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# Moving metals or indigenous mining? Provenancing Scandinavian Bronze Age artefacts by lead isotopes and trace elements

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ABSTRACT

The aim of this study is to further the discussion as to whether copper was extracted locally or imported to Sweden during the Bronze Age or if both of these practices could have coexisted. For this purpose, we have carried out lead isotope and chemical analyses of 33 bronze items, dated between 1600BC and 700BC. Among these are the famous Fröslunda shields and the large scrap hoard from Bräckan and other items from three regions in southern Sweden which are also renowned for their richness in copper ores. It is obvious from a comparison that the element and lead isotope compositions of the studied bronze items diverge greatly from those of spatially associated copper ores. Nor is there any good resemblance with other ores from Scandinavia, and it is concluded that the copper in these items must have been imported from elsewhere. The results furthermore indicate that there are variations in metal supply that are related to chronology, in agreement with other artefacts from Scandinavia as well as from other parts of Europe. Altogether these circumstances open up for a discussion regarding Scandinavia's role in the maritime networks during the Bronze Age.



## 1. Introduction

A new and original Bronze Age culture, displaying a high level of technical and artistic mastery, emerged in Scandinavia about 1600BC (Kristiansen, 1998; Vandkilde, 1996). For instance, Scandinavia shows the highest amount of bronze swords in Europe dated to 1500–1300BC (mostly from barrows) and the Scandinavian hoard finds from the Late Bronze Age include numerous spectacular bronzes such as lures and shields (Harding, 2007; Kristiansen and Larsson, 2005). There are also lots of remains of crucibles and moulds from Bronze Age workshops in Scandinavia and some ingots of tin, copper and lead have also been found. These facts show that the metal was refined and alloyed in Scandinavia into finished objects, from about 1700BC and onwards (Hjärthner-Holdar, 1993; Oldeberg, 1942–1943). This sudden rise of the Nordic Bronze Age (Fig. 1) is an enigma that still lacks satisfactory economic and social explanatory models. Thus, a classic issue has been whether copper was imported to Scandinavia or mined locally. A traditional standpoint, falling back on Oscar Montelius (1872, 1888) notion "ex-oriente-Lux" about the diffusion of objects, states that all the copper and tin was imported to Scandinavia during the Bronze Age, even if the casting and sometimes alloying took place locally (Kristiansen and Larsson, 2005; Montelius, 1872; Oldeberg, 1960, 1942–1943; Thrane, 1975; Vandkilde, 1996). Another school favours a local extraction of copper, and that the material upswing during the Bronze Age partly was connected to extraction of copper from domestic ores (Forssander, 1936; Janzon, 1984). Recently, several researchers have contributed to this issue (Melheim, 2012, 2009; Prescott, 2006).

The general arguments for the different theories could be summarised as follows, starting with those ones in favour of import of copper.

- Observations, based on typological/chronological grounds point at transmission of copper from continental sources (Montelius, 1986 [1885], 1885).
- Complete bronze objects are interpreted to have been imported to Scandinavia from the Carpathian basin and Central Europe (Liversage, 2000; Montelius, 1888; Thrane, 1975).
- There is no concrete evidence of mining in Scandinavia during the Bronze Age (Janzon, 1984; Oldeberg, 1942–1943).
- A chemical resemblance can be noted between Scandinavian bronze items and objects from Central Europe (Cullberg, 1968; Junghans et al., 1968; Liversage, 2000).

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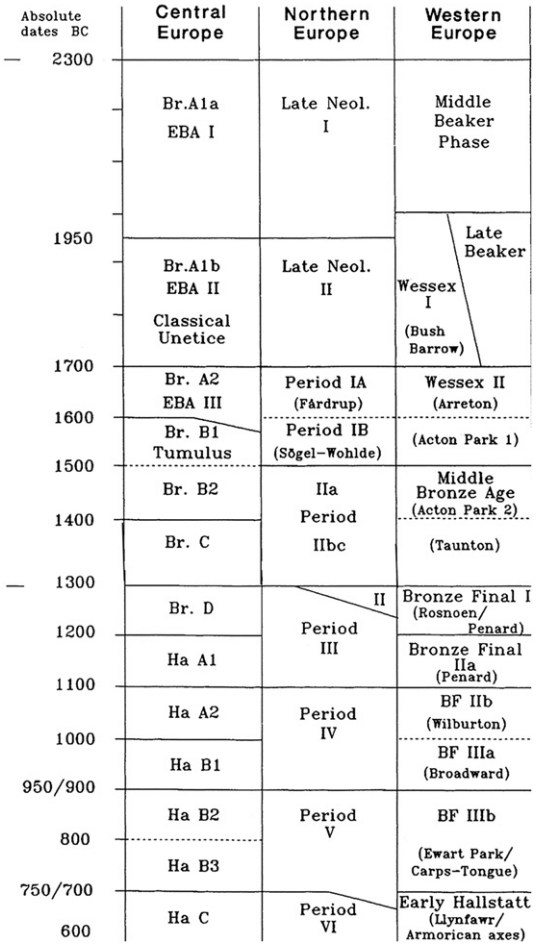


**Fig. 1.** Schematic overview of Bronze Age chronologies. After Kristiansen (1998).

- On the basis of a few published lead isotope analyses on Scandinavian objects from the Bronze Age (Kresten, 2005; Schwab et al., 2010), and from the Neolithic (Klassen and Stürup, 2001), it is shown that their isotopic signatures diverge greatly from those of Scandinavian copper ores.

There are also a number of facts that are consistent with the idea of prehistoric copper mining in Sweden.

- The suddenly increasing number of indigenous artefacts from 1600BC onwards. Southern Scandinavia is the region in the whole of Europe that has the largest number of bronze swords dated to 1500 to 1300BC (Harding, 2007; Kristiansen and Larsson, 2005; Vandkilde, 2007).
- Scandinavia is one of Europe's richest areas of sulphide ores, including e.g. Cu-rich deposits in southern and south-central Sweden (Frietsch et al., 1979).
- Findings of large stone hammers in the northernmost regions with copper ores in Scandinavia (Janzon, 1984).
- Findings of a copper slag at the famous Late Bronze Age workshop of Hallunda, in the county of Södermanland, could indicate that local ores were used (Hjärthner-Holdar, 1993; Melheim, 2012).

## 2. Aims and theory

Since archaeological evidence is not conclusive and geochemical and isotope data are few, it has not been possible to make firm statements concerning the origin of copper. Given this lack of analytical data, the aim of this project is to further the discussion as to whether copper was extracted locally or imported to Sweden during the Bronze Age or if both of these practices coexisted. For this purpose, we have carried out lead isotope and chemical analyses of 33 bronze artefacts, being spatially associated with local copper ores, and compared them with corresponding data for Scandinavian copper ores (Figs. 2 and 3).

### 2.1. Archaeological aim and theory

In explaining technological introduction and change one must also consider the relevance of social networks, geographical relations and the role of innovation (Hjärthner-Holdar and Risberg, 2009; Vandkilde, 2007). The mechanisms of innovation include not only the process of introducing something new; a new idea, material, method or device but also a successful acceptance and exploitation of these new ideas and methods (Hjärthner-Holdar, 2006; Kristiansen and Larsson, 2005). For instance, if the lead isotope data together with the trace elements show that the copper derives from Scandinavian ores, it will be necessary to re-assess the existing import "paradigm" (Melheim, 2012; cf. Fleck, 1979; Kuhn, 1962). We then need to establish new theories concerning local mining processes, production, logistic systems, networking and interaction (cf. O'Brien, 2004; Shennan, 1998) and the social mechanism behind the import paradigm that ruled research for more than a century (Melheim, 2012). However, if the analytical

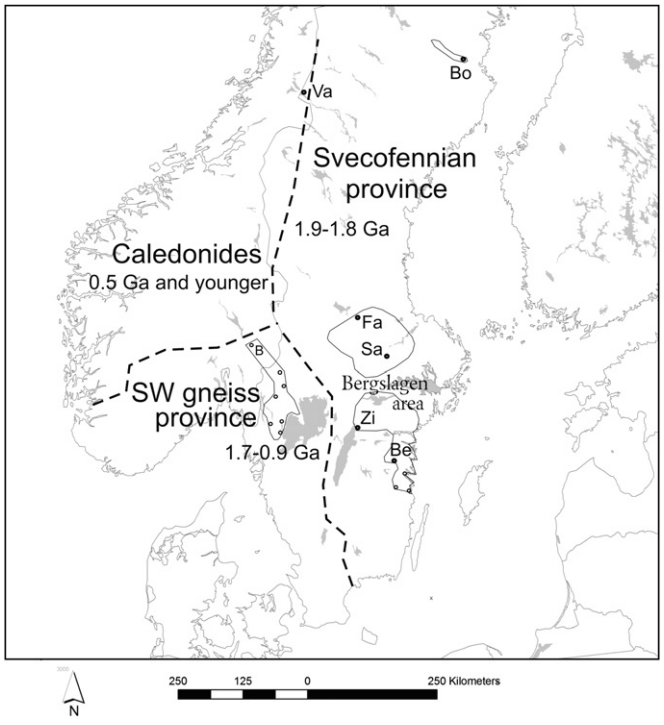


**Fig. 2.** Map illustrating the main geological provinces, with approximate ages given in billion years (Ga), which characterise the Fennoscandian shield. Encircled areas mark ore districts of different ages; one of these corresponds to the Värmland-Dalsland area which carries vein-type deposits (extrapolated to include the geologically similar Brustad Cu-occurrence (B) in Norway; Ihlen, 1986), whereas the base-metal rich Bergslagen region (including Småland) is displayed as two mineralised sub-areas. Each of these districts contains several dozens or hundreds of ore mineralisations of different sizes. Open circles are used to show examples of Cu-rich mineralisations that have been mined in historical times in the considered areas with archaeological bronze finds. Solid circles correspond to major (Zn–Cu–Pb) ore deposits (see Frietsch et al., 1979); Bo = Boliden, Va = Vassbo (mainly Zn–Pb), Fa = Falun, Sa = Sala, Zi = Zinkgruvan and Be = Bersbo.