Online Resource 1 to the paper entitled '*Composition, raw material provenance and manufacture of a unique late Roman silver folding stand (quadripus) from Kőszárhegy, Hungary*' by Mozgai et al.

The modern history, restoration and previous studies performed on the silver *quadripus* from Kőszárhegy

1. *The modern history and restoration of the silver quadripus (after Bruder et al. 2002)*

In May of 1878, fragments of a silver folding stand were found at Kőszárhegy (Fejér County, Hungary). The fragments consisted of two legs (one in three pieces and one bended) and three and a half cross bands. The fragments got into the collection of the Hungarian National Museum. The object was reconstructed in the same year as a *tripus* since three-legged folding stands, mainly made from bronze and rarely from silver, were numerous in the archaeological record from the whole territory of the Roman Empire.

1.1. The condition of the object before the restoration in 2002

After its discovery, the folding stand was completed with one leg and two and a half cross bands. The object was repaired at many places with thick soft soldering, hard soldering and overlappings. It was broken and incomplete at several places. The original silver material was conserved with ceresin and it was covered with a thin corrosion layer.

The quality of the repairs was variable.

1. The riveted, overlapping repairs, the fastening of the fragments, the replacement of the missing cast rosettes and axles (rivets) were a very good-quality work made by a bronzesmith. The material used for the repairs, the rivets and underlying plates were made of Cu-Zn-Ni alloy (similar to paktong) (Table A.1). The rivets used for fastening the half original cross band were made of unalloyed copper. The missing rosettes were made of silvered bronze casts. The missing washers were made of brass. Each of the replacements was silvered. Not only the material, but the style of the repairs was the same. Only thin soft soldering was used at the rivets.

Sample	Cu%	Zn%	Ni%
A leg rivet at fracture	61.6	24.6	13.8
A leg dovetail	61.9	24.9	13.2
A leg rivet	56.2	21.6	12.9

Table A.1. Elemental composition of the some of the repairs based on SEM-EDX analysis.

2. The galvanoplastic supplements (third leg and the cross bands) were manufactured most probably in the workshop of the Museum of Applied Arts, Budapest.
3. The low-quality repairs and rough soft soldering were considered as later repairs. It seems that the object was soldered repeatedly. At one place, the missing rosette and rivet were replaced by a nut screw. The unstable legs and joints were wired together at many places.

1.2. The restoration in 2002 – the tripus became quadripus

The broken leg and cross band were repaired without dovetailing using hard soldering. A 750 fineness silver was used for soldering. The missing parts were replaced with high-quality silver alloys. The various parts of the legs were cast separately as was done in the case of the original legs. First, it was cast in one piece, but the silver cooled too rapidly, and lost its form-filling capacity. This observation proved that the ancient craftsmen were aware of this phenomenon and cast the original legs in separate pieces consciously. The replacement pieces were denoted with letter 'C' for distinction. The moving part of leg B was replaced completely, the original one was kept separately in the collection of the museum. The recrystallization of silver and alloying with tin (from the former thick soft solders) caused a problem during restoration. The silver was cleaned with the Krefting process by using 3% sodium hydroxide solution and aluminium foil. It was artificially patinated where needed.

The folding stand was reconstructed as a quadripus. The tensions in the object, which was earlier forced together as a tripus, the 90° angle of the lugs on the original and of the galvanoplastic legs, the verifiable use of quadrupeds in the 4th century AD and the distribution in relation to halving the hidden fragments making up half the quadripus indicate that the folding stand discovered in Kőszárhegy was possibly a four-legged stand from the 4th century AD.

2. Results of previous studies performed on the silver quadripus from Kőszárhegy

2.1. ICP-OES analysis

A sample from one of the original bases of the silver *quadripus* was analysed by the Institute for Precious Metal Testing and Assay (Nemesfémvizsgáló és Hitelesítő Intézet, Budapest) with ICP-OES method in 1993 (Bruder et al. 2002). Table A.2. contains the results of the measurement.

Ag	Cu	Pb	Bi	Fe	As	Zn	Au	Sn	Sb
91.03	6.83	0.66	0.07	0.08	< 0.01	0.03	0.63	0.05	0.02

Table A.2. Chemical composition of one of the original bases of the silver folding stand measured by ICP-OES. The results are given in wt%.

Comparing our results to the previous measurement (Fig. A.1), data overlap with each other quite well, except copper, for which less amount was measured by ICP-OES analysis in 1993. Additionally, our data indicate that most probably the base of leg B was sampled and measured.

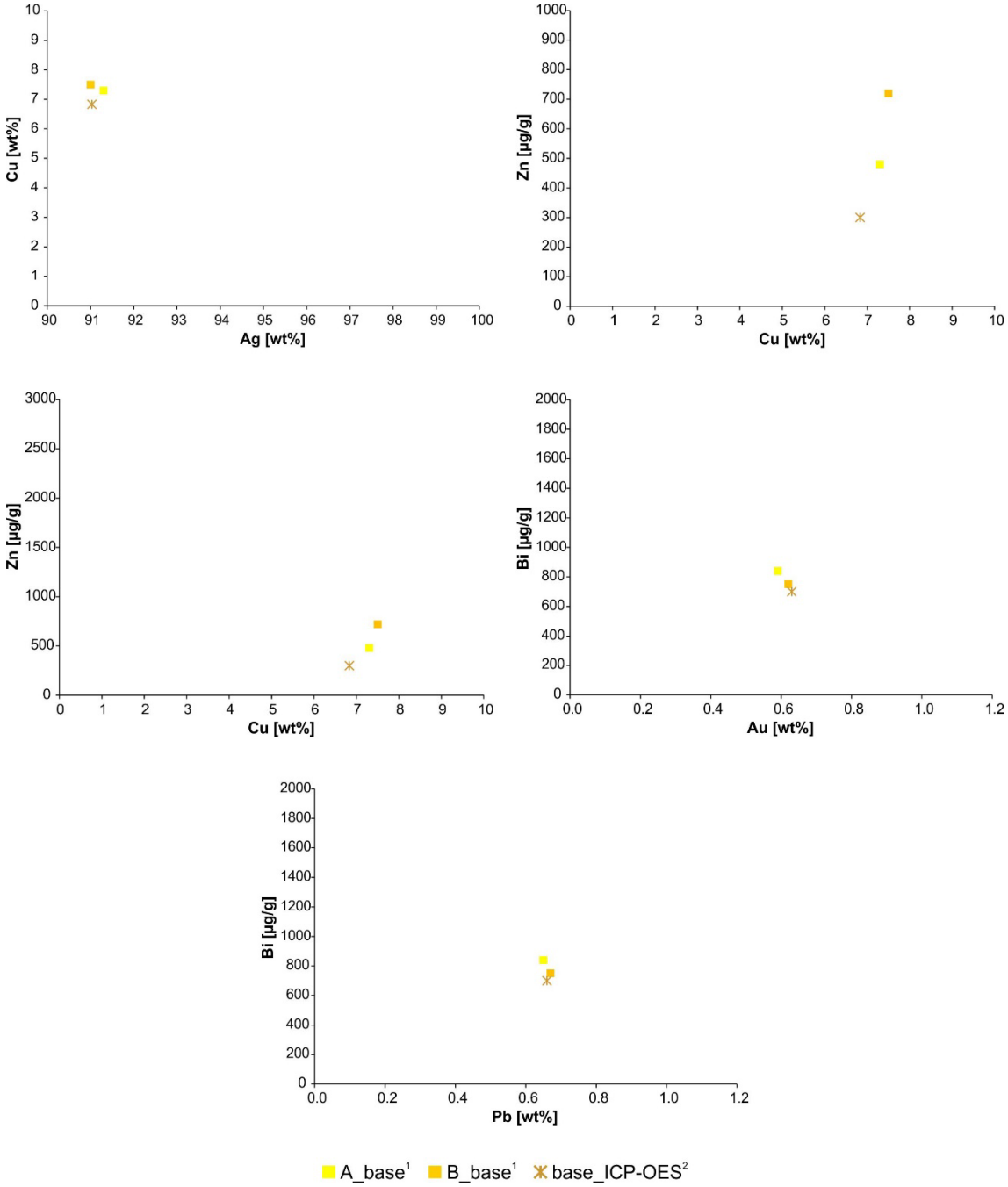

Fig. A.1. Comparison of the chemical compositions of the bases of the silver quadripus. [1]LA-QICP-MS measurements (present study); [2]ICP-OES measurement (Bruder et al. 2002).

2.2. PGAA, TOF-ND, PIXE and pXRF analysis

In 2014, one of the moving parts of the folding stand and the adherent rivet were analysed by using PGAA, TOF-ND, PIXE and pXRF by the Budapest Neutron Centre (unpublished report, 2014). The results of the PGAA, PIXE and pXRF measurements are given in Table A.3–5. The results of the various analytical methods are quite scattered and different in the case of the same part of the *quadripus* too, and therefore not well comparable to each other and to our data (Fig. A.2). It is due to the fact that pXRF and PIXE are surface analytical methods, while the bulk composition is measured by PGAA and LA-QICP-MS analyses.

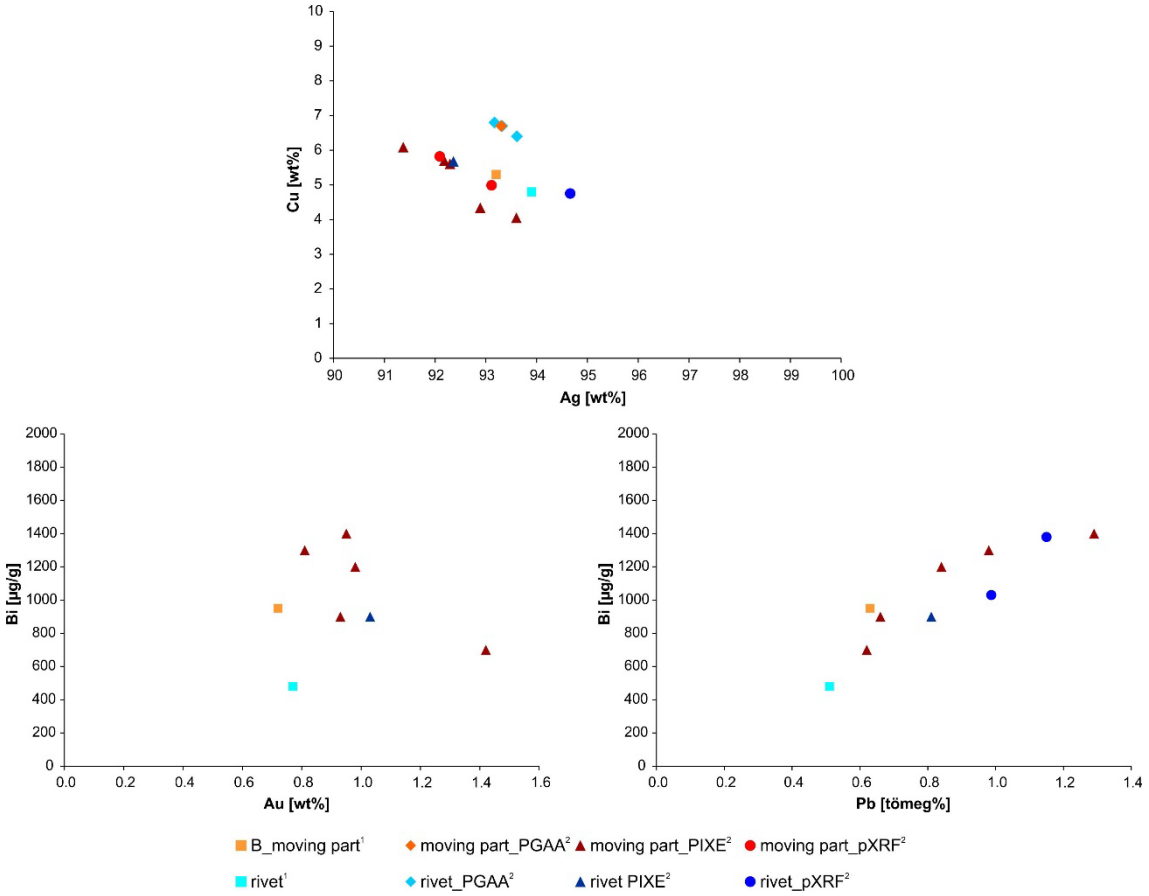

Fig. A.2. Comparison of the chemical composition of the moving part and rivets of the silver quadripus. [1]LA-QICP-MS measurements (present study); [2]PIXE, PGAA, pXRF measurements (BNC unpublished report, 2014).

Sample	Ag	±	Cu	±
Silver rivet				
AE98SILV	93.32	0.65	6.7	0.7
AF01SILV	93.61	0.7	6.4	0.7
AF26SILV	93.17	0.28	6.8	0.3
Silver moving part				
AF10SILV	93.3	0.56	6.7	0.6

Table A.3. Results of the PGAA measurements. Data are given in wt%.

Sample	Fe	±	Cu	±	Zn	±	Ag	±	Au	±	Pb	±	Bi	±
disk (moving part)	0.07	0.01	5.70		0.09	0.01	92.18	0.79	0.98		0.84	0.02	0.12	0.01
forehead	0.08	0.01	4.05	0.06	0.15	0.01	93.60	1.46	1.42	0.05	0.62	0.03	0.07	0.02
rivet	0.03	0.01	5.68	0.05	0.00	0.00	92.36	0.81	1.03	0.02	0.81	0.02	0.09	0.01
centre of the chest	0.59	0.06	4.34	0.05	0.47	0.01	92.89	0.99	0.93	0.03	0.66	0.02	0.09	0.01
outer side of the disk	0.08	0.04	6.09	0.22	0.08	0.02	91.37	7.39	0.95	0.26	1.29	0.20	0.14	0.10
inner side of the disk	0.09	0.04	5.61	0.18	0.09	0.02	92.29	3.95	0.81	0.10	0.98	0.11	0.13	0.04
soldering	0.16	0.02	16.55	0.13	6.99	0.06	71.87	0.93	0.74	0.03	2.40	0.05	0.35	0.03

Table A.4. Results of the PIXE measurements. Data are given in wt%.

Sample	Ag	±	Cu	±	Fe	±	Pb	±	Bi	±
rivet										
02/12/13 #4C	94.66	1.29	4.75	0.28			0.59	0.12		
moving part										
02/12/13 #8C	93.11	0.25	4.99	0.08	0.16	0.03	0.987	0.031	0.103	0.011
02/12/13 #9C	92.09	0.25	5.82	0.08	0.09	0.03	1.150	0.034	0.138	0.013

Table A.5. Results of the pXRF measurements. Data are given in wt%.

Based on the TOF-ND measurements, the folding stand was cast; no plastic forming was performed on it. The solidification temperatures were estimated as 510°C for the Ag-rich phase and 670°C for the Cu-rich phase.

References

Bruder KT, Mráv Zs, Veres K (2002) Az elrejtett quadripus. A polgárdi ezüstlelet újraértelmezése [The hidden quadripus. The re-evaluation of the silver find from Polgárdi]. Műtárgyvédelem 28:49–65