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Rapid communication

Extending the known distribution of the Younger Dryas Vedde Ash into northwestern Russia

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ABSTRACT: The known distribution of wind-blown Vedde Ash (ca. 10.3 ka BP) has been extended to the Karelian Isthmus in northwestern Russia. This has been possible as the result of a density separation technique that separates the rhyolitic Vedde Ash shards from the minerogenic host sediment. The Vedde Ash occurs in the middle of a pollen zone with high percentages of, for example, *Artemisia* and Chenopodiaceae, suggesting that the Younger Dryas (or GS-I in the GRIP ice-core event stratigraphy) was cold and dry throughout its duration. This is in agreement with sites in south Sweden where the Vedde Ash also occurs in the middle of a pollen zone dominated by *Artemisia*, Chenopodiaceae and Cyperaceae. Copyright © 2000 John Wiley & Sons, Ltd.

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KEYWORDS: Vedde Ash; Karelian Isthmus; northwestern Russia; tephra; GS-I; density separation.

Introduction

In a recent paper Wastegård *et al.* (2000) described the distribution of wind-blown Vedde Ash in Sweden and the British Isles. It was shown that the westerly and southerly dispersal limits probably lie at or close to the western seaboard of the British Isles. To test if the Vedde Ash could be found also east of the Baltic Sea, two sites on the Karelian Isthmus, northwestern Russia, were chosen for further investigations. These two sites are situated above the highest shoreline of the Baltic Ice Lake and both display lacustrine sediments from the last-glacial–interglacial transition. As the relatively small scale 1947 eruption of Hekla deposited tephra along the south coast of Finland (Salmi, 1948), it is not unreasonable that tephra from other Icelandic eruptions may have dispersed in areas as distal as Russia.

Stratigraphically, the Vedde Ash is the most important tephra horizon in the North Atlantic region from the last-glacial–interglacial transition (ca. 13 000–9000 ^{14}C yr BP). It consists of two distinct components, one rhyolitic and one basaltic, which probably were erupted simultaneously from the Katla volcano on southwest Iceland (Mangerud *et al.*, 1984; Lacasse *et al.*, 1995). The tephra is dated to the later part of a radiocarbon plateau at 10 400–10 300 ^{14}C yr BP (Birks *et al.*, 1996; Wastegård *et al.*, 1998) and both components have been recorded in the GRIP ice-core from central Greenland, where it is dated to ca. 12 000 GRIP yr BP (Grönvold *et al.*, 1995).

The Vedde Ash constitutes one of the main components of the ice-rafted North Atlantic Ice Zone One (e.g. Ruddiman and Glover, 1972; Kvamme *et al.*, 1989; Austin and Kroon, 1996). It was first described on land, however, from the Ålesund area in western Norway (Fig. 1) by Mangerud *et al.* (1984), where the original on-land thickness of the Vedde Ash blanket has been estimated to 2–3 mm of compacted tephra, including both basaltic and rhyolitic shards. In Scotland and Sweden so far only the rhyolitic component has been found. This has been possible following a heavy-liquid technique, which allows rhyolitic Vedde Ash shards to be extracted from the host sediment (Turney, 1998).

The use of tephra horizons as time-synchronous marker horizons has great potential for correlating and dating sediment successions in northwestern Europe. A recent review by Haflidason *et al.* (2000) shows that more than 125 tephra horizons of Icelandic origin from the last 400 kyr have been identified in the North Atlantic region. Many of these have

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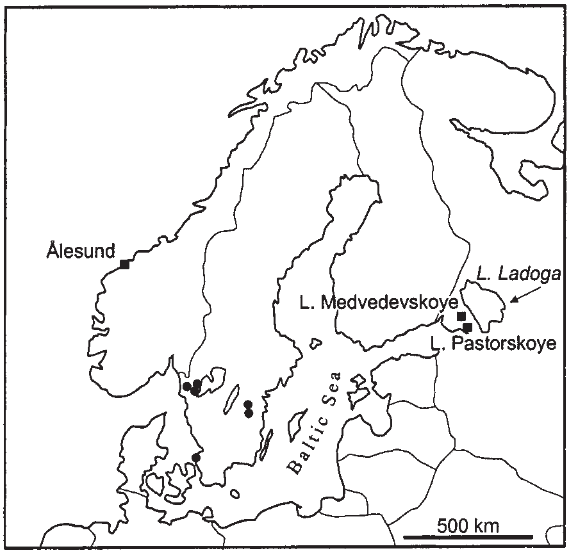

Figure 1 Map of Scandinavia and the Baltic Sea region showing the investigated lakes on the Karelian Isthmus (the land bridge between the Baltic Sea and Lake Ladoga), and sites in south Sweden (black dots) where the Vedde Ash has been recorded and confirmed with microprobe analyses (Wastegård *et al.*, 1998, 2000; Björck and Wastegård, 1999; A. Karlsson, in preparation; K. Schoning *et al.*, in preparation).

not been described outside Iceland, however, and so far only about 20 have been recorded and geochemically characterised in terrestrial deposits on the British Isles, the Faroe Islands, Scandinavia and northern Germany (e.g. van den Bogaard *et al.*, 1994; Dugmore *et al.*, 1995; Pilcher *et al.*, 1995; Boygle, 1998; Wastegård *et al.*, in press). With new techniques for detecting and extracting tephra from both minerogenic and organic deposits (Dugmore and Newton, 1992; Rose *et al.*, 1996; Turney, 1998; Caseldine *et al.*, 1999) many other tephra horizons may be discovered far from the volcanic sources on Iceland. Only a few major eruptions, however, may have dispersed tephra over such extensive areas as the Vedde eruption.

Material and methods

The two lakes investigated, Lake Medvedevskoye (LM; latitude 60°31.89′N, longitude 29°54.06′E) and Lake Pastorskoye (LP; latitude 60°13.71′N, longitude 30°02.41′E) are located on the Central Highland of the Karelian Isthmus in northwestern Russia at 102.2 m and 76.6 m a.s.l., respectively (Fig. 1). The level of the former Baltic Ice Lake is estimated at around 50–60 m a.s.l. in the central part of the Karelian Isthmus and at around 70–80 m a.s.l. in the northern part. The sites investigated were thus above the Baltic Ice Lake during deglaciation. The lakes were cored from ice with a strengthened Russian corer (chamber length of 1 m, inside diameter 5 cm). The coring sites were chosen in the centre of the lakes and two parallel profiles with 0.5 m overlap were cored. The sites have been subject to detailed pollen and diatom stratigraphy, mineral magnetic properties, organic carbon content and radiocarbon measurements (Subetto *et al.*, in preparation). Pollen diagrams showing principal Late-glacial taxa and the lithology are shown in Figs 2 and 3. Both sites became deglaciated during the later part of the Allerød (GI-1a in the GRIP event stratigraphy).

Samples for tephra analysis were taken out contiguously in 5-cm blocks from LM and in 1-cm samples from LP. Unfortunately, no samples were left from LM once tephra had been detected in a 5 cm sample. The samples were ashed in 550° for 4 h, treated in 10% HCl overnight and then sieved with meshes of 24 μm and 80 μm. The fraction between 24 μm and 80 μm was chosen for further extraction of rhyolitic tephra following Turney (1998). The samples processed for microprobe analyses were not ashed as this is known to alter the geochemical signature (Dugmore *et al.*, 1995).

Results

Colourless tephra shards were found in the sediments from both LM and LP, with the highest concentration in the

Table 1 Geochemical data for Vedde Ash shards from Lake Medvedevskoye (LM) and Lake Pastorskoye (LP), determined by electron microprobe analysis. SD = 1 standard deviation. For full data, see Appendix 1. Total iron is expressed as FeO_{tot}. Analyses were performed on a Cambridge Instruments Microscan V, with an accelerating voltage of 15 kV, a beam current of 15 nA and a beam diameter of 1 μm. The results are compared with analyses of rhyolitic Vedde Ash shards from terrestrial sites in Scotland (Whitrig Bog; Turney *et al.*, 1997), Sweden (Fågelmossen; Björck and Wastegård, 1999) and the Vedde Ash stratotype (Mangerud *et al.*, 1984). Analyses from the Vedde Ash stratotype show low totals in sodium, probably as a result of sodium mobilisation during the analysis (Mangerud *et al.*, 1984).

	LM ($n = 11$)		LP ($n = 7$)		Whitrig bog ($n = 30$)		Fågelmossen ($n = 9$)		Vedde Ash Bed ($n = 21$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SiO_2	69.84	0.65	69.92	0.62	70.32	1.05	69.28	0.52	72.87	0.97
TiO_2	0.29	0.04	0.25	0.02	0.28	0.03	0.28	0.03	0.31	0.14
Al_2O_3	13.23	0.24	13.42	0.18	13.10	0.25	13.22	0.16	13.25	0.28
FeO_{tot}	3.73	0.09	3.73	0.17	3.69	0.12	3.76	0.19	3.79	0.16
MnO	0.18	0.03	0.15	0.05	0.13	0.03	0.14	0.03	0.15	0.09
MgO	0.25	0.06	0.25	0.02	0.20	0.02	0.25	0.02	0.21	0.04
CaO	1.25	0.07	1.27	0.11	1.23	0.07	1.39	0.09	1.23	0.12
Na_2O	4.61	0.11	4.77	0.10	4.51	0.26	4.71	0.17	2.11	0.39
K_2O	3.28	0.11	3.31	0.16	3.54	0.11	3.35	0.18	3.21	0.38
Total	96.65		97.07		97.01		96.29		97.13	

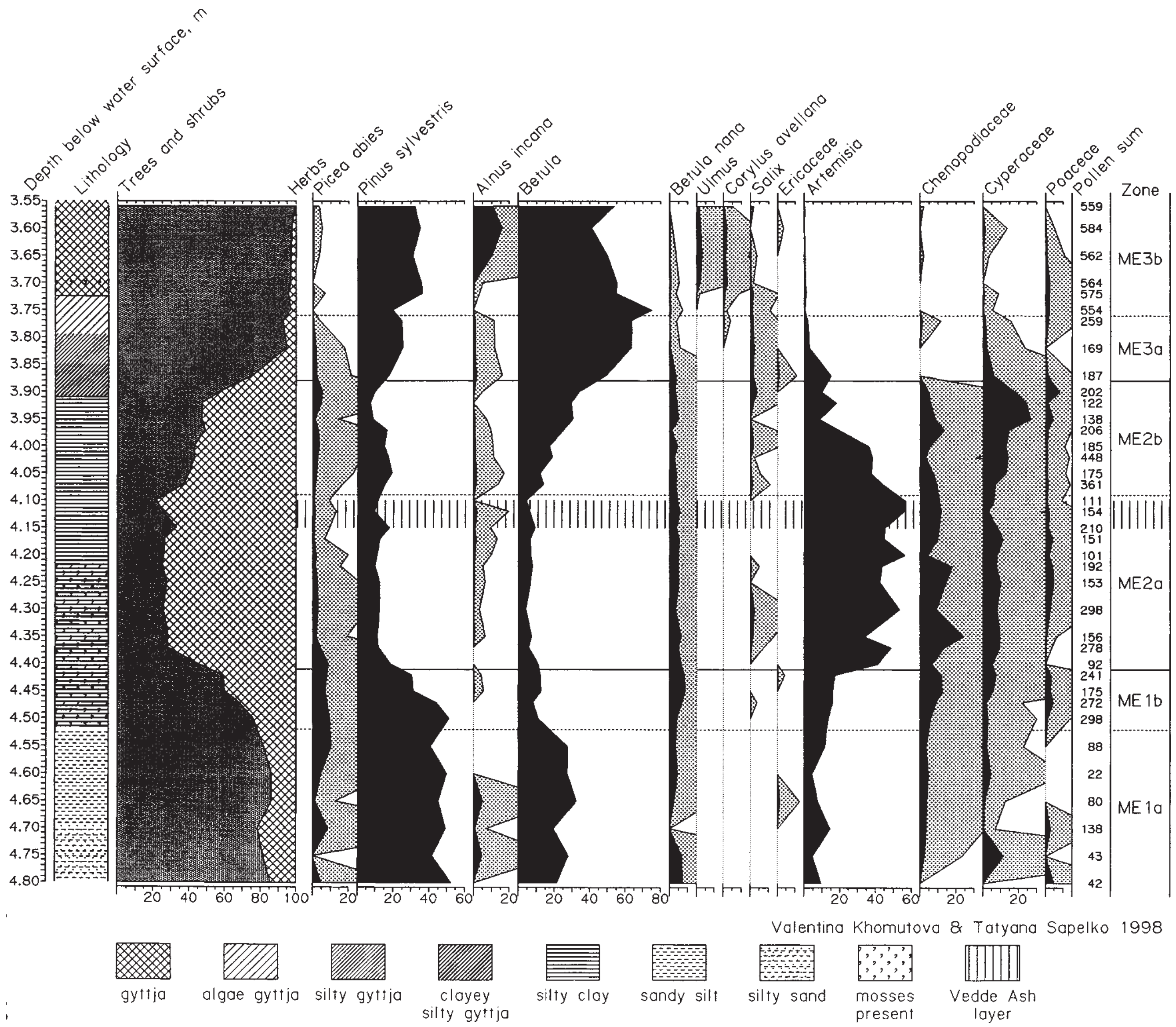

Figure 2 Pollen diagram from Lake Medvedevskoye showing principal Late-glacial pollen taxa. The Vedde Ash is marked with a hatched line. A complete pollen diagram will be presented in a forthcoming paper by Subetto *et al.* (in preparation).

middle of a twofold pollen zone dominated by *Artemisia*, Chenopodiaceae and Cyperaceae (PA 2 and ME 2; Figs 2 and 3). The tephra coincides with a minimum in tree pollen (*Picea*, *Pinus* and *Betula*), but immediately above the Vedde Ash *Betula* starts to increase. The tephra concentration was rather high between 410 and 415 cm in LM but the peak occurrence could not be determined more exactly because no samples were left for more detailed analysis. At LP, however, only a very small number of shards was found in two 1-cm samples between 939 and 941 cm. The concentration is estimated to be less than 25 shards cm^{-3} wet sediment. The shards have the same morphological characteristics (e.g. butterfly shapes) and colour as in other areas and no size difference could be noted when compared with sites in Sweden where the Vedde Ash has been detected (Wastegård *et al.*, 2000).

Microprobe analysis was carried out on shards from both sites and the results are shown in Table 1 and Appendix 1. The data are compared with terrestrial sites in Sweden and Scotland where the Vedde Ash has been confirmed (Turney *et al.*, 1997; Björck and Wastegård, 1999) and with the Vedde Ash stratotype in western Norway (Mangerud *et al.*, 1984). The analyses of tephra from LM and LP confirm the occurrence of the rhyolitic part of the Vedde Ash.

Discussion

This finding of the Vedde Ash in northwestern Russia once again shows the importance of tephrochronology as a tool for correlation and dating of Quaternary sedimentary sequences. Through this it is possible, for the first time, to correlate exactly Late-glacial sedimentary sequences situated east of the Scandinavian ice-sheet with sites on the British Isles, cores from the North Atlantic and the Greenland ice-cores. It also opens possibilities to compare pollen records and other parameters from a large number of sites situated outside the Younger Dryas ice-margin in Scandinavia and the British Isles and to test hypotheses regarding the non-synchronous responses to climate variations during the Late–glacial–interglacial transition (cf. Coope *et al.*, 1998).

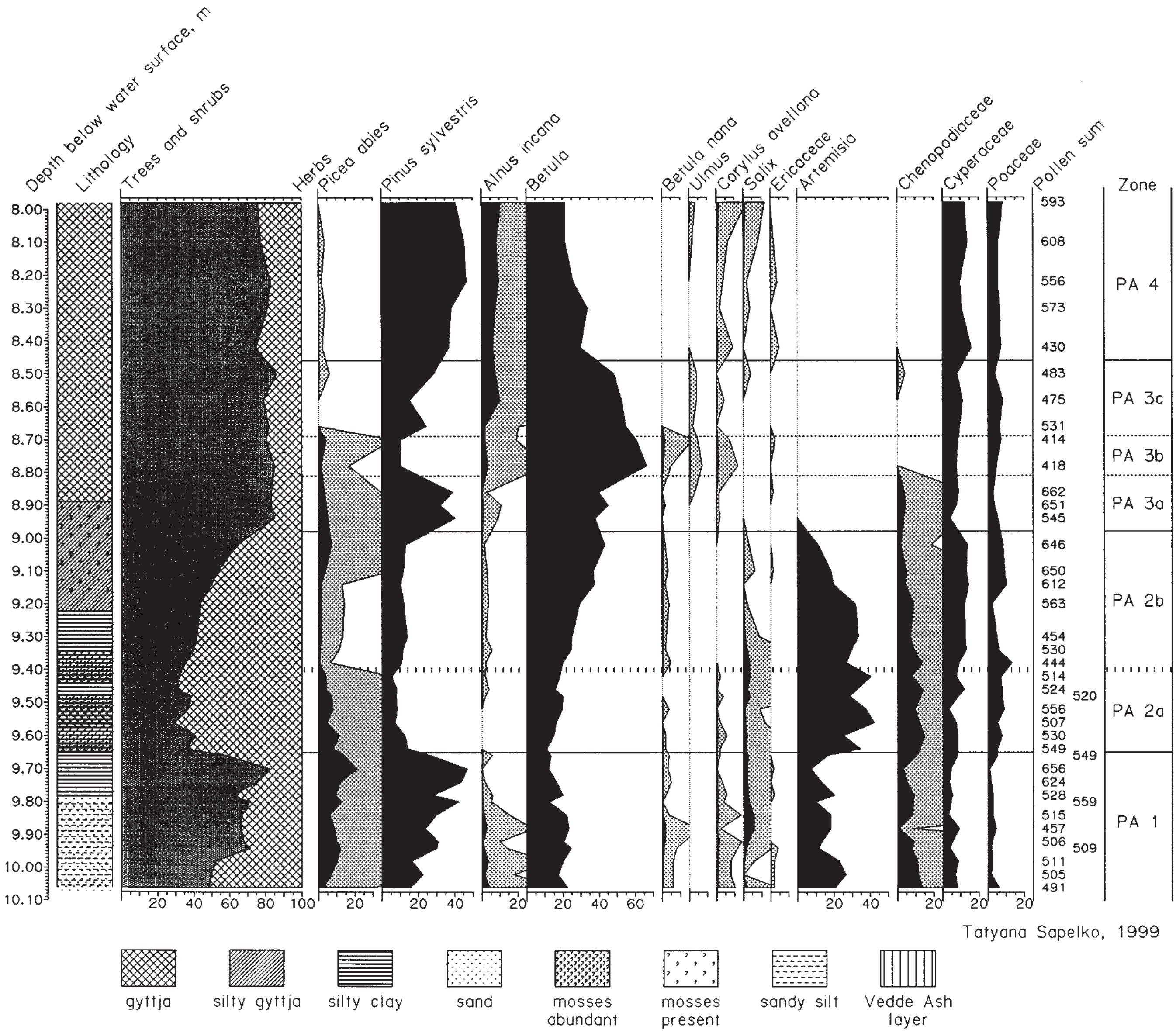

Figure 3 Pollen diagram from Lake Pastorskoye showing principal Late-glacial pollen taxa. The Vedde Ash is marked with a hatched line. A complete pollen diagram will be presented in a forthcoming paper by Subetto *et al.* (in preparation).

The stratigraphical position of the Vedde Ash in Karelia shows a similar pattern as in Sweden. The Vedde Ash occurs in the middle of a pollen zone dominated by *Artemisia,* Chenopodiaceae and Cyperaceae suggesting dry and cold conditions, which indicates that the entire Younger Dryas (GS-1) was cold and dry in northwestern Russia and Sweden and that similar climatic conditions prevailed on the eastern and western sides of the Baltic Ice Lake during the Younger Dryas. Data from other sites in south Sweden are also consistent with this interpretation (e.g. Björck *et al.*, 1996; Björck and Wastegård, 1999).

The southern Baltic Sea area (e.g. northern Germany, Denmark, south Sweden and the southern Baltic Sea) may be a key area for linking the tephrochronology of northwest Europe, which is based on Icelandic tephra horizons, with the central European tephrochronology, based on horizons from the Eifel volcanic field in west Germany, such as the Laacher See Tephra and the Ulmener Maar Tephra (e.g. van den Bogaard and Schmincke, 1985; Brauer *et al.*, 1999). The dispersal fans of the Laacher See Tephra (ca. 11 200 ^{14}C yr BP), the Vedde Ash and the Saksunarvatn Tephra (ca. 9000 ^{14}C yr BP) may in some areas coincide, so that sites with more than one tephra horizon can be found. This would be a great step forward as it would enable many sediment sequences to be tied directly to the ice-core records, and it would also provide a link between the tephrochronological frameworks of north and central Europe.

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Appendix: 1 Relative concentrations (wt %) of nine major oxides in rhyolitic Vedde Ash glass shards from Lake Medvedevskoye (LM) and Lake Pastorskoye (LP). Totals below 95% have been discarded

Lake Medvedevskoye (410–415 cm)

	1	2	3	4	5	6	7	8	9	10	11	SD	Mean
SiO_2	68.93	69.20	70.37	69.34	70.21	71.01	70.07	69.52	69.45	70.57	69.56	0.65	69.84
TiO_2	0.35	0.23	0.31	0.30	0.23	0.29	0.30	0.30	0.30	0.33	0.24	0.04	0.29
Al_2O_3	13.32	13.01	13.11	13.86	13.04	13.27	13.06	13.17	13.11	13.25	13.34	0.24	13.23
FeO_{tot}	3.66	3.83	3.86	3.70	3.69	3.82	3.57	3.65	3.69	3.78	3.79	0.09	3.73
MnO	0.18	0.22	0.14	0.13	0.16	0.24	0.20	0.19	0.17	0.17	0.17	0.03	0.18
MgO	0.21	0.21	0.25	0.41	0.23	0.22	0.24	0.25	0.21	0.25	0.26	0.06	0.25
CaO	1.18	1.18	1.17	1.28	1.36	1.32	1.28	1.32	1.17	1.28	1.18	0.19	1.25
Na_2O	4.55	4.58	4.55	4.62	4.56	4.45	4.63	4.64	4.57	4.65	4.91	0.11	4.61
K_2O	3.36	3.09	3.34	3.11	3.27	3.35	3.26	3.26	3.42	3.27	3.38	0.11	3.28
Total	95.74	95.55	97.10	96.75	96.75	97.97	96.30	96.30	96.09	97.55	96.83		96.65

Lake Pastorskoye (939–941 cm)

	1	2	3	4	5	6	7	SD	Mean
SiO_2	70.03	70.84	70.49	69.68	69.46	69.95	68.99	0.62	69.92
TiO_2	0.25	0.26	0.25	0.22	0.25	0.26	0.27	0.02	0.25
Al_2O_3	13.54	13.61	13.21	13.50	13.58	13.33	13.17	0.18	13.42
FeO_{tot}	3.74	3.91	3.73	3.69	3.78	3.39	3.89	0.17	3.73
MnO	0.15	0.22	0.10	0.14	0.10	0.14	0.20	0.05	0.15
MgO	0.28	0.25	0.23	0.23	0.26	0.24	0.24	0.02	0.25
CaO	1.19	1.41	1.36	1.33	1.24	1.09	1.24	0.11	1.27
Na_2O	4.90	4.78	4.78	4.75	4.73	4.84	4.59	0.10	4.77
K_2O	3.35	3.31	3.42	3.31	3.53	3.27	3.01	0.16	3.31
Total	97.43	98.59	97.57	96.85	96.93	96.51	95.60		97.07

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