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GEOCHRONOLOGY OF THE PLEISTOCENE AND HOLOCENE IN THE FORE-URALS

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ABSTRACT. The paper presents the results for the ^{14}C dating obtained recently in the Laboratory of the Institute of Geology, Ufa Science Centre, Russian Academy of Science, on the basis of megafaunal bones, peats, wood and mollusk shells. Dates are reported in stratigraphic sequence from the Late Würmian to the Holocene.

We applied radiocarbon dating along with biostratigraphical, geomorphological and other methods to study Pleistocene and Holocene deposits of the Fore-Urals, which comprise the part of the East European Plain adjoining the Urals (east of the Volga) from the Caspian basin in the south to the Timan-Uralian depression in the north (Fig. 1). We sampled peat, fossil wood, buried soils, megafaunal bones and mollusk shells from river terraces, lakes, bogs and archaeological sites.

^{14}C dating made it possible to revise the age of the third terrace in the Belaya River basin, which previously was considered as Mikulinian-Kalininian. The age was later estimated as Mologian-Sheksnian-Ostashkovian – regional horizons known in Russia (Yakheemovich 1971) – on the basis of two dates, 21,280 ± 550 BP (LU-145) and 29,700 ± 1250 BP (H-1856/1287), obtained from fir stumps near the Gornovo site. Later data supported this conclusion – 22,600 ± 125 BP (Bash GI-35) and 28,800 ± 125 BP (Bash GI-36).[1] The current stratigraphic scheme (Yakheemovich, Pshenichnyuk and Sidnev 1987) defines these strata as Tabuldinian (Table 1).

Tabuldinian strata were also well dated in other sections. The dates, 25,788 ± 100 BP (Bash GI-34) and 27,570 ± 480 BP (Bash GI-33), were obtained from wood near Aktanyshbash from the strata containing mammoth, bison and *Equus caballus*. In addition, ^{14}C data obtained from the Tabuldinian mammoth found at the Sukhoy Kundryak River near Tabulda, Sterlibashevo District, Bashkiria gave the following values: 31,360 ± 250 BP (LU-2153), 34,910 ± 300 BP (LU-2154) and 34,900 BP (LU-1377A). The dates are close to those of the Buribaian mammoth tusk, found on the east slope of the South Urals in the Buribai quarry – 36,000 BP (LU-1380A).

Corresponding ^{14}C dates were obtained previously in the Pechora basin from peat and wood sampled near Garevo, Kipievo, Radionovo and the "Vastyansky Kon" outcrop. The following were obtained from the Garevo peat beds: 43,800 BP (Bash GI-1), 32,740 ± 700 BP (Bash GI-2), 29,700 ± 300 BP (Bash GI-3) and 25,000 ± 280 BP (Bash GI-4).

The following dates were obtained from peat beds near Kipievo: 28,580 ± 500 BP (Bash GI-16) (from wood) and 24,975 ± 165 BP (Bash GI-17) (from peat). The age of the buried peat bog on the Pechora River 5 km south of Radionovo was dated to 21,840 ± 220 BP (Bash GI-19) and 36,630 ± 1280 BP (Bash GI-20). Both sand bodies from the "Vastyansky Kon" outcrop were dated to 24,790 ± 500 BP (Bash GI-8), 26,800 ± 370 BP (Bash GI-7), 28,380 ± 270 BP (Bash GI-49), 28,675 ± 300 BP (Bash Gl-9) and 20,470 ± 450 BP (Bash GI-10). However, these data are not considered reliable because the samples from peat beds of the lower Pechora were taken after the Novaya Zemlya nuclear tests, and may be much older.

[1] Bash GI = Institute of Geology, Bashkiria

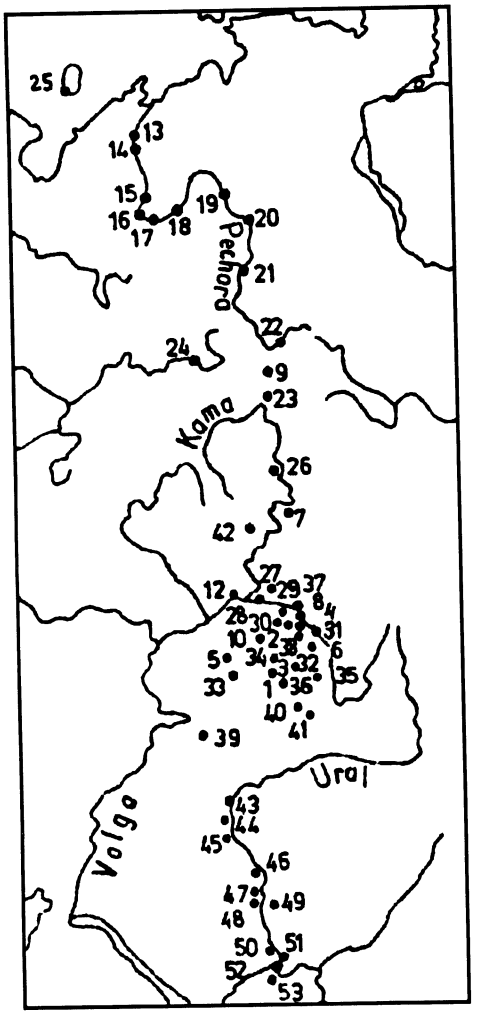

Fig. 1. Locations of sampled sections: 1. Karyatmas; 2. Ishkarovo; 3. Tally-Kulevo; 4. Yukalikul; 5. Kileevo-Ilikovo; 6. Burnak; 7. Koyanovo; 8. Kushnarenkovo; 9. Bogatyrevo; 10. Abdullino; 11. Syun 1 (Kholodny Klyuvh) and 2; 12. Krasny Bor; 13. Velikovisochnaya; 14. Vastyansky Kon; 15. Khabarikha; 16. Ust-Tsilma; 17. Garevo; 18. Kipievo; 19. Radionovo; 20. Byzovaya; 21. Dutovo; 22. Kurya; 23. Nizva; 24. Kaman-El; 25. Kolguev; 26. Sludka; 27. Orya (Staroye Kudashevo); 28. Aktanyshbash; 29. Chui-Atasevo; 30. Novo Sultanbekovo; 31. Gornova; 32. Ctarye Tukmakly; 33. Mullino; 34. Sumbugino; 35. Karmaskaly; 36. Romanovka; 37. Utyagan; 38. Ishbulatovo; 39. Domashkinsky Hills (Domashkinskiye Vershiny); 40. Tabulda; 41. Zlatoustovka; 42. Sharkan; 43. Kozhekharovsky; 44. Chapaev; 45. Mergenevo; 46. Kalmykovo; 47. Kharkino; 48. Inder; 49. Inder (lake); 50. Kurilkino; 51. Rakusha; 52, 53. Caspian shore

The Kudishevian (Ostashkovian) strata forming the upper section of the third terrace yielded the most reliable dates. The strata, up to 15 m thick, overlie the Tabuldinian and characterize periglacial conditions of the most recent glaciation; they also contain mammoth bones. The age of the main stage of the most recent glaciation is established by the dates, 18,310 ± 300 BP (Bash GI-41) and 20,000 ± 2600 BP (Bash GI-40), obtained from Orya River sections near Staroye Kudashevo and Starye Tukmakly.

In the Orya valley, ^{14}C dates on wood from lacustrine loams in Late-Glacial deposits (12,700 ± 55 BP (Bash GI-42) and 11,680 ± 90 BP (Bash GI-43)) place these deposits in the Allerød. A result of 12,330 ± 120 BP (Bash GI-107) was obtained from *Coelodonta antiquitatis* teeth found at the Ashkalar River near Zlatoustovka. This appears to be the first report of such a young Allerød or Dryas species (Table 1).

^{14}C dates and pollen analyses from river terraces, peat beds and archaeological sites enabled Nemkova (1978) to designate five Holocene phases: Preboreal, Boreal, Atlantic, Subboreal and Subatlantic. Results of 9620 ± 50 BP (Bash GI-76) and 9650 ± 50 BP (Bash GI-77) were obtained

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TABLE 1. ^{14}C Dates on Megafaunal Bone

Climatic-chronological units	^{14}C dates and sample locations	Sample material
Late Pleistocene		
Ostashkovian (Valdaian) glaciation, late stage		
Allerød, Older Dryas, Bølling, Oldest Dryas	12,330 ± 120 (LU-1668), Zlatoustovka	*Coelodonta antiquitatis* teeth
Mologo-Sheksnian interglaciation	31,360 ± 250 (LE-2153), Tabulda	Mammoth tubular bones
	34,910 ± 300 (LE-2154), Tabulda	
	34,900 ± (LU-1377 A), Tabulda	
	36,000 ± (LU-1380 A), Buribai	Mammoth tusk

for the Preboreal phase from the "Kholodny Klyuch" section (Table 2). In most regions of the Bashkirian Fore-Urals, this interval was marked by forest expansion, especially of coniferous and birch species. Treeless plains occurred only in the most southern part of the Fore-Urals.

The following Boreal dates were determined from wood at the Mullino 2 site near Oktyabrsky: 8320 ± 110 BP (Bash GI-58), 8460 ± 130 BP (Bash GI-37) and 8500 ± 180 BP (Bash GI-59). Peat dates of 8510 ± 150 BP (Bash GI-55) and 8820 ± 250 BP (Bash GI-56) were obtained near Sharkan in the middle Kama; additional peat dates from Ishbulatovo are 8570 ± 40 BP (Bash GI-31) and 8880 ± 60 BP (Bash GI-32). Dates of 9260 ± 210 BP (Bash GI-83), from the Evbazy River bank near Abdullino, and 8730 ± 160 BP (Bash GI-13), were also obtained from the upper Pechora near Dutovo. During the Boreal, Bashkiria was characterized by pine-fir forests, with locally abundant linden. Southern Bashkiria was covered by birch-pine forests alternating with steppe plains.

Atlantic deposits formed during the Holocene climatic optimum were reported from only some sections of the Fore-Urals. The dates are as follows: 7100 ± 150 BP (Bash GI-68) from the Syun River between Staro-Ilikovo and Kileevo; 7050 ± 100 BP (Bash GI-54) from near Sharkan; 6450 ± 150 BP (Bash GI-75), near Kushnarenkovo; 6300 ± 200 BP (Bash GI-72) from near Koyanovo; 5772 ± 530 BP (Bash GI-30) from near Sultanbekovo; and 5050 ± 60 BP (Bash GI-29) from near Utyagan. During the Atlantic phase, the Bashkiria region was characterized by pine-fir forests while its southern portion was covered with pine forests with birch, linden and minor elm and oak. The end of the phase was marked by the extension of treeless plains. Broad-leaved forests did not dominate during the climatic Holocene optimum in the Bashkiria region, in contrast to most of the central East European Plain.

Many ^{14}C dates are available for the Subboreal, as its deposits are widespread. Dates in the interval from 2630 ± 110 BP (Bash GI-102) to 4560 ± 150 BP (Bash GI-85) are presented in Table 2. The dates from Bash GI-1 to Bash GI-67 are reported by Yakheemovich, Pshenichnyuk and Suleimanova (1974). The onset of the Subboreal, in most parts of Bashkiria, was marked by the extension of xerophyte steppes replacing pine-birch forests (north) and birch (south). The maximum of linden forests, especially in northern Bashkiria, was characteristic of the Subboreal.

Far fewer dates are available for the Subatlantic: for example, 900 ± 90 BP (Bash GI-810) and 1920 ± 170 BP (Bash GI-71) (Table 2). These forests contained more fir; the second part of this phase was marked by an increase in deciduous species. At the end of the phase, xerophyte steppes became widespread. In contrast with the Subboreal, no floral changes were evident. The climate became warmer and drier toward the end of the Subatlantic.

TABLE 2. ^{14}C Dates on Peat and Wood

Climatic-chronological units	^{14}C dates and sample locations	Sample material and depth (m)
Late Holocene		
Subatlantic phase	900 ± 90 (Bash GI-810), Karyatmas	Peat near boundary horizon with wood, 0.7–0.8
	1380 ± 80 (Bash GI-80), Karyatmas	Peat above boundary horizon, 0.25–0.5
	1460 ± 80 (Bash GI-86), Yukalikul 1	Wood from boundary horizon, 0.6–0.7
	1920 ± 170 (Bash GI-71), Ishkarovo	Peat from workings at the Saryaz River, 1.1
Middle Holocene	2630 ± 110 (Bash GI-102), Ishkarovo	Peat covering boundary horizon, 1.3–1.4
Subboreal phase	2650 ± 70 (Bash GI-82), Karyatmas	Pine from boundary horizon, 1.4–1.6
	2720 ± 130 (Bash GI-84), Tally Kulevo	Peat ground bed, 0.5–0.6
	2760 ± 60 (Bash GI-103), Ishkarovo	Peat from middle part of boundary horizon, 1.5–1.6
	3110 ± 90 (Bash GI-104), Ishkarovo	Wood from lower part of boundary horizon, 1.6–1.7
	3130 ± 150 (Bash GI-70), Ishkarovo	Peat from workings at the Saryaz River, 2.75
	3160 ± 160 (Bash GI-88), Yukalikul 2	Peat, 1.2–1.3
	3410 ± 50 (Bash GI-89), Yukalikul 2	Peated carbonate silt, 1.3–1.5
	3470 ± 90 (Bash GI-LU-729), Karyatmas	Peat with wood, 2.0–2.2
	3720 ± 100 (Bash GI-87), Yukalikul 2	Peat with wood, 2.2–2.35
	3980 ± 180 (Bash GI-69), Kileevo-Ilikovo	
	4560 ± 150 (Bash GI-85), Burnak	Peat, 0.65
Atlantic phase	6300 ± 200 (Bash GI-72), Koyanovo	Peat, 1.5–1.6
	6450 ± 150 (Bash GI-75), Kushnarenkovo	Peat, 0.7–0.9
	6850 ± 150 (Bash GI-74), Bogatyrevo	Wood
Early Holocene		
Boreal phase	7100 ± 150 (Bash GI-86), Kileevo-Ilikovo	Peat
	7110 ± 220 (Bash GI-90), Yukalikul 2	Buried soil, 1.5–1.8
	7620 ± 90 (Bash GI-105), Ishkarovo	Peat with wood, 2.6
Preboreal phase	9260 ± 210 (Bash GI-83), Abdullino	Peat, 1.6–1.7
	9620 ± 50 (Bash GI-76), Kholodny Klyuch, Syun 1	Sand with coal, 1.2–1.6
	9650 ± 50 (Bash GI-77), Kholodny Klyuch, Syun 1	Coal, 1.2–1.6
Late Pleistocene		
Ostashkovian (Valdaian) glaciation		
Allerød, Older Dryas, Bølling, Oldest Dryas		
Main stage of Late Würm-Valdai-Ostashkovian glaciation	17,000 ± 100 (Bash GI-78), Kholodny Klyuch, Syun 1	Wood, 4.3–4.6
	17,200 ± 170 (Bash GI-79), Kholodny Klyuch, Syun 1	Wood, 4.3–4.6
Mologo-Sheksnian interglaciation	35,650 ± 180 (Bash GI-73), Krasny Bor	Wood from lower part of lacustrine loams

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Initial ^{14}C data were obtained on the age of the peat boundary horizon in Bashkiria, as well as on the beginning of peat formation (Table 2). Two boundary horizons were defined at the Karyatmas peat bog with dates of 2650 ± 70 BP (Bash GI-82) for the oldest, and 3470 ± 90 BP (LU-729) for the surface peat. The dates, 2760 ± 60 BP (Bash GI-103) and 3110 ± 90 BP (Bash GI-104), were obtained for the Ishkarovo peat bog, while surface peat was dated at 7620 ± 90 BP (Bash GI-105). At the Yukalikul peat bog, a layer with abundant fossil wood was dated at 1460 ± 80 BP (Bash GI-86).

Nemkova (1978) determined peat formation rates of 0.97 mm yr^{-1} for the lower part of the Subatlantic and Upper Subboreal, and 0.72 mm yr^{-1} for the lower part of the Subboreal at the Karyatmas peat bog. The most favorable conditions for peat formation in the southern Fore-Urals existed during the Subboreal.

Archaeological research established the duration of occupation in the Fore-Urals. Mesolithic cultures developed from the early Dryas to the second part of the Boreal; Neolithic and Eneolithic cultures existed from the middle Boreal to the second part of the Subboreal; the Bronze Age included most of the Subboreal; the onset of the Iron Age occurred at the end of the Subboreal.

In the Ural River valley (North Precaspian region) mollusk shells were sampled at Kozhekharovsky, Chapaev, Mergenevo, Inder, Kharkino, Kurilkino and Rakusha (Table 3), where Bakian, Khazarian, Khvalynian and Novocaspian strata were described (Yakheemovich, Nemkova and Dorofeev 1986). Uranium-series dates were obtained on shells from the Krasnovodsky and Cheleken peninsulas; the samples were analyzed at the Laboratory of Geochronology (Institute of Geography, St. Petersburg State University). The following dates were obtained for the Khazarian deposits from Cheleken: 1) from *Didacna pravoslavlevi* Fed., 200,000 BP (LU-831A, B) for inner and outer fractions; 2) from *Didacna porsugelica* Nev., 100,000 ± 3500 BP (LU-830A) (outer fraction) and 85,000 ± 2800 BP (LU-830 B) (inner fraction). The former are of Lower Khazarian age and the latter, Upper Khazarian (Mikulian).

The following dates were obtained by U-series method for the Khvalynian deposits from Krasnovodsky and Cheleken (Table 3): from *Didacna delenda* Bog., Krasnovodsky peninsula, Kyzyl Burun Mt.: 24,200 ± 700 BP (LU-826); and from *Didacna protracta* Eichw.: 16,700 ± 550 BP (LU-828); these are Lower Khvalynian deposits. The same samples yielded younger duplicate dates by ^{14}C method: 13,920 ± 740 BP (LU-826) and 11,810 ± 450 BP (LU-828). For the same Khvalynian deposits on the western coast of Cheleken, the U-series method yielded a date of 6200 ± 200 BP (LU-825) from *Didacna praetrigonoides* Nal., and may correspond to the Late Khvalynian. The samples from the Khvalynian deposits of the lower Ural River also gave a younger date; this probably results from the post-depositional contamination of young carbonate into shells. The following U-series dates were obtained for the Early Khvalynian terrace: 1) *Didacna protracta* Eichw., *D. subpyramidata* Prav. at Kozhekharovsky: 11,700 ± 500 BP (LU-844) and *Didacna protracta* Eichw.: 13,500 ± 700 BP (LU-845); 2) *Didacna protracta* Eichw. at Chapaev: 8090 ± 600 BP (LU-846A) and 9500 ± 400 BP (LU-846C) (*cf.* 11,830 ± 200 BP (LU-1433) by ^{14}C dating); 3) *Didacna protracta* Eichw., at Mergenevo: 11,900 ± 400 BP (LU-843); 4) *Didacna protracta* Eichw., northern bank of the Inder River: 14,400 ± 400 BP (LU-847A) and 14,900 ± 400 BP (LU-847B), both outer and inner fractions, (*cf.* from *Didacna ebersini* Fed.: 11,490 ± 380 BP (LU-1432) by ^{14}C dating).

LU-842, dated to 8850 ± 700 BP by U-series method, was obtained near Kharkino from *Didacna ebersini* Fed. whereas a ^{14}C date yielded 13,540 ± 130 BP (LU-1409). The following dates were also obtained by ^{14}C method: from *Didacna praetrigonoides* Nal. and *Cardium edule* I. at Rakusha:

TABLE 3. ^{14}C and U-Series Dates on Mollusk Shells

Climatic-chronological units	^{14}C dates and sample locations	Sample material
Late Holocene	410 ± 60 (Bash GI-89), Kurilkino	*Didacna pyramidata* Grimm., *D. Trigonoides* Pall.
	450 ± 70 (Bash GI-91), northern Caspian shore	*Didacna pyramidata* Grimm., *D. trigonoides* Pall.
	910 ± 60 (Bash GI-90), Peshny	*Cerastoderma lamarki* Reave, *Didacna trigonoides* Pall., *D. pyramidata* Grimm.
	1750 ± 60 (Bash GI-88), Rakusha	*Didacna praetrigonoides* Nal. & Anis., *Cardium edule* L.
Middle Holocene		
Subboreal phase		
Atlantic phase	6200 ± 200 (LU-825), Cheleken peninsula	*Didacna praetrigonoides* Nal. & Anis.
Early Holocene		
Boreal phase	9500 ± 400 (LU-846 C), Chapaev	*Didacna protracta* Eichw.
	8850 ± 700 (LU-842), Kharkino	*Didacna ebersini* Fed.
Late Pleistocene		
Ostashkovian (Valdaian) glaciation	11,490 ± 380 (LU-1432), northern bank of the Inder Lake	*Didacna ebersini* Fed.
	11,700 ± 1500 (LU-844), Kozhekharovsky	*Didacna protracta* Eichw., *D. subpyramidata* Prav.
	11,810 ± 450 (LU-828), Krasnovodsky peninsula	*Didacna protracta* Eichw.
	11,830 ± 200 (LU-1433), Chapaev	*Didacna protracta* Eichw.
	11,900 ± 400 (LU-843), Mergenevo	*Didacna protracta* Eichw.
	13,500 ± 700 (LU-845), Kozhekharovsky	*Didacna protracta* Eichw.
	13,540 ± 130 (LU-1409), Kharkino	Wood (a tree grown on the wash-out surface of Late Khazarian deposits)
	13,920 ± 740 (LU-826), Kyzyl-Burun Mt., Krasnovodsky peninsula	*Didacna delenda* Bog.
	14,400 ± 400 (LU-847 A), northern bank of the Inder Lake	*Didacna protracta* Eichw.
	14,900 ± 400 (LU-847 C), northern bank of the Inder Lake	*Didacna protracta* Eichw.
	16,700 ± 550 (LU-828), Krasnovodsky peninsula	*Didacna protracta* Eichw.
Mologo-Sheksnian interglaciation	24,200 ± 700 (LU-826), Kyzyl-Burun Mt., Krasnovodsky peninsula	*Didacna delenda* Bog.
Middle Pleistocene	85,000 ± 2800 (LU-830 C), Cheleken peninsula	*Didacna porsugelica* Nev.
	100,000 ± 3500 (LU-830 A), Cheleken peninsula	*Didacna porsugelica* Nev.
	200,000 (LU-831 A and LU-831 C), Cheleken peninsula	*Didacna pravoslavlevi* Fed.

1750 ± 60 BP (Bash GI-88), ^{14}C method; from *Didacna pyramidata* Grimm. and *D. trigonoides* Pall. at Kurilkino: 410 ± 60 BP (Bash GI-89); from *Cerastoderma lamarki* Raeve, *Didacna trigonoides* Pall. and *D. pyramidata* Grimm. at Peshny: 910 ± 60 BP (Bash GI-90), ^{14}C method; from *Didacna pyramidata* Grimm. and *D. trigonoides* Pall., northern coast of the Caspian Sea: 450 ± 70 BP (Bash GI-91).

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Conclusions

We conclude the following:

1. A considerable break between Lower and Upper Khazarian deposits has been confirmed, the former corresponding to the start of the Middle Pleistocene, and the latter to the beginning of the Late Pleistocene (Mikulian).
2. The age of Lower Khvalynian deposits corresponds to Tabuldinian (Mologo-Sheksnian) strata.
3. Late Khvalynian deposits date to the last glaciation.

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