Приложения / Applications

**Morphogenetic Connections of the Early Bronze Age Populations
from Mongolia from Craniofacial Morphology Perspective**
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**Морфогенетические связи населений эпохи ранней бронзы Монголии
по краниологическим данным**
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Table 1. Cranial series from Neolithic – Early Bronze Age of Eurasia used for the comparison (adults)

1.	Neolithic, Eastern Mongolia*	Mamonova, 1979; Tumen, 1985; additional measurements of the authors
2.	Neolithic, Northern Mongolia	Mijiddorj, 2016; additional measurements of the authors
3.	Afanasievo culture, Khangai mountains (Shatar-Chulu)	Tumen, 1978; Mamonova, 1980; This study
4.	Takhilgat udzuur-5, fence 31, Early Bronze, Mongolian Altai	This study
5.	Khemtseg culture, Western Mongolia	This study
6.	Boysman-2, Neolithic, Far East	Chikisheva, 2012
7.	Neolithic, Yakutia	Chikisheva, 2012
8.	Kitoi culture, Transbaikalia	Mamonova, 1983
9.	Kitoi culture, Angara	Mamonova, 1983
10.	Kitoi culture, Upper Lena	Mamonova, 1983
11.	Isakovo culture, Angara	Mamonova, 1983
12.	Serovo culture, Angara	Mamonova, 1983
13.	Serovo culture, Upper Lena	Mamonova, 1983
14.	Glazkovo culture, Transbaikalia	Mamonova, 1983
15.	Glazkovo culture, Olkhon region	Mamonova, 1983
16.	Glazkovo culture, Angara	Mamonova, 1983
17.	Glazkovo culture, Upper Lena	Mamonova, 1983
18.	Neolithic, forest-steppe, Krasnoyarsk-Kansk	Solodovnikov, Bagashev, Savenkova, 2020
19.	Neolithic-Eneolithic, Gorny Altai*	Chikisheva, 2012
20.	Neolithic, northern downhills, Altai	Average of Dremov, 1980; Chikisheva, 2012
21.	Neolithic, Kuznetsk basin	Chikisheva, 2012
22.	Neolithic, Barnaul-Biysk Obi region	Average of Dremov, 1980; Solodovnikov, Tur, 2017
23.	Neolithic, Novosibirsk-Kamen-na-Obi Ob region	Solodovnikov, Tur, 2017, Table 3
24.	Neolithic-Eneolithic, Middle Irtysh	Solodovnikov et al, 2019
25.	Neolithic, Baraba forest-steppe	Chikisheva, 2012 by: Solodovnikov et al, 2019, Table 2
26.	Eneolithic, forest-steppe, Tobol-Ishim	Solodovnikov, Tur, 2017, Table 3
27.	Afanasievo culture, Gorny Altai	Solodovnikov, 2006

Table 1 Continued

28.	Afanasievo culture, Minusinsk Basin	Alexeev, Gokhman, Tumen, 1987
29.	Gumugou, Early Bronze, Tarim Basin	Han, 1986
30.	Aimyrlyg, Okunevo type culture, Tuva	Gokhman, 1980
31.	Elunin culture, Barnaul Obi region	Solodovnikov, 2006
32.	Karakol culture, Gorny Altai	Solodovnikov, 2006
33.	Okunevo culture, Minusinsk basin	Gromov, 1997
34.	Ust-Tartas culture, Baraba forest-steppe	Chikisheva, 2012
35.	Odinovo culture, Baraba forest-steppe	Chikisheva, 2012
36.	Krotov culture, Baraba forest-steppe	Chikisheva, 2012
37.	Samus culture, Upper Obi	Dremov, 1997; Solodovnikov, 2006
38.	Yamnaya culture, Kalmykia	Kazarnitsky, 2012: Table 5
39.	Yamnaya culture, West bank of Lower Volga	Khokhlov, 2017, Table Б.17
40.	Yamnaya-Katakom type, Kalmykia	Kazarnitsky, 2012: Table 25
41.	Early Katakomb culture, Kalmykia	Kazarnitsky, 2012: Table 21
42.	Yamnaya culture, Volga-Ural forest-steppe	Khokhlov, 2017, Table Б.15
43.	Poltavkin culture, Volga region	Khokhlov, 2017, Table Б.33
44.	Tamarutkul type, Pre-Ural steppe region	Khokhlov, 2017, Table Б.31
45	Yamnaya culture, Volga steppe region	Khokhlov, 2017, Table Б.16
46.	Yamnaya culture, Lower Volga	Balabanova 2016: Table 2
47.	Yamnaya culture, Ukraine	Kruts, 1984

* – combined male and "female that is converted to male" crania

Table 2. Craniometric measurements of human remains from the Early Bronze Age
from Khangai mountain (Central Mongolia), southern and southeastern Altai (Western Mongolia, Russia)

Craniometric traits	Afanasievo culture				Afanasievo culture ?			Chemurchek (Khemtseg) culture			
	Central Mongolia (Shatar-Chulu)		High mountain areas of Altai		Takhilgat udzuur-5, Burial 31	Khuurai gobi (Kurgak govi) Burial 1						
	♂		♂		♂	♂*	–		♂		♀	
	n	Mean	n	Mean	Age at death 30-40-year-old	Old adult	Age at death Child (≈ 6 y.o)	n	Mean	n	Mean
1. Maximum cranial length	2	196,0	10	193,7	202	188	–	2	193,5	3	181,0
8. Maximum cranial breadth	2	146,0	10	140,4	140?	149	–	2	142,0	4	137,0
8:1. Cranial index	2	74,5	9	72,5	69,3?	79,3	–	2	73,4	3	76,8
17. Cranial height from *ba*	2	141,0	8	142,3	150!	131	–	2	134,0	3	129,7
17:1. Length-height index	2	72,0	8	73,4	74,3	69,7	–	2	69,3	3	71,7
17:8. Breadth-height index	2	96,6	8	101,6	107,1	87,9	–	2	94,4	3	93,3
20. Cranial height from *po*	2	121,0	6	117,8	123	114	–	3	113,0	4	107,5
5. Cranial base length	1	105,0	9	108,7	116	104	–	2	101,0	3	99,0
9. Minimum frontal breadth	2	101,1	13	100,5	105,2	98,0	88,0	3	90,1	3	88,2
9:8. Frontal-parietal index	2	69,2	9	72,1	75,1	65,8	–	2	62,8	3	63,4
10. Maximum frontal breadth	2	118,5	6	120,0	126	130	–	3	116,3	3	114,0
32. Forehead profile angle	2	82,0	10	83,0	82?	78	–	2	79,0	2	80,0
40. Basion-prostion length	1	100,0	9	105,3	111	98	–	1	100,0	2	94,0
45. Bizygomatic diameter	2	141,5	12	141,8	141	146	–	2	137,5	3	131,3
48. Upper facial height	2	67,3	12	71,0	71	76	55	2	79,0	2	65,0
48:17. Vertical facial-cerebral index	2	46,9	8	50,2	47,3	58,0	–	2	59,0	2	50,4
48:45. Upper facial index	2	47,6	12	50,1	50,4?	52,1	–	2	57,5	2	50,4
72. General facial angle	2	87,5	10	85,0	85?	89	–	2	86,0	2	84,5
74. Alveolar part angle	2	75,5	5	76,7	74?	76	–	2	74,5	2	73,0
77. Naso-malar angle	2	137,8	6	137,5	138,6		142,5	2	147,3	3	147,6
∠Zm'. Zygo-maxillar angle	2	133,3	5	124,1	128,0?		132,4	2	131,8	2	143,3
51. Orbital breadth from *mf*	2	43,8	7	43,6	44,6	40,0**	35,7r.	2	43,2	2	39,8
51a. Orbital breadth from *d*	2	42,0	11	41,5	42,0		–	2	39,3	2	36,7
52. Orbital height	2	29,8	12	32,6	30,0	35,0	31,0	2	34,4	2	31,6
52:51. Orbital index from *mf*	2	68,1	7	74,5	67,3	87,5	86,8	2	79,6	2	79,5
52:51a. Orbital index from *d*	2	70,9	11	78,1	71,4		–	2	87,4	2	86,2
55. Nasal height	2	47,5	12	52,3	50,0	59,0	39,5	2	56,5	2	48,1
54. Nasal breadth	2	26,4	13	26,8	25,8	27,0	19,3	3	26,6	2	25,0
54:55. Nasal index	2	55,7	12	51,0	51,6	45,8	48,9	1	47,7	2	52,0
75(1). Nose protrusion angle	2	37,0	8	33,6	30?	29	–	2	25,0	2	18,0
SC. Simotic breadth	2	9,1	6	8,4	7,2		–	4	7,4	3	6,7

Table 2 Continued

SS. Simotic subtense	2	5,8	6	5,0	5,2		–	4	4,0	3	3,0
SS:SC. Simotic index	2	63,1	6	59,8	72,2		–	4	54,4	2	45,2
DC. Dacrial breadth	2	25,9	6	22,5	23,4		–	3	21,9	3	22,2
DS. Dacrial subtense	2	14,8	6	13,0	13,7		–	3	11,8	3	10,2
DS:DC. Dacrial index	2	57,1	6	58,1	58,5		–	3	53,8	2	46,1
Mandibula											
68(1). Length from condyle	2	109,5	7	111,9	–	118	84	2	114,5	4	102,3
79. Mandibular angle	2	116,5	8	111,4	–	115	113	4	117,0	5	116,4
68. Length from the angle	2	84,5	7	91,6	–	91	66	4	83,0	5	79,2
70. Maximum ramus height	2	68,0	8	69,6	–	74	43	4	61,5	5	59,8
71a. Minimum Ramus breadth	2	37,1	7	39,7	–	42	28,4	6	38,0	5	35,7
65. Bicondylar breadth	–	–	6	119,2	–	127	98	2	124,0	4	119,3
66. Bigonial width	2	107,5	7	101,3	–	115	77	2	102,5	4	95,0
∠C'. Chin protrusion angle	2	70,0	6	66,8	–	–	77	3	67, 7	3	69,7

Notes: * – measurements by D. Tumen. ** - in the measurements of these and some other traits, methodological discrepancies are possible.

Table 3. Factor loads of the first two principal components (PC I–II) of male
and female (converted to "male") crania from the Early Bronze Age
of the southern, southeastern, Mongolian Altai and central Mongolia

Craniometric traits by Martin et al.	PC I	PC II
1. Maximum cranial length	-0,568	0,255
8. Maximum cranial breadth	-0,276	-0,880
20. Cranial height from po	-0,817	0,318
9. Minimum frontal breadth	-0,929	-0,102
32. Forehead profile angle	-0,721	0,046
45. Bizygomatic diameter	-0,591	-0,601
48. Upper facial height	0,223	-0,410
72. General facial angle	-0,213	-0,628
77. Naso-malar angle	0,751	-0,426
∠Zm'. Zygo-maxillar angle	0,532	-0,519
51. Orbital breadth from mf	-0,736	-0,112
52. Orbital height	0,587	0,322
55. Nasal height	0,183	-0,462
54. Nasal breadth	-0,066	-0,199
75 (1). Nose protrusion angle	-0,756	-0,097
SC. Simotic breadth	-0,807	0,017
SS. Simotic subtense	-0,857	-0,046
λ. Eigen values	6,623	2,711
P, %. Percentage in total dispersion	39,0	15,9

Table 4. Elements of the first two canonic vectors (CV I-II) of the craniological series
of the Neolithic − Early Bronze Age in northern Eurasia

| Craniometric traits by Martin and et al.	CV I	CV II
1. Maximum cranial length	-0,118	-0,184
8. Maximum cranial breadth	0,086	0,826
17. Cranial height from *ba*	-0,256	-0,135
9. Minimum frontal breadth	-0,328	-0,019
32. Forehead profile angle	0,091	0,362
45. Bizygomatic diameter	0,218	0,071
48. Upper facial height	0,237	-0,073
72. General facial angle	-0,071	0,024
77. Naso-malar angle	0,387	0,020
∠Zm'. Zygo-maxillar angle	0,438	-0,051
51. Orbital breadth from *mf*	-0,027	0,110
52. Orbital height	0,239	-0,107
55. Nasal height	0,044	-0,227
54. Nasal breadth	0,032	0,032
75 (1). Nose protrusion angle	-0,348	0,147
SC. Simotic breadth	0,037	0,014
SS. Simotic subtense	-0,405	0,148
λ. Eigen values	46,47	15,09
P, %. Percentage in total dispersion	46,1	15,0
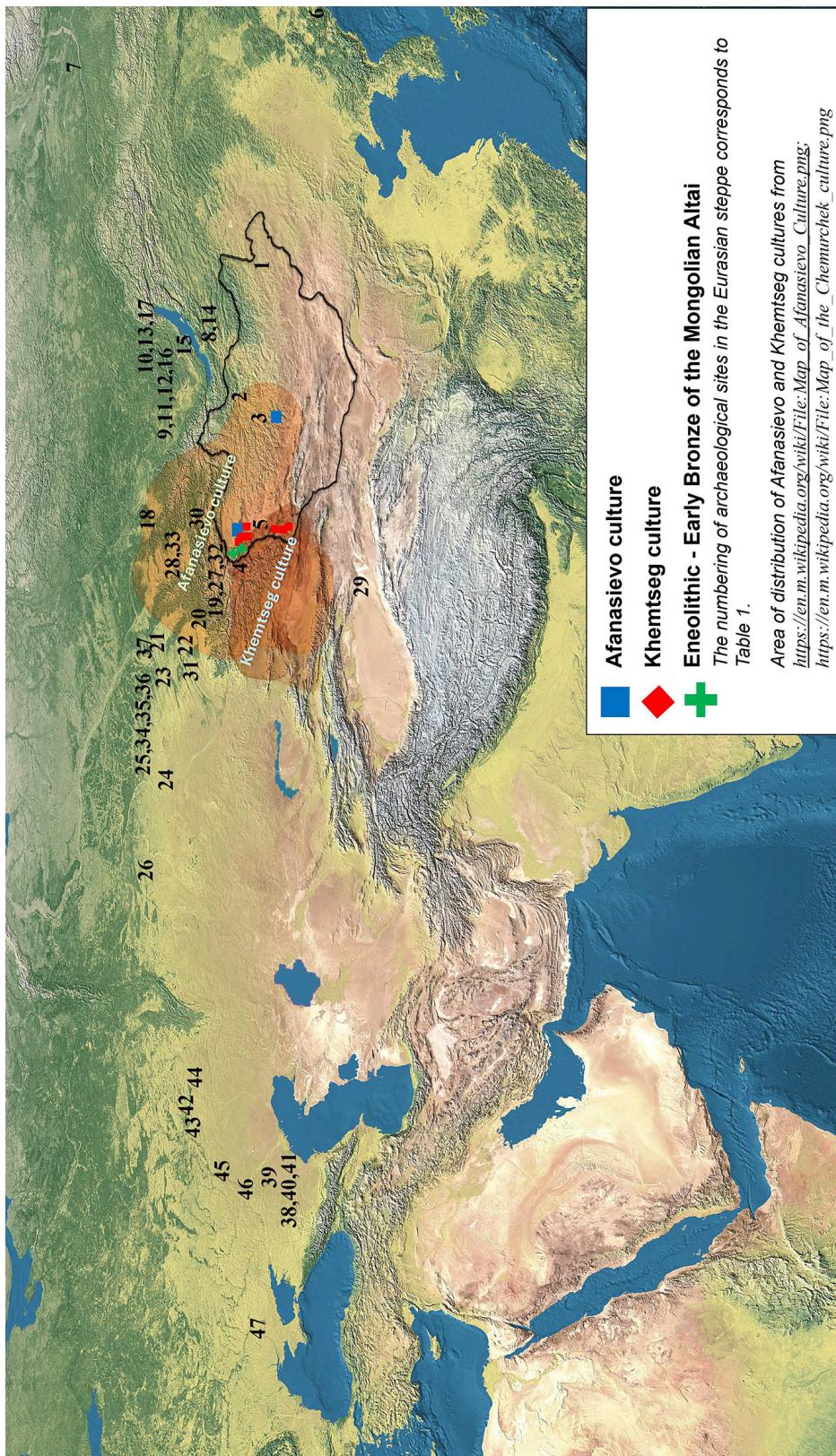
Fig. 1. Locations of Eneolithic-Early Bronze Age archaeological sites in Mongolia and northern Eurasian steppe

Legend (from the map):

Afanasievo culture

Khemtseg culture

Eneolithic - Early Bronze of the Mongolian Altai

The numbering of archaeological sites in the Eurasian steppe corresponds to Table 1.

Area of distribution of Afanasievo and Khemtseg cultures from https://en.m.wikipedia.org/wiki/File:Map_of_Afanasievo_Culture.png; https://en.m.wikipedia.org/wiki/File:Map_of_the_Chemurchek_culture.png

Fig. 2. The cranium of a 40–50-year-old man from grave 3,
Shatar-Chulu burial ground of the Afanasievo culture
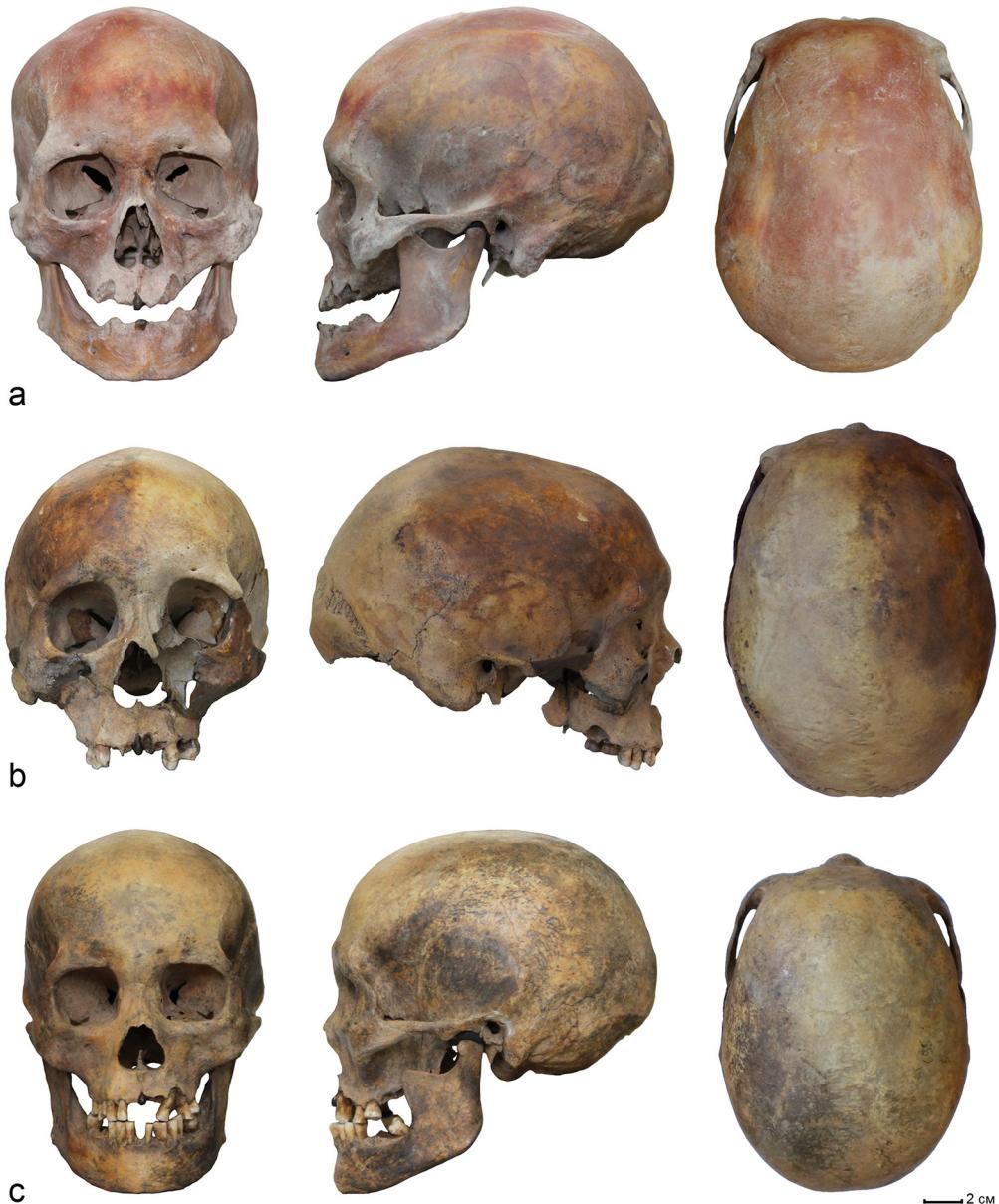
Fig. 3. Crania from the Chemurchek burials from western Mongolia.
a) 50–60-year-old man from Kurgan 1, Khulagash burial ground.
b) 40–50-year-old man from Kurgan 1, burial 2, Kulala Ula burial ground.
c) 45–55-year-old woman from Kurgan 1, Kurgak govi burial ground

Fig. 4. Crania from the Eneolithic-Early Bronze Age period, Bayan-Ulgi aimag, Western Mongolia.
a) 30–40-year-old man from grave 31, Takhilgat udzuur-5 burial ground.
b) 40–50-year-old woman from grave 1 (Individual A), Altan Tolgoi-2 burial ground
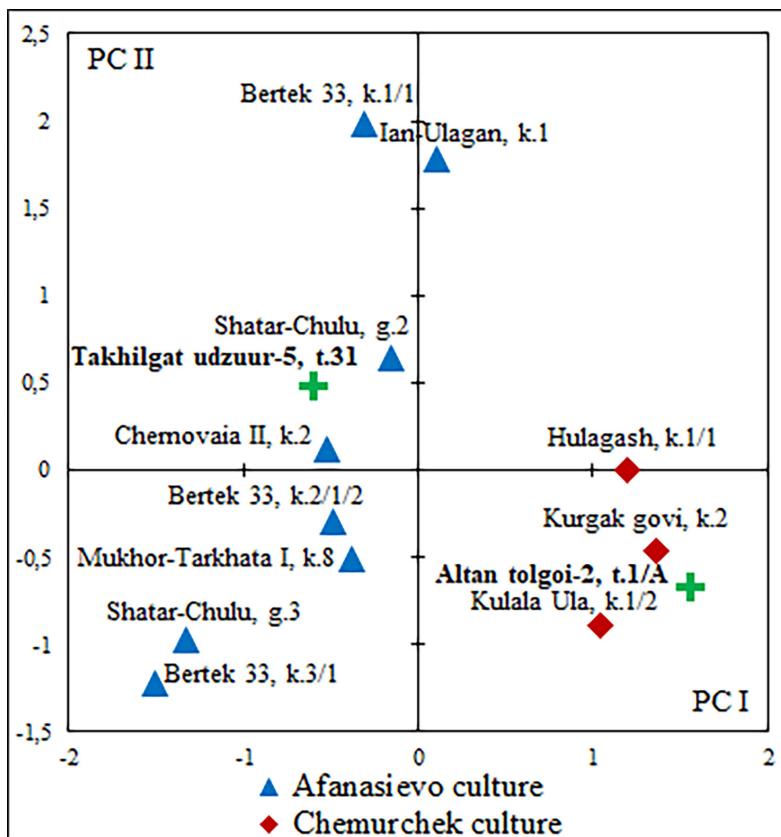
Fig. 5. The location of crania from Early Bronze Age of southern, southeastern,
Mongolian Altai and central Mongolia in the space of PC I–II
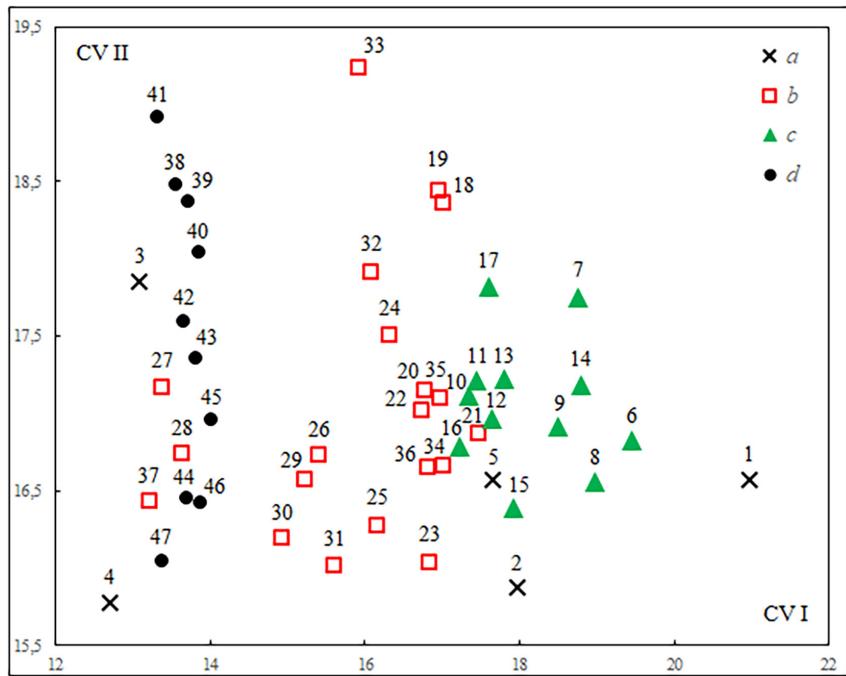
Fig. 6. Location of male craniological series and individual findings of the Neolithic —
Early Bronze Age from Eurasia in the space of CV I–II
a — Mongolia; *b* — Western and Southern Siberia, Central Asia;
c — Eastern Siberia and the Far East (Russia); *d* — Steppes of Eastern Europe.
The numbering of groups corresponds to Table 1
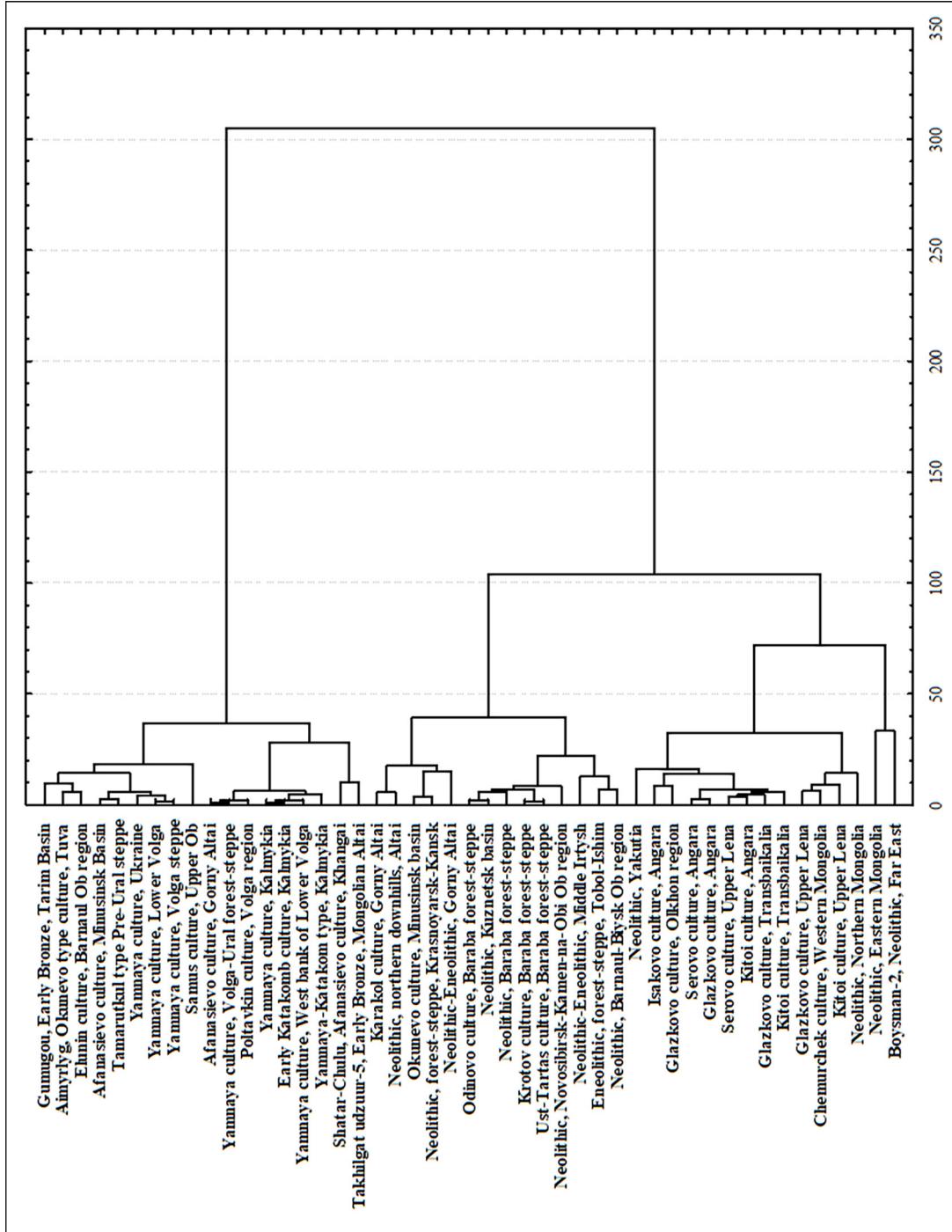
Fig. 7. Clusters of Mahalanobis-Rao D² distance of male craniological series of Early Bronze Age from Mongolia and northern Eurasia