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The food culture of the Iron Age nomadic elite from the 'Valley of the Kings' in Tuva: radiocarbon dating, stable carbon and nitrogen analysis of the Chinge Tey barrows (Turan-Uyuk Basin, Russia)

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ABSTRACT

Subsistence strategies of Eurasian pastoral populations have been broadly studied in the archaeological literature. The 'Valley of the Kings' in Tuva, Russia, has captivated archaeologists with its remarkable collection of large burial mounds, containing lavishly equipped tombs of nomadic kings, warlords, and aristocracy. These barrows bear witness to the ancestral connections between the deceased leaders, highlighting the alliances among prehistoric nomads in Central Asia. In this research, we present comprehensive radiocarbon dating and $\delta^{13}C/\delta^{15}N$ isotopic data from the Chinge Tey barrows, which represent the burial sites of 12 high-ranking individuals. The chronological alignment of both Chinge Tey monuments with the Arzhan 1 and Arzhan 2 reference frames sheds light on their historical context. This study delves into intricate aspects of ecological adaptability, pastoral food practices, social hierarchies, and nomadic mortuary rituals. Analysis of carbon and nitrogen stable isotopes indicates potential connections between the barrows in the 'Valley of the Kings' and diverse nomadic cultures, suggesting that dietary habits among neighboring populations may have exhibited significant variation.

1. Introduction

Nestled in seclusion and marked by its inhospitable nature, the Turan-Uyuk Valley in Tuva holds a distinct significance in the prehistory of the Great Steppe. This valley served as a final resting place for nomadic warlords and kings, interred with unparalleled wealth and opulence (Gryaznov, 1980; Chugunov and Zhogova, 2019). Situated in the northern part of the Tuva Republic in Russia, the Turan-Uyuk Basin, also known as the Valley of the Kings, encompasses a breathtaking landscape. The valley itself spans an elevation of 550–1200 m asl, while the encompassing mountains soar to heights of 2500–3500 m asl. Traversing through the heart of the valley is the Uyuk River, a tributary of the mighty Yenisei River. The region is encircled by the imposing Western Sayan mountains, creating a natural boundary that enhances its secluded allure (see Fig. 1).

The most recent UAV aerial survey conducted in this region has revealed the presence of approximately 1000 large tombs and other archaeological features within the landscape (Vavulin et al., 2021). Among the known monuments excavated thus far, the Arzhan 1 barrow holds significant prominence, dating back to the 9th/8th centuries BC (Gryaznov and Mannay-Ool, 1973; Gryaznov, 1980). The archaeological assemblages unearthed at Arzhan 1 serve as a benchmark for other monuments from the same period and provide the earliest example of the Scythian triad, comprising 1) characteristic components of horse harnesses; 2) conventional weaponry; and 3) nomadic art commonly associated with the Scythian animal style (Savinov, 2002, 58–59).

Chronologically, the so-called *Arzhan horizon* constitutes a separate proto-Scythian phase preceding the Early Scythian Aldy-Bel culture (VIII-VI century BC; Chugunov, 2020, 137), the development of which was associated with the rise of pastoral cultures in southern Siberia (Savinov, 2002, 37–57; Chugunov, 2009). The rise of pastoral societies in Central Asia at the time was related to the favourable climatic conditions of the early sub-Atlantic period when the bioproductivity of steppe pastures was rising (van Geel et al., 2004; Kulkova and

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Bokovenko, 2018). Nomadic warlords who ruled over large territories of Tuva and surrounding lands were buried in the Uyuk valley (Chugunov, 2009; 2011). The archaeological data confirms the incredible wealth of the deceased kings expressed in grave furnishing but also in monumental structures of sepulchral architecture unmatched in the whole of southern Siberia at that time. Particularly spectacular discoveries were made during the exploration of the Arzhan 2 royal barrow (7th century BC; Čugunov et al., 2010; Chugunov et al., 2017). It seems feasible, that the Arzhan lineage was followed by other nomadic dynasties (for genetic data from Scythian populations, see also Unterländer et al., 2017; Wang et al., 2019; Gnecchi-Ruscone et al., 2021). In later times the kings were buried in the western part of the valley, in the Chinge Tey necropolis. That can be confirmed by the initial dating of the Chinge Tey I to the 7th-6th centuries BC (Chugunov, 2011). The main chamber of the Chinge-Tey I, however, has yet not been uncovered, but the radiocarbon dating from satellite burials of the barrow indicates a clear time frame (Fig. 2).

In this study, we report detailed chronology and dietary isotopic data from 12 high-rank individuals buried in Chinge Tey I and in the Chinge Tey 1 Western Chain, excavated by Polish and Russian archaeologists recently (Oleszczak et al., 2020). The overall archaeological evidence and radiocarbon dating enable us to link these barrows to the chronological frame time of the Arzhan sepulchral complex (Oleszczak and Chugunov, 2020). The Chinge Tey I is one of the largest barrows excavated in the valley, with 70 m in diameter (106 m with the ditch surrounding the mound), and 2.30 m height (Fig. 2B; Chugunov, 2019, 92; Supp. e-file 2). Located nearby Chinge Tey Western Chain kurgan was 25 m in diameter with 0.4 m high (Fig. 2A). The Chinge Tey barrows were erected marking a very interesting period of Tuvan prehistory. In between the 7th and 6th century BC, significant transformation took place within the Early Scythian Aldy-Bel cultural environment, resulting in the rise of the Sagly culture (6th-2nd century BC; also known as the Sagly-Uyuk culture; Savinov, 2002, 102-107). This paper critically examines the chronology of the monuments, delves into the nuanced facets of ecological adaptability, pastoral dietary practices, and social hierarchy observed at Chinge Tey.

1.1. The site: Chinge Tey barrows

Since 2008, extensive excavations have been carried out at the royal barrow known as Chinge Tey I in Tuva (Fig. 2B). To date, a total of eight burials attributed to the Aldy-Bel culture have been discovered within this kurgan (Fig. 3). The majority of these findings have been documented and discussed in various archaeological publications, notably the works by Chugunov (2011, 2019). In 2019–2021, the excavation focus shifted to the Chinge Tey Western Chain kurgan 1, which unveiled four graves containing five skeletons (Fig. 2A). Remarkably, this tomb was strategically positioned in close proximity to the west-north direction of Chinge Tey I, an area of considerable ritual significance for the Aldy-Bel community. The central chamber has been completely looted, and although human bones have survived (in terms of collagen preservation), certain body parts of the deceased were missing (grave 1, Fig. 4A).

The wooden grave chamber was made of larch (*Larix sibirica*). Wooden beams were preserved in relatively good condition, and inside the grave, several scattered artefacts were found. The exploration of tomb no. 3 resulted in a spectacular discovery of the undisturbed, fully preserved burial of a young warrior furnished with a complete set of

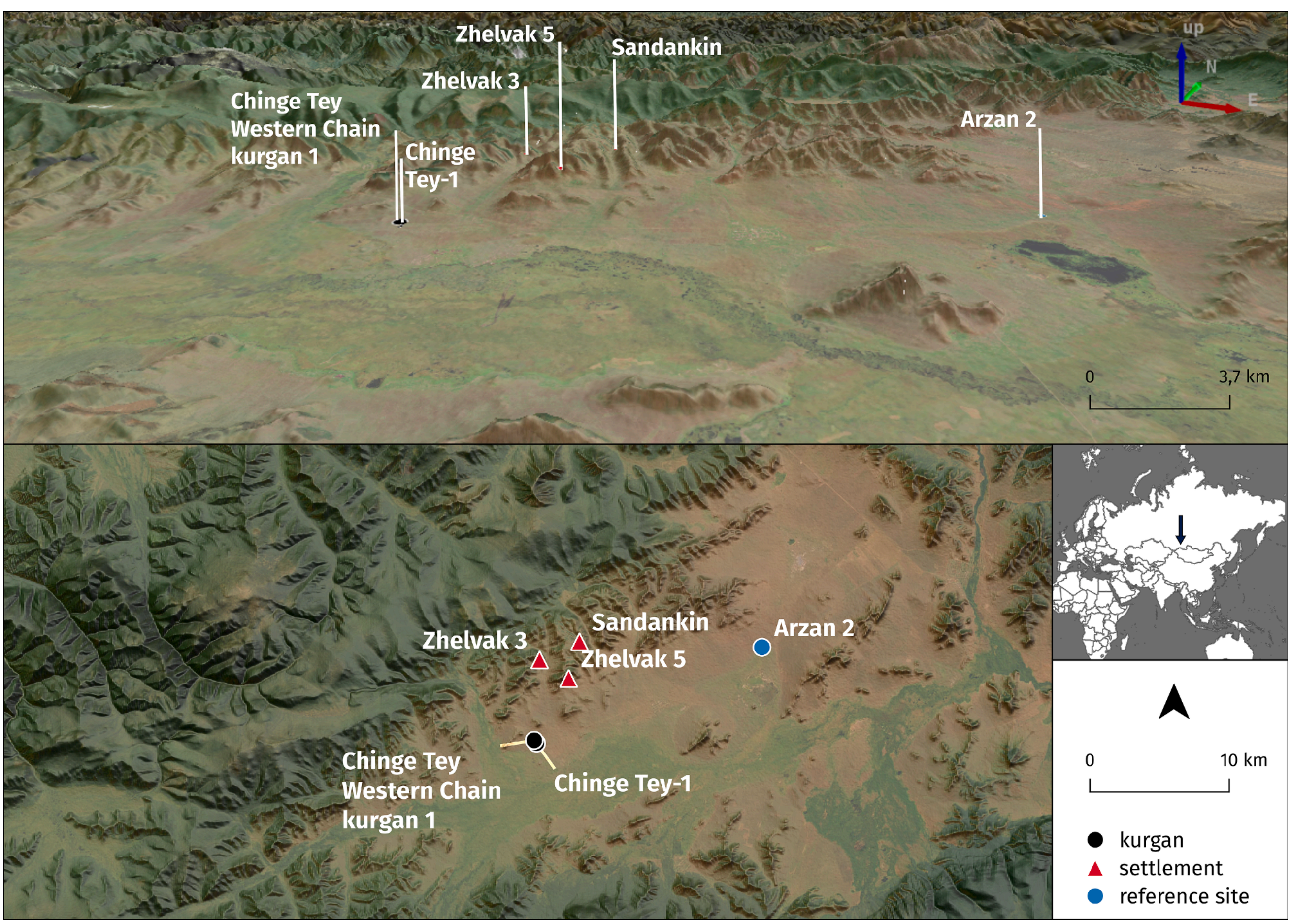

Fig. 1. Site location: Chinge Tey barrows, Tuva Republic, Russia; a 3D visualisation of the Arzhan valley based on digital elevation model (upper); a map composition of the valley from a bird perspective (lower). Graphics by P. Tóth.

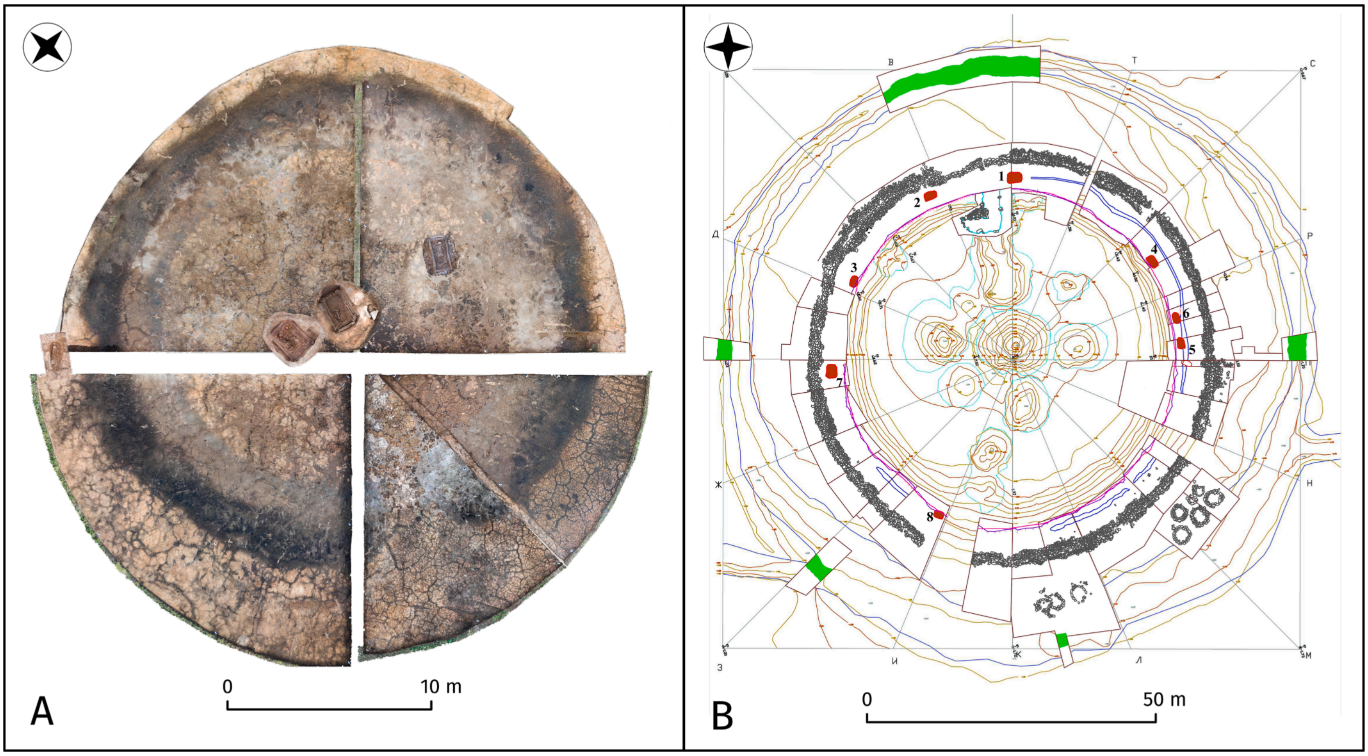

Fig. 2. Chinge Tey barrows in plan with location of graves; A) Chinge Tey 1 Western Chain; B) Chinge Tey I (plan drawing after Chugunov (2019) with modifications; see also Suppl. E-file 2).

Fig. 3. Chinge Tey I interments: A) grave no.4, adult male; B) grave no.5, adult male; C) grave no.6, adult male. In the Chinge Tey I all deceased were buried in crouched position; usually head north facing east. For grave furnishing description see Table 1. Photos by K. Chugunov.

weaponry (including preserved wooden arrow shafts, a battle-axe shaft, fragments of a leather quiver with belt), tools (a whetstone and a knife), and gold ornaments (a pectoral, a bead, and a spiral hair ornament; Fig. 4B). The orientation and position of the deceased (contracted position on the left side, with the head towards NW) fit the Aldy-Bel funerary rites. Of particular importance is the discovery of artefacts dating to the 6th century BC (confirmed by radiocarbon dating), including objects typical of the transition period which can be observed in Tuva between the Early Scythian and Scythian periods (Oleszczak and Chugunov, 2020). In 2021, new burials were excavated, containing the remains of an older woman (*Maturus/Senilis*), buried with a child (2–3 years old; Fig. 5A). In this case, the undisturbed burial chamber was constructed with three layers of larch beams. It seems feasible that a significant volume of wooden materials was linked to the high social status of the deceased as there are not many trees in the dry steppe zone of Tuva. The mentioned grave (no.2) contained a lot of interesting items,

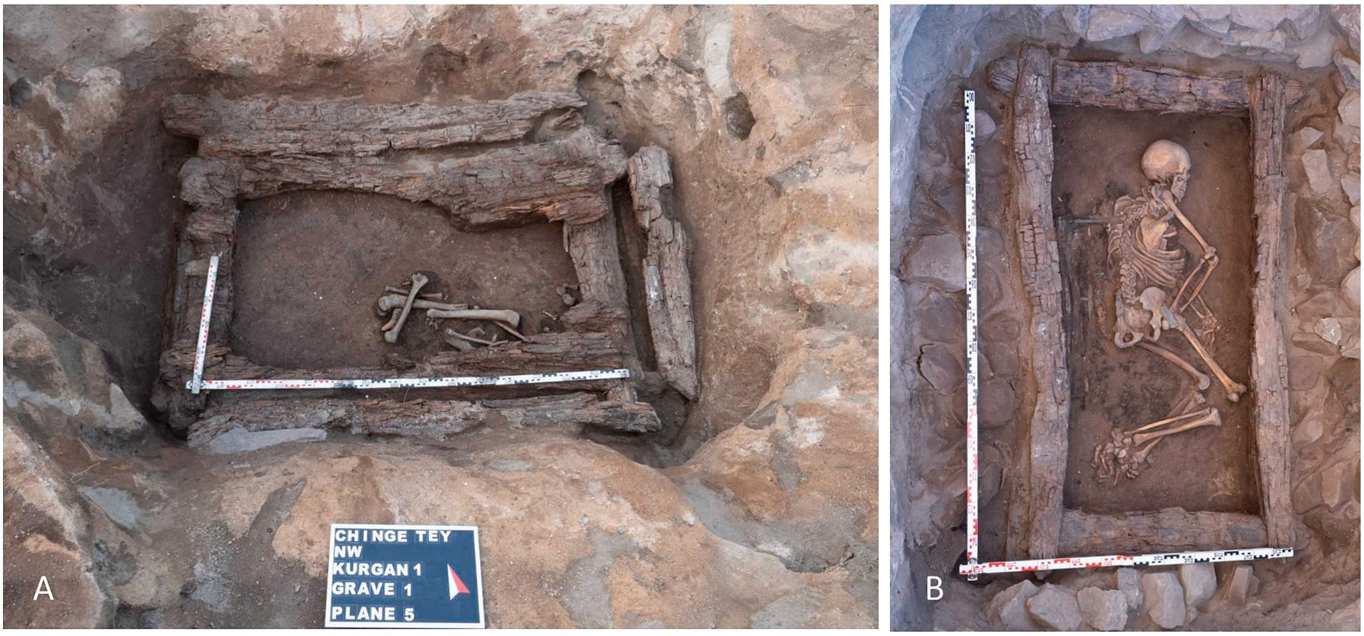

Fig. 4. Chinge Tey Western Chain barrow- interments: A) grave no.1, adult male (commingled human remains and robbery cut in the central sector); B) grave no.3, adult male. For grave furnishing description- see Table 1; more photos: Suppl. E-file 2. Photo by Ł. Oleszczak.

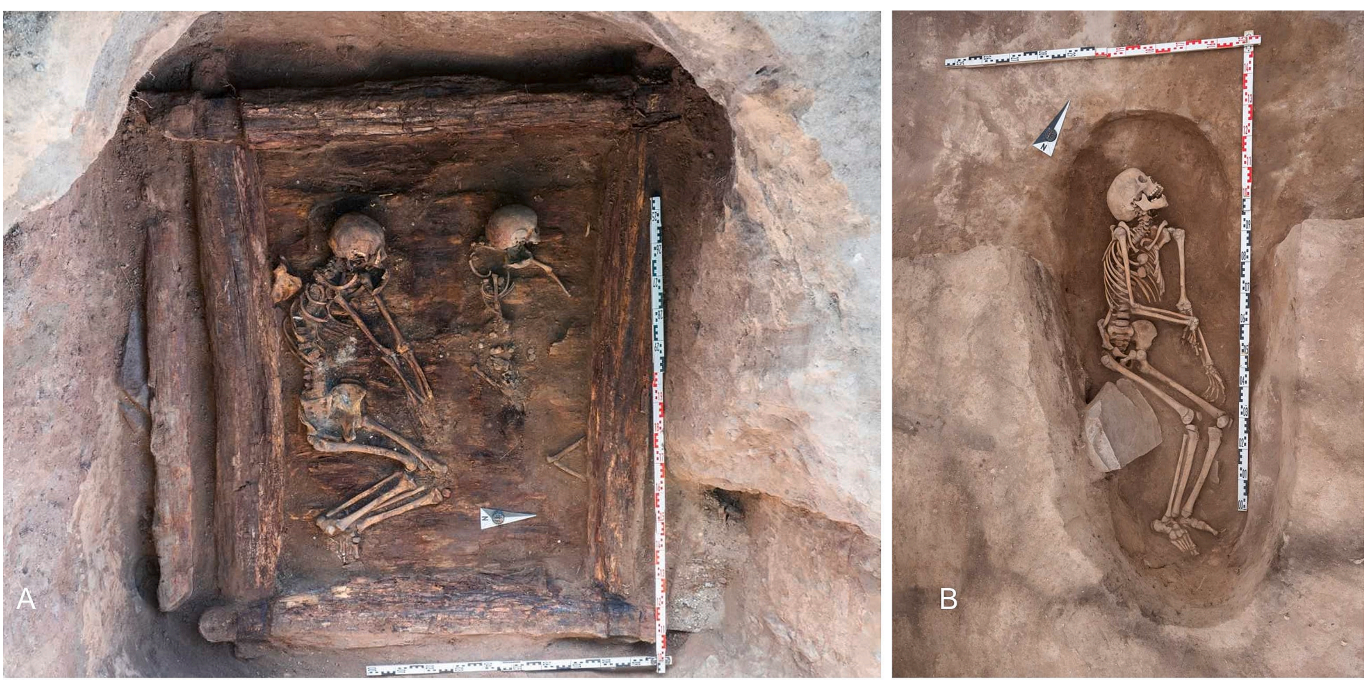

Fig. 5. Chinge Tey Western Chain- interments: A) chamber grave no. 2, skeletons 1 and 2: older female and child; B) satellite grave 4: non-adult (Juvenile). For grave furnishing description- see Table 1, Suppl. E-file 2. Photo by Ł. Oleszczak.

such as a golden pectoral (typically associated with male burials) (Fig. 6B), golden earrings (Fig. 6A), wooden comb (Fig. 7C), bronze mirror (Fig. 7B), an iron knife, the whetstone, and others. Female burials are represented by several interments from Arzhan 2 indicating the high status of women in the Aldy Bel social environment (see also Arzhan 2 female graves nos. 5, 7, 12, 13, 22; Gryaznov, 1980, 45; Chogunov et al., 2017). The last burial (grave no. 4) was found on the kurgan's periphery (Fig. 5B). The interment contained the remains of a teenage individual (*Juvenis*), marked by a large stone, with no grave goods. Graves of non-adults located on the perimeter of the barrows are a typical part of the Aldy-Bel funeral rites (Savinov, 2002, 84). In the vicinity of the barrow, in the peripheral zone, the remains of a ritual hoard have been found, containing scattered pieces of horse-riding equipment, a bronze axe, and a goat-shaped metal ornament. Similar ritual deposits located on the perimeter of the barrow are known from other elite Aldy-Bel kurgans, however, they were typically found in the 'cromlech-like' stone circle (Chugunov, 2011; Chugunov et al., 2017). It should be highlighted that barrow 1 of the Chinge Tey Western Chain is not a typical Aldy-Bel culture early Scythian tomb, because these were usually built of stones, whilst the kurgan in question was an earth-mound.

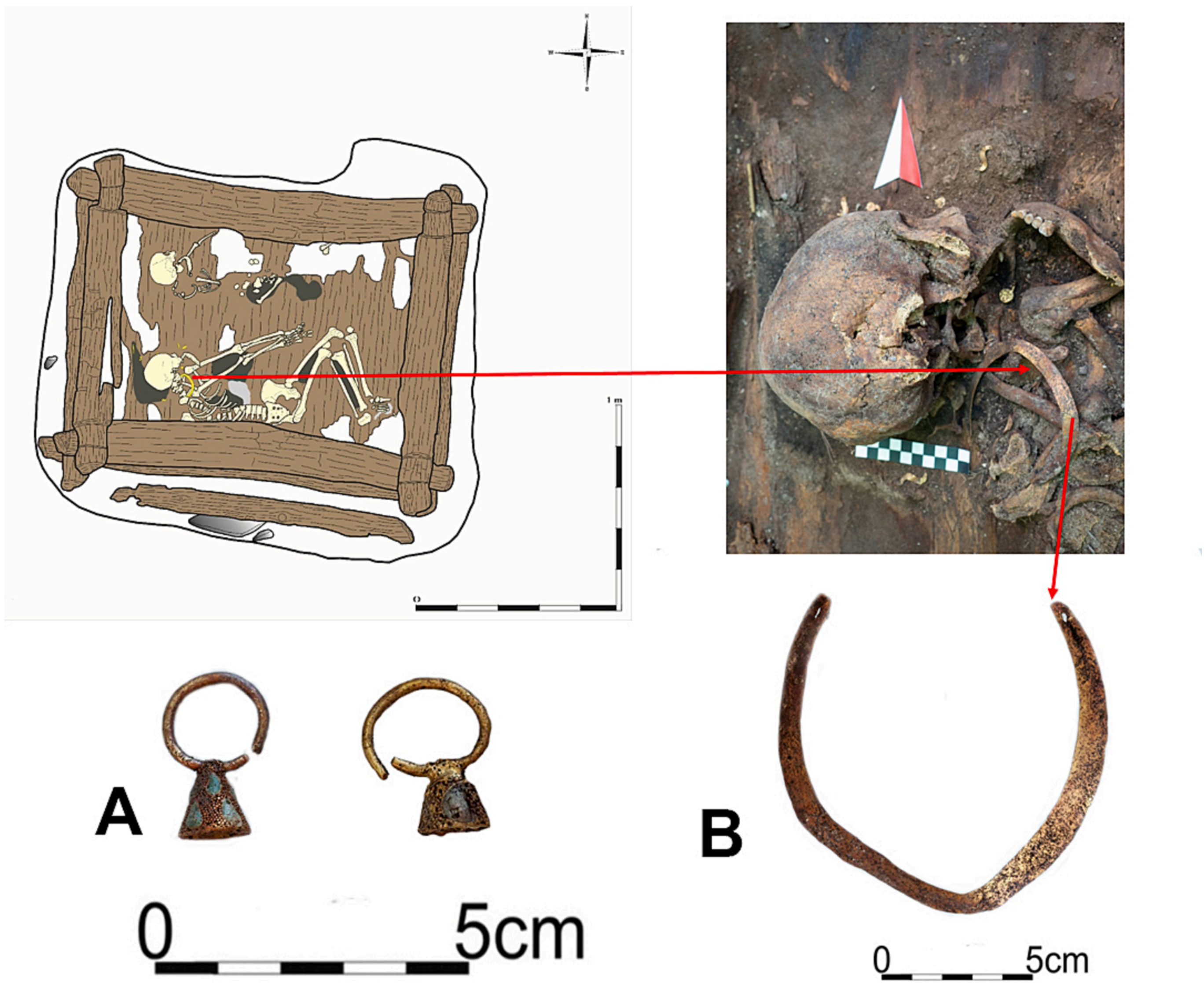

Fig. 6. Chinge Tey Western Chain- grave no.2, details: A) golden earrings with triangular semi-precious stones; B) golden pectoral found on the neck of older female (close up photo and drawing). Photo and drawings by Ł. Oleszczak.

1.2. The isotopic approach to dietary habits of the Iron Age nomadic aristocracy in Tuva

Food serves as a potent symbolic resource for expressing social differentiation patterns in past societies (Lévi-Strauss, 1965; Farb and Armelagos, 1983; Messer, 1984; Harris and Ross, 1987; Mintz and Du Bois, 2002). The composition of an individual's diet may be shaped by numerous factors, including social, psychological, sensory, and economic influences. Hence, the dietary practices of prehistoric communities may not only reflect taste preferences but also convey information about social hierarchies, agricultural productivity, environmental conditions, population density, and changes in dietary norms due to various factors (cf. Motarjemi, 2014; Koryakova and Epimakhov, 2014). In the context of Eurasian pastoral populations, particularly those in Mongolia and China, their paleodiet and subsistence strategies have been extensively studied in archaeological literature (e.g., Hanks et al., 2018; Knipper et al., 2020; Miller et al., 2014; Pan et al., 2009; Svyatko et al., 2013; Wilkin et al., 2020; Gerling, 2015; Ling et al., 2010). For instance, the food culture of the Scytho-Siberian populations from the Khakassia and Tuva regions has been analyzed by Murphy et al. (2013) based on isotopic data from Ai-Dai (Khakassia, the Tagar culture, 9th-2nd century BC; German, 2017) and Aimyrlyg cemeteries (Tuva, the Sagly culture, 6th-2nd century BC, Chugunov, 2020). Recently, Beisenov et al. (2020) conducted a new study, providing isotopic data for the Saka population in Kazakhstan (8th-2nd century BC, cf. Kadyrbaev, 1966; Beisenov et al., 2022).

In archaeology, the use of carbon and nitrogen stable isotopes has been widespread for studying paleoenvironments and paleodiet (Sealy, 2001; Schwarcz et al., 1999). This approach relies on the principle that stable isotopic values of foods are reflected in the isotopic composition of bone collagen (Ambrose, 1993; Sealy, 2001; Lee-Thorp, 2008), and it has proven successful in various bioarchaeological studies conducted over the past decades. Fractionation causes a rise in stable carbon (~1 ‰) and nitrogen (~3 ‰) isotope ratios at higher trophic levels (DeNiro and Epstein, 1978; 1981). However, when the body processes protein, it retains the heavy isotope ^{15}N and releases the lighter isotope ^{14}N, leading to an increase in δ^{15}N values as we move up the food chain (Fry, 2006; Hedges and Reynard, 2007). Consequently, an increase in δ^{15}N values in human bone collagen can be linked to protein intake. Accurate interpretation of human diets necessitates a comparison with stable isotope ratios found in local food sources. In this context, herbivore bone material is often employed as it is believed to reflect the local vegetation, particularly in the case of wild herbivores (Hedges and Reynard, 2007). The consumption of freshwater fish is typically identified by elevated

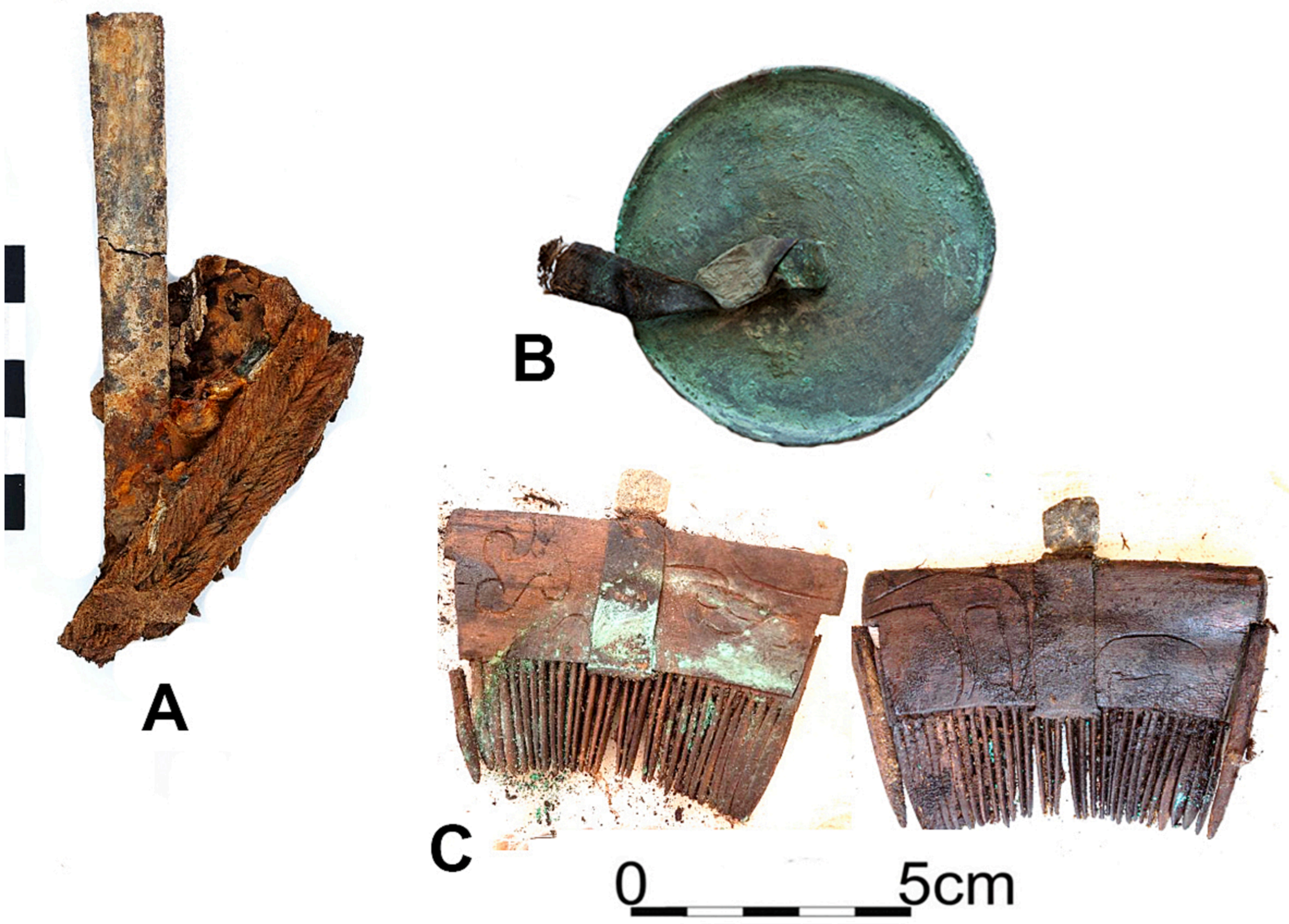

Fig. 7. Chinge Tey Western Chain- grave no.2 (older female); artefacts: A) iron knife with organic sheath; B) bronze mirror; C) wooden comb with metal clip. Photo by Ł. Oleszczak.

$\delta^{15}N$ values and reduced $\delta^{13}C$ values, although the degree of $\delta^{15}N$ elevation can vary significantly, ranging from 6 ‰ to 2.3 ‰ (Schoeninger and DeNiro, 1984; Minagawa, 1992; Katzenberg and Weber, 1999). Moreover, factors other than diet, like plant anatomy, soil composition, or manuring, can also influence $\delta^{15}N$ values (Hedges and Reynard, 2007; Britton et al., 2008; Bogaard et al., 2007, 2013). Conversely, the $\delta^{13}C$, values can be affected also by the amount of vegetation cover (van der Merwe and Medina, 1991). In the case of infants, the nursing effect can also raise $\delta^{15}N$ values by a full trophic level (Richards et al., 2002; Jay and Richards, 2006). Human bone collagen $\delta^{13}C$ values are typically 0-5 ‰ higher than those consumed in foods (Schoeninger and DeNiro, 1984; see also Fernandes et al., 2012). The $\delta^{15}N$ values of human bone collagen are enriched by approximately 3–5 ‰ compared to the $\delta^{15}N$ ratio of the protein that the human has consumed (Bocherens and Drucker, 2003; Hedges and Reynard, 2007). Individuals consuming marine/fresh water protein food typically exhibit $\delta^{13}C$ values close to −12 ‰ and $\delta^{15}N$ values between 12 and 22 ‰, while humans who consume only C_3-based terrestrial protein sources have $\delta^{13}C$ values of about −20 ‰ and $\delta^{15}N$ values ranging from 5 ‰ to 12 ‰ (Schoeninger and Moore, 1992; Richards et al., 2006).

1.3. Carbon and nitrogen cycling in vegetation within arid and semi-arid environments

Water availability stands as the foremost influential factor that governs the carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope composition in Asian arid and semi-arid environments. Nonetheless, variations may exist among locations and/or species concerning the responsiveness of plant $\delta^{13}C$ and $\delta^{15}N$ to changes in precipitation. These distinctions hold significance in the context of utilizing stable isotope signatures to extract valuable insights into paleo-vegetation and paleo-climate information (Toderich et al., 2007). Plants exhibit a selective preference against $^{13}CO_2$ during the process of photosynthetic CO_2 fixation, a phenomenon influenced by both plant metabolism and prevailing environmental conditions. Distinctive carboxylation reactions give rise to variations in photosynthetic ^{13}C fractionation and the response to environmental changes between the C_3 and C_4 photosynthetic pathways (O'Leary, 1981). The carbon isotopic composition is further influenced by the ratio of ambient to intercellular humidities, consequently serving as an indicator of changes in leaf energy budgets, which are themselves regulated by stomatal conductance (Farquhar and Sharkey, 1982). Carbon stable isotope ratios have proven instrumental in discerning the consumed type of vegetation, namely C_3 and C_4/CAM (DeNiro and Epstein, 1978). Terrestrial C_3 plants exhibit depleted stable isotopic signals (−27 ‰; Price et al., 1985), while water C_3 plants are distinguished by relatively elevated stable isotope values (−21 ‰; Fry, 2006). Subsequently, terrestrial C_4 plants display mean $\delta^{13}C$ values of approximately −12.5 ‰ (Toderich et al., 2007).

Under conditions of water stress, C_3 plants are expected to exhibit higher ^{13}C enrichment compared to plants growing under optimal water conditions. This association between mean annual precipitation and the $\delta^{13}C$ value of C_3 plants has been demonstrated in several studies

(Stewart et al., 1995; Swap et al., 2004; Liu et al., 2005; Hartman and Danin, 2010). In contrast, the $\delta^{13}C$ values of C_4 plants are anticipated to display less sensitivity to water stress (Farquhar et al., 1982), leading to the absence of a commonly observed correlation between the $\delta^{13}C$ values of C_4 plants and water availability (e.g., precipitation; Schulze et al., 1998).

Plant nitrogen isotopic composition ($\delta^{15}N$) is intricately linked to environmental variables, nutrient availability, and water accessibility, rendering it a valuable indicator of ecosystem nitrogen (N) cycling on various spatial and temporal scales (Dawson et al., 2002; Amundson et al., 2003). By examining alterations in $\delta^{15}N$ values within plants along natural precipitation gradients, it becomes possible to discern the patterns of nitrogen losses relative to turnover among different regions (Austin and Vitousek, 1998). Notably, studies conducted in arid desert environments have consistently shown an enrichment of ^{15}N in both soil and plant samples along precipitation gradients (Handley et al., 1999; Aranibar et al., 2004; Aranibar et al., 2008). In the aftermath of rain events, processes leading to nitrogen loss demonstrate a preference for the lighter ^{14}N isotope, resulting in a proportionally higher loss of ^{14}N and a subsequent increase in the $\delta^{15}N$ of the remaining nitrogen in ecosystems (Handley and Raven, 1992).

2. Materials and methods

Human bone samples used in our study, marked as the Chinge-Tey Western Chain and Chinge-Tey I, are shown in Table 1. The group comprises 9 adult males, 1 female, and 2 children (unspecified sex). The age structure is dominated by adults (*Infans I* n = 1; *Juvenis* n = 2; *Adultus* n = 7; *Maturus* n = 2; age cohorts after Hillson, 1996; for more information regarding isotopic variation and bone remodeling rates see: Fahy et al., 2017). In radiocarbon dating, we used only human long bones (femur, humerus), while in $\delta^{15}N/\delta^{13}C$ analyses of diet both long bones and dentition were analyzed (dentition was not available for all individuals, for details see Table 3). Adult individuals were sampled when possible to reduce age-related dietary variability. Very few animal remains were found in the vicinity of the Chinge Tey. No waste pits or larger deposits of animal bones were uncovered, therefore faunal isotopic data presented in our study is modest and cannot be considered representative. Faunal bone fragments comprising both domesticated and wild animals (n = 7) have been collected from adjacent Zhelvak 5 settlements and the Chinge Tey Western Chain during excavations (Fig. 1; Table 3). Animal bones were uncovered in the ditch surrounding the tomb. Feasibly, they were deposited as consumption waste associated with mortuary feasting rituals (Table 3).

2.1. Collagen extraction and stable isotope measurements

Collagen was extracted from human and animal bone samples following the procedure according to Brown et al. (1988) in the Archaeological Research Laboratory University of Stockholm. Samples were decalcified using 0.5 N HCl over 48 h. The decalcified material was solved in 0.01 N HCl and gelatinized at 58 °C for 18 h. Subsequently, the gelatin solution was filtered to remove any remaining solids, and ultrafiltered to remove the <30-kD fraction. The purified solution was lyophilized for 20 h to obtain dried collagen. In continuous-flow mass-spectrometry, solid sample processing consists of several steps, such as chemical preparation of the material, introduction, and conversion to gaseous form, separation of CO_2, injection of reference gas to IRMS, and injection of sample to IRMS. The sample is converted into a simple gas that has to be isotopically representative of the original sample before entering the ion source of an IRMS (Lidén, 1995; Meier-Augenstein, 1999, 2010). Measurements were conducted with a continuous flow

Table 1
Barrow interments from the Chinge Tey 1 Western Chain and Chinge Tey I barrows analysed in this study: archaeological overview; cf. Suppl. e-file 2.

Sample ID	Site/barrow/burial	Sex	Age	Grave	Prestige objects/funerary furnishings	Weaponry
H1	Chinge Tey Western Chain 1, burial 1	Male	*Maturus* 40–50 (?)	Wooden chamber	Unknown	Single arrow
H2	Chinge Tey Western Chain 1, burial 3	Male	*Adultus* 20–25 (?)	Wooden chamber with stone embankment	Breastplate, large and luxurious belt, 3 golden items: pectoral, bead, spiral hair ornament	Arrows, leather quiver, iron knife, whetstone, axe
H3	Chinge Tey I burial 2	Male	*Adultus* 25–35	Stone box	Single cone-shaped earing	Dagger, axe
H4	Chinge Tey I burial 3	Male	*Adultus* 30–40	Stone box	Leaf-shaped earing, luxurious belt, tin necklace	Arrows, axe
H5	Chinge Tey I burial 4	Male	*Juvenis* 13–16	Stone box	Leaf-shaped earing, luxurious belt	Arrows, axe
H6	Chinge Tey I burial 5	Male	*Adultus* 25–30	Stone box	Large, luxurious belt	Arrows
H7	Chinge Tey I burial 6	Male	*Adultus* 20–25	Stone box	Unknown	Arrows
H8	Chinge Tey I burial 7	Male	Juvenis/ Adultus 15–19	Wooden chamber	Breastplate, luxurious belt	Arrows
H9	Chinge Tey I burial 8	Male	*Adultus* 25–30	Wooden chamber	Single cone-shaped earing, luxurious belt	Arrows
H10	Chinge Tey Western Chain 1, burial 2, skeleton 1	Female	*Maturus/ Senilis*	Wooden chamber	Golden pectoral, golden earrings, wooden comb, bronze mirror, iron knife	None
H11	Chinge Tey Western Chain 1, burial 2, skeleton 2	Non-adult	*Infans I* 2–3	Wooden chamber	Poss. organic goods	None
H12	Chinge Tey Western Chain 1, burial 4	Non-adult	*Juvenis* 13–16	None?	Large boulder within grave	None

mass spectrometer, Finnigan Elemental Analyzer Delta-V Advantage™ at the FTMC in Vilnius. Carbon and nitrogen stable isotope ratios are expressed relative to the VPDB standard for carbon and atmospheric nitrogen (AIR) (Schwarcz et al., 1999) for nitrogen, respectively. The contents of carbon and nitrogen, the C: N atomic ratios, and the values of $\delta^{13}C$ and $\delta^{15}N$ of all samples are listed in Table 3. All human and faunal samples were well-preserved and correspond to the technical standards of collagen quality: the contents of C (%), and N (%) in collagen and C:N atomic ratios (DeNiro, 1985; Ambrose, 1990). The radiocarbon dating has been performed in the Tandem Laboratory University of Uppsala, Sweden.

3. Results

3.1. Chinge Tey chronological sequence: radiocarbon dating of burials

The results of the radiocarbon dating are shown in Table 2 (Fig. 8, Fig. 9). The priority was to establish a sequential and artefactual correlation between the barrows and the Arzhan 1 and Arzhan 2 chronological referential point (Zaytseva et al., 2005; Alekseev et al., 2001; Alekseev et al., 2002). Chinge Tey barrows yielded some chronologically indicative artefacts, especially arrowheads and bronze belt fittings. The arrowheads and the quivers found in Chinge Tey I allow these burials to be assigned to the Aldy-Bel culture in the early Scythian period (8th/7th until the mid-6th century BC). Most of the chronologically sensitive traits suggest the graves can be dated to the final decades of the 7th century BC or potentially to the first half of the 6th century BC (Fig. 8). The artefacts seem to be contemporary with the assemblages discovered within the well-known barrow Arzhan 2, which is credibly dated to the end of the 7th century BC (Chugunov, 2011). The assembly of 11 arrows (nine of which was found with preserved bronze heads) from grave 3 (Chinge Tey 1 Western Chain) allows typological/chronological harmonisation with the larger barrow of Chinge Tey I. Some artefacts uncovered in Chinge Tey 1 Western Chain, for example, a bird head bronze battle-axe or trapezium-shaped belt clasp, can be firmly dated to the first half of the 6th century BC or later (Oleszczak and Chugunov, 2020).

The ^{14}C dating of human remains has confirmed the chronology of artefacts found in interments (Table 2; Figs. 8-9). The data places the analysed artefacts with a very high likelihood (95.4 %) within the Aldy-Bel culture's time frame (8th-6th centuries BC). It is worth noting that all the samples produced results that also allow the graves to be placed with a high probability within the second half of the 7th/mid-6th century BC. The interpretation of the ^{14}C-data has been affected by the Hallstatt radiocarbon calibration plateau (Bronk Ramsey, 1998; Speranza et al., 2000; Bond et al., 2001; Bruins et al., 2003), and Russian nuclear bomb testing sites in Kazakhstan. Despite that, however, the radiocarbon dating is consistent with the chronology of artefacts in both barrows (end of 7th century-the first half of the 6th century BC).

3.2. Dietary practice of nomadic aristocracy buried in the Chinge Tey barrows

The scatter plot of $\delta^{13}C$ and $\delta^{15}N$ values of the faunal and human samples from the sites are shown in Fig. 10 and Fig. 11. Local isotopic ecology has been analysed based on values from animals, both domesticated and wild shown in Table 3. The $\delta^{13}C$ values of terrestrial herbivores bone collagen (n = 4) are between −22.14 ‰ and −21.11 ‰, averaging −21.69 ± 0.4 ‰. The animals fed mainly on terrestrial C3 plants. The mean $\delta^{15}N$ value of bone collagen is 6.05 ± 0.6 ‰ indicating a typical herbivorous diet in a dry continental environment. The $\delta^{13}C$ values of wild omnivorous animals and carnivores (black grouse n = 1, dog n = 1, corsac fox n = 1) represent a broader range of values between −21.78 ‰ and −17.58 ‰ (−20.27 ± 0.2 ‰). The $\delta^{15}N$ values of this group range between 8.46 ‰ to 11.24 ‰ respectively, with an average of 10.24 ± 1.4 ‰, showing mixed omnivorous dietary regime. The values obtained from faunal remains should be interpreted in a context of a continental climate and steppe environment of the study area (cf. O'Connell et al., 2012; Wilkin et al., 2020).

The $\delta^{13}C$ and $\delta^{15}N$ values of humans are shown in Table 3. The chronological time frame for both barrows is very short (Table 2; Fig. 8). The human $\delta^{13}C$ values observed in both Chinge Tey barrows exhibited a range from −16.7 ‰ to −13.9 ‰, while the $\delta^{15}N$ values ranged from 10.1 ‰ to 13.2 ‰ (in the long bones). The mean $\delta^{13}C$ value for the entire group was −15.38 ‰ ± 0.97, with a corresponding $\delta^{15}N$ value of 12.07 ‰ ± 1.15. To assess the homogeneity of the analyzed group, the coefficient of variation (CV) index was utilized. The CV index, which represents the ratio of the standard deviation to the mean, serves as a simple measure of variability relative to the population mean. In this analyzed group, the CV index for $\delta^{13}C$ values indicated a low dispersion level of −0.0633 %, while for $\delta^{15}N$ values, it was 0.095 %, indicating high homogeneity of the isotopic dataset. Further comparison and analysis of the data were conducted through hierarchical cluster analysis of the isotopic data from the barrow inhumations, employing the PAST 4.1 software (Hammer et al., 2001). The results were visualized in a clustering dendrogram in Fig. 12 (also see Table 3 and Supplemental e-file 1). The hierarchical clustering procedure, based on Ward's method, facilitated the identification of relationships among observations. At the computational distance of 2.5, the dendrogram for Chinge Tey indicated two main data clusters. The first cluster comprised five individuals exhibiting a mean $\delta^{13}C$ value of −15.44 ‰ and a mean $\delta^{15}N$ value of 10.84 ‰ (TUV1, TUV2, TUV3, TUV10, and TUV12). These data were primarily associated with the Chinge Tey 1 Western Chain barrow, with the exception of one individual (TUV3). The second cluster encompassed all other individuals analyzed in this study, predominantly from Chinge Tey I barrow, displaying a mean $\delta^{13}C$ value of −15.34 ‰ and a mean $\delta^{15}N$ of 12.95 ‰ (Fig. 12).

For five individuals, $\delta^{13}C/\delta^{15}N$ values were measured from teeth formed during earlier phases of individual life history (Fig. 10; incisors, canines, molar, and premolar; TUV/H4-4a, TUV/H5-5a, TUV/H6-6a, TUV/H7-7a, TUV/H8-8a; Suppl. E-file 1). While the exact age of

Table 2
Radiocarbon data and chronology of the Chinge Tey barrows, Tuva Republic, Russia.

Lab code	Site and burial	Material	^{14}C dating (BP)	Probability range 95.4 % (BC)	Mean (calBC)
Ua-65156	Chinge Tey 1 WC, Burial 1	unburnt human bone	2 501 ± 30	778–522	645
Ua-65157	Chinge Tey 1 WC, Burial 3	unburnt human bone	2 506 ± 30	780–540	648
Ua-65158	Chinge Tey I, Burial 2	unburnt human bone	2 523 ± 30	790–544	659
Ua-65159	Chinge Tey I, Burial 3	unburnt human bone	2 474 ± 30	769–423	623
Ua-65160	Chinge Tey I, Burial 4	unburnt human bone	2 491 ± 30	776–487	638
Ua-65161	Chinge Tey I, Burial 5	unburnt human bone	2 473 ± 30	769–423	622
Ua-65162	Chinge Tey I, Burial 6	unburnt human bone	2 523 ± 30	790–544	659
Ua-65163	Chinge Tey I, Burial 7	unburnt human bone	2 530 ± 30	794–544	666
Ua-65164	Chinge Tey I, Burial 8	unburnt human bone	2 512 ± 29	781–542	651
Ua-71103	Chinge Tey 1 WC, Burial 2, skeleton 1	unburnt human bone	2494 ± 30	776–515	640
Ua-71104	Chinge Tey 1 WC, Burial 2, skeleton 2	unburnt human bone	2479 ± 30	772–429	629
Ua-71105	Chinge Tey 1 WC, Burial 4	unburnt human bone	2539 ± 30	797–649	678

Table 3
Chinge Tey barrows, Tuva: stable carbon and nitrogen isotope results of faunal and human bone materials.

Sample ID	Species	Bone element	Site	δ^{13}C(‰ VPDB)	C%	δ^{15}N(‰ AIR)	N%	C:N
Humans								
TUV/H1	*Homo Sapiens*	long bone	Chinge Tey 1 (WC), burial 1	−15.2	38.89	11.1	14.08	3.2
TUV/H2	*Homo Sapiens*	long bone	Chinge Tey 1 (WC), burial 3	−15.3	32.87	11.1	11.91	3.2
TUV/H3	*Homo Sapiens*	long bone	Chinge Tey I, burial 2	−15.8	40.50	11.2	14.60	3.2
TUV/H4	*Homo Sapiens*	long bone	Chinge Tey I, burial 3	−14.4	40.63	13.0	14.92	3.2
TUV/H4a	*Homo Sapiens*	canine	Chinge Tey I, burial 3	−16.2	48.12	11.4	13.64	3.5
TUV/H5	*Homo Sapiens*	long bone	Chinge Tey I, burial 4	−14.7	26.41	13.5	9.71	3.2
TUV/H5a	*Homo Sapiens*	incisor	Chinge Tey I, burial 4	−16.8	39.37	13.6	11.59	3.4
TUV/H6	*Homo Sapiens*	long bone	Chinge Tey I, burial 5	−14.6	38.92	12.8	14.28	3.2
TUV/H6a	*Homo Sapiens*	canine tooth	Chinge Tey I, burial 5	−17.2	43.01	11.8	13.10	3.2
TUV/H7	*Homo Sapiens*	long bone	Chinge Tey I, burial 6	−14.7	25.53	12.9	9.45	3.2
TUV/H7a	*Homo Sapiens*	premolar	Chinge Tey I, burial 6	−18.9	43.32	12.8	12.06	3.2
TUV/H8	*Homo Sapiens*	long bone	Chinge Tey I, burial 7	−16.1	38.24	13.2	14.08	3.2
TUV/H8a	*Homo Sapiens*	molar 3	Chinge Tey I, burial 7	−18.4	42.42	12.5	11.76	3.6
TUV/H9	*Homo Sapiens*	long bone	Chinge Tey I, burial 8	−16.7	39.64	13.0	14.60	3.2
TUV/H10	*Homo Sapiens*	long bone	Chinge Tey 1 (WC), burial 2/1	−17.0	40.01	10.7	14.78	3.2
TUV/H11	*Homo Sapiens*	long bone	Chinge Tey 1 (WC), burial 2/2	−16.2	26.74	12.3	9.40	3.3
TUV/H12	*Homo Sapiens*	long bone	Chinge Tey 1 (WC), burial 4	−13.9	45.10	10.1	16.46	3.2
Faunal materials								
TUV/E1	*Equus caballus*	long bone	Chinge Tey 1 (WC)	−21.78	41.76	5.41	11.68	3.5
TUV/E2	*Equus caballus*	long bone	Chinge Tey 1 (WC)	−21.74	44.44	5.84	13.63	3.2
TUV/E3	*Equus caballus*	premolar	Chinge Tey 1 (WC)	−21.11	44.63	5.99	13.57	3.3
TUV/S	*Spermophilus*	long bone	Zhelvak 5 settlement	−22.14	44.67	6.97	14.96	2.9
TUV/V	*Vulpes corsac*	long bone	Zhelvak 5 settlement	−21.45	42.68	8.46	11.72	3.6
TUV/CAN	*Canis familiaris*	long bone	Zhelvak 5 settlement	−21.78	43.95	10.43	12.93	3.4
TUV/LT	*Lyrurus tetrix*	long bone	Zhelvak 5 settlement	−17.58	45.89	11.24	14.55	3.1

formation and eruption of these teeth varies on an interpopulational scale, the isotopic values they represent pertain to childhood (Hillson, 1996; Mitchell and Mitchell, 2014; for formation/eruption time, see AlQahtani et al., 2010). All analyzed individuals shared a similar pattern, indicating a significant shift towards more positive δ^{13}C values in later years (ranging from 2.14 ‰ to 4.28 ‰), while the δ^{15}N values remained relatively stable at 12.46 ‰ to 12.15 ‰. This pattern suggests that more negative δ^{13}C values from early childhood correspond to a diet lacking the C_4 isotopic component, while less negative values, indicating a mixed C_3/C_4 nutritional regime, become more apparent in adulthood. The range of δ^{15}N values (11.86 ‰ to 13.63 ‰ vs. AIR) suggests a diet rich in high-protein and high-purine foods (especially organ meat), a distinctive cultural trait of Asian nomadic food practices (Brule et al., 1989; Badiani et al., 1997; Lorenzo et al., 2014).

According to Murphy et al. (2013), it has been suggested that Iron Age pastoral populations in Tuva may have consumed millet (*P. miliaceum*) and engaged in millet-based agriculture. These authors analyzed a specific number of non-elite burials, chronologically later, belonging to the Tagar and Sagly cultures in the Ai-Dai and Aimyrlyg cemeteries (cf. Radzyun and Kazarnitskiy, 2011; see Fig. 11). However, our results do not confirm this hypothesis (see Table 3 and Figs. 10–11). Studies on the quality of soils in the Tuva Basin and prehistoric climatic conditions indicate highly changeable and challenging conditions for agriculture, including a dry steppe bordering on desert, frequent uncontrolled fluctuations in humidity, and high salinity of poor soils (cf. Rietkerk et al., 2002; Gracheva, 2004; Prikhodko et al., 2018). Nevertheless, it is worth noting that some δ^{13}C/δ^{15}N values from the Chinge Tey barrows fall within the isotopic range reported by Murphy et al. (2013). Isotopic data from cluster 1 align with data from the Ai-Dai cemetery (−15.1 ± 0.9 ‰ in δ^{13}C, δ^{15}N: 10.6 ± 0.5 ‰; after Murphy et al., 2013). It is important to highlight that the Ai-Dai burial ground is associated with the Tagar culture from the Minusinsk Basin (Martynov, 1979; Murphy et al., 2013; German et al., 2020). On the other hand, the majority of data from burials in Chinge Tey I (clusters 2) may potentially be linked with a pastoral subsistence type, as indicated by isotopic data from the Sagly culture population in the Aimyrlyg cemetery (δ^{13}C −15.3 ± 1.25 ‰, with δ^{15}N 13.2 ± 0.5 ‰; after Murphy et al., 2013). The interpopulational comparison of the δ^{13}C/δ^{15}N dietary data from Central Asia can be seen in Fig. 11. It shows several Iron Age populations from the Tuva region and adjacent territories: the Ai-Dai and Aimyrlyg non-elite cemeteries (Murphy et al., 2013), the pastoral Tuoba culture in Northern China (Xianbei cemetery; Zhang et al., 2015); the Bronze Age/Iron Age Kazakhstan (Bestamak and Lisakovsk cemeteries; Miller et al., 2014); and Iron Age Central and Eastern Kazakhstan (Ananyevskaya et al., 2018). Isotopic data points towards potential cultural, regional, or/and zonal variations in feeding practices among members of the nomadic aristocracy in general. Therefore we infer that the different food resources or individual mobility (not analysed in our study) may primarily account for potential differences in diet between analysed high-status individuals.

4. Discussion

4.1. Prehistoric subsistence strategies in the Tuva region during the Iron Age

During prehistoric times, the territory of Tuva was not conducive to farming and agriculture, leading the inhabitants to primarily practice transhumance. The region experienced a continental and arid climate, with prevalent chestnut soils characterized by thin soil cover (usually 0.3–0.5 m) and inadequate drainage, low moisture, alkalinity, increased salinity, and soil heterogeneity (Dergacheva and Ochur, 2012). The majority of the soil cover in Tuvan valleys belonged to the steppe cryoarid type (Nosin, 1963; Blyakharchuka et al., 2019). Pollen and dendrochronological data from Arzhan 2 and the Beloe Lake, however, indicate that around 4600–2600 BP, the climate of Tuva was more humid, leading to the expansion of forests in the area. After approximately 2600 BP, a progressive drying occurred, resulting in the current continental climate (Dirksen and Chugunov, 2007). Some other researchers propose that climatic fluctuations during the Iron Age period in Tuva were more frequent and erratic. Analysis of the Tere-Khol Lake sediments, located in SE Tuva, indicates a wet climatic interval occurring around 4600–2600 BP, which was interrupted by several dry intervals and represented two wet subperiods (3800–3500 BP and 2700–2300 BP; Panin et al., 2012). Bolikhovskaya and Panin (2008) suggest that a dry period lasted from about 4500 BP to 3200 BP, but

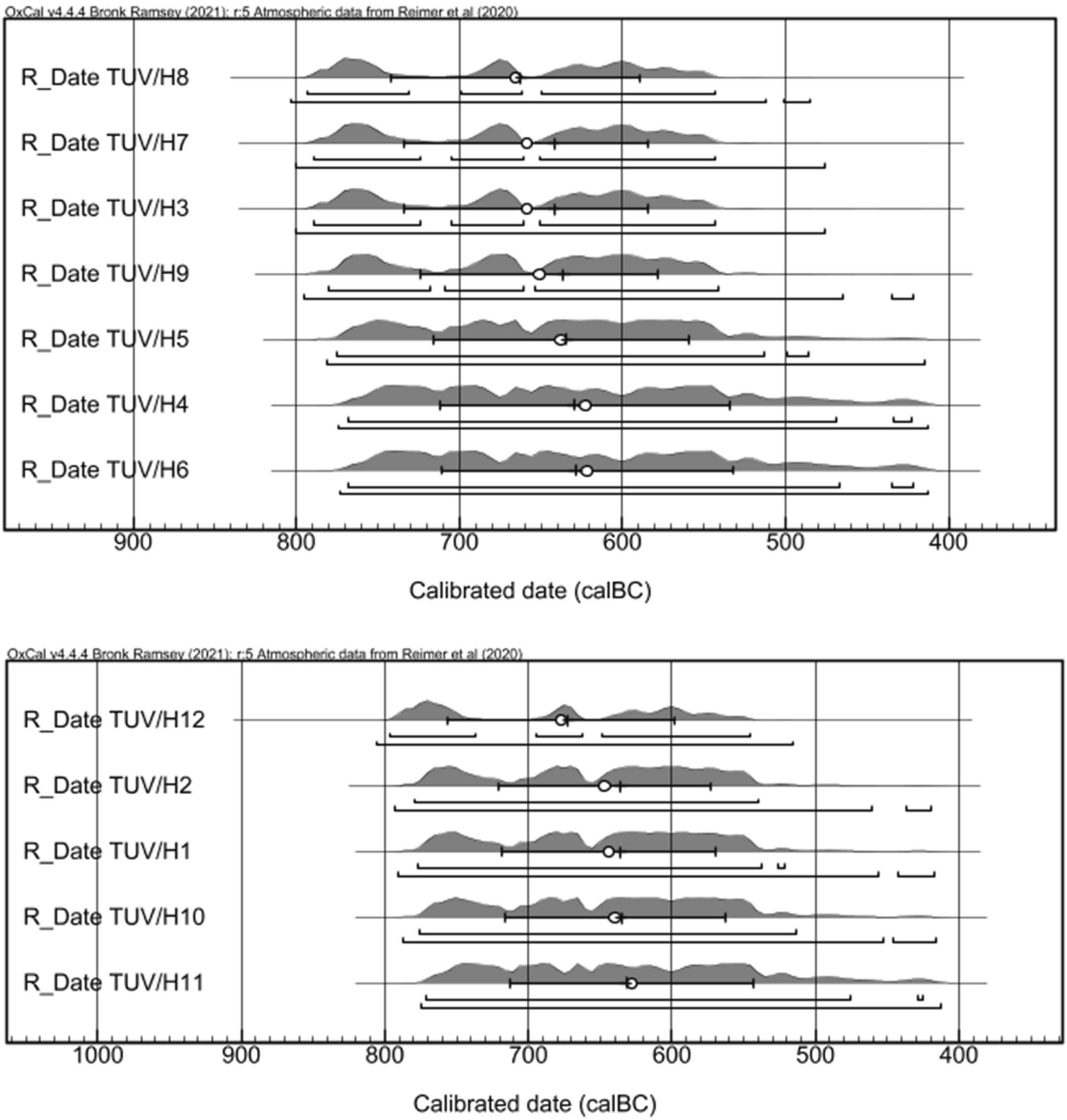

Fig. 8. Radiocarbon dating of Chinge Tey I (upper plot) and Chinge Tey 1 Western Chain (lower graphic) burials compared. For details see Table 2.

between 3200 BP and 1500 BP, there were five wet periods alternating with four dry periods.

From an archaeological perspective, around 850 BC, the temperature stabilized, and the climate became more humid, leading to the transformation of the dry steppe into meadows and pastures. The expansion of Scythian populations in the region was a result of opportunistic adaptations to ecological changes in Southern Siberia and Central Asia. The Tagar culture emerged in the Minusinsk Basin around the mid-9th century BC, and simultaneously, the Aldy-Bel population arose in the steppe zones of the Turan-Uyuk Valley (cf. Kulkova and Bokovenko, 2018). The Aldy-Bel culture in the territories of Upper Yenisei is considered a typical, almost exclusively pastoral population. Based on data from Chinge Tey, there is no evidence of their involvement in agricultural or semi-agricultural activities, including fishing (fishing was also excluded by Murphy et al., 2013; cf. Drobyshev and Syrtypova, 2016). Most Asian pastoral populations predominantly refrained from consuming fish, and if fish consumption did occur, it was typically regarded as a medicinal remedy (Drobyshev and Syrtypova, 2016). In the Aldy-Bel archaeological record, fishing hooks and net weights, which indicate fishing traditions, are absent despite the proximity of a large river (for a detailed commentary on marginal fish consumption in Central Asia, see Drobyshev and Syrtypova, 2016). Therefore, relatively

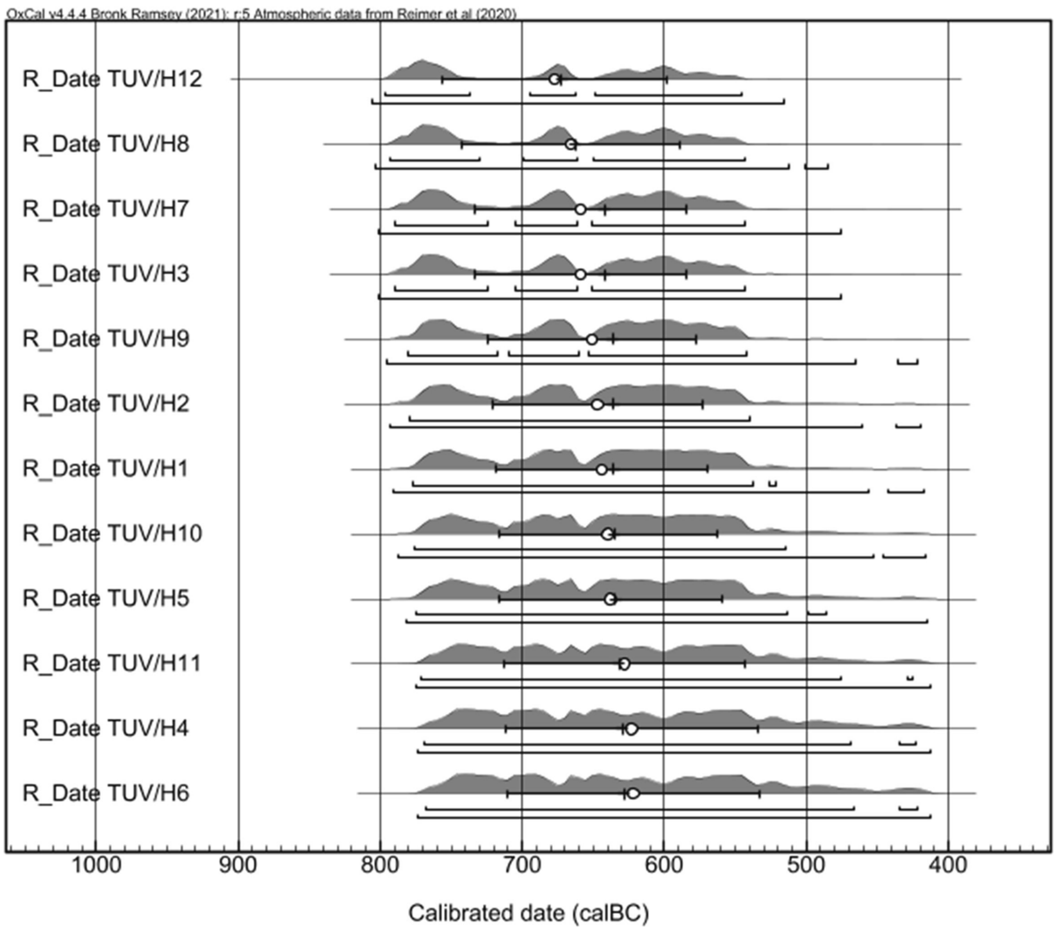

Fig. 9. Radiocarbon chronology of the Chinge Tey barrows – an overview. The Oxcal graph plots 'likelihood' distributions; 'posterior' distributions are not included. For details see Table 2.

high $\delta^{15}N$ values from Chinge Tey individuals should not be directly linked to freshwater fish consumption.

The enrichment of ^{15}N in humans is still not well understood, and various sources generally report values for mammalian species ranging between 3‰ to 5‰ (Hedges and Reynard, 2007). When humans consume plants with high $\delta^{15}N$ values, their own collagen's nitrogen isotope compositions can increase, deviating from typical values expected for higher trophic levels. The elevated $\delta^{15}N$ isotopic range observed in the Aldy-Bel burials in Aimyrlyg and Chinge Tey 1, along with an imbalance in $\delta^{13}C$, appears to be associated with two factors.

The first factor is related to the metabolic stress responses of plants in harsh environments. These stress responses can be triggered by factors like drought, soil salinity, and nitrogen depletion due to starvation (Zhang et al., 1999). The $\delta^{13}C$ has been employed to assess water use efficiency in plants, as it reflects the degree to which primary CO_2 assimilation is limited by carboxylation or CO_2 diffusion in leaves. Environmental stresses, such as drought, can alter $\delta^{13}C$ through effects on the balance between stomatal conductance and carboxylation (Brugnoli et al., 1998). Plant $\delta^{15}N$, on the other hand, reflects the potentially variable $\delta^{15}N$ values of external nitrogen sources and the fractionations of $^{15}N/^{14}N$ that occur during nitrogen assimilation, transport, and loss (Handley et al., 1998). For instance, Handley and Scrimgeour (1997) demonstrated that $\delta^{15}N$ varied by up to 2.4‰ among wild barley (*Hordeum spontaneum*) grown on a common nitrogen source. There is a strong inverse relationship between mean annual rainfall and average foliar $\delta^{15}N$ in a wide range of ecosystems. Links have been observed between $\delta^{15}N$ and stress tolerance under dry conditions and during nitrogen starvation (Handley et al., 1999). Unfortunately, at present, we lack isotopic data on the $\delta^{13}C/\delta^{15}N$ variability in plant responses to physiological stress in the Tuva region. However, similar processes have been observed in African savanna's C_3 and C_4 plant communities, where higher foliar $\delta^{15}N$ in C_3 plants has led to C_4 plants being superior competitors for nitrogen (Wang et al., 2010, 2013; Codron et al., 2016).

The second aspect concerns pastoral herding practices, particularly the grazing management of horses. Horses require more water and better fodder compared to sheep, and they need to graze in different meadows to avoid nutritional competition and overuse of pastures (Zhang et al., 2020). A study by Knipper et al. (2020) observed that $\delta^{15}N$ values in sheep/goat bones were higher (7.8–10.2‰) compared to other ruminants (5.8–9.3‰) in the steppe zone of the Northern Caucasus. New isotopic data from Kazakhstan reveal significant differences in the diets of horses compared to other animals, suggesting specific husbandry practices for horses (Ananyevskaya et al., 2020). It is plausible that the separation of horses from sheep and goats played a crucial role in the grazing systems of Iron Age Tuva, particularly considering the impact of climatic fluctuations and seasonally limited land fertility.

The Aldy Bel culture in Tuva represents a typical pastoral lifestyle. However, some archaeological evidence suggests subsistence practices related to farming during certain subperiods of Tuvan prehistory, indicating dynamic coexistence with a predominantly pastoral environment. The Scythian population of the Tagar culture in the Minusinsk Basin practiced agriculture, as evidenced by numerous artifacts associated with farming activities and sedentism, such as bronze sickles, plough marks, irrigation canals, grain deposits in graves, stone graters and querns, and chimneys in houses (German et al., 2020). Barley (*Hordeum sp.*) and millet (*Panicum sp.*) deposits were found in Tagar culture burials in Serebryakovsky (near Tomsk, Martynov, 1979; Ryabogina, 2006).

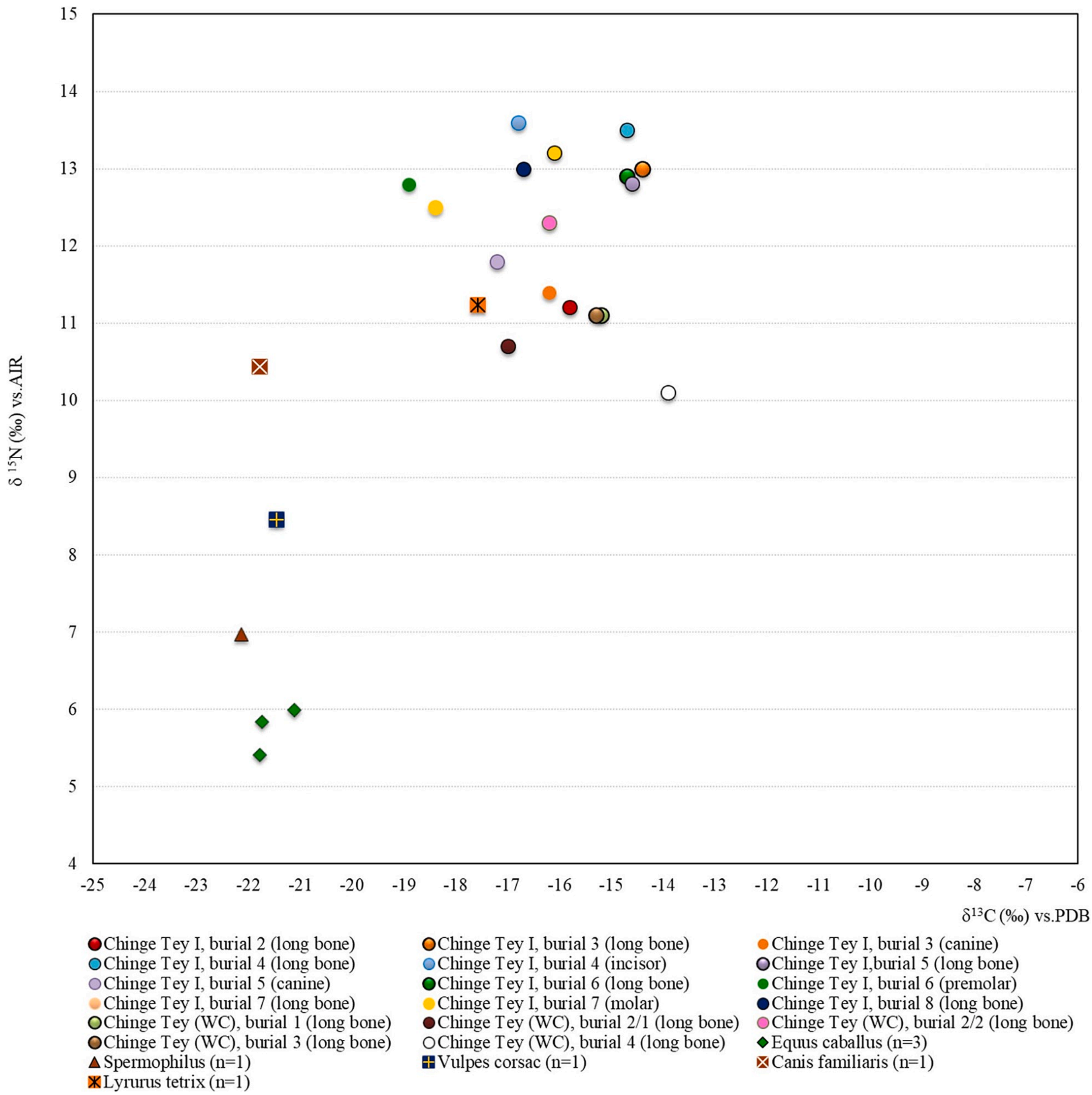

Fig. 10. The δ^{13}C and δ^{15}N isotopic values of all human and faunal samples analyzed in this study. For five individuals from Chinge Tey 1 (H4, H5, H6, H7 and H8) the isotopic values have been measured from both dentition (representing earlier stages in life, childhood) and long bones (indicating nutritional status in adulthood). Faunal materials derive mainly from local settlement located nearby, dating to roughly the same time period (see also Fig. 1; Table 3).

Excavations at Tagar settlements in Staraya Kop site 1 (Karatuzsky district, Krasnoyarsk) revealed a large number of grain grinders (Amzarakov et al., 2015). Moreover, a unique deposit of 200 sickles was discovered in the Krasnoyarsk territory (Chernikov, 1960). Isotopic analyses of human remains from the Karasuk and Tagar populations support the notion of reduced animal protein consumption and increased cereal intake in their diets (Svyatko et al., 2013; Svyatko, 2014). It is conceivable that the introduction of millet cultivation occurred around 1300 BC, following a humid subperiod lasting for a few centuries (Bolikhovskaya and Panin, 2008). The isotopic data also verify the consumption of millet in the Karasuk population inhabiting the territories of neighboring Khakassia (Svyatko et al., 2013). Settlement studies, combined with stable isotope analyses on human remains, suggest a millet-oriented sedentary economy in the Early Iron Age Central Kazakhstan as well. Stable isotopic analyses of 31 burials of the Tasmola culture (the Saka period, 8th-5th centuries BC; n = 37) also indicate a wide range of δ^{13}C/δ^{15}N variation typical for arid environments, with the potential presence of C_4 plants and millet (*Panicum sp.*; Koitas, Taldy-2, Akbeit, and Karshoky cemeteries). However, due to the scarcity of faunal materials, the question of whether millet was grown as an agricultural crop in Kazakhstan or imported remains unanswered (Beisenov et al., 2020). The archaeological record of the Tasmola culture exhibits indications of crop cultivation and consumption, as evidenced by agricultural tools and cereal grinders (Chernikov, 1960; Matuzeviciute et al., 2015; Beisenov et al., 2020).

Ananyevskaya et al. (2020) reported that during the Early Iron Age, the consumption of millet in western Kazakhstan was limited, with dietary patterns influenced by the geographic location of water resources, leading to notable distinctions between inland regions and oases. Anthropological data from the Pazyryk culture communities in the Altai

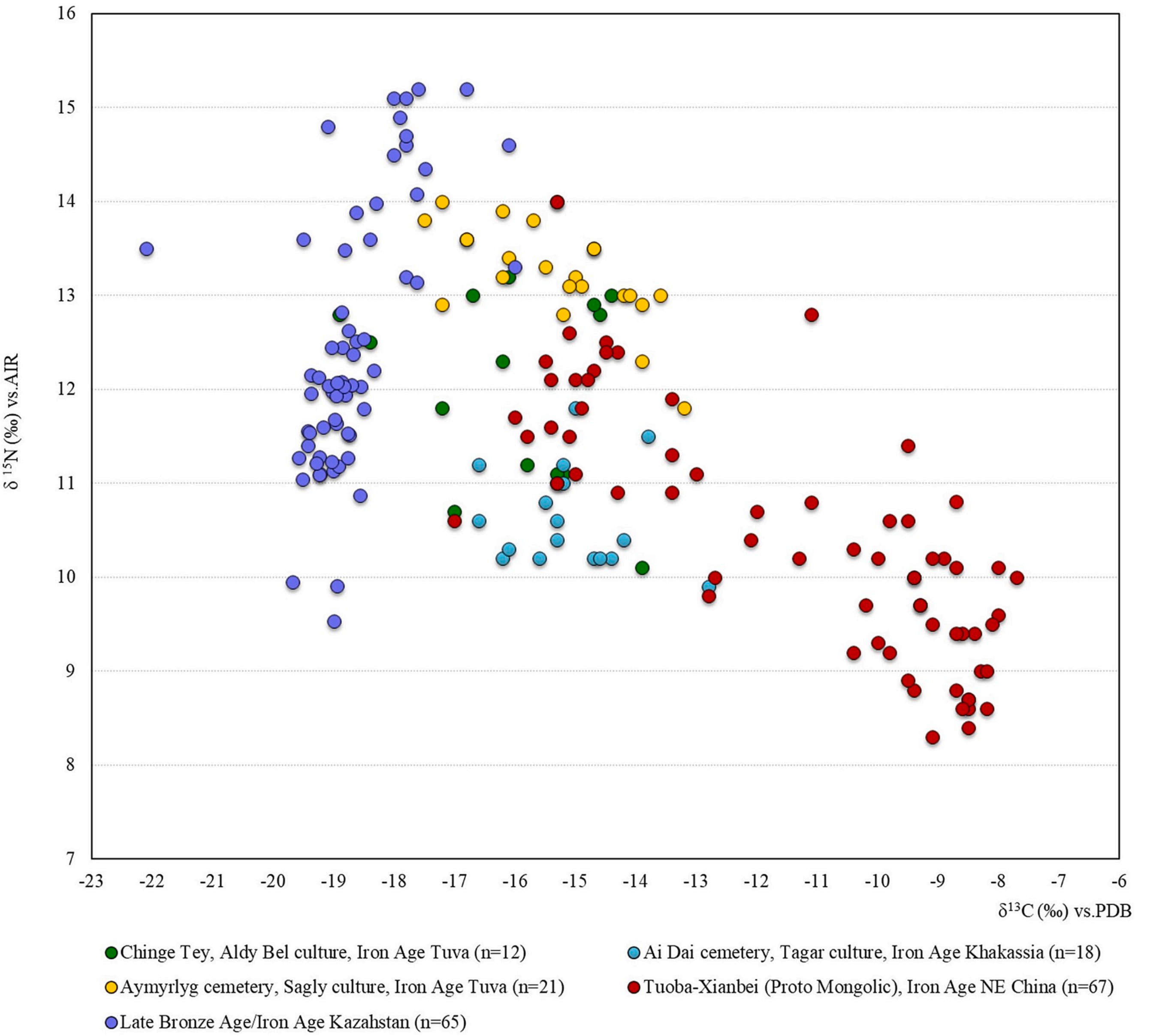

Fig. 11. Chinge Tey barrows in context: the $\delta^{13}C$ and $\delta^{15}N$ isotopic values of humans (n = 12) compared with Iron Age dietary patterns in transregional scale (n = 171); the Ai Dai and Aymyrlyg cemeteries in Tuva (data after Murphy et al., 2013); the pastoral Tuoba culture in northern China, Xianbei cemetery (Zhang et al., 2015); the Bronze Age/Iron Age Kazakhstan; Bestamak and Lisakovsk cemeteries (Miller et al., 2014); and Central and Eastern Kazakhstan (data after Ananyevskaya et al., 2018).

region revealed a higher incidence of dental pathologies and caries during the Scythian period, suggesting the potential coexistence of farming alongside a pastoral economy in this area. Borodovsky and Tur (2015) found that in Pazyryk burial grounds in Northern Altai, dental caries, calculus, and pathologies typically associated with the consumption of grain and cereals affected up to 18% of non-adults and 84 % of adults (Roberts and Cox, 2003; Pokutta et al., 2019). Meanwhile, in the Central Altai and high mountain territories of the Upper Altai, these indicators were 10% and 1.8%, respectively (Borodovsky and Tur, 2015). These findings demonstrate the diversification of economic strategies, encompassing both nomadic pastoralism and sedentary farming, not only across a broader territory but also among populations sharing otherwise similar material culture.

4.2. The Aldy-Bel funerary ritualism: social ranking and the concept of power

The Chinge Tey barrows, share certain common traits with other monumental tombs located in the Turan-Uyuk Valley. Regardless of the state of preservation, the barrows are of significant sizes and their location is carefully arranged within the surrounding landscape (Gryaznov, 1980; Parzinger, 2006). Barrows derive from different chronological subperiods, horse burials may or may not be present, the quality and volume of grave goods may vary as well, ranging from exceptional to relatively basic indicators of power (e.g. Chinge-Tey Western Chain). The majority of the deceased are males. The exceptionally high status of burials is incontrovertible and is linked with ideological concepts of prehistoric power. In that context, the whole *Valley of the Kings* phenomenon in Tuva can be seen not only as an archaeological fact or a place, but also as social landscape. In this context, the Aldy-Bel culture feasibly represents the horsemen warrior

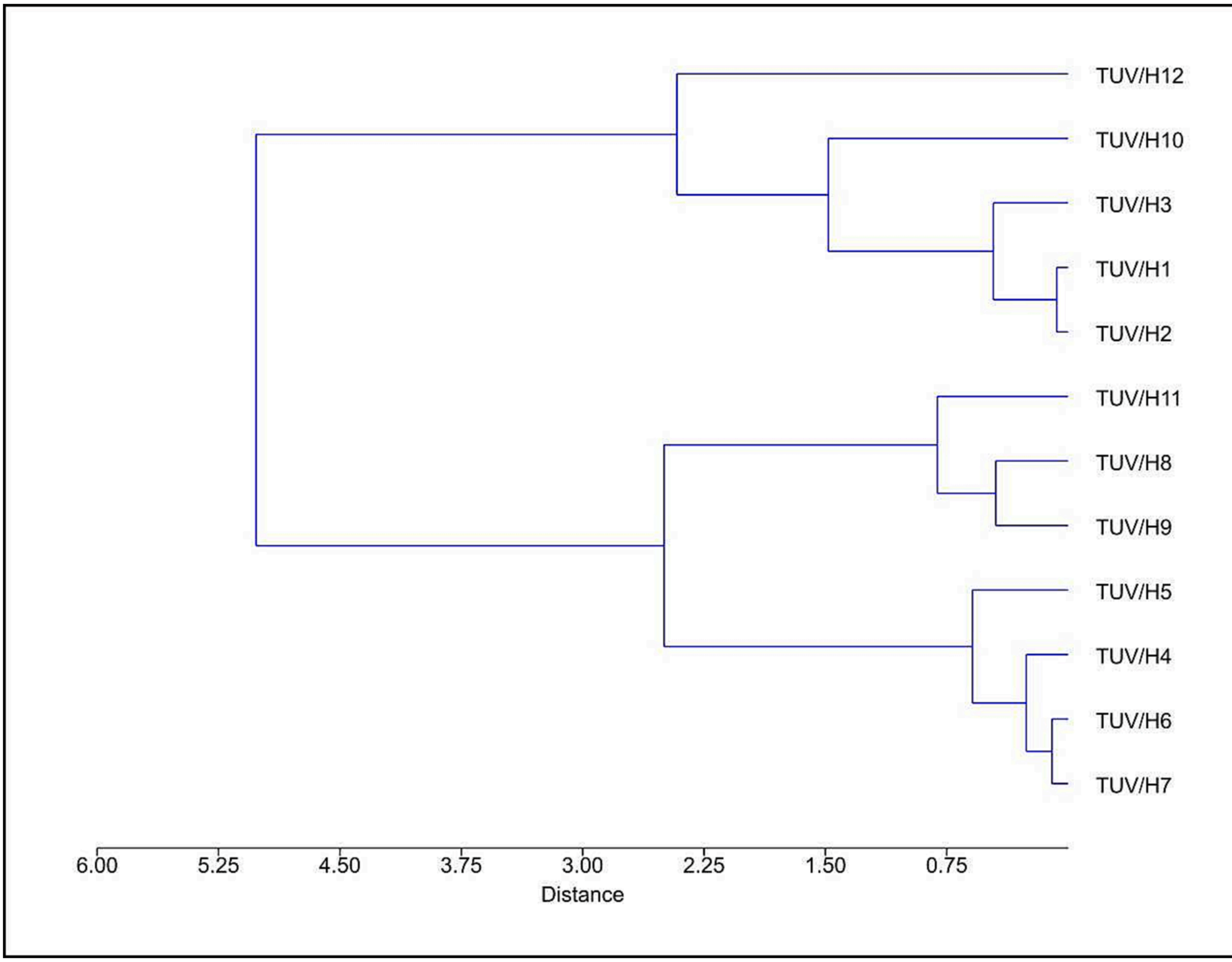

Fig. 12. Chinge Tey barrows: cluster dendrogram (PAST 4.1).

elite of the society (Chugunov, 2020). In the cultural environment of the Early Scythian Tuva, the burial rites of an elite (the Aldy-Bel) versus commoners (or lower social strata) differed considerably. This aspect seems to be related to the continuation of the Late Bronze Age traditions (the descendants of the so-called Mongun-Taiga culture), while the Aldy-Bel represents a new, allochtonic, and internally diversified social element (Chugunov, 2020).

The typical non-elite burial ground comprises several small barrows shared usually by families, extending to two or three generations. The central burials often contain skeletons of women, which underlines their significant role in the families. The example of those traditions can be found at the cemetery of Bai-Dag 8, burial grounds Eki-Ottug sites 1–2, in Ak-Dag and Khendei-Aksy cemeteries in Tuva (Hudiakov et al., 2013; Kilunovskaya et al., 2017). Some non-elite burials had been also uncovered in Kopto cemetery, located in the valley of the Kaa-Khem river (right tributary of the Little Yenisey; Chugunov, 2005). The inhabitants of the Kopto valley were buried in small barrows, round or oval in plan. Satellite burials contained the remains of children and juveniles. The dead were interred in a flexed position, head north-west. This body alignment is most commonly found in the Aldy Bel burial tradition. Grave goods were relatively few and mediocre, consisting of knives, bone-made artifacts (e.g. ornamented comb), bronze mirrors, or pendants. Burials dated to the 7th/6th century BC were poorly furnished with weaponry (Chugunov, 2005).

The elite, tribal and supra-tribal leaders were buried in another type of necropolis (Vdovchenkov, 2019a). The high-status burials from Chinge Tey reflects a militarized community of armed men (Vdovchenkov, 2019a; Vdovchenkov, 2019b). Funerary complexes built in the 9th-7th centuries BC and located in the *Valley of the Kings* reflect the idea of political power. That can be supported by the archaeological record of the Arzhan barrows (9th century BC; Gryaznov and Mannay-Ool, 1973). The immensity of the embankments and tombs speaks of the significant manpower used for its creation, the strong social attraction of the place, and its political significance.

The evolution of the Aldy-Bel culture was markedly affected by the mobility of nomadic groups in the region (Chikisheva, 2008; Chugunov, 2020). The high diversity and mobility of the prehistoric population of Tuva, possibly originating from outside the local region, undoubtedly add complexity to the study of cultural processes. As a result, employing isotopic analysis to investigate dietary strategies and food supply systems presents significant promise as a valuable resource for future research endeavors.

5. Conclusions

This paper focuses on a crucial bioarchaeological aspect that plays a fundamental role in understanding the concept of power and social organization among prehistoric elites: food resources, dietary status, and subsistence. At this stage of our study, the analysis of mobility and provenance has not been incorporated. However, the isotopic data obtained from the Chinge Tey burial mounds suggests that at least some members of the nomadic elite shared different food cultures and likely belonged to different tribal groups or populations. The nobility buried in the Chinge Tey mounds likely consumed lamb, mutton meat, and dairy products, with a minor contribution from C_3 plant staples. This dietary pattern aligns with a typical pastoral subsistence regime, where plant staples are limited or even absent. When comparing the isotopic data more broadly, we find that the diet of the Aldy Bel elite members did not differ in terms of quality but rather in quantity from the food culture of tribal groups. This hypothesis suggests the need for further isotopic analyses, such as $^{87}Sr/^{86}Sr$ isotopes, and aDNA screening of human bone materials.

The isotopic composition of animal tissues, especially mutton/goat meat and milk, which are primary components of the pastoral diet, depends on the stable isotopic composition of the animals' diet as well as fractionation and metabolism processes (McCutchan et al., 2003). In prehistoric Tuva, the animals consumed various shrubs and wild grasses, resulting in varied $\delta^{13}C/\delta^{15}N$ ratios due to physiological stress caused by arid and harsh environmental conditions. Modern studies indicate that the $\delta^{13}C$ values of animal tissues, including milk, are often influenced by the isotopic C_3/C_4 composition of the fodder and the relative digestibility of diet components. The $\delta^{13}C$ values primarily reflect the animals' feeding habits, although they can vary significantly among different meat fractions, with a higher difference observed in protein than in fat (up to 5.0‰ difference). The $\delta^{15}N$ values of the meat protein fraction exhibit differences among ruminant species, irrespective of the feeding regime (Inácio and Chalk, 2017). The dynamic relationship between sedentary, semi-sedentary, and pastoral economies has been examined in various regions of the Scythian-Siberian world. To a certain extent, all human adaptations are influenced by changing ethnic, ecological, or climatic conditions. The emergence and evolution of pastoral farming as a non-nomadic form of pastoralism demonstrate how seemingly distinct ways of life, such as nomadism and sedentism, can merge and coexist.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

We have shared all data in Supplements 1 and 2.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2023.104186.

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