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Archaeometallurgical investigations of a Viking brass ingot hoard from the Hedeby Harbor in northern Germany

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ABSTRACT

A hoard of twenty-five copper-alloy bar ingots was discovered on the edge of the harbor of the Viking-period settlement of Hedeby during excavations in the 1980s. The typology and the location of the hoard indicate a date in the early 9th century AD. Each bar ingot was sampled and analyzed by mass spectrometry and the elemental compositions and lead isotope ratios were used to assess the degree of standardization and to explore the question of source. The results show that the bars are made of a freshly produced, standardized, high-quality brass alloy. The lead isotope analysis indicates that the brass is not consistent with the ore deposits of the Rhine area, commonly assumed to be the source of brass in northern Europe in the Viking Age. The brass bar ingots are possibly products originating from the Balkans or Andalusia, and thus, provide further evidence of the importance of long-distance trade of raw materials in the early Middle Ages.

1. Introduction

The use of copper-alloy bar ingots during the Viking Age marks an important innovation in the development of long-distance trade. Though the idea of an ingot of standard form and weight is not a new concept, in the Migration and Vendel periods of northern Europe, copper alloys were traded as scrap metal and not as bars. Whereas iron was traded in bars because of the practicality of production and use, the copper-alloy bar ingot must be cut into small pieces before casting and denotes a movement away from the practicality of metalworking and towards a form that is better suited for transport and exchange (Sindbæk, 2001). This conceptual shift in the way copper-based metal was exchanged appears to have occurred in the early Viking period, a period when long-distance trade networks reached a new level complexity (Hilberg, 2009; Lebecq, 1999; Lieber, 1981; Melleno, 2014; Noonan, 1981; Sindbæk, 2008; Steuer, 2009), but additionally, it also coincides with the reemergence of a brass making industry in Europe north of the Alps (Eiwanger, 1996; Lammers, 2009; Merkel, 2016a; Merkel, in press).

Brass, an alloy of copper and zinc, was widely used by the Romans and was used primarily for coinage, military attire and decorative items like brooches (Craddock, 1978). The Byzantine and Islamic Empires were the inheritors of the Roman metallurgical traditions and the production of zinc-bearing copper alloys persisted and grew in importance in the Middle Ages (Craddock et al., 1998). Roman brass ingots are known from Aleria shipwreck in the Mediterranean (Weisgerber, 2007) and are loaf-shaped and weigh much more than the medieval bar ingot (5 kg compared to 100–400 g of the typical medieval bar ingot). Two examples of Roman bar ingot hoards are known from Germany. One hoard of 12 unalloyed copper bar ingot fragments dated to the 3rd century from Trier (Bunk and Kuhnen, 2008). A hoard of 57 copper-alloy bar ingots was found in the Rhine near Mainz, which consists of ingots of gunmetal, high tin bronze and copper; brass was not identified (Bachmann and Jockenhövel, 1974), nor are any brass bar ingots dated to the Roman period known.

Starting at the beginning of the Viking Age, there is a sudden appearance of copper-based bar ingots in hoards and trading centers of northern Europe (Sindbæk, 2001). These bar ingots are almost exclusively made of brass and ternary copper-lead-zinc alloys and are typically found far from potential production centers. In northern Europe, brass ingots are known mostly from hoards and settlement contexts in Scandinavia (Oldeberg, 1942: 42–46; Drescher, 1983: 175; Eiwanger, 1996; Pedersen, 2016: 154–158; Merkel, in press) and the British Isles (Bayley et al., 2014) with very few examples on the continent where they were supposedly made.[1] Scandinavia is the northern periphery of the exchange network of brass ingots, but, to the south, brass ingots of similar form dated to the 11th century have been found as far as western Africa (Werner and Willett, 1975; Eiwanger, 1996) giving an impression of the enormous geographical distribution of brass bar ingots. Whether they are linked through a common production center is currently not known, but even if they do not share a common origin, they represent shared ideas and practices that cross diverse

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[1] There is a possible bar ingot fragment from Höxter-Corvey (Hess, 1993; Zientek, 1998) and examples from Bardowick, near Hamburg (Fellenger et al., 2013).

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Table 1
List of brass bar ingots from the harbor ingot hoard.

Nr.	DBM lab number	Find number	Length (mm)	Width (mm)	Thickness (mm)	Mass (g)
1	4367_13	KSD 602.148a	243	12.4	5.8	147.0
2	4356_13	KSD 602.148b	243	11.7	4.8	110.6
3	4357_13	KSD 602.148c	248	11.4	5.5	120.9
4	4358_13	KSD 602.148d	232	11.8	5.4	114.7
5	4359_13	KSD 602.148e	230	11.4	5.5	122.4
6	4360_13	KSD 602.148f	241	12.0	6.3	130.7
7	4361_13	KSD 602.148 g	223	11.8	6.5	146.9
8	5131_12	KSD 602.148 h	232	12.0	5.7	119.6
9	5132_12	KSD 602.148i	234	12.2	6.9	158.1
10	4362_13	KSD 602.148j	246	12.5	5.6	138.1
11	5133_12	KSD 602.148 k	236	11.9	5.4	116.3
12	5134_12	KSD 602.148 l	254	11.7	6.0	133.4
13	5135_12	KSD 602.148 m	167	13.0	7.4	103.7
14	4355_13	KSD 602.148n	233	12.1	5.0	130.3
15	4364_13	KSD 602.148o	242	12.0	5.8	125.9
16	4365_13	KSD 602.148p	227	12.3	7.1	145.4
17	4366_13	KSD 602.148q	225	11.7	5.0	110.5
18	4363_13	KSD 602.148r	237	11.6	5.8	140.7
19	4368_13	KSD 602.148 s	239	12.2	5.5	123.1
20	4369_13	KSD 602.148 t	242	12.0	6.4	133.1
21	4370_13	KSD 602.148u	239	12.2	7.2	159.9
22	4371_13	KSD 602.148v	241	12.0	7.1	148.6
23	4372_13	KSD 602.148w	177	12.3	8.0	118.3
24	4373_13	KSD 602.148 ×	250	11.9	5.1	120.2
25	4374_13	KSD 602.148(y)	240	11.6	5.1	106.4

cultural and linguistic groups.

1.1. The Hedeby Harbor Hoard: description and dating

During the Hedeby harbor excavations in the 1980s, a hoard of twenty-five copper-alloy bar ingots was found (Ulbricht, 1992: 252). The total weight of the hoard is about 3.2 kg. The bar ingots are between 16.7 cm and 25.4 cm long and are on average about 1.2 cm wide and 0.6 to 0.7 cm thick and weigh between 100 g and 160 g (Table 1). They typically have an ovular or D-shaped cross-section, but parts can have a rhomboidal or C-shaped section. The morphology of the bars is consistent with casting in an open-faced mold, which could have been made of ceramic or stone (for examples from Hedeby, see Resi, 1979: 58–64; Schietzel, 2014: 414–415; for a medieval African example, see Fenn, 2006: 29) or, as Theophilus the Presbyter writes (12th cent. AD), bar ingots could be cast into grooves carved in the ground (Hawthorne and Smith, 1979: 144). The ingot hoard (Fig. 1) was found at a depth of 120–135 cm (arbitrary spit IX) near the shore of the Haddebyer Noor, but due to problems with the recording of the archaeological levels, relative dating of the hoard by stratigraphy is not possible. Although this is the case, the dimension and shape of the ingots have their closest parallels to examples in the late 8th – early 9th century AD (Sindbæk, 2001: 57) and this date is consistent with the depth of the hoard location in relation to early 9th century settlement layers at Hedeby (Kalmring, 2010: 438–439); however, it must be restated that the ingot hoard cannot be precisely dated.

Fig. 1. Hedeby harbor hoard containing twenty-five brass bar ingots (Photo courtesy of the Archäologisches Landesmuseum in der Stiftung Schleswig-Holsteinische Landesmuseen Schloss Gottorf).

1.2. Questions

As it is known that ingot molds with similar size and shape to the harbor ingots have been found at Hedeby, which would imply that the casting of such bar ingots was indeed possible, in this particular case it is unlikely. The three ingots analyzed in a previous unpublished study have been shown to contain about 20 wt% zinc (Eiwanger, 1996: 220). It is a well-known problem that brasses tend to lose zinc during remelting due to the evaporation of zinc above 907 °C, though the amount of loss is variable; the high amount of zinc in the ingots could indicate that they were freshly made i.e. direct products of cementation (see Dungworth, 1997: 905–906; Pedersen, 2015: 60). Brass making in Carolingian-Ottonian Westphalia is evidenced by the numerous cementation crucibles found (Rehren et al., 1993; Krabath et al., 1999; Lammers, 2009; Merkel, 2016a), and it is likely that brass produced elsewhere would have also been made in cementation crucibles. There is no evidence that the brass cementation technology or the raw materials needed to produce brass were available in early medieval Scandinavia. The source of the Harbor Hoard ingots is an important question. The production centers for brass are likely to be found in areas where zinc ore can be found, such as the Rhenish Massif region of Belgium/western Germany, the Byzantine eastern Mediterranean or Islamic lands such as Andalusia, the Middle East or Central Asia, though little is known about the production and origin of brasses from any of these regions during this period.

It has been suggested in several publications that the origin of the Harbor Hoard bar ingots could be the Aachen area, which is renowned for its rich calamine ore and is known for its Roman and medieval brass making traditions (Ulbricht, 1992; Eiwanger, 1996; Day, 1998; Sindbæk, 2001: 58–59). Analysis of the lead content and the lead isotope ratios may be helpful in clarifying the issue of source. Although the

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