The Ølby Woman: A Comprehensive Provenance Investigation of an Elite Nordic Bronze Age Oak-Coffin Burial

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ABSTRACT
The Early Nordic Bronze Age oak coffin burials include some of Europe's best preserved human remains. Although traditional typological examinations thereof have not always found clear foreign references, recent provenance investigations from Egtved and Skrydstrup suggest that the two women were of non-local provenance. In order to investigate potential mobility patterns and how these might or might not be related to the archaeological evidence at first sight, we conducted comprehensive multi-analytical investigations on the rich burial of the Ølby Woman, another key female oak coffin burial. Her grave included, *inter alia*, a large number of metal items, the remains of a corded skirt and a glass bead recently identified as of Egyptian origin. We conducted strontium isotope analyses of the dental tooth enamel of Ølby Womans's first, second and third molars to investigate her provenance and potential mobility through childhood. Furthermore, we conducted lead isotope and craft technical analyses of her belt plate and sword/dagger. Our results suggest that the Ølby Woman is of local provenance and that the belt plate and sword were manufactured in Scandinavia, while the raw materials for each item were imported from different places in Europe.

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Introduction:

Often heralded as 'Europe's first Golden Age' (e.g. Demakopoulou et al. 1998, 5), the Bronze Age can best be characterized as a period of heightened and wide-ranging cultural transmission. Although scholars have confirmed various currents and trajectories for the movement of objects, materials and ideas in this dynamic period (Anthony 2007, Earle and Kristiansen 2010, Kristiansen and Suchowska-Ducke 2015, Kristiansen and Larsson 2005, Kristiansen 2017, Ling et al. 2014, Ling et al. 2012) and typologically demonstrated the presence of foreign-seeming personal objects (Jockenhövel and Kurbach 1994, Jockenhövel 1995, Jockenhövel 1991, Jockenhövel 1980, Wels-Weyrauch 1989b, Wels-Weyrauch 1989a, Treherne 1995), it is only fairly recently that strontium isotope analyses have been conducted on human remains from this period (e.g. Oelze et al. 2012, Frei et al. 2015a, Frei et al. 2017c, Knipper et al. 2017a, Bergerbrant et al. 2017, Cavazutti et al. 2019b, Price et al. 2017, Frei et al. 2019). In like fashion, in spite of the scholarly awareness of artefact mobility and the lack of prehistoric exploitation of Scandinavian metal sources (Ling et al. 2012), provenance studies on Danish bronzes are also relatively recent additions to the field, i.e. (Nørgaard et al. 2019, Melheim et al. 2018, Nørgaard, 2017b).

Strontium isotope analyses conducted thus far on southern Scandinavian human remains suggest a certain degree of mobility during the Nordic Bronze Age, (Bergerbrant et al. 2017, Frei et al. 2015a, Frei et al. 2017c, Frei et al. 2019). Furthermore, other recent studies in Germany and Italy (e.g. Knipper et al. 2017b, Cavazutti et al. 2019b, Cavazutti et al. 2019a) seem also to point to a rather high degree of mobility – more specifically, of female mobility – during the period as a whole. In order to investigate the provenance of the Ølby Woman who was interred with a glass bead of Egyptian provenance (Varberg et al. 2015, Kaul and Varberg 2017, Varberg et al. 2016) among other items, we conducted strontium isotope analyses of three of her molars. This mobility study was complemented with lead isotope analyses of the bronze belt plate and sword/dagger.

Figure 1. Ølby mound as it is at present (Photo by F. Kaul). Inset: Map of Denmark showing the location of the mound in which the Ølby Woman was buried (star). The mound is located south of Copenhagen near to the Bay of Køge (København Amt, Ramsø Herred, Højelse Sogn, Sb number 3). Montage by M.J. Walsh.

The Archaeological Context

Ølby is located on the island of Zealand south of Copenhagen near the town of Køge (Figure 1). The site consists of four burial mounds. The Ølby Woman was buried in the northernmost of the mounds (SB no. 3) (Boye 1896). The 'Nordhøj' (lit. 'North Mound') was excavated by the National Museum of Denmark by archaeologist Sophus Müller in 1880. Even today, the remains of Müller's excavations are still visible in the well-preserved prehistoric monument. Although the mound had been partially damaged by human activity and by a series of fox burrows, Müller was nonetheless able to ascertain the presence of a broken Iron Age cremation urn situated directly above the 250 × 63 cm coffin which predated it (Aner and Kersten 1973).

Placed on a NW-SE axis close to the centre of the mound, the Bronze Age oak coffin contained preserved human skeletal remains (See Figure 2). Müller (1880) remarked upon the good preservation of the skeleton's maxilla and mandible. Although other parts of the skeleton were recognizable, they were unfortunately not as well preserved as the maxilla and mandible, except where in contact with bronze objects (Boye 1896, Jensen 1998). The remnants of an animal hide as well as wool textiles (including the remains of finely woven cloth thought to represent a belt) were also discernible (Broholm and Hald 1939, 97). The Ølby Woman's grave goods include a series of small bronze spirals, a dark blue glass bead and two amber beads found in the area where the corpse's left arm is expected to have lain. Her midriff was graced with an ornate bronze belt plate decorated with two spiral rows. This was crossed by the broken off lower part of a small bronze sword (or dagger) in a wooden sheath (Aner and Kersten 1973, Boye 1896). The belt and the small sword/dagger were surrounded by four bronze tutuli. Additionally, the Ølby female had a bronze neck collar and 125 thin bronze tubes around the skeleton's pelvic girdle which offer mute testimony to the erstwhile presence of a corded skirt (Broholm, 1943, Bender Jørgensen, 1986). The contents of the grave (See Figure 2) allow for a date within Period II of the Nordic Bronze Age, a period corresponding to 1500-1300 BC (Jensen 2006, Montelius 1986, Vandkilde et al. 1996). More concretely, the Ølby burial has been suggested to date between 1400 and 1300 BC based on typology (Randsborg 2006).

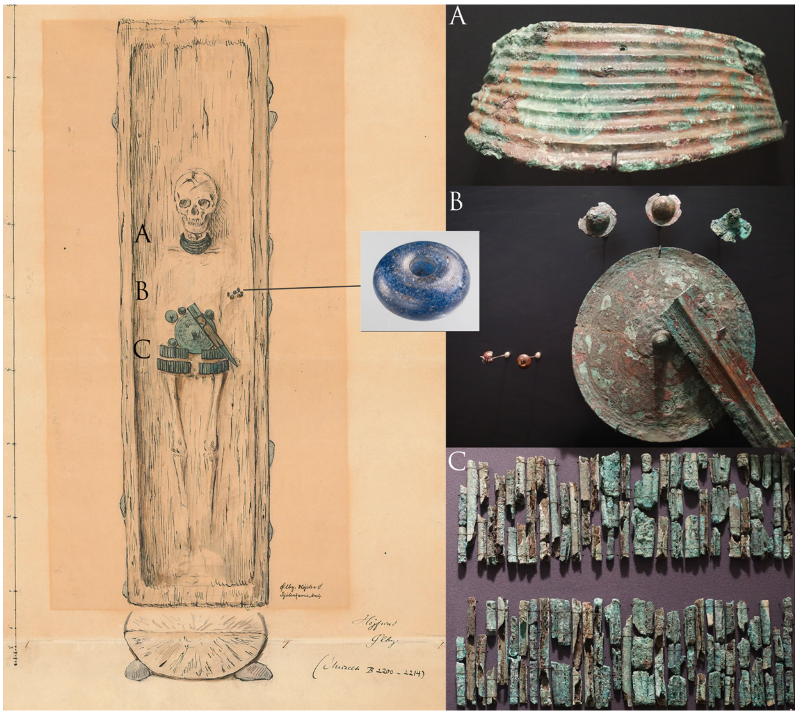


Figure 2. At left, annotated watercolour of Ølby grave (V. Boye 1880; digital reconstruction by M.J. Walsh). At right, pictures of the A) neck collar, B) tutuli, belt plate, sword/dagger and amber beads and C) bronze tubes from corded skirt (photos by S.S. Reiter). Inset with arrow shows blue glass bead (photo by A. Mikkelsen, National Museum of Denmark). Montage by M.J. Walsh.

Material and Methods

Material

Although Müller (1880) remarked upon the preservation of the mandible and maxilla, the only physical remains of the Ølby Woman that were conserved after the 19th century excavation were her teeth. Today, these form part of the National Museum's human remains collection. Although little dentine remained (NM B2200-14), the enamel crowns from the first (maxillary left), second (mandibular right) and third (mandibular right) molars were well preserved, providing the opportunity to conduct multiple strontium isotope analyses. While dental enamel alone is not suitable for an age estimate, it was the only material available for study. The fact that Ølby Woman's third molars had fully erupted, and also show some signs of wear suggests that Ølby Woman was an adult at the time of her death (after Brothwell 1981, 72).

Ølby Woman's grave goods are curated by the National Museum of Denmark and are partially on display in the museum's Bronze Age permanent exhibition and partially in storage. Unfortunately, the metal accoutrements analysed here are in an advanced state of corrosion. As is visible on the majority of artefacts from other oak coffin burials, the metal items buried with Ølby Woman are covered by a thick greenish layer of what is very likely copper carbonate and copper chloride, indicative of deposition in a moist environment (Nørgaard 2017c, Oudbashi et al. 2013, Robbiola et al. 1998, Chase 1994). The corrosion makes craft technical analysis difficult and requires specific precautions for the provenance analyses (see below).

Strontium Isotope Analyses

Tooth enamel samples were pre-cleaned by removing the enamel's surface with a drill bit. Subsequently, a few milligrams of enamel were sampled from each tooth. The tooth enamel samples were dissolved in 7 ml Teflon beakers (Savillex™) in a 1:1 solution of 0.5 ml 6 N HCl (Seastar) and 0.5 ml 30 % H_2O_2 (Seastar). The samples typically dissolved within a few minutes, after which the solutions were dried on a hotplate at 80° C. Thereafter, the enamel samples were taken up in a few drops of 3N HNO_3 and then loaded onto disposable 1 ml pipette tip extraction columns into which we fitted a frit to retain a 0.2 ml stem volume of pre-cleaned mesh 50-100 SrSpec™ (Triskem) chromatographic resin. The elution recipe essentially followed that of Horwitz et al. (1992), albeit scaled to our needs (insofar as strontium was eluted/stripped by pure deionized water and then dried on a hotplate).

Thermal ionization mass spectrometry was used to determine the Sr isotope ratios. Samples were

Location 1: Skensved Å			
Sample No.	**Sample Type**	$^{87}Sr/^{86}Sr$	**(+/- 2SE)***
KF1532	Water	0.70911	0.00001
Location 2: Køge Å			
Sample No.	**Sample Type**	$^{87}Sr/^{86}Sr$	**(+/- 2SE)***
KF1538	Soil	0.70975	0.00001
KF1541	Plant	0.70912	0.00001
KF1534	Water	0.70879	0.00001
Location 3: Tranemose Bæk (A)			
Sample No.	**Sample Type**	$^{87}Sr/^{86}Sr$	**(+/- 2SE)***
KF1542	Plant (both plant samples from site A+B mixed)	0.70924	0.00001
KF1533	Water	0.71031	0.00001
Location 4: Tranemose Bæk (B)			
Sample No.	**Sample Type**	$^{87}Sr/^{86}Sr$	**(+/- 2SE)***
KF1535	Water	0.70871	0.00001

Table 1. Strontium isotope results of bioenvironmental samples from four locations in the area surrounding the Ølby burial mound *2SE = uncertainty of the mean at a 95 % confidence level.

dissolved in 2.5 µl of a Ta_2O_5-H_3PO_4-HF activator solution and directly loaded onto previously- outgassed 99.98 % purity single rhenium filaments. Samples were measured at 1250-1300° C in a dynamic multi-collection mode on a VG Sector 54 IT mass spectrometer equipped with eight Faraday detectors (Institute of Geosciences and Natural Resource Management, University of Copenhagen). Five nanogram loads of the NBS 987 Sr standard that we ran during the time of the project yielded $^{87}Sr/^{86}Sr = 0.710239$ +/- 0.000011 (n = 15, 2σ and results normalized to 0.710245).

In order to interpret the results obtained in this manner, it is important to have an understanding of the local bioavailable strontium isotope baseline range. However, there is as yet no consensus regarding which type of proxy (e.g., surface waters, plants, soils, fauna, etc.) is the most suitable for delineating the isotopic range of bioavailable strontium signatures of an area (Grimstead et al. 2017). For the area of Zealand (where the Ølby Woman was buried), several baselines have been established based on different types of environmental samples including surface waters, soil samples and faunal remains (Frei and Frei 2011, Frei and Frei 2013, Frei 2013, Frei and Price 2012, Price et al. 2011, Price et al. 2007). Furthermore, though more general, a recently published baseline study from almost 1200 soil samples taken throughout Europe adds yet another layer of data (Hoogewerff et al. 2019). All in all, these studies seem to indicate that the local bioavailable baseline of this region ranges between $^{87}Sr/^{86}Sr = 0.708$ to 0.711. In our present study, we complemented the existing data with seven additional environmental samples from plants, surface water and soils collected from the surroundings of the Ølby site. As the area of Køge is partially agriculturally cultivated, it was difficult to avoid samples from farmed areas entirely (See Table 1). However, we tried to avoid sampling within farmed areas as much as possible.

Metallurgical Analyses

The sampling and preparation of the metal artefacts for provenance analyses, namely the neck collar (NM B2200), belt plate (NM B2202) and sword/dagger blade (NM B2201) took place at the National Museum in Copenhagen. Sampling consisted of drilling a hole with a 1mm drill in the back side of the collar and the belt plate and in the broken edge of the sword/dagger blade. Corroded material within the drill shavings was carefully removed before sampling. The elements Cu, Mn, Fe, Co, Ni, Zn, As, Se, Ag, Cd, Sn, Sb, Te, Au, Pb and Bi were measured using energy-dispersive X-ray fluorescence (EDX-

RF) at the CEZA in Mannheim (Germany) using an Thermo Scientific ARL Quant X instrument with a 20-position sample changer. Two reference materials obtained from the *Bundesanstalt für Materialprüfung* in Berlin (BAM211 and BAM376) were included in each run. The detection limits are 0.05 % for Fe, around 0.01 % for Co, Ni, and As and around 0.005 for Ag, Sb, Sn, Au, Pb and Bi. Mn, Cd, Se and Te were also measured, but were below 0.005 % in all samples. Zn was below the detection limit of 0.1 % in all samples.

Common Pb lead-isotope analyses (^{208}Pb, ^{207}Pb, ^{206}Pb, ^{204}Pb) were performed at the same laboratory by multiple collector inductively coupled plasma mass spectrometry (MC–ICP–MS, Thermo Scientific Neptune Plus mass spectrometer). The chemical pre-treatment resulted in solutions with 100ng ml^{-1} of lead. The procedure was as follows: the samples were rinsed with dilute HNO_3 to remove surface contamination and were then dissolved in half-concentrated HNO_3 in an ultrasonic bath (70° C) for several hours. Insoluble residues were removed by decantation from the resulting solution, which was then diluted with deionised water (Niederschlag et al. 2003). Columns were prepared with PRE filter resin and Pb resin and were preconditioned with 500µl 3N HNO_3 before the solution was added. In four steps, the matrix was eluted using HNO_3, and the Pb was eluted using HCl. After drying (48 h), a volume of a 50 ppb thallium solution was added to the sample solution as a control solution. During analysis, standard measurements were interspersed between every four sample batches and intensive rinsing of the system was conducted after every sample. Recording of ^{203}Tl and ^{205}Tl (added to the sample solutions as an internal isotopic standard) allowed for the correction of an internal mass fractionation of the lead isotope ratios (Dunstan et al. 1980).

Results

Strontium Isotope Analyses

Strontium isotope analyses of the environmental samples yielded a range from ^{87}Sr/^{86}Sr = 0.70871 (surface water from Tranemose Bæk, location B) to ^{87}Sr/^{86}Sr = 0.71031 (surface water from Tranemose Bæk, location A) (Table 1), which fall within the baseline range from previous studies covering the area of Zealand (Frei and Frei 2011, Frei and Frei 2013, Frei 2013, Frei and Price 2012, Hoogewerff et al. 2019, Price et al. 2011, Price et al. 2007). The results of the strontium isotope analyses conducted on Ølby Woman's three molars ranged between ^{87}Sr/^{86}Sr 0.70998 to 0.71085 (Table 2). Mineralization of tooth enamel occurs within different times over the life course from childhood to early adolescence (i.e. the formation of the first molar's tooth enamel takes place *in utero* until ca. 3 years of age, the second molar between the ages of ca. 2-8 years and the third molar from ca. 7-16 years) (Montgomery 2010, Hillson 1996). Thus, it is possible to provide a temporal dimension to individual life stories of detectable geographic mobility. The results of the multi-molar sampling strategy of Ølby Woman's first, second and third molars suggest that the Ølby Woman was local to the island of Zealand. Furthermore, the isotopic differences exhibited by her tooth enamel – between the second and third molars – suggest the possibility of internal mobility within the region probably after the age of ca. 8 years, or during early adolescence.

Sample No.	Molar	^{87}Sr/^{86}Sr	(+/- 2SE)*
KF1872	M1	0.70998	0.00001
FK1873	M2	0.71002	0.00001
KF1874	M3	0.71085	0.00001

Table 2. Strontium isotope results of the human remains of the Ølby Woman (NM B2200-14). *2SE = uncertainty of the mean at a 95 % confidence level

However, as the mineralization period in the third molar represents an average of several years (ca. 8), it is difficult to elaborate further on the type of mobility in which the Ølby Woman might have engaged. It is also not possible to exclude mobility outside of this region. However, even though this female seems to have been local, some type of mobility seems to have been part of her life.

Metallurgical Analyses

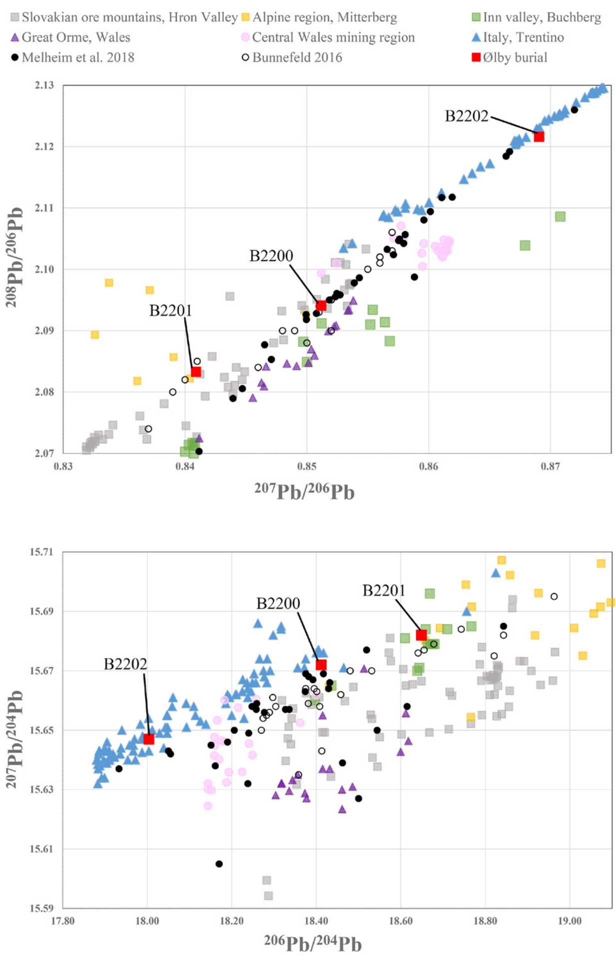
The results of the metallurgical analyses of the samples taken from the three large bronze objects from the Ølby burial were surprisingly diverse. While all

Sample No.	Object	Museum No.	^{208}Pb/^{206}Pb	^{208}Pb/^{206}Pb (+/- 2 SE)*	^{207}Pb/^{206}Pb	^{207}Pb/^{206}Pb (+/- 2 SE)*	^{206}Pb/^{204}Pb	^{206}Pb/^{204}Pb (+/- 2 SE)*
MA-180945	Sword/ dagger	B2201	2.08330	0.00001	0.84089	0.00001	18.6490	0.0001
MA-180946	Neck collar	B2200	2.09410	0.00001	0.85117	0.00001	18.4120	0.0001
MA-180947	Belt plate	B2202	2.12160	0.00001	0.86906	0.00002	18.0040	0.0001

Table 3. Lead isotope ratios of the artefacts from the Ølby burial. *2SE = uncertainty of the mean at a 95 % confidence level.

Sample No.	Object	Museum No.	Cu	Fe	Ni	As	Ag	Sn	Sb	Pb	Bi
			wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %
MA-180945	Sword/ dagger	B2201	88	0.07	0.57	0.403	0.008	10.2	0.117	0.011	< 0.000
MA-180946	Neck collar	B2200	92	< 0.01	0.67	0.511	0.010	6.9	0.154	0.087	< 0.001
MA-180947	Belt plate	B2202	88	0.20	0.91	0.468	0.022	10.1	0.166	0.091	0.006

Table 4. Element concentrations of the copper measured in the artefacts from the Ølby burial. Concentrations of elements Mn, Co, Zn, Se, Cd, Te and Au were below detection levels.



three artefacts were made of low-impurity copper with tin concentrations of 7-10 % (as Tables 3 and 4 indicate), which would be normal for the bronzes of this time, the differences in the trace element compositions (though minor) preclude that the artefacts were made from a single batch of raw material. The lead isotope ratios further highlight these differences (See Table 4 and Figure 3). Moreover, the results shown in Figure 3 indicate that the three artefacts were made of copper from different ore sources.

The belt plate (NM B 2202), isotopically characterized by values of 2.1216 for ^{208}Pb/^{206}Pb, 0.86906 for ^{207}Pb/ ^{206}Pb and 18.004 for ^{206}Pb/^{204}Pb, fits very well with the signatures of the Trentino region in the

Figure 3. Lead isotope ratios of the artefacts from the Ølby burial compared with possible ore sources. Data from Mitterberg ore district (Pernicka et al. 2016), Hron Valley, Slovakia (Schreiner 2007, Modarressi-Tehrani et al. 2016), the Buchberg and the Inn Valley in the Alpine region (Schubert and Pernicka 2013), Great Orme and central Wales mining regions (Williams 2018, Williams 2014, Joel et al. 1997, Rohl and Needham 1998, Rohl 1996) and contemporary data (Melheim et al. 2018, Bunnefeld 2016). The analytical uncertainties are comparable with the size of the symbols.

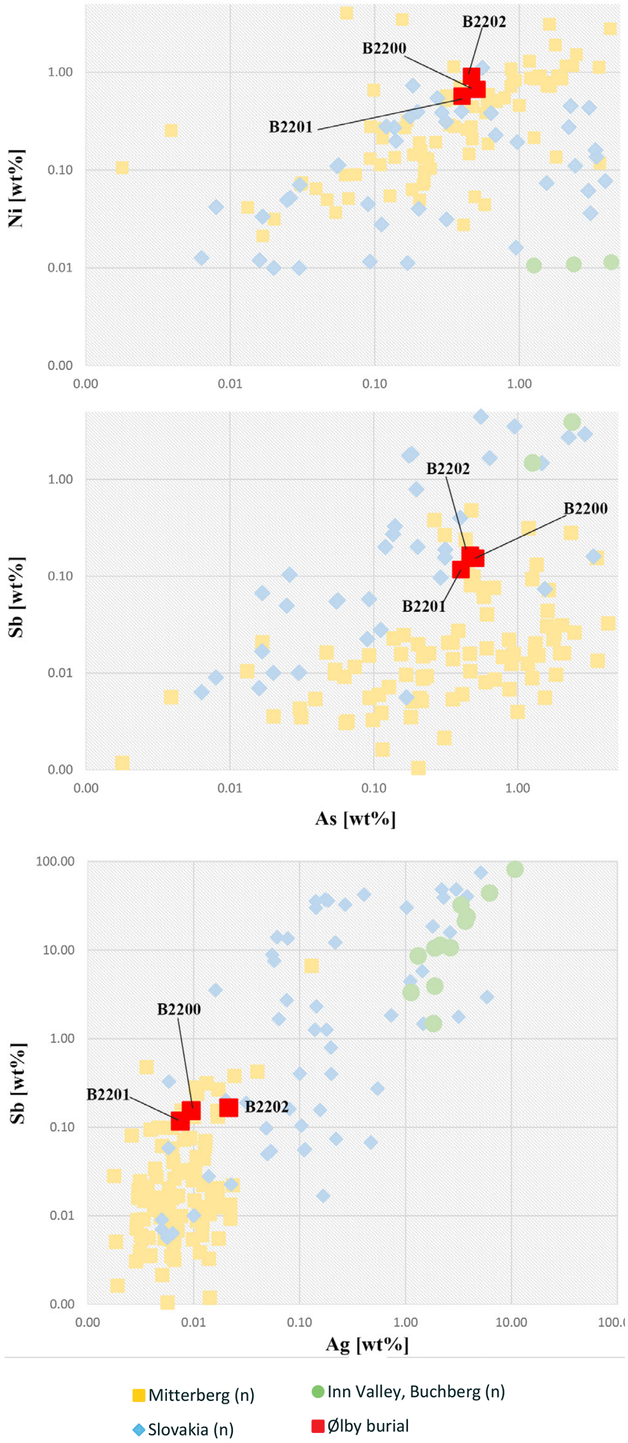


Figure 4. Trace element concentrations of As–Ni, As–Sb and Ag– Sb of the artefacts from the Ølby burial compared to the relevant ore bodies in the Slovakian Ore Mountains and the eastern Alps. Ore values are normalized to copper and based on regional, interdisciplinary investigations of the specific mining regions (Höppner et al. 2005, Schubert and Pernicka 2013, Schreiner 2007, Modarressi-Tehrani et al. 2016, Pernicka et al. 2016).

eastern Italian Alps (Addis et al. 2016, Addis 2013, Nimis et al. 2012, Artioli et al. 2015). On the other hand, the lower value of 2.0833 for $^{208}Pb/^{206}Pb$ and the higher value of 18.649 for $^{206}Pb/^{204}Pb$ measured in the sword/dagger blade (NM B2201) indicate a closer match with Mitterberg ore sources (Pernicka et al. 2016). The neck collar (NM B2200), isotopically characterized by values of $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ ratios of 0.85117 and 2.0941, respectively, seems to be compatible with leads from Slovakian ores (Schreiner 2007, Modarressi-Tehrani et al. 2016). Although these differences are not as clear-cut as those exhibited by the trace elements (Figure 4; excluding the Trentino region due to its lack of comparable trace element data), the trace element concentrations of silver (Ag) and antimony (Sb) lend further support to the idea that the objects were made from metals originating from different sources. At present, it seems, therefore, as though the three objects analysed herein were made from metals sourced from different areas.

Discussion

An overarching examination of the style and material goods associated with Ølby Woman would categorize her burial as being a wealthier version of an otherwise typical Nordic Bronze Age elite style female grave, like e.g. that of the Egtved Girl. Of these, what would be considered one of the most iconic elements is Ølby Woman's corded skirt (Bergerbrant 2014, Bergerbrant 2005, Skals and Mannering 2014, Bergerbrant et al. 2012, Nosch et al. 2013, Randsborg 2006, Randsborg 2011). However, this association might be due to the fact that the environmental conditions of Northern Europe are more favourable to the preservation of textiles on the whole than to any apparent regional preference for corded skirts (Broholm 1943, Broholm and Hald 1935). In fact, not only have corded skirts been found throughout Scandinavia (Bergerbrant 2007, Bergerbrant 2014, Randsborg 2011, Broholm and Hald 1935) but also in various other places in Europe (Fages 1986, Fagles 1990, Furmánek and Pieta 1985) as well as elsewhere (Wade 2010, Bian and Xin 2014, Sanz et al. 2014,).

The only remaining recognizable aspect of Ølby Woman's corded skirt is the bronze tubes that adorned the cords (Aner and Kersten 1973, Broholm 1943, Boye 1896, Randsborg 1973, Randsborg 2006, Randsborg 2011, Broholm and Hald

Figure 5. The spirals on the belt plate (B2202) were very likely made with a spiral-stamp in the wax model. The spirals of the inner and outermost row can be projected onto each other and make a perfect match with their centres and the width of the grooves at the distance between each turn. Importantly, these similarities hold for both of the two spiral rows (Photo: H.W. Nørgaard).

1935). Further examples of metal tubes are known from other grave contexts (e.g. Danish Hverrehus and Hagendrup and Swedish Åskarps Villans among others) (Broholm 1943, Aner and Kersten 1976, Oldeberg 1974) as well as from votive deposits, such as that at e.g. Vognserup Enge (Aner and Kersten 1976, Randsborg 2006, Rieck 1972, Frost 2011). Metal tubes have had a long history of use (Bergerbrant 2005). Cold-hammered copper tubes such as those recovered from 7th to 6th millennium BC contexts at Çatal Hüyük (Barber 1993) are thought to have served a similar function as their later Danish equivalents. Still other metal tubes have been found in the Carpathian Basin, Austria and Saxony (Bergerbrant 2005, Gimbutas 1982). Within Denmark, the tradition seems to have continued at least into the Late Bronze Age, as can be seen from the Period V grave at Bevtoft (southern Jutland), which included sheet metal tubes alongside a bracelet and horse gear (Broholm 1943).

The richness of Ølby Woman's metal accoutrements as a whole is also worthy of particular note, because of the sheer quantity of metal with which she was interred (although the presence of metal in the grave has been interpreted as a sign of increased social status) (Sprenger 1995, Randsborg 1974, Vandkilde 1996). In recent years, our knowledge of the metal supply of the Nordic Bronze Age has risen steadily (Nørgaard et al. 2019, Melheim et al. 2018, Bunnefeld 2016), especially between 1600-1100 BC. Likewise have opportunities to compare the analyses made from objects coming from that period also increased. The three possible sources for the raw material used for the metal artefacts of the Ølby burial, as suggested by our data, mirror the three main metal suppliers that have recently been recognized for Scandinavian artefacts during this period: the Slovakian mountains, the Trentino region in northern Italy and the Mitterberg mining area in Austria (Melheim et al. 2018; Bunnefeld 2016) (Figure 3). Although not evident in the material from Ølby, other metal objects from period II of the Nordic Bronze Age also show evidence of raw materials from an additional metal source from the Welsh mining region (Ling et al. 2019, Melheim et al. 2018).

Interestingly, the different metal sources within the Ølby material do not seem to be related to specific artefact categories. For example, at least five artefacts within the body of data used for comparison with the Ølby material indicate the crafter's use of metals from the Trentino mining region (See Figure 3). The artefacts produced therefrom include Ølby Woman's belt plate (NM B2202), a tutuli, sickle fragments and a tube (data from Melheim et al. 2018). Further, the swords analysed from period II (Bunnefeld 2016) show a wide lead isotope range matching both the ores from the Slovakian and the Mitterberg mining regions. We would suggest, therefore, that the motivation for using a specific metal from a specific source must have some other guiding principle than the requirements of the object being produced.

To this end, a craft technical investigation was conducted on the three artefacts from the Ølby burial in order to determine whether they might be allocated to a specific production workshop, and thereby shed more light on the choice of metals

Figure 6. The centre part of the sword blade (B2201) is very well preserved and displays four parallel running grooves along the centre ridge (Photo: H.W. Nørgaard).

utilized for each item. It is very likely that both the belt plate and the neck collar were made within the technological traditions of the Nordic Bronze Age (See Nørgaard 2011, Nørgaard 2018). Moreover, it can be shown that the belt plate´s decoration corresponds with the specific technological repertoire of the Danish Islands (See Nørgaard 2017a), as the spirals were made using a stamp-like tool impressed in what was probably a decorated wax-model of the belt plate (Figure 5). As such, the spirals from the neck collar (NM B2200) and the belt plate (NM B2202) might help to clarify a workshop affinity. The sword/dagger blade itself (Figure 6) unfortunately does not provide enough characteristic crafting traces to draw a clear conclusion. Previous studies documented the use of identical stamps and allowed for the identification of what one might call 'analytical' workshops (i.e. workshops with an unknown physical location) during period II in NBA (Nørgaard 2018). Each workshop seemed to use one or two specific stamp tools. However, due to advanced corrosion, the Ølby belt plate unfortunately does not allow for a one-to-one comparison of the spirals (i.e. one in which the spirals of the different artefacts are placed on top of each other in order to align characteristic tool traces, such as the shape of the centre of the spiral and the width of the grooves at the distance between every turn).

Therefore, we conducted direct comparison analyses with several contemporary artefacts instead. These yield some information about possible workshop affiliation. Firstly, it seems that the spirals on the neck collar and belt plate were made using different tools. Secondly, both were impressed in a wax model and were only slightly reworked post-casting, indicating a high level of skill in the craftsperson. Thirdly, the belt plate´s spirals display a very characteristic centre with rounded pointy ends; the space between the ends at the single groves is above average and the grooves themselves are narrow and very regular. Similar characteristics have been documented on the spirals from the belt plate from Rye (NM B7615), Frankerup (NM CMXIII) and Lavø, Zealand (NM 11686)(See Figure 7). The spirals on the neck collar, however, cannot be compared with the artefacts mentioned above, as they are much smaller (0.9 cm compared to 1.5 cm at Frankerup, Rye and Ølby Woman's own belt plate) and have a parallel running centre in which one part is distinctively straight (Figure 8). Documented tool traces (see arrows Figure 8) are similar to traces found on the belt plate from Vognserup (VM1680KD).

The preservation of the Ølby artefacts does not fully allow for an allocation of the artefacts to an analytical workshop as defined by Nørgaard (2018). However, when the detectable crafting traces were compared to artefacts it seems likely that they were made by different craft groups, i.e. workshops (See Nørgaard 2018).

Somewhat similar complex patterns for the import of raw materials with a local crafting affinity have been suggested previously by Frei et al. (2017a) regarding wool trade and production of textiles within the Nordic Bronze Age. Research on wool threads from textiles dating also to the Nordic Bronze Age and partially contemporaneous with that which must have been present at Ølby suggests that approximately 75 % of the wool analysed was spun

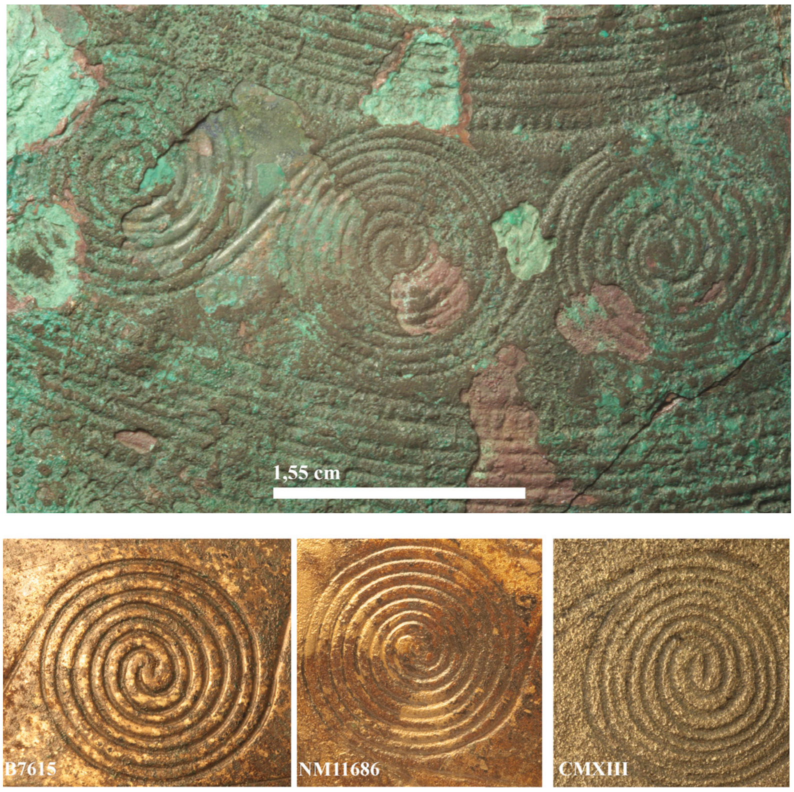


Figure 7. The spirals on the Ølby belt plate (B2202) are on average 1,5 cm wide and can be compared in their characteristics with the spirals on the belt plates from Rye (B7615), Lavø (NM 11686) and Frankerup (CMXIII) found on Zealand (Photos: H.W. Nørgaard).

from the wool of animals that had grazed outside of present day Denmark (excluding Bornholm). While this trend seems to drastically decrease to 25 % in the Early Iron Age (Frei et al. 2017a), it has been suggested that the marked technical similarities in the production of many of the preserved Nordic Bronze Age textiles would suggest 'local' (i.e. Nordic) weaving production (Strand et al. 2016). In this way, wool and bronze seem to point to similar patterns of trade and production insofar as raw materials were imported to Scandinavia for local crafting.

Other materials included as part of Ølby Woman's grave goods which merit further discussion are the amber and glass beads. Nordic amber is found locally in Denmark (especially in the west coast of Jutland) and around the Baltic Sea. It should also be noted that the shores along Køge Bugt (the Bay of Køge, not too distant from the Ølby burial) are considered 'amber beaches' (Faber et al. 2000). As a raw material, amber was traded across long distances during this period, even reaching the eastern Mediterranean and Syria (Bouzek 1993, de Navarro 1925, Czebreszuk 2009, Sprincz and Beck 1981, Krause 2003, Beck 2000, Mukherjee et al. 2008, Czebreszuk 2013), and seems to have had ties to the northward-bound glass trade (Bellintani 2014, Kaul et al. 2015, Varberg et al. 2015, Purowski et al. 2016). Both glass and amber represent materials often associated with status. The latter is thought to have served as a crucial part of Scandinavia's overall economic importance in the Bronze Age (Sprincz and Beck 1981, Beck 2000, Bátora 1995).

However, glass was not locally produced within Scandinavia. Müller (1882) was the first to specifically point at Egypt while discussing the potential Middle Eastern origins of the Danish glass beads, and he did this just two years after his excavation of Ølby mound in 1882. Recent chemical analyses seem to have confirmed his hypothesis, as two beads from Danish oak coffin burials (both from Nordic Bronze Age Per. II) were made of Egyptian glass, one from a rich female burial from Hesselager (Funen, Denmark) and the other from Ølby (Varberg et al. 2015, Varberg et al. 2016)(See Figure 2). The remaining Danish beads which have been analysed date from Nordic Bronze Age Per. II-III (1500-1100 BC) come from a further 20 burials and are of Mesopotamian glass (Varberg et al. 2016).

The Ølby bead and the Hesselager bead are both characterized by low chromium/lanthan and variable zirconium/titanium ratios, indicating an Egyptian origin. The remaining Danish glass beads exhibit higher chromium/lanthan and lower zirconium/titanium ratios, thus indicating a Mesopotamian origin (Varberg et al. 2015, Kaul et al. 2015, Varberg et al. 2016, Kaul and Varberg 2017). The Egyptian

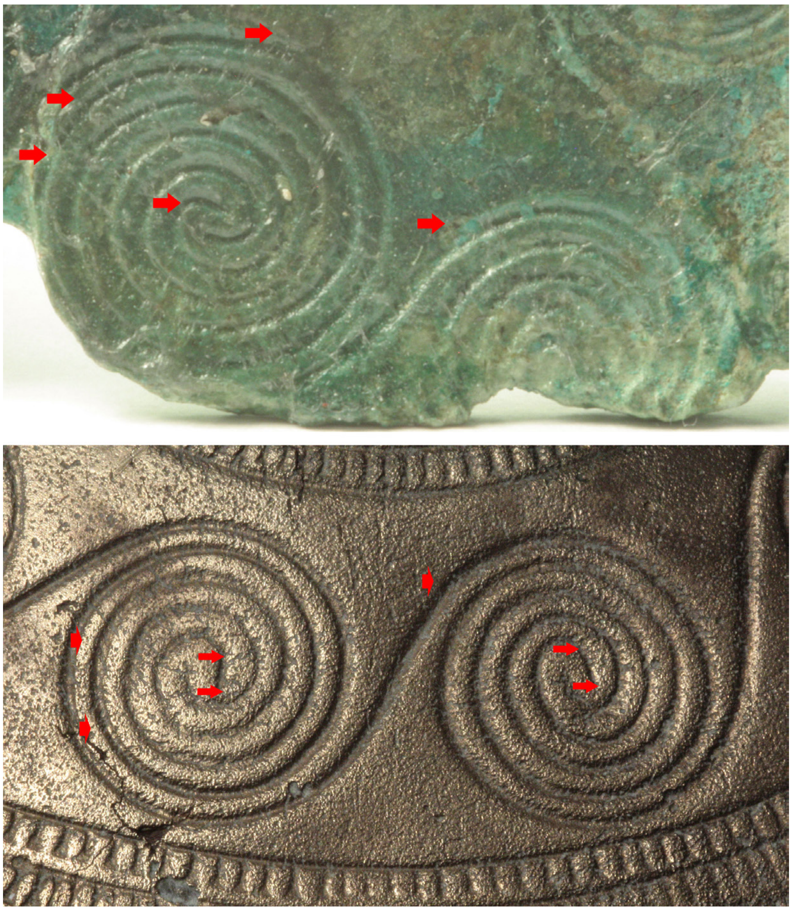


Figure 8. The spirals on the neck collar from the Ølby burial (B2200, pictured above) display a much sharper impression in the spirals' centres and also have wider distances between the grooves. Similar characteristics (see the red arrows) were documented on the spirals from the small belt plate in Vognserup (VM1680 KD, pictured below) (Photos: H.W. Nørgaard).

origin of the glass bead of the Ølby grave seems to be confirmed by the colorant composition, consisting of cobalt with nickel, zinc and manganese. This type of colorant combination has been shown to be typical of the cobalt colorant extracted from Egyptian alum deposits, such as those at the Kharga and Dakhla oases in the Western Desert (200 and 350 km west of the Nile). Similar trace element compositions related to the cobalt colorant have been observed in glass waste from a 14th century BC glass workshops at Malkata and Amarna (Egypt), in the glass ingots found on the Uluburun shipwreck off the southwest coast of Turkey and in Mycenaean glass beads as well (Shortland et al. 2006, Shortland et al. 2007, Jackson and Nicholson 2010, Smirniou and Rehren 2013).

Recent work by a Polish research team has documented the presence of a blue bead of Egyptian cobalt glass from a Middle Bronze Age burial at Kietrz in southwest Poland (Purowski et al. 2016). This bead showed a similar composition to that of the Ølby and Hesselager glass beads. The Kietrz find site is near the source of the Oder River and the watershed for the Danube tributaries. Thus, the Kiertz Egyptian cobalt bead marks another node along Bronze Age trade route following along the Oder River to the Baltic Sea and from the Baltic to Ølby on Zealand. Naturally, one must also consider other routes. Recent chemical analyses have also demonstrated the occurrence of four beads Egyptian glass at the Bronze Age settlement sites at Landunvez and Plomeur in Finistère (Brittany, France)(Cherel and Gratuze 2018).

The cobalt blue Ølby bead stands among the northernmost finds of Bronze Age material from Egyptian origin, nearly at 'the northern end' of the ancient routes of exchange of valuable and prestigious commodities. Given the other goods from the Ølby Woman's rich equipment, including the corded skirt adorned with bronze tubes, it is likely that she would have held a particular status within her society. Perhaps the decorated corded skirt was used in a cultic or ritual manner, as has previously been suggested (Kristiansen and Larsson 2005. Thomsen 1929).

The fact remains that Ølby Woman was interred with both local trade goods (the amber beads) and imported trade goods (the bead of Egyptian glass). Analysis of the metal objects interred with her acts as further evidence for diverse and wide-reaching networks of trade and exchange, both abroad (for the procurement of the raw materials) and within present-day Denmark (for the production of the metal objects themselves as well as the material needed for her amber beads). Her central position within the mound speaks to the importance she may have had within the local community. .

The European Bronze Age has long been conceptualized as a period in which society was founded on systems of gift exchange and kinship networking suspected to have been anchored in the movements of elite females for marriage alliances (Rowlands 1980, Kristiansen 1998). The idea of women travelling within these networks as breathing manifestations of Lévi-Strauss' 'supreme gift' (Lévi-Strauss 1969, 65) has become emblematic of Bronze Age research, especially within the many fine-grained typological studies that have been undertaken in this vein (Jockenhövel and Kurbach 1994, Jockenhövel 1995, Jockenhövel 1991, Wels-Weyrauch 1989b). However, the results discussed in this article, as well as those recently published on the mobility patterns exhibited by the Egtved Girl (Frei et al. 2015b) and the Skrydstrup Woman (Frei et al. 2017b), show that elite women buried in oak coffins during the Nordic Early Bronze Age appear to exhibit highly divergent mobility patterns. Moreover, women's origins seem not always readily apparent within the funerary context. Recent work in Scania suggests that non-elite Bronze Age individuals were also mobile (Bergerbrant et al. 2017b). These results can be contrasted with recent work from Italy, showing tendencies for higher elites to have been mobile (Cavazutti et al. 2019a).

Roughly contemporary evidence from other parts of Europe is gradually mounting. Results from Early Bronze Age Singen near Lake Constance exhibit a similar disconnect between movement/non-movement, social status and the apparent local/nonlocal origins of the deceased (Oelze et al. 2011). Similarly, while the investigations of the Lech Valley in southern Germany disclosed an unexpectedly large number of females that were non-local, their nonlocal status was otherwise not apparent through investigation of archaeological context alone (Knipper et al. 2017). The increasing amount of data emerging from strontium isotope analyses from the Bronze Age thus far indicates that persons from that time seem to have engaged in highly complex mobilities with potential regional differences. More research is needed in order to gain a better handle on the emerging picture of the European Bronze Age.

Conclusion

The Ølby Woman, one of the well-known oak coffin female burials from the Early Nordic Bronze Age, was buried with a rich assemblage of grave goods. These include several large bronze items, a corded skirt with the characteristic bronze tubes and a bead of Egyptian glass, among other things. Our strontium isotope analyses of three of her molars yielded values that seem to indicate a local provenance. Additionally, differences in the strontium isotopic signatures (between the second and third molar) suggest the possibility of mobility during early adolescence, most probably within the local region of Zealand. While the crafting tradition of the metal items in her grave as well as the presence of amber reveal connections to local traditions, the metals used in the production of her bronze goods and the Egyptian glass bead are testimony to the wide range of long-distance trade networks. Hence, Ølby Woman's local provenance provides yet another layer of complexity to our understanding of the oak-coffin graves of elite women from the Early Nordic Bronze Age. This study points to the necessity for further investigation of elite burials combined with context and the objects with which they were buried to better understand the socio-economic dynamics of this formative period in Scandinavia.

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Declaration of Interest Statement

No conflicts of interest are known at present by the authors in relation to the material addressed in this manuscript.

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