Geoarchaeological Studies of Kurgans with Moustaches: Achievements and Prospects

Ivan V. Grudochko

Abstract The paper presents the results of geoarchaeological studies of kurgans with two stone ridges (referred to as moustaches) from the dual perspective of geology and radiocarbon dating. The first describes the survey of rocks in a monument and their sources, as a result of which we proposed the reconstruction of the construction process of the entire complex. We believe that the construction of one complex could be carried out within a fairly short period: a month or no more than one season. Radiocarbon data quite confidently date the kurgans with moustaches to the III/IV to mid-VII centuries.

Keywords Middle ages · Great migration of peoples · Steppe · Nomads · Kurgans with Moustache · Geology · Radiocarbon dating · Chronology

1 Introduction

The history of the Eurasian nomads is closely connected with the Ural-Kazakh region. It was in these steppes that the main migrations of the nomads of antiquity and the Middle Ages occurred. The history of the formation of the Scythian-Saka, Sarmatian, Hunnic, Turkic, and other cultures cannot be studied without archaeological materials of the South Ural region and Kazakhstan (Tairov 2017; Botalov 2008). One of the turning points in world history is the Migration Period, which can be traced here through the disappearance of the Hunno-Sarmatian (Late Sarmatian) archaeological culture and the emergence of a completely new historical and archaeological phenomenon called kurgans with moustaches. We believe that it is these complexes that testify to the initial stage of the Turkification of the Ural-Kazakh steppes.

Kurgans with moustaches were discovered in the first half of the XX century. This original archaeological complex is a burial mound from which two arched stone ridges (referred to as moustaches) 15 to 200 m or more in length extend. These monuments are mainly located in the Ural-Kazakhstan steppes (Fig. 1), although

I. V. Grudochko (✉)
South Ural State University, Chelyabinsk, Russia

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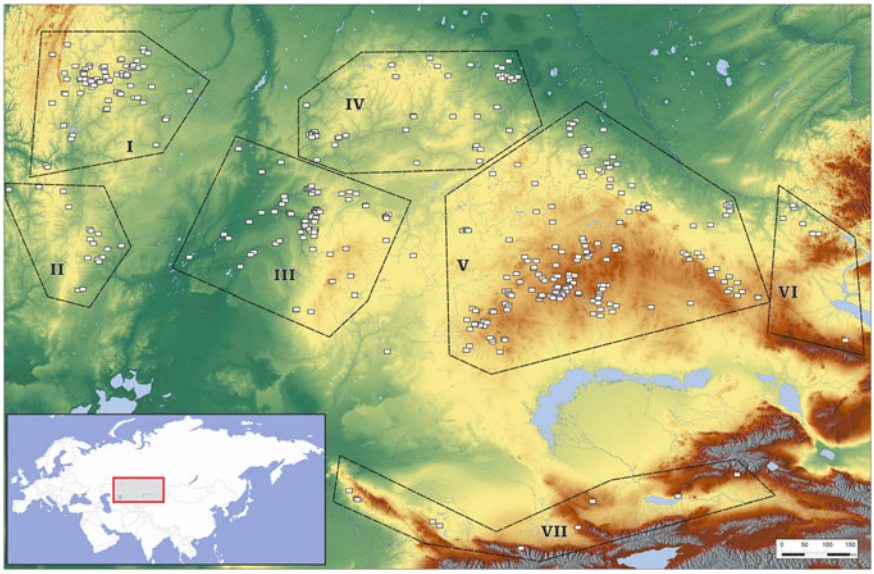


Fig. 1 The zonality of kurgans with moustaches. I—Southern Trans-Urals; II—ugodzhary; III—Ulytau and Turgay; IV—Northern Kazakhstan; V—Central Kazakhstan; VI—East Kazakhstan; VII—Southern Kazakhstan

there are isolated cases of their presence in Kalmykia, the Dnieper region, and in Crimea (Botalov et al. 2006; Tihomirov 2020; Tihomirov et al. 2020).s

Their cultural and chronological definitions are still being debated. They belong to the Early Saka period (Beisenov 1996; Habdulina 2007; Beisenov 2020[1]) or the Great Migration of Peoples Era and the Middle Ages (Botalov et al. 2006). We share the latter idea (Grudochko 2020). This ambiguous assessment results from the small number of found inventory and different opinions on its interpretation: some believe that the objects of the first millennium AD were placed into the kurgans with moustaches, and supporters of the late (early Medieval) interpretation believe that the kurgans with moustaches were built near and on top of early nomadic monuments.

In the last decade, geoarchaeological methods have been actively applied to the study of kurgans with moustaches. Let us describe the results of two approaches—geological and radiocarbon dating—which significantly expanded the knowledge on these complexes, and also allow us to determine their chronology.

The first approach was applied to two monuments from the Kamenny Ambar microdistrict (the Chelyabinsk region) and published in 2015 (Nikolski and Grudochko 2015). We assumed that a survey of the rocks from which kurgans were built, as well as searching for the source of raw materials, would help to reveal the construction process, labor costs, knowledge, and architectural and construction

[1] A. Z. Beysenov has recently expressed the need to review the chronology of kurgans with moustaches.

skills. In other words, this study is primarily aimed at studying the technological capabilities of the ancient population rather than the ritual or spiritual sphere of life. We are attempting to discover how long it would have taken to build these planned megastructures.

In our study, we completed a survey of the area, determined the raw materials used for the construction of the kurgans, and established the regularity of the raw materials' location in the kurgan with moustaches. We concluded that the workflow during the construction of the kurgans with a moustache in Sukhodol and Sarbulat-1 was as follows: (1) stone collection; (2) storing the stone in piles or immediately delivering them; (3) delivery of stone material to the site; (4) unloading, and possibly immediately laying out the structures; (5) returning for more stone materials. For both monuments, we have adopted the minimal values of labor resources to fulfill all labor costs. However, they also allow us to state with a high degree of probability that the construction of one kurgan with moustaches could be carried out within one season, and most likely—no more than a month.

The 16 radiocarbon dates (as of 2018) indicate the period from the III to the mid-VII centuries AD. A comparison with the inventory typology allows us to suggest the period of the IV–VII centuries as the most probable time of construction. It would seem that it is necessary to finally abandon the Scythian-Saka attribution of these monuments.

2 Materials and Methods

2.1 Geological Research

We examined two sites from the Kamenny Ambar microdistrict (Kartalinsky district, Chelyabinsk region): Sukhodol and Sarbulat-1. The tasks of our geological survey included: (1) identifying the stones used and establishing the regularity of their location as part of the structure; (2) survey of the surrounding area to detect possible sources of raw materials for construction; (3) calculating the mass and volume of raw materials used and attempting to restore the technological process, labor costs, and time of construction. The volume of the stone material was calculated by measuring the area and approximate volume, taking into account the volume weight of a particular type of rock. These data are listed in Tables 1 and 2.

The kurgan with moustaches of Sukhodol (Fig. 2, *2*) consisted of a central stone embankment, two arched stone ridges (moustaches) extending from the embankment in an easterly direction, and stone platforms at their beginnings and ends. The diameter of the central embankment is 12 m; the height is 0.15–0.2 m. It consisted of stones of different sizes, laid in 1–3 layers. The thickness of the rock layer increased from the periphery of the embankment to its center. The arc length of the northern moustache is 203 m, the southern moustache—85.5 m. In straight lines, they were measured at 194.5 and 172 m, respectively. The ridges vary in width from 1 to 2.5 m

Table 1 The composition and the parameters of the Sukhodol kurgan with a moustache

Size/diameter (m)	Square (for a circle of $3.14 \times r^2$)	Height (m)	Volume (m^3)	Volumetric weight (t/m^3)	Volume weight (t)	Stone type
The Central kurgan						
12 (d)	≈113:4 = 28.3	≈0.18	5.1	2.6	5.1 × 2.6 = 13.3	Granite
	≈113:4 = 28.3	≈0.18	5.1	3	5.1 × 3.0 = 15.3	Gabbro
	≈113:4 = 28.3	≈0.18	5.1	2.8	5.1 × 2.8 = 14.3	Basalt
	≈113:4 = 28.3	≈0.18	5.1	2.7	5.1 × 2.7 = 13.8	Quartz
	$\sum = 113.2$		$\sum =$ 20.4		$\sum = 56.7$	
The western platform of the northern moustache						
4.3 × 5.8	≈25.0	0.18	≈4.5	2.6	11.7	Granite
The western platform of the southern moustache						
4(d)	12.6	0.18	≈2.3	≈2.8	6.4	Gabbro, Basalt, Quartz
The eastern platform of the northern moustache						
4.25 × 5.75	≈24.44	0.18	≈4.4	2.7	11.9	Quartz
The Eastern platform of the South moustache						
4.25 × 5.75	≈24.44	0.18	≈4.4	2.7	11.9	Quartz
Northern moustache						
82.5 × 1.8	148.5	0.18	27	2.7	73	Granite
29.7 × 1.8	53.46	0.18	8	3	24	Gabbro
24.5 × 1.8	44.1	0.18	14	2.8	39	Basalt
42.3 × 1.8	76.14	0.18	14	2.7	38	Quartz
					$\sum = 174$	
Southern moustache						
4 × 1.8	7.2	0.18	1.3	2.6	3	Granite
33.6 × 1.8	60.5	0.18	11	3	33	Gabbro
49.3 × 1.8	88.7	0.18	16	2.8	43	Basalt
84.6 × 1.8	152.3	0.18	27	2.7	73	Quartz
	$\sum = 308.7$				$\sum = 152$	

The total weight of the volume of stone material of the Sukhodol complex is 424.6 t

Table 2 The composition and the parameters of Sarbulat-1 kurgan with moustaches

Size/diameter (m)	Square (for a circle of $3.14 \times r^2$)	Height (m)	Volume (m^3)	Volumetric weight (t/m^3)	Volume weight (t)	Stone type
The Central and South kurgans						
11(d)	95	0.4	38	2.6	98.8	Granite
The Central and Northern kurgans						
8(d)	50.2	0.3	15.1	2.6	39.3	Granite
Four platforms of moustaches						
4(d)	12.6	0.2	2.5	2.6	$6.5 \times 4 = 26$	Granite
Northern moustache						
164×1.5	246	0.2	49.2	2.6	127.9	Granite
Southern moustache						
138×1.5	207	0.2	41.4	2.6	107.6	Granite

The total weight of the volume of stone material of the Sarbulat-1 complex is 399.6 t

(the average width is 1.8 m). The platforms at the ends of the moustaches are sub-rectangular in shape and vary in size from 4×4.5 to 5.5×6 m, or: the western platform of the southern ridge had a circular shape with a diameter of 4 m (Botalov et al. 2006, 39–40). The moustaches were constructed of alternating stone types with different lithological compositions. The composing rocks of the right shore side of the river valley also alternate, replacing each other in the latitudinal direction, and the moustaches of the Sukhodol complex (intentionally or not) repeat the lithology of the side (Fig. 3, *I*, *II*).

The complex was built using 4 types of rocks: granite, gabbro, basalt, and quartz. The technical and geological parameters of the Sukhodol kurgan with moustaches are provided in Table 1.

The Sarbulat-1 monument consisted of two stone kurgans, from which two stone ridges branched off in the eastern direction. The northern embankment is 8.0 m in diameter and 0.3 m high; the southern embankment is 11.0 m in diameter up to 0.4 m high. The northern moustache extends to the East with an arc length of 164 m. The western and eastern ends are decorated with rounded platforms with a diameter of about 4 m and a height of 0.2 m. The southern moustaches, stretching out from the kurgan to the NW, had the shape of an arc with the length of 138 m; with its ends made in the form of rounded pads with a diameter of 4 m and a height of 0.2 m. The widths of both ridges ranged from 1.0 m to 2.0 m. The Northern kurgan was square-shaped with the side length of about 8.5 m, and the South as a more or less regular pentagon with the length of the northside of 8.5 m, NE—7 m, SE—8.5 m, SW—8 m, and NW—8 m (Botalov et al. 2006, 59–61).

Technical and geological characteristics of the kurgan with the moustaches of Sarbulat-1 are in Table 2.

The kurgans of the central structure and the ridges are composed of leucogranites and individual blocks of quartz. The composition of the rocks of this complex differs

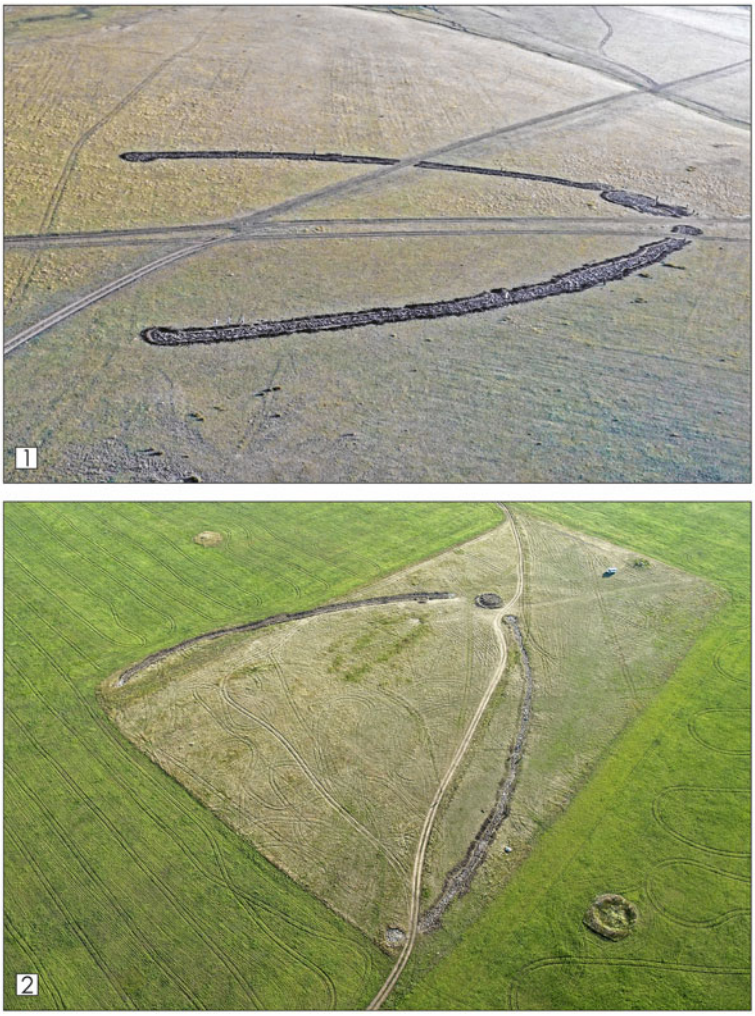


Fig. 2 Kurgans with moustaches of the Southern Trans-Ural Region. 1—Sarbulat-1; 2—Sukhodol

from the site of Sukhodol, mainly because there is no alternation of different rocks throughout the ridges. However, the location of variegated stones and white blocks of quartz is subject to a certain pattern. Their concentrations mark the ends of the ridges and their end layouts, except for the western end of the southern ridge.

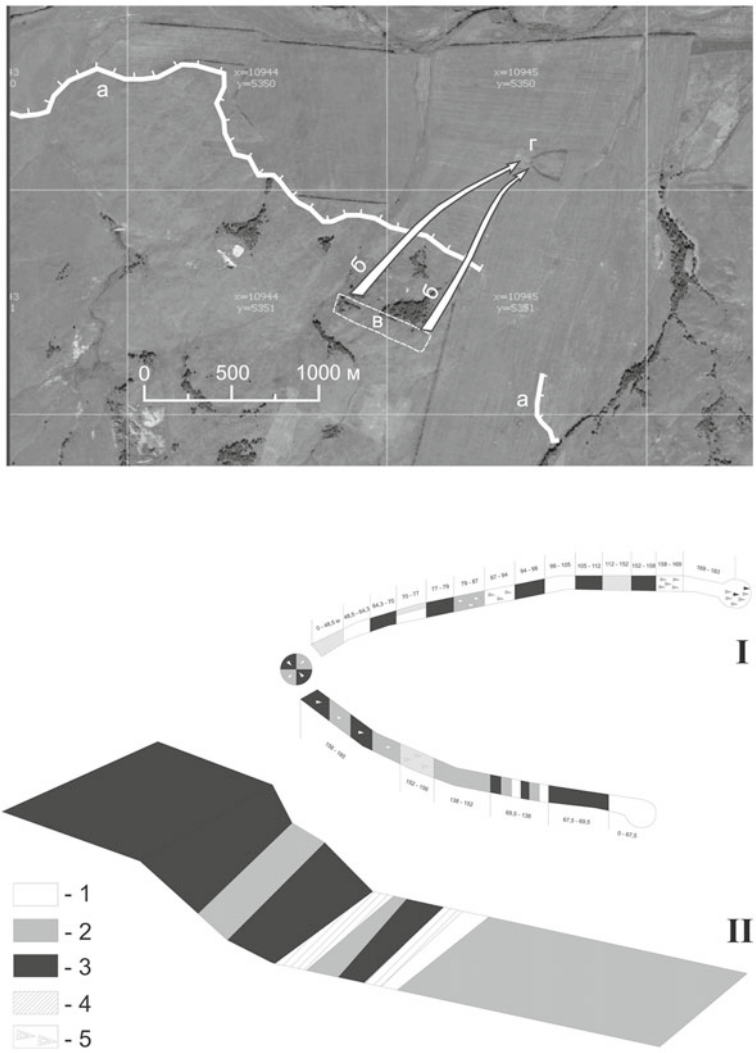


Fig. 3 The layout of the Sukhodol kurgan with moustaches, sources of stone raw material, and the most convenient delivery paths (satellite image with legend). а—tectonic scarp; б—the most convenient delivery path; в—stone storage location; г—the Sukhodol kurgan; I, II—scheme of linking structures of Sukhodol kurgans (I) the lithology of its location (II); I—lithology intervals of Sukhodol kurgan moustaches (no scale); II—geological map of the tape; 1—quartz; 2—basalt; 3—gabbro; 4—granite; 5—inclusion of serpentinites

2.2 Radiocarbon Chronology

As of 2018, we know and processed 16 dates obtained from 12 complexes (Table 3).

Six complexes originate from the Southern Trans-Urals (Sarbulat-1, Sukhodol, Kainsai, Gorodishchenskoe IX, Rymniksky, Selentash) (Botalov 2009, 129; Botalov 2013, 71; Grudochko and Epimakhov 2015), six are from Central Kazakhstan (Tandaily 2, Zhamantas, Kyrykungir, Koytas, Besoba, Kabantau) (Beisenov et al. 2016a, b, 2017, 2018). Thirteen samples are from the kurgans of the central structure, and three came from the end sites of the moustache (Gorodishchenskoe IX, Kabantau). The measurements were conducted in the four laboratories (Le, SPb, Ki, UBA) by scintillation and accelerator mass spectrometry (AMS). The following materials were used as sources of carbon isotopes: ceramics (4), animal bone (9), human bone (2), and charcoal (1). The OxCal 3.10 program (the IntCal13 calibration curve) was used to calculate the calibrated intervals; all uncalibrated dates (BP) are from 1950. The results are presented in Table 3. A combined date was formed for kurgan 5 of the Selentash burial ground (Fig. 4, *selentash_comb*). Despite the relatively low level of statistical agreement between the two dates (Ki-17075 and SPb-958), the result seems quite realistic (1539 ± 29 BP) if compared to the rest of the values in our series. In the further work on the summation of probabilities. In general, the series looks quite homogeneous, which is well recorded on the chart (Fig. 4, *4–5*).

3 Results and Discussion

3.1 Geological Research

The workflow during the construction of the complex Sukhodol can be described as following: (1) collected raw material (Fig. 3, *e*) could be stored in piles or loaded and shipped for the construction site of the monument (Fig. 3, *б*); (2) unloading for the construction and (3) a return for additional material. While constructing the kurgan with the moustache, the horse-drawn transport could be probably used, since many stones could not be moved manually at a distance of about 1.5 km due to their size and weight (this is the distance from the procurement site to the site the kurgan. Theoretically, the team of people involved in the construction was divided into groups by specialization: (1) stone pickers and loaders; (2) people who drove horses and delivered building material to the site; (3) builders. We suppose that the stone pickers and loaders were assigned to spots with various lithological compositions. Therefore, during the delivery and construction of the kurgan, an alternation of intervals consisting of different rocks was obtained. Judging by the

Table 3 Radiocarbon chronology of kurgans with moustaches from Southern Trans-Urals and Central Kazakhstan

Monument	Complex	Lab code	Kind of analysis	Material	Convention date	Calibrated date	
						68.20%	***95.40%***
Sarbulat	Kurgan 2	Ki–15634	Scintillation	Ceramics	1540 ± 80	430-590AD (68.2%)	340-660AD (95.4%)
Suhodol	Kurgan 5	Le-8303	Scintillation	Animal bone	1550 ± 100	410-610AD (68.2%)	250-300AD (3.2%) 310-660AD (92.2%)
Kajnsaj	Kurgan 14	Ki–15635	Scintillation	Ceramics	1470 ± 80	460-490AD (4.2%) 530-660AD (64.0%)	410-690AD (95.4%)
GorodishchenskoeIX	Northern moustache	SPb–535	Scintillation	Charcoal	1460 ± 50	560-645AD (68.2%)	430-490AD (5.0%) 530-670AD (90.4%)
Rymnikskij	Central kurgan	SPb–957	Scintillation	Horse bone	1560 ± 65	420-570AD (68.2%)	380-640AD (95.4%)
Selentash*	Kurgan 5	Ki–17075	Scintillation	Ceramics	1760 ± 150	80-430AD (68.2%)	100BC-650AD (95.4%)
Selentash*	Kurgan 5	SPb–958	Scintillation	Ceramics	1530 ± 30	430-490AD (25.9%) 530-580AD (42.3%)	430-600AD (95.4%)
		*combined date			1539 ± 29	430-490AD (41.7%) 530-570AD (26.5%)	420-590AD (95.4%)

(continued)

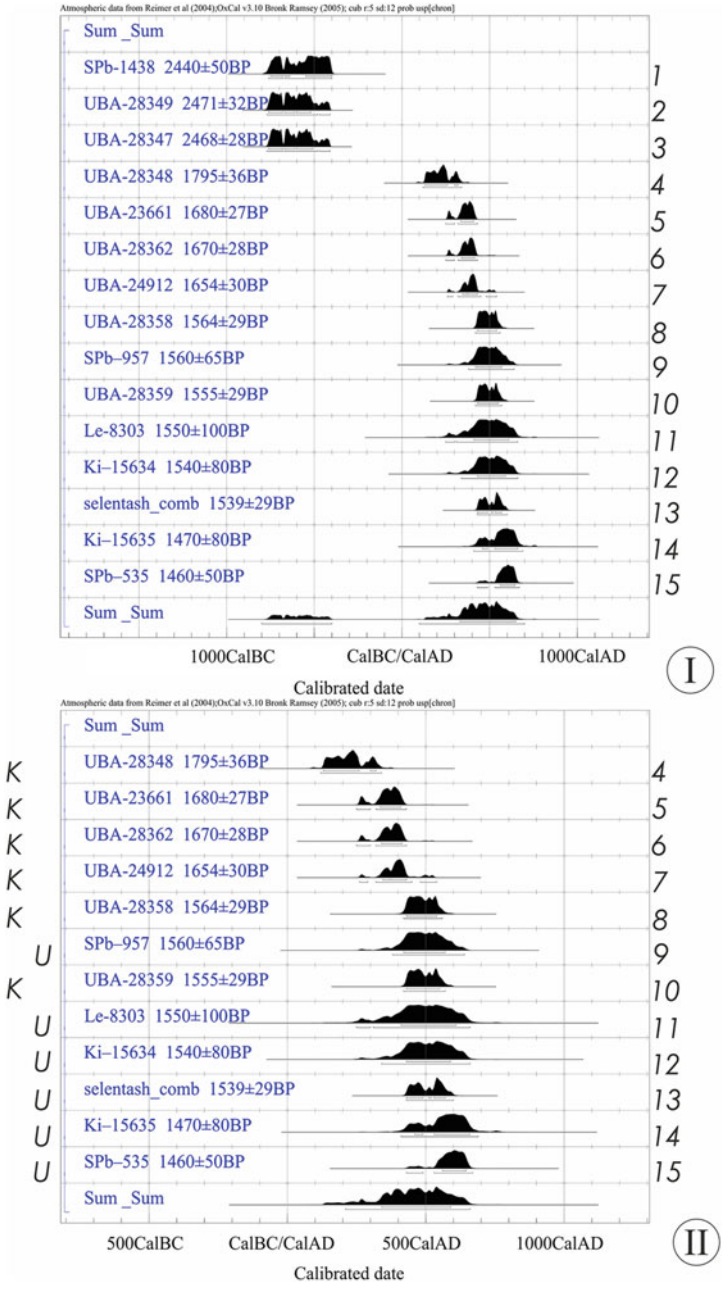
Table 3 (continued)

Monument	Complex	Lab code	Kind of analysis	Material	Convention date	Calibrated date	
						68.20%	***95.40%***
Tandajly 2	Kurgan 2a (east)	UBA-28348	AMS	Horse bone (jaw fragment)	1795 ± 36	300-320AD (6.2%) 130-260AD (62.0%)	120-340AD (95.4%)
Tandajly 2	Kurgan 2 (west)	UBA-28347	AMS	Human bone	2468 ± 28	670-610BC (14.4%) 760-680BC (26.0%) 600-510BC (27.7%)	470-410BC (8.7%) 770-680BC (28.9%) 670-480BC (57.8%)
Kyrykungir	Central kurgan	SPb-1438	scintillation	Horse bone	2440 ± 50	670-640BC (5.0%) 750-680BC (16.9%) 550-400BC (46.3%)	757-678BC (21.2%) 670-400BC (74.2%)
Zhamantas	East kurgan	UBA-24912	AMS	Animal bone (horse?)	1654 ± 30	345-370AD (13.8%) 375-430AD (54.4%)	260-290AD (3.8%) 480-540AD (6.9%)

(continued)

Table 3 (continued)

Monument	Complex	Lab code	Kind of analysis	Material	Convention date	Calibrated date	
						68.20%	***95.40%***
Zhamantas	West kurgan	UBA-28349	AMS	Human bone	2471 ± 32	670-610BC (16.2%) 760-680BC (25.0%) 600-520BC (27.0%)	470-410BC (8.5%) 770-480BC (86.9%)
Kojtas	East kurgan	UBA-23661	AMS	Horse bone	1680 ± 27	335-410AD (68.2%)	250-300AD (12.2%) 320-430AD (83.2%)
Besoba	East kurgan	UBA-28362	AMS	Horse bone	1670 ± 28	340-415AD (68.2%)	250-300AD (8.6%) 320-430AD (86.8%)
Kabantau	East platform of north moustache	UBA-28358	AMS	Animal bone (small cattle)	1564 ± 29	430–540 AD (68.2%)	420-560AD (95.4%)
Kabantau	East platform of north moustache	UBA-28359	AMS	Animal bone (small cattle)	1555 ± 29	430–550 AD (68.2%)	420-570AD (95.4%)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UBA-28347 2468±28BP
UBA-28348 1795±36BP
UBA-23661 1680±27BP
UBA-28362 1670±28BP
UBA-24912 1654±30BP
UBA-28358 1564±29BP
SPb–957 1560±65BP
UBA-28359 1555±29BP
Le-8303 1550±100BP
Ki–15634 1540±80BP
selentash_comb 1539±29BP
Ki–15635 1470±80BP
SPb–535 1460±50BP
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UBA-28358 1564±29BP
SPb–957 1560±65BP
UBA-28359 1555±29BP
Le-8303 1550±100BP
Ki–15634 1540±80BP
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II

◀**Fig. 4** Radiocarbon chronology of kurgans with moustaches. I—all dates; II—dates excluding early complexes; K—Central Kazakhstan; U—Southern Urals; 1—Kyrykungir (Beisenov et al. 2016); 2—Zhamantas, Western kurgan (Beisenov et al. 2017); 3—Tandajly 2, kurgan 2 (Western kurgan); 4—Tandayly 2, kurgan 2a (Eastern kurgan) (Beisenov et al. 2016); 5—Koytas, Eastern kurgan; 6—Besoba, Eastern kurgan (Beisenov 2017); 7—Zhamantas, Eastern kurgan (Beisenov et al. 2017); 8—Kabantau (Eastern platform of the Northern moustache) (Beisenov et al. 2018); 9—Rymnikski (Grudochko and Epimahov 2015); 10—Kabantau (Eastern platform of the Northern moustache) (Beisenov et al. 2018); 11—Sukhodol, kurgan 5; 12—Sarbulat-1, kurgan 2; 13—Selentash; 14—Kajnsay, kurgan 14; 15—Gorodishhenskoe IX, kurgan 5 (Botalov 2009, 2013; Grudochko and Epimahov 2015)

assortment in the kurgan with the moustache, there were 4 brigades. Each part of the brigade had collectors and transporters with horses. It is also possible that the transporters worked independently and drove up to the assembly points where the stone material was ready for loading.

The average working capacity of one horsepower is 75 kg m/s, which means the power expended when a load weighing 75 kg is lifted evenly vertically at a speed of 1 m/s or 75 kg m of work per 1 s (Work and energy of a horse, 2015). The same value can be represented as 4500 kg m/min or 270 tm/h. The working capacity of a person aged 20 to 49 years on average is from 11 to 16 (average 14.1) kg m/min per 1 kg of body weight. Taking 60 kg as the average value of body weight, we get a working capacity of 846 kg m/min or 14 kg m/s (50.76 tm/h) (Evaluation test 2015). According to other data, the human working capacity of the same age in indicators below the average ranges from 500 to 700 (average 600) kg m/min or 10 kg m/s (36 tm/h) (Sirotin and Belozerova 2015).

To calculate the time required for delivery of the total quantity of stone with one horse, the following calculation will be made 424,6 (the total weight of stones) divide into 270 (the horse performance), and multiply by 1500 (the distance from the place of gathering stones to a kurgan). We get a value of about 2359 h (98.2 days). It does not take into account the time of loading and unloading, weather conditions, etc. It is difficult to say how much time per day people had to work. We will conditionally accept daylight hours with breaks for eating and resting people and horses. If we accept the hypothesis of four brigades and a light day of 12 h, then it would take 2359: 4 (horses) = 589: 12 = 49 days, i.e., about 1.5–2 months to build the Sukhodol kurgan with a moustache. This calculation does not take into account the working capacity of a person, which is approximately 0.1–0.2 of the working capacity of a horse. Theoretically, this could be enough for loading, unloading, and laying the stone.

The scope of work during the construction of the Sarbulat-1 monument was similar to the previous complex: collection, transportation, construction. The total weight of the stone material used to create the kurgan with the moustache of Sarbulat-1 was 399.6 t (see Table 2). The location of granite where the raw material was collected,

Table 4 Modeling the construction time of Sukhodol and Sarbulat-1 burial kurgans with moustaches, depending on the number of horses and working hours

Monument	Distance from the place of collecting stones to the burial kurgan (m)	The number of horses and the total running time at 12-h/6-h workday			
		1 horse (days)	4 horses (days)	10 horses (days)	50 horses (days)
Sukhodol	1500	196/393	49/98	19.6/39.3	3.9/7.9
Sarbulat-1	300	37/74	9.3/18.5	3.7/7.4	0.7/1.5

is at a distance of about 300 m to the west of the monument, that is, 5 times closer than on Sukhodol. The calculation of the time of delivery of stone material when using one horse was made similarly and amounted to 444 h (18.5 days), or about 37 workings 12-h-long days, just slightly longer than a month. Since the structure of the ridges does not show the alternation of sections with different types of stones, it is difficult to assume the number of brigades that could be involved in the construction.

When analyzing the Sukhodol complex, we assumed the presence of the four brigades corresponding to the assembly sites of various bedrock. In Sarbulat-1, 37 working days correspond to the use of only one horse. For both monuments, we have adopted the most minimal values of labor cost resources to fulfill all labor requirements. However, they also allow us to state that the construction of a single kurgan with moustaches could be carried out within no more than one season. The actual number of laborers and draft power remains unknown, but given that these monuments were left by the pastoral population, the number of horses involved as the main draught power was no more than one to four. The construction time of a single kurgan with a moustache would be less if more labor will be involved: draft the horses and people serving them (with a competent organization of the work process). In Table 4, we tried to describe the modeling using different numbers of horses depending on the 12-h and 6-h workday. It should be noted that the proposed scenarios are just a mathematical description of a horse continuously walking for 6/12 h a day with a constant working capacity of 75 kg-m/sec. However, with all the assumptions, it can be assumed that the construction of a burial kurgan with moustaches hardly required colossal labor costs in nomadic communities.

It is most likely that the construction of these ritual complexes was associated with some collective events (holidays, commemorations), which were arranged by the pastoral population during their summer stay in the southern Trans-Urals.

3.2 Radiocarbon Chronology

Before proceeding to a discussion of the results, it is necessary to point out the shortcomings of the initial data. The dates were obtained in different ways (scintillation counting and AMS) from different territories. Table 3 and Fig. 4 clearly show that the dates were distributed in the same way: earlier dates (AMS) in Central Kazakhstan and later ones (scintillation counting) in the Southern Trans-Urals. This nuance must be taken into account when interpreting radiocarbon dates. However, on the other hand, this picture does not contradict our historical knowledge about the vector of nomadic migrations from east to west, implying that the earlier complexes are in the east, and the later ones are in the west.[2]

Summing up the probabilities of the results of radiocarbon dates formed two intervals, amount which the early ones are the large kurgans and the kurgan with the moustache of Kyrykungir (Fig. 4, *I*). The second interval is comprised of the actual kurgans with moustaches and shows the following values (Fig. 4, *II*): 340–590 AD at 68.2%, and—210–660 AD at 95.4%. Thus, the radiocarbon dates available today allow us to state with a high degree of confidence (95.4%) that the events of interest occurred from the beginning of the III to the middle of the VII centuries AD.

The Southern Urals monuments (Fig. 4, *U*) demonstrate the interval of 420–620 AD (68.2%) and 380–670 AD (95.4%), or from the last decades of the IV century AD to the second half of the VII century AD. The Central Kazakhstan monuments (Fig. 4, *K*) are older with 330–550 AD (68.2%) and 160–570 AD (95.4%), or the middle of the II—first quarter of the V centuries AD. The extension is due to the Tandaily-2 complex (UBA-28348, 1795 ± 36), which is still the earliest among the kurgans with moustaches (according to the radiocarbon dating). At the same time, the relative chronology between the earlier (Central Kazakhstan) and the later (the Southern Urals) complexes is documented. It should also be noted that all the dates are consistent with each other, showing a continuous column throughout the entire period of construction of kurgans with moustaches.

Separately, we will single out the Tandaily 2 and Zhamantas complexes from Central Kazakhstan consisting of larger kurgans, to which complexes with a moustache are attached. The dates from the large kurgan date back to the Early Iron Age (2468 ± 28 and 2471 ± 32), while the head kurgan of the complex with the moustache was built some 700–800 years later (1795 ± 36 and 1654 ± 30). This observation is quite consistent with the concept of those researchers who state that in Central Kazakhstan there was a developed tradition of using older kurgans for the construction of kurgans with moustaches (Botalov and Gutsalov 2000, 197–198;

[2] It is quite evident that there are absolutely no AMS dates for the territory of the Southern Trans-Urals to clarify the chronology. Therefore, in 2021, we sent 4 duplicate samples for three burial kurgans with moustaches of the Southern Trans-Urals. Their results and generalization with previously available data will be published in the next papers.

Botalov et al. 2006, 89–91). Only one date of the Kyrykungir complex (SPb-1438, 2440 ± 50) contradicts the general column of radiocarbon values. The monument consists of a single kurgan, from which the ridges depart, but it is not necessary to exclude the secondary use of this kurgan for the construction of the kurgan with the moustache. We also did not use the dates from the Kyzylshilik burial ground, which show significant deviations. The sample from Kurgan 2b was taken from a pile of bones of domestic animals (18 cm from the top of the kurgan) with the result of 99 ± 28. The remaining three samples obtained from different objects of kurgan 6 showed inconsistent values (140 ± 24; 890 ± 26 and 1351 ± 26) (Beisenov and Kasenalin 2018, 97).

We compared the artifacts that relate to the burial under the kurgans with moustaches. The radiocarbon chronology of the kurgans with moustaches does not contradict the typology of the inventory (Fig. 5).

From the point of view of radiocarbon dating, the number of available dates for both, Central Kazakhstan and Southern Trans-Urals is not enough. Nevertheless, the data available today outline the period of construction of kurgans with moustaches during the III/IV to the middle VII centuries AD (95.4%).

4 Conclusions

As we have seen, the geoarchaeological method allowed us to significantly expand our knowledge about the kurgans with moustaches. The earliest complexes (III/IV centuries) appeared in Eastern Kazakhstan, Tarbagatai, and Chingistau as a result of the migration of nomads from Central Asia. For the more eastern regions, we know several complexes from the Xinjiang Uyghur Autonomous Region (Grudochko et al. 2020), where we should look for the origins of this tradition. At the initial stage, the new population develops the Eastern Sary-Arka, and by about the second half of the century reached the Trans-Urals. However, a separate study should be devoted to this issue.

For the construction of kurgans with moustaches (not only Sukhodol and Srabulat-1 but also other similar monuments), it is necessary to align the terrain of the site, the proximity, and accessibility for the extraction of stone material. Judging by the area of the kurgans with a moustache of the Trans-Ural group, all of them are located within the Trans-Ural peneplain and the continental-marine basement plain, which have such surfaces with numerous small rocky outcrops of bedrock and deposits of blocky-gravelly material, especially along modern river valleys. Thus, these geomorphological areas had rational conditions for the availability of stone material and, accordingly, optimal labor costs in the construction of kurgans with moustaches. Simply put, the labor costs for their construction were not as large as it seems at first glance.

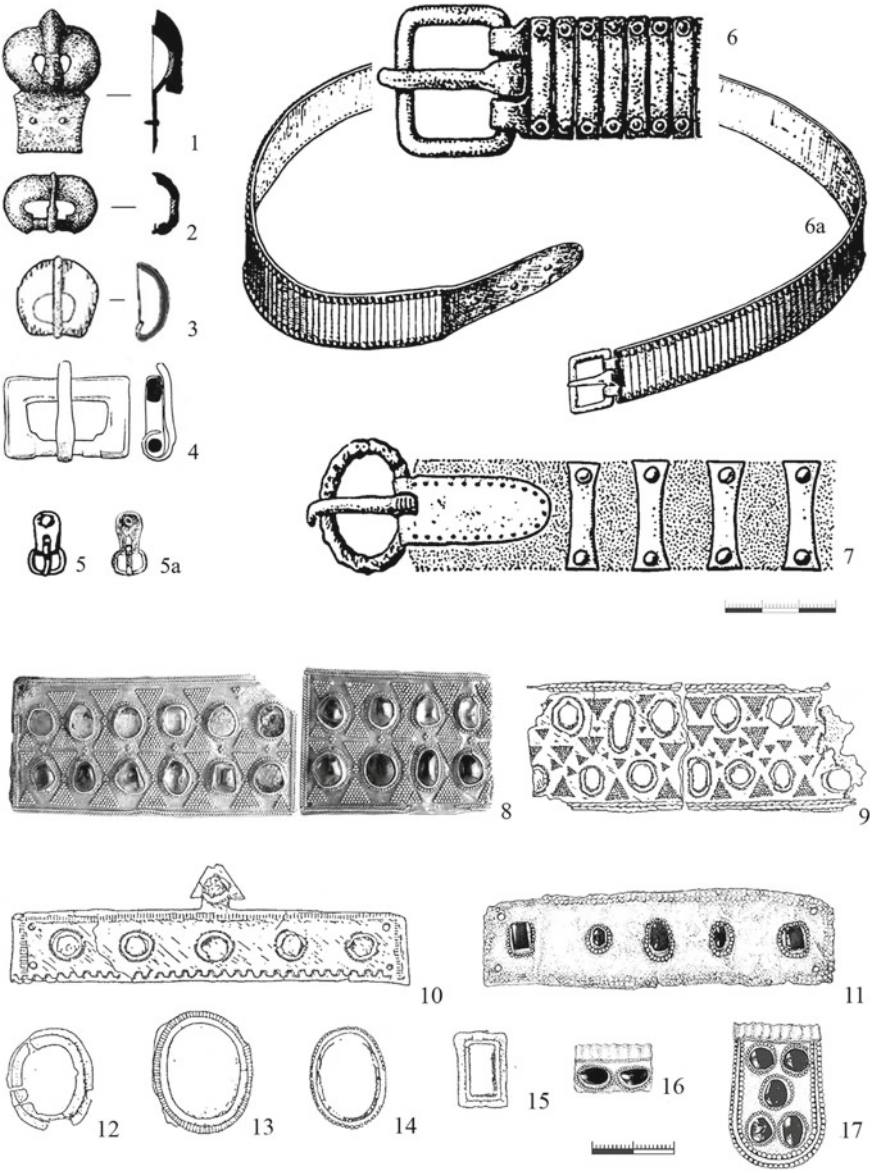

Fig. 5 Inventory from the kurgans with moustaches and synchronous burial monuments of the 5th–sixth centuries in the Ural-Kazakhstan steppes. 1, 2—Kamenny Ambar (kurgan 6); 3—Arkaim; 4—Borovoe; 5, 5a, 6, 6a, 8—kurgan with moustaches Kanattas (kurgan 19); 5/5a—variants of drawings the buckle; 6a—reconstruction of the belt; 7—kurgan with moustaches Zevakino (kurgan 1); 9, 10, 12–15—kurgan with moustaches Solonchanka I; 11, 16, 17—kurgan with moustaches Atasu-2

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