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Geochemical and mineral composition of bottom sediments of the last glaciosedimentation cycle from Lake Onega (NW, Russia)

Malov V.I.[1]*, Strahovenko V.D.[1], Subetto D.A.[2], Rybalko A.V.[3], Belyaev P.S.[3], Belkina N.A.[4], Potakhin M.S.[4]

[1] V.S. Sobolev Institute of Geology and Mineralogy SB RAS, 3 Akademik Koptyug Prospect, Novosibirsk, 630090, Russia
[2] Herzen State Pedagogical University of Russia, 48 Moika Embankment, Saint-Petersburg, 191186, Russia
[3] A.P. Karpinsky Russian Geological Research Institute (VSEGEI), 74 Sredny Prospect, St. Petersburg, 199106, Russia
[4] Northern Water Problems Institute of the Karelian Research Centre RAS, 50 Alexander Nevsky Prospect, Petrozavodsk, 185030, Russia

ABSTRACT. The study of the geochemical and mineral composition of the bottom sediments of Lake Onega (the Petrozavodsk Bay) described fundamental differences between the chemical composition of sediments formed at the Holocene and Upper Pleistocene. It suggested the reason for mechanical to chemical type of weathering.

Keywords: Lake Onego, bottom sediments, Late Pleistocene, Holocene, geochemistry

1. Introduction

Lake Onega is the second largest and largest body of water in Europe. The lake basin is located between the Archean and Proterozoic rock, and a complex path of tectonic transformations in the continental and marine regime. The last glaciers deepened the depression and covered the relief with moraine, fluvioglacial, and limnoglacial deposits. Recent Holocene deposits are already formed in lacustrine, nepheloid sedimentation condition.

This work was carried out with the aim of a detailed study of the geochemistry and mineralogy of bottom sediments in Lake Onega.

2. Materials and methods

The object of the study is Lake Onega. The collection of samples was taken by drilling from the ice in March 2019. Cores of bottom sediments of the supraglacial section were taken with entry into the dense layers of glacial sediments of Lake Onega. The work was carried out using a piston system for sampling cores of bottom sediments manufactured by UWITEC (Austria). Bottom sediment cores were sawn along their axis for description and further study of the geochemical and mineral composition.

Elemental analysis of bottom sediment samples was performed by inductively coupled plasma mass spectrometry on an ELEMENT high-resolution mass spectrometer (FinniganMAT) with a pneumatic concentric Meinhard sprayer. In addition, for this purpose X-ray spectral fluorescence analysis (silicate) was used. The measurements are performed on an X-ray spectrometer “ARL-9900-XP” (Applied Research Laboratories, USA) The study of the morphology, phase and chemical composition of the samples was carried out using a scanning electron microscope “MIRA 3 TESCAN” (Tescan, Czech Republic), equipped with an energy spectrometer “Oxford” (Oxford Instruments, UK) The mineral composition of bottom samples was analyzed by X-ray diffractometry (XRD) using an ARLX’TRA diffractometer (CuKα radiation) (ThermoFisher Scientific (Ecublens) SARL, Switzerland).

Analytical work was carried out at the Analytical Center for multi-elemental and isotope research SB RAS, Novosibirsk, Russia.

3. Results and discussion

At present, the official stratigraphic scheme of the North-West of Russia (Maksimov et al., 2015) includes units that make up the bottom of the lakes (from bottom to top): 1) Tills and fluvioglacial deposits of the Upper Pleistocene - coarse sand with pebbles, clays with boulders, boulder loams (gIII; fIII, where g - glacial, f - fluvioglacial); 2) Upper Pleistocene deposits of lakes associated with the Ostashkov stage of the

*Corresponding author.
E-mail address: Malov@igm.nsc.ru (V.I. Malov)

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Valdai glaciation - banded clays (lgIII, where lg are limno-glacial); 3) Holocene lacustrine deposits - silt and sand (lH, where l - lacustrine)

During the sampling of bottom sediment cores, we uncovered the following deposits from bottom to top: glacial deposits of the Ostashkov stage of the Valdai glaciation (gIIIost), represented by moraines; fluvioglacial deposits of the Ostashkov stage of the Valdai glaciation (fIIIost), represented by medium-fine-grained sands with interlayers of medium-grained sand, which overlaps with the erosive contact of clay; Limnoglacial deposits of the Ostashkovian stage of glaciation (Onega layers) (lgIIIost) in which three members are distinguished.

The lower member is represented by proximal limnoglacial shales (lg1IIIost), representing an irregular interbedding of brown sandy shales and gray shaly sands. Above is a member of rhythmically interbedded gray-brown and brownish-gray banded clays (lg2IIIost). The upper unit of limnoglacial deposits (lg3IIIost) is represented by microlayered clays of gray, light brown, brown-gray color, sometimes with a creamy or greenish tint, which turn into homogeneous light gray fluid-plastic clays. The upper part of the exposed deposits is represented by two packs. Member of homogeneous gray greenish-gray compacted aleuropelitic sediments (lglIII-H) - New Onega layers, lower member; Member of greenish-gray and brownish-gray organogenic-mineral aleuropelitic sediments (silts) (lH) - Novonezhsk layers, upper member.

For the tested horizons, the macro- and microelement composition was studied: glacial–fluvioglacial and limnoglacial deposits have similar spectra (Fig.) of the distribution of macro- and microelements, with a difference in absolute contents (lower concentrations are characteristic of fIIIost-gIIIost). The reason for this is the dominance of quartz in the composition (SiO_2 = 91.8 and 66.5 wt % for fIIIost-gIIIost and lgIIIost, respectively, which is the reason for the lower concentrations of other elements (Table)).

Holocene deposits (lH) differ in elemental composition from glacial–fluvioglacial and limnoglacial deposits. The main difference lies in the higher content of Fe, Mn, K, P and low content of S (Table). Moreover, the maximum concentration of Fe, Mn and P is observed for the same samples, and the correlation coefficient for Fe-P and Mn-P pairs are 0.94 and 0.97, respectively.

This is also reflected in the mineral composition of bottom sediments: quartz, feldspars, chlorite, illite, Fe and Mn hydroxides, as well as in samples with a high content of phosphorus, the Fe phosphate mineral was found (Strakhovenko et al., 2020). One of the factors regulating the formation of vivianite, as the main antigenic iron phosphate in bottom sediments, is the content of S (Rothe et al., 2016). The Holocene deposits of Lake Onega are characterized by low values of sulfur compare to the Pleistocene deposits. Thus, the content of SO_3 in lH is 0.09 wt %, while in fIIIost-gIIIost and lgIIIost they are 0.14 and 0.26 wt. %, respectively.

The difference in the chemical composition of the Holocene deposits (high contents of Fe, Mn, P) indicates a change in the composition of the incoming material. The reason for this is the change from mechanical weathering during the glacial to chemical weathering today. This also likely explains low content of sulfur. The input of material from shungite rocks that emerge in the north of Lake Onega (mean concentrations SO_3 = 0.6 wt. % (Filippov, 2002)), has decreased due to resistance to chemical weathering.

4. Conclusions

The study of the geochemical and mineral composition of the bottom sediments of Lake Onega in the Petrozovodsk Bay most likely evidenced:

1. Glacial, fluvioglacial, limnoglacial deposits have a similar macro- and microelement composition, differing only in absolute concentrations, which are regulated by the amount of quartz in the composition of bottom sediments.
2. Holocene and Pleistocene deposits was differed as high content of Fe, Mn, K, P and low S.
3. The Holocene bottom sediments is characterized by the chemical composition due to to change of mechanical to chemical weathering.

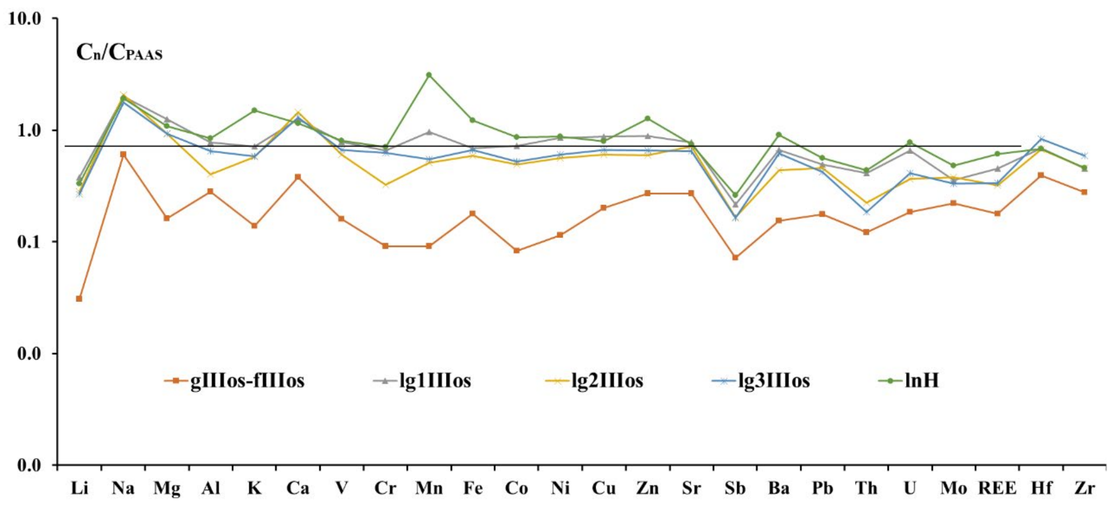

Fig. Distribution of element contents in bottom sediments normalized to PAAS (Post-Archaean AustralianShale) (Taylor and McLennan, 1985).

Table. Chemical composition of bottom sediments of Lake Onega, content in wt. %

	SIO_2	TIO_2	AL_2O_3	FE_2O_3	MNO	MGO	CAO	NA_2O	K_2O	P_2O_5	SO_3
gIIIos- fIIIos	91.83	0.18	3.04	1.32	0.02	0.38	0.62	0.61	0.57	0.04	0.14
lg_1IIIos	59.93	0.76	15.88	7.15	0.15	3.25	2.25	2.58	3.20	0.15	0.34
lg_2IIIos	70.19	0.58	12.18	4.51	0.07	2.14	2.22	2.41	2.31	0.12	0.21
lg_3IIIos	69.43	0.64	12.07	4.94	0.08	2.08	2.14	2.16	2.30	0.12	0.31
lnH	58.17	0.70	13.94	8.96	0.43	2.51	1.97	2.26	2.53	0.34	0.09

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Conflict of interest

The authors declare no conflict of interest.

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