The role of the Valdai Glaciation in the formation of quaternary deposits of the Novgorod region

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Abstract. The article is devoted to the peculiarities of quaternary deposits formation in the territory of the Novgorod region, under the influence of the first four phases of the last covering Valdai glaciation. The authors show the role of this glaciation as the basis for the formation of genetic types of parent rocks for the soils of this area.

1. Introduction

The main feature of the quaternary period, which continues at the present time, is the periodic climate changes and the alternation of glacial and interglacial epochs. There is still disagreement among scientists in determining the number of glaciations. However, all researchers identify the four largest glacial and interglacial periods associated with certain climate cycles. There distinguished the Oka, Dnieper, Moscow and Valdai glaciations [1].

The Oka glaciation, the southern border of which reached the Oka river and the lower borders of the Pripyat river, took place 650–350 thousand years ago (according to other data, 500–400 thousand years ago) on the territory of the European part of Russia.

The Dnieper glaciation occurred in the middle Pleistocene 300–250 thousand years ago and is characteristic of a certain part of the East European Plain. The glacier narrowly penetrated the valley of the Dnieper river from the north and northeast, reaching the mouth of the Orel river in the south. The result was a flattened terrain in the northern part of the plain, while the central part remained elevated. The ice of the Dnieper glaciation also crossed the territory of the Novgorod region.

The Moscow glaciation is the second of the middle Pleistocene cover glaciations of the East European Plain, with a time period of 195–130 thousand years ago, the southern border of which ran from Brest in the west to the Urals along the Kaluga–Moscow–Vladimir line.

The last Valdai glaciation covered the north-western part of the East European Plain in the late Neo-Pleistocene, reaching the borders of the Valdai Hills, which are the marginal moraine ridge of this glaciation. The ice cover reached Smolensk in the south, then its border turned north-east to Tver and Vologda and then went north to the coast of the White Sea [2].

2. Objects and methods of research

The object of the research is the quaternary deposits formed during the Valdai glaciation. Stratigraphic and cartographic materials were used for the analysis of the quaternary deposits.
3. Results and Discussion

At the beginning of the Kainozoic Era, in the early Paleogen, the physical and geographical conditions typical for the end of the Mesozoic Era, i.e. the tropical climate with weakened tectonic movements maintained in the territory occupied by the Novgorod region. Geomorphologically, the area was a raised plateau, so a layer of chemical weathering crust continued to be formed.

Gradually, the climate became more continental, due to restructuring in the Oligocene, spreading zones and changing the direction of the lithospheric plates’ movement. The last era of the Paleogen period (Oligocene) is also characterized by some revival of tectonic activity leading to the elevation and equiplanation of the East European platform's relief.

Intensive climatic cooling continued in the northern hemisphere in the Neogen (Pliocene) Era. In late Neogen, the climate became significantly colder and drier. Some revival of tectonic activity in the Neogen resulted in the rise of the territory and the deepening of the hydrological network.

The rise of the territory of the Novgorod region as part of the Russian Plate in the Kainozoic Era (Paleogen and Neogen) led to the fact that deposits were not formed, and the formation of weathering crusts occurred as a result of exogenous activity [1].

Therefore, in the sedimentary cover of this territory on the Paleozoic thickness there are quaternary deposits, very diverse by nature, due to the activities of the Valdai glaciation.

From the side of Scandinavia, in the wall-like shape there penetrated multi-meter glaciers, which, having reached any obstacle, like a bulldozer razed it to the ground and moved on. The disturbance of the formation of mountain rocks occupied by the glacier is associated with its ploughing activity - huge blocks of sedimentary material, from giant clamps to clay, formed as a result of rubbing, sorting and deposition of debris during the movement of the glacier (morene), were transferred by tens and hundreds of kilometers from their root formation [3].

As the glacier melted, the so-called glaciolacustrine basins emerged, in which corresponding deposits were formed. In periglacial lakes, a kind of fine-grained layered sediments—“ribbon clays”—were formed. They received such a structure due to the change of seasonal sediment accumulation. In summer, a larger turbid material, which formed the sandy part of the ribbon (layer), arrived in the periglacial lakes, and in winter, the clay elements settled, forming the winter part of the ribbon. Thus, the ribbon consists of the summer (sandy) layer and the winter (clay) layer. Glaciolacustine deposits are widely spread in Novgorod region. Numerous deposits of different types of clay originate from them (The Borovichy deposit, the Demyansk deposit, the Uglov deposit, the Novgorod deposit, etc.) [4].

Fluvioocular deposits are also associated with glacier activity. During the interglacial period, under the influence of the ambient temperature, the glacier begins to melt, small channels are formed inside it, through these channels, melt water with all impurities begins to descend in the lowering of the relief. This is how temporary water-glacial flows, which transfer, sort and lay deposits along the way, are formed.

Several stages (phases) are distinguished in the Valdai Glaciation, such as, Bologovskaya, Edrovskaya, Vepsovskaya, Krestetskaya, Luzhskaya, Salpaulsekiy, separated by interglacial period, during which sedimentary layers with the same name were deposited [3]. It should be noted that only the first four phases of the Valdai Glaciation played an important role in the formation of the sedimentary quaternary cover of the territory of the Novgorod region.

Therefore, the deposits of this area are represented by Bologovsky, Edrovsky, Vepsovsky, Krestetsky and partly Luzhsky layers. All of them were repeatedly mixed up as a result of transgression and regression of a glacier, resulting in chaotic distribution of deposits and emergence of the combined (integrated) layers, such as Bologovsky and Edrovsky, Edrovsky and Vepsovsky, Vepsovsky and Krestetsky in the territory of the area [4].

The Bologovsky layers are represented by glacial deposits, boulder loams and loamy sands, which occupy the eastern part of the Moshenskoe district, and small areas of Demyansk and Valdai districts, as well as the western part of the Pestovo district, forming fluvioglacial sands with gravel and pebbles.

The Edrovsky layer is represented by fluvioglacial sands with gravel and pebbles, mixed with glacial boulder loams and loamy sands and clay loams, and occupy the central part of the Moshenskoe and
Khvoynaya districts, and small border sections of Demyansk and Valdai districts on the border with the Tver region. During the completion of the Edrovsk stage in the eastern part of the Pestovo district, a combined layer with the Bologov deposits was formed, represented by glaciolacustine sands and fluvioglacial sands with gravel and pebbles.

The Vepsovsky layer consists of glaciolacustine clays, fluvioglacial sands with gravel and pebbles, and glacial boulder loams and loamy sands. They occupy the western part of Moshenskoe and Khvoynaya districts and the eastern part of Borovichy and Lubytino districts.

The Krestestky layer is characteristic of the largest part of the Novgorod region, and is widely spread everywhere up to the boundary of the glacier, which goes through the eastern parts of Borovichy and Lubytino districts, the border part of the south-east of the Novgorod region. This large-scale spread is due to the fact that the next stages of the Valdai Glaciation did not reach the Novgorod region, or did not spread to the western part of the region, for example, in the case of the Luga phase. These layers are presented with glaciolacustine sands and clays, fluvioglacial sands with gravel and pebbles, and glacial boulder loams and loamy sands.

The Krestetsky and Vepsovsky layers of quaternary deposits are also combined into glaciolacustine sands and clays, fluvioglacial sands with gravel and pebbles, and glacial boulder loams and loamy sands. They are spread in the territory of Moshenskoe, Demyansk and Valdai districts.

The layers of the Luga glaciation stage are represented by laciolacustine sands and ribbon clays, glacial boulder loamy sands. The layers of this stage occupy a large part of the territory near the Ilmen lowland in areas of large rivers, such as: the Msta river, the Lovat' river, the Volkhov river and the Shelon river [4].

Modern quaternary deposits are represented by alluvial sands, clay loams, loamy sands, which form the first overhead terrace of major rivers of the region, as well as marsh deposits, and fluviolacustine clays and sands in the area of Lake Ilmen, in the northern part of the region in the area of the Volkhov River, and the northern part of Demyansk district [4].

4. Conclusion
The foregoing shows that the formation and distribution of quaternary deposits in the territory of the Novgorod region has been a long process and is associated with the phases of the Valdai glaciation described above. These deposits are the main genetic types of parent rocks and owe their existence to this glaciation. These include morainic, fluvio-glacial, and lacustrine–glacial deposits that occupy almost the entire territory of the Novgorod region in the upper layer of the sedimentary cover, with the exception of modern deposits.

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