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Touchstones from early medieval burials in Tuna in Alsike, Sweden

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ABSTRACT

Tools for determining the value of metal appear among grave goods in prehistoric and early medieval Europe: they served as symbols of access to precious metal. As is the case with many other sites, four prestigious early medieval burials excavated in Tuna in Alsike, Sweden, contained stone artefacts with the characteristic shape of touchstones. The intent of the article is to present the results of chemical microanalyses of metal traces preserved on the stone artefacts from Tuna. The streaks of precious and other non-ferrous metals are as common as those that appear on touchstones throughout Europe, however, in this case are presented and discussed also traces of nickel and zinc.

1. Introduction

Attributes of access to precious metals in graves are among the most important indicators of the deceased's social standing. Balance scales and weights are relative common in early medieval burials. However, European archaeological collections record hundreds of thousands of stone artefacts described as whetstones, from burials as well as from settlements, metallurgical workshops and trade centres. Traces of non-ferrous metals, including precious metals preserved on a number of such artefacts: these objects served as touchstones – tools to test the quality of precious metal (Ježek and Zavřel, 2011). In grave inventories, they served as a sign of social standing beginning from the period when uses for metal were being discovered (for examples, see Ježek, 2013).

Touchstones traditionally had a carefully worked oblong shape with a right-angled cross-section, flat and smooth walls and were made of a hard raw material, most often metamorphic rocks like schist, slate (or phyllite) and quartzite, or various types of fine-grained and solid metasediments or homfels. Many of the touchstones found in prestigious burials have been elaborately worked into elegant forms, and the dimensions of certain specimens were superfluous for the purpose of testing the quality of metal. The purpose of the dimensions of these mostly impressive artefacts can be found in the realm of ostentation, or demonstration, which had already been applied during the life of their user.

Three of a dozen boat burials excavated among (at least) 14 early medieval graves with the remains of 17 individuals in Tuna in Alsike (Uppland, Sweden) in the 1890s contained stone artefacts with characteristics typical for touchstones (Fig. 1). Two of these boat burials contained the remains of men, one belonged to a woman. With the exception of two graves from the sixth century AD, the graves excavated in Tuna in Alsike date to the Viking Age. A typical stone artefact was found in one of the two earliest graves (No. XIV), which contained a male skeleton beneath the layers of stones. All four burials furnished also with stone artefacts were richly furnished (see Arne, 1934). Although the wealth of the cemetery in Tuna does not match that of the cemeteries in Vendel and Valsgärde (also in Uppland), these three cemeteries, along with Tuna in Badelunda, are among the most prestigious medieval boat-burial graveyards in Sweden.

2. Stone artefacts from Tuna in Alsike: research objectives

Burial No. XIV dates to the sixth century AD (Arne, 1934, 75; Arrhenius, 1980). T. J. Arne dated boat burial No. IV to the second half of the ninth century, boat burial No. VIb to the first half of the tenth century and boat burial No. XI to the turn of the eleventh century. However, he only mentions the artefact 19 cm in length from burial No. VIb, ascribed to a woman, in the inventory of finds (Arne, 1934, 34, 71). Unlike the others in the publication, it however does not appear in the illustrations; perhaps it had already gone

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Fig. 1. Stone artefacts from burials Nos. IV, XI and XIV in Tuna in Alsike (the asterisk in the map). Historiska Museum, Stockholm.

missing during its preparations. One additional difference can be noted: unlike the three others, T. J. Arne did not classify it as a whetstone (perhaps due to its length?).

The stone artefact from burial No. IV has a length of 8.2 cm and at least one end of the object is original, perhaps both. The cross-section of the four-sided artefact with rounded edges is nearly square, with sides approximately 1.6 cm in width. The artefact is made of a fine-grained grey slate.

The artefact discovered in grave No. XI is made of fine-grained banded schist with alternating violet–grey and greenish layers. The length of the artefact is 9.4 cm. Its cross-section is rectangular, and the object slightly narrows toward the end with a perforated hole (diameter 0.4 cm) with a preserved bronze ring (diameter approximately 2.8 cm). The maximum width of the stone artefact is 1.8 cm, the minimum width 1.4 cm. The height is 1.3 cm. The edges are slightly rounded. A groove runs along the middle of one of the wider sides of the artefact from the wider end to the hole (the purpose of the groove is unknown).

The precisely worked four-sided artefact from grave No. XIV has sharp edges, and, one end is bevelled. The length of the longest side is 12.1 cm, the height of the artefact is 2.7 cm and the width 3.0/3.2 cm. The object weighs 222 g. The stone was fine-grained banded schist, the layers of which divide the object lengthwise into a sandy coloured part and a greyish-violet part.

All three artefacts have perfectly smoothed walls. They were subjected to a chemical microanalysis. The aim of the analysis was to determine whether the stones featured streaks of iron, which would confirm their function as whetstones, or whether they revealed traces of non-ferrous metals, which would indicate an interpretation as touchstones. We utilized the method of chemical microanalysis combined with surface observations of the objects using a scanning electron microscope (SEM). Even minute streaks of metal on the surface of the touchstones appear as luminous colours on a grey or black background (Figs. 2 and 3) in the image created by back scattered electrons (BSE). These anomalies can then be precisely measured and subjected to chemical microanalysis using the energy-dispersive X-ray spectroscopy (EDS). It furnishes data on the content of individual oxides, or chemical elements in the investigated metal. The analyses were conducted in Zeiss Supra 35-VP SEM equipped with an EDAX Apex 4 EDS-detector (high voltage 22 kV, chamber pressure 20 Pa). The findings are given in weight percent (wt.%) and calculated at 100% in tables below; these data are semi-quantitative (for the method and its problems see Ježek and Zavřel, 2011, 127; Ježek, 2013, 714).

In the case of the stone artefacts from Tuna in Alsike, due to the number of the streaks of non-ferrous metals, it was necessary to make a selection in the analysis phase. The chemical composition of the traces of metal detected on various positions was often identical or differed to such a minor extent that, considering the likelihood of the low homogeneity of the metals that left traces on the stone artefacts, the streaks could have been produced by objects with the same chemical composition, or by the same objects. The tables below therefore present only a selection of the observed streaks to illustrate their variety, albeit negligible in many cases. The author apologises to the readers for the possible repetition or similarity of data: Quantifications are accompanied in our database by spectra and by photographs recorded at the same time, from which a radical selection had to be made for the purposes of this publication, and this is a way how to avoid confusion.

3. Analytical results and their discussion

The main complication in making a positive identification of touchstones among stone artefacts usually relates to their actual use in the distant past: Before a touchstone could be used, it was necessary to remove the remnants of the previous test. Touchstones were cleaned with salty water, wax, they were also sanded. The finds are cleaned again after an archaeological excavation.

In the case of touchstones from Tuna in Alsike, streaks (or remnants of streaks) of precious metals were preserved on all three stone artefacts. Gold appears in either pure form (Table 1: 20; 2: 15; 3: 8) or with a negligible admixture of copper (Table 1: 15; 2: 8, 19). In two cases gold appears as a minor admixture of silver (Table 3: 19, 20). Silver or its alloys are often accompanied by sulphur, a phenomenon we interpret as the result of the natural reaction occurring when silver comes in contact with an organic material (the “blackening”, or tarnishing of silver: see e.g. Pope et al., 1968; Sinclair, 1982). The presence of a minor amount of chlorine in cases involving silver is presumed to be the result of the effect of the reaction of the silver streaks with airborne chlorides, with NaCl

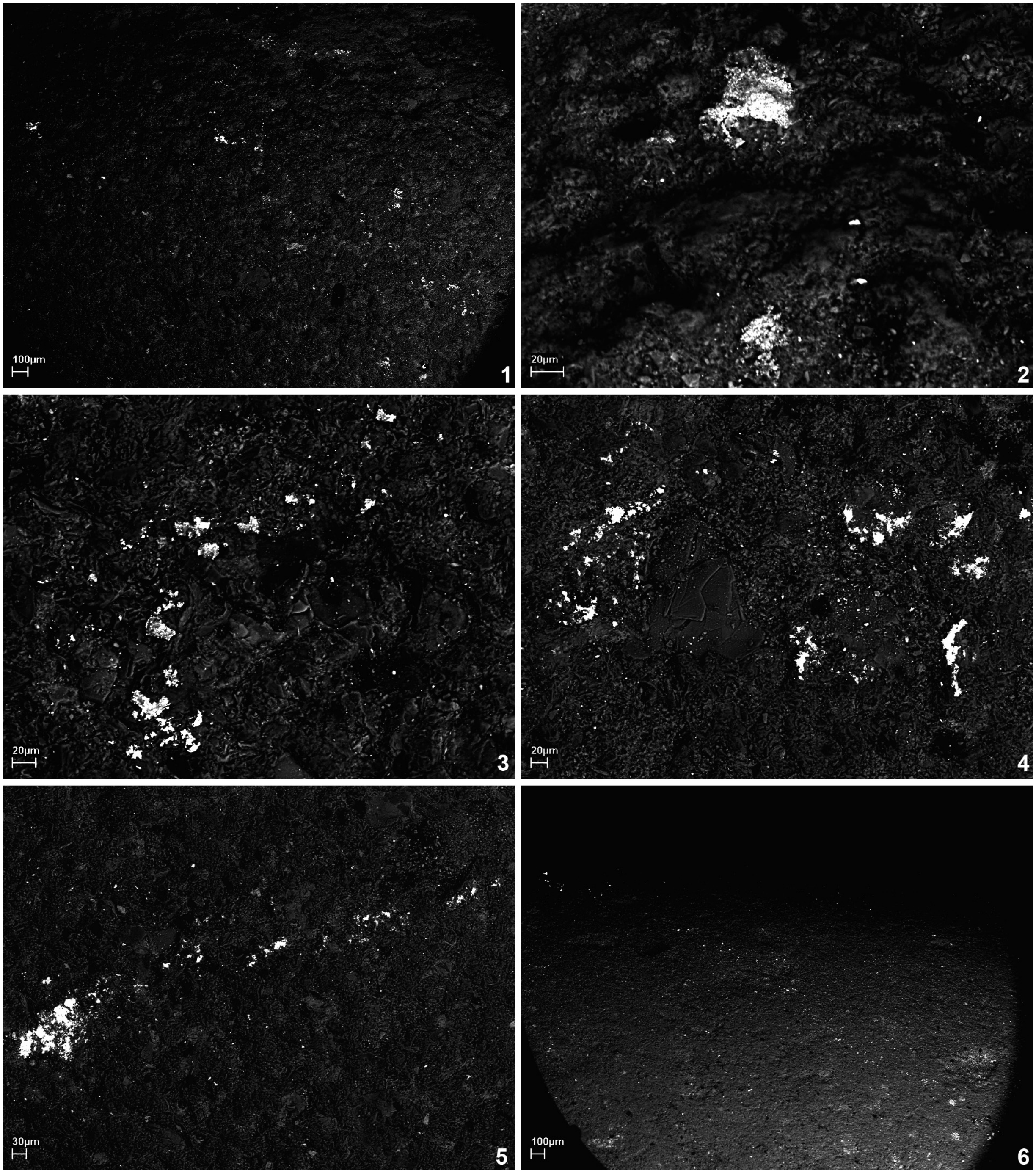

Fig. 2. Microphotographies of selected traces of metal on touchstones from Tuna in Alsike. 1–5 burial No. IV, 6 burial No. XI. 1 gold with admixture of copper (Table 1: 15); 2 zinc (Table 1: 16); 3 nickel with admixture of copper (Table 1: 17); 4 silver with admixture of copper (Table 1: 18); 5 lead (Table 1: 19); 6 gold with admixture of copper (Table 2: 8). Photos by Gary Wife.

from human sweat, or hydrogen sulphide resulting from the decomposition of organic material, with hydrochloric acid concentrated in the digestive juices of higher animals or the effects of microorganisms. Silver with an admixture of copper appears regularly, in two such cases (Table 1: 18; 3: 17) accompanied by iodine. This element has not yet been recorded on the hundreds of analysed touchstones from central Europe. Conversely, it is often present in streaks of silver and/or copper alloys on touchstones from Birka (Sweden). Iodine occurs in oxidizing gossans of silver ore deposits, forming minerals iodargyrite (AgI), miersite [(Ag,Cu)I] or marshite (CuI). The discussed occurrence of iodine could therefore be the result of its presence in copper ores, as indicates an alloy (Table 3: 16; Fig. 5: 3) composed of copper, zinc and nickel (which also often accompanies copper ore). Compared to medieval touchstones from other European sites, brass is a rare find on the stone artefacts from Tuna in Alsike.

In one case silver is the predominant component of an alloy with copper and tin (Table 3: 11), while in other cases it forms a minor

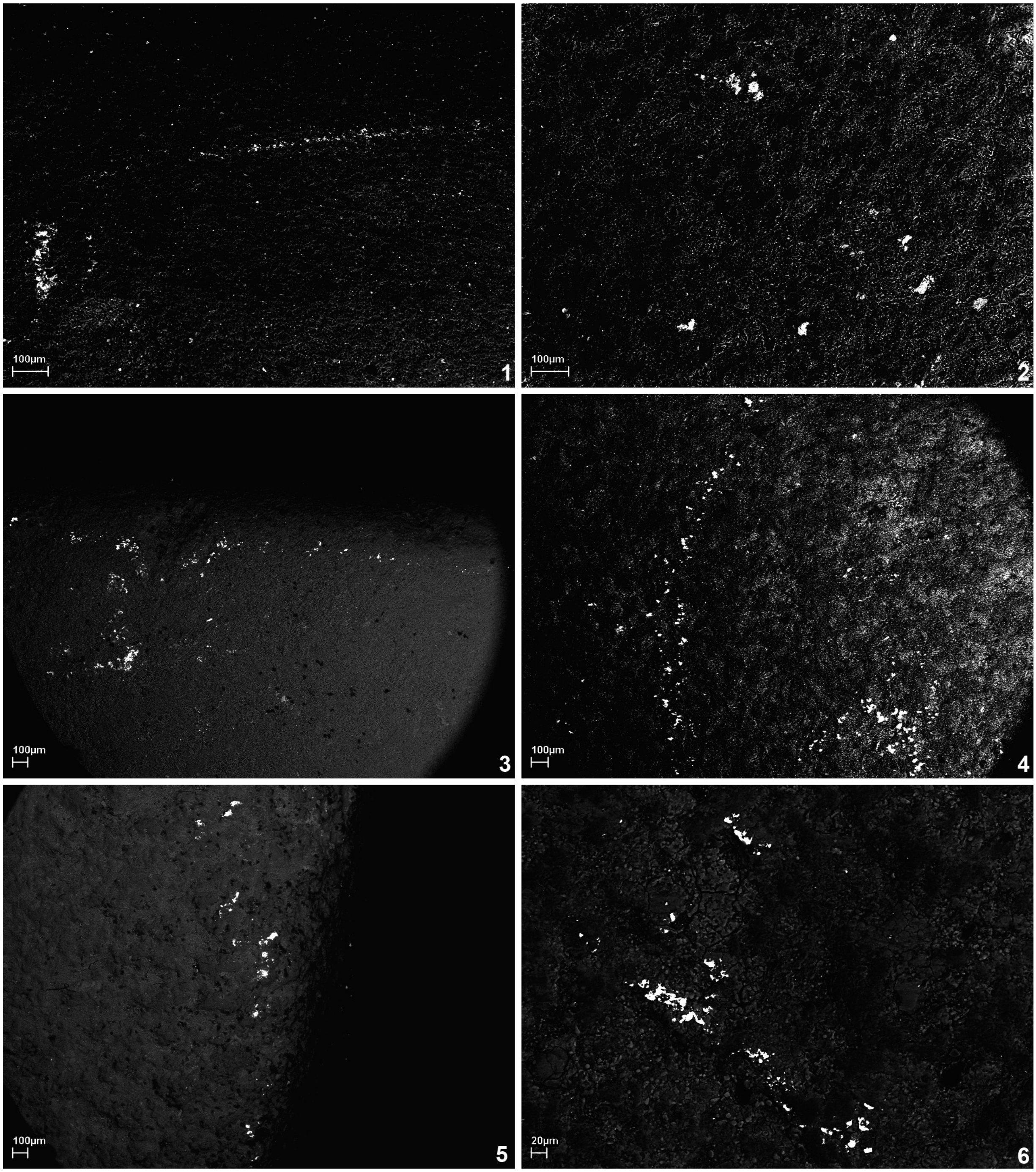

Fig. 3. Microphotographies of selected traces of metal on touchstones from Tuna in Alsike. 1–3 burial No. XI, 4–6 burial No. XIV. 1 brass (Table 2: 9); 2 nickel (Table 2: 14); 3 the line above: gold with admixture of copper (Table 2: 19), the fleck left below: lead with admixture of chrome and zinc (Table 2: 18); 4 silver (Table 3: 6); 5 silver with admixture of gold (Table 3: 19); 6 silver with admixture of gold (Table 3: 20). Photos by Gary Wife.

admixture in alloys of copper and/or lead (Table 1: 10; 2: 5; 3: 10). Streaks of lead frequently appear on touchstones throughout Europe, and streaks of lead and copper alloys as well as lead, copper and tin alloys are also common, sometimes with a small amount of zinc. Streaks of tin and copper, even with their admixtures, are similarly common. A minor admixture of sulphur in the streaks of tin and copper, and also of nickel with an admixture of copper (Table 1: 17; Fig. 4: 4), can apparently be explained by the imperfect separation of sulphur during the smelting of tin and copper ores. The presence of chlorine in the streaks of copper or copper-alloy objects can be explained by corrosive processes accompanied by the formation of mixed oxy-hydroxy-chloride $Cu_2Cl(OH)_3$. Under natural conditions, this compound mostly originates in the oxidation zone of copper deposits in seashore regions of the arid zone (mineral atacamite).

Although concentrations of zinc are also sporadically found on touchstones from other parts of Europe (e.g. Ježek and Zavřel, 2013), they are much smaller in size than in Tuna. Theoretically, the grains could represent the remnants of brass streaks, however, no traces of copper were found nearby. Zinc is found on the stones

Table 1
Tuna in Alsike, grave No. IV. Selected results of chemical microanalysis of metal traces on the surface of stone artefact. Each analysis number (An.) belongs to another streak. The data are given in weight percent (wt.%) and calculated at 100%; the data are semi-quantitative. The geochemical background, i.e. elements coming from the raw material of the stone, is excluded (cf. Fig. 4: 1–4). On Cl and S see in text. For the complete analyses Nos. 1 and 16 see Table 4, for No. 17 see Table 5.

An.	Ag	Au	Cl	Cu	I	Ni	Pb	S	Sn	Zn	Σ
1										100	100
2										100	100
3			2	7			91				100
4			11	62			17			10	100
5			2				14		84		100
6							100				100
7				13			84			3	100
8	98			2							100
9				5			95				100
10	7		4	66			14		9		100
11			6	49			35			10	100
12							100				100
13			7	65			17		11		100
14			4	67			24		5		100
15		96	1	3							100
16										100	100
17			1	4		93		2			100
18	71			1	19			9			100
19							100				100
20		100									100

Table 3
Tuna in Alsike, grave No. XIV. Selected results of chemical microanalysis of metal traces on the surface of stone artefact. Each analysis number (An.) belongs to another streak. The data are given in weight percent (wt.%) and calculated at 100%; the data are semi-quantitative. The geochemical background, i.e. elements coming from the raw material of the stone, is excluded (cf. Fig. 5). For the complete analysis No. 15 see Table 4.

An.	Ag	Au	Cl	Cu	I	Ni	Pb	S	Sn	Zn	Σ
1	81		7	8				4			100
2	86			4				10			100
3				88				2		10	100
4				6			94				100
5			3	91			6				100
6	93							7			100
7				80						20	100
8		100									100
9			1	97				2			100
10	16		6	53				25			100
11	39		6	15				12	28		100
12	62		6	17				15			100
13	92		5					3			100
14			1					1	98		100
15										100	100
16			2	27	30	13		4		24	100
17	80		2	2	9			7			100
18	62		14	22				2			100
19	87	3	9					1			100
20	94	1	4					1			100
21	95		5								100

from Tuna in Alsike in the form of grains (together or scattered in various ways) with a maximum size of around 30 μm (Table 1: 1, 2, 16; 3: 15; Fig. 2: 2; 4: 1, 3; 5: 2). The complete analytical results of zinc concentrations are presented in Table 4. Noteworthy here is the variability in the amount of carbon (also see Figs. 4: 3 and 5: 2): while in one case carbon has around 18 wt.%, in another it does not occur at all. In the first case it would be possible to speculate on the effect of the presence of a binder in paint (or solvent) theoretically used for the inscription (or removal) of file numbers in the nineteenth or twentieth centuries. However, as suggested by a stoichiometric recalculation, observed zinc traces do not pertain to zinc white. Moreover, no inscription in such paint has been preserved on the studied stones. The traces probably pertain to metallic zinc, occasionally slightly oxidized into a mixture of carbonates. However, no linear streaks of zinc have been observed on the touchstones from Tuna, and any conclusion would be premature. In any case, the age of the zinc traces on the medieval touchstones can be verified by none of the currently used analytical method.

The same is true for the streak of nickel recorded on one stone artefact from Tuna in Alsike (Table 2: 14; Fig. 3: 2, 4: 5), in other instance with an admixture of copper (Table 1: 17; Fig. 2: 3, 4: 4; for the complete analytical results see Table 5). The second case leads to question on the origin of nickel in the copper ores, so-called Ni-laterites, however, we record traces of nickel without copper admixture on touchstones from various corners of Europe. Also possible is the use of nickeline (NiAs), which occurs throughout Europe as part of non-ferrous ore deposits and as a secondary mineral (for example, for Brunflo, Sweden, see Nyström and Wickman, 1991). It has also been reported from Sala mine (Sweden), used at least since the Late Middle Ages, where silver ore contains small amounts of lead and zinc (Jansson, 2007, with refs.). However, it is unknown whether ancient metallurgists were able to remove arsenic completely from nickeline in the smelting process. In any case, this does not mean that they knew which metal they were working with. Nevertheless, it is necessary to consider all of the possible interpretations: Preference of metal of meteoritic origin may also be considered, especially in the highest elite environment (see as early as Eliade, 1956). Regarding the mandatory reference to the possibility of modern contamination let's remark that streaks of nickel are recorded even on finds from the last quarter-century where such contamination is most unlikely (for example, the "royal" burial in Mušov, Czech Republic, the second century AD).

One metal forming a streak on a touchstone from burial No. XI in Tuna in Alsike has not been encountered on any of the hundreds of previously analysed touchstones from various parts of Europe. The presence of chrome in the streak of lead (Table 2: 18; Fig. 3: 3 below left; Fig. 4: 6) can apparently be explained as coming from a type of lead deposit in which both galenite and probably chromite were present. However, a reliable explanation for the streak of this metal

Table 2
Tuna in Alsike, grave No. XI. Selected results of chemical microanalysis of metal traces on the surface of stone artefact. Each analysis number (An.) belongs to another streak. The data are given in weight percent (wt.%) and calculated at 100%; the data are semi-quantitative. The geochemical background, i.e. elements coming from the raw material of the stone, is excluded (cf. Fig. 4: 5, 6). For the complete analysis No. 14 see Table 5.

An.	Ag	Au	Cl	Cr	Cu	Ni	Pb	Sn	Zn	Σ
1					10		90			100
2			1					99		100
3					14		86			100
4			2		79		9	4	6	100
5	4				39		57			100
6					85				15	100
7					100					100
8		98			2					100
9					85				15	100
10					28		30	42		100
11					100					100
12					30		70			100
13					62		38			100
14						100				100
15		100								100
16					90			10		100
17					2		98			100
18				19			78		3	100
19		99			1					100
20			4		45		51			100

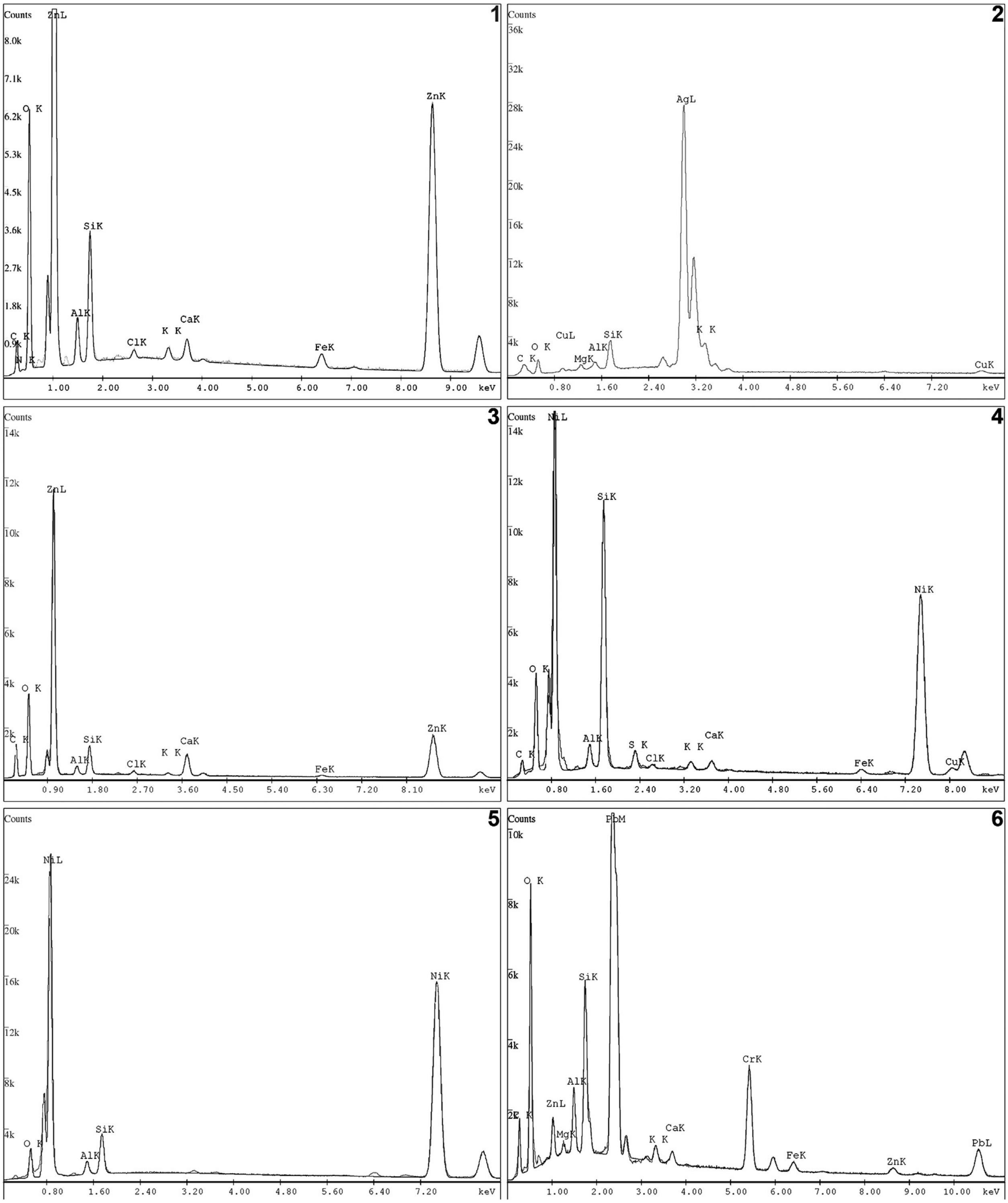

Fig. 4. Spectra of selected traces of metal on touchstones from Tuna in Alsike. 1–4 burial No. IV, 5–6 burial No. XI. 1 – Table 1: 1; 2 – Table 1: 8; 3 – Table 1: 16; 4 – Table 1: 17; 5 – Table 2: 14; 6 – Table 2: 18. Measurement Gary Wife.

(or mineral?), which also contains a small amount of zinc, is missing today, unless we wish to resort to the usual reference to the possibility of modern contamination.

Sporadic, micrometrical traces of iron – a metal that is sometimes, though rarely, found on touchstones – were identified on artefacts from burial Nos. IV and XIV. As the origin of iron traces can also be ascribed to archaeological tools, especially in the relatively frequent occurrence of a chromium admixture (not the case in this instance), they are not listed in the tables. In any case, the sharpening of iron tools would leave far heavier streaks than the micrometrical traces as documented in our cases.

4. Conclusion

Streaks of precious and other non-ferrous metals preserved on all three studied stone artefacts from prestigious burials in Tuna in

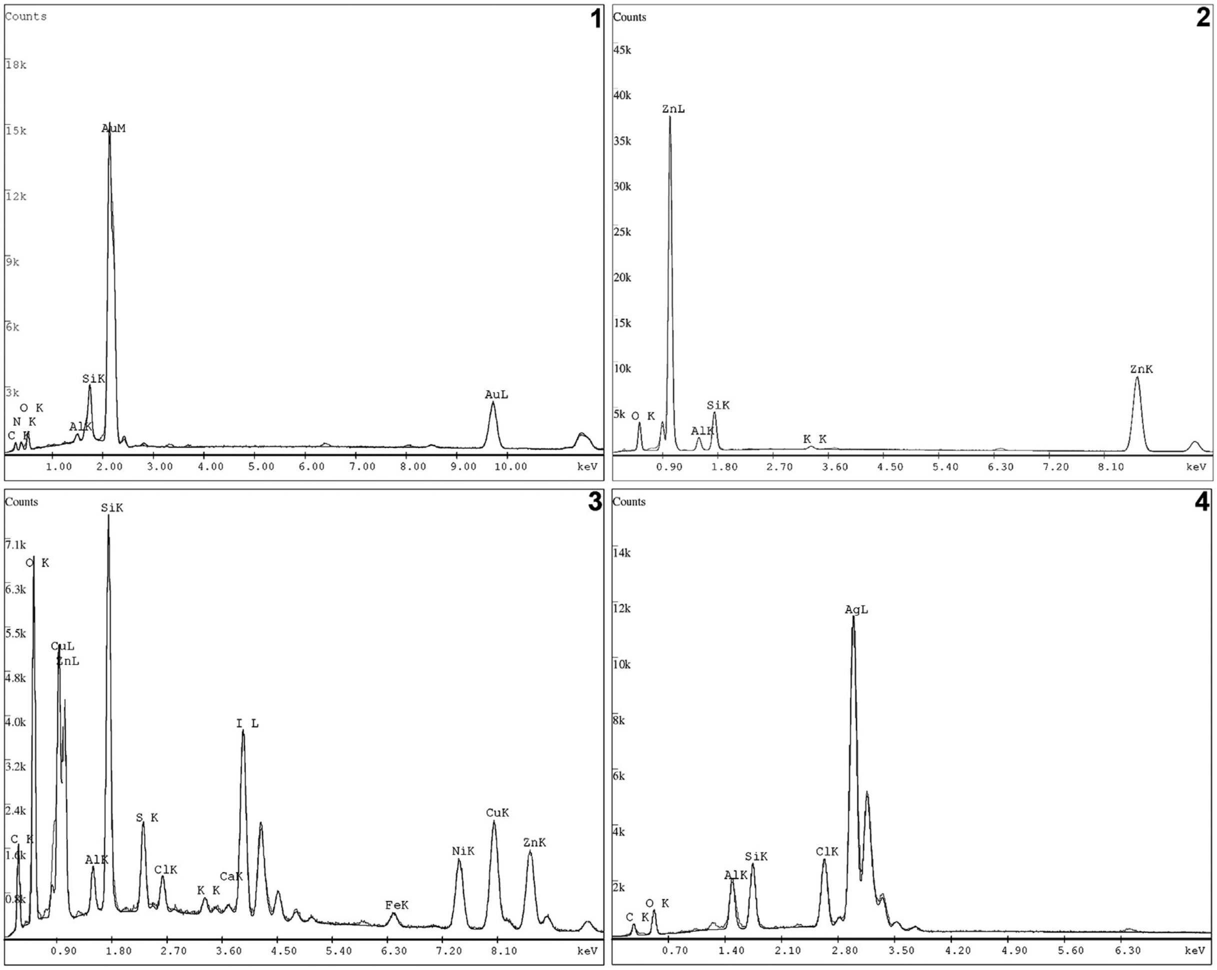

Fig. 5. Spectra of selected traces of metal on touchstones from burial No. XIV in Tuna in Alsike. 1 – Table 3: 8; 2 – Table 3: 15; 3 – Table 3: 16; 4 – Table 3: 21. Measurement Gary Wife.

Alsike. We therefore regard the objects as touchstones, deposited in the graves as symbols of social standing of the deceased. Tools to test the quality of precious metals also served as a symbol during parents' final parting with their children, and traces of precious metals are often preserved on the surface of touchstones from children's graves, including burials of sucklings (see Ježek, 2013, 720). The same holds true for many female graves, probably including the lost stone artefact from burial No. VIb in Tuna in Alsike.

It would be inappropriate to assess social standing solely on accidentally preserved evidence such as imperfectly cleaned traces of metal. Nevertheless, in the case of Tuna in Alsike it is impossible to ignore the striking difference between the frequency of documented streaks of precious metals (and their alloys) on the touchstone from grave No. XIV and the touchstones from the other two discussed graves. A difference arises especially in comparison with evidence of streaks of lead (and its alloys), for which the opposite condition applies. Although not long, the touchstone from burial No. XIV, which is dated as being three hundred years earlier than the oldest of other local graves furnished also with touchstones, has a truly impressive dimension. In Sweden, similarly representative artefacts come from Vendel era prestigious boat burials (Valsgärde, Vendel). They were also found in aristocratic

Table 4
Complete results of selected point analyses of zinc traces on the surface of touchstones from burial Nos. IV and XIV. The data are given in weight percent (wt.%) and atomic percent (at.%) and calculated at 100%; the data are semi-quantitative. Al comes from the SEM chamber, additional elements (with the exception of C, Cl and O) from the geochemical background, i.e. from the stone raw material.

Burial refs.		Al	C	Ca	Cl	Fe	K	N	O	Si	Zn	Σ
IV Table 1: 1	wt.%	3	5	1	–	1	1	–	15	7	67	100
Fig. 4: 1	at.%	4	16	1	–	1	–	1	33	8	36	100
IV Table 1: 16	wt.%	2	18	4	1	1	–	–	23	5	46	100
Fig. 2: 2; 4: 3	at.%	2	38	2	–	–	–	–	36	4	17	100
XIV Table 3: 15	wt.%	4	–	–	–	–	1	–	7	9	80	100
Fig. 5: 2	at.%	6	–	–	–	–	1	–	20	15	58	100

Table 5
Complete results of the point analyses of streaks of nickel on the surface of touchstones from burial Nos. IV and XI. The data are given in weight percent (wt.%) and atomic percent (at.%) and calculated at 100%; the data are semi-quantitative. Al comes from the SEM chamber, additional elements (with the exception of C, Cl, O, and S) from the geochemical background, i.e. from the stone raw material. Analyse of the streak on the touchstone from the burial No. XI does not quantify the contents of elements represented by values below 1 wt.% in the complete analysis (C, Ca, Fe, K: see Fig. 4: 4).

Burial refs.		Al	C	Ca	Cu	Fe	K	Ni	O	S	Si	Σ
IV Table 1: 17	wt.%	2	4	1	3	1	1	56	10	1	21	100
Fig. 2: 3; 4: 3	at.%	3	12	1	1	–	1	33	22	2	26	100
XI Table 2: 14	wt.%	2	+	+	–	+	+	88	4	–	6	100
Fig. 3: 2; 4: 4	at.%	4	+	+	–	+	+	73	12	–	10	100

cremation burials (e.g. the Western mound in Gamla Uppsala, Skrävsta, Broby: see Lamm, 2008, 117–118), however, their surface is often ablated by heat. Even longer specimens are known from prestigious burials in northern part of Europe, for example, from Sutton Hoo, Uncleby (England), Risø, Eide (Norway; for refs. see Ježek, 2013, 716–717).

In any case, it is possible to claim that the impressive objects served as symbols of power, or sceptres, during the lives of their owners. The demonstration of access to precious metal continued to be important: In Sweden, stone artefacts longer than 30 cm are known also from Viking Age burials (e.g. burial Nos. 644, 842, 1143 in Birka, burial No. 4 in Röstahammaren in Ås). Nevertheless, a comparison of find inventories from the Anglo-Saxon and Vendel period environments, in which impressive stone artefacts appear in high status burials, with the situation in following epochs in various corners of Europe reveals a decline in the demonstrative role of those artefacts in favour of the broad expansion of utility tools. However, a more elegant (or more "modern") solution combining demands on representation and comfort was handy touchstone made of material with a striking colour: in northern Europe especially banded schist (see Johansen et al., 2003, 155), in eastern Europe red schist (see Ježek, 2013, Fig. 8).

Traces of gold, silver, copper, tin, lead and their alloys on the surface of touchstones are not surprising. However, besides these metals, touchstones from Tuna in Alsike revealed also traces of zinc and nickel. Streaks of nickel, including linear, are occasionally observed on touchstones from various parts of Europe, however, exclusively in elite circumstances. The traces of zinc on the surface of touchstones from the burials in Tuna remain puzzling. Although archaeologists and archaeometallurgists keep on slowly collecting evidence of zinc production in the Classical Antiquity and the Middle Ages in Europe (Rehren, 1996, with refs.; Th. Rehren in Fellmann, 1999; cf. Craddock, 1998, 1–2; 2009, 145–146, with refs.; Nováček, 2004), possible post-excavation contamination has to be considered in case of the touchstones from Tuna in Alsike – also for the really micrometric dimension and the figure of the observed zinc grains (no distinct linear streaks). On the other hand, the proportion of carbon in two of the three observed cases poses the question of the oxidizing of zinc streaks in a mixture of carbonates during the decay of organic material. After all, authenticity of streaks of precious metals on stone artefacts shaped as typical touchstones may be disputed in the same way: modern science likes to wear blinders.

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