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# Identifying kurgan graves in Eastern Hungary: A burial mound in the light of strontium and oxygen isotope analysis

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#### Abstract

Isotopic analyses of human tooth enamel are increasingly applied to provide answers to archaeological questions.  $^{87}$ Sr/ $^{86}$ Sr and  $\delta^{18}$ O analyses are used to investigate small- and large-scale mobility and migration of prehistoric human individuals. Within a pilot study looking into the kurgan graves in the Eastern Carpathian Basin, we analysed the tooth enamel of

8 humans from the Early Bronze Age burial mound of Sárrétudvari-Őrhalom, Hungary. According to the archaeological record, the kurgan is linked to the Northern Pontic Yamnaya regional groups. Certain foreign burial traditions suggest that the connection is close, or even that the individuals buried in the mound had migrated from the East into the Great Hungarian Plain. Strontium and oxygen isotope analyses reveal an earlier period of 'local' burials, spanning the period 3300–2900 BC, followed by burials that postdate 2900 BC that exhibit 'nonlocal' isotopic signatures. The combination of the isotope values and the grave goods associated with the nonlocal burials point to the foothills of the Carpathian Mountains as the nearest location representing a possible childhood origin of this nonlocal group.

#### Keywords

Mobility,  ${}^87Sr/{}^86Sr$  and  $\delta{}^{18}O$  analyses, Early Bronze Age, Yamnaya, Hungary, Sárrétudvari-Őrhalom.

### Introduction

Within the Excellence Cluster 264 TOPOI, based at the *Freie Universität* and *Humboldt-Universität* in Berlin, one research group concentrates on the spatial effects of technological innovations and changing ways of life. One of the subprojects being conducted by that group uses isotope analysis to investigate mobility and subsistence strategies in the Western Eurasian steppes and adjacent areas. We concentrate on the Late Eneolithic and Early Bronze Age (3500–2000 calBC), but for reasons of comparison Early Iron Age individuals, with their historically attested high degree of mobility, are also sampled. In this paper we focus on the preliminary results of the investigation of a burial site of Yamnaya individuals located in the eastern part of the Great Hungarian Plain (Fig. 1), which is part of a research cooperation between *Freie Universität* Berlin, the University of Bristol (UK), and the Hungarian Academy of Sciences.

In prehistoric times the eastern part of the Great Hungarian Plain was a region undergoing profound cultural changes. In the Early Bronze Age and the transition period leading to it, new elements in burial traditions, differing from the local traditions, appear to the east of the river Tisza. These foreign elements are generally explained in terms of some kind of influence from the east. In the past, several archaeologists postulated that an expansion of steppe people took place, described on various occasions as, in the most extreme terms, a "steppe invasion by the kurgan culture" (Gimbutas, 1979) in its most extreme form, as "moving shepherd tribes" (Ecsedy, 1979), or as an infiltration of Yamnaya individuals into the eastern European lowlands (Häusler, 1985). Even today, many researchers share the opinion that the foreign features are to be explained by migration to the Lower Danube and Eastern Hungary (Anthony, 2007; Harrison and Heyd, 2007).



Fig. 1 | Relief map of Hungary and adjacent areas (© Institute of Archaeology HAS, modified)

Yamnaya groups were present in the Northern Pontic region from the end of the 4<sup>th</sup> millennium BC to c. 2500/2400 calBC (Kaiser, 2011; Rassamakin and Nikolova, 2008: 2900 to 2300 calBC). The Yamnaya population is considered highly mobile, its economy primarily based on stockbreeding, with agriculture in a subordinate role. Despite a lack of unambiguous archaeological evidence, most researchers believe the Yamnaya to have been an at least partly pastoralist society (e.g. Bunyatyan, 2003; Anthony, 2007). At about 3000 calBC, they appear, rather abruptly, west of their original homeland (Heyd, in press); although a phenomenon described as the pre-Yamnaya intrusion occurs as early as 3400/3300 calBC. The fact that burials in this eastern tradition are only found under the steppe-like environmental conditions of the eastern European plains could well be an indication that people themselves – rather than ideas alone – were on the move and introduced new cultural elements to the West. However, there is as yet no substantive set of scientific data that would support the assumption of such a westward migration of Early Bronze Age steppe.

West of the Black Sea, the 'Yamnaya phenomenon' is represented by several hundred burials, characterized by a funeral rite similar to that of the Northern Pontic Yamnaya groups. These burials are situated in the lowlands of modern Bulgaria, Romania, Serbia and Eastern Hungary, and are restricted chronologically to the very end of the 4<sup>th</sup> and the first half of the 3<sup>rd</sup> millennium calBC. The graves are mostly west—east in orientation, and a supine position with flexed legs is typical for this burial tradition, as is the crouched position. The skeletons were buried in oval or rectangular grave pits, either covered by a single burial mound or arranged in groups or chains. Wooden beams or stone slabs usually overlay the grave pits, and walls and bottoms of the graves are sometimes covered with mats of some kind of organic material. Grave goods are characteristically scanty or completely missing. While ochre staining on the grave bottom or the skeleton itself and/or pieces of ochre are frequently found, ceramics are extremely rare. Somewhat more abundant are offerings consisting of meat, flint, as well as necklaces and chains of perforated animal teeth. The objects most frequently found, although generally in low numbers per burial,

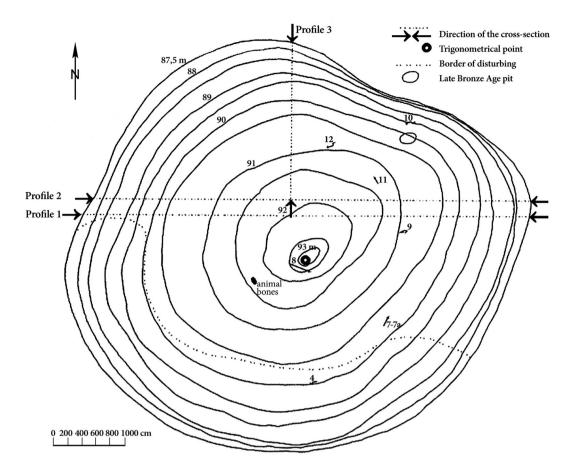


Fig. 2 | Contour map of the burial mound of Sárrétudvari-Őrhalom. Modified after Dani and Nepper (2006, p. 30 Fig. 2.I)

are hair rings and hair spirals made of gold, silver and natural electrum (Dani and Nepper, 2006). Tools and weapons hardly ever occur. The majority of the burials are those of adult males, though all age groups and both sexes are represented (see Heyd, in press, for further literature).

## Archaeological setting

The burial mound of Sárrétudvari-Őrhalom (Fig. 1–2) was excavated in the second half of the 1980s by Nepper. Nepper and Dani were able to distinguish two phases of kurgan construction, with an earlier mound covering the primary burial (Grave 12) and a second mound covering Graves 4,7/7a, 8, 9, 10 and 11. According to the radiocarbon data, the burial mound was in use between the end of the 4<sup>th</sup> millennium and the mid 3<sup>rd</sup> millennium calBC (Dani and Nepper, 2006; Szántó et al., 2006).

Both stratigraphically and archaeologically, Graves 8, 10, and 12 are the earliest burials of the mound. Grave 12 (3361–3097 calBC, 2 $\sigma$ , OxCal 4.0; deb-6869) contains the remains of a juvenile lying in a NW–SE orientation in a strongly contracted side position. Multiple strands of evidence, based on <sup>14</sup>C dating, stratigraphy, the lack of grave goods and the non-Yamnaya-like burial style, indicate a late Copper Age date. Grave 10 is the second oldest (3090–2894 calBC, 2 $\sigma$ ; deb-6639) and contained a W–E oriented

maturus male, found in a slightly contracted position. In addition to traces of ochre on the bones, the excavators found a grinding stone that can be considered as belonging to the burial; bones of horse and cattle were found in the grave filling. As Grave 8 had been thoroughly disturbed, it could only be reported that the skeleton might have been oriented NW–SE or SE–NW and was laid on some kind of mat, covered by something like a blanket, the organic remains of which are still evident.

A second 'group' of younger graves consists of Graves 4, 7/7a, 9 and 11. In Grave 4 (2886–2503 calBC, 2 $\sigma$ ; deb-7182) the poorly preserved skeleton of an ENE–WSW oriented elderly adult (*maturus*) male was found. He was buried in a slightly contracted position on his left side. The skeleton was probably covered by some kind of organic material, probably leather. With a ceramic vessel, two *Lockenringe* and an animal bone, the grave is relatively well equipped. Grave 7/7a also contains rich burial objects: a ceramic vessel, *Lockenringe*, a copper axe and a dagger, as well as a lump of ochre. In addition, the bottom of the grave was covered by some kind of organic substance. A NE–SW oriented *maturus* male was buried next to a child (5 to 7 years old). A young adult male in supine position on his back with legs flexed in rhomboid position was found in Grave 9 (2861–2472 calBC, 2 $\sigma$ ; deb-6871). The disturbed grave consisted of a ceramic vessel, a dog's tooth in the fill and some kind of organic substance on the grave bottom. Grave 11 was disturbed to such an extent that only a NW–SE(?) position of the skeleton, a ceramic vessel and cattle bones in the grave filling could be reported (cf. Dani and Nepper, 2006).

## Application of isotope analyses

Increasingly, researchers are turning to geochemical methods, particularly strontium, oxygen and, less frequently, lead and sulphur isotope analyses, to identify human mobility and migration in prehistoric central Europe (e.g. Price et al., 1994; Grupe et al., 1997; Bentley et al., 2003, 2004; Price et al., 2004; Bentley and Knipper, 2005; Nehlich et al., 2009, Nehlich et al., 2010). Nevertheless, until now, no study has attempted to identify mobility patterns for Early Bronze Age individuals in regions occupied by Yamnaya groups. The only similar study on the region of South-eastern Hungary was conducted by J. I. Giblin, who investigated mobility patterns for individuals of the Neolithic/Copper Age transition (Giblin, 2009).

Strontium isotope analysis is based on differences in underlying geology, or more precisely, differences in the isotope ratios in rocks and sediments which vary according to their age and composition (Ericson, 1985; Faure, 1989). Weathering causes strontium to pass from bedrock into sediments, water and plants, with the isotope ratio remaining almost unchanged, as fractionation is minimal. At the end of the food chain, it reaches animals and humans, where it is incorporated into their bones and teeth. Because tooth mineralization is complete by the end of childhood and the strontium ratio in teeth does not change after mineralization and because enamel is not subject to severe diagenetic changes while deposited in soil (Budd et al., 2000; Evans et al., 2006; Montgomery et al., 2005), the 87Sr/86Sr ratio in tooth enamel reflects the local geology of the region where an individual spent his or her childhood. Within a pool of individuals buried in one location, one can distinguish between those who grew up locally and those who migrated later in life by comparing the isotope ratios in their tooth enamel with local isotopic signatures established by sampling local sediments, plants and modern or ancient animals local to the site under study (Price et al., 2002; Bentley et al., 2004; Sjögren et al., 2009). Where there is a lack of other reference samples, dentine has been used to establish the local range, or at least the 87Sr/86Sr ratio of the immediate burial environment on the basis of dentine's susceptibility to the uptake of Sr (Beard and Johnson, 2000; Montgomery et al., 2007; Nehlich et al., 2009).

Oxygen isotope analysis is based on differences in drinking water that are associated with the isotopic composition of rainfall in varying geographical regions (Longinelli, 1984; Luz et al., 1984). The  $\delta^{18}$ O value of meteoric water is enriched in warmer climates or temperatures while in cooler surroundings it is depleted (Dansgaard, 1964). Furthermore,  $\delta^{18}$ O values are dependent on the distance from an ocean as well as altitude (Craig, 1961). Seasonal variations caused by huge differences in summer and winter temperatures can complicate the situation. The fact that all available comparative data is based on modern climate situations and models, which do not necessarily mirror the palaeoclimate of 5000 years ago, creates additional complications. Yet more problems are associated with breastfeeding and weaning, which result in an enrichment of  $\delta^{18}$ O in the teeth that mineralize in earlier childhood, i.e. first (and second) molars (White et al., 2004).

#### Material and methods

We sampled dental enamel from eight individuals from the burial mound of Sárrétudvari-Őrhalom. Since first molars were not available in every case, the set of samples for strontium and oxygen isotope analyses comprised two second premolars, two first molars, two second molars and two third molars. Tooth identification data and the results of the analyses are provided in Table 1. Various authors have proposed different sampling strategies for establishing the local Sr signature (cf. Price et al., 2002; Bentley et al., 2004). As bulk rock samples do not necessarily reflect biologically available strontium, most researchers recommend the collection of tooth enamel of small modern animals, such as rodents, or prehistoric animals whose range is locally restricted, e.g. pigs. In the absence of other samples, we analysed one soil, one plant sample and one ancient and one modern sheep bone. In addition, we sampled the dentine from four of the eight human individuals (Table 2).

Samples were prepared at the laboratory of the Department of Archaeology and Anthropology, University of Bristol, and analysed at the laboratories of the Department of Earth Sciences, University of Bristol (87Sr/86Sr), and at the Research Laboratory for Archaeology and the History of Art and the laboratory of the Department of Earth Sciences, University of Oxford ( $\delta^{18}$ O). The strontium isotope analysis was performed according to the procedure described in Haak and colleagues (Haak et al., 2008), with minor modifications. Oxygen isotope analysis followed the general procedure of the Bristol Isotope Group as described by Wilson and colleagues (Wilson et al., in press). For both Sr and O isotope analysis a longitudinal wedge of tooth enamel was removed using a flexible diamond-impregnated dental saw. The inner and outer surfaces of the enamel were cleaned using a tungsten carbide dental burr. After sequential washings with ultrapure water and drying in an oven, one enamel section was transferred to the laboratories of the Department of Earth Sciences, University of Bristol. Another longitudinal section of enamel was ground to powder in an agate mortar and the powder was weighed in minispin tubes and sent to the Research Laboratory of Archaeology, University of Oxford, for analysis. For strontium isotope analysis, the clean enamel section was dissolved in 3 ml 7N HNO3, dried down and redissolved in 3N HNO<sub>3</sub>. A 3 mg aliquot of this solution was made up to 0.5 ml with 3N HNO<sub>3</sub> and loaded onto ion exchange columns. Strontium was separated using standard ion exchange chromatography (70 µl of Eichrom Sr Spec resin). The eluant after column chemistry was dried down and loaded onto preconditioned rhenium filaments. Isotope ratios were measured using a ThermoFinnegan Triton Thermal Ionization Mass Spectrometer. Strontium ratios are corrected to a value for NBS 987 of 0.710248. Each sample was reanalysed to check reproducibility: results were identical to the fifth decimal place. For oxygen isotope

Table 1 | Summary of the anthropological data (after Zoffmann, 2006) and results of  ${}^{87}Sr/{}^{86}Sr$  and  $\delta{}^{18}O$  analysis for the sampled individuals of the Sárrétudvari kurgan. Errors for  ${}^{87}Sr/{}^{86}Sr$  are given at 20; typical errors for oxygen values are 0.2%

| Grave | Sex    | Age at death | Sample           | <sup>87</sup> Sr/ <sup>86</sup> Sr | δ <sup>18</sup> O <sub>water</sub> |
|-------|--------|--------------|------------------|------------------------------------|------------------------------------|
| 4     | male   | old adult    | maxilla M3       | 0.710905 ± .000004                 | -11.75                             |
| 7a    | ;      | child        | Mı               | 0.710161 ± .000004                 | -7.30                              |
| 7     | male   | old adult    | mandibula M2(?)  | 0.711015 ± .000003                 | -11.44                             |
| 8     | ;      | young adult  | Mı               | 0.710339 ± .000003                 | -8.27                              |
| 9     | male   | young adult  | mandibula M3 (?) | 0.710976 ± .000004                 | -10.94                             |
| 10    | male   | old adult    | maxilla M2       | 0.710470 ± .000003                 | -7.18                              |
| II    | male?  | young adult  | maxilla P2       | 0.711566 ± .000004                 | -10.54                             |
| 12    | female | juvenile     | maxilla P2 (?)   | 0.709963 ± .000003                 | -8.48                              |

Table 2 | Results of 87Sr/86Sr analysis for reference material for the estimation of the local signature of the region around Sárrétudvari. Errors are given at 2σ

| Location | Sample          | Period      | Contamination      | <sup>87</sup> Sr/ <sup>86</sup> Sr |
|----------|-----------------|-------------|--------------------|------------------------------------|
| grave 9  | dentine         | prehistoric | diagenetic changes | 0.710360 ± .000003                 |
| grave 10 | dentine         | prehistoric | diagenetic changes | 0.710271 ± .000003                 |
| grave 11 | dentine         | prehistoric | diagenetic changes | 0.710475 ± .000003                 |
| grave 12 | dentine         | prehistoric | diagenetic changes | 0.710164 ± .000003                 |
| field    | soil            | modern      | very probable      | 0.711224 ± .00001                  |
| field    | plant           | modern      | unknown            | 0.710534 ± .000003                 |
| grave 8  | bone sheep/goat | prehistoric | diagenetic changes | 0.710205 ± .000003                 |
| field    | bone sheep/goat | modern?     | unknown            | 0.710430 ± .000004                 |

analysis at Oxford samples were treated with 0.5 ml of 3 % NaOCl in 1.5 ml centrifuge tubes for 24 hours and sequentially rinsed in deionized water in a centrifuge. After a treatment with 0.5 ml of 1M calcium acetate buffered with acetic acid (24 hours), samples were sequentially rinsed with distilled water and dried in an oven. This was done following a procedure described by Koch and colleagues (1997). At the Department of Earth Sciences, oxygen isotopes were measured on a VG Isogas Prism II mass spectrometer with an on-line VG Isocarb common acid bath preparation system. Calibration against the NOCZ Carrara Marble standard had a reproducibility of < 0.02 %. O ratios are reported relative to the VPDB international standard. Data was converted to  $\delta^{18}O_{water}$  using Daux's version of Longinelli's equation (Daux et al., 2008; Longinelli, 1984).

#### Results and discussion

The results of the strontium and oxygen isotope analyses are shown in Table 1 and Figure 3. The <sup>87</sup>Sr/<sup>86</sup>Sr ratios of the human enamel from individuals in Graves 4, 7, 7a, 8, 9, 10, 11 and 12 show a limited variability between 0.7100 and 0.7116. The values appear to group into two clusters. The primary burial, Grave 12, is the least radiogenic. Its value is close to those determined for Graves 7a, 8 and 10. A second

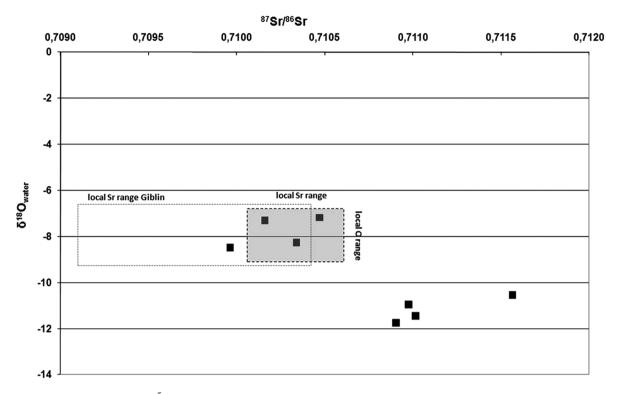


Fig. 3 | Results for Sárrétudvari-Őrhalom,  $\delta^{18}$ O plotted against  ${}^{87}$ Sr/ ${}^{86}$ Sr. The Sr local range (0.710348 ± 20) and expected  $\delta^{18}$ O values (~ -9 to -7) are highlighted. Sr local range given by Giblin is also demarcated (0.7091–0.7104)

cluster can be made out for Graves 4, 9, 7 and 11. The same two clusters can be distinguished in the  $\delta^{18}O$  ratios. The values for Graves 10, 7a, 8 and 12 range between -7.18 and -8.48, those for Graves 11, 9, 7 and 4 between -10.54 and -11.75.

The local \$7\$\$r/86\$\$r range was determined by analyzing samples of modern plants, modern and archaeological sheep bones and dentine samples from four individuals. The use of dentine is problematic as in some cases values for dentine can fall midway between the enamel and the diagenetic signal best represented by bone. Here, though, we found that the dentine values (mean 0.710318) are indistinguishable from the animal bone values (mean 0.710318), and thus we have combined both dentine and bone values to define the local range. The results are given in Table 2. Calculating a two-standard-deviation envelope around the mean of the comparative samples results in a local Sr signature of 0.7101 to 0.7106. This narrow range for Sr values is not surprising in view of the geological homogeneity in the eastern part of the Carpathian Basin and bearing in mind that bones and dentine were used as baseline samples: those substances reveal the Sr isotope ratio of the immediate burial environment rather than that of the wider region. A sample of sediment taken from a field under cultivation gave a more radiogenic signal at odds with all other baseline samples, including the plant matter. This value was ignored as we presumed it to be associated with a high risk of contamination by fertilizers.

The use of dentine and bone samples to define the local range is less than ideal, since the diagenetic Sr signal obtained from such samples probably represents the immediate burial environment, rather than a more meaningful average strontium value for the broader dietary catchment area of a single locally based community. While we did find a high level of correspondence between the Sr isotopic values of our local proxy samples of dentine, plant and animal bone and three of the human

enamel samples, we have not measured further indicators of local and regional strontium variability that would allow us to capture the size of the local catchment area. We can, though, get an indication of the Sr variability of the region from other studies. Giblin analysed prehistoric faunal samples from the sites Vésztő-Mágor, Vésztő-Bikeri, Okány 6 and Gyula 114, all of which are situated within an 80 km radius from our study site (Giblin, 2009). These samples define the local Sr range for her study area as 0.7091 to 0.7104, and overlap with 3 of the enamel samples we take to be local. Additionally, water samples from the rivers Danube and Tisza gave 87Sr/86Sr ratios of 0.7089 and 0.7096 (Palmer and Edmond, 1989; Price et al., 2004), although these probably represent average Sr values from the very wide catchment of the river. Despite the considerable variability in Sr values across these studies, there is sufficient overlap between our local range and that of Giblin to present difficulties in defining a meaningful local range for the Sárrétudvari-Örhalom burial mound. This is perhaps to be expected for a site on the geologically homogenous Hungarian Plain that is composed of sediments, sands, silts and clays that derive from tertiary and quaternary rocks (Trunkó, 1969), young rocks that should result in relatively low 87Sr/86Sr ratios. The values for our "local group" are consistent with an origin here though. More importantly, the 'local group' is distinct with respect to both Sr and O isotope values from the individuals in the second cluster, which, we can be confident, do not have their origins in a location similar to that of the first group.

No comparison data is available for the results of oxygen isotope analysis. In an attempt to get an idea of what O values one should expect for the region around Sárrétudvari, we used the Online Isotopes in Precipitation Calculator (www.waterisotopes.org). According to the OIPC, modern  $\delta^{18}$ O ratios in precipitation for the Eastern Great Hungarian Plain should range between -6.5 and -8.5%. Annual average temperature in the Carpathian Basin in around 5000 BP was slightly lower than it is today (<-1 °C), therefore we would expect prehistoric  $\delta^{18}$ O values to be marginally more negative (Paleoclimate Modelling Intercomparison Project Phase II; http://pmip2.lsce.ipsl.fr). Yurtsever and Gat have estimated a difference of 0.5% per °C (Yurtsever and Gat, 1981).

Both isotopic systems suggest a distinction between the same two clusters of data for the burials (Fig. 3). Graves 12, 7a, 8 and 10 form one group that falls within the local  $^{87}$ Sr/ $^{86}$ Sr range of ~ 0.7101 and 0.7106 and within the expected regional  $\delta^{18}$ O range of ~ 7 to -9%. Grave 12 is slightly outside the limits of the local  $^{87}$ Sr/ $^{86}$ Sr range but, as mentioned above, our local range represents only the immediate vicinity rather than the likely dietary catchment area of an individual, and the individual in Grave 12 does fall within the Sr signature that Giblin determined for her area of study. According to  $^{14}$ C dates, Graves 12 and 10 are the oldest burials. Grave 8 is not dateable, and according to the grave goods the double burial of Graves 7a and 7 are of a later date. Grave 7a belongs to a child, and the isotopes suggest that this child was born in the same region in which it died.

Summarizing, we can state that the individuals in the first group of graves lived during their child-hood in the region around Sárrétudvari or a region geologically and geographically similar to that of our study site. A second cluster consisting of Graves 4, 7, 9 and 11, can be identified as 'nonlocals' on the basis of their  $^{87}$ Sr/ $^{86}$ Sr and  $\delta^{18}$ O ratios. The two graves of younger date (Graves 4 and 9) and the two graves with exceptional burial objects cluster together in this group. The Sr value of the individual in Grave 11 is more radiogenic than the values of the other individuals, but its O value falls into the same range defined by the other three values of below -10.5%. Here, in contrast to the values for the first group, both isotopic systems suggest a place of origin different from the region around Sárrétudvari. More radiogenic strontium ratios together with more negative oxygen ratios indicate regions of older rocks, and higher altitudes or more inland eastward regions.

The regions of the Carpathian Mountains, with their geological variety, come into consideration with respect to the place of origin of the individuals in the second cluster. These nearby regions, being composed of both very old rock and very young rock units, offer a huge variety of Sr values. Expected modern oxygen isotopic values range between -8 and -11% for the lower Carpathians (OIPC, www.waterisotopes.org). Again, taking the slightly colder average temperature of the Early Bronze Age into account (Paleoclimate Modelling Intercomparison Project Phase II; http://pmip2.lsce.ipsl.fr), the  $\delta^{18}$ O values of the second cluster would overlap with the expected values for the hilly parts of the Carpathian Mountains. Consequently, the Carpathians represent one possible place of origin for the individuals in the second cluster of graves. 'Place of origin' as we use the term here does not necessarily refer to the birthplace. Since we were not able to test first molars in every case, we can speak only of a stage in the childhood of the individual in question. Furthermore, one must bear in mind that variations in Sr values can also be caused by differences in food sources or subsistence strategies, while climate fluctuations can account for variations in O values.

We can simplify the search for possible places of origin of the 'nonlocal' individuals in the second cluster by incorporation the archaeological information concerning burial traditions in our analysis. According to the excavators, parallels for the ceramics can be found in local Makó/Kosihy-Čaka groups. Some of the vessels, however, can be connected with finds associated with the Transylvanian Livezile group, which is located on the eastern boundary of the Apuseni Mountains, a part of the Carpathian Mountain range. The metal objects, by contrast, show connections to both the eastern Balkans and the Northern Pontic region (Dani and Nepper, 2006). The combination of 1) local and nonlocal funerary equipment in association with 2) a burial rite (inhumation in pit graves covered by a burial mound), which is not characteristic of Early Bronze Age archaeological groups in Eastern Hungary, but is probably linked to the Yamnaya burial rite of the Northern Pontic steppes, and 3) Sr as well as O isotope values that would not be expected for the eastern part of the Great Hungarian Plain opens different possible scenarios for consideration:

- Probable is the connection between the Sárrétudvari nonlocals and the Transylvanian Livezile group, which is chiefly distributed in the eastern belt of the Apuseni Mountains and shows similarities in burial tradition (Ciugudean, 1996, 1998). Both the isotopes and some of the burial objects suggest that the Sárrétudvari nonlocals spent at least a part of their childhoods in a hillier region, possibly the mountainous area southeast of the study site.
- 2) Differences in subsistence or a wider subsistence range might explain the variety in the isotopic values, e.g. an economy based on transhumance could produce an average of mountainous and lowland isotopic values.
- 3) Some of our Early Bronze Age study sites in the Northern Pontic have yielded similar <sup>87</sup>Sr/<sup>86</sup>Sr ratios and oxygen values. Therefore we cannot exclude a Northern Pontic place of origin for the Sárrétudvari individuals. Furthermore, Northern Pontic individuals might have picked up the Transylvanian isotopic signature or a mixed signature on their way to the Eastern Great Hungarian Plain.

To sum up, we can state that initially, at the transition to and the very beginning of the Bronze Age, individuals with 'local' signatures were buried in a nonlocal tradition in the Eastern Great Hungarian Plain, i.e. the Sárrétudvari-Őrhalom burial mound. These individuals might have had exchange systems, kinship and descendent or other relational links to the east that resulted in their adopting this burial tradition. Subsequently individuals with a 'nonlocal' isotopic signature and, to some degree, 'nonlocal' funerary equipment were buried in the same mound. Wherever they came from and whoever they were,

some of the burials are equipped with prestigious goods. The inference is that they may have held positions of some importance in a population made up of a mixture of locals and immigrants from the East or in an immigrant population that coexisted with local groups (cf. Kulcsár, 2009, for further literature).

#### Conclusion

From the end of the 4<sup>th</sup> until the middle of the 3<sup>rd</sup> millennium calBC, burial elements that are linked to the Northern Pontic steppe region are found in the South-eastern European lowlands. These are indicators for a connection to the Early Bronze Age Yamnaya groups, which are considered to have led a highly mobile way of life. The key argument for Yamnaya mobility is not only their abrupt appearance west of the Pontic, but also the small number of known settlements in the Northern Pontic, the lack of settlements in the Western Pontic and their dependence on steppe-like environment. To investigate the mobility of the individuals deposited in the burial mound of Sárrétudvari-Őrhalom, we drew on strontium and oxygen isotope analyses, two methods that are independent indicators for the origin of humans, with  $\delta^{18}$ O correlating to hydrology and  ${}^{87}$ Sr/ ${}^{86}$ Sr to geology. Both methods yielded results suggesting nonlocal origins for some of the individuals (Fig. 3). The individuals in the older graves grew up locally, while individuals in the later graves show 'nonlocal' isotopic signals. Not least because this result is in itself surprising, despite the small size of the sample set, further analysis is already in progress to confirm our conclusions with regard to the westward migration of Yamnaya groups.

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