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RADIOCARBON DATING OF THE UPPER PLEISTOCENE STRATUM IN THE BAIKAL SIBERIA

1. INTRODUCTION

The purpose of this study has been to investigate the Upper Paleolithic cultural chronology in the Northeastern Asia by radiocarbon dating. The area of Baikal Siberia is cultural importance for study of early human dispersal and the peopling of the New World and the Japan Islands. A Siberian Paleolithic Radiocarbon Database has already been compiled, allowing us to get chronological comprehension of human colonization of this area (Vasilev, Kuzmin, Orlova, Dementiev 2002). However, charcoal and bone remains almost were not found in several the Upper Pleistocene sites, the time scale was decided by few radiocarbon dates in each site. Furthermore, thin occupational layers coupled with variability and complexity of physically mixed artifacts often yield ambiguous ^{14}C results from nearby material but not intrinsic to the artifact. Therefore, in order to get the accurate and precise radiocarbon chronologies for this period, it is necessary to construct a soil science procedure for radiocarbon dating which has the potential to overcome the problems.

In this study, we have mainly present the comparison of radiocarbon dates among total organic carbon, humins, humic acids and carbonate in soil samples, charcoal and bone remains associated with artifacts in Bal'Shoj Naryn sites, located the Northwest of Lake Baikal (Fig. 1). The interpretation of soil materials in radiocarbon analysis have been widely discussed (e.g., Chen, Polach 1986; Orlova, Panychev 1993; Kristiansen, Dalsgaard, Holst, Aaby, Heinemeier 2003) , but the dates in Baikal Siberian sites have not been reported. Our results showed that the dates of charcoal and bone remains comparatively corresponded with soil components. We conclude that our method of soil science procedure and radiocarbon dating of soil materials has the potential of being a useful tool which evaluate the dates of archaeological sites and the process of the deposit in the Baikal Siberia.

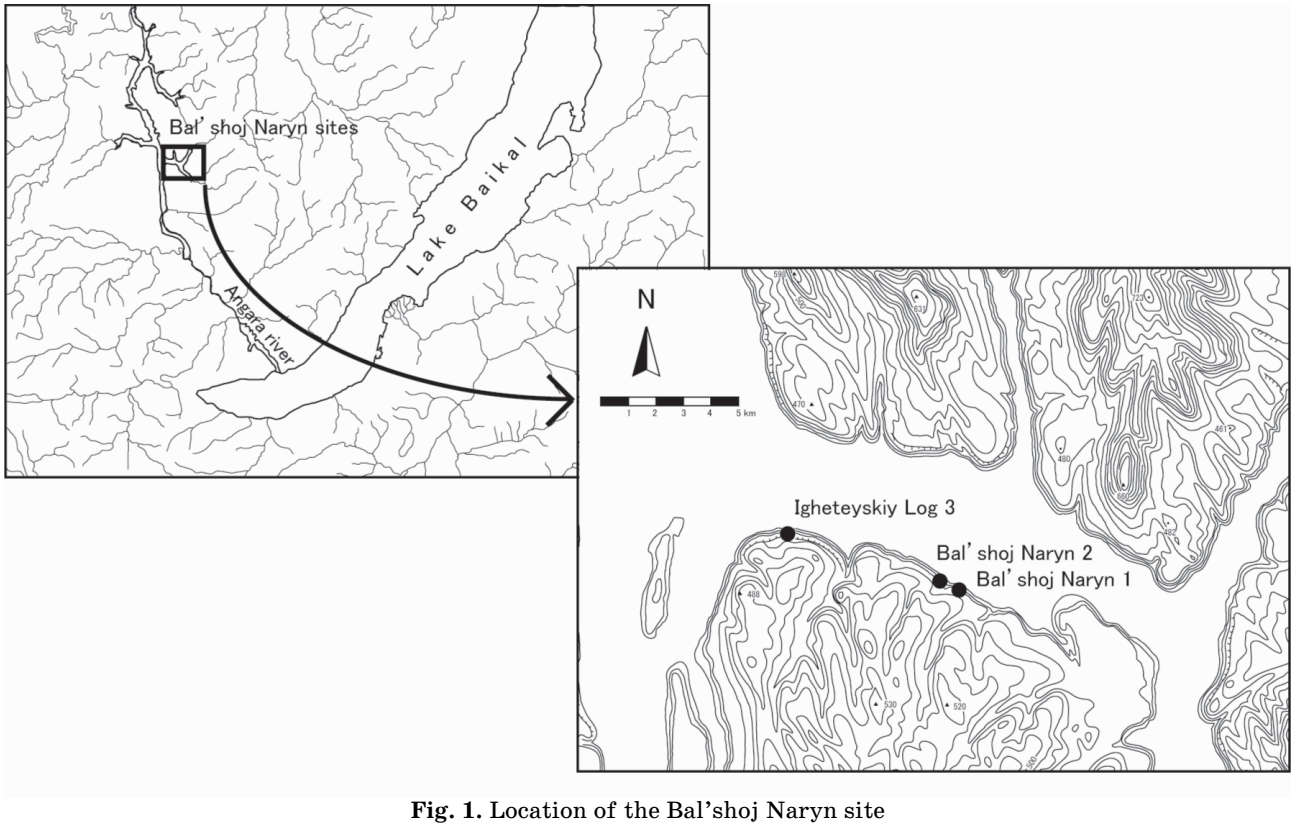

Fig. 1. Location of the Bal'shoj Naryn site

2. SITE AND SAMPLES

The excavation of the Bal'Shoj Naryn sites was performed by a joint Russian and Japanese expedition. The team started the excavation and research of Bol'shoj Naryn sites from 2003, and the research is ongoing. Although, it is still impossible to clarify the whole picture, at this site we have found a lot of stone artifacts and animal fossils compatible with oxygen isotope stage 3. In this paper, we focus the method of soil science procedure and radiocarbon dates, and the subject of stone artifacts and vertebrate fossils have been reported this issue (Suzuki *et al.*).

The Bal'Shoj Naryn sites is located at approximately latitude 53 degrees north and longitude 103 degrees east in the hills facing the Osa Bey, in the Bratsk Reservoir. Because of water level fluctuations in the Bratsk Reservoir, the bluff of the hills are being eroded, most of artifacts and vertebrate fossils flowed down from the hills with soil erosion and were scattered along the shore of the reservoir. The sedimentation on the strata was almost the same in the each shore of the reservoir.

We set up survey districts on the edges of the hills above the shore between the Bal'Shoj Naryn 1 and 2 site in 2003. In this districts, sandy loess layers of the Sartansk glacial period had accumulated approximately 1 m deep immediately beneath the surface soil layer, and a paleosol layer with high viscosity, formed in the Kargin and several tens cm thick, had accumulated beneath the sandy loess layers. We obtained 17 soil samples every ten cm from this section. In this year, the first excavation the Bal'Shoj Naryn 1 site was perfomed and obtained 1 soil sample of paleosol, 2 bone samples (in the paleosol), 5 bone samples (beneath the paleosol). Besides these samples, 1 bone sample (the test survey district in the shoe), 1 bone sample (the collection from the shoe, antler point), 1 charcoal sample (from another bluff) were measured.

In 2004 and 2005, we started our excavation work (extension of the Bal'Shoj Naryn 1 site

district, the first and second excavation of the Bal'Shoj Naryn 2 site, the first excavation of the Igheteyskiy Log 3), and then obtained many charcoal samples with precise context in order to i) compare the radiocarbon dates of the soil components taken comprised of total organic carbon, humins, humic acids and carbonate, ii) evaluate radiocarbon chronologies for Bal'Shoj Naryn sites and sedimentation processes of the tableland along the Osa Bey.

3. METHODS

In the soil organic matter fractionation and soil carbonate procedure were performed in conformity with the flowchart (Fig.2, applied Kristiansen 2003), the soil organic matter (SOM) was separated into 3 compartments : total organic carbon (TOC, acid-extractable), humins (+ mineral constituents, residual), humic acid. Soil sample was examined under a microscope, and plant roots

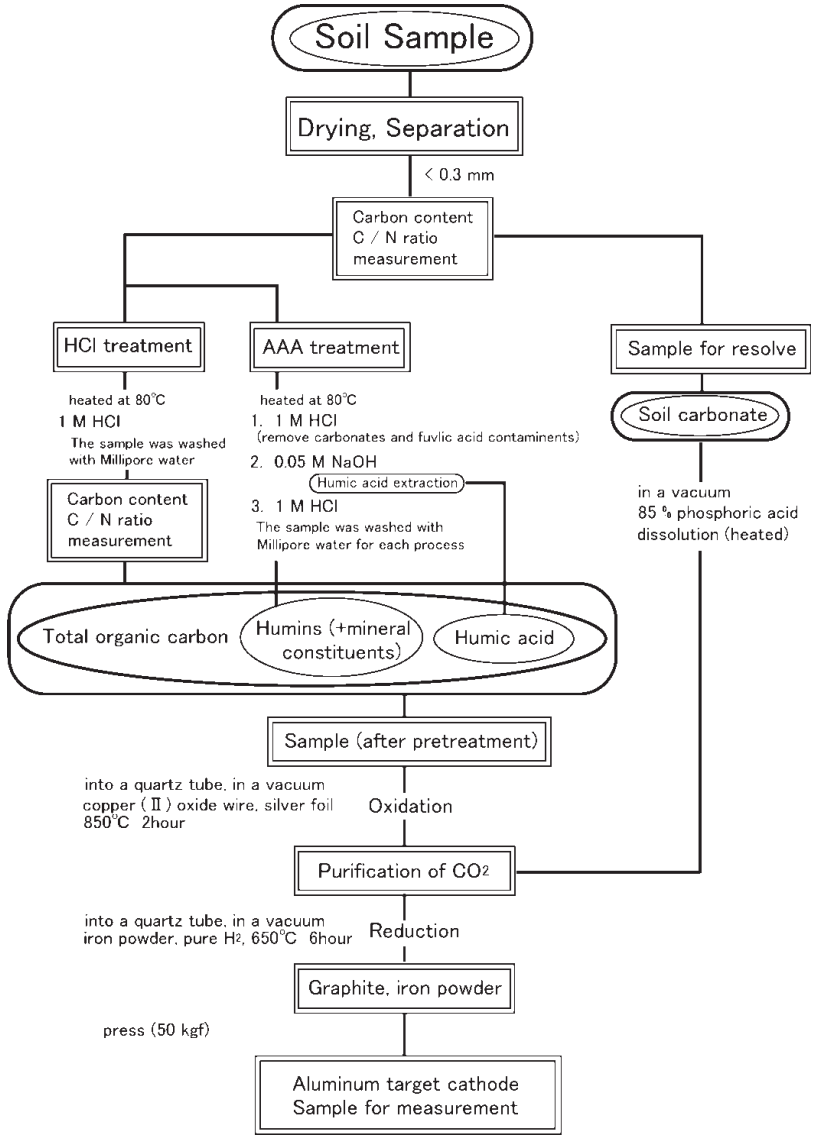

Fig. 2. Method of the soil science procedure

or other visible contaminants were removed with tweezers. 0.5–5 g of soil was acid-washed in 1 M HCl (15ml) at 80°C for >10hr, which yields the total organic carbon. The another soil was then treated with an acid-alkali-acid (AAA) treatment performed at 80°C, which left a non-soluble organic fraction, the residual (humins + mineral constituents), and a soluble fraction. Addition of 12 M HCl to the soluble fraction precipitated the humic acid fraction. Soil carbonate sample directly was dissolved by 85% phosphoric acid in a vacuum, which yields the CO_2.

The material after pretreatment was then, in individual quartz tube, converted to CO_2 via sealed-tube combustion. Following standard graphitization practices, the CO_2 was cryogenically purified to remove water and other impurities and reduced to elemental carbon in the presence of a stoichiometric excess of hydrogen. Samples were pressed into aluminum target holders and the ^{14}C / ^{12}C ratio determined at the MALT (Micro Analysis Laboratory, Tandem accelerator, The University of Tokyo) facility. Radiocarbon results are reported as conventional ^{14}C ages in accordance with Stuiver and Polach and include an on-line r^{13}C correction for fractionation during sputtering analysis, and a background subtraction based on analysis prepared commercial graphite (dead carbon).

4. RESULTS AND DISCUSSION

We report initial radiocarbon results, from the 71 total samples taken comprised of 14 total organic carbon, 6 humins, 3 humic acids, 14 soil carbonates, 9 bones, 25 charcoal are presented in Table 1and 2.

Dating of all fractions roughly was not inconsistent with relation of sedimentation, with the exception of conflicting total organic carbon dates beneath the sandy loess layers (deep 120 cm)

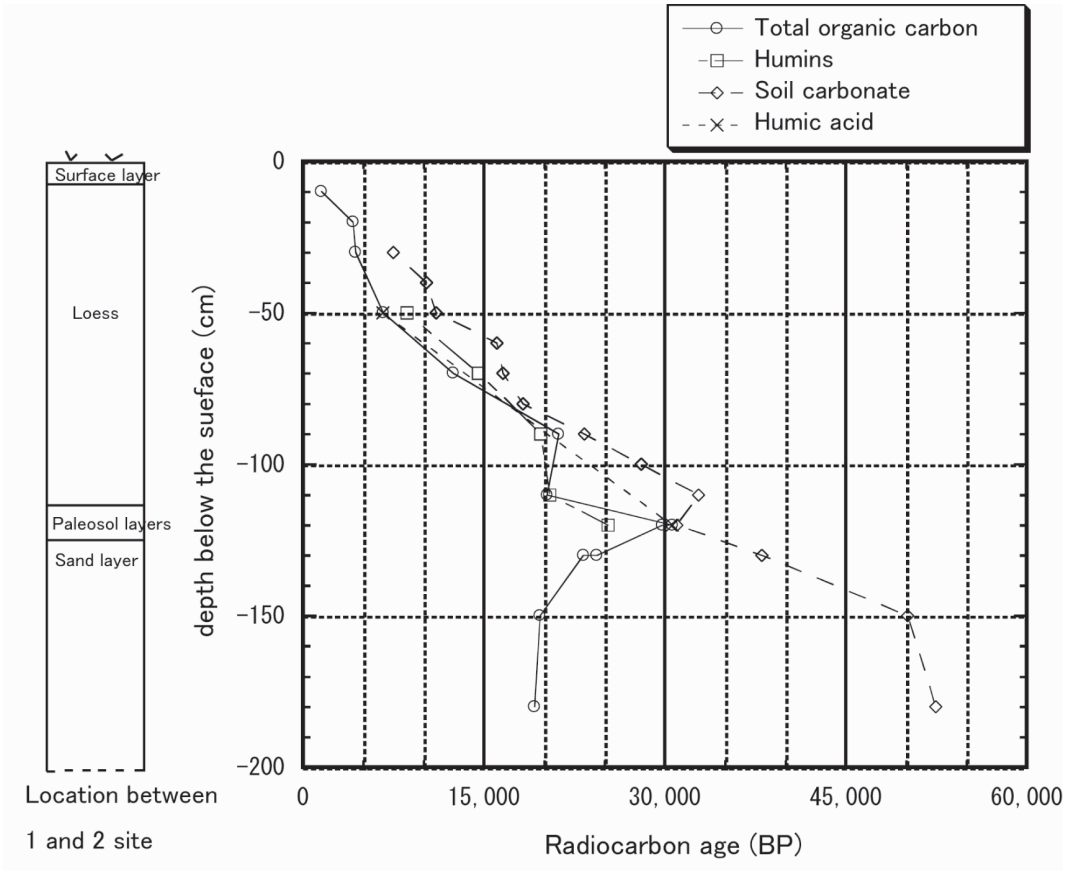

Fig. 3. Comparison between the soil elements in the Bal'shoj Naryn site

(Fig. 3). The humins fraction dates did not follow the constant pattern compared to TOC, the part of upper layer (<90 cm) was older than the other dated TOC, conversely the part of lower (>90 cm) was younger. This conflicting may be primarily associated with the ratio of the contamination of SOM had younger C (e.g. plant roots, rainwater, water-soluble C) and carbon content, rather than soil formation process – that is, it is difficult to evaluate the reliable ^{14}C ages provided that the carbon content is low (about <0.1%) and the ^{14}C dates is older (about >20,000 BP) in the Bal'Shoj Naryn sites. The soil carbonates in these soils is suggested to extract older than the organic fractions. A possible interpretation of these result is that, i) the soil carbonates were probably caused by water-soluble older C leached from the sources of supply (e.g. limestone), or ii) the processes were formed the soil carbonates appear older than the actual time of burial, which were formed on the basis of the its lower elements, or iii) the reliable estimates were derived from the soil carbonates than the organic fractions. Whether or no, an important finding here is that the soil carbonates were dated up to older 50,000 BP, in accord with the relations between layers.

In the Bal'Shoj Naryn 1 and 2 survey districts, artifacts mainly were excavated from the parts of the paleosol layer. In the Bal'Shoj Naryn 1 site, the radiocarbon results of the 11 charcoal (Fig.5, at the upper left), and 6 bones except for the soil samples were obtained, and estimated on the basis of the charcoal that those in the upper part of the paleosol layer were in the age range of 25,000 to 26,000 BP, and those in the lower part of the paleosol layer were aged in the range of 26,000 to 32,000 BP (Fig. 3). The ^{14}C ages of the bones samples in the paleosol were 31,110 and 37,420 BP, beneath the paleosol were 29,000 to 40,000 BP. The SOM and charcoal in the paleosol roughly had the same age, in contrast, the bones and soil carbonates was up to several thousand older. In the Bal'Shoj Naryn 2 site, 12 charcoal samples in the paleosol were dated to between 25,000 to 29,000 BP (Fig. 5, at the upper right), these results are very similar to results in the Bal'Shoj Naryn 1 site. In the Igheteyskiy Log 3 site, the ^{14}C date of charcoal in the different paleosol from 4 m depth below the surface was 44,680 BP, where were not found artifacts. Besides, the bone artifacts (point made of deer antler) collected in the shore also were estimated the radiocarbon age to be 27,750 BP. Accordingly, it is clear that the remains found in the paleosol layer had an age range of more than several thousand years (25,000 to 32,000 BP), at least, in the second half of the Kargin interstadial.

In order to determine precise and accurate radiocarbon chronologies was related to human activities in these sites, the detailed layers and positions found the artifacts can be a problem. Since it is assumed that the several paleosol layers exist in the tableland along the Osa Bey as mentioned above (Fig. 4), we must infer the position of the artifact, attempts were made to see which paleosol layer can be related. However, it is difficult to decide these things because of variability and complexity of physically mixed artifacts by the glacial influence. To avoid this problem, the combinations of radiocarbon dating, soil science procedure in the paper are being increasingly utilized to evaluate comprehensive chronologies.

5. CONCLUSION

In this study, we preset the initial radiocarbon chronology for the Bal'Shoj Naryn sites in the Baikal Siberia. Of particular note is determining the radiocarbon age of soil components, which agrees well with the relationship among sedimentary layers. For the present, radiocarbon dating concerned with stone artifacts at these sites determined to be about 25,000 to 32,000 BP in the second half of the Kargin interstadial.

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Table 1 Radiocarbon ages of the Bal'shoj Naryn sites

Locality / Site (year)	Sample number	Sampling depth (cm)	Material	CO_2 content (%) (for a oxidation/dissolution)	$\delta^{13}C_{PDB}$ (‰ Mass, AMS*)	^{14}C age (BP ± 1σ)	Lab code TKa NO.
Bal'shoj Naryn (2003) (test survey district between 1 and 2 site)	03BN-1(A)	10	Total organic carbon	2.24	−25.7	1580 ± 90	12902
	03BN-2(A)	20	Total organic carbon	0.40	−23.6*	4190 ± 80	13161
	03BN-3(A)	30	Total organic carbon	0.39	−23.0	4370 ± 110	12919
	03BN-3(Ca)	30	Soil carbonate	2.53	−8.6	7540 ± 110	13162
	03BN-4(Ca)	40	Soil carbonate	2.06	−6.3	10,300 ± 120	13167
	03BN-5(A)	50	Total organic carbon	0.28	−22.6	6710 ± 80	12920
	03BN-5(AAA)	50	Humins	0.06	−27.7*	8620 ± 130	12965
	03BN-5(HA)	50	Humic acid	28.0	−29.2*	6650 ± 50	13234
	03BN-5(Ca)	50	Soil carbonate	1.76	−6.9	11,090 ± 140	13168
	03BN-6(Ca)	60	Soil carbonate	1.89	−5.6	16,130 ± 70	13169
	03BN-7(A)	70	Total organic carbon	0.17	−20.9*	12,470 ± 160	12921
	03BN-7(AAA)	70	Humins	0.04	−18.2*	14,560 ± 70	13170
	03BN-7(Ca)	70	Soil carbonate	1.91	−6.3	16,610 ± 160	13173
	03BN-8(Ca)	80	Soil carbonate	2.60	−6.4	18,280 ± 150	13174
	03BN-9(A)	90	Total organic carbon	0.16	−21.8	21,250 ± 140	12922
	03BN-9(AAA)	90	Humins	0.04	−21.8*	19,730 ± 170	12966
	03BN-9(Ca)	90	Soil carbonate	2.80	−5.8	23,380 ± 280	13175
	03BN-10(Ca)	100	Soil carbonate	2.24	−5.8	28,110 ± 350	13176
	03BN-11(A)	110	Total organic carbon	0.09	−18.7*	20,260 ± 220	13177
	03BN-11(AAA)	110	Humins	0.04	−16.4*	20,440 ± 200	13178
	03BN-11(Ca)	110	Soil carbonate	1.88	−4.0	32,830 ± 240	13179
	03BN-12-1(A)	120	Total organic carbon	0.26	−17.8*	30,640 ± 160	12923
	03BN-12-2(A)	120	Total organic carbon	0.29	−19.8*	29,800 ± 420	13005
	03BN-12(AAA)	120	Humins	0.05	−23.4*	25,310 ± 170	12967
	03BN-12(HA)	120	Humic acid	36.1	−24.9*	30,650 ± 260	13118
	03BN-12(Ca)	120	Soil carbonate	1.54	−7.6	31,020 ± 320	13109
	03BN-13-1(A)	130	Total organic carbon	0.08	−25.6*	24,390 ± 210	12968
	03BN-13-2(A)	130	Total organic carbon	0.09	−17.0*	23,250 ± 150	13006
	03BN-13(Ca)	130	Soil carbonate	1.79	−6.8*	38,040 ± 330	13110
	03BN-14(A)	150	Total organic carbon	0.03	−22.0*	19,660 ± 220	13007
	03BN-14(Ca)	150	Soil carbonate	1.70	−3.2	50,120 ± 850	13111
	03BN-15(A)	180	Total organic carbon	0.02	−24.4*	19,240 ± 150	13008
	03BN-15(Ca)	180	Soil carbonate	1.51	−1.7	52,500 ± 1800	13112
Bal'shoj Naryn 1 (2003)	03BN-18(A)	−	Total organic carbon	0.68	−24.8	27,740 ± 430	12924
	03BN-18(AAA)	−	Humins	0.10	−17.0*	24,190 ± 290	13004
	03BN-18(HA)	−	Humic acid	53.8	−25.7*	28,710 ± 270	13119
	03BN-18(Ca)	−	Soil carbonate	1.36	−8.7	25,730 ± 110	13180
	03BN-20(a)	−	Bone (in the paleosol)	42.1	−18.8*	31,110 ± 190	13230
	03BN-20(b)	−	Tooth (in the paleosol)	43.2	−16.8*	37,420 ± 600	13113
	03BN-21	−	Bone (beneath tha paleosol)	36.2	−16.8*	39,110 ± 370	13171
	03BN-22	−	Bone (beneath tha paleosol)	36.6	−18.8*	33,090 ± 210	13231
	03BN-23(a)	−	Bone (beneath tha paleosol)	37.0	−17.7*	29,440 ± 290	13172
	03BN-24(a)	−	Bone (beneath tha paleosol)	44.7	−17.3*	38,540 ± 680	13120

Table 2 Radiocarbon ages of the Bal'shoj Naryn sites

Locality / Site (year)	Sample number	Material	CO_2 content (%) (for a oxidation/dissolution)	$\delta^{13}C_{PDB}$ (‰ Mass, AMS*)	^{14}C age (BP ± 1σ)	Lab code TKa NO.
Bal'shoj Naryn (2003) (test survey district in the shore)	03BN-25(a)	Bone	43.0	-19.6*	29,640 ± 170	13232
Bal'shoj Naryn (2003-from the bluff)	03BN-19	Charcoal	64.3	-23.0*	28,340 ± 150	13235
Bal'shoj Naryn (2003-collection from the shore)	03BN-26 03BN-27	Bone (arctic fox) Bone artifact (antler)	42.0 47.6	-18.6* -16.5*	44,770 ± 480 27,750 ± 320	13233 13121
Bal'shoj Naryn 1 (2004)	04BN I -199MAT33 04BN I -200MAT34 04BN I -201MAT35 04BN I -203MAT36	Charcoal Charcoal Charcoal Charcoal	61.3 63.9 61.9 63.5	-26.7* -22.1* -21.9* -25.3*	27,200 ± 130 27,260 ± 110 27,520 ± 120 28,160 ± 120	13794 13795 13796 13797
Bal'shoj Naryn 1 (2005)	05BN I -02 05BN I -03 05BN I -29 05BN I -30 05BN I -32 05BN I -69 05BN I -70	Charcoal Charcoal Charcoal Charcoal Charcoal Charcoal Charcoal	65.3 68.1 48.7 56.7 21.4 61.3 61.8	- - -24.5* -24.0* -26.7* - -	31,470 ± 260 31,090 ± 250 25,230 ± 110 25,790 ± 110 26,500 ± 140 30,660 ± 200 29,670 ± 260	13703 13704 13761 13762 13763 13705 13706
Bal'shoj Naryn 2 (2004)	04BN II -44MAT52 04BN II -45MAT53 04BN II -46MAT54 04BN II -47MAT55 04BN II -48MAT55 04BN II -51MAT61 04BN II -93MAT114 04BN II -95MAT116 04BN II -96MAT118 04BN II -117MAT159 04BN II -119MAT161 04BN II -124MAT171	Charcoal Charcoal Charcoal Charcoal Charcoal Charcoal Charcoal Charcoal Charcoal Charcoal Charcoal Charcoal	66.7 62.9 58.2 65.5 65.7 67.5 63.1 62.8 62.0 69.4 63.8 66.9	-24.6* -26.0* -21.9* -20.2* -22.1* -20.5* -21.4* -22.8* -25.3* -21.1* -20.9* -21.6*	27,410 ± 320 26,980 ± 170 25,190 ± 120 27,160 ± 130 26,030 ± 120 28,260 ± 150 27,020 ± 130 27,390 ± 160 26,460 ± 140 27,980 ± 140 26,870 ± 140 28,660 ± 160	13438 13439 13525 13526 13527 13500 13528 13501 13529 13502 13503 13504
Igheteyskiy Log 3 (2005)	05IG-1	Charcoal (about -4 m)	64.6	-	44,680 ± 500	13707

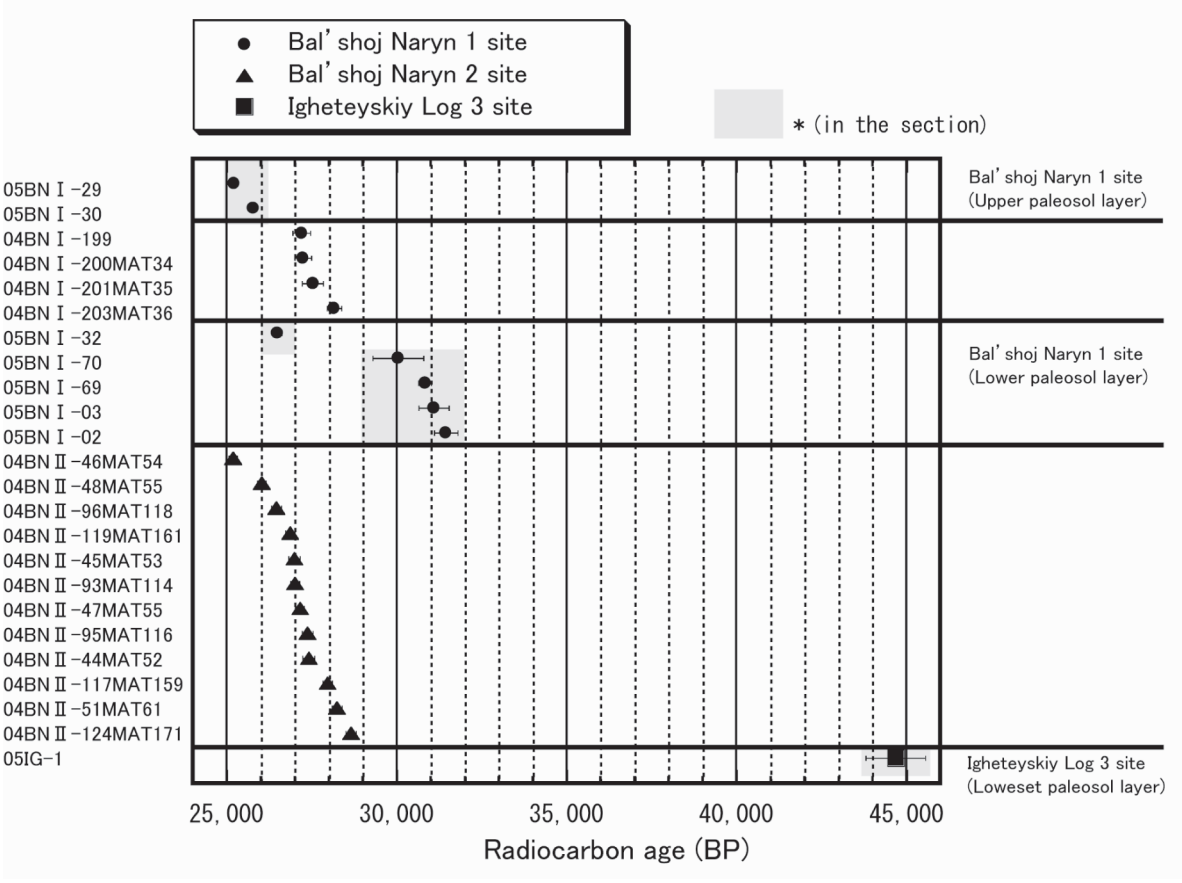

Fig. 4. Radiocarbon ages of the charcoal in the Bal'shoj Naryn sites

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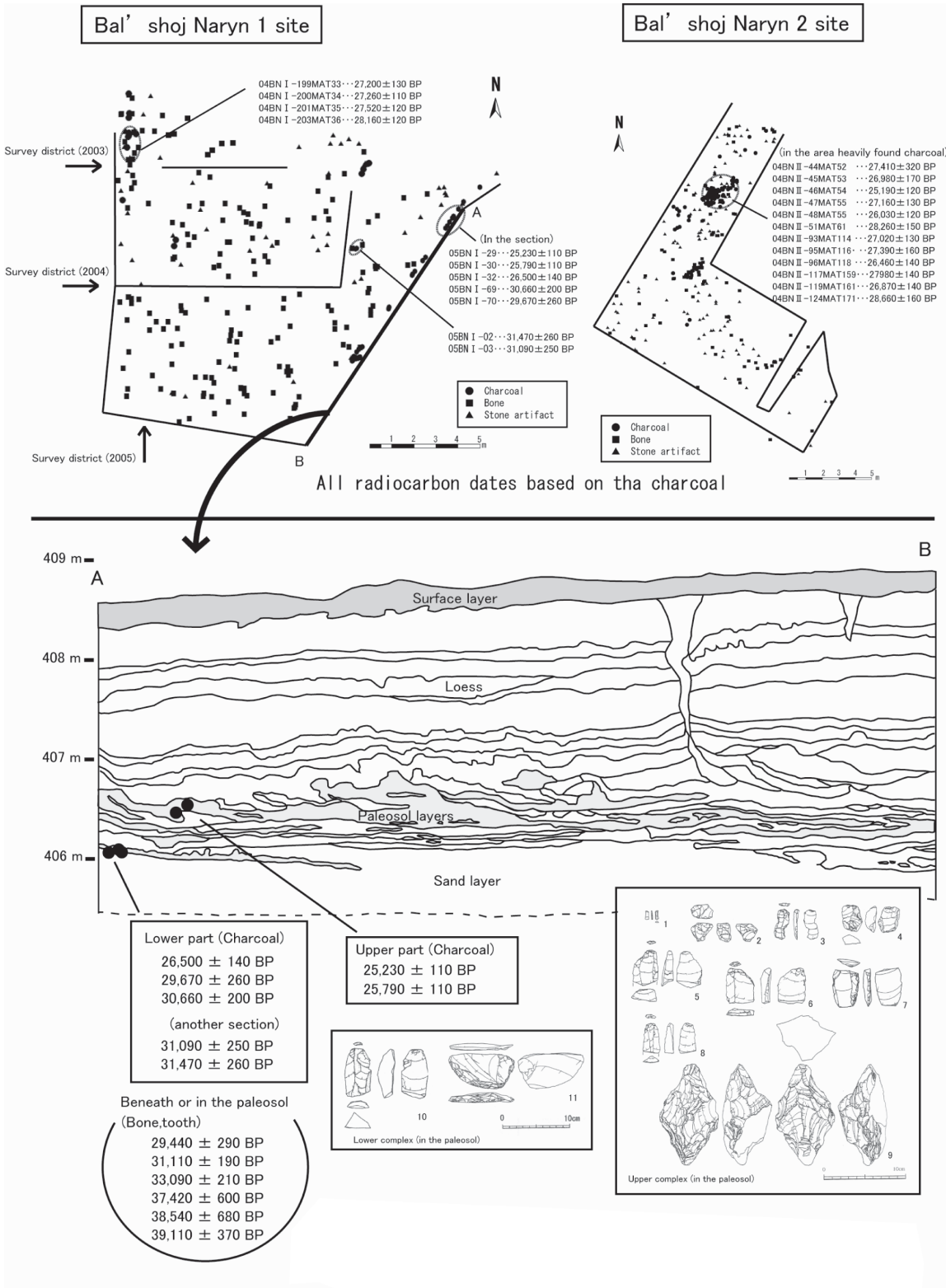

Fig. 5. Radiocarbon dates and stone tools of paleosol layer near by the east section of the Bal'shoj Naryn 1