Author: Oelze, Viktoria Martha
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4. Applications to prehistoric Germany

4.1. The Neolithic

The Neolithic transition in Europe is marked by the spread of agricultural societies from the Near East to the European continent, introducing a sedentary way of life as well as domestic crops and animals. This new lifeway included settlements with communal houses and the use of ceramic pottery which allowed for the storage of foods year round (Price 2000; Whittle and Cummings 2007). The first fully agricultural population in central Germany is the *Linearbandkeramik* (LBK), arriving around 5500 BC. In the last two decades, archaeological sciences have improved our understanding of Neolithic subsistence strategies and mobility. Research from an increasing number of laboratories using mass spectrometry on skeletal material has led to an output of numerous isotope studies covering most regions of Europe. The first study on Neolithic human material was conducted on the Mesolithic-Neolithic transition in Portugal (Lubell *et al.* 1994). In the last decade, research has made progress and Neolithic isotope studies cover nearly the entire European continent including France (Le Bras-Goude *et al.* 2006; Herrscher and Le Bras-Goude 2010), Belgium (Bocherens *et al.* 2007), the Netherlands (Smits *et al.* 2010), Scandinavia (Richards *et al.* 2003; Liden *et al.* 2004; Fischer *et al.* 2007; Fornander *et al.* 2008) and Britain (Montgomery *et al.* 2000; Schulting and Richards 2002; Richards *et al.* 2003; Hedges *et al.* 2008), as well as Slovenia (Ogrinc and Budja 2005), Ukraine (Lillie and Richards 2000; Lillie *et al.* 2011), Greece (Papathanasiou 2003), the Balkans (Bonsall *et al.* 2004; Borić *et al.* 2004; Nehlich *et al.* 2010) and Turkey (Richards *et al.* 2003; Lösch *et al.* 2006). Moreover, Neolithic strategies of animal husbandry have been reconstructed by using isotope techniques, e.g. in the contexts of herding strategies and weaning ages (Balasse and Tresset 2002; Noe-Nygaard *et al.* 2005; Balasse *et al.* 2006; Pearson *et al.* 2007).

Table 4.1: Isotope research on Neolithic skeletons from Germany

site	chronology	isotopes	humans	fauna	reference
32 sites, Bavaria	Early-Late Neolithic	C, N	96	#	Asam et al. 2006
Pestenacker	Late Neolithic	C, N, O	1	120	Bösl et al. 2006
Ostorf	3300 BC	C, N	15	10	Olsen et al. 2010
Benzingerode	Bernburger culture	C, N	20	6	Meyer et al. 2007
Trebur	Grossgartach culture	C, N	20	4	Dürrwächter et al. 2003, 2006
Trebur	Hinkelstein cultur	C, N	20	20	Dürrwächter et al. 2003, 2006

Westerhausen	Late Neolithic	C, N, Sr	2	2	Nehlich et al. 2009a
Nieder-Mörlen	LBK	Sr, C, N	17	9	Nehlich et al. 2009b
Herxheim	LBK	C, N	20	14	Dürrwächter et al. 2003, 2006
Derenburg	**LBK**	**C, N**	**39**	**7**	**Oelze et al. 2011a**
Halberstadt	**LBK**	**C, N**	**36**	**6**	**Oelze et al. 2011a**
Kardsorf	**LBK**	**C, N**	**22**	**32**	**Oelze et al. 2011a**
Flomborn	LBK (Early)	Sr	11	#	Bentley et al. 2002
Schwetzingen	LBK (Middle)	Sr	39	#	Bentley et al. 2002
Dillingen	LBK (Middle-Late)	Sr	17	#	Bentley et al. 2002
Talheim	LBK	Sr	28	#	Price et al. 2006
Stuttgart-Mühlhausen	LBK	Sr	53	#	Price et al. 2003
Vaihingen	LBK	Sr	11	36	Bentley & Knipper 2005, Bentley et al. 2004
Altdorf	Bell Beaker	Sr	2	#	Price et al. 2004
Augsburg	Bell Beaker	Sr	17	#	Price et al. 2004
Irlbach	Bell Beaker	Sr	12	#	Price et al. 2004
Künzing-Bruck	Bell Beaker	Sr	6	#	Price et al. 2004
Landau	Bell Beaker	Sr	6	#	Price et al. 2004
Manching	Bell Beaker	Sr	3	#	Price et al. 2004
Osterhofen	Bell Beaker	Sr	8	#	Price et al. 2004
Pommelsbrunn	Bell Beaker	Sr	1	#	Price et al. 2004
Straubingen-Öberau	Bell Beaker	Sr	1	#	Price et al. 2004
Weichering	Bell Beaker	Sr	9	#	Price et al. 2004

The spread of Neolithic cultures throughout Central Europe is a particularly challenging question in human mobility research. Strontium isotope analysis has been applied to several LBK sites in south-western Germany (Fig. 4.1, Tab. 4.1). At most sites, non-local individuals were identified and females were commonly shown to be the dispersed sex. At the LBK sites of Flomborn and Dillingen, over half of the sampled individuals were identified as non-local and at Schwetzingen it was at least one quarter of the population (Bentley *et al.* 2002). Within the earlier phase of the LBK cemetery of Stuttgart-Mühlhausen, one third of the sampled individuals were immigrants, whereas the later phase was almost completely represented by local individuals (Price *et al.* 2003). Additionally, one third of the sampled humans at the site of Vaihingen and one quarter of the adults at the site of Talheim were non-local (Bentley *et al.* 2003; Price *et al.* 2006). This generally high degree of mobility is a good explanation for the rapid expansion of the Neolithic throughout Europe. However, LBK farmers settled almost exclusively on highly productive loess soils which are known to have relatively consistent strontium isotope signatures across Europe with values of 0.708 - 0.710 and possibly 0.711 (Price *et al.* 2003; Nehlich *et al.* 2009). Looking at the summarized data from the previously mentioned LBK sites (Bentley 2006), apparently most data fall within this range. If an LBK individual actually migrated from one settlement to the other, this may not be detectable with this method if they moved from one loess soil to another loess soil with similar isotope ratios. An isotope study at the LBK settlement of Niedermörlen had significantly more radiogenic $^{87}Sr/^{86}Sr$ signatures in most individuals due to different provenances, although the settlement was located on loess soil as well. Only one individual was considered local. The variability of the remaining human $^{87}Sr/^{86}Sr$ values indicated different origins, which was consistent with the finding of various pottery styles at the site (Nehlich *et al.* 2009). Apart from the extensive studies on LBK mobility, human remains from several Bell Beaker sites have been studied in southern Germany (Fig. 4.1). Price and Grupe started their work in the early 1990s and studied samples from ten sites in Bavaria (Price *et al.* 1994; Grupe *et al.* 1997). As the Bell Beaker people dominated large parts of Europe in the late Neolithic and Early Bronze Age, it has been suggested that high levels of mobility or even migration were the cause of the rapid expansion of this culture. The $^{87}Sr/^{86}Sr$ data obtained from enamel and bones of 65 individuals indicated that most had migrated during their lifetimes. The only exception was the site of Irlbach, were only two out of twelve individuals were non-local. Moreover, migrants were evenly distributed between males and females, as well as among the age classes (Price *et al.* 2004). Contrary to the isotopic evidence on LBK and Bell Beaker mobility, we know much less about diet in Neolithic Germany. Only two studies on the diet of LBK farmers have been published. While the diet of the LBK people from the site of Herxheim (n=20) was similar to the later Neolithic populations from Trebur, the data suggested that some (n=3) individuals consumed freshwater fish and that animal protein was an important component of the diet. However, the high number of secondary inhumations at Herxheim makes it likely that the dataset does not encompass a settlement community (Dürrwächter *et al.* 2006). At the site of Niedermörlen (n=15), humans had a terrestrial C_3-plant based diet. Yet, the data from the LBK individuals were difficult to interpret, as the associated herbivore fauna was highly variable in $\delta^{15}N$ and $\delta^{13}C$, indicating that young (suckling) animals and domesticates from different pasture conditions were included in the baseline sample (Nehlich *et al.* 2009).

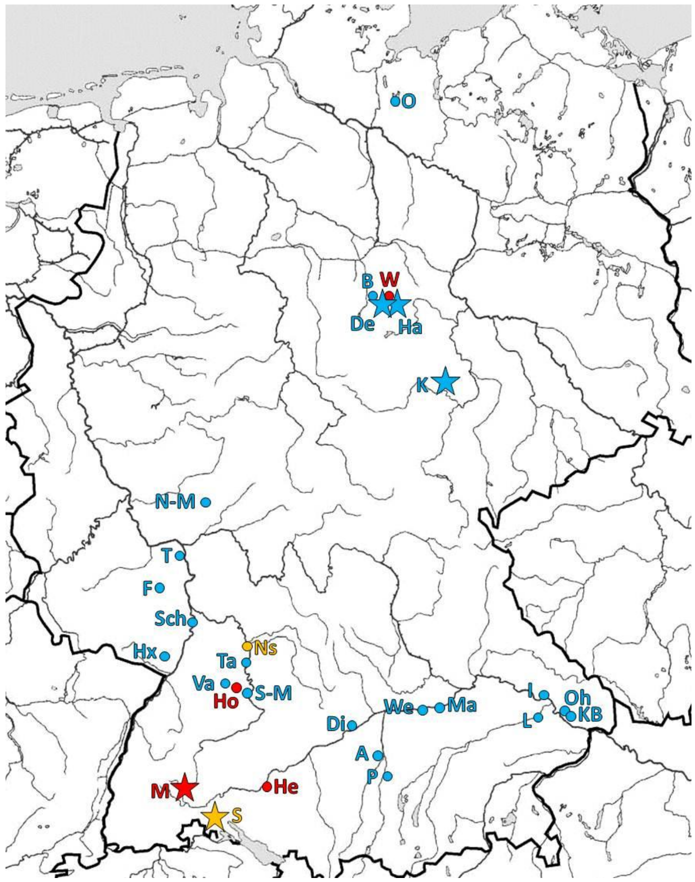

Figure 4.1: Map of Germany including all archaeological sites (n>=2) listed in Tables 4.1, 4.2 and 4.3 (blue symbols = Neolithic, yellow = Bronze Age, red= Iron Age).
The asterisks mark the case study sites Derenburg, Halberstadt, Karsdorf, Magdalenenberg and Singen.

Only a few sites from later Neolithic periods have been studied and most datasets only present small sample sizes or individuals from different sites were compiled in a single study without faunal baseline information (see Tab. 4.1). While these studies could show that Neolithic people were eating C_3-plant based diet and depended on their domestic animals, we know very little about the diet of whole living populations or even neighbouring groups. In chapter 5, I present the first comprehensive stable isotope study on three Neolithic populations representing several generations of LBK communities in central Germany, including children, women and men and their domestic animals.

4.2. The Bronze Age

The Bronze Age in Central Europe dates from 2200 to 1500 cal BC and refers to sedentary societies that utilized copper alloys as the primary material for the production of tools, ornamentation and weaponry. However, copper also predates the Early Bronze Age and bronze remained an important material throughout the Iron Age. The Bronze Age is also characterized by the spread of literacy and the rise of large palace-based societies in the Mediterranean. It appears likely that these significant changes in social and economic life in the Aegean area also affected the people in the Central European hinterland. Accordingly, movements of prestige goods and metals over considerable distances are known from this time period, including 'barbarian' Europe. By the middle Bronze Age, metallurgical skills for the production of bronze, raw material, alloys and objects were required and became common. Moreover, the abundance of metal objects as 'commodities' and exchange goods gained social meaning as they could be used to demonstrate social division and hierarchy (Harding 2000). Contrary to these socioeconomic developments, the subsistence strategy did not significantly change in the Bronze Age. However, it has been shown that Bronze Age farmers moved their cultivation to marginal soil, possibly due to climatic changes in this time period (Champion *et al.* 1984). The Bronze Age in Germany ended with the introduction of Iron after the Urnfield culture (800 BC) and the rise of the Hallstatt culture with their chiefly seats and princely burials (Harding 2002). Here, I present a brief summary of isotope research on Bronze Age Germany.

Table 4.2: Isotope research on Bronze Age sites from Germany.

site	chronology	isotopes	humans	fauna	reference
Neckarsulm	Urnfield culture	C, N, S	47	5	Nehlich & Wahl 2011
Singen	**Early Bronze Age**	**C, N, S, Sr , O**	**25**	**0**	**Kupke 2010, Oelze et al 2011b**

Apart from the site of Singen presented in this dissertation and the masters thesis of Kupke (2010), only one Bronze Age site has been studied by means of stable isotopes (Fig. 4.1, Tab 4.2). Nehlich and Wahl (2011) presented isotope data from a remarkable Bronze Age site in southwest Germany. The Early Urnfield culture necropolis of Neckarsulm contained a total of 52 individuals buried in 32 graves. Besides the fact that inhumation of the dead was a rather uncommon burial custom for the Urnfield culture, the necropolis also exclusively contained male individuals buried after puberty. Carbon, nitrogen and sulphur stable isotope data for 47 humans and five animals were presented. The faunal specimens, including cattle, horse and deer had isotope values in the expected range for terrestrial herbivores. The Bronze Age males however did not show a dietary pattern depending solely on these animals and domestic plants. Their elevated carbon and nitrogen isotope values could only be explained by the consumption of isotopically enriched dietary sources, additional to terrestrial animals and plants. The sulphur isotope data obtained from both faunal and humans provided the additional information to verify this interpretation. The herbivores showed a local terrestrial isotope signal with little variation while the $\delta^{34}S$ values measured in humans indicate the influence of another dietary source of sulphur, likely freshwater fish. As no skeletal material of freshwater fish was available for sampling, mixing models could not be applied to further investigate the dietary amounts of fish. However, the combination of three isotope systems provided strong arguments for the consumption of freshwater fish for this population. Due to the low variability in these isotope systems, the authors assume that the males at the necropolis represent a settlement population. Finally, individuals buried within the same grave had similar isotope values, indicating they had similar diets and belonged to the same household. Fortunately, strontium isotope analysis on the male necropolis of Neckarsulm is in progress so that these assumptions will soon be tested (Wahl and Price, cited in Nehlich and Wahl 2011).

Isotope data from the site of Singen shows a different dietary pattern. Kupke reported 25 human bone samples in her unpublished masters thesis. The $\delta^{13}C$ and $\delta^{15}N$ values show no evidence of freshwater fish consumption, although the site is located in proximity to several smaller and larger lakes and streams. The $\delta^{34}S$ values, reported in this doctoral thesis (Chapter 6), confirmed this finding. The diet of this population was terrestrial and was dependent on C_3-plants and domestic animals. Moreover, the diet was quite homogeneous within the group and no significant differences according to sex or grave goods could be found (Kupke 2010; Koch and Kupke in print).

4.3. The Iron Age

In Central Europe, the Iron Age began with the gradual replacement of bronze metallurgy with iron around 800 BC. Although bronze remained an important metal for prestige goods like jewellery, iron became the common raw material for weaponry, ornaments and various household goods (Wells 2002). Iron ores were accessible in many European upland regions, making local production feasible where previously copper and tin had to be imported. Nevertheless, the trade of metal objects and prestige goods such as glass was an important component of cultural life in Iron Age Europe and communities maintained regular contact (Stary 1993; Wells 2008). In Germany, the Iron Age is represented by the Hallstatt (Ha C-D) and La Tène culture. These cultures established prominent centres of production and political influence, the so called 'princely sites' or 'chiefly seats' (in German *Fürstensitze*), which are commonly characterized by hill forts and massive burial constructions, containing luxury goods from the Mediterranean. They can be considered the first step to urbanism, whereas the sedentary population lived in small scale farmsteads or hamlets. While subsistence in Iron Age Germany was similar to the foregone Neolithic and Bronze Age, the introduction of iron ploughs and scythes allowed for a more efficient cultivation of richer soils, and thus supplying more people with smaller farms (Wells 2002). Moreover, isotope data suggests that millet became an especially important crop at least in parts of Central Europe (Murray and Schoeninger 1988). Although isotope research on Iron Age Germany is limited, I briefly present the previous work below.

Only two studies have been published so far (Fig. 4.1, Tab. 4.3). At the site of Westerhausen, 14 (pre-Roman) Iron Age individuals were sampled for carbon, nitrogen and strontium isotopes. The dietary signal suggested a terrestrial-based omnivorous diet. The $\delta^{13}C$ values were enriched compared to a small sample of Neolithic specimens, indicating that possibly also the C_4-crop millet was cultivated and consumed, as it has been shown for other Iron Age populations in central Europe (Murray and Schoeninger 1988; Le Huray *et al.* 2006). However, the authors hypothesised that the enriched $\delta^{13}C$ values were attributed to a possible deforestation of the region or changing climatic conditions. In order to categorize the local $^{87}Sr/^{86}Sr$ range, the isotope data measured in human enamel were compared to dentine from the same teeth. While eleven individuals originated locally from the foothills of the Harz Mountains, two adult individuals had significantly more radiogenic $^{87}Sr/^{86}Sr$ ratios, suggesting they grew up within the Harz Mountains (Nehlich *et al.* 2009).

Table 4.3: Isotope research on Iron Age sites from Germany.

site	chronology	isotopes	humans	fauna	reference
Hochdorf & Heuneburg	Hallstatt-La Tène	Sr	#	65	Stephan 2009
Westerhausen	(pre-Roman) Iron Age	C, N, Sr	14	0	Nehlich et al. 2009a
Magdalenenberg	**Hallstatt**	**C, N, S, Sr, O**	**78**	**10**	**Oelze et al. in print Kupke 2010**

Stephan (2009) conducted strontium isotope analysis on faunal remains from the chiefly seats of the Hallstatt culture in southwest Germany. She analysed teeth of domestic fauna (horse, cattle, goat/sheep and pig) from the hillfort sites *Heuneburg-Vorburg* (Ha D1 and Ha D3, n=37) and *Eberdingen-Hochdorf* (Early La Tène period, n=28). By analysing the $^{87}Sr/^{86}Sr$ ratios in different teeth of the same individual (M1, M2, M3/P4) as well as different parts of the enamel crown (cusp tip, 'middle' and cervical area), she intended to track the mobility of individual animals during tooth formation. The differences observed within a single individual and between animal species agree with the general perception of Iron Age animal husbandry by archaeologists: animals were mainly kept in direct proximity of the hillforts, and the various species grazed on different pastures according to their feeding demands. Larger variation in $^{87}Sr/^{86}Sr$ values of cattle, sheep/goat and pigs were related to higher degrees of mobility or even trade of these domestics between different Hallstatt communities in the region. As will be demonstrated, this study is chronologically and spatially relevant for the site of Magdalenenberg (chapter 7).