

Development of erosion cuts and accumulative fans in the Serteyka river valley in the Vitebsk Lakeland

The conducted studies made it possible to determine the relationship between natural (mainly geological, geomorphological and climatic factors) and anthropogenic influences on the shaping of environmental processes that led to the development of erosion cuts on the slopes and accumulative fans in the bottom of the Serteyka valley in the young glacial area of the Vitebsk Lake District. The research aimed to identify: morphology, geological structure, genesis, age, conditions for the development of erosional forms and the accompanying accumulative fans located on the slopes of the so-called Great Sertean Lake Basin (GSLB).

The field work carried out included detailed geological and geomorphological mapping of the gully system and the largest storage fan in the research area (gays A - see: Piech 2021, Fig. 2) and their surroundings, as well as six gullies and their storage fans located within the GSLB (steam B, C, D, E, F, G), as well as sampling and core collection. In the central and distal zones of the main accumulative fan, two geological outcrops were made in the 2017 season, measuring 5x2 m and 1 to 2 m deep. On the slope of the erosion cut (gully), in its central part, an exposure was made in the form of successive cutting steps. into the wall of the cut.

Two sediment cores (monoliths) were collected from the top of the biogenic sediments underlying the sediments of the accumulative fan (STPIIbio profile), the other from the distal one (STPIbio profile). The cores were intended for palynological analysis, macroscopic plant remains, analysis of subfossil Chironomidae and Cladocera, as well as sedimentological and geochemical analyzes (analysis of elemental composition using the AAS method, %CaCO₃, LOI, pH, electrolytic conductivity, redox). In addition, wood fragments and tree remains located at the top of organic sediments or at the bottom of mineral sediments of the accumulative fan were collected for radiocarbon dating. Macroscopic plant remains prepared from the mineral deposits of the largest fan were also used in further geochronological analyzes (radiocarbon dating using the AMS method).

At the bottom of the studied section of the Serteyka River valley, erosional formations of various types and sizes have been documented cutting through the valley slopes and accumulative fans, some of which deposits lie directly on the surface of the kame terraces. This suggests that the first fans were formed within several hundred years after the retreat of the Valdai Ice Sheet. The sediments of the remaining, later fans are covered with Holocene biogenic deposits, which proves their younger age.

The initiation of erosion processes mainly affected the eastern slope of the modern valley. Then, these forms were transformed in later erosion and accumulation phases, which was visible in variable sedimentological indicators. The oldest documented gullies on the western side of the valley were created in the period 4700-4150 BC. In turn, around 3700 BC a lateral STA accumulative fan was formed at the mouth of this form. The next phase of modeling the studied forms took place in the years 1850-1600 BC. However, from the 1st century AD an increasingly stronger anthropopressure is recorded, which indirectly caused a gradual increase in the efficiency of erosion and accumulation processes, clearly visible only at the end of the Middle Ages. This was probably the result of the development of agricultural activities in the Sertesian microregion (Tarasov et al. 2019; Wieckowska-Lüth et al. 2021, Kittel et al. 2022).

Within the largest fan studied in detail, four dominant sediment layers were documented: lower deluvium, middle deluvium, upper deluvium and tillage diamicton. Each of the above-mentioned units is characterized by distinct structural, textural and geochemical features. Numerous macroscopic plant remains and microcarbons were also recorded in the fans' mineral deposits, based on which changes in land use can be inferred. In the biogenic formations covered with sediments of the studied accumulation cone, frequent changes in the reservoir water level and periods of transformation of the lake into a peat bog were recorded. These fluctuations were recognized thanks to, among others, documented changes in the former vegetation (palynological analysis was carried out), including the appearance of peat and its disappearance, as well as the detection of remains of Chironomidae and Cladocera characteristic of the water column. The period of the Medieval Climatic Optimum and the Little Ice Age (LIA) were marked in geochemical indicators and in the results of palynological analysis.

It was shown that one of the main causes of the formation of the largest fan was deforestation and intensified agricultural use of the plateau, which resulted in increased mass movements and surface runoff on the steep slopes of the valley. During the accumulation of deluvial sediments, numerous and intense floods were also observed. It is also documented that biogenic accumulation ended at the latest in the 18th century, probably in the second half of the 17th century. It was crucial to determine the impact of the climatic conditions of the Little Ice Age on the development of slope processes and, as a result, the development of erosional cuts. Changes in climatic conditions occurring during the LIA led to the intensification of large-scale erosion and accumulation processes. Anthropogenic

transformations of the landscape were also a very important factor influencing the course of slope processes.

The conducted studies allowed to determine the influence of natural and anthropogenic environmental components on the course of slope processes and on the structural, textural and geochemical features of slope sediments. The obtained results regarding the intensification of slope processes and floods correlate well with the results of research on other sites in the European part of Russia and sites in Central Europe from this period.