Received: 2024-02-15 | Accepted: 2024-07-09 | Published: 2024-10-31

Roman Lead Finds from *Troesmis* (Turcoaia, Tulcea County, Romania) and Its Surroundings – an Investigation Based on Lead Isotopes and Trace Element Analyses

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Keywords

Troesmis, Roman, lead, bronze, pipes, statues, *Moesia Inferior*, provenance, Cévennes, Serbia/Kosovo, Yorkshire

Abstract

Lead samples and one leaded bronze sample from five identifiable objects (e.g. large-scale bronze statues, lead pipes) and three lead chunks from the area of the ancient center of *Troesmis*, in the *Moesia Inferior* province, have been investigated by elemental and lead isotope analyses. Among the analyzed samples, four are dated into the 2nd-3rd centuries AD and were found in the civil settlement near the fortress of the *legio V Macedonica* and the *municipium* of *Troesmis*, while one was uncovered in a rural settlement in the surroundings of this ancient center, at Horia, in a context dated to the 2nd century AD. A fifth object of study is a fragmented lead pipe from a private collection in Bucharest, from *Carnuntum*, according to the seller, but bearing a maker stamp that relates it to Rome. Furthermore, three lead chunks, presumably used to hang on wall objects like

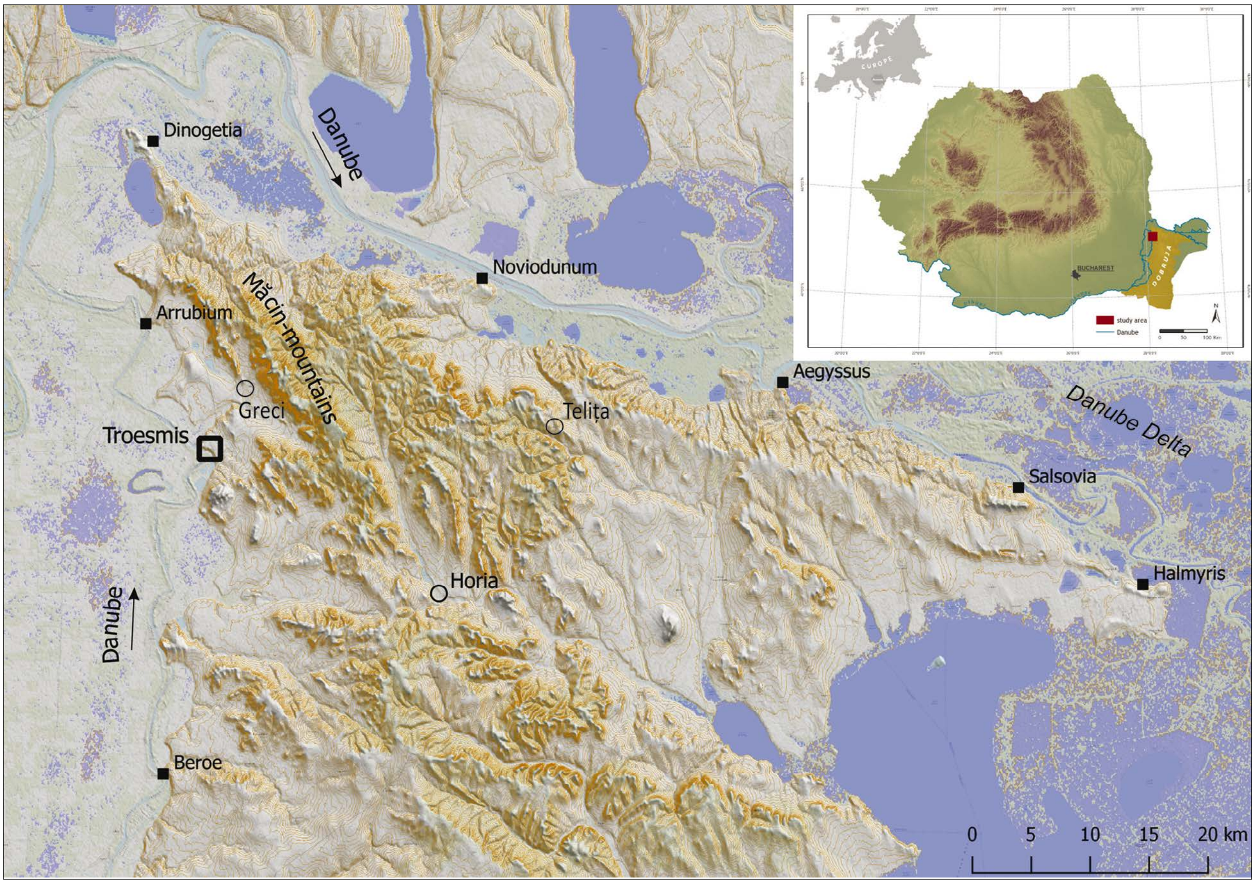

Figure 1. Map of northern *Moesia Inferior,* showing *Troesmis* (large black square) and its surroundings. The map in the upper right corner shows the location of the study area (red square) within Romania. Illustration: C.-G. Alexandrescu.

DOI:10.46586/metalla.v28.2024.i1.41-65

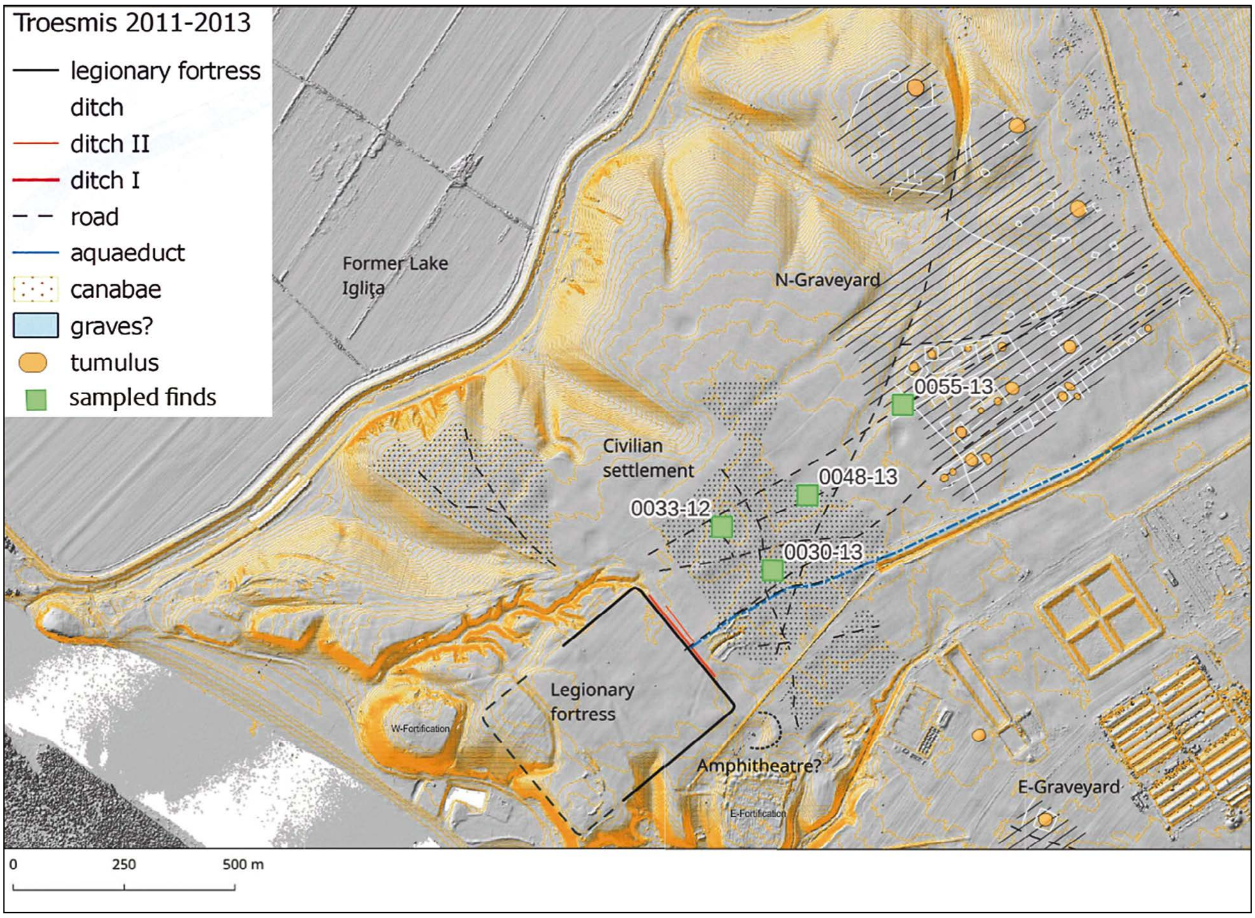

Figure 2. Mapping of the investigated lead finds from the ancient *Troesmis* core area (samples RO-4 to RO-9, see also Table 1 for the mapped inventory numbers). Illustration: C. Gugl (ÖAW-ÖAI); DTM: ALS data provided by Airborne Technologies (Wiener Neustadt).

the bronze plates with the *lex* of the *municipium*, have also been analyzed. The provenance investigations of the eight *Troesmis* finds point to two different lead sources in the Roman Empire, the Central Balkans (Serbia/Kosovo) and the Cévennes (Massif Central) in France, while the lead source for the pipe fragment in Bucharest might be Yorkshire in Great Britain.

Introduction

The paper provides additional information on the lead used in *Moesia Inferior*, particularly for the micro-region of *Troesmis*/Turcoaia, Tulcea county, Romania – see Figures 1 and 2, as well as a starting point for other potential systematic investigations on lead supply and processing at provincial and interprovincial levels.

The status of the archaeological research at *Troesmis* is only in its early stages (especially compared with ancient sites that have been intensively investigated over several decades). Therefore, detailed observations on possible differences within the known periods in the history of *Troesmis*, between certain uses of lead (building projects, water supply systems, etc.), and the procurement of raw materials or even monuments (i.e. large-scale statues) is not possible at this time.

This paper tries to fill the gap in the current knowledge of ancient lead artefacts in this part of Europe, as until recently archaeometric studies of archaeological lead finds from Romania were rare and there are just a few publications of Roman lead finds discovered at the archaeological sites of Roman *Dacia* and *Moesia Inferior*. The material provenance investigation of the selected lead fragments and one bronze fragment and the interpretation of the analytical results alongside archaeological information are expected to provide a clearer picture of the historical evolution of *Troesmis* The analyses will also be used to investigate which supply routes and which regions of origin were used to supply raw materials at that time and to gain a better understanding of the economic situation, cultural connections and trade network of the region.

The initial reason for the present study was to assess a documentation of an old looting pit during the 2012

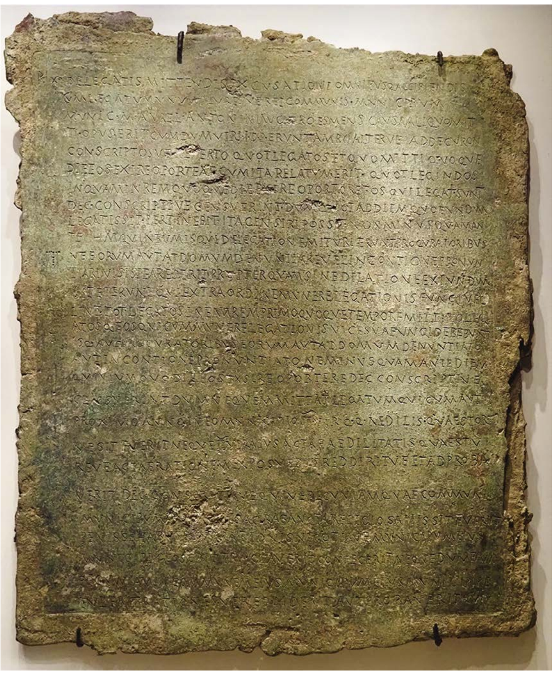

Figure 3. *Troesmis* municipal law fragments on bronze table A (left), with details of its backside (right) with lead chunks from fixing it to the wall. Photo (left): Laci3 – Creative Commons CC0 1.0 Universal Public Domain Dedication. Photo (right): Eck (2016b, Fig.200).

archaeological survey conducted at *Troesmis*, where unspecific flat chunks of lead next to building ceramics were found (see, e.g. Figure 11).

In 2016, C.-G. Alexandrescu raised the question of investigating these fragments (Figure 2: location 0033-12) and their place of discovery, along with one of the most spectacular archaeological finds from *Troesmis*: two bronze tables (tabula A: 66.5 × 54.5 × 0.6 cm, 26.41 kg; tabula B: 59.5 × 50 × 0.6 cm, 23.6 kg). The two tables were conventionally named and illustrated, including their back by W. Eck (2016a; 2016b), with texts from the law of the Roman *municipium*.

The bronze tables were uncovered as a result of looting in early 2000 in the core area of ancient *Troesmis*. Soon after, they were offered on the international antiquities market (Eck 2016b, p.484). But the texts they bear betrayed their provenance and started an international investigation and complex and long-lasting procedures for bringing the finds back to Romania, which was completed only in 2015 (Eck, 2016a, p.570). At that time, it was observed that on the back patches of lead, used to mount the tables on a wall, were still attached to them (Figure 3, right photo)[1].

Since 2016, we have repeatedly requested permission to investigate these fragments, but the National History Museum of Romania (as custodian of the looted and subsequently recovered artefacts) have not grant us access[2]. To be more precise, the completion of our research and the publication of results have been postponed several times since 2017, as we still hoped that the examination and sampling of the lead chunks attached to the two tables would be permitted. However, we received no response regarding the reasons for the refusal. After a third attempt in September 2023, we decided to finally publish the available chemical and lead isotope results of the other lead finds (and one bronze fragment) from *Troesmis* and the northern *Moesia Inferior* (presentation next chapter, listed in Table 1).

The fact that it was not possible to sample at least the lead stuck to the two bronze tables is incomprehensible from our point of view. The methods of trace element and lead isotope analysis used in our study could have linked the provenance results obtained with the other metal objects presented here and might possibly identify a further (lead) source. It is possible that sampling the bronze tables would have yielded equally exciting results as the bronze fragment of the equestrian statue (sample RO-3).

The ancient center of *Troesmis*

The first mention of *Troesmis*, a strategically located center on the right bank of the Danube (Figure 1), dates back to the 1st century AD and can be found in the writings of Ovidius (Pont. IV, 9.78-79; 16.15); it refers to an impressive battle when the Romans lifted the siege of the stronghold of *Troesmis* (with a supposed Odryssian garrison) by the *Getae*, an event that took place in 15 AD. From about 106 AD onwards, the *legio V Macedonica* was stationed in *Troesmis*. Around 168 AD, the legion left *Troesmis*, but a Roman town of *municipium* status flourished there. The town is attested to by several inscriptions and the above-mentioned bronze tables bearing the carved fragments of the city law. This latter exceptional find provides the full name of the city: *municipium Marcum Aurelium Antoninum et Lucium Aurelium Commodum Augustum Troesmensium*. The name also allows for the dating of the *municipium*, as cities regularly took the names of the emperors who founded them or changed their legal status. Based on its name, *Troesmis* became a *municipium* when Commodus was already co-ruler and 'Augustus', but Marcus Aurelius was still reigning in about 178-180 AD.

Archaeological survey activities and geophysical prospections carried on at this site since 2011 localized (Figure 2) the fortress of *legio V Macedonica*, its adjacent civil settlement (*canabae*), additional Roman time rural settlement nuclei, as well as necropolises, main roads and aqueducts (Alexandrescu, Gugl and Kainrath, 2016).

In the Late Roman and Middle Byzantine fortification (East and West fortification, respectively) that dominate the landscape today, stone blocks with inscriptions were reused as building elements. These inscriptions are of particular significance, as they testify for the existence of several settlement nuclei during the 2nd and 3rd centuries AD: a legionary camp, two civil settlements, and after the dislocation of the legion, a Roman *municipium* (Alexandrescu, Gugl and Kainrath, 2016).

Despite the relevance of this site during antiquity - at both provincial and Empire-wide level - no systematic archaeological research of *Troesmis* has been undertaken up to these days.

In July 1865, a French mission sent by Emperor Napoleon III made a series of archaeological excavations at the E-fortification (Alexandrescu, Gugl and Kainrath, 2016; see Figure 2). At that time, the site and the surrounding area belonged to the Ottoman Empire.

In 1977, an archaeological rescue excavation campaign took place, occasioned by the construction of an irrigation pipeline along the plateau between the two fortifications (Simion, et al., 1980). It uncovered a so-called baths building. However, this construction was not completely excavated, but the pipeline was eventually relocated and built above ground in order to protect the newly discovered ancient edifice. Given the purposes of the present contribution, it is worth noting that no lead finds were reported in the publications resulting from these two previous episodes of archaeological excavations in 1865 and 1977.

In the course of the recent survey, several finds of lead and slags of various kinds were documented. The finding spots of lead chunks and items with poured lead were within the area of the civilian settlement and at the southern boundary of the N-graveyard (Figure 2). As survey finds, the fragments can only be dated to the 2nd-3rd centuries AD. In the vicinity of *Troesmis*, several settlement nuclei of different character, necropoleis, road sections, as well as structures related to the water supply were identified (Alexandrescu, et al., 2023). For example, in the area of the Horia commune, Tulcea county (Figure 1), located about 30 km from the core area of *Troesmis*, it has been assumed that, in addition to an early Roman building, called a *villa* by V.H. Baumann, there was a *statio* and possibly a *mansio*. The lead pipe fragment sampled as RO-2 was uncovered there (see Table 1). To have it precisely, it was at the junction point of a secondary road coming from the north with the main road through the north of the province, oriented E-W (Alexandrescu, Gugl and Kainrath, 2016, pp.450-451). The location was certainly both administratively and functionally directly connected to the military structures of the *legio V Macedonica* stationed in *Troesmis*.

Lead finds in *Moesia Inferior*

To be able to appreciate both the number of finds of Roman lead objects and the necessity and usefulness of material analysis, a brief overview of the state of research will be outlined. Lead artefacts are rarely found in the northern *Moesia Inferior*. It is noticeable that large objects involving either an elaborate production process or a large amount of material are poorly represented. This can certainly be an expression of the status of research or discoveries, but at the same time it is not advisable to compare provinces and expect the same quantity of finds. One such issue is lead plumbing, which is scarcely represented in *Moesia Inferior* (Lemke, 2019), particularly in its northern part. At the same time, objects that are easily manufactured and involve a small amount of material, sometimes with an obvious potential for recycling, occur more frequently.

Within *Moesia Inferior,* some small finds categories have up to now been almost neglected by research, with some significant exceptions, such as the mirror frames[3] and sling projectiles published by Avram, Chiriac and Matei (2013). As in other Roman provinces[4], the categories of known finds, sometimes with only a few examples, are water pipes, sarcophagi, vessels, mirror frames, sling projectiles, *plumbata* heads, seals, weights, caps, merchandise labels, price tags, curse tablets (see, e.g. Avram, Chiriac and Matei, 2007), votive figurines and votive tablets.

The numerous finds of lead anchors reported from Cape Čirakman/Kavarna, Bulgaria (Nuţu, 2019, p.87),

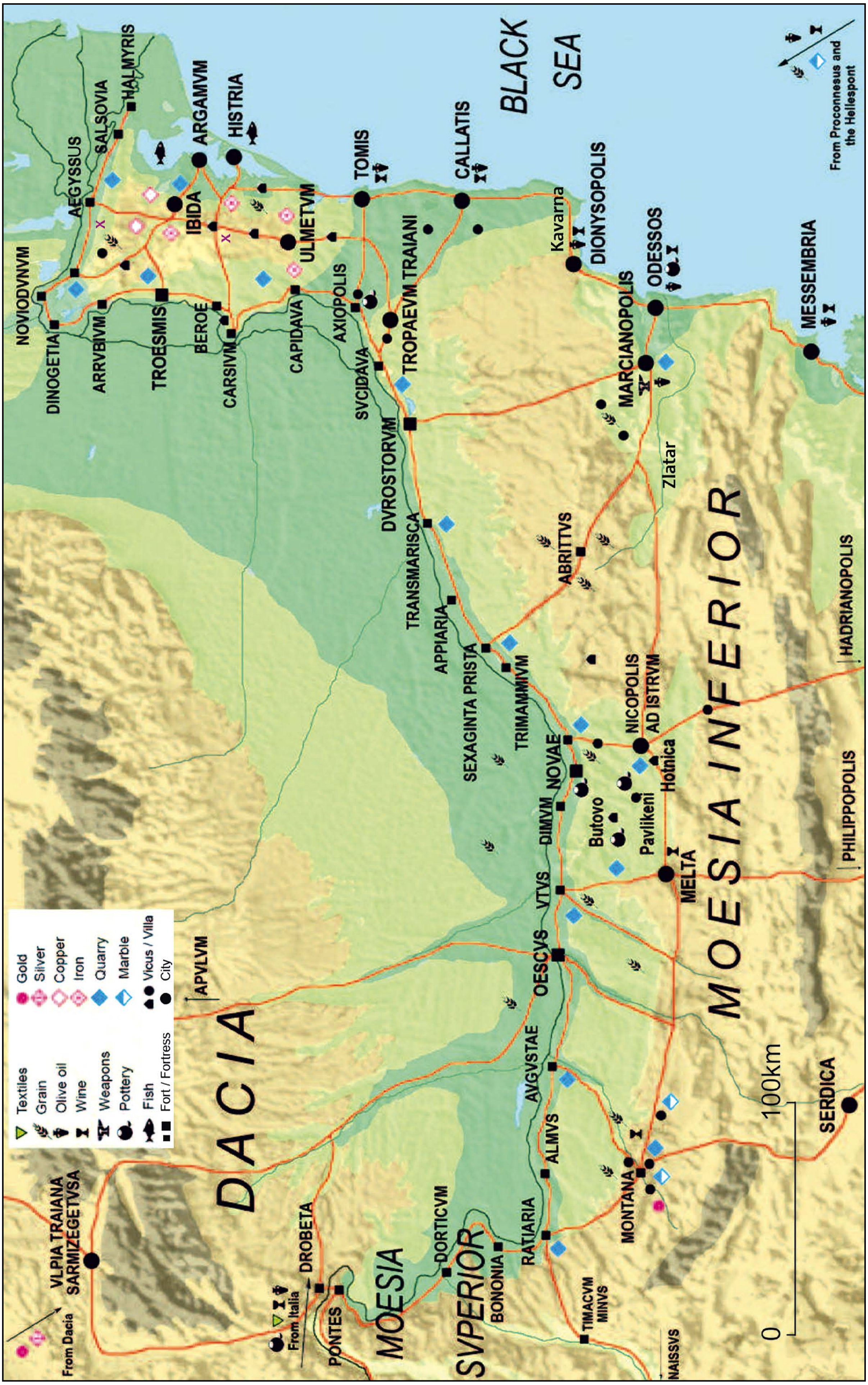

Figure 4: Map with locations on the Lower Danube in Bulgaria and Romania mentioned in the text. Illustration: C.-G. Alexandrescu, based on Lemke (2016, Fig.1).

near the city of *Dionysopolis* (Figure 4), could not be dated. It is important to mention the use of lead for fastening statues into the plinth and for connecting the parts of large-scale bronze statues. The most common use was to fasten iron clamps in stone building elements, to connect lids and coffins of sarcophagi, or to attach iron parts of millstones. Lead processing is another research topic for the territory of *Moesia Inferior* (see, for an overview, Nuţu, 2019), including pre-Roman and medieval periods (Stănică, 2015, pp.211-212).

Concerning mining archaeological evidence, field and analytical data are up to now very scarce (for the mining area from *Montana*, in the western part of *Moesia Inferior*, see Hirt, 2010, pp.70-71; Duch, 2017, p.73). For the northern region of *Moesia Inferior*, metal processing and available natural resources (Olteanu, 1973-1975; Zah, 1971; Stănică, 2015, p.202) have been approached in different short studies, most recently by Nuţu (2019) and Stănică (2015). However, as yet no satisfying answer can be given to the question if in the pre-Roman, Roman and/or medieval periods local resources (as in the areas of Somova, 10 km East of Tulcea/*Aegyssus* and Altân Tepe, near Slava Rusă/*Ibida* marked with an x on Figure 4, upper right corner) were used and to what extent (see also Talmaţchi, 2011, p.84). Imported materials – such as certainly ingots or sometimes even objects that were locally recycled or reused for special purposes – seem to have been an important lead source (for a detailed overview see Talmaţchi, 2011; for the case example of sling projectiles see Avram, Chiriac and Matei, 2013; Vlad, et al., 2011).

There are only a few lead ingot finds from this region (see Figure 4): one in *Novae* - found in a granary and dating to Late Antiquity (Dyczek, 2002, p.271) - and two ingot fragments (lead isotopically virtually identical and therefore most likely from the same ingot) kept at the Varna museum and uncovered in the vicinity of Zlatar, Shumen province, NE Bulgaria (Varna Archaeological Museum, inv.no. II8665 and II8666), dated to the early Roman period and bearing stamps of Spanish mines (Kouzov, 2002, p.98). The ingot from *Novae* is dated to the 4th century AD, bears 13 stamps and one inscription. It was read (Kolendo, 1986; Dyczek, 2002, pp.271-273) as an indication of the mining district in *Moesia Superior*, at Kosmaj (on the mining district see Merkel, 2007). Duch (2017, p.220, with further references) states that this either might refer to its provenance or could have just referred to the overseer of the smelter. All three pieces were epigraphically and geochemically analyzed in the context of the CRLI-project[5], producing the result that the late Roman ingot from *Novae* is very probably from the Derbyshire mining area (compare Recław, et al., 2024, e.g. p.10, with a different provenance result) while the two Republican ingot fragments from Zlatar were imported from the mines of Cartagena (pr. Murcia) in SE Spain.

Also worth noting are publications on lead finds – mirror frames, water pipes and seals – from the military and urban center of *Novae* (Svištov, Bulgaria) (Mrozewicz, 1981; Recław, 2002; 2003; 2009). Dyczek (2002) mentions about 300 fragments of lead objects, 89 of which (dated to 1st–6th centuries AD and with an identifiable use/shape), including the *Novae* ingot, were investigated by means of physico-chemical analyses. The described method does not mention details but refers to four possible lead sources, none of them in the Kosmaj mining district (Daszkiewicz, Recław and Gaulitz, 1998, p.168; Dyczek, 2002; Lemke, 2019). Five chronological slots between the 1st and the 6th century AD in the lead supply for *Novae* have been worked out (Dyczek, 2002, pp.279-280). It would be highly interesting to continue the investigation in order to understand the dynamics of this ancient center as well as the supply for the military along the Danube. It should also be added that in the vicinity of *Novae*, in the rural settlement of Vardim, fragments of lead sheets were uncovered in a context interpreted as a wine press (Duch, 2017, p.189).

The lead finds from *Durostorum* (Silistra, Silistra province, Bulgaria and Ostrov, Constanţa county, Romania), also one of the important military and urban centers of the province, given their character (manufacturing scraps, unfinished pieces, etc.), were subject to dedicated short publications which did not go beyond a simple description. Also, different small finds, votive statuettes and mirror frames from this site were published (Muşeţeanu and Elefterescu, 1978; Elefterescu, 2010; 2021). Furthermore, one of the richest and most interesting funerary inventories of a high-ranking military officer in *Durostorum* is also included the up to now singular find of a wooden coffin lined with lead sheeting[6], dated to the late 3rd - 4th centuries AD.

Recently, several lead finds from *Argamum* (Capul Dolojman, Jurilovca, Tulcea county), one of the Greek cities on the western shores of the Black Sea, were reported from the 'extra muros' sector (Nuţu, 2019, p.86), particularly due to their interpretation as processing debris.

In the nearby province of *Dacia*, the other Roman province on today's territory of Romania, about a decade after Volker Wollmann´s monographic publication (1996; see, on lead, pp.150-151, 392-395) on ore mining, salt extraction and stone quarries in Roman *Dacia*, Doina Benea (2007a; 2007b; 2008a; 2008b) presented a quite thorough overview of (lead) workshops as well as a survey of the possible local sources used in Roman times. Lead pipes and ingots recovered in the main urban center of *Dacia*, *Ulpia Traiana Sarmizegetusa* (Figure 4, upper left corner) are also to be mentioned (Băeştean, 2007; 2008, pp.108-113; see also Benea, 2016). Finally, fragments of lead pipes were reported for two bath buildings in a rural settlement and near *castra* (Băeştean, 2008, pp.133, 137-138).

Investigated finds

The relatively few lead finds of the 2011 to 2015 surveys in *Troesmis* and its surroundings cannot be considered representative for all the uses of lead in a Roman fortress and town and its countryside. However, they can confirm supply chains already discussed in previous publications and for this rather peripheral region of the Empire. Thus, the other finds taken into consideration as comparanda were either known to have been found in the same region or to have the same destination (bronze statue, water pipe) (Table 1).

Lead pipes

The two samples of lead pipes (*fistulae*) RO-1 and RO-2, made by applying the bend-soldering method (Fahlbusch, 1982, pp.78-80, with Fig.45), come from fragmentary pieces. Both were of small size, featuring, when closed, a diameter of about 9 cm up to 15 cm. Thus, they were potentially used for the piping of smaller buildings or fountains.

The younger history of the first lead pipe fragment to be discussed (Figures 5 and 6), sampled as RO-1 (Bucharest Municipal Museum, inv. 20261, former inv. 1078/957 C.S. and 5878, part of the collection "Maria and Dr. George Severeanu") is problematic at first sight. Its dimensions are as follows: preserved length 25.5 cm; preserved width 5 to 7 cm, while the lead sheet was about 0.55 to 0.60 cm thick. The fragment bears a manufacturer stamp in relief, with letters of about 2.3 to 2.6 cm in height: *[EX OF(ficina) MA]RTINI P<I=L>VMBARI(i) <r=V>(egionis) VI].*

The museum register in Bucharest and the hand written label by Dr. Severeanu[7], still preserved on the inner side of the fragment, state that it was purchased from Kallai, Vienna in 1923, indicating that it came from *Carnuntum* (Petronell – Carnuntum, Austria), the main military and urban Roman center in *Pannonia*, which Dr. Severeanu obviously assumed to label the excavations in *Carnuntum*.

The pipe fragment bears only a part of the initial stamp (the left part is broken) and features several peculiarities that cannot be fully explained given the state of conservation and the singularity of the piece. On the inside, a deposit of residue (sinter?) can be seen, the nature of which cannot be visually determined. Further worth mentioning are the perforations (present only over about 8 cm of the fragment's length) and denticles on the edges of the fragment, which could have been executed only into a warm and still ductile lead sheet (Figure 6, left photo). Denticles are also present on one of the short sides of the fragment. The time of this working cannot be determined, for it was not possible to identify any analogy. It is certain that this happened after the pipe was not in use any longer.

On the surface, traces of a metallic tool can be observed (Figure 6, left photo), for which analogies exist and which might come from the production phase of the sheet, namely of its bending to form a pipe. Some of the

Table 1. Roman lead objects from *Troesmis*, Horia and Greci (Romania) and a Roman water pipe fraction from Rome with short description, project, lab and archaeological numbers (DBM = Deutsches Bergbau-Museum Bochum, MMB = Muzeul Municipiului Bucureşti, MINAC = Muzeul de Istorie Naţională şi Arheologie Constanţa).

Project no.	Object	Inv.-no. DBM	Inv.-no.
RO-1	Lead water pipe (Rome)	3247-17	MMB 20261
RO-2	Lead water pipe (Horia)	3248-17	ICEM 2224
RO-3	Fragment of a bronze statue (Greci)	3249-17	MINAC
RO-4	Lead chunk for mounting/fastening a statue	3250-17	0055-13
RO-5	Lead chunk for junction of bronze statue parts	3251-17	0030/13
RO-6	Lead waste / bronze patch for fastening	3252-17	0033-12/A
RO-7	Lead waste / bronze patch for fastening	3253-17	0033-12/B
RO-8	Lead waste / bronze patch for fastening	3254-17	0033-12/C
RO-9	Lead filling of a millstone	3255-17	0048-13

Figure 5. Lead pipe fragment from Rome (sampled as RO-1), surface (upper picture) and inner side (lower picture), formerly part of the K. Hollitzer collection in Bad Deutsch-Altenburg, now at the Bucharest Municipal Museum, “Maria and Dr George Severeanu collection”, inv. no. 20261. Red arrow marks the sampling spot. Photos: C.-G. Alexandrescu.

Figure 6. Close-up of the lead pipe fragment from Rome (sampled as RO-1), surface (left) and inner side (right), formerly part of the K. Hollitzer collection in Bad Deutsch-Altenburg, now at Bucharest Municipal Museum, “Maria and Dr George Severeanu collection”, inv. no. 20261. Photos: C.-G. Alexandrescu.

letters were also flattened (Figure 5, upper photo) while the material was still warm or when the lead sheet was detached from the mold. Further, the edges of the fragment also bear traces of the cutting (Figure 6), using a flat chisel, possibly from the time when the intention might have been to cut out the inscription from the rest of the reused *fistula*. Thus, this pipe fragment shows traces of at least two further interventions after its production.

The stamp assigns the fragment to a group of Late Roman lead pipes from Rome made in the workshop of Martinus - *ex officina Martini plumbari* - from *regio VI* of the city: from *Portus*, CIL XIV 2010a; from Rome, CIL XV 7647a1, 7647a2 and 7647b, 7763 (Bruun, 2008, p.141; cf. De Kleijn, 2001, p.187, 288). The stamp is not very common, as it states the term *plumbarius* (for the terminology overview see Bruun, 2010, pp.47-48; Rothenhöfer and Hanel, 2013, p.278). The mention of the *regio* “cannot reflect any systematic recording practice and must arise from specific circumstances such as the desire to advertise a particular workshop, distinguish between people with similar names or specify where a pipe should be installed” (Goodman, 2020, p.140).

Relevant to the present discussion is CIL XV 7647a2, which at the time of the publication (1899)

Figure 7. Lead pipe fragment from Horia, near *Troesmis* (sampled as RO-2). Total recording (left), close-up with red arrow marking the sampling spot and close-up from the hardly damaged end (right). Photos: (left) C. Bodea (ICEM), (right) C.-G. Alexandrescu.

was part of the collection of the Hollitzer museum in Bad Deutsch-Altenburg but was previously part of the collection of Monsignore Cesare Taggiasco[8] in Rome. The Taggiasco collection was sold at an auction in Vienna around 1887, as the CIL quotes the auction catalogue as well. How the piece ended up at the shop of D. Kallai[9], where Dr. Severeanu bought it in 1923, is not clear. The Karl Hollitzer[10] collection is known to have been on display at the museum of the Carnuntum Association (Kubitschek, 1894, p.160). Thus, it is most probable that the piece was among those mentioned in the guide of 1894 (Kubitschek and Frankfurter, 1894, p.62) as "Bleiröhren von einer Wasserleitung (aus Italien)", next to "Bleiröhren aus dem römischen Bade in Deutsch-Altenburg". In the first edition of the *Carnuntum* guide "Wasserleitungröhre aus Blei und aus Thon" (Kubitschek, Frankfurter, 1891, p.52) and "Stücke von Bleiröhren für Wasserleitungszwecke" (Kubitschek and Frankfurter, 1891, p.54) are mentioned as parts of the collections displayed in the house in Badhausgasse. There is no statement as to whether the lead and clay pipes were inscribed[11]. In the three years between the editions of the *Carnuntum* guide, the display in the house of the association was obviously organized. It is not the purpose of this contribution to pursue the history of this institution. However, it is necessary to mention that some finds[12], including the lead pipe fragment of interest here, have been sorted out at some point in time by collection owners, eventually in order to keep only the finds from *Carnuntum* and its surroundings.

Initially the fragment was selected by us for analysis for comparative reasons only. However, in addition to determining the provenance of the lead itself it was important that we were able to clarify the history of this find and to illustrate it for the first time after its initial documentation for CIL at the end of the 19^{th} century.

The lead pipe fragment (Figure 7) from a main building in the rural settlement of Horia (Tulcea county) in the region south of *Troesmis* (Figure 1), sampled as RO-2 (now at the Tulcea museum, inv. 2224), is up to now an isolated find in the northern part of the province of *Moesia Inferior*. V. H. Baumann dates the building (that he identifies as a *villa*) to the 2^{nd} century AD. The fragment measures about 29.5 cm in length, its diameter is of about 8 cm (difficult to measure, as it is quite flattened), and the lead sheet itself is about 0.3 cm thick. It shows traces of fire and is strongly damaged, while on the side there is a perforation through the pipe wall (Figure 7, left illustration, central photo), most likely made for being used in the piping system.

The archaeological context of the pipe fragment (Baumann, 1983, p.183, Pl.XLI/4), in the baths area from

Horia (Baumann, 1972, p.52, Fig.22) or in Annex I next to the southern wall of the main building (Baumann, 1983, p.183), is not easy to pursue. It seems to have been under a layer of building remnants/debris? at a substructure level, which made the author of the excavation (erroneously) relate it to the sewer system (Baumann, 1983, p.119). During the excavations, in the annexes of the main building, several metal items were found, indicating that the area was not searched in antiquity for recyclable materials. Thus, it remains open to interpretation if this fragment was found in situ or lost in a layer of debris, or eventually brought there for the purpose of being reused.

Architectural elements and remnants of wall painting were found in the main building in Horia; both were simple, but part of a kind of portico, all giving expression to the taste of the owner of the building for more luxurious facilities following Mediterranean patterns. The author of the excavation considers that the building had a single phase of use. However, the other finds suggest that at first the pipe might have been used in one of the basins or in the garden, before being damaged and collected for recycling. Further finds are quite scarce, but a group of glass items is worth mentioning (Baumann, 1983, pp.182-183, Fig.66).

The character and extent of the rescue excavation do not allow for proper evaluation. It is worth noting that nearby, given the strategic location of the site, further settlements and necropolis areas are recorded, some dated to the 4th century AD. They show evidence of the reuse of lithic materials from earlier monuments, including a marble votive relief bearing the name of Annaeus Pulcher (Baumann, 1983, p.123), considered by Baumann to have been the owner of the *villa*. This, together with the example of a folded lead sheet (re)-used as an anvil for making or repairing small items found in the rural settlement of Teliţa-Valea Morilor, 'Hogea' site (Baumann, 1995, pp.276-280, pl. LVI/2), in the vicinity of the ancient center of *Noviodunum* (Figure 1), in a context dated to the 4th century AD, supports the hypothesis of a general collection for recycling purposes. This practice was investigated in other regions of the Roman Empire (particularly for lead scrap collecting and reuse see e. g. Fort, Tisserand and Simonin, 2010).

Figure 8. Fragment of large-scale bronze statue (horse leg) from Greci (sampled as RO-3), now in MINAC, inv. no 4901. In the interior of the statue, a chunk of lead used for a large repair inlay (lower right picture). The red arrow marks the position of the loose bronze pieces. Photos: C.-G. Alexandrescu.

Figure 9. *Troesmis* – lead filling for fixing a statue's foot (?) to the plinth (sampled as RO-4). The red arrow marks the sampling spot. Photo: C.-G. Alexandrescu.

Large-scale bronze statues

The assumed large-scale bronzes in and around ancient *Troesmis*, the legionary camp and the later *municipium* were archaeologically recorded based on several fragments. These are an old chance find from the 1950s, made in the agricultural fields of the Greci commune, Tulcea county (Figure 1), and fragments documented in 2013 in the civil settlement in the course of a surface survey (Barbu, 1965, pp.399-400; Alexandrescu, Gugl and Kainrath, 2016). Two finds were suitable for sampling for material provenance analysis.

RO-3 was taken from the fragmentary horse's right hind leg (preserved height of 53.5 cm) from an equestrian statue (Figure 8) found in Greci (now in MINAC, inv. no 4901). Inside the leg there are chunks of lead from additional repairs made after casting, using quite large patches fastened from the inside of the statue (see details in Figure 8).

As the fragment is broken above the hoof, it cannot be verified if some of the lead inside is part of the lead poured into the leg as a weight to improve the balance of the statue or if it was connected to fixing the statue to the plinth. It was not possible to take an actual drill sample, but then, at the laboratory, two collected loose pieces turned out to be leaded tin bronze, so actually part of the statue.

It is probable that the chunk of lead 0055-13 (Figure 9), found near the area of the northern necropolis, sampled for RO-4, may be poured lead for fixing a statue (not necessarily a bronze statue) to the plinth. It measures about 14 x 11 x 7 cm. It features the negative of large pin/iron (3.5 x 3.5 cm) reinforcement and traces of tools. In the Roman Imperial age, a statue was often rather fixed to a metal panel or base than to the stone base itself (Willer, 1996). However, exceptions are known, such as the fragments of the larger-than-life statue from the Jupiter column from the *canabae* of Mainz (Riemer, 2014, pp.87-89; Willer, Schwab and Mirschenz, 2016, pp.148-150).

Sample RO-5 comes from a lead square patch (6 × 4 x 0.4 cm) by help of which two elements of a bronze statue (0030-13; dimensions of the bronze parts 13.4 × 18 cm, about 0.26-0.3 cm thick, see Alexandrescu, Gugl and Kainrath, 2016, cat. no. Bz1, pl.54), possibly from a horse, were connected on the back (Figure 10). To

Figure 10. Fragment of a large-scale bronze statue from *Troesmis* – in the interior (right photo), a chunk of lead used for joining two bronze elements (sampled as RO-5). The red arrow marks the sampling spot. Photos: C.-G. Alexandrescu.

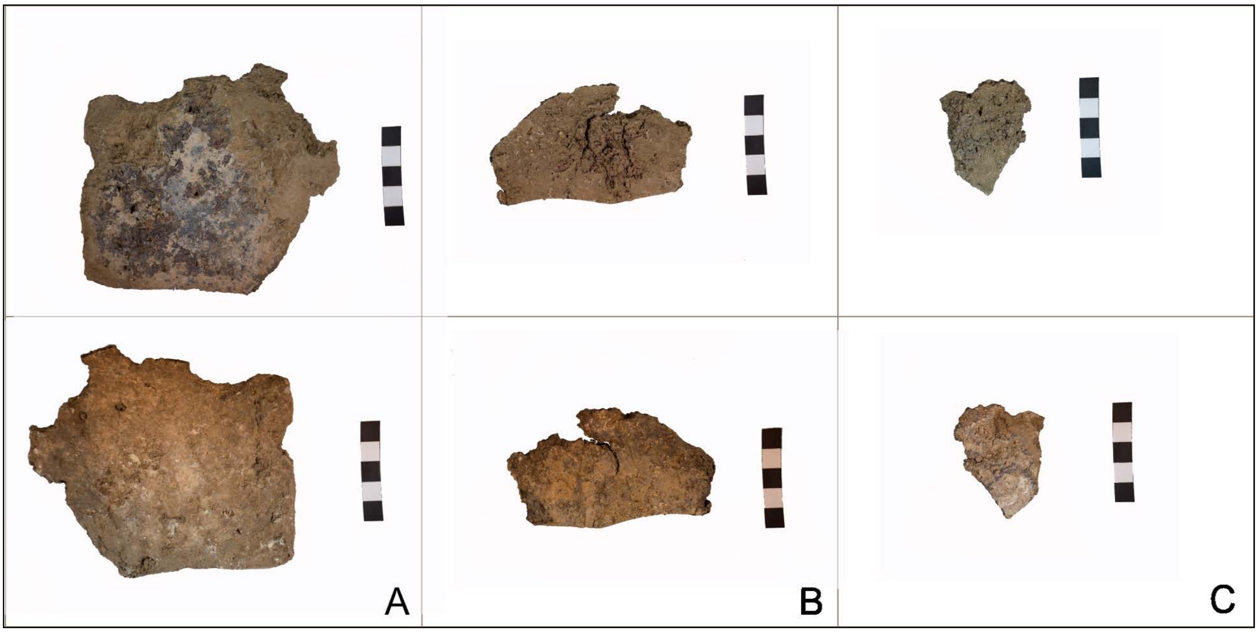

Figure 11. Three lead fragments from location 0033-2012, both sides shown (sampled for RO-6 to RO-8). Photos: C.-G. Alexandrescu.

date, however, no such similar mounting has been found among finds of this type.

The production procedures and techniques for large-scale bronze statues, large bronze tables with inscriptions, and lead pipes are known to have been the work of specialists. Furthermore, the final steps of mounting and putting into service monuments and plumbing might require at least adequate know-how, if not specialist craftsmen. The lead was needed in large quantities for several works related to those major objects within a fortress or city, not only during production (repairs of potential cast errors, the connecting of statue elements, cast separately) but also during fixing to a plinth or a wall. The question of the production of large-scale bronze statues in the provinces of the Roman Empire is still subject to debate (see, e.g. Willer, 2014), while the matter of the used lead was more or less neglected until recently (Willer, Schwab and Mirschenz, 2016).

The fragments from the large bronze statues, especially the equestrian one, may possibly be dated to the early 2nd century or the last quarter of the 2nd century AD, as the main historical events in *Troesmis* are recorded: the dislocation of *legio V Macedonica* and the building of its new headquarters, respectively, granting *Troesmis* the status of a *municipium*.

Flat chunks of lead for mounting items like the bronze tables from *Troesmis*

In the course of the surface survey in the area of the civilian settlement of *Troesmis,* looting excavation pits are not an infrequently encountered disturbance. In one case (0033-12, Figure 2), however, the extent of the excavation was striking and thus a reason for a closer examination. Numerous roof tiles, debris and fragments of flat chunks of lead, which might have served for fixing, were documented. Three flat chunks of lead were sampled as RO-6, RO-7 and RO-8 (Figure 11). They

Figure 12. Hand millstone from *Troesmis*, with iron elements fixed with lead. The red arrow marks the sampling spot for sample RO-9. Photo and drawing: C.-G. Alexandrescu, after Alexandrescu, Gugl and Kainrath, 2016, pl.53.

have a surface of about 12 x 11 cm (Fragment A, RO-6), 6 x 9.5 cm (Fragment B, RO-7) and 5 x 4 cm (Fragment C, RO-8), respectively, and are about 0.3 to 0.6 cm thick. All feature blue shaded coloured oxidation, with fresh aspect, similar to the one observable on the back of Table A of the *lex Troesmensium* (Figure 3, right photo).

Poured lead for the millstone

Sample RO-9 was taken from a runner (Figure 12), i.e. the upper part of a rather common hand millstone, used for the grinding of grains, documented during the surface survey in the area of the Roman period civilian settlement of *Troesmis* (TR0048-13; Alexandrescu, Gugl and Kainrath, 2016, cat. no. S8, Pl.53). The iron elements are fixed to the stone element by help of poured lead.

Roman hand millstones in the northern part of the province were imported from the southern regions of *Moesia Inferior*, where a suitable stone type was available (Alexandrescu, Gugl and Kainrath, 2016, p.242). As the millstone was functional with its metal elements, it can be assumed that it was delivered already in finished state, i.e. with the lead poured for the fastening of the iron parts.

Analytical Procedures

Sampling

With the sampling strategy described above, a total of eight lead samples and one sample of a leaded tin bronze (sample RO-3 was taken from the thicker, loose piece) were collected for lead isotope and trace element analysis (Table 1). Drill samples were taken using 1 mm steel drill bits. The drill bits were replaced after each sampling, to minimize contamination. Samples of about 0.5 cm^2 were taken from the lead chunks (samples RO-4 and RO-6 to RO-8), the two loose pieces of bronze from the inside of the statue fragment had the size of a finger nail. The sampling spot respectively the place where they broke off (see Figure 7) is marked with a red arrow on Figures 4 and 6 to 10.

Chemical treatment and analytical methods

50 mg of each lead sample (RO-1 to RO-2, RO-4 to RO-9) were dissolved in dilute nitric acid (2.5 ml $H_2O_{dest.}$/1.5 ml $HNO_{3conc.}$) for chemical analysis. The stock solution was filled up to a concentration of ca. 1000 mg/l with $H_2O_{dest.}$. The sample solution was further diluted 1:10 with 5 % nitric acid for the trace element measurement. The analytical procedure was carried out with a SF-ICP-MS (Element XR, Thermo Fisher Scientific). Like also with the bronze sample, quantification was performed with external calibration using single element standard solutions. The introduction system was running with FAST SC-system, ST 5532 PFA μ-FLOW nebulizer, Peltier-cooled PFA spray chamber and 1.8 mm sapphire injector. Analyses were running in triple detector mode at all three different mass resolutions. The measurements were controlled by help of standard materials PG 3 to PG 5 (Brammer Standard Company, Inc., Houston, USA). The relative standard deviation for the trace elements varied between 0.5 and 5 %, depending on intensities (counts per second).

25 mg of bronze sample (RO-3) were dissolved in a mixture of 2 ml $H_2O_{dest.}$/1.5 ml $HNO_{3conc.}$/1.5 ml $HCl_{conc.}$ for bulk chemical analysis. The stock solution was filled up to a concentration of ca. 1000 mg/l with $H2O_{dest.}$. As with the lead samples, the solution was further diluted 1:10 with 5 % HNO_3 for the trace element measurement. Before, for the determination of the amounts of major and minor elements, the stock solution was diluted 1:100 with 5 % HNO_3. Standard materials for comparison were copper metal standard BAM 376 (Bundesanstalt für Materialforschung, Berlin) and tin bronze standard Bronze C (British Chemical Standards, Middlesbrough, UK).

The digestion solutions of all nine samples were used for lead isotope determination without further chemical treatment (for bronze sample RO-3, compare e.g. method of Karasiński, et al. (2023), for MC-ICP-MS analysis without matrix separation). Analyses were performed at FIERCE (Frankfurt Isotope & Element Research Center, Goethe Universität Frankfurt, Germany) with a MC-ICP-MS (Neptune Plus, Thermo Fisher Scientific). Generally, 40 samples are measured in a series. The dried lead eluate is diluted with 2% HNO_3 to about 125 ppb Pb. A 10 ppb concentrated Tl solution standard solution (NIST SRM-997) is added for internal fractionation correction. Solutions of 125 ppb NIST SRM-981 lead standard are interposed after every 5 samples to check the accuracy and stability (mass drift). Standard deviations are shown in Table 4.

Interpretation of the analytical results

The chemical compositions of the lead samples and the leaded bronze sample

Lead samples

A comparison of trace element patterns between ancient lead objects and potential ores is strongly limited, since ancient metallurgists found out that lead ore is

Table 2. Trace element composition of the lead samples.

Project no.	wt.% Ag	wt.% Sn	wt.% Sb	wt.% Te	wt.% Bi	wt.% P	wt.% S	wt.% Fe	wt.% Co	wt.% Ni	wt.% Cu	wt.% Zn	wt.% As	wt.% Se
RO-1	0.009	0.009	0.007	0.000	0.002	0.001	0.004	0.004	0.000	0.000	0.028	0.007	0.000	0.000
RO-2	0.017	0.002	0.026	0.002	0.039	0.020	0.007	0.012	0.000	0.003	0.10	0.000	0.001	0.000
RO-4	0.008	<0.0002	0.052	0.001	0.007	0.001	<0.0010	0.004	0.000	0.001	0.045	<0.0003	0.012	<0.0003
RO-5	0.017	0.003	0.008	0.000	0.002	<0.0004	0.002	0.001	0.000	0.001	0.068	<0.0003	0.017	0.000
RO-6	0.013	0.18	0.027	0.000	0.016	0.001	0.002	0.004	0.000	0.000	0.037	<0.0003	0.003	0.000
RO-7	0.011	0.15	0.023	0.003	0.013	<0.0004	<0.0010	0.000	0.000	0.000	0.032	<0.0003	0.003	<0.0003
RO-8	0.013	0.19	0.027	0.001	0.016	0.005	0.001	0.004	0.000	0.001	0.056	<0.0003	0.003	<0.0003
RO-9	0.013	0.18	0.028	0.001	0.017	0.002	0.001	0.002	0.000	0.000	0.038	<0.0003	0.003	<0.0003

also an important silver carrier (e.g. Hess, et al., 1998). With the cupellation of silver-bearing lead at high temperatures and enforced oxygen supply, its trace elements behave different. For example, precious metals such as gold or platinum alloy intensively with the remaining silver. Other elements only partially migrate into the silver (e.g. Cu, Bi), oxidize very easily together with the liquid lead (e.g. Fe) or behave in a rather volatile manner (e.g. As, Sb) (Pernicka and Bachmann, 1983, pp.592-597; Pernicka, 1990, p.58). With regard to the very low silver contents in Roman lead ingots, it is obvious that the extraction of silver was practiced hand in hand with their production. Therefore, it is rather unlikely to find Roman lead with a pristine chemical composition.

In addition to information about how to interpret the silver content (Tylecote, 1987, p.139; Rehren and Prange, 1998, p.189), the chemical composition shows the quality of the lead ores. Copper or As and Sb values e.g. indicate a significant intergrowth with Cu ores and/or fahlores. In general, significant features in the trace element pattern might still be useful provenance indicators or help group lead objects with the same chemical character. The composition in some cases may also be considered as an authenticity test.

The silver contents of all samples are in the range of 0.01 wt.%. This observation supports the hypothesis that Roman lead is in principle desilvered (see Table 2). However, this does not necessarily apply to samples RO-6 to RO-9 (or even RO-2), since no significant depletion of Bi (together with Ag) can be observed with these samples, as recently verified by cupellation experiments (L'Héritier, et al., 2015, p.66). For our case studies, however, it must be mentioned that we have no information about the composition of the smelted ores and thus of the initial lead composition. It is particularly striking in Figure 13 (plot c) that samples RO-6 to RO-9 show very similar Sn contents. This is not surprising for objects RO-6 to RO-8, as they come from a single looting trench within the settlement area, while the lead of RO-9, with the grain mill, is most probably an import from the southern areas of the same province, where it was possibly also put together. The four samples are symbolized as red triangles (also in the following lead isotope diagrams). Diagrams a and b in Figure 13 underline a close relationship. It must then be assessed if the lead isotope results give a similar picture.

The leaded tin bronze sample

The leaded bronze RO-3 is a deliberate alloy of Cu, Pb and Sn (Table 3). It is relatively rich in impurities such as Ag, As, Sb or S, which very probably entered the bronze with fahlore-bearing Cu ore. The strong corrosion of the object has significantly influenced the Cu and Sn contents in the dissolved sample (a light white SnO_2 precipitation in the solution visible), so that the Sn content in the fresh bronze metal may be supposed to have originally been higher.

The lead isotope compositions of the lead samples and the leaded bronze sample and deduced provenance of the lead

The lead isotope ratios in Table 4 show that the lead of the objects presumably comes from four different sources, or perhaps from common sources with a relatively

Table 3. Bulk chemical composition of the leaded bronze sample RO-3 (lack of sum due to severe corrosion).

Project no.	wt.% Ag	wt.% Sb	wt.% Te	wt.% Bi	wt.% P	wt.% S	wt.% Fe	wt.% Co	wt.% Ni	wt.% Zn	wt.% As	wt.% Se	wt.% Sn	wt.% Pb	wt.% Cu	wt.% sum
RO-3	0.031	0.28	0.002	0.004	0.15	0.27	0.066	0.002	0.015	0.003	0.049	0.002	6.98	17.8	62.4	88.0

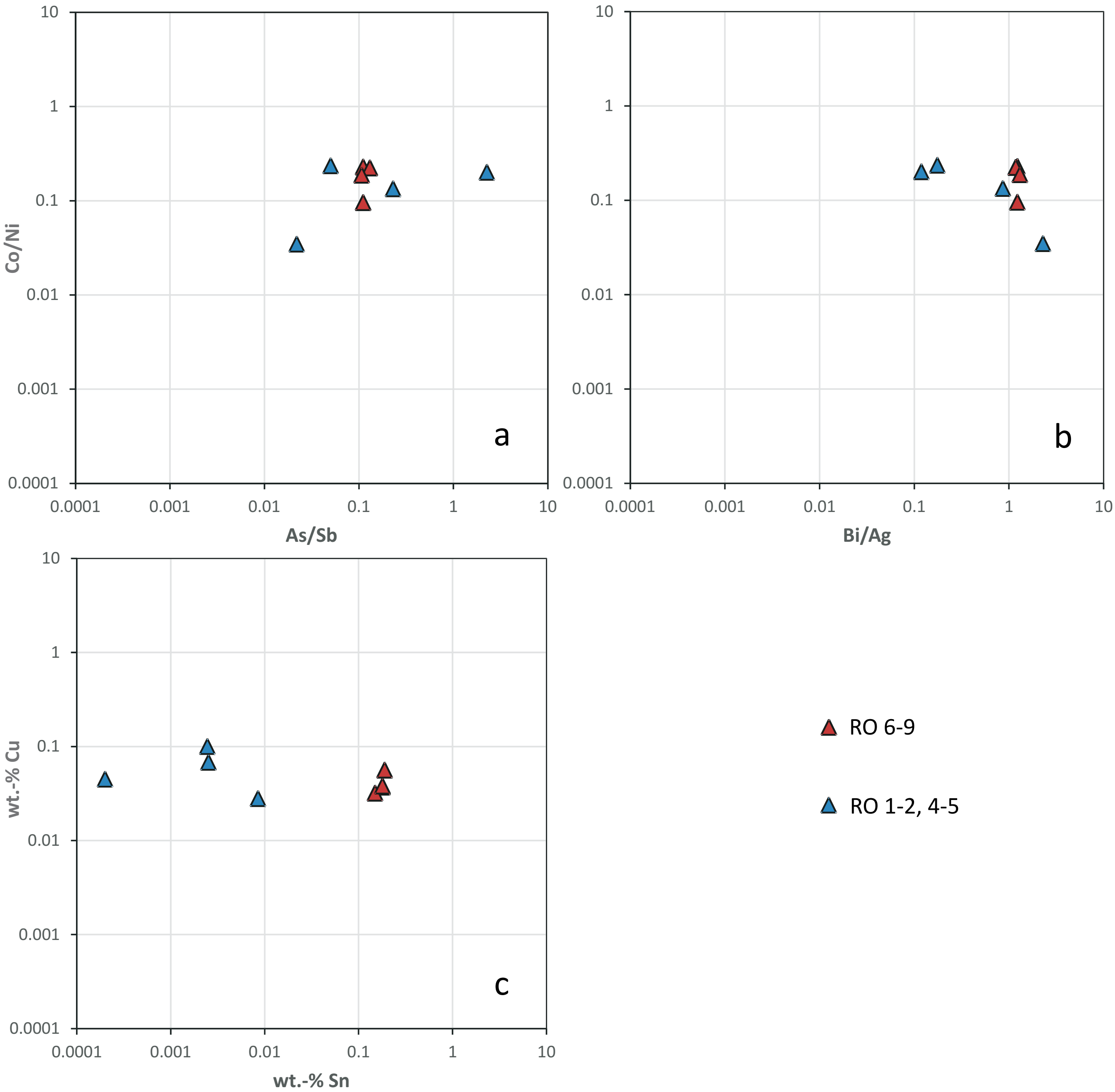

Figure 13. Trace element plots a and b with As, Bi, Co and Sb as ratios and c with Cu- and Sn-values for RO-1 to 2 and 4 to 9 (note: sample RO-4 for Sn is within the detection limit, compare Table 2). Trace element ratios are selected according to similar chemical behavior and tendency to oxidize. Graphics: M. Bode.

Table 4. Lead isotope compositions of samples RO-1 to RO-9 with 2-sigma standard deviations.

Project no.	$^{206}Pb/^{204}Pb$	2SD	$^{207}Pb/^{204}Pb$	2SD	$^{208}Pb/^{204}Pb$	2SD	$^{207}Pb/^{206}Pb$	2SD	$^{208}Pb/^{206}Pb$	2SD	$^{204}Pb/^{206}Pb$
RO-1	18.445	±0.0049	15.646	±0.0046	38.538	±0.013	0.848	±0.00006	2.089	±0.00025	0.054
RO-2	18.612	±0.0038	15.656	±0.0036	38.758	±0.010	0.841	±0.00008	2.082	±0.00018	0.054
RO-3	18.379	±0.0047	15.639	±0.0043	38.485	±0.013	0.851	±0.00008	2.094	±0.00026	0.054
RO-4	18.702	±0.0036	15.665	±0.0038	38.827	±0.010	0.838	±0.00009	2.076	±0.00031	0.053
RO-5	18.691	±0.0034	15.665	±0.0035	38.805	±0.009	0.838	±0.00008	2.076	±0.00027	0.054
RO-6	18.717	±0.0040	15.665	±0.0038	38.848	±0.012	0.837	±0.00005	2.076	±0.00020	0.053
RO-7	18.717	±0.0041	15.665	±0.0043	38.849	±0.011	0.837	±0.00008	2.076	±0.00027	0.053
RO-8	18.717	±0.0033	15.665	±0.0034	38.848	±0.010	0.837	±0.00006	2.076	±0.00027	0.053
RO-9	18.685	±0.0069	15.664	±0.0059	38.808	±0.016	0.838	±0.00010	2.077	±0.00034	0.054

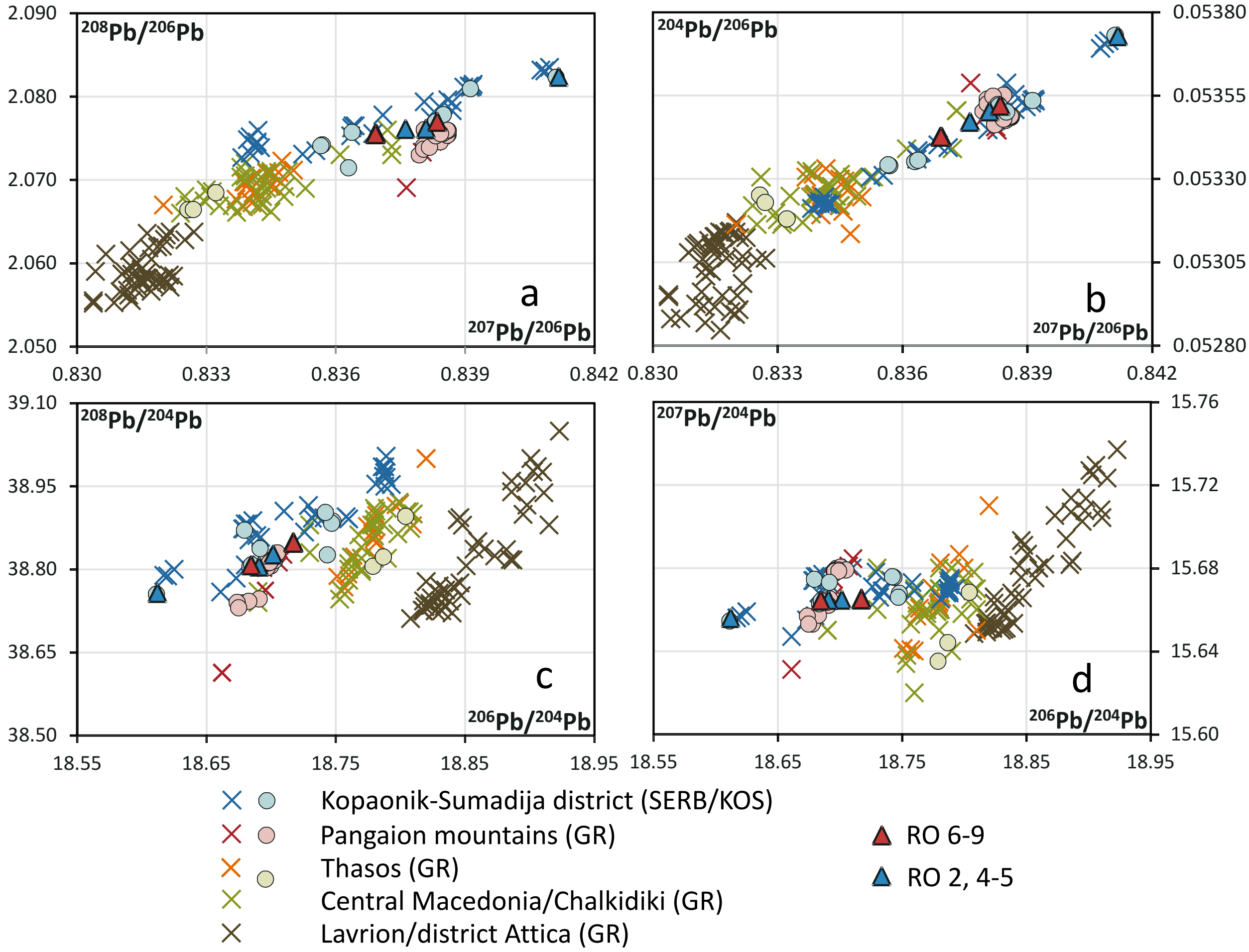

Figure 14. Lead isotope Diagrams a to d in different ratio combinations with data from lead ore deposits (colored crosses) in Kosovo/Serbia and Greece and assigned Roman lead ingots (similar colored circles, for visual reasons not for data from Thasos) in comparison with the lead objects from *Troesmis*, Horia and Greci. Most ore data was performed with thermal ionization mass spectrometry (TIMS) and errors of ca. 0.1 % (external reproducibility). Error bars of our data and ingots are of symbolic size. Ore data from Gale (1980); Wagner, et al. (1986); Chalkias, et al. (1988); Gale, Picard and Barrandon (1988); Vavelidis, et al. (1988); Pernicka, et al. (1993); Stos-Gale, Gale and Annetts (1996); Veselinovíc-Williams (2011); Westner (2017). Roman lead ingot data from Domergue, et al. (2012); Bode, Hanel and Rothenhöfer (2021)[15]. Graphics: M. Bode.

wide range of isotopic signature (RO-1, RO-2, RO-3, RO-4 to RO-9). The following lead isotope diagrams not only provide a comparison with potential Roman lead ore deposits but also with Roman lead ingot data (Domergue, et al., 2012; Rothenhöfer, Bode and Hanel, 2018; Bode, Hanel and Rothenhöfer, 2021; Rothenhöfer, Bode and Hanel, forthcoming) (Figures 13 to 15). The addition of lead ingot data is advisable because, as mining products, they show the isotopic composition of the ores mined at that time. Secondly, due to a mixing effect during smelting and casting, the LI data generally show a smaller range for the lead ingots than for the original ore material, leading to much more concrete lead isotope fields for the Roman lead sources. Furthermore, lead ore data in literature were in most cases produced for geological/geochemical studies and not taken from old mining areas or ancient dumps. The comparison with lead ingots is therefore more direct and accurate.

Provenance of the lead objects from *Troesmis*, Horia and Greci (Romania)

For the lead objects RO-2 and RO-4 to RO-9, ancient lead mines from South-Eastern Europe and ingots produced there are possible as the best matching candidates (Figure 14). For the Danube region including Serbia and Kosovo, Roman lead mining is attested in several places[13]. And, more recently, there is also strong evidence for the mass production of lead on the Chalkidiki peninsula and in the Pangaion mountains in the Roman province of *Macedonia* (Bode, Hanel and Rothenhöfer, 2021 with references for mining archaeological information, more recent information for Pangaion in Nerantzis, Nodin and Papadopoulos (2022, pp.66-78)). The old mining district of Lavrion on the Attica peninsula can easily be ruled out as a supplier. None of the lead ingot groups in Diagrams a to d show an overlap with the lead isotope fields of the ore deposits there, which is under-

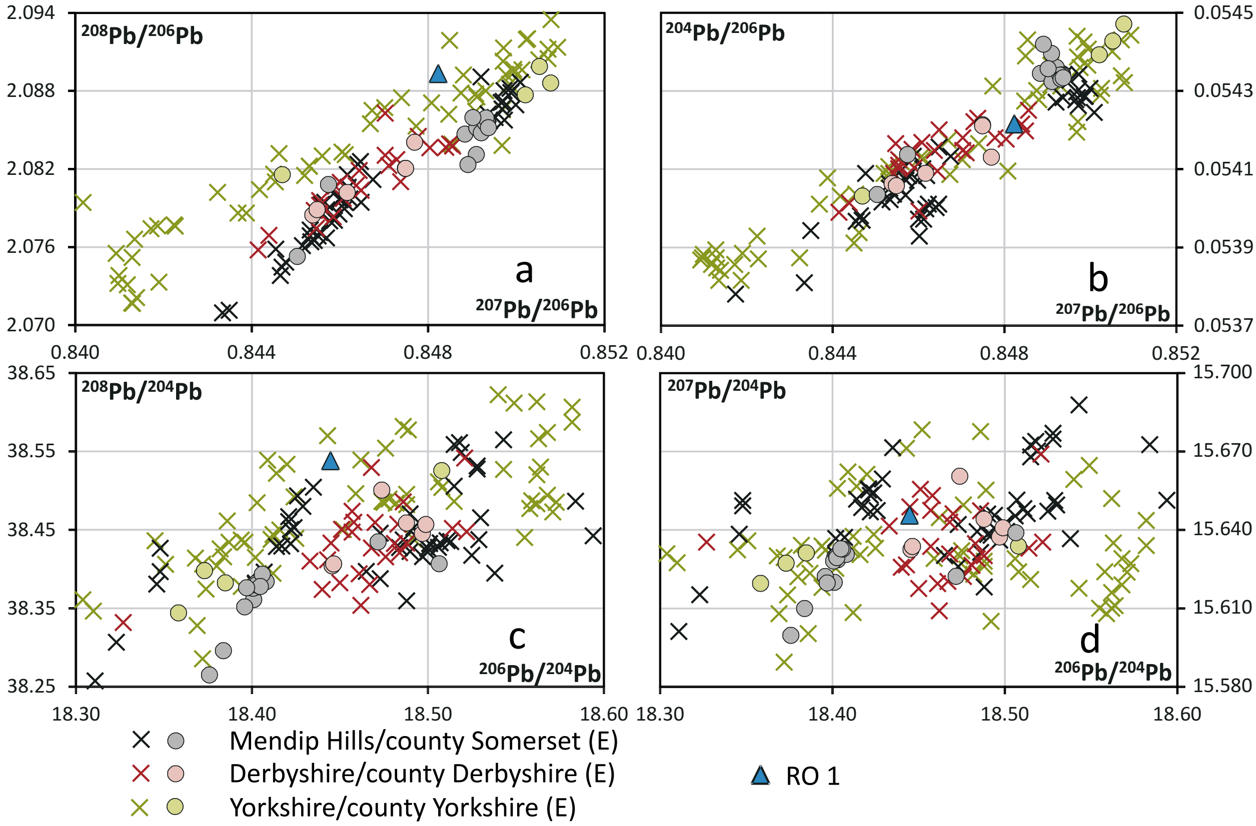

Figure 15. Lead isotope Diagrams a to d in different ratio combinations with data from lead ore deposits (colored crosses) in Britain and assigned Roman lead ingots (similar colored circles) in comparison with the water pipe fraction from Rome. Ore data was performed by way of thermal ionization mass spectrometry (TIMS) and errors of ca. 0.1 % (external reproducibility). Error bars of our data and ingots are of symbolic size. Ore data from Rohl (1996). Roman lead ingot data from Gardiner (2000); Rothenhöfer, Bode and Hanel (forthcoming). Graphics: M. Bode.

standable, because the silver mines of Lavrion had no economic significance in the Early Imperial Period (see e.g. Kalcyk, 1982, p.245; Nriagu, 1983, p.140).

The lead objects of *Troesmis*, Horia and Greci, which are again divided into red and blue triangles according to their chemical grouping (see Figure 13), partly overlap with lead ingots and/or lead ores of the Pangaion (pale red crosses and circles) or Chalkidiki deposits (olive crosses). But the orientation of the two groups in the diagrams clearly indicate that the lead originates from the districts in Serbia and Kosovo (blue crosses). Interestingly, the lead of water pipe RO-2 seemingly comes from the mining district of Novo Brdo (Kopaonik district), for which a lead ingot from the Roman aristocrat Messallinus has recently been described (Rothenhöfer, Bode and Hanel, 2018)[14]. The fact that the lead isotopy of RO-9 deviates slightly from the values of RO-6 to RO-8 is understandable given the fact that it is lead from an imported grain mill.

However, a small number of galena data from the Roman Au-Ag-mining district of Roșia Montana (Cetate, Țarina, Romania), which apparently played no significant role in the Au-Ag extraction on site (which was depending on lead imports from Roman Pb-Ag mining in the region), were also cross-checked with our lead object data (Baron, et al., 2011, p.1099, Fig.1, Tab.2) and also with galena samples from the Apuseni and Baia Mare ore districts in the Romanian Carpathian Mountains (Marcoux, et al., 2002, p.177, Tab.1). It turned out that both data sets (not presented in Figure 14) did not provide any convincing match with the *Troesmis* lead object data.

Provenance of the water pipe fragment from Rome

The water pipe fragment RO-1 does not match lead or lead ore from south-eastern European provinces. In Figure 14, upper part, its data symbols are outside the windows in all diagrams. The most likely origin is *Britannia*. Figure 15 now brings together lead ore data from British deposits where the exploitation and export of lead during the early Principate (1st to 2nd centuries AD) is confirmed by a significant number of ingots from Britain, France, Italy and the Netherlands[16]. It must be noted here that a convincing provenance result is not directly obvious, but focusing on Diagrams a and c it can be concluded that an origin for the lead of the water pipe

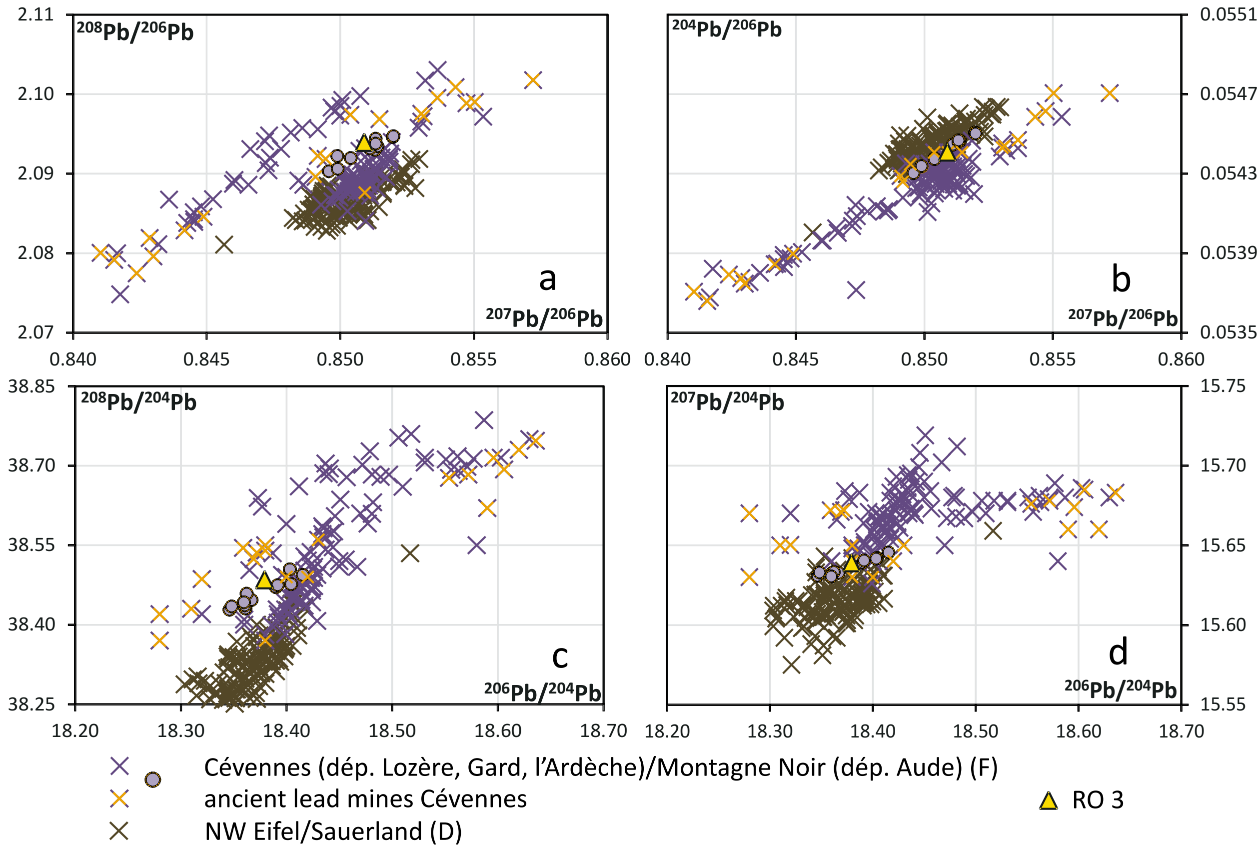

Figure 16. Lead isotope Diagrams a to d in different ratio combinations with data from lead ore deposits (colored crosses) in South France and North-West Germany and the Cévennes assigned Roman lead ingots (similar colored circles) in comparison with the leaded bronze fragment from *Troesmis*. Ore data was performed by way of thermal ionization mass spectrometry (TIMS) and errors of ca. 0.1 % (external reproducibility). Error bars of our data and ingots are of symbolic size. Ore data from Brévart Dupré and Allègre (1982); Le Guen, Orgeval and Lancelot (1991); Sinclair, Macquar and Rouvier (1993); Baron, et al. (2006); Bode (2008). Roman lead ingot data from Rothenhöfer, Bode and Hanel (forthcoming). Graphics: M. Bode.

from the mining districts in Yorkshire (green crosses) is most likely (two further lead ingots from Yorkshire do not coincide with RO-1)[17]. Interestingly, together with the water pipe two lead ingots also attest to lead trade with Rome. They were most probably produced in the Mendip Hills, but lead from Yorkshire also reached the continent (shown by the Roman lead ingot fragment from Franekeradeel-Achlum (pr. Fryslân, NED), see e.g. Rothenhöfer and Bode, 2012, p.349)[18].

Provenance of the leaded bronze fragment from *Troesmis* (Romania)

According to the lead isotope comparison, the lead of the bronze fragment RO-3 was produced in Southern France. Figure 16 shows a very good match with data from ancient mining sites in the Cévennes and assigned Roman lead ingots (purple-orange crosses and circles with orange rims)[19]. Other ancient mining regions with relatively comparable isotope compositions, e.g. in Germany (dark olive crosses), can be ruled out. The lead ingots shown in the diagrams date to the Augustan period and come from a shipwreck near Rena Maiore (Sardinia) (see Riccardi and Genovesi, 2002; Genovesi, 2018; Hanel, 2018). But there are more finds highlighting the southern region of France: silver objects from Georgia, an Augustan denarius from Colchester (E) (Parjanadze and Bode, 2018, pp.43-47)[20], lead bronze fragments from Narbonne (F), a group of brass artifacts from the territory of Bohemia, and a shipload of brass ingots (Aléria, Corse) (Hanel and Bode, 2016, pp.172-174; Bode and Hanel, 2022, pp.55-63; Bursák, et al., 2022). They all testify to a supra-regional metal production in the *Gallia Narbonnensis* in the Early Imperial Period.

Conclusion and prospects

The finds examined show a relatively diverse picture according to the provenance of the material: most lead objects were made of lead from relatively nearby mines in Serbia and Kosovo. But the fact that the lead addition of the bronze alloy of the equestrian statue (RO-3) most probably was produced from lead ores originating from the Cévennes is surprising and highlights this mining region once again (see above). Further investigations of the fragment in order to verify more of the lead patches and this way perhaps the place of manufacturing the statue would enrich this result. However, the identified provenance confirms once more the functioning long distance trade network between the province of *Moesia Inferior* during the Early Imperial Period, especially for the sites along the Danube, and the known supply regions for different materials (marble, lead) and trade, like ceramics, glass, or textiles (see Lemke, 2016; 2019; Duch, 2017).

An intact transportation system also seems to have existed in the Late Roman Empire. For this article, this assumption is underlined not only by the late Roman British lead ingot from *Novae*, but also by the lead pipe fragment from Rome (RO-1). Generally, the only documented active lead producer for this period are the mining regions in Britain (Derbyshire, Yorkshire) (Rothenhöfer, Bode and Hanel, forthcoming).

It is important to mention that the analyses presented here must be supplemented in the future by provenance analyses of the two bronze tables with the municipal law of the *municipium Troesmis*. This would provide the only evidence for the provenance of the two tables.

Acknowledgements

This study, especially the material analyses, was carried out with the financial support of the project PNII-RU-TE-2014-4-2063: *Natural resources, landscape and ancient settlements in north-western Moesia - case study Troesmis*. C.-G. Alexandrescu would like to thank the colleagues from the museums in Tulcea and Bucharest, for the permission to investigate the lead pipe fragments from Horia and "Carnuntum", and to the colleagues from the museum in Constanța for the access to the horse leg from a large bronze statue from Greci. We would also like to thank the anonymous reviewers and the native speaker for their corrections and constructive suggestions.

Notes

1 The tables are in very good condition, except for a crack in the lower left corner of table B and for the fact that the last few lines of the same table are barely legible, due to surface damage. Judging by the marks, the two tables were bordered by a frame, according to the common practice for similar bronze tables. However, there are no holes for fastening the tables, thus the tables may have been fastened with mortar and lead rather than nails or hooks – such tables had to be hung in a busy place in the town in question, probably on the wall of a public building (Eck, 2016b).

2 Information on the applied methods and investigated issues kindly provided in 2016 via email by the late Dr. B. Constantinescu, who made the expert report for the Court of Law. Material provenance investigation of the lead was not included in the analyses of materials conducted within the procedures for returning the finds to Romania, although their main aim was to establish the material connection between artifacts and their supposed provenance.

3 The lead mirror frames are better investigated due to their find contexts (e.g. as part of the funerary inventory, see Oţa, 2013, p.231). Especially after the discovery in *Sucidava*, a fortification on the Danube, on the territory of the Dacia province, of an assemblage considered (given the featured variety in shape and ornament) a trader's inventory, a collection of votives removed from a sanctuary or a scrap metal deposit (Tudor, 1959), this category of lead finds was more thoroughly published (see, for example, from the Roman province of interest for the present discussion, Culică, 1966; Petcu and Petcu-Levei, 2017; Stoian and Matei, 2005), in some cases even considering aspects of their making and material provenance analysis (Streinu, Schwarcz and Mirea, 2020). Further, the lead mirror frames kept at the Archaeological Museum in Varna have been published (Kouzov, 2002; Kouzov, 2008). However, research has not made any progress when it comes to determining the source of the material used and addressing the issue of producing centers of this category of artifacts.

4 See e.g. the overview by Rothenhöfer and Hanel, 2013 and the monograph catalogue on Roman lead finds from Serbia in Milanović (2017).

5 CRLI-project, here cited as Rothenhöfer, Bode and Hanel (forthcoming) is a corpus that provides available information on the epigraphy, ancient history, archaeology and archaeometallurgy of almost all known Roman lead ingots (c. 2500 individuals). A total of 450 ingots were exemplarily sampled from 2009 to 2014, and trace element contents and lead isotope compositions were determined. The publication will be in 2024/25. The late-Roman ingot from *Novae* has the CRLI no. 2593, the two ingot fragments from Zlatar 2594 and 2595.

6 The find (made in 1968) has not yet been fully published; more interesting are the weapons and ornaments as well as the carriage from the funerary inventory. It seems that the grave was recovered 'en bloc' and brought to the restoration laboratory. See, for references and details, Diaconescu (1999); images of the extraction, with recognizable lead sheets (some authors describe the find as a lead sarcophagus, although there is no lid to be seen) were presented by Dumanov (2013).

7 Radiologist Dr. George Severeanu (1879-1939) was a passionate collector of antiques and the first director of the Bucharest Museum (since 1931). His collection of archaeological objects includes ancient Greek pottery, clay statuettes, bronze and marble objects, Roman glassware, ancient gems and cameos. He also owned one of the most valuable numismatic collections (about 9,000 items from different historical periods). The collection was donated to the Bucharest Municipal Museum in 1939 by his wife Maria

Severeanu. The donation was completed in 1949 (including prehistoric, Greek and Roman archaeological items, ancient, mediaeval, modern and contemporary numismatics, medals, art, paintings, as well as personal belongings of Dr. Severeanu) and made accessible to the public in 1956 at the family residence, which was donated by Maria Severeanu for this purpose.

8 Monsignore Canonico Cesare Taggiasco was known as a collector and dealer of antiques, coins, and works of art in Rome in the second half of the 19th century (Pollak, 1994, pp.130-131). However, L. Pollack points out that he constantly sent groups of pieces abroad to be auctioned and did not organize any collection per se (see also, Gardner, 2019, p.111, *s.v.* TAGGIASCO, monsignor Cesare - Rome).

9 David Kallai (1857-1928) was a numismatist, coin and antiquities dealer in Vienna (1st district, Lobkowitzplatz 3). In 1891 he joined the Numismatic Society in Vienna (Kenner, et al., 1901, p.304). The shop was family-owned from 1908 to 1938 and was managed for most of the time by his wife Auguste Kallai (1879-1952) and his son-in-law Robert Wadler (Hecht, 2012, pp.80-81; Schoenbrun, 2022).

10 Karl Hollitzer (1831-1917) was a building contractor with a special interest in Roman antiquities, archaeology and numismatics. He was a member of the Carnuntum Association founded in Vienna in 1884/1885 and since 1887 a member of the Numismatic Society in Vienna. He made a house in Bad Deutsch-Altenburg available for archaeological excavations. The house hosted and displayed the collection of the Novatzi family, the Hollitzer collection (including finds from Brigetio, Aquileia, and Rome etc.), parts of the collection of Baron Ludwigstorff and the finds made by the Carnuntum Association since its foundation (Kubitschek and Frankfurter, 1891, p.49). Alongside Petronell Castle and Ludwigstorff Castle, most finds from the area were hosted at this house - his collection of Roman finds is still a central part of the Museum Carnuntinum, which was officially opened by Emperor Franz Joseph I in Bad Deutsch-Altenburg in 1904 (Hollitzer (Verlag), 2024). He was also a curator of the museum (Hollitzer, 2023a and b).

11 W. Kubitschek (1894, p.160, note) mentions six lead pipes from the former Taggiasco collection, all bearing stamps, that were bought by K. Hollitzer and brought to the museum in Bad Deutsch-Altenburg. Their (only) publication seems to be the auction catalogue of 1887 (Auctions-Katalog der Kunst-, Antiquitäten- und Gemälde-Sammlung, III. und letzte Serie, aus dem Besitze des Monsignore Canonico Cesare Taggiasco in Rom: Versteigerung: Montag, den 25. April und die folgenden Tage, Vienna: Verlag E. Hirschler & Company, 1887 p.22, no 270; see Kubitschek, 1894), a volume which was not available to us and was rare even by the end of the 19th century.

12 One other example is the marble epitaph of the *liberti* Caius Iulius Astragalus and Iulia Semne, found in the third columbarium on the Via Appia in Rome, in the Vigna Codini, published in CIL VI 5430. The inscription is mentioned in the *Carnuntum* guide (Kubitschek and Frankfurter, 1891, pp.53-54; Kubitschek and Frankfurter, 1894, p.61). The left part, with the epitaph of Astragalus, still exists in Klagenfurt. Its recent publication (Cenati, 2020, with literature) makes no reference to its "stay" in Bad Deutsch-Altenburg.

13 Compact information about mining archaeological remains e.g. in Davies (1935, pp.214-223); Meier (1995, pp.91-99) and Westner (2017, pp.114-115).

14 In 2019, a second Messallinus ingot with an identical cast inscription (cast in the same mould!) appeared on the art market (no longer accessible on the Internet).

15 Data of three Roman lead ingots assigned to Serbia/Kosovo is kindly allowed to be used and published in Rothenhöfer, Bode and Hanel (forthcoming) and belong to a project by Dragana Mladenović (University of Southampton) and Matthew Ponting (University of Liverpool). Publication is in preparation (Title: 'Upper Moesian lead ingots and their implications for the Balkan silver production').

16 Lead isotope data of British Roman lead ingots from Gardiner (2000), published in Rothenhöfer, Hanel and Bode (forthcoming).

17 As no lead ingots exported from Yorkshire are known for the 3rd century, *plumbum Britannicum* ingots from this century have not been included in Figure 15.

18 A mixture of lead from two or more deposits cannot be ruled out for any sample. For the lead pipe from Rome, a 1:1 composition of lead from Cartagena-Mazarrón and the Sierra Morena (Linares-La Carolina) is possible, but according to the dating of the lead pipe it is improbable. It should be assumed that lead ingots and not scrap metal were generally used for the production of larger and more massive objects.

19 Trincherini, et al. (2001, Tab.8, p.404) list Le Bleymard, Vialas, Mont Faulat and La Rabasse in the Cévennes to bear Roman mining works (cf. also Prassl, 1997, for Bleymard; Léchelon, 2007, p.249, for La Rabasse etc.). Furthermore, according to Ploquin, et al. (2003, pp.641-642), who did pollen and peat sample studies at Narses Mortes on the south-western edge of Mont Lozère, in the mines lead smelting took place also during the ancient period ('Latenian level, may be continued in Galloroman time') (see also Baron, Le Carlier and Ploquin, 2010, p.154). A further indication for Roman lead (silver) mining/smelting activities in South-Eastern France was recorded in sediment cores from Lake Anterne (Haute-Savoie) in the western Alps, showing a lead peak at 200 AD (Arnaud, et al., 2010).

20 Lead isotope data of the Augustan denarius was taken from Butcher and Ponting (2005, Tab.3, p.191).

Abbreviations

ALS = Airborne Laser Scanning
CIL = *Corpus Inscriptionum Latinarum*
CRLI = Corpus of Roman Lead Ingots
DTM = digital terrain model
ICEM = Institutul de Cercetări Eco-Muzeale „Gavrilă Simion", Tulcea
ÖAW-ÖAI = Austrian Archaeological Institute at the Austrian Academy of Sciences

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