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Genesis, ^{14}C age, and duration of development of the Bryansk paleosol on the Central Russian Upland based on dating of different materials

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ABSTRACT

The radiocarbon dates for the Bryansk paleosols in different sections of the Central Russian Upland, Alexandrov quarry, Zheleznogorsk, KBS-13, Taneyev quarry, Fatyanovka, Monastyrshchina, Kostenki-14, were obtained for different carbonaceous materials including sum of humic acids, pedogenic carbonates, charcoal, and bone collagen. The morphogenetic analysis of the paleosols including micromorphological observations was also conducted. Palaeosolos are meadow-carbonate or sod-carbonate with evidence of permafrost processes. The interval of the Bryansk paleosols development in the Late Pleistocene was between 33–26 ka BP, formed over 5–7 ka. The majority of radiocarbon dates obtained for humic acids and pedogenic carbonates from the Bryansk paleosols are rejuvenated. This fact was explained by the existence of the soils on the surface for a long time at the maximum of glaciation in MIS 2. The beginning of the last phase of loess accumulation at the Central Russian Upland was 17–15 ka BP.

1. Introduction

The middle part of the last (Valdai, Wurm, Weichselian) pleniglacial (60–25 ka BP) on the Central Russian Upland as well as in other world regions is characterized by a significant softening of severe periglacial conditions, interpreted as a mega-interstadial and synchronized with MIS 3 (Van Andel and Tzedakis, 1996; Velichko et al., 1997a; Velichko, 2002). After that the most extreme events of the Last Pleistocene occurred, the Last Glacial Maximum (LGM) and its further degradation in the Late Glacial, the Last Glacial transition (LGT) (Peltier and Fairbanks, 2006; Markova et al., 2008).

However, a long period of MIS 3 was not homogeneous. It was characterized by climatic oscillations that can be seen from the changing of ocean, ice and lake sediments, paleobotanic spectra, and other indicators of the most complete Late Pleistocene sections (Imbrie et al., 1984; Martinson et al., 1987; Soowers et al., 1993; Bibus et al., 1996; Van Andel and Tzedakis, 1996; Meese et al., 1997; Velichko, 2002; Boettger et al., 2005).

Series of warming inside the Middle Valdai megainterstadial (MIS 3) separated by cold snaps were not as significant as interstadials of the early glacial period. During the first of the early glacial interstadial (MIS 5a) the Kukuevka paleosol was formed on the Russian Upland, and the Strelitsa paleosol during the second interstadial (MIS 5c) (Sycheva and Gunova, 2004; Sycheva et al., 2007; Sycheva, 2008, 2010; Guidebook for field excursions, 2013; Pushkina and Sycheva, 2014). Both paleosols were of the Chernozem-type and developed within the moderate forest-steppe area which was cooler than the modern forest-steppe of the East European plain. In sections with low sediment activity those two paleosols were superimposed on each other and on the underlying interglacial paleosol (MIS 5e), creating the Ryshkovo pedolithocomplex, and together form the main stratigraphic marker of the Late Pleistocene (geosol) (Sycheva, 1998, 2012; Sycheva et al., 2007; Sycheva and Sedov, 2012; Guidebook for field excursions, 2013). This Late Pleistocene interglacial–early glacial pedolithocomplex (Mezin, Berdsk, Gorokhov, PK I + PK II, Stillfried A, Rocourt and other temporal analogues) is widely distributed (Tsatskin, 1980; Morozova, 1981; Bogucky, 1987; Bronger and Heinkele, 1989; Zoller et al., 1991; Konescka-Betley, 1994; Havlíček and Smolikova, 1995; Velichko et al., 1997a; Bibus, 1999; Gerasimenko, 2000, 2004; Haesaerts and Mestdagh, 2000; Antoine et al., 2001, 2008; Frechen et al., 2001; Zykina, 2006; Terhorst et al., 2011; Jary and Mroczek, 2014).

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During interstadials of MIS 3 on the Central Russian Upland, paleosols also developed but these were paleosols of the periglacial forest-steppe: Alexandrovka about 50–46 ka BP, Gidrouzel about 36 ka BP, and Bryansk 33–26 ka BP (Sycheva and Gunova, 2004; Sycheva et al., 2007; Sycheva, 2012; Guidebook for field excursions, 2013). The end of the MIS 3 interstadial is a widespread significant event in the history of the Late Pleistocene. Paleosols of this interstadial (Bryansk paleosol in European Russia, Lohner soil in Germany, Stillfried B soil in Austria, paleosol of the Denekamp interstadial in Netherlands; Grand Bois and Arcy in France, Dubno in the western part of Ukraine, Vytachiv 3 in the central and eastern parts of Ukraine, Iskitim pedocomplex in Western Siberia, Osin pedocomplex in south-central Siberia, pedocomplex I in Czech Republic, Farmdale in USA, and other equivalents), are the most widely distributed in the loess-paleosol sequences of Eurasia and the Northern Hemisphere (Velichko and Morozova, 1972; Tsatskin, 1980; Bogucky, 1987; Bronger and Heinkele, 1989; Konescka-Betley, 1994; Havlíček and Smolikova, 1995; Bibus, 1999; Haesaerts and Mestdagh, 2000; Antoine et al., 2001, 2008; Frechen et al., 2001; Van Andel, 2002; Zykina, 2006; Peticzka and Terhorst, 2008; Jacobs et al., 2013). The Bryansk paleosol is a major paleogeographic boundary finalizing the warming interval of the megainterstadial inside the last glacial period. In the periglacial area of the Valdai glaciations, it is the second important geosol separating the Middle and Late Valdai loesses.

As shown by the previous radiocarbon studies (Morozova, 1981; Chichagova, 1985; Chichagova and Cherkinskiy, 1988), the age interval of the Bryansk paleosols is wide and ranges from 22–24 to 32–34 ka BP (Table 1). The duration of the Bryansk pedogenesis is 10–12 ky, and commensurate with the duration of the interglacial Holocene or Eemian. However, the morpho-type and physical and chemical characteristics of the Bryansk paleosols do not correspond to the interglacial soils (Velichko and Morozova, 1972; Morozova, 1981; Udartsev and Sycheva, 1985). This unconformity cannot be explained by different paleoecological conditions only, but also by the history of soil development and loess accumulation and denudation at the end of MIS 3 on the high geomorphological positions.

Table 1
Radiocarbon dates for the Middle-Late Valdai loess-paleosols series in different sections on the Russian Upland.

Site	Geomor-phological position	Depth, cm	Horizon, paleosol, loess, cultural layers	Laboratory N	^{14}C BP	Dated material
Bryansk[a]	Flat interfluve	505	AB, Br	IGAN-492	22,760 ± 410	Humic acids
Bryansk[b]	«	«	«	Mo-337	24,920 ± 1800	«
Arapovichi[a]		700	«	IGAN-46	24,000 ± 300	«
Mezin[b]		300	«	Mo-342	24,200 ± 1680	«
Mezin[a]		«	«	IGAN-88	24,300 ± 370	«
Mezin[a]	«	320	«	IGAN-89	24,210 ± 270	«
Fatyanovka[c]	Ancient terrace	520	AB, Br	IGAN-197	22,300 ± 250	«
Zheleznogorsk[d]	Paleo-hollow	230	«	IGAN-338	24,180 ± 900	«
Shpikulovo[c]	Flat interfluve	150	«	IGAN-511	24,580 ± 560	«
Monastyrshchina[e]	Paleoslope	210	«, Br 1	Ki-8475	24,400 ± 700	«
«,[e]	«	250	«, Br 2	Ki-7684	29,100 ± 340	«
Kostenki 14[f]	Paleo–ravine		Cl II	OxA-4115	28,580 ± 420	Bone
«,[f]	«		«	CrA-13312	29,240 ± 330	Charcoal
«,[f]	«		Cl III	CrN-21802	30,080 ± 590	«
«,[f]	«		«	CrA-13288	31,790 ± 430	«
KBS-13,[g]	Flat interfluve	180–190	AB, Br	Ki-16670	16,670 ± 140	Humic acids
Taneiev[i]	Slope	105–120	«	Ki-15277	23,400 ± 230	«
Alexandrov, 2001,[h]	Dell	160	AL	Ki-9360	11,140 ± 190	«
«,[h]	«	190	BO	Ki-9361	12,200 ± 180	«
«,1999,[h]	Paleo-ravine	200–250	AB, Br	Ki-8211	33,140 ± 230	«
«, 1999,[h]	«	310	ls, Tu	Ki-10868	40,200 ± 420	Bone collagen
«, 2001,[h]	«	300	«	Ki-9362	39,710 ± 580	«
«, 2005,[h]	«		A, Alx	Ki-15275	49,600 ± 700	Humic acids
«, 2008,[i]	«	230	AB, Br	Ki-16586	16,330 ± 200	Humic acids
«,[i]	«	260	«	Ki-15823	15,150 ± 250	«
«,[i]	«	290 cm	«	Ki-15815	15,520 ± 180	«
«, 2013,[i]	Paleo-slope	200–220	Bk, Br	Ki-18388	13,200 ± 160	Carbonates
«,[i]	«	220–240	«	Ki-18400	16,300 ± 190	«
«,[i]	«	240–260	«	Ki-18401	16,920 ± 260	«
«, 2014,[i]	«	130–135	«	Ki-18714	15,400 ± 100	«
«,[i]	«	90–100	AB, Br	Ki-18715	17,920 ± 250	Humic acids

[a] Morozova, 1981.
[b] Chichagova, 1985; Chichagova and Cherkinskiy, 1988.
[c] Sycheva, 1979; Morozova, 1981.
[d] Guide of the INQUA excursion C-3, 1982; Sycheva, 1993.
[e] Sycheva, 2002.
[f] Sinitsyn and Hoffecker, 2006, Guidebook for Field Excursions, 2013.
[g] Guidebook for Field Excursions, 2013.
[h] Sycheva, 2000, 2010, 2012.
[i] This paper. Notes: AB, Br–AB horizon of the Bryansk paleosol; Bk, Br–Bk horizon of the Bryansk paleosol; Br 1 – upper Bryansk paleosol; Br 2 – lower Bryansk paleosol; Cl II – cultural layer II in the Kostenki 14 section; Cl III – cultural layer III in the Kostenki 14 section: Al – Alleroed: B – Bölling: Ls, Tu – Tuskar loess; A, Alx – the A horizon of Alexandrovka paleosol.

Apart from the discrepancies of age and duration of soil formation, the Bryansk paleosols have a number of unique macro- and micromorphological characteristics and physical and chemical properties that are difficult to interpret from the standpoint of actualism (Velichko and Morozova, 1972; Morozova, 1981), including intensive argillization of the A and AB horizons without