Q&A
11:20-11:40	coffee break
Second Morning Session (11:40-13:20) *Session Chair:* ***Siniša Krznar***	
11:20-11:40	online greenroom – speakers for the Second Morning session
11:40-12:00	**Matija Črešnar, Branko Mušič, Barbara Horn, Jaka Burja:** Cvinger near Dolenjske Toplice and Early Iron Age iron-production centre and the new wave of its interdisciplinary research

12:00-12:20	**Tena Karavidović, Tajana Sekelj Ivančan:** Iron production management: a case study of bloomery iron production at Hlebine – Velike Hlebine and Dedanovice site
12:20-12:40	**Aleksandra Bugar:** The Okuje Site – Iron production during the Roman Period
12:40-13:00	**Tena Karavidović, Ivan Drnić:** Traces of iron production in the area of Donje Pokuplje in the 1st millenium BC
13:00-13:20	Discussion // online Q&A
13:20-15:30	lunch break
Afternoon Session (15:30-17:30) *Session Chair:* ***Katarina Botić***	
15:15–15:30	online greenroom – speakers for the Afternoon session
15:30-15:50	**Ladislav Lazić, Aleksandar Durman:** Mining and Metallurgy in the Mount Trgovi and Northwestern Bosnia in the ancient period with special emphasis on the iron production
15:50-16:10	**Mirko Vranić:** Medieval iron mining of the Kopaonik region: state of exploration and potential future research
16:10-16:30	**Bartul Šiljeg, Hrvoje Kalafatić:** Aerial archaeology in the study of metallurgical activities in eastern Croatia
16:30-16:50	**Branko Mušič, Tajana Sekelj Ivančan, Barbara Horn** TransFER – Iron production along the Drava river in the Roman period and the Middle ages: Creation and transfer of knowledge, technologies and goods. Case studies of Virje, Velike Hlebine, Dedanovice, Bakovčice, Nađbarice and Ždala
16:50-17:10	**Ivan Valent:** Archaeological finds of metallurgical activities on the territory of the River Drava Basin during Antiquity
17:10-17:30	Discussion
17:30-17:50	coffee break

	online greenroom – Poster session
17:50-18:20	Poster session (online Q&A) **Damir Doračić, Jiři Hošek, Michael Brauns, Ivana Miletić Čakširan:** Conservation and examination of the early medieval sword from Bojna-Brekinjova Kosa **Ferenc Fazekas:** Roman ironwork from the roman auxiliary fort Lussonium (Paks-Dunakömlöd), W-Hungary **Gerard Fernàndez Molina:** The iron armament in the north-eastern Iberian Peninsula during the Early Iron Age **Ana Konestra, Fabian Welc, Paula Androić Gračanin, Kamil Rabiega, Bartosz Nowacki, Agnes Kukela:** Evidence of iron working on the island of Rab - Podšilo bay and Fruga **Daša Pavlovič, Jaka Burja:** Settlement Pržanj in Ljubljana – metallurgy with tradition? **Vitalii Shcherbakov:** Household knives of North-Eastern Rus' rural population of the second half of the XII-XIV centuries (production technology) **Ádám Thiele, Béla Török:** Controlling possibilities of the phosphorus content in the iron bloom during iron smelting **Ivan Valent:** Traces of iron smelting on the Koprivnički Ivanec – Log-Parag I site **Olga Zaitceva, Evgeny Vodyasov:** Medieval burials with blacksmith tools in Siberia
19:00	Exhibition opening „***Secrets of iron***" Zagreb City Museum, Opatička Street No. 20

Friday, 11th September 2020	
08:30-09:00	Registration // online greenroom– speakers for the First Morning session
First Morning Session (09:00-11:00) *Session Chair:* ***Juraj Belaj***	
09:00-09:20	**Sanda Rončević:** Advanced Instrumental Methods in Chemical Profiling of Archaeological Samples
09:20-09:40	**Ivan Nemet:** Archaeometallurgical Samples: Top-down View
09:40-10:00	**Tomislav Brenko, Sibila Borojević Šoštarić:** Mineralogical and geochemical composition of different bog iron ore types from the Podravina region, NE Croatia
10:00-10:20	**Péter Barkóczy, Attila Bán, Szilvia Gyöngyösi, Géza Szabó:** Steel casting in the Middle Ages?
10:20-10:40	**Alan Williams:** A comparison of non-invasive and traditional methods of analysis for arms & armour
10:40-11:00	Discussion // online Q&A
11:00-11:20	coffee break
Second Morning Session (11:20-13:20) *Session Chair:* ***Tatjana Tkalčec***	
11:00-11:20	online greenroom– speakers of the Second Morning session
11:20-11:40	**Márk Haramza:** Traces of Migration Period Sword Manufacture in the Carpathian Basin
11:40-12:00	**Ümit Güder, Alptekin Yavaş, Muharrem Çeken, Ünsal Yalçın, Dierk Raabe:** A New Type of Steel-Making Crucible from Medieval Anatolia
12:00-12:20	**Jiří Hošek, Estelle Ottenwelter, Petr Žákovský, Patrick Bárta:** Types of luxurious and special 9th-to-14th-century knives known from the territory of the Czech Republic

12:20-12:40	**Gašper Oitzl:** The Transfer of Ironworking Technologies in Slovenian Territory between the 14th and 16th Centuries
12:40-13:00	**Silviu I. Oța:** An iron processing workshop at Caransebeș (17th century)
13:00-13:20	Discussion // online Q&A
13:20-15:00	lunch break
Afternoon Session (15:00-16:20) *Session Chair:* ***Tena Karavidović***	
14:40–15:00	online greenroom – speakers for the Afternoon session
15:00-15:20	**Ana Konestra, Enrico Cirelli, Gaetano Benčić, Bartul Šiljeg, Tea Zubin Ferri:** A smithy at Tarovec (St. Blek, Tar-Vabriga)? Identification, chronology and workshop features
15:20-15:40	**Mike Charlton** The design of ironmaking experiments
15:40-16:00	**Ondřej Merta, Dominik Talle, Martin Barak:** Historic and prehistoric iron smelting and processing workshops in Stará huť u Adamova (The Old Ironworks near Adamov), Czech Republic
16:00-16:20	Discussion // online Q&A End of Conference
16:30-19:30	Excursion to the ancient site Andautonia, Ščitarjevo Organized guided tour – Andautonia, Dora Kušan Špalj

Gömöri János:
Bloomery iron smelting in Hungary - videofilm

A book about the Early Medieval iron production in Hungary (10th - 13th centuries AD) represents an important milestone in historical, archaeological and archaeometrical research into iron in Hungary (G. Heckenast – Gy. Nováki – G. Vastag and E. Zoltay, 1968). It distinguished two essential types of furnaces from the 10th - 12th centuries. Since then, during the last 50 years, several iron-smelting workshops with five different types of furnaces have been discovered, mainly in the northeastern, northwestern and southwestern regions of Hungary. This paper contains a systematization of the excavated iron smelting sites, which have already been partly recorded in the Register of Industrial Archaeological Sites in Hungary (https://**archeoindustrysites**.com/) (Magyarország Iparrégészeti Lelőhelykatasztere /MILK/)
After describing iron ore deposits and methods of mining, (e.g. "Pingenfeld" near Sopron, or bog ore in Somogy County), the author surveys by period the main excavated sites with iron production and processing. For the Iron Age, this consisted of Celtic reheating furnaces (Sopron) and smith workshops (Szilvásvárad, Velem). Until the present, there had not been authentically documented Roman period iron production sites in Hungary, only smith workshops, iron blooms, and iron bars (the latter as commercial goods possibly from the territory of Siscia) had been uncovered (Intercisa, Regöly, Heténypuszta). In recent decades, there have also been detailed studies of iron smelting sites and various types of furnaces in the Late Migration – Early Medieval period, mostly Avar, 7th - 8th cent. AD, and Carolingian, 9th century (Nemeskér, Iván, and Dénnesfa). This includes the 10th - 12th centuries bloomery workshops (Somogyfajsz, Bodrog-Bű) and their connections to various toponyms, or to the few historical sources. The author also refers to the archaeometrical methods utilized for exploration, and the results of several determinations of the physical age of burnt furnace materials (Archaeomagnetic, TL, 14C).

Brigitte Cech:
The production of *ferrum Noricum* in Hüttenberg, Austria

Noric steel (*ferrum Noricum*) is mentioned in numerous Latin and Greek texts as being iron of exceptionally good quality. It has long been suspected that Hüttenberg, with its managnese-rich iron ore, was the centre of production of this famous steel. Roman inscriptions referring to iron production found in the vicinity of Hüttenberg have confirmed this hypothesis.

Hüttenberg was the focus of an interdisciplinary research project from 2003 to 2010. Archaeological research at the site of Semlach/Eisner has shown that Roman iron production started in the second half of the 1st century AD and continued until the beginning of the 4th century AD. During that time, the spatial layout of this industrial site was changed numerous times. All together, six exceptionally well preserved large furnaces have been discovered, as well as twelve small hearths for bloom-smithing, and an ore roasting pit.

The peak of production can be dated to the second half of the 2nd century AD to the mid 3rd century AD. This phase consists of a smelting area of four large furnaces and numerous small smithing hearths, and a building with a hearth for heating and cooking. Finds of glass ware, imported pottery, a bronze door knocker, and a stylus in the vicinity of this house shows that workers as well as administrators lived on site. Skeletons of two newborn babies and fibulae worn only by women offer evidence that the families of the workers also lived on site.

What makes this site unique is the long duration of iron production, the well-preserved furnaces, and the presence of buildings. The objects found at the site offer an insight into the daily life of the smelters and their families.

Vladimir Zavyalov, Nataliya Terekhova:

Ironmaking in the Rural Settlements of Ancient Rus

Ironmaking and ironworking was the basis of the medieval economy. Rural manufacturing centers played an important role in this process. Such a center, dating from the 12th – 13th centuries, was discovered near the village of Istye in the immediate vicinity of the Staraya Ryazan – the capital of the Ryazan principality. Metallurgical production at the site is documented by accumulations of iron ore, numerous fragments of iron slag, bloomery iron, ceramic nozzles, including a unique fragment with the Rurik sign in the form of a trident, clumps of burned clay and charcoal, and the remains of bloomery furnaces. The ore found in the settlement contains more than 45% iron (Fe_2O_3 – 66.42%, FeO - 59.73%). The phosphorus content did not exceed 0.2%, silicon – 3.35%.

A large collection (more than 150 artifacts) of iron objects was collected during archaeological excavations at the site. Of this, 46 items, most of which (43 artifacts) were knives, were analyzed using the archaeometallographic method.

The most common techniques in the manufacture of knives were cementation of the blade (11 items) and welding onto a steel blade (11 items). The high quality of blacksmithing operations should be noted. Forging of iron and bloomery steel was also present.

The significant area of the site and its production character poses a question about the place of sale for the metal produced at the site. Using the method of fluorescence

analysis, it can be shown that a similarity in the content and ratio of micro-impurities is observed between the metal of the forge products from Istya 2 and Staraya Ryazan. Thus, there is every reason to consider the settlement of Istye 2 as a source of raw materials for such a large production center as Staraya Ryazan.
The work was supported by the Russian Science Foundation (grant number 19-18-00144).

Szilvia Gyöngyösi, Zsuzsa Bánóczy, Péter Barkóczy, Géza Szabó:
Specialized iron production in Roman period

Mining and metallurgy were managed in a centralized way in the Roman Empire according to the sources for this period. The Pannonian territory was mainly supplied with smelted and processed iron raw material from the Majdan mountains. This area was used for iron production until the early Iron age. The raw material was used and processed locally adjusted to the local needs. Square based iron prisms such as slabs, which were found and excavated at more deposits in South Transdanubia, raise interesting questions. Similar slabs were found in 1880 in the vicinity of Hrvatska Dubica, Croatia. Aleksander Durman supposed the origin of slabs was the Roman Age. The length of the slabs is approximately 20 cm and the weight of these is between 11 and 15 libras, equal to 2.6-4.91 kg. All of these slabs are forged. Syrian effects on the production and the slabs themselves are assessed based on the other artefacts found near the place of the deposition. Two places are known in Pannonia, next to the Danube (Intercisa-Dunaújváros) and next to Kapos river (Dombovár, Regöly) where similar iron prisms were found. However, these slabs have heavier weight: 5.4-10 kg. Iron smelting and metallurgy strongly depend on the raw material and the technique. The technology was necessarily traditionalist in all its details due to the quality assurance. Therefore, the metallography of these slabs has a great importance in the research project of the slabs. An investigation of the Pannonian slabs reveals that more pieces of bog iron were forged together to build up the prisms. The microstructure of the slabs is heterogeneous as in the case of bogs. Mainly ferrite and perlite built up the microstructure, where Widmanstätten ferrite was also discovered. All estimated properties of the slabs show that these slabs as raw materials proved a standard quality for the manufacturing of iron tools.

Evgeny Vodyasov, Olga Zaitceva:
Recent research on iron-smelting sites in the Altai Mountains (South Siberia)

The report will present the first results of our project on the ancient iron metallurgy of the Altai Region. The earliest Altai iron-smelting furnaces are dated to the 4th and the 5th centuries AD, while in the 7th and the 8th centuries AD an inexplicable “sud-

den" disappearance of all the smelting sites (!) occurred in the Altai Mountains. Three types of furnaces existed in Altai at that time: box-shaped linear furnaces, shaft furnaces, and semicircular furnaces with a curved C-shaped back wall. The box-shaped linear furnaces with a large number of holes on each of the longitudinal walls were the largest ones in North and Central Asia in 400-600 AD.

We conducted comprehensive geoarchaeological research on the unique box-shaped furnaces at the Kuyahtanar iron-smelting site in 2018-2019. A series of non-destructive procedures were carried out: aerial photography, creation of 3D terrain models, and magnetic surveying. The report will also present the results of excavations.

In order to find the ore sources for the ancient metallurgy, we examined the mountainous regions of Altai and discovered large early medieval mines. The results of the XRF analysis of ore from different metallurgical sites show that, with a high degree of probability, the discovered mines were the actual ore sources.

The research was supported by Russian Science Foundation (project no. 18-78-10076).

Matija Črešnar, Branko Mušič, Barbara Horn, Jaka Burja:

Cvinger near Dolenjske Toplice: an Early Iron Age iron-production centre and a new wave of interdisciplinary research

The prehistoric complex of Cvinger near Dolenjske Toplice occupies a limestone hill between the modern towns of Meniška vas and Dolenjske Toplice in the Dolenjska/Lower Carniola region (SE Slovenia). It consists of a hillfort, three tumulus cemeteries, and an iron-smelting area. The settlement holds a strategic position, which enables visual control of the surrounding lowlands, with key routes running across this landscape. The first occupational phase of Cvinger can be dated to the Late Bronze Age (Ha B). After a hiatus, the hillfort was resettled in the Late Hallstatt period, most probably in the late 6th century BC and remained inhabited until the end of the Late Hallstatt period, i.e. until the end of the 4th century BC.

The history of research into the archaeological complex at Cvinger is lengthy and goes back to the end of the 19th century. The most recent research campaign started in 2014. In the first step of our research, airborne laser scanning (ALS) was utilized in order to build the base documentation of the site and the broader area around it. The identified features were then studied by large-scale multi-method geophysical measurements (magnetic method, low-frequency electromagnetic method, electrical resistivity tomography, and magnetic susceptibility of surface layers), as well as an intra-site surface collection and trial trenching.

One of the key areas for understanding Cvinger is definitely the Branževec iron-smelting site, which is to date the largest of its kind in the region. Therefore, intensive research was focused in and around this zone, but also in other parts of the complex

that might offer information about iron production. As a part of our investigation, the remains of metallurgical activity, such as ore, slag, furnace walls, and hammer-scale were also analysed further.

Tena Karavidović, Tajana Sekelj Ivančan:

Iron production management: a case study of bloomery iron production at the Hlebine – Velike Hlebine and Dedanovice sites

Can we distinguish and interpret the source and level of influence between socio-economic and enviromental (pre)conditions on choices made regarding workshop location selection, stages of iron production employed in different working spaces, and the strategy of natural resource exploitation and usage? The presentation will address these questions through a case study of two sites interrelated by chronology, character, and landscape. Based on the results of extensive field survey and geophysical research, two sites, Hlebine – Velike Hlebine and Hlebine – Dedanovice (first half of the 7th – mid 7th century) were excavated in several campaigns from 2016 to 2018. At the Hlebine – Velike Hlebine site, a complete bloomery iron production workshop was excavated, while at the Dedanovice site, a pair of furnaces for primary and/or secondary smithing were identified. Both sites are situated at the edge of a flood-plain in the lowland area of the Upper Drava River basin, the Podravina region (NW Croatia). While the bloomery iron production workshop was located on an isolated sandy ridge several hundred meters from the contemporary settlement, the smithing furnaces were set on the edge of the settlement grounds. Bog iron ore of local/regional origin was used for iron production. The correlation of REE (ICP – MS) of bog iron ore samples from both sites shows that they originated from the same micro-environment, which opens the question about the exploitation strategy. Through macroscopic analysis of metallurgical waste at both sites, the character of activities undertaken was presumed, while the spatial distribution of archaeological features and metallurgical waste indicate a structured spatial organisation of the workspace based on the activities undertaken and their order in the iron production sequence. Patterns that could indicate interdependent labour organisation can be seen at both sites. The presented research is carried out within the TransFER project (IP-06-2016-5047), financed by the Croatian Science foundation.

Aleksandra Bugar:

The Okuje Site – Iron production during the Roman Period

The archaeological site of Okuje is located in the Turopolje Region, south of Zagreb. During the Roman period, a smaller rural settlement existed near the *Emona – Siscia* road. The site is located about 15 km from the site *Andautonia*, and it was part

of the estimated territory of the Andautonian *municipium*. It is a multi-layered site, with traces of life from the Early Bronze Age, the La Tène period, the Roman period, the Early and High Middle Ages, and the Modern Era. In addition to other artefacts, a group of waste pits were examined and a large amount of slag (over 500 kg), i.e. metallurgical waste, was discovered. Chemical analyses (XRF and ICP-AES) showed that this waste was a by-product of the iron smelting process. The type of slag and the remnants of ceramic nozzles indicated that this waste was a remnant of the iron smelting process conducted in bloomery furnaces, whose remains have not been found at the site, but it is nonetheless assumed that they were in the immediate vicinity of the excavated area. In addition to metallurgical waste in the pits, small lumps of what was assumed to be the iron ore involved in the smelting process were also found. The geological strata at the site are fluvial in character, thick clay deposits have been observed, and the dried beds of former streams explored, while the environment surrounding Okuje was once forested, which could have provided a prerequisite for the production of the charcoal required in the process of smelting iron ore. The conditions at the site therefore were obviously suitable at the time for the iron smelting process.

Tena Karavidović, Ivan Drnić:

Traces of iron production in the area of Donje Pokuplje in the 1st millennium BC

The area of metalliferous hills in northwestern Bosnia, as well as their natural extension into central Croatia, the Petrova and Trgovska Gora hills, was actively exploited on a large scale during Antiquity and the Middle Ages, while traces of iron exploitation and production in preceding archaeological periods are scarce. Nevertheless, several sites in the broader region dated to the Iron Age show signs of local iron production. During an intensive systematic field survey, surface debris indicating iron production within a fortified Early Iron Age settlement was identified. The site is situated in a lowland area (the village of Donje Pokuplje), near the confluence of the Dobra and Kupa Rivers. Traces of iron production debris were also found within another settlement (the Pogorelec site within the town of Sisak) dated to the late Hallstatt period (6th – 5th centuries BC). The site was a major regional centre of the period, with established bronze metalworking, and textile and pottery production. In the Late Iron Age, the site was also actively occupied, while in the Roman period a regional urban centre, the city of Siscia with the rank of a colony, was founded in the broader area of the present town of Sisak. Iron production and trade were major activities during the Roman period in this area.

Ladislav Lazić, Aleksandar Durman:

Mining and Metallurgy in the Trgovi Heights and Northwestern Bosnia in the Roman period with special emphasis on the iron production

Metallurgy in the territory of the present-day Sisak and Banovina, as a region of Sisak-Moslavina County, was developed from the Vučedol Culture as well as later Celtic and Roman elements. The main reason for this connection between Sisak and iron metallurgy lies in the immediate hinterland, south of Sisak, next to the mouth of the Sana River where it flows into the Una River. The main deposits and occurrences of metals are related to the border area of the Zrinska Gora and Trgovi Heights on the direction Gvozdansko – Trgovi on both sides of the Žirovac stream. The prevailing opinion is that the iron, copper, silver-bearing lead, and barite deposits of the Trgovi Heights were formed from Upper Paleozoic sediments and belong to the Hercynian metallogenic epoch. The Paleozoic of the Trgovi Heights is a northwest extension of the much larger and more metallogenetically important Una-Sana Paleozoic, i.e. the area located between the cities of Bosanski Novi, Prijedor, and Sanski Most. In Illyrian and Roman times, it was primarily mined for hard limonite ore from the oxidation zone of siderite deposits. The ore deposits in the Trgovi Heights and Northwestern Bosnia are listed, with an emphasis on traces of mining for metal ores in the ancient period. Also, the goal is to shed light on the then-existing technologies of metal production, particularly iron.

Mirko Vranić:

Medieval iron mining of the Kopaonik region: the state of exploration and potential future research

The development of ore mining and processing technology started in the mid-13th century, which led to the spread of mining centres in all parts of the Serbian medieval state. There is not much information regarding the production of iron ore in the written sources, however, the toponyms and different types of material remains indicate a certain level of production. The Kopaonik basin has a confirmed continuity of mining and metallurgy since prehistory and encompasses several mines. In addition to confirmed lead mining, iron mining was also developed. Geological and archaeological investigations have revealed traces of mining and metallurgical complexes in the vicinity of which iron ore and slag were deposited. These remains were mostly located alongside rivers. Furthermore, mining equipment and tools point to the existence of local workshops (smithies). In addition to summarizing the published results of the aforementioned archaeological and geological research regarding iron mining in the Kopaonik region, this paper will also present the spatial distribution of

known medieval sites of different types (fortifications, settlements, cemeteries), in relation to iron ore deposits known in the Middle Ages.

Bartul Šiljeg, Hrvoje Kalafatić:

Aerial archaeology in the study of metallurgical activities in eastern Croatia

The project Aerial Archaeology in Eastern Croatia started in 2012 at the Institute of Archaeology. This part of Croatia was chosen for various reasons: archaeological sites from all periods are abundant, the fertile land divided into large plots is ideal for aerial survey, airports with planes suitable for aerial photography exist, as well as a tradition of local museums and conservation offices who have diligently surveyed their regions from the end of the 19th century onwards. The project has also been supported by the Croatian Ministry of Culture since 2014, so there has been an intensification of photographing and remote sensing. Remote research into sites involved recognition using classic archaeological methods: crop marks, soil marks, and more rarely shadow marks. Some 350 sites have been documented throughout the entire region of eastern Slavonia. The combination of the analysis of aerial photographs from various sources and field surveys has provided a completely new view of land use, population distribution, and manners of survival in all historical periods in the area under observation. Certain finds that indicate metallurgical activity in the region were gathered during field survey. They are associated with Roman, medieval, and modern period sites. A spatial image will be presented of the sites in the region of eastern Croatia.

Branko Mušič, Tajana Sekelj Ivančan, Barbara Horn:

TransFER – Iron production along the Drava river in the Roman period and the Middle ages: Creation and transfer of knowledge, technologies and goods. Case studies of Virje, Velike Hlebine, Dedanovice, Bakovčice, Nađbarice and Ždala

The archeological goals of geophysical research using the magnetic method were to identify the remains of medieval ironworks (iron-smelting workshops, iron production waste material in the form of different slag types, burnt clay from furnace walls in various forms, etc.). All of these sites with indications of ironworks have been discovered by a previous archaeological field survey as part of the regular activities of the TransFER project (IP-06-2016-5047), financed by the Croatian Science foundation. Magnetic method prospections has revealed concentrations of refuse material associated with iron-production activities at all of these sites which are situated in the Croatian lowland, on the bank of the upper course of the Drava river. Since these

types of sites are quite rare in northern parts of Croatia, and in order to get a better understanding of the development and organization of the settlement, non-invasive methods were applied. With the help of magnetic method, measurements of apparent magnetic susceptibility, several waste depots of a workshop, pit furnaces from the Late Roman period (4th and 5th centuries), as well as settlement remains from the Late Iron Age (3rd/2nd, and 1st centuries BC) were discovered. In addition, magnetic method results, applying gradient and single sensors measurements together with 2D resistivity tomography, were carefully analyzed for determining origin of iron ore deposits and detailed correlation with excavated archaeological structures in order to check possibilities and limitations of magnetic and resistivity methods inselected iron production centers in specific environmental contexts.

Ivan Valent:

Archaeological finds of metallurgical activities on the territory of the Drava River Basin during Antiquity

In the course of research on the secondary documentation of the Koprivnica Town Museum's study material, archaeological finds connected with metallurgical activities in Antiquity have been found. The material was collected during archaeological investigations conducted between the 1970s and 1990s, but no mention of it exists within the published articles. The aim of the paper is to present the "forgotten" pieces of slag within their archaeological context and to preliminary classify them properly. Furthermore, the finds are compared to similar finds of slag collected during field surveys of the Drava River Basin to establish the archaeological topography of the area during the mentioned period. Moreover, based on the context and the attribution of the slag, the paper discusses the type and role of metallurgical activities within rural Roman settlements. The presented research is carried out within the TransFER project (IP-06-2016-5047), financed by the Croatian Science foundation.

Sanda Rončević:

Advanced Instrumental Methods in Chemical Profiling of Archaeological Samples

Compositional analysis of archaeological objects and findings by mineralogical, petrographic, and chemical methods provides valuable information about provenance, technology of production, and authenticity. Advanced instrumental analytical methods are adopted as the most helpful tools in the chemical characterization of archaeological artefacts. Spectroscopy methods such as instrumental neutron activation analysis (INAA), proton induced X-ray and gamma-ray emission (PIXE, PIGE), scanning electron microscopy (SEM), X-ray diffraction and fluorescence (XRD, XRF), and laser

ablation coupled to plasma mass spectrometry (LA-ICP-MS) have been employed in a broad spectrum of archaeological research. The notable advantages of atomic spectrometry methods based on an inductively coupled plasma source with optical or mass detection (ICP-AES, ICP-MS) lies in reliable and high dimensional quantitative elemental characterization of various materials. A multi-sample and/or multi-method analytical approach has showed to be suitable for the collection of sufficient compositional data, which are a prerequisite for the characterization of finds. The statistical treatment of large sets of spectrometric data provides better insight into differences among the visually similar features of heterogeneous material. Thus, chemometric methods based on univariate and multivariate statistics are often applied in archaeometric studies. Multivariate statistics using principal component analysis (PCA) and hierarchical clustering by exploiting chemical signatures allows the distinctions among objects to become visible. The combinations of analytical instrumental methods and chemometric tools enable the classification of artefacts with quite similar characteristics at a macroscopic scale. However, identifying the provenience of archaeological objects based on chemical fingerprinting is still a challenging task. Therefore, the main objective of this paper is to present an overview of advanced instrumental techniques along with their advantages and disadvantages in a specific area of archaeological sample recognition.

Ivan Nemet:
Archaeometallurgical Samples: A Top-down View

Chemometric methods for the investigation of early iron production artefacts in combination with advanced instrumental methods are presented in this work. The significant advantages of both inductively coupled plasma source with optical or mass detection (ICP-AES, ICP-MS) are due to their ability for high dimensional quantitative elemental characterization of different materials. Samples were excavated in the Turopolje region, NW Croatia, under supervision of the Municipal Museum of Zagreb, and were randomly collected according to their visual similarity prior to analysis. Various kinds of archaeological remains were analysed for an enlarged set of elements including major (Al, Ca, Fe, K, Mg, Mn, P, Si, Ti) and trace constituents (Cr, Cu, Mo, Ni, Pb, V, Zn, Zr, and REE's), by use of a combination of plasma spectrometric methods with XRF and SEM-EDS for surface analysis. The combination of morphological data obtained from SEM-EDS along with the elemental signature and performed statistical treatment enables identification of exceptions in the set of analysed archaeometallurgical remains. Moreover, by use of statistical analysis (PCA and HCA) on the enlarged set of measured data, the similar features of heterogeneous material become clearly discernible. Thus, different types of slags, such as bloom slag, ceramic-rich slag, and iron-rich tap slag, can successfully be perceived. The col-

lected results are advantageous for forthcoming studies of early iron production in the Pannonian area. The combination of the presented methods facilitates recognition of various kind of inhomogeneous slag material from archaeometallurgical production sites, especially when numerous similar samples are found scattered at an excavation site.

Tomislav Brenko, Sibila Borojević Šoštarić:

The mineralogical and geochemical composition of different bog iron ore types from the Podravina region, NE Croatia

Through continuous archaeological surveying over the previous 30 years, a vast quantity of sites with signs of iron smelting have been documented throughout the Podravina region that are dated to Late Antiquity and the early Middle Ages. Due to the amount of sites where iron smelting was observed, it is proposed that the iron ore was locally mined. Based on the geomorphology of the area, in the lowland region of the meandering Drava River (Feletar and Feletar, 2008), with a relatively high groundwater table (Brkić and Briški, 2018), and similar case studies at various archaeological sites in southern Hungary (Gömöri, 2006; Török et al., 2015), it is believed that bog iron ore was used for iron production. Bog iron ores are sedimentary iron deposits (Ramanaidou and Wells, 2014), typically occurring in low-lying areas such as swamps, bogs, meadows, or river valleys, and in micro-depressions with a groundwater table close to the surface (Kaczorek and Zagórski, 2007). They are developed in hydromorphic, loamy, sandy and clayey alluvium and soil (De Geyter et al., 1985; Landuydt, 1990), and their occurrence has been reported in central and northern Europe, Asia, and North America (Crerar et al., 1979; Breuning-Madsen et al., 2000; Ratajczak and Rzepa, 2011). In this study, three different types of bog iron ores were found: soft bog irons, bog iron nodules, and bog iron fragments. Their mineralogical and geochemical composition was determined using the XRD, ICP-MS, and SEM-EDS analytical methods. Mineralogically, bog iron samples consist of goethite, quartz, and variable amounts of alumosilicates. The geochemical composition of the samples collected in the area under discussion shows that iron (Fe_2O_3) and silicon (SiO_2) are the main components of various bog iron phases, which is typical for bog iron ores in general (Thelemann et al., 2017 and references therein). Changes in the distribution of several microelements, even at the same site, suggest that bog iron ores from the study area were developed in different micro-environmental conditions. The presented research is carried out within the TransFER project (IP-06-2016-5047), financed by the Croatian Science foundation.

Péter Barkóczy, Attila Bán, Szilvia Gyöngyösi, Géza Szabó:
Steel casting in the Middle Ages?

A cannon with an unusual shape was found in the castle of Szigetvár. The barrel is damaged and the end of it is missing. Observation shows that the barrel was shortened due to the mentioned damage. The current total length of the cannon is 185 cm, the original calibre could be 9.5 cm. No analogies could be found for a long time, but at Buda Castle in front of the Museum of Military History, a cannon thinner and longer than most others was investigated. The documentation of the cannon noted it as a front-loading three-pound cannon with an 8.5 cm calibre from the 16th century. The literature mentions a parallel between these cannons from the 16th century, and the material of the cannon was defined as cast-iron. It was kept in Nürnberg but unfortunately it was lost. The metallography of the cannons from Szigetvár and Buda shows a low ~0.1-0.15 w/w% carbon content. A dendritic character can be noted in the secondary structure on optical micrographs, which is typical in the case of castings. This discovery differs from current knowledge about the iron metallurgy from the 16th century. These cannons could have been produced in Europe just after the patent of Bessemer (1885) and the spread of crucible steel production. Cast irons with high carbon content were produced regularly in large amount at the smelters of Western Europe, which were converted to steel with different techniques. Rods and rings were produced from these steels and forged onto cannons around 1380. But the examined cannons from Szigertvár and Buda differed in shape and production technology from the forged cannons. The presentation tries to solve this contradiction, in addition to introducing the results of the investigation. The presentation seeks the possible place and time for the production of these large cast steel cannons.

Alan Williams:
A comparison of non-invasive and traditional methods of analysis for arms & armour

Traditional metallography is well-suited to the analysis of plate armour, and is micro-invasive. However, it is less suitable for swords, because their constructional details are only apparent when viewed in section. Neutron diffraction is proving to be a valuable method for their analysis.
Examples of swords and daggers from the Wallace Collection have been studied by this technique at the Rutherford-Appleton Laboratory, Harwell, and the Helmholtz Zentrum, Berlin, and the results are discussed.

Phase analysis of blades makes identification of crucible steels possible, while anisotropy in the cementite identifies patterns hidden by over polishing, and apparent changes in the texture of cementite are related to thermal history of their manufacture.

Márk Haramza:
Traces of Migration Period Sword Manufacture in the Carpathian Basin

Migration period long-blade weapons are of paramount importance in early medieval military history, both in combat and social terms. Various single- and double-edged swords – such as spathas, seaxes, or sabers in the late Migration Period – not only defined the European weapon culture for centuries, but in many cases were regarded as weapons of a limited social class. Modelling the use of weapons in combat, the trade in these objects, and the mechanical properties and efficiency, can be inferred from the results of archaeometallurgical investigations.
The aim of this work is to represent and interpret the swords from the Carpathian Basin containing technological traces (some of them also metallographically examined), like pattern welding, ferrous and non-ferrous inlays, and inscriptions. Through the identification of technologies in time and space, we can also get closer to reconstructing the trade in weapons, and the interactions between different workshop traditions.

Ümit Güder, Alptekin Yavaş, Muharrem Çeken, Ünsal Yalçın, Dierk Raabe:
A New Type of Steel-Making Crucible from Medieval Anatolia

This paper presents the recent steel-making crucible finds from Kubadabad, a medieval Anatolian archaeological site. Kubadabad, which is situated on the coast of the Konya-Beyşehir lake in Central Anatolia is a huge city-palace consisting of dozens of buildings spread not only on the coast of the lake but also on the islands and the Anamas mountainside. In the Kubadabad city-palace complex, workshops, used during or after the construction of the palace for productions like iron smithing, pottery, glass and tile were localized (Arık 2002, 264). The excavations of the workshop area provided valuable information on the character of special productions of the workshops.
As a result of the archaeometrical analysis on archaeological finds from Kubadabad, besides the steel tools which were produced by highly skilled blacksmiths, crucible steel knives were revealed (Güder et al., 2018). During the recent excavations of the workshop area, several fragments of ceramic crucible sherds, clay heap used for the production of crucibles, metal pieces that resemble crucible steel fragments and manganese pellets have been found. Crucible sherds found belong to a unique form

which has a standardized cylindrical shape with a pointed end. A solid lid covers the top of the crucible and no holes were detected in the center of it. During the thin section analysis of the crucible sherds, coarse quartz particles and organic material were detected as temper material to the light red clay. Iron prills, observed in the clay matrix, are seen as the proof of the highly reductive atmosphere during the steel-making process.
The Kubadabad crucible form with pointed end is distinctive from Central Asia and Persian crucibles (Alipour & Rehren, 2015; Papakhristu & Rehren, 2008). Additionally, the highly porous structure of crucible and the use of organic temper in the clay are seen as differences from Central Asian examples.

Jiří Hošek, Estelle Ottenwelter, Petr Žákovský, Patrick Bárta:
Types of luxurious and special knives (9th – 14th centuries) known from the territory of the Czech Republic

The known 9th - 14th centuries types of knives from the territory of the Czech Republic, also include those that differ from common production parameters. While some of them were undoubtedly luxurious pieces (such as pattern-welded knives), others could have served for "specific" purposes (e.g. all-metal knives usually described as 'healer knives'). A basic overview of these types, the methods of their blacksmith production, and the possibilities of their identification and archaeological study will be discussed and presented.

Gašper Oitzl:
The Transfer of Ironworking Technologies in Slovenian Territory in the 14th century

In the mid-14th century, significant progress in ironworking was made in Slovenian territory in which foreign ironworking masters and entrepreneurs were of crucial importance. They predominantly originated from the area of northern Italy, which was one of the most technologically developed ironworking centres in Europe at the time, where water was used to power ironworking facilities as early as in the 13th century. Around the mid-14th century, this technology was transferred to Slovenian territory. It was first implemented in the Selca and Kanal Valleys, where ironworking masters bearing Italian names have been documented in the written sources. Around the year 1400, masters of Italian origin were also attested in the developing ironworking centre of Bela Peč (Fusine in Valromana).
During the first half of the 16th century, blast furnace technology was introduced into Slovenian territory. Ironworking masters from northern Italy again played a crucial role in the implementation of this technology. The master craftsmen were followed

by many entrepreneurs of Italian origin, who invested the required capital to develop mines and ironworking facilities. However, Italian masters were not equally represented in the Carniolan and Carinthian ironworking centres. While their presence was very significant in the Kanal and Selca Valleys, it was much weaker in other major ironworking centres, especially in Carinthia. It seems that the Italian influence spread only to the southern part of this province. The territory of northern Italy also played an important role as the biggest export market for the products of the Carniolan and Carinthian ironworks.

Silviu I. Oța:
An iron processing workshop at Caransebeș (17th century)

The historical sources about iron processing in Caransebeș (Banat, SW Romania) are rather poor. We know that iron from the Bocșa region (well known for its rich iron ore) was brought into Caransebeș in the 16th century.
During excavations in 2017 and 2018, some agglomerations of iron and iron items were found in the central area of the fortified medieval town.
The excavated area is situated west of the inner fortification and the medieval road. From the very beginning, fragments of molten iron were found, at depths between 0.28-0.34 m, either spread or grouped, apparently without connections between them. The excavated furnace or fireplace was built on a pavement made of small stones. Its dimensions were 3 x 3 m, including the area in front of it, where fragments of molten iron were found. Towards the west, in S2/2018, on the edge of the burned area, a group of small and medium-sized stones, containing iron, was observed. Probably, this iron processing installation functioned during the Ottoman rule of the Banat, more precisely between the years 1658 – 1688.
After the destruction of the houses, and of the iron processing workshop, too, the area was partially covered with a clay layer, with variable thickness (0.20 – 0.30 m). These new improvements took place at the same time as the arrival of the Imperial Austrian army in Caransebeș.
Most probably, iron items of everyday use were produced here, such as nails, spikes, and possibly horseshoes, too. The processing tools used for this activity, like anvils, chisels, hammers, or pliers were not found.

Ana Konestra, Enrico Cirelli, Gaetano Benčić, Bartul Šiljeg, Tea Zubin Ferri:
A smithy at Tarovec (St. Blek, Tar-Vabriga)? Identification, chronology, and workshop features

At St. Blek (Tar-Vabriga/Torre-Abrega, Istria, Croatia), remains of a Roman rural site that developed into a village in the Middle Ages have been studied from 2008. Traces of pyrotechnological activities belonging to a post-Antiquity phase were identified in 2011 to the south of the central tower/building, a still preserved several meters high structure, and within the perimeter of a later annexed room flanking the then

de-functionalised Roman cistern. These included layers of ash, black silty soil, burnt soil, and possibly remains of installations that could be connected, due to the numerous lumps of slag, to a metalworking craft. Recently, the area to the west of the described sector was excavated, again yielding similar traces, in particular lumps of slag and localised ash layers.
In order to define the typology of the metalworking taking place at the site, three types of identified slug lumps have been analysed using SEM-EDS. Also, a re-evaluation of the layout of features, as well as the results of new excavations, helped in proposing a reconstruction of the supposed smithy. Lastly, a coin find from recent excavations, datable to the 11th - 12th cent., provides a TAQ for the establishment and functioning of the workshop.
While some questions are still open, wider analogies, as well as those within the Istrian peninsula, allow us to propose a model of craft organisation connected to post-Roman/early Medieval metalworking in rural areas.

Mike Charlton:
The design of ironmaking experiments

Experiments are essential undertakings for the evaluation models of ironmaking practices that left their traces in the archaeological record. Such experiments are also expensive undertakings that demand compromises in both study design and the number of variables to be explored. Design of Experiments, a branch of applied statistics, offers a systematic approach and set of tools for exploring the effects of process inputs and their interaction on responses. This paper reviews approaches to the design of direct process ironmaking experiments, the results obtained, and their impact on archaeological explanation. It argues that the adoption of a Design of Experiments philosophy in ironmaking and other pyrotechnologies can offer the most efficient path to developing robust models. Ideas are illustrated with reference to a recent series of experiments in Meroe, Sudan and the subsequent analysis of products.

Ondřej Merta, Dominik Talle, Martin Barak:
Historic and prehistoric iron smelting and processing workshops in Stará huť u Adamova (The Old Ironworks near Adamov), Czech Republic

One of the technological monuments administered by the Technical Museum in Brno is the Old Ironworks near Adamov – the remains of a metallurgical complex which was built in one of the valleys of the Moravian Karst in the first half of the 18th century by the Princes of Lichtenstein.
Since 2009, there have been workshops dedicated to historic and prehistoric iron

smelting and processing, following a series of experimental and educational iron smelting runs for the public held here since the first half of the 1990s. Reconstructions of 9th century embanked furnaces with a thin front wall based on archaeological finds from the vicinity are used for smelting.
The furnaces are constructed using the local kaolinic fireclay, charcoal is prepared on site in a charcoal pile, the ore used is predominantly local limonite, and the air is presently blown exclusively using hand powered bellows.
The aim of the lecture is to present the workshop itself and also the early medieval iron metallurgy in this part of the Czech Republic / Moravia.

Posters:

Damir Doračić, Jiři Hošek, Michael Brauns, Ivana Miletić Čakširan:
Conservation and examination of the early medieval sword from Bojna-Brekinjova Kosa

The sword (classified as type H based on the typology of Jan Petersen) was discovered accidentally in 2011 during the exploitation of a quarry at Bojna-Brekinjova Kosa that preceded preventive archaeological excavations of the site, resulting in a discovery of an early medieval graveyard with findings of exceptional importance for early Croatian history.
Standard conservation-restoration treatment included preliminarily investigations (radiography and microscopic inspection), stabilization, mechanical cleaning, consolidation, and surface protection. During treatment, a sample was taken in order to carry out a metallographic examination of the blade, which revealed a rather common pattern-welded blade structure typical for Carolingian swords (rods forming cutting edges were forge-welded to a middle portion consisting of pattern-welded surface panels attached to a blade core). The sword was probably manufactured in one of the Frankish workshops in the late 8th or beginning of the 9th century and imported to the territory of early medieval Croatia either as a gift, trade, or war booty. In order to trace the origin of the iron used for manufacture of the sword, osmium isotope analysis was performed. Based on Os-isotope signature (i.e. $^{187}Os/^{188}Os$ ratio) and Os concentration, it seems that the sword is quite compatible with iron ores from Schwäbische Alb, Southern Germany. However, due to little reliable data for Carolingian iron smelting, as well as practically no available data from Croatian ore deposits (except recently analyzed ore samples from the nearby Trgovska Gora mines), the results should be regarded more as an indication then as a straightforward fact.

Ferenc Fazekas:

Roman ironwork from the Roman auxiliary fort of Lussonium (Paks-Dunaközmlöd), W. Hungary

The Roman fort Lussonium (Paks-Dunaközmlőd, W. Hungary) is located in *Pannonia inferior*, in the middle section of the *ripa Pannonica*. The site was in use between the middle of the 1st century to the beginning of the 5th century AD. Systematic excavations was carried out at the site between 1987 and 2011. In addition to the remains of the fort, a large number of finds came to light, one of the most interesting groups among them are Roman ironwork. In the NE section of the Roman fort, a workshop area was excavated. Near the industrial structures, a load of iron slag and a substantial number of iron tools, especially blacksmith tools, were identified. The Roman ironwork tools presented in this poster from the fort *Lussonium* will be compared to ironwork finds from *Pannonia inferior* and contextualized for different military sites along the *ripa Pannonica*.

Gerard Fernàndez Molina:

The iron armament in the northeastern Iberian Peninsula during the Early Iron Age

The Early Iron Age in the northeastern Iberian Peninsula is characterised by a cultural transformation context where different social, economic, and political changes took place, at the same time when the introduction of the first iron objects began.
Within the first half of the 6th century BC, this territory witnessed a generalised rise in the number of iron weapons as funerary grave goods in a cremation necropolis context. Although some examples of iron weapons dated back to the latest part of the 7th century BC, at the beginning of the next century, there was an increase in the number of them, and the types were diversified. This fact could have been related to the typical tendency at cremation necropoles in the Ancient Iberian period, where the main elements of the warrior panoply predominated. Nevertheless, the assimilation of iron weapons presents exceptions throughout the analysed territory, depending on the different cultural areas.
Whilst iron weapons had a special predominance in the provinces of Girona and Barcelona during the Early Iron Age, they had a lower representation in the region of Segre-Cinca and in the lower course of the Ebre River. So, this rising tendency in warlike paraphernalia would be nuanced and there is no necessity to relate it to a nascent Iberian culture, due to the fact that during the Ancient Iberian period, in the provinces of Girona and Barcelona, a generalised abandonment of this kind of funerary site is documented, evoking a rupture of this dynamic.
Despite the unequal necropolis distribution throughout the studied territory, these

differences seem to show heterogenic assimilation patterns in relation to iron weapons, allowing reflection of an arrhythmical evolution of consumption, linked to the particularities in the different human groups constituting the cultural substrate.

Ana Konestra, Fabian Welc, Paula Androić Gračanin, Kamil Rabiega, Bartosz Nowacki, Agnes Kukela:

Evidence of iron working on the island of Rab – Podšilo Bay and Fruga

Within the *Archaeological Topography of the Island of Rab* project, a different set of multidisciplinary research activities have been carried out since 2013.
Among other, evidence for the processing of iron have been detected in two separate cases: within the Roman rural site at Podšilo Bay (Lopar peninsula) and on the outskirts of Fruga field (Kamenjak rigde).
In the first case, within a Roman rural complex, evidence that might point to metalworking activities was established. In particular, slag and possible iron ore deposits might indicate not only smithing, but also smelting. Moreover, a feature identified through magnetometry measurements might indicate the possible location of pyrotechnological installations. While it is too early to tell whether these belong to the same timeframe as the settlement, though evidence strongly points to that, as well as to how the craft was developed and organised, the presence of other craft activities on the site might be viewed in the context of mixed production, while the possibility to interpret them as self-supply or market oriented production remains elusive.
In the second case, on the northwestern edge of Fruga field an area subject to very strong erosion was surveyed, and within the profiles created by landslides evidence of a possible smelting furnace has been identified. Moreover, as a lime kiln was discovered in its proximity, the possibility of a multiple crafts establishment emerges, as well as a manifold interpretation of the means of exploitation of this resource rich area. Though no chronological markers are present, the existence of an early Modern road in close vicinity points to a possible timeframe for the identified features.

Daša Pavlovič, Jaka Burja:

The settlement of Pržanj in Ljubljana – metallurgy with tradition?

In 2004, the lowland settlement of Pržanj in Ljubljana was archaeologically investigated. It is radiocarbon dated from the 5th to the 12th centuries, with the majority of dates spanning from the 8th to the 10th centuries. Although it can be defined as an agrarian type settlement on the border between a fertile plain and a hilly landscape, and along a stream, this site is most marked by the discovered traces of intense metallurgical and blacksmith activity. This characteristic also stands out, or is unique, from other contemporaneous researched settlements in Slovenia. It is probably the

processing of iron that allowed the inhabitants to trade in long distances or with traders from afar, as evidenced by the discovered mosaic glass beads coming from the eastern Mediterranean along the routes leading to Scandinavia.

On the other hand, the settlement of Pržanj, together with the settlement at Dragomelj, represent a specific type of lowland settlement in the northern part of the Ljubljana plain (Ljubljansko polje). At these sites, the type of buildings, pottery, and radiocarbon dating show a late Antique character that survives deep into the early Medieval period. This sheds a light on long-standing questions about the continuity of settlement in the lowlands from late Antiquity to the early Middle Ages in Slovenia, and in what type of archaeological material can this continuity best be recognized. Understanding the metallurgical knowledge of the inhabitants of Pržanj will certainly contribute greatly to the resolution of those questions.

Therefore, at least 20 slag and smelt samples from the Pržanj site will be metallurgically and chemically analysed in 2020. We hope that with the results obtained, we will be closer to answering questions such as: did metallurgical knowledge in the area in question exist continuously since late Antiquity into the early Middle Ages? Or did new inhabitants come to the area at the beginning of the early Middle Ages, who, although exploiting the same resources, had different metallurgical knowledge?

Vitalii Shcherbakov:

Household knives of the Northeastern Rus' rural population in the second half of the 12th – 14th centuries (production technology)

Knives are the most common type of tools found during excavations of Northeastern Rus' rural settlements in the second half of the 12th – 14th centuries. Most of the artefacts of this group are represented in the archaeological collections by fragments. The informational potential from broken knives is limited. One source of additional information about blacksmith products are laboratory tests. The present report is based on the results of metallographic analysis.

An analysis was undertaken of 35 knives dated to the second half of the 12th – 14th centuries collected from 8 rural settlements. Welded knives prevail (71%). A welded blade was revealed on 10 artifacts, a three-layer blade on 9 objects, 6 knives had a packaged blade, including 4 knives from two metal strips. Ten knives were made without using technological welding. Four objects were completely forged from iron and steel, 1 knife from carbon steel, and 2 artefacts were produced from scrap metal. Cementation was used on three knives' edges. From 25 welded knives, 20 knives were heat-treated. In the group of tools forged without the use of technological welding, heat treatment was noted on 6 knives.

Knives used among the rural population in the second half of the 12th – 14th centuries, differ from those used by townspeople (Suzdal, Rostov). In the cities, there are more

knives with welded blades and less knives with three-layer blades.
The differences were based on economic factors, including the faster introduction of technological innovations in knife-specialized urban production. Rural craftwork was universal, non-specialized. One craftsman would have been engaged in the manufacture of various tools, and would repair equipment. Blacksmith production in Northeastern Rus' rural settlements is characterized by conservatism in the selection of production technologies. The work was supported by the Russian Science Foundation (grant number 19-18- 00144).

Ádám Thiele, Béla Török:

Controlling possibilities of the phosphorus content in the iron bloom during iron smelting

Controlling the carbon and the phosphorus (P) content in the iron bloom during iron smelting might be important because the chemical composition determines its workability and usability. Besides iron and steel, which were the most used iron alloys for different constructions, phosphoric-iron (P-iron, C<0.3wt%, P>0.1wt%) was mainly used in decorated and pattern-welded blades between the 2nd and the 14th centuries.
The detrimental effects of P include various forms of embrittlement, as P decreases ductility, dynamic and static toughness. Three main types of P-iron could be distinguished regarding workability; 1) Non-forgeable P-iron (P>1.5wt%), 2) Forgeable but brittle P-iron (0.4wt%<P<1.5wt%), which cracks during cold-working (cold-shortness) and 3) Cold-workable P-iron (P<0.4wt%).
Iron smelting was very intensive in Somogy County, Hungary during the Avar and Conquering Age (6th - 10th centuries), but all the local bog iron ore deposits we have discovered in the past years are very rich in P (as is also true in several other parts of Europe). P diffuses into the iron bloom during the iron smelting process and makes the extracted iron bloom brittle or even non-forgeable, unusable, so P may have caused intrinsic technological problems for the ancient smelters in Somogy.
We carried out 7 smelting experiments with a P-rich (ca. 7wt% of P_2O_5 and 83wt% of Fe_2O_3) bog iron ore from Somogy County to find a way to control the P-content of the blooms. After smelting, we tried to compress the resulting blooms by forging, and cross sections for metallographic examinations were sliced from the compressed blooms. The rest of the blooms were forged to bars on which further chemical analyses and mechanical tests were done. We could extract all the three main types of P-iron. Charging limestone had an effect of decreasing the P-content of the bloom, but this alone was insufficient. The high FeO content of the slag and the low smelting temperature also played an important role. We found a simple technique (which may also have been applied by the ancient smelters) to control the P-content of the bloom and to produce almost P-free, cold-workable iron material during the smelting of a typical P-rich bog iron ore from Somogy County.

Ivan Valent:
Traces of iron smelting at the Koprivnički Ivanec – Log-Parag I site

During the excavation of the Koprivnički Ivanec - Log Parag I site, pieces of smelting slag were found within an Early Medieval context. The poster presents a statistic analysis and distribution of the slag within the excavated pits, as well as of slag found during several field surveys. Based on the pottery material found in the same context, a date for the presumed smelting workshop is given.

Olga Zaitceva, Evgeny Vodyasov:
Medieval burials with blacksmith tools in Siberia

The report will be devoted to Siberian burials with blacksmith tools from the 1st and 2nd millennium AD. Virtually all the burials in question contain an abundance of weapons, belts, jewellery, crockery, and horse harnesses. Many burials contained unique religious objects that have no analogies. Moreover, some burials are among the 'richest' early medieval burials in the *taiga* zone of Siberia. The discovery in burials of blacksmith tools along with other prestigious items raises a number of questions in relation to the buried people's social status in life and to the functions these very blacksmith tools performed in burial rites. If no blacksmith tools had been found in the studied burial mounds, the status of the deceased would most probably have been defined by researchers as 'social elite', 'warriors of high rank', etc. However, the presence of these tools complicates such an interpretation. In many medieval societies, there existed ideas of a close relationship of military rulers with blacksmithing. For example, the medieval Mongols had a myth about the iron durability of the people, led by the blacksmith leader. The name Genghis Khan (Temüjin) is translated as "blacksmith", although he did not engage in blacksmithing. That is why we cannot exclude the fact that this symbolism of blacksmith tools acting as a marker of a high status and power became reflected in the burial rite of the medieval population of Siberia.
The research was supported by the Russian Science Foundation (project No. 18-78-10076).

List of participants / Popis sudionika

Androić Gračanin, Paula
Paula Androić Gračanin, mag. arheol.
Independent researcher
paula.androic@gmail.com

Bán, Attila
Attila Bán, leutenant-colonel
Military History Museum
Deputy Museum Director for External Exhibitions
1014 Budapest, Kapisztrán tér 2-4., Hungary
ban.attila@mail.militaria.hu

Bánóczy, Zsuzsa
Zsuzsa Bánóczy
Institute of Physical Metallurgy,
Metalforming and Nanotechnology,
University of Miskolc
H-3515 Miskolc-Egyetemváros, Hungary

Barák, Martin
Martin Barák
Independent researcher
martin@fotobarak.cz

Barkóczy, Péter
Péter Barkóczy
FUX Zrt..,
3527 Miskolc, Besenyői út 8., Hungary
peter.barkoczy@fux.hu

Bárta, Patrick
Patrick Bárta, Mgr.,
restorator/conservator of metal
The Institute of Archaeology in Brno,
Czech Academy of Sciences,
Čechyňská 363/19, 602 00 Brno, Czech Republic
barta@arub.cz

Belaj, Juraj
Juraj Belaj, PhD
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
jbelaj@iarh.hr

Benčić, Gaetano
Gaetano Benčić, mag. hist.
Decumanus 9, 52440 Poreč, Croatia
gaetano.bencic@muzejporec.hr

Borojević Šoštarić, Sibila
Prof. Sibila Borojević Šoštarić, PhD
Faculty of Mining,
Geology and Petroleum Engineering
Pierottijeva 6, 10 000 Zagreb, Croatia
sibila.borojevic-sostaric@rgn.hr

Botić, Katarina
Katarina Botić, PhD
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
katarina.botic@iarh.hr

Brauns, Michael
Michael Brauns
Curt-Engelhorn Zentrumarchäometrie
D 6,3 68159 Mannheim, Germany
michael.Brauns@ceza.de

Brenko, Tomislav
Tomislav Brenko
Faculty of Mining,
Geology and Petroleum Engineering
Pierottijeva 6, 10 000 Zagreb, Croatia
tbrenko@rgn.hr

Bugar, Aleksandra
Aleksandra Bugar
Zagreb City Museum
Opatička 20, 10000 Zagreb, Croatia
abugar@mgz.hr

Burja, Jaka
Jaka Burja, PhD
Institute of Metals and Technology
Lepi pot 11, SI-1000 Ljubljana, Slovenia
jaka.burja@imt.si

Cech, Brigitte
Brigitte Cech, Univ. Doz. Dr.
University of Vienna
Quaringasse 22/3/7, 1100 Wien, Austria
b.cech@gmx.at

Çeken, Muharrem
Muharrem Çeken
Ankara University,
Dögol Street 06100, Beşevler,
Ankara, Turkey
mceken@gmail.com

Charlton, Mike
Mike Charlton
UCL Institute of Archaeology
31-34 Gordon Square, London WC1H 0PY, UK
m.charlton@ucl.ac.uk

Cirelli, Enrico
Enrico Cirelli, PhD
Piazza San Giovanni in Monte 2,
51000 Bologna, Italy
enrico.cirelli2@unibo.it

Črešnar, Matija
Matija Črešnar, doc. dr.
University of Ljubljana, Faculty of Arts,
Department of Archaeology,
Centre for Interdisciplinary Research in Archaeology
Aškerčeva 2, 1000 Ljubljana, Slovenia
Institute for the Protection of Cultural Heritage
of Slovenia, Centre for Preventive Archaeology
Poljanska 40, 1000 Ljubljana, Slovenia
matija.cresnar@gmail.com

Doračić, Damir
Damir Doračić
Archaeological Museum in Zagreb
Zrinjevac 19, 10000 Zagreb, Croatia
ddoracic@amz.hr

Drnić, Ivan
Ivan Drnić, PhD
Archaeological Museum in Zagreb
Zrinjevac 19, 10000 Zagreb, Croatia
idrnic@amz.hr

Durman, Aleksandar
Aleksandar Durman, Prof.
University of Zagreb,
Faculty of Humanities and Social Sciences
10 000 Zagreb, Ivana Lučića 3, Croatia
adurman@ffzg.hr

Fazekas, Ferenc
Ferenc Fazekas, PhD
University of Pécs & Town Museum of Paks
7624 Pécs, Rókus u. 2. & 7030 Paks Deák Ferenc u. 2., Hungary
fazekas_ferenc@yahoo.de

Fernàndez Molina, Gerard
Gerard Fernàndez Molina, PhD candidate
University of Barcelona
Carrer Montalegre 6, CP 08001 Barcelona, Spain
gefmolina@gmail.com

Gömöri, János
János Gömöri**,** Dr. C. Sc.
Scarbantia Archaeological Park,
Museum „Forum Scarbantiae"
H-9400 Sopron, Fő tér 8. Soproni Múzeum,
Hungary
forum.muzeum@gmail.com

Güder, Ümit
Ümit Güder
Max-Planck-Institut für Eisenforschung,
Max-Planck-Straße 1, 40237 Düsseldorf, Germany
uguder@comu.edu.tr

Gyöngyösi, Szilvia
Szilvia Gyöngyösi
Debreceni Egyetem, Gépészmérnöki Tanszék
4002 Debrecen, Pf.400, Hungary
szilvia.gyongyosi83@gmail.com

Haramza, Márk
Márk Haramza
University of Pécs, Faculty of Humanities,
Department of Archaeology, Hungary
Janus Pannonius Museum, 7621 Pécs,
Széchenyi tér 9.
haramza.m@gmail.com

Horn, Barbara
Barbara Horn
University of Ljubljana, Faculty of Arts,
Department of Archaeology, Zavetiška 5,
1000 Ljubljana, Slovenia
Gearh d.o.o.
Radvanjska 13, 2000, Maribor, Slovenia
barbarahorn01@gmail.com

Hošek, Jiří
Jiří Hošek, PhD
The Czech Academy of Sciences,
Institute of Archaeology, Prague
Department of Natural Science and Archaeometry
Letenská 4, 118 01 Praha 1 – Malá Strana,
Czech Republic
hosek@arup.cas.cz

Kalafatić, Hrvoje
Hrvoje Kalafatić, PhD
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
hrvoje.kalafatic@iarh.hr

Karavidović, Tena
Tena Karavidović, mag. arheol.
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
tkaravidovic@iarh.hr

Konestra, Ana
Ana Konestra, PhD
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
ana.konestra@gmail.com

Krznar, Siniša
Siniša Krznar, PhD
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
skrznar@iarh.hr

Kukela, Agnese
Agnes Kukela, PhD
University of Latvia,
Faculty of Geography and Earth Sciences
Jelgavas iela 1, Zemgales priekšpilsēta,
1004 Rīga, Latvia
agnese.kukela@gmail.com

Lazić, Ladislav
Ladislav Lazić, Prof.
University of Zagreb, Faculty of Metallurgy
44 000 Sisak, Aleja narodnih heroja 3, Croatia
lazic@simet.unizg.hr

Merta, Ondřej
Ondřej Merta, Mgr.
Technické muzeum v Brně /
Technical Museum in Brno
Purkyňova 105, Brno 612 00, Czech Republic
merta@technicalmuseum.cz

Miletić Čakširan, Ivana
Ivana Miletić Čakširan, PhD
Department for the protection of cultural heritage, Conservation department Sisak,
Nikole Tesle 17, 44000 Sisak, Croatia
ivana.miletic@min-kulture.hr

Mušič, Branko
Branko Mušič, doc. dr.
University of Ljubljana, Faculty of Arts,
Department of Archaeology,
Centre for Interdisciplinary Research in Archaeology
Zavetiška 5, 1000 Ljubljana, Slovenia
Gearh d.o.o.
Radvanjska 13, 2000, Maribor, Slovenia
branko.music@ff.uni-lj.si

Nemet, Ivan
Ivan Nemet, PhD
Faculty of Science, University of Zagreb
Horvatovac 102 a, 10000 Zagreb, Croatia
inemet@chem.pmf.hr

Nowacki, Bartek
Bartek Nowacki
Independent researcher
barteknowacki@gmx.net

Oitzl, Gašper
Gašper Oitzl, M.A.
National Museum of Slovenia
Prešernova 20, 1000 Ljubljana, Slovenia
gasper.oitzl@nms.si

Oța, Silviu I.
Silviu I. Oța, PhD
National Museum of History, Romania
Calea Victoriei, nr. 12, sect. 3, Bucharest, Romania
silviuota@yahoo.com

Ottenwelter, Estelle
Estelle Ottenwelter
The Czech Academy of Sciences,
Institute of Archaeology, Prague
Natural Sciences and Archaeometry,
Restoration Laboratory
Letenská 4, 118 01 Praha 1 – Malá Strana,
Czech Republic
ottenwelter@arup.cas.cz

Pavlovič, Daša
Daša Pavlovič, PhD
Narodni muzej Slovenije
Prešernova cesta 30, 1000 Ljubljana, Slovenia
dasa.pavlovic@nms.si

Raabe, Dierk
Dierk Raabe, Prof.
Max-Planck-Institut für Eisenforschung,
Max-Planck-Straße 1, 40237 Düsseldorf, Germany
d.raabe@mpie.de

Rabiega, Kamil
Kamil Rabiega, mag. arheol.
Cardinal Stefan Wyszynski University in Warsaw
Insitute of Archaeology
Wóycickiego 1/3, 01-938 Warsaw, Poland
kamilrabiega@onet.eu

Rončević, Sanda
Sanda Rončević, PhD, Assoc. Prof.
Faculty of Science, University of Zagreb
Horvatovac 102 a, 10 000 Zagreb, Croatia
roncevic@chem.pmf.hr

Sekelj Ivančan, Tajana
Tajana Sekelj Ivančan, PhD
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
tsivancan@iarh.hr

Shcherbakov, Vitalii
Vitalii Shcherbakov, PhD
Autonomous non-profit organization
"Center for Historical and Cultural Research and Design", Kostroma, Russia Kostroma city, 156007,
Pushkina street, 43/102, room 7, Russian Federation
Scherbakov-V-L@yandex.ru

Šiljeg, Bartul
Bartul Šiljeg, PhD
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
bartul.siljeg@iarh.hr

Talla, Dominik
Dominik Talla
Independent researcher
sutrar@volny.cz

Terekhova, Nataliya
Nataliya Terekhova, PhD
Institute of Archaeology
Russian Academy of Sciences
Russia, 117036, Moscow, Dm. Ulyanov str., 19

Thiele, Ádám
Ádám Thiele, PhD
Budapest University of Technology and Economics,
Department of Materials Science and Engineering
H-1111 Budapest XI. Bertalan L. u. 7., Build. MT, Hungary
thiele.adam@gmail.com

Tkalčec, Tatjana
Tatjana Tkalčec, PhD
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
ttkalcec@iarh.hr

Török, Béla
Béla Török, PhD
Institute of Metallurgy, University of Miskolc
3515 Miskolc-Egyetemváros, Hungary
bela.torok@uni-miskolc.hu

Turkalj, Kristina
Kristina Turkalj
Institute of archaeology
Ulica Ljudevita Gaja 32, 10000 Zagreb, Croatia
kristina.turkalj@iarh.hr

Valent, Ivan
Ivan Valent, mag. arheol.
Koprivnica city museum
Trg dr. Leandera Brozovića 1,48000 Koprivnica,
Croatia
ivalent@muzej-koprivnica.hr

Vodyasov, Evgeny
Evgeny Vodyasov
National Research Tomsk State University
634029, Tomsk, Lenina av. 36
vodiasov_ev@mail.ru

Vranić, Mirko
Mirko Vranić, M.A.
Laboratory for Bioarchaeology,
Faculty of Philosophy, University of Belgrade
Čika Ljubina, 18-20, 11000 Beograd, Serbia
mirkov4@gmail.com

Szabó, Géza
Géza Szabó
Wosinsky Mór Museum
7100 Szekszárd, Szent István tér 26.
kaladeaa@gmail.com

Zaitceva, Olga
Olga Zaitceva
National Research Tomsk State University
634029, Tomsk, Lenina av. 36
vodiasov_ev@mail.ru

Zavyalov, Vladimir
Vladimir Zavyalov, Doctor of Science
Institute of Archaeology Russian Academy of Sciences
Russia, 117036, Moscow, Dm. Ulyanov str., 19
v_zavyalov@list.ru

Zubin Ferri, Tea
Tea Zubin Ferri, PhD
Independent researcher
tea.zubin@gmail.com

Žákovský, Petr
Petr Žákovský, PhD
The Czech Academy of Sciences,
Institute of Archaeology, Prague
Letenská 4, 118 01 Praha 1 – Malá Strana,
Czech Republic
zakovsky@arub.cz

Yavaş, Alptekin
Alptekin Yavaş
Canakkale Onsekiz Mart University,
Barbaros, 17100 Kepez/Çanakkale Merkez/, Turkey
alptekinyavas@hotmail.com

Yalçın, Ünsal
Ünsal Yalçın, Prof.
Deutsches Bergbau-Museum,
Am Bergbaumuseum 28, 44791 Bochum, Germany
Uensal.Yalcin@bergbaumuseum.de

Welc, Fabian
dr. hab. Fabian Welc, prof. UKSW
Cardinal Stefan Wyszynski University in Warsaw
Insitute of Archaeology
Wóycickiego 1/3, 01-938 Warsaw, Poland
f.welc@uksw.edu.pl

Williams, Alan
Alan Williams
The Wallace Collection, London
alan.williams@wallacecollection.org

BILJEŠKE/NOTES

BILJEŠKE/NOTES

BILJEŠKE/NOTES

BILJEŠKE/NOTES