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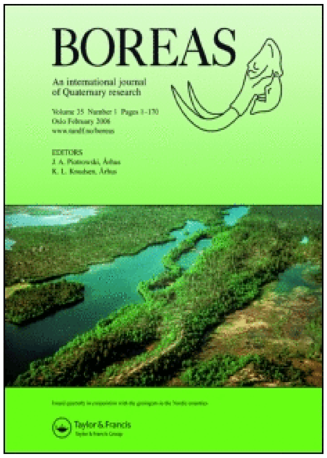

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Timing of the last deglaciation in Belarus

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BOREAS

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We measured ^{10}Be concentrations in boulders collected from the Orsha and Braslav moraines, associated with the Last Glacial Maximum extent and a recessional stage of the Scandinavian Ice Sheet (SIS), respectively, providing a direct dating of the southeastern sector of the ice-sheet margin in Belarus. By combining these data with selected existing radiocarbon ages, we developed a chronology for the last deglaciation of Belarus. The northeastern part of the country remained ice free until at least 19.2 ± 0.2 cal. kyr BP, whereas the northwestern part of the country was ice free until 22.3 ± 1.5 cal. kyr BP. A lobate ice margin subsequently advanced to its maximum extent and deposited the Orsha Moraine. The ice margin retreated from this moraine at 17.7 ± 2.0 ^{10}Be kyr to a position in the northern part of the country, where it deposited the Braslav Moraine. Subsequent ice-margin retreat from that moraine at 13.1 ± 0.5 ^{10}Be kyr represented the final deglaciation of Belarus. Direct dating of these moraines better constrains the relation of ice-margin positions in Belarus to those in adjacent countries as well as the SIS response to climate change.

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The last advance of the southern margin of the Scandinavian Ice Sheet (SIS) in Belarus occurred during the Late Pleistocene Poozerian Glaciation (Matveyev 1995; Karabanov *et al.* 2004). Geomorphological (Matveyev 1994; Matveyev & Pavlovskaya 2001), geological (Pavlovskaya & Murashko 2002) and palynostratigraphic (Yelovicheva & Sanko 1999) data distinguish two broad moraine belts in northern and northwestern Belarus (Fig. 1). The Orsha Moraine corresponds with the maximum extent of the SIS during the Last Glacial Maximum (LGM) and the Braslav Moraine corresponds with a re-advance of the ice margin following retreat from the LGM position. However, the ages of these moraines are only constrained by a few limiting radiocarbon dates (Vozniachuk *et al.* 1981; Zimenkov & Kuznetsov 1985; Zimenkov 1989; Rinterknecht *et al.* 2006). Rinterknecht *et al.* (2006) directly dated ice-margin positions of the southeastern sector of the last SIS using cosmogenic ^{10}Be. Here we discuss further the ^{10}Be dating of the local Orsha and Braslav moraines, providing a detailed description of the exposure ages with respect to their sample context and issues specific to the glacial history of Belarus. Our results significantly improve the chronology of the last deglaciation of Belarus.

^{10}Be chronology

We sampled 10 boulders on the Orsha Moraine and four boulders from the Braslav Moraine, including duplicate samples of one boulder. We extracted beryllium from quartz at Oregon State University and Washington State University, USA, and the Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse, Orsay Campus, France. Quartz (0.25–0.71 mm) was boiled in pyrophosphoric acid to dissolve most of the aluminosilicates, and then leached repeatedly with solutions of HNO_3 and HF until satisfactory quartz purity was reached, as determined by ICP-AES. A reference 0.25 mg ^{9}Be spike was added to each sample. Anion exchange, cation exchange and selective precipitation techniques were used to isolate the beryllium progressively (Rinterknecht *et al.* 2005).

We measured ^{10}Be/^{9}Be ratios on our 15 samples (Table 1) by accelerator mass spectrometry (AMS) at the Tandetron facility in Gif-sur-Yvette, France (Raisbeck *et al.* 1994). The ratios were normalized to the National Institute of Standards and Technology (NIST) certified ratio of ^{10}Be/^{9}Be ($26.8 \pm 1.4 \times 10^{-12}$). The analytical uncertainty (1σ) is the combination (in quadrature) of the counting statistics, an additional conservative 5% uncertainty based on long-term

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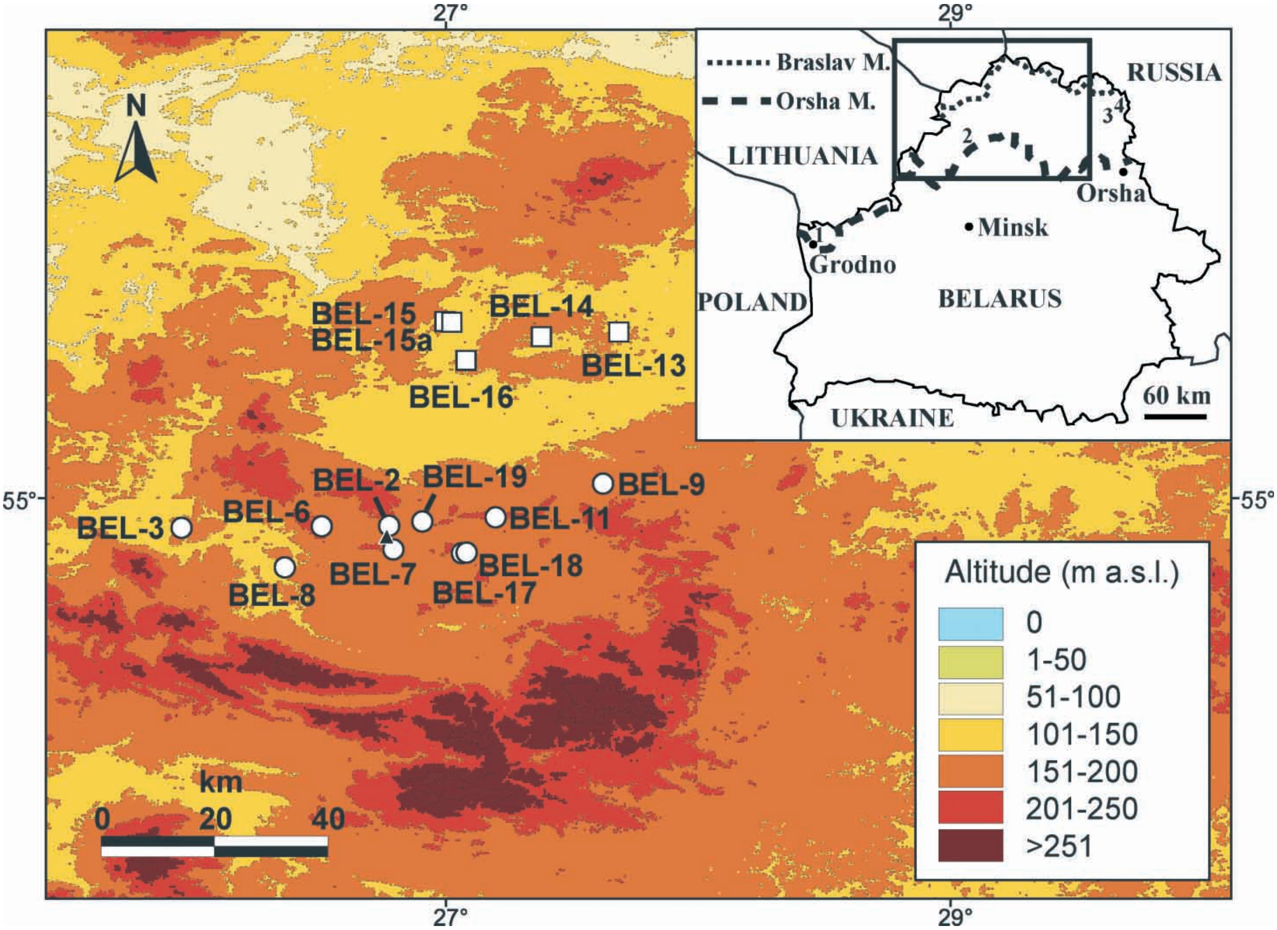

Fig. 1. Topography of the sampling area (adapted from http://lpdaac.usgs.gov). ^{10}Be sampling sites: white circles are samples from the Orsha Moraine, white squares are samples from the Braslav Moraine. Radiocarbon sampling sites: 1 = Gozha, Plaskovtsy, Kukali; 2 = Studenets (black triangle); 3 = Drichaluki, Sloboda; 4 = Brigitpole, Kaspliane.

measurements of standards, and the uncertainty in blank corrections. Total analytical uncertainties associated with the AMS measurements on our samples varied from 7% to 10%. All individual exposure ages are reported with a 1σ error corresponding to the analytical uncertainties only. Because of an apparent difference of 12.5% (Middleton *et al*. 1993) between the ^{10}Be NIST standard (SRM 4325) used in Gif-sur-Yvette and the ICN Biomedicals standard used to compile most available production rates (including the production rate used in this study), we lowered our ^{10}Be production rate by a factor of 0.875 before calculating exposure ages. We report exposure ages (Table 1, Fig. 2) using an assumed ^{10}Be production rate of 5.1 atom/g/yr (before adjustments for sample thickness and altitudinal as well as latitudinal scaling) at 1013.25 hPa air pressure at latitude >60°. We scaled this production rate for each site's altitude and latitude using the correction factors based on air pressure as described in Lal (1991) and Stone (2000).

Snow cover could have an effect on the exposure ages. Assuming a conservative estimate of 50 cm snow depth for 4 months/yr with an absorption length of 160 g/cm^2, the production rate decreases by 1.5%. Because our samples came from the top of boulders, we assumed that any snow was blown off rapidly after storms and had a negligible effect on production. Thus we did not correct for potential snow cover.

Samples were from granitic boulders, which are generally resistant to erosion. A conservative erosion rate of 3 mm/kyr (Gosse *et al.* 1995) increases our exposure ages by 4%. Because this is likely to be an overestimation, the exposure age difference between corrected and uncorrected results is likely to be less than 4% and we chose not to apply any correction to our age calculations for erosion.

We rejected data for four of the 10 samples from the Orsha Moraine on the basis of clear age discrepancies and analytical criteria, as follows. Because BEL-8 is the southernmost sample collected from the Orsha sampling sites (Fig. 1), its young age (9.3 ± 0.7 ^{10}Be kyr) indicates that it was not deposited during the Orsha stage. This young age may reflect unrecognized boulder erosion or late-stage stagnant ice that continued to

Table 1. Sample characteristics and ^{10}Be exposure ages in Belarus (excerpt from Rinterknecht *et al.* 2006).

Sample ID	Quartz (g)	Latitude, N (DD)	Longitude, E (DD)	Altitude (m a.s.l.)	Scaling factor for spallation[1]	Scaling factor for muon[1]	Scaling factor for thickness	[^{10}Be] (10^4 atom/g)[2]	^{10}Be production rate (atom/g/yr)[3]	Exposure age (^{10}Be kyr)[4]
Orsha Moraine										**17.7±2.0**[5]
BEL-2	70.912	54.889	26.773	177	1.211	1.091	0.982	6.78±0.60	5.3	12.8±1.1
BEL-3	71.382	54.881	25.951	196	1.234	1.101	0.968	8.72±0.58	5.3	16.5±1.1
BEL-6	70.018	54.888	26.507	201	1.240	1.104	0.980	11.37±0.73	5.4	21.1±1.4
BEL-7	70.150	54.795	26.791	188	1.224	1.097	0.971	13.51±0.99	5.3	25.7±1.9
BEL-8[7]	70.189	54.723	26.361	153	1.182	1.078	0.968	4.73±0.36	5.1	9.3±0.7
BEL-9	70.178	55.056	27.621	179	1.213	1.092	0.977	7.28±0.53	5.3	13.8±1.0
BEL-11[7]	70.124	54.922	27.195	200	1.239	1.103	0.977	11.85±2.26	5.4	22.1±4.2
BEL-17[7]	70.036	54.780	27.060	210	1.251	1.109	0.964	34.75±2.39	5.4	65.7±4.5
BEL-18[7]	70.164	54.781	27.082	214	1.256	1.111	0.991	46.87±2.83	5.5	86.3±5.2
BEL-19	71.152	54.906	26.906	207	1.247	1.107	0.964	8.57±0.61	5.4	16.1±1.2
Braslav Moraine										**13.1±0.5**[6]
BEL-13	71.447	55.658	27.683	151	1.180	1.077	0.974	7.18±0.70	5.1	14.1±1.4
BEL-14	71.029	55.639	27.375	150	1.179	1.077	0.984	6.19±0.47	5.2	12.0±0.9
BEL-15	29.117	55.699	26.994	144	1.171	1.074	0.995	6.99±0.62	5.2	13.5±1.2
BEL-15A	34.198	55.699	26.994	144	1.171	1.074	0.995	7.39±0.62	5.2	14.3±1.2
BEL-16	70.022	55.544	27.076	152	1.181	1.078	0.982	6.63±0.46	5.2	12.9±0.9

[1] Scaling factor accounts for the mode of production of ^{10}Be atoms at the boulder surface: 97.8% by spallation and 2.2% by muon capture (Stone 2000).

[2] ^{10}Be/^{9}Be ratios were measured relative to the National Institute of Standards and Technology (NIST) certified ratio of ^{10}Be/^{9}Be ($26.8 \pm 1.4 \times 10^{-12}$). Analytical uncertainties (propagated at $\pm 1\sigma$ level) include a procedural blank of $6.41 \pm 3.51 \times 10^4$ atom/g ($n = 19$).

[3] We used an assumed production rate of 5.1 atom/g/yr and scaled it for each sample location and thickness. Most production rate estimates are based on other standards, which are lower by 12.5% relative to the NIST one (Middleton *et al.* 1993). We corrected the production rates for that difference in our exposure age calculation.

[4] For single exposure ages we report the $\pm 1\sigma$ analytical uncertainty only.

[5] Mean moraine age. The $\pm 1\sigma$ uncertainty corresponds to the standard deviation of the mean exposure ages.

[6] Error-weighted mean moraine age. The $\pm 1\sigma$ uncertainty corresponds to the error-weighted mean of the analytical uncertainties.

[7] Sample not included in the moraine mean age.

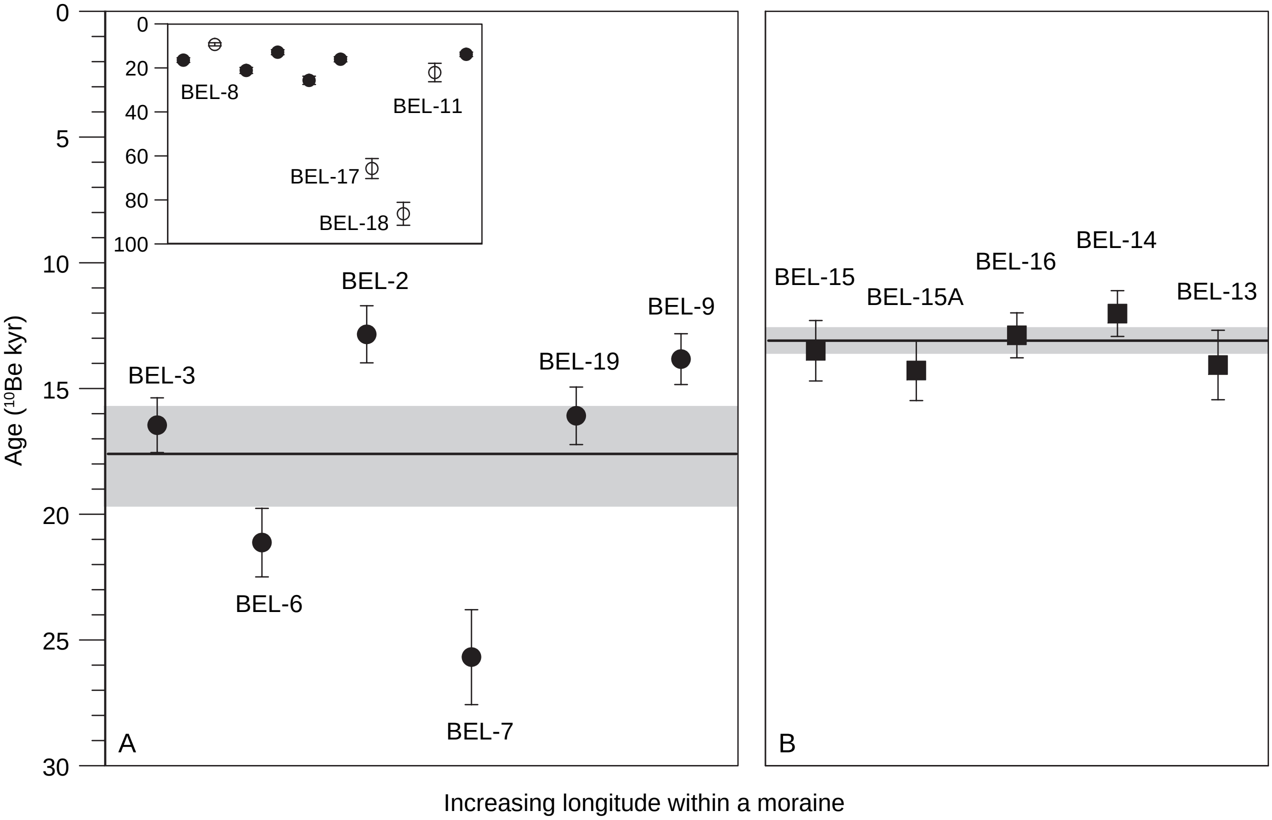

Fig. 2. Single exposure ages and mean moraine age for the Orsha Moraine (A) and error-weighted mean moraine age for the Braslav Moraine (B). ^{10}Be exposure ages are ordered within a moraine using the sample longitudes (west to east). Inset in (A) corresponds to the full data set. Solid circles are ^{10}Be exposure ages used in the moraine age calculation. Open circles are outliers not included in the moraine age. Error bars for single ^{10}Be exposure ages correspond to 1σ analytical uncertainty only. The black horizontal lines identify the mean age (A) and the error-weighted mean age (B). Shaded grey bands correspond to 1σ uncertainty: the standard deviation of the mean exposure age (A) and the error-weighted mean of the analytical uncertainties (B).

cover the boulder for an extended period of time following ice-margin retreat. Alternatively, based on the boulder's altitude, we can speculate that the boulder was deposited by a lower altitude Braslav ice tongue (*c.* 150 m a.s.l.) compared with the previous ice margin advance during the maximum extent that reached altitudes between *c.* 180 m a.s.l. and *c.* 210 m a.s.l. (Fig. 3). Samples BEL-17 (65.7 ± 4.5 ^{10}Be kyr) and BEL-18 (86.3 ± 5.2 ^{10}Be kyr) were clearly too old, which we attributed to incomplete boulder erosion and attendant inherited ^{10}Be. The samples' southern position on the moraine indicates that the boulders may have been reworked from older, more extensive advances associated with the Dniepr and the Sozh glaciations (Karabanov *et al.* 2004). The boulders' altitudes, 214 m a.s.l. and 210 m a.s.l., the highest altitudes among our samples (Fig. 3), supported this hypothesis. Lastly, we excluded BEL-11 (22.1 ± 4.2 ^{10}Be kyr) from the sample population based on analytical criteria. This sample had a very low ^{9}Be current that resulted in few ^{10}Be events (30 events) and thus had a large analytical uncertainty (19%).

The observed variability (*c.* 27%) among the six remaining exposure ages is four times what is expected based on analytical uncertainties alone (*c.* 7%). This suggests that random uncertainties are dominated by geological uncertainties rather than by analytical ones. Recognizing the relatively small sample sizes, we also noted that the standard deviation of the Orsha Moraine age population is significantly larger than the standard deviation from the Braslav Moraine population. This larger variability probably reflects some combination of a prior exposure of pre-existing boulders and their incomplete erosion during advance to the Orsha Moraine (inherited ^{10}Be), the longer duration of the Orsha event relative to the younger Braslav event, and subsequent boulder erosion. Although some exposure ages were demonstrably too young or too old, as suggested by the radiocarbon ages constraining the Orsha advance and retreat, we included them in the mean moraine age because there was no objective basis for rejecting them. A Shapiro–Wilk test indicated that we could not reject the data normal distribution assumption ($W = 0.90$,

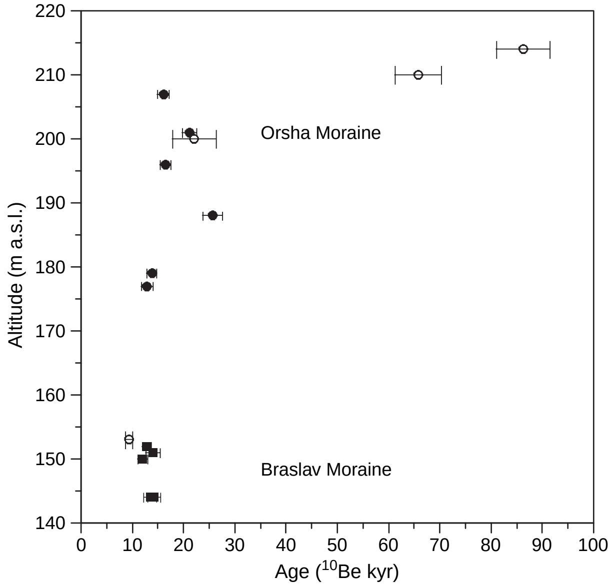

Fig. 3. Time–altitude dependence of the boulders' exposure ages. Solid circles are exposure ages from the Orsha Moraine. Solid squares are exposure ages from the Braslav Moraine. Open circles are data not used in the Orsha Moraine age calculation (see text for discussion). Error bars correspond to 1σ analytical uncertainty only.

p-value = 0.40). Because the observed variability between the exposure ages was larger than the analytical uncertainty, we report the Orsha Moraine age as the average of the six exposure ages, 17.7 ± 2.0 ^{10}Be kyr (Fig. 2A), and the error as the standard deviation of the mean exposure ages (11%).

The four boulders sampled from the Braslav Moraine were close geographically as well as having a similar altitude (144–152 m a.s.l.) (Fig. 3), and we thus expect the four boulder surface histories to be similar. Samples BEL-15 (13.5 ± 1.2 ^{10}Be kyr) and BEL-15A (14.3 ± 1.2 ^{10}Be kyr) were sampled from two different sites on the same boulder surface and their ages agreed within analytical uncertainties. The mean was assigned as the boulder age. The five exposure ages range from 12.0 ± 0.9 ^{10}Be kyr to 14.3 ± 1.2 ^{10}Be kyr (Fig. 2B). A Shapiro–Wilk test indicated that we could not reject the data normal distribution assumption ($W = 0.94$, *p*-value = 0.70). Because the observed variability between the exposure ages (7%) is about what is expected on the basis of our analytical uncertainties (7–10%), we report the Braslav Moraine age as an error-weighted mean age of 13.1 ± 0.5 ^{10}Be kyr (Fig. 2B). The error corresponds to the error-weighted mean of the analytical uncertainty (4%).

Radiocarbon chronology

Forty-one existing radiocarbon ages at seven different sites (Fig. 1, Table 2) provide limiting ages for the advance of the SIS margin to its maximum LGM extent in Belarus. In addition, we dated wood macrofossils from post-glacial sediment at the Studenets site (Fig. 1) (Rinterknecht *et al.* 2006), which provides a limiting age of 11.0 ± 0.1 ^{14}C kyr BP (13.0 ± 0.1 cal. kyr BP) for deglaciation of the site.

The Gozha, Plaskovtsy and Kukali sampling sites are located in northwestern Belarus, about 20 km downstream from the city of Grodno (Fig. 1). The most detailed sequence occurs at the Gozha site (Table 2), where laminated lacustrine clays contain scattered organic material. The clays are overlain by three units of glaciolacustrine–glaciofluvial deposits (Zimenkov & Kuznetsov 1985; Zimenkov 1989) that record the presence of a proglacial lake dammed by the advancing SIS margin to its maximum extent (Matveyev 1994). The absence of till at the site, and its position distal to the Orsha Moraine, indicates that the SIS did not override the site during the LGM (Pavlovskaya *et al.* 2002). In addition, the maximum ice margin extent during the LGM was mapped to run just north of this region in southern Lithuania by Guobyte (2002) based on geomorphological evidences. Radiocarbon ages from the Gozha site suggest that the region was ice free from >24.9 ± 0.2 ^{14}C kyr BP (29.8 ± 0.5 cal. kyr BP) until the SIS margin reached its maximum extent in the Grodno region, sometime ≤18.7 ± 1.2 ^{14}C kyr BP (≤22.3 ± 1.5 cal. kyr BP).

The Drichaluki, Brigitpole, Kaspliane and Sloboda sites are located in northeastern Belarus (Fig. 1). All sites are overlain by till deposited during the SIS advance to its LGM position. The Drichaluki site provides the most detailed sequence, where radiocarbon ages suggest ice-free conditions between ≥24.5 ± 0.3 ^{14}C kyr BP (≥29.1 ± 0.4 cal. kyr BP) and ≤16.0 ± 0.2 ^{14}C kyr BP (≤19.2 ± 0.2 cal. kyr BP) (Vozniachuk *et al.* 1981; Zimenkov & Kuznetsov 1985; Zimenkov 1989). At the Kaspliane site, the youngest age on organic-rich sediments overlain by till suggests ice advance across the site ≤18.5 ± 0.5 ^{14}C kyr BP (≤21.9 ± 0.6 cal. kyr BP).

Implications for the last deglaciation of Belarus

Boulton *et al.* (2001) describe the extreme lobation of the southeastern margin of the SIS in Belarus as reflecting the Riga ice stream advancing into Belarus from the northwest and the Novgorod ice stream advancing from the northeast. The calibrated radiocarbon ages thus indicate that the margin of the Riga ice stream advanced to its maximum extent in northwestern Belarus ≤22.3 ± 1.5 cal. kyr BP (radiocarbon sampling site 1 in Fig. 1 insert), or *c.* 3000 years earlier than the Novgorod ice stream, which advanced into northeastern Belarus ≤19.2 ± 0.2 cal. kyr BP (radiocarbon sampling site 3 in Fig. 1 insert). The limiting

Table 2. Radiocarbon ages within the last glaciation extent in Belarus (excerpt from Rinterknecht *et al.* 2006).

Site	Laboratory reference	^{14}C age	Cal. yr BP[1]
Gozha	LU-76A	18 730 ± 1230[2,3]	22 280 ± 1520
Gozha	Mig-39	22 600 ± 290[2,3]	27 100 ± 300
Gozha	LU-76B	22 740 ± 250[2,3]	27 240 ± 280
Gozha	LU-89	22 950 ± 440[2,3]	27 460 ± 470
Gozha	Mig-38	23 060 ± 330[2,3]	27 580 ± 360
Gozha	LU-76C	23 200 ± 520[2,3]	27 730 ± 560
Gozha	Mig-37	23 480 ± 340[2,3]	28 020 ± 370
Gozha	Tln-138	23 850 ± 300[2,3]	28 410 ± 330
Gozha	Mig-35	24 730 ± 380[2,3]	29 550 ± 650
Gozha	Mig-36	24 790 ± 360[2,3]	29 640 ± 640
Gozha	Mig-34	24 810 ± 380[2,3]	29 680 ± 660
Gozha	LU-90B	24 860 ± 230[2,3]	29 750 ± 510
Plaskovtsy	Tln-139	24 050 ± 450[2,3]	28 640 ± 530
Plaskovtsy	Mig-31	24 300 ± 450[2,3]	28 950 ± 600
Kukali	Mig-33	23 960 ± 470[2,3]	28 540 ± 550
Studenets	AA-53600	10 990 ± 140[4]	12 950 ± 140
Drichaluki	Tln-469	15 960 ± 180[2,3]	19 150 ± 180
Drichaluki	Mig-1	17 600 ± 400[2,3]	20 810 ± 520
Drichaluki	LU-95A	17 770 ± 170[5]	20 980 ± 270
Drichaluki	Tln-471	17 880 ± 240[2,3]	21 120 ± 390
Drichaluki	LU-95B	17 900 ± 160[2,3]	21 150 ± 290
Drichaluki	Tln-36	18 020 ± 110[2,3]	21 310 ± 260
Drichaluki	Tln-435	18 100 ± 500[2,3]	21 500 ± 630
Drichaluki	Mig-15	18 150 ± 190[2,3]	21 630 ± 330
Drichaluki	LU-96	18 370 ± 180[2,3]	21 860 ± 290
Drichaluki	Tln-437	18 700 ± 1000[2,3]	22 240 ± 1290
Drichaluki	Tln-486	19 700 ± 220[2,3]	23 540 ± 370
Drichaluki	Tln-470	20 300 ± 150[2,3]	24 290 ± 200
Drichaluki	Tln-513	21 600 ± 450[2,3]	25 970 ± 570
Drichaluki	LU-97	23 630 ± 370[2,3]	28 180 ± 400
Drichaluki	Tln-327	24 450 ± 300[2,3]	29 090 ± 430
Sloboda	Tln-309	17 470 ± 210[2,3]	20 630 ± 270
Brigitpole	Tln-429	17 300 ± 80[2,3]	20 410 ± 130
Brigitpole	Tln-438	18 060 ± 90[2,3]	21 390 ± 250
Brigitpole	Tln-484	18 600 ± 130[2,3]	22 190 ± 130
Brigitpole	Tln-482	21 050 ± 110[2,3]	25 300 ± 270
Brigitpole	Tln-485	29 030 ± 260[2,3]	33 960 ± 540
Brigitpole	Tln-426	29 300 ± 250[2,3]	34 380 ± 500
Kaspliane	Tln-425	18 480 ± 470[2,3]	21 870 ± 600
Kaspliane	Tln-309	18 850 ± 80[2,3]	22 380 ± 80
Kaspliane	LU-615B	19 550 ± 190[2,3]	23 310 ± 350
Kaspliane	LU-615A	21 080 ± 340[2,3]	25 460 ± 530

[1] Calibration was performed using IntCal04 (Reimer *et al.* 2004). Calibration of radiocarbon ages older than 21 381 BP is based on the calibration curve given in Fairbanks *et al.* (2005).
[2] From Zimenkov (1989).
[3] From Zimenkov & Kuznetsov (1985).
[4] From Rinterknecht *et al.* (2006).
[5] From Vozniachuk *et al.* (1981).

radiocarbon age in the northwest probably closely constrains the timing of the SIS advance to its maximum extent in that region, as the sampled site was not overridden by ice, and the initiation of deposition of glaciolacustrine and glaciofluvial sediments above the radiocarbon date records the first presence of ice in the drainage basin. In contrast, the sampling sites in the northeast are located up-ice of the maximum position reached by the SIS (inset Fig. 1) and thus record a minimum age for the advance of the SIS margin towards its maximum position in that region. Our data from the Orsha Moraine then suggest that the SIS margin began to retreat from its maximum extent at 17.7 ± 2.2 kyr BP (the error includes a 6% uncertainty in the production rate; Stone 2000).

We then address possible explanations for the large variability in the LGM moraine sample population. At the time of the LGM the southern SIS included several ice streams, the largest one being the Baltic ice stream advancing through the Baltic Basin and reaching as far west as Denmark in the proximity of the Norwegian Channel ice stream that ultimately merged with the British Ice Sheet (Boulton *et al.* 2001). Southward-heading secondary ice streams, including the Riga and the Novgorod ice streams, branched out from the Baltic ice stream and advanced into the Baltic countries, including Belarus. A rapid rise in global sea level starting at *c.* 19 cal. kyr BP (Yokoyama *et al.* 2000) would first have affected the western sector of the SIS, where it was in contact with the sea, inducing calving and attendant eastward retreat of the Baltic ice stream margin into the isostatically depressed Baltic Basin. Flow to secondary ice streams draining southwards from the Baltic ice stream (Boulton *et al.* 2001) may then have been reduced or cut off, leaving remnant stagnant ice masses in Belarus that would have taken millennia to melt. Accordingly, boulders from the LGM moraine in Belarus may have been deposited over a period of several millennia.

Our radiocarbon date at the Studenets site (radiocarbon sampling site 2 in Fig. 1 insert) (Rinterknecht *et al.* 2006) indicates that this region was deglaciated by 13.0 ± 0.1 cal. kyr BP. This is consistent with our ^{10}Be data from the Braslav Moraine further north, which suggests the ice margin started to retreat from the moraine at 13.1 ± 0.9 kyr BP (the error includes a 6% uncertainty in the production rate; Stone 2000).

Conclusion

Although there is considerable scatter in the ^{10}Be ages associated with the Orsha Moraine, our new data provide the first direct age estimate of the LGM in Belarus. In addition, the moraine age provides supporting evidence that the glacial limit, otherwise identified by means of geomophological and stratigraphical evidence, corresponds to the LGM ice position. We suggest that the LGM boulders were deposited in association with stagnant ice that was disconnected from the Baltic ice stream, its former source, in response to the rapid sea level rise at *c.* 19 cal. kyr BP.

The timing of the SIS retreat from the Braslav Moraine (13.1 ± 0.5 ^{10}Be kyr) is significantly younger than the timing of the SIS retreat from the Pomeranian Moraine in Poland, 14.8 ± 0.4 ^{10}Be kyr (Rinterknecht *et al.* 2005), to which it had previously been correlated. We interpret this difference as reflecting a slower response of the southeastern sector of the SIS to the warming of the North Atlantic region associated with the onset of the Bølling interstade, *c.* 14.6 cal. kyr BP. Alternatively, the Braslav Moraine in Belarus may represent a younger recessional phase of the SIS than that represented by the Pomeranian Moraine in Poland.

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