Pastoralists and mobility in the Oglakhty cemetery of southern Siberia: new evidence from stable isotopes

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Research

Mobility has long been recognised as a key feature of later prehistoric communities in eastern Eurasia. Isotope analysis of human hair offers new potential for studying individual mobility patterns within these communities. Hair samples from individuals of the Tashtyk culture buried in the Oglakhty cemetery in southern Siberia (third to fourth centuries AD) reveal variations in diet during the last months of their lives. Millet and fish were important in summer and autumn, C_3 plants and meat and dairy products at other times of year. The results indicate strong seasonal shifts in diet, and seasonal movement between different areas.

Keywords: Siberia, third–fourth centuries AD, isotope analysis, hair, diet, mobility

Introduction

Southern Siberia is a mosaic of forest and steppes, with mountain ranges, vast plains, depressions, rolling hills and large river systems. From the earliest times, this diversity in the landscape attracted a range of communities of different cultures who are believed to have developed and disseminated an economy based on animal-herding (Gryaznov 1983). Agriculture also became important, adopted among pastoralist groups throughout the second millennium BC. Millet, barley and wheat were staple crops, although millet was a late introduction (Spengler *et al.* 2014).

During the subsequent millennium of the Early Iron Age, the mobility of the pastoralist groups increased and their economic strategy became more diverse. All natural food resources of the occupied landscape—a vast area of the East Eurasian steppes—came to be exploited

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with a mixed economy combining mobile herding on the steppes with small-scale agriculture in the foothills, as well as foraging, fishing and hunting (Chlenova 1992).

The societies occupying different ecological zones within the Eurasian steppes were noted for their diversity and high levels of individual mobility, the latter dependent on the productivity of the areas exploited. One such region was the Khakassia-Minusinsk Depression, between the Kuznetsk Ala-Tau Mountains in the north and the Western Sayan Mountains in the south, at 200–700m asl. This landscape includes steppe and forest-steppe, with a continental climate (hot, dry summers and cold winters); at present, it is dedicated to arable farming.

Evidence for the diverse nature of the subsistence practices of Early Iron Age pastoralist groups in this region comes exclusively from traditional archaeological analyses of the material culture (Vadetskaya 1999). Detailed analyses of other archaeological sources, i.e. animal bones and plant macro remains, are very limited. Grains and glumes of gramineous plants are, however, recorded in several burials of the period (Vadetskaya 1998; 1999: 31, 235). Kyzlasov (1969: 45), for instance, noted "millet glumes", whereas Adrianov (1903: 4) mentioned that "fine seeds resembling Chinese green foxtail [*Setaria viridis*] were scattered under the heads of some skeletons". Sosnovsky (1933: 39) also referred to millet grains. It should be noted, however, that identifications of plant species in these instances were made by archaeologists, not by trained palaeobotanists, and the collections are no longer available for verification.

Recently, new evidence of the subsistence practices developed by Bronze and Iron Age communities occupying the Minusinsk Depression and adjoining areas was obtained through analyses of the stable isotope composition of human and animal samples, including bone collagen and hair. O'Connell *et al.* (2003) analysed samples of human and animal hair and skeletal material from Early Iron Age sites in southern Central Asia (Kazakhstan, Altai). They identified the importance of fish as a food resource in the diet of Central Asian populations from the Mesolithic to the Iron Age. Fish, indeed, provided half of the total human intake of dietary protein. The study of human and animal samples dating to the Bronze and Early Iron Ages (*c.* 2700–100 BC) from the Minusinsk Depression also demonstrates that fish was a very important component in the diet of all population groups. For the earlier period, however, the diet of Aeneolithic and Middle Bronze Age individuals (of the Afanasievo, Okunevo and Andronovo cultures) was based on C_3 plants. This changed in the Late Bronze Age (Karasuk culture) and Early Iron Age (Tagar culture) with the introduction of C_4 millet consumption (Svaytko *et al.* 2013: 3939–40).

The most recent stable isotope data for the Early Iron Age in Tyva (southern Siberia) show that these populations had a highly developed pastoral economy combined with agriculture (Murphy *et al.* 2013). Isotopic studies and analyses of dental palaeopathology from individuals in the burial mounds (kurgans) of Ai-Dai (Tagar culture) and Aymyrlyg (Uyuk culture) demonstrate that here, too, C_4 plants and river fish were components of the local diet (Murphy *et al.* 2013).

These studies reveal variations in the diets of populations of different periods in the Minusinsk Depression, but they provide no direct information about the Tashtyk culture. The communities belonging to this group left numerous burial sites with an expressive funeral rite famous for its tradition of funeral masks and 'dummies': leather-made models

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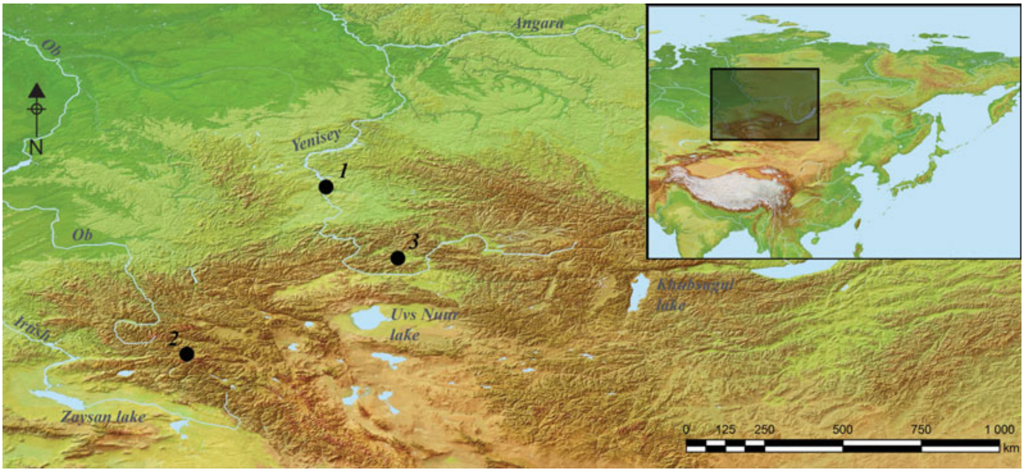

Figure 1. Location of Oglakhty (1), Arzhan (2) and Ak-Alakha (3) burial grounds.

of human bodies up to 1.5m in length, stuffed with grass, and containing charred human bones (Kyzlasov 1960; Vadetskaya 1999; 2009; Kyzlasov & Pankova 2004). They also used false hairpieces. The fragments of human hair and false hairpieces in these burials provide an opportunity to assess the diet of the local population at the level of the individual, and to evaluate its consistency or variability within the short time span of a single year. New dietary information from Tashtyk individuals buried in the Oglakhty burial ground therefore expands significantly upon previous isotopic studies in the Minusinsk Depression and adjoining areas, offering new levels of insight. In the course of this analysis, we were able to reconstruct temporal sequences of changing carbon and nitrogen isotope compositions along the length of individual hair samples (dietary shifting). This enabled us to identify changing food supplies season by season, and to evaluate the mobility of the local population.

The Oglakhty site and archaeological context of samples

The Oglakhty burial ground, attributed to the Tashtyk culture, is located in the Minusinsk Depression near the Middle Yenisey River in the Republic of Khakasia (Figure 1). More than 300 Tashtyk graves have been uncovered in this region, but only in the Oglakhty burial ground did graves contain well-preserved bodies and organic matter, and so were able to provide an insight into details of the burial rite, including the clothes and the funerary offerings: mostly items of wood, leather and fur.

In 1903, Adrianov examined seventeen pits, including three graves containing well-preserved bodies and organic matter (Adrianov 1903: 4). Between 1969 and 1973, seven further graves were examined by a Moscow University expedition led by Leonid Kyzlasov. Polychrome silk cloth—similar to that found in burial grounds in the Tarim River Basin—helped place Oglakhty between the third and early fourth centuries AD (Loubo-Lesnichenko 1994: 194). This dating has been confirmed by ^{14}C wiggle-match dating of logs from one of the timber graves (Pankova *et al.* 2010).

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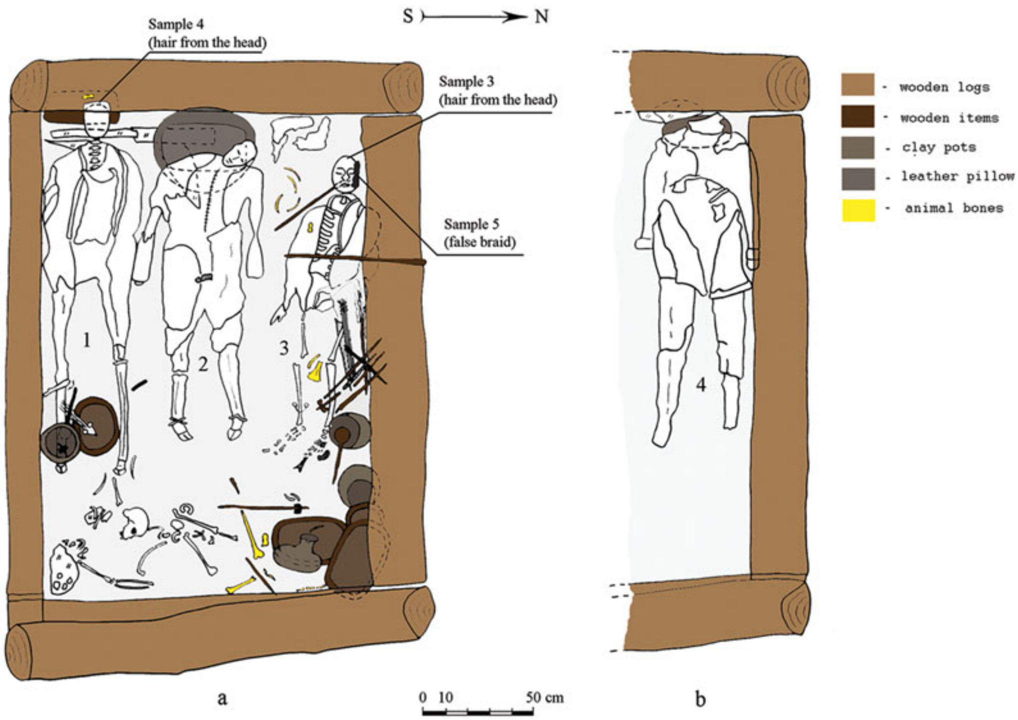

Figure 2. Oglakhty burial ground; grave 4, plan.

The Oglakhty burials are noted for a distinctive practice: individuals were interred in timber graves composed of two to three courses of carefully fitted and jointed pine and larch logs. The timber framework was wrapped with thick strips of birch bark; similar strips also covered the floor of the chamber. This airproof and watertight insulation created a dry microclimate, resulting in good preservation of the bodies and any organic matter (Kyzlasov 1969). The excavated graves contained human remains from between two and five individuals, both adults and children. Mummies and 'dummies' were uncovered in graves 1 and 4. Various kinds of braided hairpiece were also found that seem to have been placed as wigs on the heads of both the mummies and the dummies (Figure 2).

Of special interest is the fact that different rites were used to bury individuals in the same grave: the mummies and dummies both contained human bones. Remains of the mummies, i.e. dry bodies with trepanned skulls and faces covered with gypsum masks (Figures 3 & 4), were lying side by side with the dummies. Two such mummies, a female and a male, and two dummies were buried in grave 4, which was uncovered by Kyzlasov.

Samples (see Table 1)

Samples 1 and 2 were taken from two braided hairpieces from grave 1 (now in the collection of the State Historical Museum; Figures 5 & 6). Only one skull was preserved from this grave and it is not possible to link it with either of the braided hairpieces.

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Samples 3 and 4 were taken from the heads of a female and a male mummy, both found in grave 4 (collection of the State Hermitage Museum). The male mummy had a red moustache and a thick lock of hair at the crown of the head (Figure 4). A rectangular cut-out for this lock of hair had been made in the mask placed over his face. The surviving hair strands were of various lengths; the hair may have been unevenly cut or this may simply be a result of the way it was preserved. The mask placed on the female mummy from the same grave (Figure 3) did not have a cut-out, but short hair strands of various lengths were preserved at the top of the woman's head. There was no hair at the nape as the skin was in a very poor condition.

Figure 3. Gypsum mask on the head of the female, grave 4, Oglakhty burial ground (image courtesy of the State Hermitage Museum).

Two braided hairpieces were also found in grave 4, but only one of these (sample 5; Figure 7) was analysed. It was found near the female mummy, but separate and without any clear device for its attachment.

A second, small, folded braid belonged to one of the dummies. Both of the dummies from graves 1 and 4 were filled with grass, providing samples 6 and 7 respectively.

Methodology

The five hair and two straw samples were subjected to isotopic analysis, with stable isotope analyses of local flora and fauna providing a baseline for interpretation. Specimens of horse hair from the Arzhan 1 kurgan in the Tyva Turano-Uyuk Depression, belonging to the Early Iron Age Pazyryk culture (Figure 1), were also analysed (samples 8 & 9).

Hair samples were ultra-sonicated in distilled H_2O, then twice in chloroform and methanol (2:1, v/v), and again in distilled H_2O (O'Connell *et al.* 2003). Measurements of the stable isotope ratio were made at the Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, using the DELTA Plus XP isotope mass-spectrometer (ThermoFinnigan), linked to the Flash EA element analyser. Collagen integrity was assessed from the yield relative to the total sample weight and the C:N atomic ratio. Each sample was measured in triplicate. The standard deviation for δ^{13}C is ±0.2‰ and for δ^{15}N ±0.2–0.3‰. The isotope ratios are reported in per mil deviation with regard to the international standards VPDB and AIR for δ^{13}C and δ^{15}N respectively.

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Stable isotope studies of $\delta^{13}C$ and $\delta^{15}N$ provide a means to explore the dietary habits of different cultures, and to identify exploited natural resources. The isotope profiles of animals and humans reflect the consumption of dietary components with distinctive isotopic signatures. Stable isotopes in human bone collagen reflect diet over the last 10–15 years of life (Schwarcz & Schoeninger 1991; Ambrose 1993). Hair, which is 95% keratin—a protein cross-linked biopolymer—has a much faster growth rate of 10mm per month; the first 10mm of the scalp hair correlates with food consumed during the last month of life. Measurement of the isotopic signal along the length of a hair can be used to track diet over several months, and to identify changes between dietary regimes, which might, for example, reflect seasonal variation. The isotopic composition of carbon and nitrogen in the hair and bones therefore reveals sources of proteins in food over two different time scales (O'Connell *et al.* 2003; Webb *et al.* 2013). Bone collagen in modern humans is enriched relative to their hair keratin by 1.4‰ in ^{13}C and 0.86‰ in ^{15}N (O'Connell *et al.* 2003; Lehn *et al.* 2015: 73–74). Phytolith analysis was also undertaken on two plant samples taken from the dummies from graves 1 and 4. The silt fraction was removed from 10g soil samples by elutriation, with subsequent boiling in a 20% solution of hydrogen peroxide, and separation with a 0.5mm sieve. Fractions <0.5mm were examined with a ×400 microscope. Plant remains and elements of animal origin were counted.

Figure 4. Gypsum mask on the head of the male, grave 4, Oglakhty burial ground (image courtesy of the State Hermitage Museum).

Results

The $\delta^{13}C$ and $\delta^{15}N$ data obtained for all samples are provided in Table 2. Isotope values for segments of sample 1 (the first braided hairpiece from grave 1) reflect the diet of the individual from whom the hair was taken over a period of around 14 months and show substantial variations between segments: the $\delta^{13}C$ values vary by 2.3‰; for $\delta^{15}N$, they vary by 2‰. Segment 1-1 from the part of the braided hairpiece closest to the scalp has the highest $\delta^{13}C$ value of −16.6‰, while segment 1-3 has the highest $\delta^{15}N$ value at +12.2‰.

For sample 2 (the second braided hairpiece from grave 1), each segment reflects the diet of the individual over two and a half months, the overall period of analysis being two years.

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Table 1. Details of hair samples.

Sample	Grave	Description
1	1	A 145mm length of the hair style, which looks like a twisted strand of hair, pulled together around a leather accessory piece/cord and folded so that the resulting 'braid' is very thick and arranged as a tight, elongated bun (Figure 5). The hair was divided into eight segments, each 20–30mm in length.
2	1	A 205mm braid of three strands, the upper part of which is thicker, with the hair strands pulled together loosely; the middle part is pulled more tightly, and the lower part is looser (Figure 6). The braid appears as a natural hair style. Nine segments from one hair sample were taken.
3	4	A fine hair, 150mm long, from a woman's head (at the scalp; Figure 3).
4	4	A fine hair, 150mm long, from a man's head (Figure 4).
5	4	A fragment of the braided hairpiece (the lower part), 245mm long (Figure 7). The braid is carefully secured at both ends, in a form known as 'wheat ear' or 'fishtail' braiding. This hairpiece was found under the head of the female mummy whose hair provided sample 3.
6	1	Plant (straw) from the dummy.
7	4	Plant (straw) from the dummy.
8	–	Hair samples of horse 1 from the early Iron Age Arzhan 1 burial mound, Republic of Tyva (M.P. Gryaznov's excavations of 1971–1974; collection from the 60 Warriors Tyva Republican Museum of Local Lore).
9	–	Hair samples of horse 2 from the early Iron Age Arzhan 1 burial mound, Republic of Tyva (M.P. Gryaznov's excavations of 1971–1974; collection from the 60 Warriors Tyva Republican Museum of Local Lore).

Some segments had similar isotope values; others deviated. δ^{13}C in some segments varied by 1.4‰, while δ^{15}N values varied by 3‰. Segment 2-7 had the highest value of δ^{13}C at −16.4‰ and the second highest value of δ^{15}N at +12.2‰; segment 2-8 had the lowest δ^{15}N value at +9.3‰, with a δ^{13}C value of −17.6‰.

In sample 3 (hair from the scalp of the female mummy in grave 4), the values are isotopically close to those of both segment 1-8 from sample 1 and segment 2-9 from sample 2. Sample 4 (hair from the scalp of the male mummy in grave 4) has the highest δ^{13}C value at −15.1‰, with a δ^{15}N value of +10.8‰. The lowest overall nitrogen and carbon isotope values were recorded for sample 5 (false braided piece from grave 4), i.e. $\delta^{13}C = -21.9$‰, $\delta^{15}N = +9.5$‰.

The carbon isotope data indicated that the straw samples from the two dummies are of C_3 type, and phytolith analyses show that these are gramineous plants, but the δ^{13}C values vary by 5‰. Two horse-hair samples from Pazyryk Arzhan 1 kurgan have elevated δ^{15}N values of up to 7‰.

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Discussion

The analysis yielded important dietary information about the Oglakhty individuals, and demonstrates the variability of individual diets. The two braided hairpieces from grave 1 were made of hair from two individuals, 'A' and 'B', whose dietary intake differed in some months of the year but was similar in other months, as is detailed below.

Figure 5. Braided hairpiece, grave 1, Oglakhty burial ground (1903 excavations; image courtesy of the State Historical Museum).

Braid 1: individual A

For braid 1, three dietary patterns are observed within the eight segments (Figure 8a).

1) The first dietary pattern (food consumed immediately before death)—segment 1—reflects the consumption of C_4 plants, and meat or dairy products that were obtained from the steppe area (Shishlina *et al.* 2012). Murphy *et al.* (2013: 11–12) assumed that, in some cases, elevated $\delta^{13}C$ values in Tagar and Uyuk human bone samples were caused by consumption of C_4 plants rather than fish.

We do not see elevated values in the human hair sample from Ak-Alakha analysed by O'Connell *et al.* (2003) (Table 3). The C_4 plant responsible was probably millet. Millet appeared in Central Asia at the end of the third millennium BC, and was widespread during the Early Iron Age (Spengler *et al.* 2013; Spengler 2015). An alternative explanation might be that the individual consumed meat from animals that grazed on C_4 pastures in arid regions.

2) The second dietary pattern—segments 1-2 to 1-6 (several months before death)—suggests a different diet, assumed to comprise C_3 plants. The high $\delta^{15}N$ value (+12.2‰) in segment 1-3 might have been caused by the consumption of freshwater fish, as suggested in another context by O'Connell *et al.* (2003), but might also have been caused by the consumption of animal products from livestock husbandry on local arid pastures (Shishlina 2014). This would correlate with the elevated $\delta^{15}N$ values (10.2‰) of gramineous plants from the dummy in the same grave.

3) The third dietary pattern—segment 1-8—characterised by low ^{13}C and ^{15}N values, developed over a period of 5–6 months at least half a year before the death of the individual. During this period, the individual may have consumed only terrestrial C_3

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food (meat, probably dairy products and C_3 plants); fish and C_4 foods were not part of the diet.

Braid 2: individual B

Three dietary patterns are also observed in the nine segments of braid 2 (Figure 8b).

1) For almost six months before death—segments 2-1 to 2-6—the diet was very stable, based on C_3 plants, and meat or dairy products. High ^{15}N values can be explained either by the individual living in an arid environment during this period or consuming fish.
2) The second pattern—segment 2-7—suggests the consumption of millet and fish for a relatively short period (one to two months), perhaps reflecting time spent in another region before settling in Oglakhty, but we do not know exactly where.
3) The third pattern—segments 2-8 to 2-9— (at the lower end of the braid) indicates the consumption of C_3 plants, and meat.

The two braided hairpieces from grave 1 reflect differences in the diet of the two individuals. It is clear that they often resided in different geochemical environments, and consumed food with different signals. At times, their diet included C_4 plants or the meat of herbivores that grazed on C_4 pastures (segments 1-1 & 2-7). At other times, millet and fish were not part of the diet (segments 1-4 & 2-8).

Figure 6. Braided hairpiece, grave 1, Oglakhty burial ground (1903 excavations; image courtesy of the State Historical Museum).

We believe this variability reflects seasonality in human dietary patterns. Millet has a short growing season, high sowing-to-return values, and drought tolerance (Spengler 2015: 19). It was probably consumed as soon as it was harvested, i.e. in summer or autumn. During these seasons, fish were perhaps also available. In winter, the temperature falls to −40 to −50°C; rivers and streams freeze. We therefore assume that in summer and autumn both A and B consumed millet and fish, which were not available in winter. The milk yield of cows increases in autumn and early winter (Davydov 1973), and meat and dairy products, as well as C_3 plants, were probably major food components. Many historical nomads from the Eastern Eurasian steppes, e.g. the Mongols, also collected tulip bulbs and other wild plants, drying and consuming them during the cold part of the year (Zhukovskaya 1988). The comparable values of $\delta^{13}C$ and

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Table 2. Variations of the $\delta^{13}C$ and $\delta^{15}N$ values for hair samples from the Oglakhty burial ground.

Sample	Segment	$\delta^{13}C$, ‰ VPDB	%C	$\delta^{15}N$, ‰ AIR	%N	C:N
Oglakhty: grave 1						
Sample 1: braided hairpieces (segments)	1-1	−16.6	34±3	+10.7	13±2	3.3
	1-2	−18.4	34±3	+10.3	13±2	3.3
	1-3	−17.5	34±3	+12.2	13±2	3.3
	1-4	−18.3	34±3	+10.8	13±2	3.3
	1-5	−18.0	34±3	+11.3	13±2	3.3
	1-6	−18.2	34±3	+11.0	13±2	3.07
	1-7	−18.9	34±3	+11.0	13±2	3.07
	1-8	−17.7	34±3	+10.9	13±2	3.07
Sample 2: braided hairpieces (segments)	2-1	−17.5	32±1	+11.5	12±1	3.3
	2-2	−17.8	32±1	+11.0	12±1	3.3
	2-3	−17.7	32±1	+11.4	12±1	3.3
	2-4	−17.8	32±1	+12.3	12±1	3.3
	2-5	−17.8	32±1	+11.2	12±1	3.3
	2-6	−17.8	32±1	+11.9	12±1	3.3
	2-7	−16.4	32±1	+12.2	12±1	3.3
	2-8	−17.6	32±1	+9.3	12±1	3.3
	2-9	−17.8	32±1	+10.9	12±1	3.3
Sample 6: plant from the dummy (gramineous plant)	–	−22.2	–	+10.2	–	2.4
Oglakhty: grave 4						
Sample 3: female mummy hair	1	−17.2	36	+10.5	14	3.3
Sample 4: male mummy hair	1	−15.1	34	+10.8	14	3.3
Sample 5: false hairpiece from female mummy	1	−21.2	34	+9.5	13	3.3
Sample 7: plant from the dummy (gramineous plant)	–	−27.0	–	+8.8	–	2.4
Arzhan: kurgan 1						
Sample 8: horse 1 hair	1	−24.2	36	+7.0	14	3.2
Sample 9: horse 2 hair	1	−22.3	36	+7.2	14	3.2

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Figure 7. False braided hairpiece/attached braid of the female mummy, grave 4, Oglakhty burial ground (image courtesy of the State Hermitage Museum).

δ^{15}N in the lower segments of braids 1 and 2 indicate that A and B lived in similar conditions and consumed food with similar isotope signals during this period, probably spring.

Isotope results from the scalp hair of the mummified individuals from grave 4 correlate with data obtained for the braided pieces. Shortly before his death, the male consumed C_4 plants (probably millet). The isotope values of the hair from the female correlate with segment 2-9 from braid 2 (individual B); shortly before her death, her diet comprised terrestrial C_3 food (meat, dairy products and C_3 plants).

'False' braid—human or animal hair?

No data are available to distinguish whether the false braided hairpiece from Oglakhty (sample 5) is of human or animal origin. This braid was not attached to either of the two mummies in grave 4 but was lying near the female mummy. Carbon and nitrogen values are lower than those for other human-hair specimens from Oglakhty, yet the nitrogen isotope values are 4–4.5‰ higher than those of horse-hair specimens from Ak-Alakha. They also differ from the horse-hair samples obtained from the Arzhan kurgan (Tables 2 & 3).

If we assume that sample 5 is horse hair, this animal most probably grazed on C_3-type pastures in an arid climate. Horse hair has a special isotope signal due to isotopic fractionation in the food chain. Results of previous analyses of horse hair, mummy hair and hairpieces from Early Iron Age Pazyryk sites are shown in Table 3; among these, one hairpiece from Ak-Alakha was determined to be horse hair (O'Connell *et al.* 2003).

Variability in the isotope signals of the horse hair samples from Ak-Alakha (O'Connell *et al.* 2003) and Arzhan may have been caused by differences in the isotopic composition of vegetation growing in different geochemical environments. The high δ^{15}N values of the grass from the Oglakhty dummies (+10.2‰ in grave 1; +8.8‰ in grave 4) suggest that it grew in arid steppe conditions (Shishlina *et al.* 2012). The variation in δ^{13}C values between the two dummies demonstrates that the grass used in each case grew in a different ecological zone, as isotopic composition depends on annual precipitation rate, altitude and canopy effect: the more arid the location, the higher the δ^{13}C value (Shishlina 2014). Other climatic and anthropological factors affecting the isotope values of plants include soil salinity, manuring and wildfire. The Turano-Uyuk Intermountain Depression (1000m asl), where

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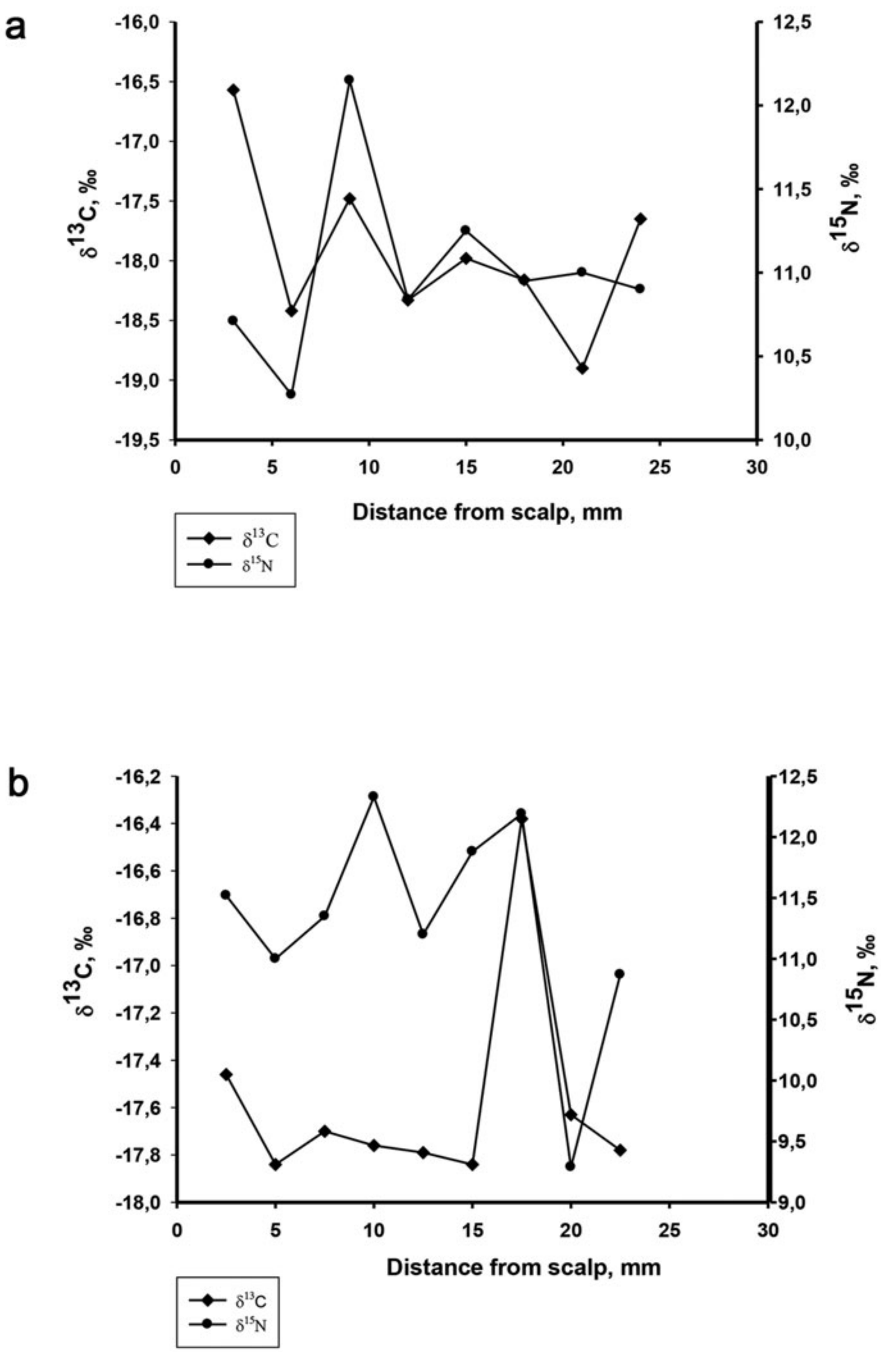

Figure 8. $\delta^{13}C$ and $\delta^{15}N$ values of hair from sample 1 (a) and sample 2 (b) plotted versus the length of hair in millimetres.

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Table 3. Variation of $\delta^{13}C$ and $\delta^{15}N$ values in the human mummies' hair, false hairpieces and horse hair from the Early Iron Age sites in southern Siberia (according to O'Connell *et al.* 2003).

Item	Site	Sample	$\delta^{13}C$	$\delta^{15}N$
	Verkh-Kaljin II, Altai region, Pazyryk culture, 500–300 BC			
1	Kurgan 3	horse hair	−22.1	+5.7
2	Kurgan 3	human hair	−19.8	+11.8
3	Kurgan 2	wig	−18.8	+12.3
	Ak-Alakha 3, Altai region, Pazyryk culture, 500–300 BC			
4	Kurgan 1	horse hair	−22.0	+5.1
5	Kurgan 1	horse hair	−22.1	+5.7
6	Kurgan 1	horse hair	−21.5	+5.3
7	Kurgan 1	horse hair	−21.8	+4.9
8	Kurgan 1	horse hair	−21.4	+5.3
9	Kurgan 1	wig	−21.6	+5.8
	Abatsky 3, south-western Siberia, Early Iron Age			
10	Kurgan 2	human hair	−22.4	+11.5

Arzhan 1 is located, is rich with winter steppe pastures and gentle slopes that are snow-free in winter (Gryaznov 1983); Ak-Alakha is on the high mountain plateau of Ukok in the Altai Mountains (2200–2500m asl), also with winter pastures free of snow. The Oglakhty graves are located in the steppe area near the Yenisey River, which is located to the north.

If, however, sample 5 was *human* hair, the individual from whom it originated must have resided for some months in a geochemical region characterised by isotopic landscapes or dietary components different to those at Oglakhty. The nitrogen isotope values show that sample 5 ($\delta^{15}N = +9.5‰$) is comparable to segment 2-8 of human braid 2 (sample 2; $\delta^{15}N = +9.3‰$), although the carbon isotope value ($\delta^{13}C = -21.2‰$) is substantially lower than that of this segment ($\delta^{13}C = -17.6‰$). The individual whose hair was used for the sample 5 braid probably consumed only C_3 plants, the meat and milk of a herbivore and did not eat fish. The difference in $\delta^{13}C$ values was probably caused by increased mobility of the donor of braid 2 during the one-to-two month period reflected in segment 2-8. We suggest that for a short period this individual lived in a different cultural and social environment, where food with a different isotopic signature was a major dietary component.

Individual mobility

The variability in hair isotope values, reflecting several months of life for individuals A and B represented by the braided hairpieces from grave 1, demonstrates that food resources from multiple production zones were exploited. This variability may have been the result of seasonal shifts in diets. In summer and autumn, these individuals consumed C_4 plants (most probably millet), C_3 plants and fish. In winter, the main foods were C_3 plants and meat, and

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probably dairy products; fish was not regularly available. During seasonal movements, these individuals exploited pastoral and agricultural resources in two different environments.

The isotope data also indicate that these two individuals, supposedly buried in grave 1 at the same time, had different levels of mobility. Individual A (sample 1) demonstrates a greater level of mobility, probably moving first from the C_3 open steppe to a river valley and agricultural area, or to a pasture area with a predominance of C_4 vegetation, and then on to new, or back to previous, C_3 pastures. Individual B (sample 2) lived in a location with a predominance of C_3 vegetation for half a year, then moved to an agricultural C_4 millet area. Fish was part of their diet but was not always available.

Conclusions

Hair specimens from mummified individuals and unknown donors in two graves in the Oglakhty cemetery contain preserved isotopic signatures that reveal their owners' respective diets from several months before death; braided hairpieces from grave 1 reflect dietary changes over a much longer period. Comparative data are scarce, but the results from Oglakhty vary to those of analyses of similar material from other sites in the steppe zone of eastern Eurasia.

The results suggest that the Tashtyk people had a highly diverse diet of wild and domestic resources drawn from different areas. Its main components were C_3 plants and the meat and dairy products of herbivores that grazed on grasslands with a predominance of C_3 or C_4 vegetation. These grasslands were located in different geographic areas, including arid regions. Fish and millet—the latter developed as a staple agricultural crop in southern Siberia at that time (Frachetti 2012)—were an important additional component, although these were only accessible in summer and autumn.

Until direct archaeobotanical evidence is available, it is difficult to declare that the Tashtyk pastoral groups developed small-scale millet agriculture independently. The strong isotopic signature (high ^{13}C value) in the hair samples is evidence of C_4 consumption, but not of its production. Future studies of plant residue from Tashtyk settlements will answer the question of whether Tashtyk pastoral groups developed millet cultivation as a part of their own economic system or obtained millet through exchange.

The preliminary analysis allows us to advance several working hypotheses.

Hypothesis 1: seasonal variations in diet were typical of several individuals buried at Oglakhty.

Hypothesis 2: the isotopic signatures confirm the previous suggestion (Adrianov 1903; Kyzlasov 1969; Vadetskaya 1999) that millet (a C_4 plant) was a component in the local diet. In certain months (seasons), millet was unavailable, with the isotopic signature showing the consumption of C_3 plants, and the meat and milk of domesticated animals that grazed on C_3 pastures.

Hypothesis 3: river and lake fish were an important component in the diet of the Oglakhty individuals, although segment 2-8 of samples 2 and 5 (if human) demonstrates that at some times of the year, most probably winter, fish was not part of the diet. This correlates with the ethnographic data for steppe nomads (Belousov 1928).

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Hypothesis 4: if sample 5 is human hair, the diet of this person was different from that of other individuals buried in the same cemetery. If it is horse hair, the animal grazed on arid pastures.

It remains unclear why the hair samples reveal different isotopic signatures among individuals who were buried together in the same grave. Additional isotopic data from cemeteries dating to the same period, together with chemical, biological and palaeobotanical studies will provide greater insight. Furthermore, to verify the results presented and the hypotheses proposed, additional isotopic analysis of these hair samples should be conducted, covering the entire length of the individual hairs, with additional detailed analysis of the false braided hairpiece (sample 5) to test whether this too was made of human hair. As this analysis has shown, well-preserved hair samples from graves such as these have considerable potential in studying the level of mobility in these populations, taking us far beyond the generalisations provided by early written sources.

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