13 EBERDINGEN-HOCHDORF: PROVENIENCING THE PRINCE

T. Douglas Price

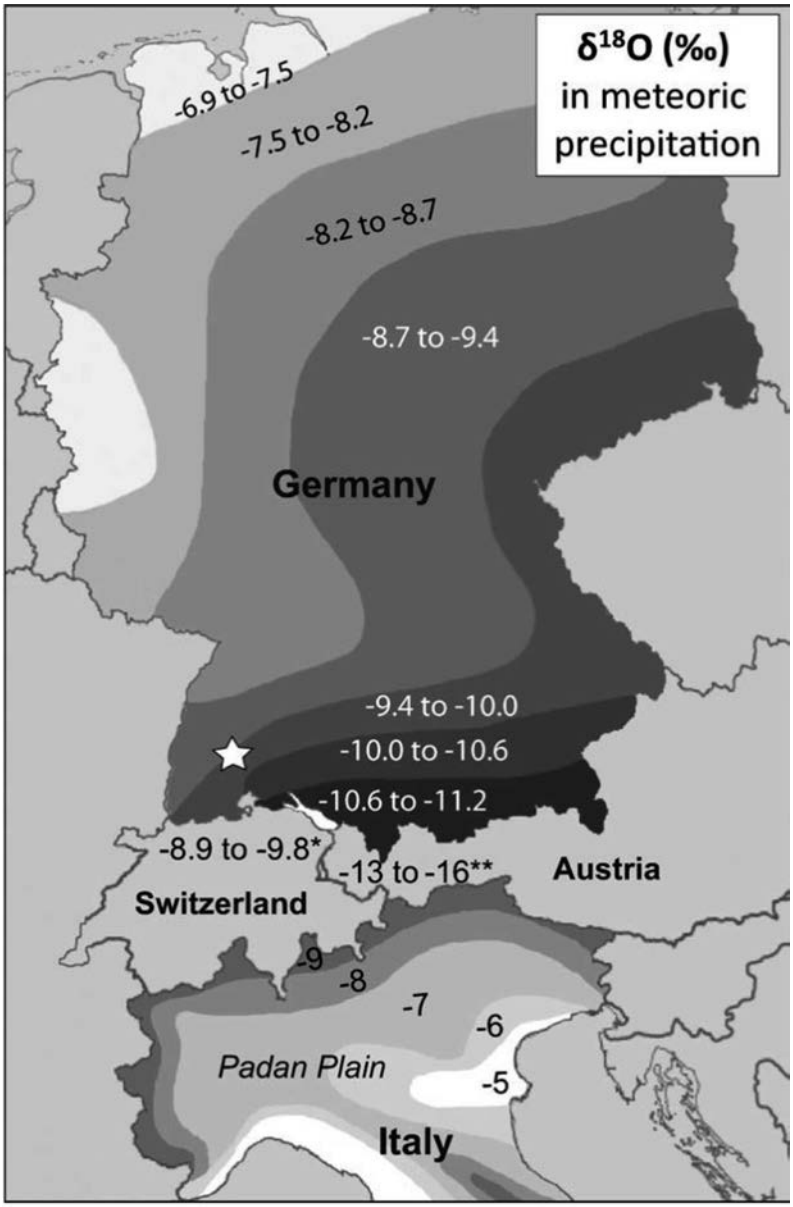
Isotopic proveniencing has become almost standard procedure in bioarchaeology (Montgomery 2010; Slovak/Paytan 2011) Isotopic proveniencing has been undertaken for several burials from the famous site of Eberdingen-Hochdorf, Kreis Ludwigsburg, in Baden-Württemberg, Germany. Strontium, oxygen, and carbon isotope ratios have been measured in tooth enamel. Strontium and oxygen isotope ratios vary geographically in nature and carbon varies with certain dietary components. These isotope ratios are deposited during enamel formation in very early childhood and do not change through life. Strontium isotope ratios vary with local geology depending on the age and composition of bedrock and sediments. Oxygen isotope ratios vary with rainfall, depending on latitude, distance from water source, and other factors (Chenery et al. 2012). Thus tooth enamel in archaeological burials retains isotopic signals of the place of birth. Isotopic proveniencing has been used successfully in a number of studies of human remains from the Neolithic and later periods (e. g. Price et al. 1994a; 2001; 2004; Knipper 2011).

ISOTOPIC BASELINES IN SOUTHWESTERN GERMANY

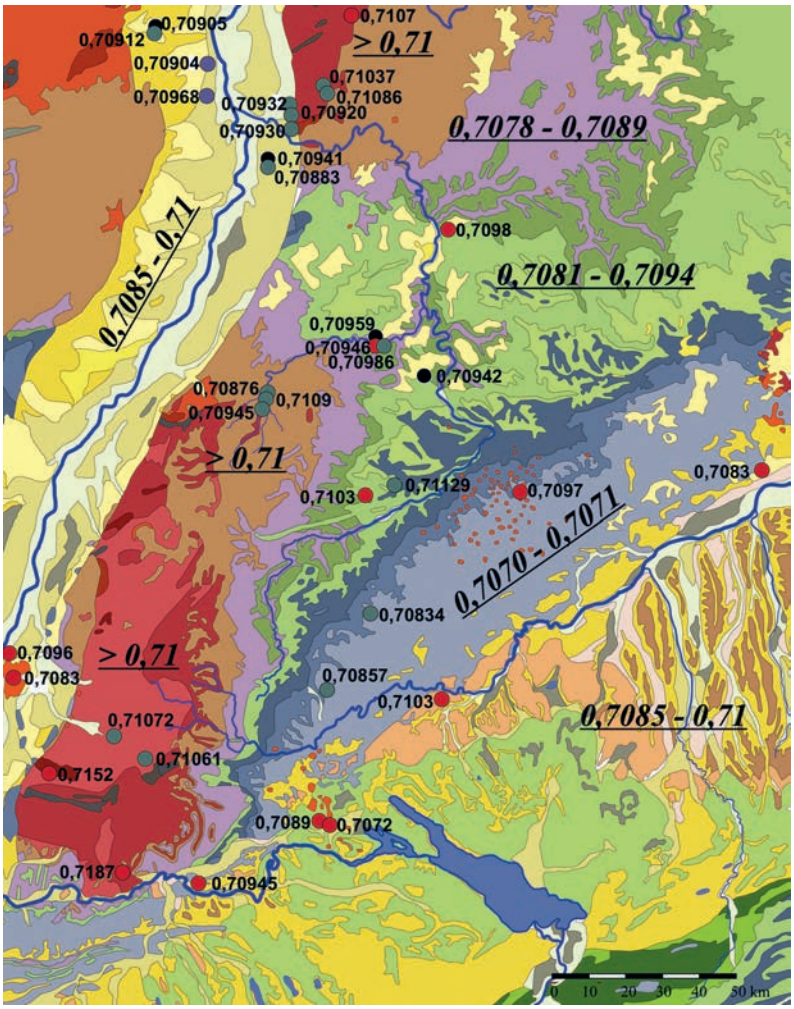
It is essential that local baseline values for isotopic studies be recorded in order to compare observed human tooth enamel ratios with the expected local values (Price et al. 2002). Figure 1 presents a map of variation in modern rainfall $\delta^{18}O$ in Germany (Oelze et al. 2012). Oxygen isotope ratios ($\delta^{18}O$) along the Danube in southeastern Baden-Württemberg should range between -9‰ and -11‰ based on measured values in the region (Knipper 2011; Tütken et al. 2004) (fig. 1). The star on this map is Hochdorf.

Baseline strontium isotope ratios are also available for this region. Fortunately, southwestern Germany is one of the most thoroughly studied areas in Europe in terms of strontium isotope ratios across the landscape (e.g., Bentley/Knipper 2005; Bentley et al. 2004; Knipper 2011; Oelze et al. 2011; Price et al. 2001; Schutkowski 2002; Stefan et al. 2009). Figure 2 is a map of major geological units and measured strontium isotope ratios in southwestern Germany (Knipper 2011).

Southwestern Germany is quite varied geologically and isotopically. There are a number of major geological units, defined here by



1 Oxygen isotope ratios (SMOV) in modern German rainwater (Oelze et al. 2012).

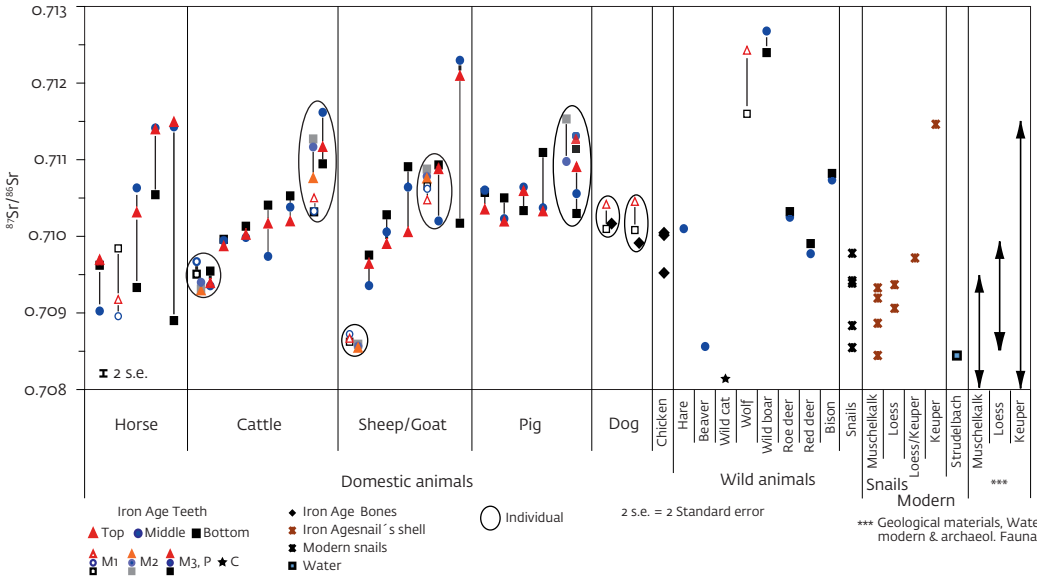


2 Map of geological units and $^{87}Sr/^{86}Sr$ baseline values in southwestern Germany (Knipper 2011).

the boundaries of Baden-Württemberg. Older gneiss and granites dominate the higher elevations of the Black Forest and Odenwald to the east of the Rhine. The Buntsandstein is a red sandstone from the Lower Triassic that outcrops at the base of these highlands. Another upland zone, the Swabian Alb, composed of Jurassic limestones, runs northeast-southwest across the area largely to the north of the Danube. To the south of the river, deep deposits of Tertiary molasse – a sandstone derived detritus from the formation of the Alps – are found along with younger glacial and alluvial sediments.

The central part of the study area, east of the Black Forest and north of the Swabian Alb, is dominated by the Muschelkalk and Triassic Keuper deposits, overlain by fluvial sediments and loess. The Muschelkalk is a Middle Triassic shell limestone and dolomite that lies against the eastern slopes of Black Forest and Odenwald highlands and is found intermittently across the study area. The Keuper deposits are Upper Triassic sandstones and mudstones that fill much of this region. Major rivers in this area, the Neckar and the Enz and their tributaries, cut though the overlying loess and the underlying Keuper sandstone beds, until they reach the hard limestones of the Middle Triassic Muschelkalk. In general terms the lowlands have $^{87}Sr/^{86}Sr$ values between 0.708 and 0.710. The upland regions of largely crystalline rock such as the Black Forest and the Odenwald can have values exceeding 0.712 and higher. Specifically the larger region around Hochdorf exhibits a range of $^{87}Sr/^{86}Sr$ values from approximately 0.708 to 0.715 and higher.

A study of fauna from Eberdingen-Hochdorf was recently published and provides a good picture of baseline $^{87}Sr/^{86}Sr$ values for the area around the site (Stephan u. a. 2012). In most of the area, low strontium ratios are predominant. Fig. 3 provides detailed information on the strontium isotope ratios in the fauna and estimated values for the local geological deposits. Hochdorf and its immediate environs are geologically characterized by extended loess deposits as well as Keuper and Muschelkalk



3 Strontium isotope ratios from archaeological and modern faunal remains from Eberdingen-Hochdorf (Stephan et al. 2012).

formations. Muschelkalk is present in the areas southwest of Hochdorf and is exposed predominantly along the valley slopes. The Keuper sandstones form the hilly landscape of the Löwenstein and Stromberg mountains and larger areas of the lowlands northwest of the Swabian and Frankonian Alb. The site itself is located on loess. The strontium isotope signatures of loess vary between 0.7090 and 0.7100.

Detailed investigations of modern and archaeological faunal and human remains from the Early Neolithic (LBK) sites Vaihingen a. d. Enz und Stuttgart-Mühlhausen near Hochdorf yielded $^{87}Sr/^{86}Sr$ values from 0.7093 to 0.7100 (Bentley et al. 2003; Bentley/Knipper 2005; Knipper/Price 2009; Price et al. 2004b). Vaihingen lies just 3 km northwest. Mühlhausen is approximately 9 km southeast of Hochdorf. Detailed studies of strontium isotope variation have been undertaken on both human skeletons and archaeological and modern animal remains at these sites. Oxygen isotope ratios were not recorded. Human bones and tooth enamel at Vaihingen had an average $^{87}Sr/^{86}Sr$ of 0.7095. Analysis of faunal remains from four animals established the baseline range for the site of Vaihingen between 0.7089 and 0.7010. These values are presented in Table 1. Analysis of human remains and baseline samples from Stuttgart-Mühlhausen indicated a local baseline between 0.7090 and 0.7098 (Price et al. 2004) (tab. 1).

Finally, it is important to reiterate that while isotopic proveniencing of human remains is often useful for determining non-local individuals, the identification of a specific place of origin is difficult because there are often a number of locations with a similar isotopic signature that cannot be distinguished. It may, however, be possible to suggest a potential homeland using a combination of isotopic and archaeological information.

Table 1 Faunal $^{87}Sr/^{86}Sr$ enamel values from Vaihingen a. d. Enz.

Lab No	Species	$^{87}Sr/^{86}Sr$
F1385	Caprine	0.7010
F1386	Dog	0.7094
F1387	Deer	0.7089
F1389	Cow	0.7091

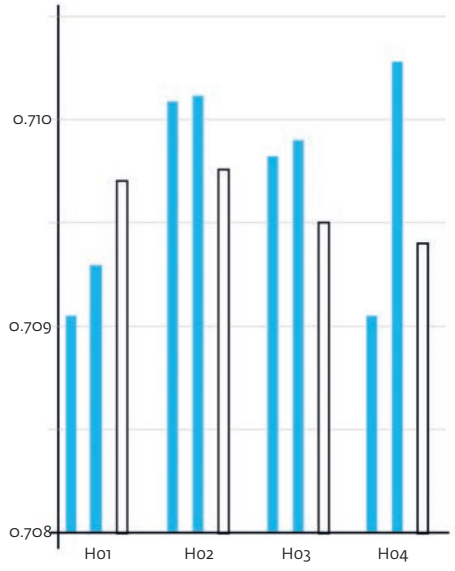
Table 2 Isotopic values for Sr, Ca, and O from Hochdorf samples. Laboratory numbers are from the Laboratory for Archaeological Chemistry at the University of Wisconsin-Madison. Tooth or bone samples are identified as to specific tooth or part of the skeleton. L = lower, U = upper, L = left, R = right, M = molar, C = canine, 1, 2, 3 are molar number. There are four individuals sampled in this study and individual samples from the same individual are indicated as 1, 2, and 3. Age is designated as LM for late mature, EA for early adult, MM middle mature, and EM for early mature. The strontium isotope ratio is $^{87}Sr/^{86}Sr$. Carbon and oxygen isotope ratios are provided as per mil values (‰). Both carbon and oxygen values are based on a PDB reference standard. Oxygen was measured in the carbonate portion of the enamel.

Lab No.	Tooth/bone	Burial	Age	Sex	$^{87}Sr/^{86}Sr$	$d^{13}C$	$d^{18}O$
F8141	LLM1	HO1.1	LM	M	0.7091	-11.0	-6.1
F8142	LLM3	HO1.2			0.7093	-12.3	-6.2
F8143	HUMERUS	HO1.3			0.7097		
F8144	ULC	HO2.1	EA	M?	0.7101	-12.4	-6.0
F8145	ULM1	HO2.2			0.7101		
F8146	HUMERUS	HO2.3			0.7098		
F8147	URM3	HO3.1	M-LM	M	0.7098		
F8148	LLM2	HO3.2			0.7099	-11.7	-5.5
F8149	TIBIA	HO3.3			0.7095		
F8150	ULM3	HO4.1	EM	M?	0.7090	-12.5	-5.8
F8151	LRM2	HO4.2			0.7103		
F8152	TIBIA	HO4.3			0.7094		

RESULTS AND INTERPRETATION

The isotopic measurements from tooth and bone from four individuals from Hochdorf are presented in Table 2. Sample Ho1 is the famous prince, the primary burial at Hochdorf. The other individuals are supplementary burials in the mound. The specific tooth or bone sampled, the individual and sample number, age, and sex are also listed in the table.

A bar graph of is presented in Figure 4. All of the individuals have generally similar bone values (an average of 0.7096). Bone is a fragile and spongy tissue, subject to contamination. The similar values for bone may reflect such post-mortem diagenesis. These bone values may reflect a local $^{87}Sr/^{86}Sr$ baseline around 0.7095. Ho1 is unusual in that both of the enamel values are lower than the bone measurement. Ho4 has the highest enamel value and a bone value generally similar to the oth-



4 Bar graph of $^{87}Sr/^{86}Sr$ from Hochdorf. The four individuals are shown in individual groups of 3 bars each. Blue is enamel, white is bone.

ers. This difference must reflect either a move or a significant change in dietary food sources during early childhood. A move to an area with lower strontium isotope ratio would seem more likely. Ho4 may have moved in childhood as the M3 forms later in childhood than the M2. The M3 value is similar to the ratios from Ho1 enamel and perhaps these two individuals came from the same location. The remaining three individuals have generally similar pairs of enamel values.

Ho1 is of particular interest in terms of $^{87}Sr/^{86}Sr$ values. The enamel values are lower than the bone sample, as noted above and the two enamel values are similar and at the low end of the baseline from Hochdorf, perhaps suggesting a childhood spent elsewhere. Because the range of bone and enamel sample values from Hochdorf is low (0.7091–0.7103) it is difficult to make reliable statements regarding place of origin. All of the strontium isotope ratios found among the Hochdorf individuals could have come from nearby areas around the site and certainly from the immediate region. Nevertheless differences between bone and tooth values and especially the two low enamel values for Ho1 suggest that the princely burial did not grow up in the immediate area of Hochdorf. The remaining individuals also have values slightly different from the suggested local value at Hochdorf (0.7095) but in fact we do not know the exact range of baseline values for the site.

The carbon and oxygen isotope ratios from these individuals show relatively little variation among the four. Carbon values reflect dietary intake and neither marine foods nor C4 plant species such as millet appear to play a role in the diet. The oxygen isotope ratios are consistent with other enamel carbonate PDB values from the region and have a range of variation typical of a normal human population. Neither of these isotope ratios appears to provide much information on variation in diet or origins.

There are two other isotopic provenienc-ing studies of Iron Age tumuli from Germany (Knipper et al. 2014; Oelze et al. 2012). Knipper et al. 2014 report the isotopic analysis of a series of burials from Glauberg (Glauburg, Wetteraukreis) a late Hallstatt/early La Tène princely seat in the state of Hesse, north of Frankfurt. One of the rich tumulus graves contained a young male with non-local strontium isotope ratio (0.7128). This individual also consumed a "superior" diet based on carbon and nitrogen isotopes in the bone collagen. The $\delta^{18}Op$ values of the human second and third molars range from 15.1‰ to 17.1‰ with an average of 16.5‰. The remaining burials analyzed from Glauberg exhibited highly variable strontium isotope ratios reflecting the larger area of resource exploitation outside the immediate area of the site. Because the range of local baseline values is also highly variable it is not possible to distinguish non-locals from distant areas at the site.

Oelze et al. 2012 examined more than 75 individuals from the Magdalenenberg, tumulus, an elite burial community, at the eastern edge of the Black Forest. The Magdalenenberg (Villingen-Schwenningen, Schwarzwald-Baar-Kreis, Baden-Württemberg) is located at the edge of Buntsandstein deposits with an $^{87}Sr/^{86}Sr$ value ca. 0.713. The mound contained a central "princely" burial along with 126 secondary graves. Unfortunately a sample was not available from the primary individual. The study found a heterogeneous range of both strontium (0.70725 to 0.71923, n = 76) and oxygen (13.4‰ to 18.5‰, n = 78) measured in tooth enamel. The authors concluded that although many of the individuals had values consistent with southwest Germany, some individuals likely originated from further afield. Suggested places of origin included the Alps of Switzerland and Austria and even locations in Italy. The results were argued to demonstrate the presence of far reaching social and economic networks in the early Iron Age.

With regard to Hochdorf, the relatively small number of samples and the narrow range of strontium isotope ratios recorded make it difficult to say much about human mobility at the site. The wide range of baseline values within 100 km of Hochdorf covers most of the values observed among archaeological humans in the region. It does seem likely that the principle burial Ho1 did not grow up in the immediate area of the site but he could easily have been raised nearby. The other individuals generally appear to be local. Oxygen isotopes added no additional information to this interpretation.

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FIGURE CREDITS

Fig. 1: Oelze et al. 2012. – Fig. 2: Knipper 2011. – Fig. 3: Stephan et al. 2012, Abb. 4. – Fig. 4: author.

ABSTRACT

Investigation of the origins of the individuals buried in the massive Iron Age earthen tomb at Hochdorf focused on the isotopes of strontium, carbon and oxygen in tooth enamel as signatures of childhood residence and diet. Tooth enamel forms on early childhood and remains largely unchanged through life and long after death. Sources of strontium in the vicinity of Hochdorf were highly varied making distinction of homeland difficult. Isotopes of strontium and oxygen vary geographically and differences among the individuals buried at Hochdorf, compared to local isotope ratios, suggested that the primary burial may have been non-local.

Keywords: isotopic proveniencing, strontium, oxygen, carbon, archaeological chemistry

ZUSAMMENFASSUNG

Die Untersuchung der Herkunft der in dem mächtigen eisenzeitlichen Grabhügel in Hochdorf bestatteten Personen konzentrierte sich auf die Isotope von Strontium, Kohlenstoff und Sauerstoff im Zahnschmelz als Signaturen von Ernährung und Wohnort im Kindesalter. Der Zahnschmelz bildet sich in der frühen Kindheit und bleibt zeitlebens und bis lange nach dem Tod weitgehend unverändert. Die Strontiumsignale in der Umgebung von Hochdorf waren sehr variabel, was die Abgrenzung des Herkunftsorts erschwerte. Die Isotope von Strontium und Sauerstoff variieren geographisch, und die Unterschiede zwischen den in Hochdorf bestatteten Personen im Vergleich zu den lokalen Isotopenverhältnissen legen nahe, dass die primär bestattete Person möglicherweise nicht aus der direkten Umgebung stammte.

Schlagworte: isotopische Herkunftsbestimmung, Strontium, Sauerstoff, Kohlenstoff, archäologische Chemie