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Living at the Outskirts of the Roman Empire after the Fall. A Study of 5th Century Bavarian Burials

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A B S T R A C T

The long lasting transformation process from the Roman Imperial Age to Early Middle Ages reaches its zenith in the 5th century AD. The present study focuses on southern Bavaria during this specific time period, which up to that point was incorporated into the Roman Empire as the province *Raetia Secunda*. All known existing anthropological data were collected and examined in order to provide an overview of a momentary anthropological understanding for this time period. The study is augmented by additionally-conducted anthropological and strontium isotope analyses on skeletons from four recently-discovered contemporary cemeteries to provide information on the health and living conditions of the past local populations there. However, results show that anthropological data for this time and region are rare and therefore generalized conclusions based on anthropological information are seldom possible. Nonetheless, it is interesting to note that an increase in body height near the end of the 5th century, as well as differences in the frequency of stress markers, were observed in the small cemeteries investigated. Furthermore, strontium analysis showed that in contrast to the late Roman period, immigrants from areas with high strontium values were detected near the end of the 5th century.

1. Introduction

Beginning around the middle of the 3rd century AD, internal crises and external conflicts occurring at various sections of the imperial border eventually led to the start of Rome's retreat from certain areas of its northern Alpine provinces. In particular, Germanic invasions during the 3rd century led to the abandonment of the „Upper Raetian Limes“ in favour of a Roman defence line along the Rhine, Iller and Danube rivers (Donau-Iller-Rhine-Limes). Rome's withdrawal from its northern province, however, began even before the Limes was abandoned in 254 AD. A widespread decline in the material as well as cultural sectors followed. This is the beginning of the transformation process from antiquity to the Middle Ages in what is today Southern Germany. The transformation process from the Late Roman to the Medieval period in central Europe specifically spans the time between the 3rd and 6th century AD. The 5th century AD is especially relevant for this transitional period and will be the focus of study for the region of Bavaria. This epoch is characterized by the finalization of Rome's military retreat and the emergence of a new burial practice in which the dead are interred side by side in rows, a practice considered typical for the Early Middle Ages in this region (*cf.* Haas-Gebhard 2013a, 54–87). Bavaria can be divided into three large areas which take on different developmental features during the Late Antiquity to Early Medieval times:

- Southern Bavaria (R2) – the main part of the Roman province "*Raetia Secunda*" during the entire period, located on the southern banks of the Danube.
- Northern Bavaria (R3) – north of the Raetian Limes and east of the Limes of Germania Prima within the banks of the River Main, that was never part of Roman provinces.

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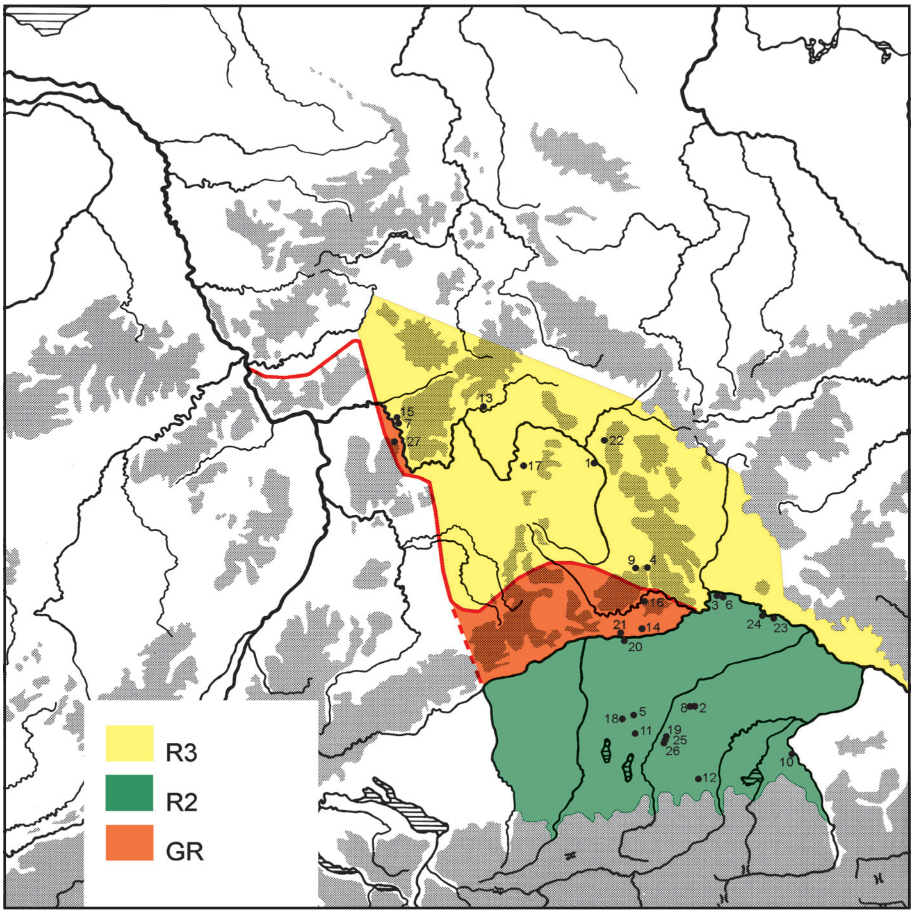

Figure 1. Separation of southern Germany into different areas with regard to their historiography. R3 – Region R3, Northern Bavaria; R2 – Region 2, Southern Bavaria; GR – "Grenzraum" or Frontier Region. Locations of cemeteries of the 5th century are indicated with dots, 1 – Altendorf, 2 – Altenerding, 3 – Barbing-Irmlauth, 4 – Berching-Pollanten, 5 – Bergkirchen, 6 – Burgweinting, 7 – Dettingen, 8 – Erding-Kletthamer Feld; 9 – Forchheim/Opf., 10 – Fürst, 11 – Germering, 12 – Götting, 13 – Hammelburg, 14 – Ingolstadt-Etting, 15 – Kahl a.Main, 16 – Kipfenberg, 17 – Kleinlangheim, 18 – Maisach-Gernlinden, 19 – München-Perlach, 20 – Neuburg/Donau, 21 – Neuburg-Bittenbrunn, 22 – Scheßlitz, 23 – Straubing-Azlburg, 24 – Straubing-Bajuwarenstraße, 25 – Unterbiberg, 26 – Unterhaching, 27 – Wenigumstadt.

- Frontier Regions (Grenzregion: GR) – These include the late Roman province borders situated in southern Bavaria as well as areas abandoned following the fall of the Limes in the 3rd century AD. There are zones which were under Roman control for only 6 generations (from the initial building of the Limes to its completion) situated between the Main and Danube rivers and between the former frontiers.

In this study, various archaeological and anthropological characteristics of southern Bavaria are compared with those observed for the border regions. Prior to the 3rd century AD cremating the dead was the primary form of burial ritual practiced in the Roman Empire. Following this era, inhumations became the dominant form of burial in southern Bavaria. These late Roman burials were interred in small cemeteries containing no more than 40 individuals. It is a widespread assumption that this cemetery form was discontinued shortly before or around 400 AD (Keller 1971). Burials lacking any grave goods whatsoever are found in almost all of these cemeteries. There is some indication that they represent the final phase of the burial ground; however, dating these burials is extremely difficult. It is likely that these cemeteries do not always date to around 400 AD and that the burials may in fact bridge the gap between the end of the late Roman period and the beginning of Early Medieval times in the middle of the 5th century AD. No other evidence for inhumations or cremation burials for the first half of the 5th century exists in southern Bavaria (R2). Only at the Augsburg-Schwalbeneck cemetery in Augsburg, the capital of the province *Raetia II*, is their evidence for continuous use throughout this time frame (Bakker, Fleps 2002). In contrast, examples for a direct succession from late Roman fort cemeteries to new Early Medieval burial grounds can be found at the frontier region (GR) adjoining the late Roman province border along the Danube (*e.g.* Straubing-Azlburg, Straubing-Bajuwarenstraße), (Christlein 1968; Geisler 1998).

The emergence of larger cemeteries only began in southern and northern Bavaria in the last decades of the 5th century and those were located far behind the former frontier (*e.g.* Altenerding; Losert; Pleterski 2003).

We present a summary of available data for cemeteries of southern Bavaria (R2) and the border region (GR) to give an overview of the *status quo* of anthropological research in this area. In addition, four recently-excavated, small, contemporary cemeteries situated in this area are presented here in more detail. These are notable due to the abundance of grave goods documented in some of the burials:

1. Erding-Kletthamer-Feld is an example of a Late Roman cemetery, dating from the second half of the 4th century AD to the first quarter of the 5th century AD (*cf.* Sofeso *et al*. 2012) in southern Bavaria (R2, Erding, Upper Bavaria). Some of the graves found there are unique for rural Raetia at that time: three adult aged women were buried with gold jewellery and several glass vessels.
2. The archaeological site "Unterhaching" (near Munich)

is also located in southern Bavaria. This cemetery dates to around 500 AD and contained 10 burials. One of the women (grave 5) was found buried with various linen and wool fabrics, one gold textile object, pleated cloth, silk, decorated leather, fur and feathers. These grave goods are extraordinary finds for which no parallels during this period in southern Germany have yet been found (Haas-Gebhard 2013b).

3. The so-called Nord-West II grave group (Codreanu-Windauer, Schleuder 2013; Zintl 2012, 128–130) of Burgweinting (near Regensburg, GR) comprises 15 burials scattered along a north to south oriented strip of ground measuring about 48 m in length. One of the richest graves is that of a female, burial 10255, dated to ca. 500 AD and contains a pair of silver bow fibulae with a semi-circular headplate bearing five knobs and a rectangular footplate, all decorated with gilded chip carvings. A pair of bird fibulae with garnet inlay on the feet are also present in this grave.
4. The Burgweinting-Kirchfeld-West group comprised of 19 graves is located only 200 m south of the Nord-West II burial ground (Codreanu-Windauer 2003; Zintl 2012, 134–140). Two burials constructed with niches had the richest furnishings, such as gilded silver fibulae similar to the ones documented in the female burials in the Nord-West II group. The graveyard dates to the last third of 5th and early 6th century AD.

As no historical sources to these finds exist, analysing these skeletal remains is the only way to gain insights into the living conditions, health status and mobility of the populations living during this time subsequent to the retreat of the Roman Empire from its northern frontier.

2. Methods

Statistical analyses were conducted using IBM© SPSS© Statistics version 23 software.

2.1 Archaeological selection and classification of 5th century burials

All known graves from the R2 (southern Bavaria) area and GR (frontier region) that can be dated to the 5th century were selected from the literature (*cf.* Table 1). In order to

Table 1. Burial grounds mentioned in the text in chronological order and according to the separated regions. Number and type of burials are in brackets (C = Cremation burial, Ih = Inhumation grave).

Time period	Period after Koch 2003	GR	R 2	R 3
1	C3/D–SD I	Ingolstadt-Etting (Ih) (1); Neuburg-Donau (2) (gravenumber: 10, 65); Straubing-Azlburg 1 (6) (gravenumber: 15, 33, 40, 84, 91, 98); Straubing-Azlburg 2 (14 a, 14b, 18, 21).	Keller, Südbayern (30 est.); ED-Kletthamer Feld (10); Unterbiberg (2 est.); Maisach-Gernlinden (10 est.).	Berching-Pollanten (Ih) (3); Scheßlitz (Ih) (1); Forchheim/Opf. (C) (100 est.); Kahl a.M. (C) (12); Kahl a.M. (Ih) (1); Kleinlangheim I (C) (9); Kleinlangheim I (Ih) (1); Altendorf (C) (7).
2	SD I–SD II	Neuburg-Donau (2) (gravenumber 47, 84, 90); Neuburg-Donau-Bittenbrunn (3) (gravenumber 6 (?), 19, 22); Wenigumstadt (10); Kipfenberg (1); Straubing-Azlburg 1 (4) (grave number: 47, 60, 78, 79, 32, 50, 52, 56, 63, 65, 70, 71, 73, 99); Straubing-Azlburg 2 (2) (grave number: 1, 41); Straubing-Bajuwarenstraße (2) (grave number: 73,84).	Germering (1) ; Götting (1); Fürst (1).	Altendorf (Ih) (2); Altendorf (C) (1); Dettingen (Ih) (2); Kahl a.M. (Ih) (12); Kahl a.M. (C) (9).
3	SD II–SD III + associated graves (*e.g.* all burials of a small burials place)	Neuburg-Donau (7) (gravenumber 6 (?), 9, 13, 16, 20, 50, 52); Barbing-Irlmauth (4); Burgweinting Kirchfeld-West (19); Burgweinting Nordwest-II (15); Wenigumstadt (7); Straubing-Bajuwarenstraße (25) (gravenumber: 99, 227, 238, 248, 266, 273, 303, 314, 316, 323, 352, 353, 632, 220, 228, 310, 328, 355, 360, 361, 470, 491, 502 (?), 535, 708).	Altenerding (15); Bergkirchen (4?); München-Perlach (8); Unterhaching (4).	Hammelburg 1895, 1937 (2); Kleinlangheim II (2?).

provide a comparison, burials north of the frontier (northern Bavaria) are also included. Anthropological analyses of these burials do not appear because they are mainly cremations. Burials were grouped according to Koch (2001) into three time periods designated as C3/D–SD1, SD1–SD2, SD2–SD3. Classifications were made by re-evaluating grave goods documented in the relevant literature (compiled in Haberstroh, Harbeck 2013). Period 1 comprises roughly the years 350/60 until 420/30 AD (C3/D–SD1), period 2 the years 420/30 until 450/60 AD (SD1–SD2) and period 3 the years 450/60 until 500 AD (SD2–SD3).

2.2 Compilation of anthropological data

Table 2 is a list of the anthropologically-examined, 5th century cemeteries relevant to the geographic regions GR and R2 (with the exception of München-Perlach, which is described by von Heyking and Zintl, 2016 in this issue). The cemetery sites were chosen based on their archaeological relevance to the period of interest (*cf.* Table 1), and availability of anthropological data. Therefore, the present study does not presuppose completeness of the available data. The strict focus on 5th century skeletal remains requires a selection based on the archaeological dating of cemeteries used

Table 2. List of Bavarian cemeteries relevant to the period under study (5th century) with anthropological background data available.

Archaeological site	Anthropological-morphological data: Sex and age	Body height	Cribra orbitalia and enamel hypoplasia	Further morphological data such as dental record or pathologies *etc.*	Molecular genetic or isotopic data
Unterbiberg	Schefzik, Volpert 2003	–	–	–	–
Erding-Kletthamer Feld	Staskiewicz (unpublished): Erding, Kletthamer Feld, Ausgrabung 2006, Skelettfunde der römischen Kaiserzeit. Anthropologischer Befundkatalog (data partly presented in Haberstroh and Harbeck 2013).				stable isotope analysis of light elements from collagen and carbonate (Sofeso *et al.* 2012); DNA-analysis (Sofeso *et al.* 2012)
Unterhaching	Harbeck *et al.*2013		this paper	Harbeck *et al.* 2013, this study	strontium isotope analysis (Harbeck *et al.* 2013); stable isotope analysis of light elements C and N from collagen (Harbeck *et al.* 2013); DNA-analysis (Harbeck *et al.* 2013)
Straubing-Azlburg I und Azlburg II	Czaya (1988), Schweissing (2005)	–	–	Czaya (1988)	strontium isotope analysis (Schweissing 2005)
Straubing-Bajuwarenstraße	Geisler (1998)	Hagemann-Ziegler (1988) and Geisler (1998)*	–	partly in Geisler (1998)	strontium isotope analysis (Schweissing 2000, 3 individuals only); stable isotope analysis of light elements from collagen and carbonate (Hakenbeck *et al.* 2010)
Neuburg	Schranner (1974) and Ziegelmayer (1979)		–	–	strontium isotope analysis (Schweissing, Grupe 2003)
Neuburg-Bittenbrunn	Pohl (1995)	–	–	–	–
Altenerding	Sage (1984)** Zink (1999, children only)		Zink (1999, children only)	partially Sage (1984), Zink (1999, children only)	stable isotope analysis of light elements (Hakenbeck *et al.* 2010); strontium isotope analysis (Schweissing 2000, 2 individuals only)
Wenigumstadt	von Heyking (this study and Haberstroh, Harbeck 2013)			von Heyking, partly presented in this study	strontium isotope analysis (Vohberger 2012); stable isotope analysis of light elements C and O from carbonate (Vohberger 2012)
Burgweinting Nord-West	this study and Codreanu-Windauer, Schleuder 2013			this study	this study, partly in Codreanu-Windauer, Harbeck (in press)
Burgweinting Kirchfeld	this study and partly in Codreanu-Windauer & Schleuder 2013			this study	this study, partly in Codreanu-Windauer, Schleuder 2014

* Body height calculation probably based on the regression formulae of Bach/Breitinger (or comparable formulae) – this inference was made by comparing the data of Geisler (1998) with more detailed data of Hagemann-Ziegler (1988) who unfortunately did not examine the majority of the graves relevant for the present study which is why the less precise data of Geisler (1998) had to be used.
** Body height values given without specification of the regression formula used – a comparison with body height data of other studies is therefore not possible.

Table 3. Anthropological data sets of the small graveyards used in this study; see text for explanations of individual features.

Site	Individual	Sex	Age	Max. length femur (cm)	Max. length humerus (cm)	Body height (Bach/ Breitinger) (cm)	Cribra orbitalia	Enamel hypoplasia	Strontium-Isotope-Vaules
Erding-Kletthamer Feld	1662	M	mature	40.8	29.40	162	1	1	0.70897
	1663	F	adult	–	29.00	160	1	1	0.70908
	1664	M	mature	42.5	–	164	1	1	0.7088
	1665	M	late juvenile – early adult	–	–	–	0	0	0.71007
	1699	M	adult	44.4	32.00	167	1	2	0.70937
	1700	F	mature – senile	43.8	30.08	164	2	1	0.70929
	1702	F	adult	–	28.25	158	0	0	–
	1703	M	adult	–	–	–	0	0	0.70937
	1704	M	adult – mature	–	–		0	0	0.70895
	1717	M	mature	–	–	–	1	1	0.70954
	1719	M	mature – senile	–	–	–	0	0	0.70909
	1720	M	Infans I	–	–	–	0	1	0.70913
	1721	F	adult – mature	–	–	–	0	0	–
Unterhaching	1	F	mature	45.0	–	165	0	1	0.71156
	2	F	mature	–	–	–	1	1	0.71214
	3	M	juvenile	–	–	–	2	1	0.70884
	4	F	Infans I	–	–	–	1	0	0.71010
	5	F	adult	–	34.00	170	1	2	0.70886
	6	M	mature – senile	–	–		1	1	0.71068
	7	M	mature	47.6		172	1	1	0.71175
	8	F	mature	–	–		1	1	0.71096
	9	F	adult – mature	44.4	–	165	2	1	0.71195
	10	F	adult	–	–	–	1	2	0.71241
Wenigumstadt	1	F	adult	–	–	–	0	1	–
	33	F	juvenile	37.0	–	155	2	2	–
	34	F	senile	44.8	–	165	1	1	–
	40	M	adult	–	–	–	1	1	–
	52	M	mature	50.3	34.90	177	2	2	–
	70	M	mature	47.9	33.90	173	1	2	–
	73	M	adult	50.0	–	176	2	1	–
	106	F	mature	42.3	–	162	1	1	–
	115	F	mature	44.5	31.90	165	1	0	–
	126	M	mature	–	–	–	0	0	–
	141	M	adult	53.2	36.90	181	1	0	–
	230	M	mature	–	–	–	0	0	–
	231	F	adult	–	31.90	166	2	1	–
	232	M	Infans II	–	0.00	–	2	0	–
Burgwetinting Kirchfeld	3732	M	mature	43.0		165	2	1	0.711536
	3733	F	adult – mature	45.4		166	2	1	0.711269
	3734	M	adult	46.2		170	1	1	0.712472
	3735	F	mature	43.0		163	1	2	0.714264
	3736	M	adult	49.1		175	1	1	0.710629
	3737	F	mature	48.3		170	1	1	0.711704
	3738	F	adult	43.7		164	1	2	0.709061
	3739	F	mature	43.7		164	2	2	0.713401
	3740	F	adult	46.8		168	1	2	0.713728
	3741	F	senile	43.5		164	1	1	0.712776
	3742	F	mature	42.9		163	1	1	0.708685
	3743	F	mature	47.9		170	1	1	0.711880
	3744	F	juvenile – adult	43.5		164	2	2	0.709807
	3745	F	infans I	–			2	1	0.710042
	3746	M	mature	55.2		185	2	2	0.711067
	3747	F	infans II	33.4		138	1	1	0.710113
	3748	M	mature – senile	44.6		168	1	1	0.709515
	3888	M	infans I	–			2	1	0.711029
	3889	F	adult	48.9		171	1	1	0.708889
Burgwetinting North West II	10071	M	adult – senile	–		–	0	1	0.710756
	10072	F	senile	43.8		164	1	1	0.710558
	10073	M	senile	49.0		175	1	0	0.710329
	10074	F	adult	–		–	2	1	0.710722
	10075	F	mature – senile	–		164	2	1	0.710366
	10076	F	infans I	–		–	2	1	–
	10077	F	adult	44.3		165	2	2	0.712969
	10078	F	adult – senile	–		–	1	1	0.709907
	10079	M	adult – senile	–		–	0	1	0.710016
	10249	F	adult	44.0		165	1	1	0.710696
	10250	M	infans II				2	1	0.710385
	10252	F	adult – mature	47.5		169	1	2	0.711442
	10253	M	mature	45.6		169	1	1	0.713093
	10254	F	adult – mature	42.5		163	1	2	0.708729
	10255	F	mature	45.7		167	1	2	0.710061

over a long period. This can result in a skewing of results because the individuals under study derive from a selected subpopulation and do not represent a normal biological population. In the present study, this restriction applies to the cemeteries from Neuburg/Donau, Straubing-Azlburg, Straubing-Bajuwarenstraße, Bittenbrunn and Altenerding. All individuals from the smaller burial sites of Unterhaching, Burgweinting Nord-West II, Burgweinting Kirchfeld and Erding-Kletthamer Feld were included in the study. New anthropological data were produced only for this latter burial ground.

2.3 Age-at-death and morphological sex determination

Basic data including age-at-death and sex were collected for all individuals stemming from the cemeteries selected. Methods for determining age and sex are referenced in Table 2. Sexing is based on universally-used criteria (Ferembach *et al*. 1979; Grupe *et al*. 2015). Sex determination for subadults was not performed due to inaccuracies associated with sexing subadult skeletons. Age estimation in adult individuals was based on cranial suture obliteration (modified after Vallois 1937) and age-related modification of the pubic symphyseal surface (Nemeskéri *et al.* 1960). Age estimation for subadults was assessed according to dental development (Ubelaker 1978). Cranial ossification as well as epiphyseal and apophyseal fusion were also used (compiled in Grupe *et al*. 2015). Morphological age was specified using age classification according to Martin (1928): Infans I (0–6 years), Infans II (7–12 years), Juvenile (13–20 years), Adult (20–40), Mature (40–60), Senile (60–∞) (Grupe *et al*. 2015). Adult individuals that could not be precisely categorized were designated as “adult-senile”.

2.4 Body height

Table 3 shows long bone measurements (*cf.* Steckel *et al.* 2005) and body height estimations based on regression formulae from Bach (1965) or Breitinger (1938) that were collected from the literature and all newly-recorded measurements. Calculation of body height was based primarily on femur length. The humerus was used when the femur was not available. Average bone length is given in cases where the right and left long bones were measurable.

2.5 Stress markers

Cribra orbitalia and enamel hypoplasias were analysed as unspecific stress markers (for details *cf.* contribution by von Heyking and Zintl in this issue) for all cemeteries listed in Table 3. Because of the small number, no differentiation was made between varying degrees and/or unilateral versus bilateral presence; for enamel hypoplasia, only the canines were examined. The classification applied followed the Global History of Health Project Data Collection Codebook (Steckel *et al.* 2005).

Cribra orbitalia: 0 = orbital region absent, 1 = at least one orbit analysable but no *cribra orbitalia* diagnosed, 2 = *cribra orbitalia* diagnosed in at least one of the orbits.

Enamel hypoplasia: 0 = no canine tooth present, 1 = at least one canine tooth present but no enamel hypoplasia diagnosed, 2 = enamel hypoplasia diagnosed in at least one of the canines.

2.6 Strontium isotope analysis

The stable isotopic ratio $^{87}Sr/^{86}Sr$ is used for detecting immigrants within a population. The method is based on the following: ^{87}Sr content of a given type of rock is a function of the primary content of rubidium and the rock’s geological age. Therefore, the measured $^{87}Sr/^{86}Sr$ ratio can be used to characterize these rocks. In the course of weathering, strontium is dissolved in the rocks, which retains its specific isotopic signature after it enters the soil and ground water where it becomes biologically available. This specific isotopic ratio enters the food chain via plants and is incorporated into the tooth enamel and bone tissue of animals and humans (for a detailed description see Bentley 2006). It should be noted that in contrast to bone, tooth enamel is not remodelled during life and, therefore, preserves the isotopic signature of the environment in which the individual spent their childhood (or juvenile years, depending on the type of tooth analysed).

Strontium isotopic data are available for several cemeteries discussed in this survey. Because problems with contamination are inherent in the strontium isotope analysis of bone material (Bentley 2006), only tooth data, mainly from first molars, were included (for methods of strontium isotope analysis, see references given in Table 2).

Detecting immigrants within a population requires knowledge of the local habitat-specific range of biologically-available strontium-isotopic signatures. However, in the majority of investigations no archaeological faunal remains of small mammals like rodents are available. These represent the best reference material to determine such local isotopic-value ranges. Yet, all of the cemeteries referred to in this contribution (except Wenigumstadt) are located within a relatively homogeneous geological region between the Alps and the Danube, predominantly characterized by sedimentary rocks exhibiting similar strontium isotopic signatures. Soil samples from this region display $^{87}Sr/^{86}Sr$ values between 0.708 and 0.71 (Grupe *et al.* 1997; Schweissing, Grupe 2003). Moreover, some data from human and animal bones exist for different archaeological sites in this area. Based on this, the biologically available $^{87}Sr/^{86}Sr$ signatures for this geological region range between 0.708 and 0.7103 (Bentley, Knipper 2005; Grupe *et al.* 1997; Schweissing, Grupe 2003).

However, higher values of up to 0.7115, possibly reflecting local signals, have been observed in the frontier region along the Danube, which could be explained, among other things, by food imported from regions north of the Danube (Codreanu-Windauer, Harbeck, in press). Hence, the data from the previous studies were reevaluated using the very broad range of 0.708 to 0.7115 as representative of “local” isotope values.

3. Results

3.1 Burial numbers

The charts in Figure 2 (based on the quantities shown in Table 1) illustrate the quantitative developments. In R2 the use of the ~40 known late Roman burial grounds ends in the 1st third of the 5th century following a brief period characterized by a significant reduction in burial numbers. Single burials and small groups of burials bridge the middle of the 5th century. After that, grave numbers rise markedly in the last quarter of the 5th century. This period marks the beginning of the large Early Medieval cemeteries as well as of the smaller cemeteries of the "Unterhaching-type", which were in use only for two or three generations. In R3, the 1st third of the 5th century is characterized by the continued practice of cremation, even if a quantitative stagnation is detectable after the dynamic growth during the 4th century. The middle third of the 5th century witnesses an abrupt stoppage with cremations. The charts show a clearly different picture in the frontier regions close to the Danube River (GR). A considerable number of inhumations are documented for the 1st half of the 5th century. Burial grounds containing inhumations are recorded beginning with the middle of the 5th century. A chronological gap between these cemetery types has yet to be found.

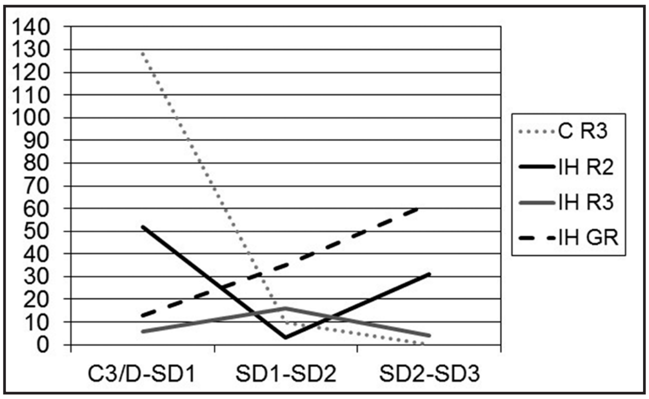

Figure 2. Number scale of inhumations and cremation burials in the separated Regions in chronological order.

3.2 Problems associated with compiling anthropological data

The compilation of anthropological data from the literature brought with it a multitude of difficulties. For example, earlier anthropological studies, in particular, are rarely accessible since they appear in unpublished archaeological papers, catalogues, or excavation reports. Many existing publications lack individualized anthropological data; only giving average body height or average age-of-death, for example, without any specification of individual raw data or a list of measurements or diagnostic indicators, *etc.* Archaeological catalogues that also include anthropological data (*e.g.* Altenerding and Straubing-Bajuwarenstraße) normally provide individual body heights; however, the regression formulae used are seldom indicated. As a result, reliable comparisons with other cemeteries are impossible.

Stress markers could not be assessed at all in those skeletal series in which anthropological data were taken solely from the literature. In fact, published catalogues of the respective burial sites or skeletal series often mention the presence of *cribra orbitalia* and/or enamel hypoplasia in an individual. The absence of a marker or respective skeletal element, however, finds no mention. This means it is often possible to determine which individual and how many individuals had *cribra orbitalia* or enamel hypoplasia, but not who or how many did not. It remains unclear if the absence of information about the stress markers results from an actual absence of the feature or from an absence of the skeletal region upon which the marker is manifested. Correspondingly, this of course also applies to fractures and other pathological changes like periostitis, *etc.* Therefore, in the majority of cases it is impossible to specify the frequency of the studied feature in a population and so reliably compare different cemeteries.

Frequently, only basic anthropological data such as sex and age-at-death are provided for the cemeteries important for the period in focus (*e.g.* Bittenbrunn), and unfortunately, no anthropological data is available at all for many of the archaeological sites in question.

3.3 Collected osteological data

All osteological data gathered in this study are listed in Table 3. Furthermore, the following analysis includes data from the literature as stated in Table 2. In all, data from 198 individuals was compiled. However, complete data sets (including stress markers) were obtained for only a subsample set of 72 individuals (Table 3). Basic anthropological data like sex and age-of-death of the buried individuals were frequently provided in the literature. Yet, because this survey does not reflect normal, biologically-existing populations, but rather selected data (see above), the results should be treated with caution. Also, for this reason, we deliberately refrain from paleodemographic interpretations.

In general, the sex ratio of the entire collective studied shows a small surplus of female individuals, which is not significant (n=198; non-adult individuals, age classes Infans I, Infans II and Juvenile, n=44): undetermined=86.4%,

Table 4. Age-at-death distribution for all individuals that could be classified to one age class (n=187).

	Male		Female		?	
	n	%	n	%	n	%
infans I	0	0.0	0	0.0	–	–
infans II	0	0.0	0	0.0	–	–
juvenis	3	4.6	3	3.6	3	7.7
adultus	20	30.8	36	43.4	2	5.1
maturus	38	58.5	33	39.8	2	5.1
senilis	4	6.2	11	13.3	1	2.6
total	65	100.0	83	100.0	39	100.0

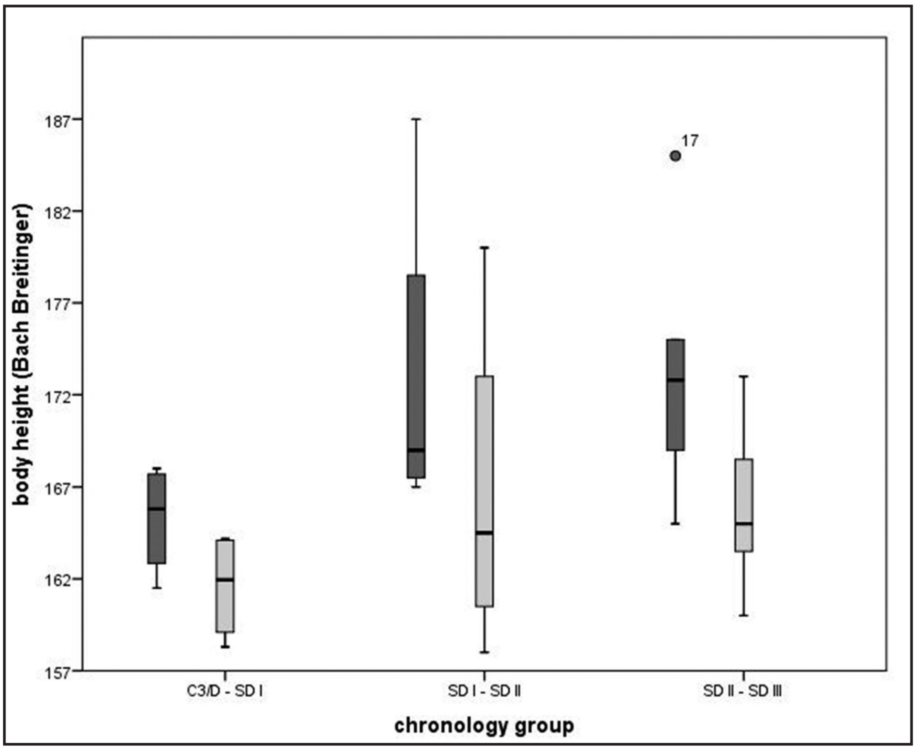

Figure 3. Comparison of body heights in different chronological periods (chronology groups); minimum value (lower end of the bar), maximum value (upper end of the bar) and average body height (thick line).

male=6.8%, female=6.8%, *c.f.* Table 4; adult individuals, n=154: undetermined=3.2%, male=42.2%, female=54.5%).

The Early Medieval cemeteries in which the entire skeletal collective was analysed show a surplus of women (Unterhaching: 6 women, 3 men), Burgweinting-Kirchfeld (11 women, 5 men, 3 undetermined) and Burgweinting-Nord-West II (4 men, 9 women), while the late Roman cemetery of Erding-Klettham shows a surplus of men (9 men, 4 women). Table 4 shows the age-at-death distribution for all individuals that could be classified to only one age class (n=187). These obvious differences between sexes were not tested statistically because of the relatively small sample size in each age class.

3.3.1 Body height

Body height was estimated in only 70 individuals. Men (n=24) are on average 172 cm tall (±6.3 cm), while women have a mean body height of 165 (±4.5). These body height calculations were collected mainly from individuals buried at

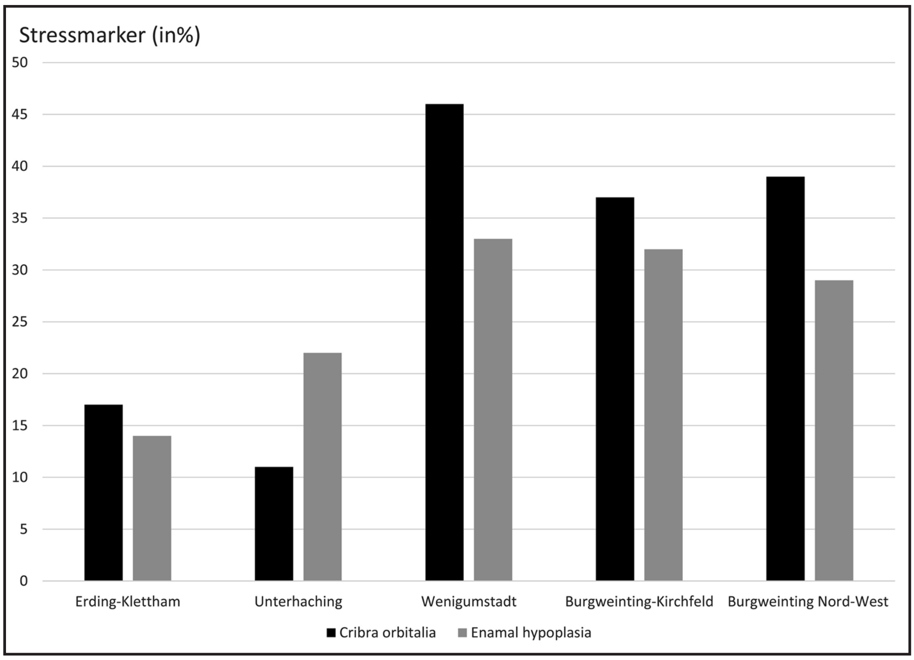

Figure 4. Frequency of stress markers of individuals buried at small Bavarian graveyards analysed here and the Early Medieval cemetery Wenigumstadt (only 5th century individuals considered).

the Erding-Kletthamer Feld (male: n=3, 164.4±3 cm; female: n=3, 161±3 cm), Unterhaching (male: n=1, 173 cm; female: n=3, 167±3 cm), Burgweinting-Kirchfeld (male: n=5, 173±7.8 cm; female: n=11, 166±3 cm) and Burgweinting Nord-West II (male: n=2, 172±4 cm; female: n=6, 166±2 cm) cemeteries. A statistically-significant difference between the regional groups GR and R2 was not detected, which may be due to the small sample size. However, a significant difference in body height for male individuals, but not for females, is detectable using the Kruskal-Wallis-Test (p=0.042). Figure 3 shows that men belonging to the first time period (C3/D–SD 1) are comparably small. Chronological period 2 is negligible due to the small sample size (n=4).

3.3.2 Stress markers

Stress markers were investigated only for the individuals shown in Table 3. *Cribra orbitalia* in at least one orbital roof was observed in 17% of the Erding-Kletthamer Feld individuals (only 6 individuals evaluable – n), 11% of the Unterhaching individuals (n=9), 46% of the Wenigumstadt individuals (n=11), 37% of the Burgweinting Kirchfeld individuals (n=19), and 39% of the Burgweinting Nord-West II individuals (n=13).

Enamel hypoplasias were found in 14% of the Erding-Kletthamer Feld individuals (n=7), 22% of the Unterhaching individuals (n=9), 33% of the Wenigumstadt individuals (n=9), 32% of Burgweinting-Kirchfeld individuals (n=19), and 29% of Burgweinting Nord-West II (n=14) individuals.

There are neither obvious differences between men and women, nor between the different regional and chronological groups, although differences between different cemeteries are notable (Figure 4).

3.4 Strontium isotopes

At present, strontium isotope data are only available in usable numbers for several individuals from the relevant period from the cemeteries: Erding-Kletthamer Feld (n=13), Straubing-Azlburg I (n=6), Unterhaching (n=10), Neuburg/Donau (n=6), Wenigumstadt (n=9), Burgweinting- Kirchfeld (n=19) and Burgweinting Nord-West II (n=14) (*cf.* Table 3). Figure 5 shows the distribution of $^{87}Sr/^{86}Sr$ ratios for the sites located south of the Danube. Vohberger (2011) identified four of the eight individuals from Wenigumstadt included in this study as immigrants.

4. Discussion

4.1 Population dynamics

A lack of evidence for cremation burials, as well as for inhumations, is observable in southern Bavaria for the time around 450 AD. Conversely, no reduction in burial numbers was found for the border regions. In fact, a steady increase in the number of burials in this region from late Roman to Early Medieval times is observable. Numerous inhumations during the first half of the 5th century are documented, but not a single cremation burial. Yet, there is evidence for cremations in the R3 region during this same time span. From the middle of the 5th century onwards, newly-established burial grounds with inhumations can be found in close proximity to the older so-called Roman "Kastellfriedhöfe" (fort cemeteries), such as Straubing Azlburg (Moosbauer 2005). A chronological gap between these cemeteries and the following "Reihengräberfelder" cannot be found. At the same

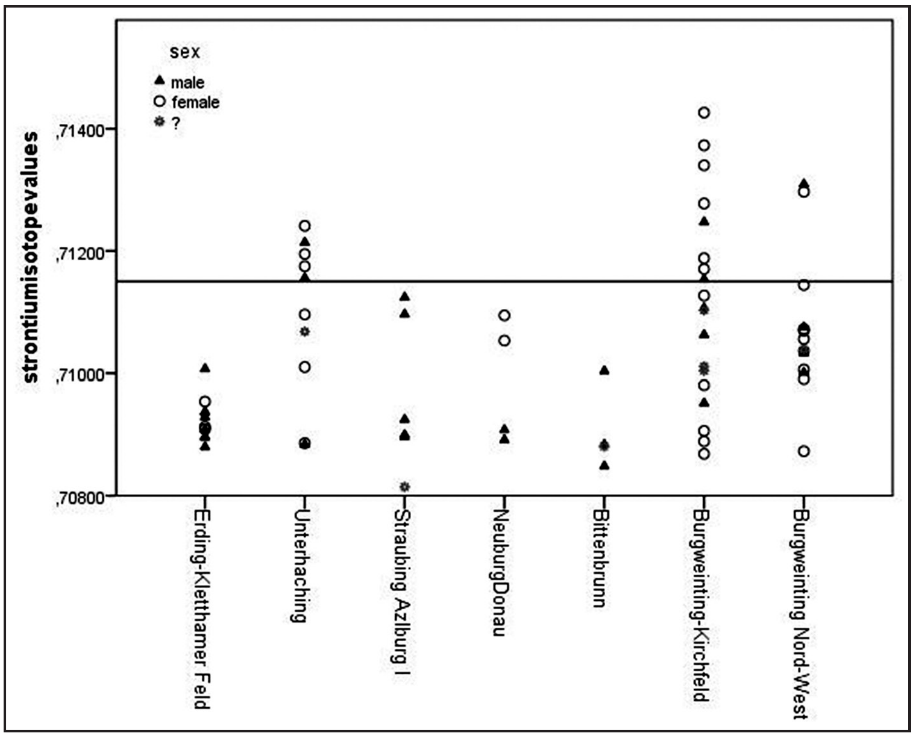

Figure 5. Strontium signatures ($^{87}Sr/^{86}Sr$) from different 5th century Bavarian graveyards.

time a dynamic increase in inhumations is presumed, which probably reflects growing population size. It seems probable that population density in the hinterlands declined sharply prior to the implementation of new structures. This decline in the hinterlands likely reflects a pronounced reduction in population size. However, a change of burial customs that is not evidenced archaeologically cannot be excluded. Regardless of which interpretation is accurate, developments that took place at the late Roman frontiers along the Rhine and the Danube rivers suggest the area from there to the old frontier along the Obergermanisch-Raetischer Limes played a crucial role in the transformation process.

After the break in the middle of the 5th century, the south of Bavaria and the frontier regions on the banks of the Danube River experience a vigorous recovery, while the areas along the Limes act as a model that stimulates development in the other regions. In particular, this applies to a standardization of burial customs. The phenomenon of the so-called row grave cemetery ("Reihengräberfeld") has its roots in the frontier regions of the late Roman Empire. Later on, patterns specified here become characteristic for southern Germany and even beyond (*e.g.* Fehr 2012).

4.2 Living at the outskirts – first insights

The survey of anthropological data deriving from the time and geographical region under study shows that, so far, there is only a limited amount of analysable anthropological data. At present, the conclusion that can be drawn regarding the living conditions and health of populations that lived in 5th century Bavaria is limited.

As far as the artificial composition of the given collective permits, the age-at-death distribution of the total number of surveyed individuals does not show any abnormalities. The sex-specific differences for the age-at-death distribution for this historical period, often noted in previous studies, are also detectable here: more female individuals died in the Adult age class, whereas male individuals predominate in the Mature age class. This is generally explained as being the result of women of reproductive age dying due to maternal complications (*cf.* also discussions in the contributions by von Heyking and Zintl 2016, in this issue). However, it appears that women who survive the adult phase have an increased chance of reaching old age. Many more women than men reached the senile age class. This pattern is observed at almost all times and in all areas of the world, provided that the respective living conditions of women are not significantly worse (*e.g.* Austad 2006).

A lower average body height in males from the late Roman time period C3/D–SDI was shown statistically. However, the small sample size suggests exercising caution: the "male population of C3/D–SDI" consists of three individuals from Erding-Kletthamer Feld and one individual from Neuburg/Donau, only. Therefore, skewed results are possible; however, this observation is well supported by the general finding of Köpke (2008), who noticed an average increase in body height of more than 2 cm (in both sexes) in the European population during the 5th and 6th century. Köpke explains this by stating that "people under the Roman regime" are generally shorter. She suggests this is the result of income inequality (a very small upper class had a disproportionately large share of the total income), and due to the spread of new infectious diseases through contacts with Persia, Asia, *etc.*, during the era of the Roman Empire. However, because body height is determined in part by genetic factors (*e.g.* McEvoy, Fischer 2009), it is also possible that the increase in mean height later on is caused by the arrival of men from taller populations.

Strontium isotope analysis of bones and teeth is the method of choice employed to identify migration. Strontium isotope data are available for individuals from seven of the archaeological sites under study. It should be noted that only the minimum number of migrants is determined based on strontium isotope analysis. Some migrants may remain hidden after analysis since they possess isotopic signatures similar to the "local" strontium signature, even though they originate from foreign regions.

Figure 5 shows that a considerable number of immigrants was detected in Early Medieval hinterland burial sites like Unterhaching, as well as cemeteries from the frontier region like Burgweinting and Wenigumstadt. All of these immigrants show higher strontium isotopic values than the rest of the population, which indicates an origin from a geological area characterized by granite. The nearest regions characterized by distinctively-higher strontium signatures are the Bavarian forest north of the Danube, most parts of the Bohemian Massif, and also the eastern Alps.

Interestingly, individuals that immigrated from "high-$^{87}Sr/^{86}Sr$-regions" were only found in hinterland and frontier cemeteries dating to Early Medieval times (SDII–SDIII and later), while late Roman cemeteries (C3D–SDII) located in these regions contain none. Whether this is a sign of increased migration from north of the Danube, or results from the small number of samples, remains uncertain. Further strontium isotope data is needed, especially for late Roman sites.

4.3 Small 5th century Bavarian cemeteries

The sex ratio differences in some of the small cemeteries located in Erding, Unterhaching and Burgweinting are remarkable. No selection of dated subpopulations had to be made in these cases. Both the Burgweinting and Unterhaching cemeteries were completely excavated. Several explanations for the surplus of females observed are suggested: a considerable number of unmarried women living at agricultural estates; mobile lifestyle of men taking care of scattered properties; remarriage of men after the early death of their wives; or armed conflicts in which men are buried far from home (see also Czermak 2012). The male surplus in the Erding-Kletthamer Feld skeletal series can be explained by the military context of this archaeological site (Sofeso *et al.* 2012). However, unbalanced sex ratios may have stochastic causes in small cemeteries.

Skeletal enamel hypoplasia and *cribra orbitalia* were analysed for all four sites. Both features indicate nonspecific skeletal stress. Dental hypoplasia is symptomatic for a number of childhood physiological stresses such as malnutrition, infectious or febrile diseases, or trauma. *Cribra orbitalia* is associated with anaemia (Walker *et al.* 2009), which can be caused by poor diet, parasitic infestation or enteric diseases. The observed simultaneous fluctuations in frequency of these skeletal changes in nearly all of the skeletal series analysed, may be explained by the fact that some of the underlying causes for these stress indicators are the same. However, enamel hypoplasia indicates stress during childhood, while *cribra orbitalia* can be observed in all age groups of a population.

For the late Roman cemetery of Erding-Klettham, the frequency of *cribra orbitalia* seems comparatively low (<20%). *Cribra orbitalia* frequencies between 19% (Vicenne (VII e. AD) and 60% (Ravenna area I–IV AD) have been observed in Roman skeletal remains originating from the same time period in Italy (Belcastro *et al*. 2007; Facchini *et al*. 2004). The relatively low frequency in Erding might suggest a comparatively healthy environment. One reason may be less swamp area and endemic malaria (which is known to produce anaemia), both of which were present in the Ravenna area at this time (Facchini *et al*. 2004). The rate of enamel hypoplasia in Erding-Klettham lies in the usual range: in Italy, between 19% (Ravenna area) and 25% (Rimini area) of the individuals showed these childhood stress markers (Facchini *et al*. 2004). Also, the Early Medieval skeletal remains in Unterhaching, located only 50 km south of Erding in the hinterland region, show only a moderate frequency of stress markers. A slightly higher frequency of enamel hypoplasia compared to *cribra orbitalia* was observed, indicating more stress during childhood.

However, the comparatively higher incidence of *cribra orbitalia* and enamel hypoplasia in the population of both the Wenigumstadt and Burgweinting cemeteries is noteworthy. The frequency is comparable with the stress-marker incidence in the population of München-Perlach, a cemetery discussed in detail in another contribution in this issue. For a discussion on the causality for this increased frequency in stress markers, see the article by von Heyking, Zintl 2016 in this issue.

4.4 Status quo and open questions

Although a great deal of anthropological research focussing on the time period and region under study has been conducted over the past 50 years, little data is available for comparative approaches to understand the living conditions (*cf.* Table 2). The synopsis presented here demonstrates that the main reason for this is insufficient anthropological data "processing". Another unfortunate dilemma is that scientists do not use a standardized method for data collection. This results in difficulties when pooling data or conducting comparative studies. Furthermore, various skeletal features, such as pathological changes, are generally described but not classified, making comparisons difficult or impossible. This underlines the importance of standardised anthropological investigations, like those for pathological features established by the "Global History of Health" project (Steckel *et al.* 2005). This is the only way to achieve in-depth insights into living conditions of an entire epoch. In line with this thinking, the State Collection for Anthropology and Palaeoanatomy in 2014 developed documentation guidelines for skeletal remains (Harbeck 2014), which must be followed by all researchers who analyse skeletal remains from the collection. The motivation is to allow for anthropological (meta-) studies (exceeding individual cemetery populations) in the future and to augment and complete the osteological database for the 5th century.

Compared to other regions, a number of archaeometric studies for Bavaria exist in the literature, especially those containing isotopic data such as $^{87}Sr/^{86}Sr$-values. However, more data is needed for the time span under study to make a comprehensive assessment of 5th century population mobility. Because the association of mobility and social status in Early Medieval society is not well understood, anthropological analyses should not just be focused on high status individuals, but spread evenly over all social levels. Additional information on human mobility during the 5th century will be produced not only by isotopic investigations, but also through the analysis of ancient DNA (see *e.g.* www.ba-fim.de).

From an archaeological standpoint, the group of unfurnished inhumation burials is promising with respect to future interdisciplinary analysis. Although cremation burials can still be found in R3 (even if not suitable for anthropological research) during the first half of the 5th century, there is a lack of evidence for cremation burials as well as for inhumations in southern Bavaria (R2). If this means that region R2 (Raetia II) is not completely empty, even 80 years before Saint Severin's Vita writes about the Romans from Noricum emigrating southwards (see *e.g.* Haas-Gebhard 2013a, 64–65), then other explanations are needed for this archaeological enigma. Comprehensive ^{14}C dating of unfurnished burials is necessary for better chronological interpretations. Similar to the study concerning the unfurnished burials of Erding-Kletthamer Feld, the ^{14}C analyses of skeletons from the Early Medieval cemetery in Unterhaching do not support the "bridging idea" (Haberstroh 2013). However, Unterhaching might have been an unsuitable case study or the wrong type of burial ground to test this hypothesis. Furthermore, there is a lack of ^{14}C dates for corresponding burials from the large Early Medieval cemeteries in R2, such as Altenerding, Straubing-Bajuwarenstraße, Bergkirchen or Aschheim, which were founded one or two generations later (Gutsmiedl-Schümann 2010). In addition to chronology, uncertainties to functional continuity and migration also remain and require corresponding and contrastive analyses, which are still lacking.

To generate a better understanding of the hiatuses in the Bavarian hinterlands, a comparison with Bohemia, where the historical and spatial conditions for development are different, could prove beneficial. There is no comparable sharp break in the middle of the 5th century in Bohemia. Cemeteries like Plotiště nad Labem (Rybová 1988), Kolín or Praha-Zličín bridge the middle of the century, as is also shown by the chronology of the younger phases of the Vinařice-culture (Tejral 2006).

A combination of anthropological and archaeological methods of analysis, supplemented by scientific dating methods should provide further information and produce new questions on this topic. Based on the observations given in Figure 1, three time periods (C3/D, SD I, SD II) should be compared within the regions R2, R3, GR and Bohemia.

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