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Antanas Karolis Giedraitis' geological investigations in Lithuania

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Abstract. This work is dedicated to Antanas Karolis Giedraitis (Antoni Karol Giedroyć, A.K. Gedroïz, А.К. Гедройц) (1848–1909) geological research that he did in Lithuania territory for geological mapping. In the History of Science, A.K. Giedraitis is called the first professional geologist of Lithuania, who investigated geology of our and neighboring countries. In 1895 he compiled a geological map of very large territory – Russian Empire governorates of Vilnius, Kaunas, Suvalkai, Gardinas, and Minskas according to international standards. It is important to understand A.K. Giedraitis' approach to the formation of Quaternary sediments and the theory of polyglacialism. He took at that time the bold position that this entire region two or even three times had been covered by a glacier that advanced from the North. Based on the weathering (wearing) of erratic boulders and glacial incisions, he tried to describe the limits of glacier expansion and the directions of its movement. A.K. Giedraitis' professional achievements are well-known, they are evidenced by the detailed reports and publications of his geological research in German, Polish, and Russian, which were published in 1886, 1887, and 1894. A summary of all his research was published in 1895, together with a geological map to a scale of 1:420 000. Interestingly, research carried out nowadays has confirmed some of the more than 130-year-old insights of A.K. Giedraitis about the geological formation of our country.

Keywords: *Quaternary; continental glaciation; polyglacialism; geological mapping*

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INTRODUCTION

It is difficult to understand and evaluate the old geological research in Lithuania without knowing the history of country. Therefore, it is important to remember that after the last division of the Polish-Lithuanian Commonwealth in 1795 until the First World War, Lithuania was occupied by the Russian Empire, and in 1915 – by Germany. Only on 16 February 1918 Lithuania was re-established as an independent state.

When the population came under the influence of the Russian government, they expressed their dissatisfaction with conspiracies and uprisings. Particularly important 1830–1831 (The November Uprising) and 1863–1864 (The January Uprising) uprisings were brutally suppressed by the tsarist army. After each defeat, the conditions of Lithuanian political and cultural life worsened, and the persecutions of the Russian authorities became more and more severe. In 1832 the center of Lithuanian science – Vilnius University was closed and geology, like other sciences, stopped developing. True, a decade before 1842 the Vilnius Academy of Medicine and Surgery operated, where geology was also taught. The tsar's government was not interested in searching for local minerals, so even eighty years of geological research in the territory of Lithuania was only episodic. They were carried out by an individual, mostly by geologists who were born not in Lithuania and worked at other universi-

ties and belonged to Russian scientific societies or geological committees. Duke A.K. Giedraitis was the first professional geologist who was born, grew up, later lived, and worked in Lithuania. He studied geology at the Freiberg Mining Academy and the University of Tartu (Dorpat) (Baltrūnas, Pukelytė 2021). 1877–1878 after receiving the St. Petersburg Mineralogical Society, and in 1883–1887 commissioned by the Russian Geological Committee, he explored the South-western part of the western Russian Empire (Vilnius, Kaunas, Gardinas (Blrs. *Гродна,* Russ. *Гродно*), Minskas (Blrs. *Мінск*, Rus. *Минск*), Suvalkai (Pol. *Suwałki*) governorates). Before completing this work, he was invited to an expedition by the Russian Ministry of Communication Roads to explore the old courses of the Amu Darya River and the Uzboy Old Oxbows in Turkmenistan (1879–1883). It was a significant trip that led to a later collaboration with the Russian Geological Committee, which distributed funds for geological research. Later A.K. Giedraitis had to conduct geological research and compiled 10 versts (Rus. *верста* – Russian unit of length equal to 1.0668 km) (1:420 000) scale geological map of the western Russian Empire. A study summarizing this work appeared in 1895 **(**Baltrūnas, Pukelytė 2021; Satkūnas, Žalūdienė 2023a, b; Гедройц 1895).

A.K. Giedraitis' knowledge of Quaternary sediments and their layers, as well as the cross-sections of the studied outcrops and their descriptions suggest that he was familiar with the new theory of continental glaciation and was a supporter of it. In support of the theory of polyglacialism, he said that Lithuania has been covered by more than one glaciation, but he still lacks the data to accurately name their number (Гедройц 1895). But in some outcrops, A.K. Giedraitis saw the sediments of two or even three glaciers, and the theory of polyglacialism, in his opinion, is also confirmed by the aging of the surface relief going from North to South.

MATERIALS AND METHODS

The investigations of this work are based on literature sources and discoveries from various archives. The authors relied on A.K. Giedraitis' research publications and the material of other scientists about his works.

RESULTS AND DISCUSSION

The analysis of the works of A.K. Giedraitis made it possible to distinguish his most important scientific interests and now we can say that geological mapping was one of the most important.

A.K. Giedraitis researched Lithuania and the surrounding territories (more than a third of the area is the current territory of Lithuania) in three directions – two in the meridional and one in the latitudinal, whose purpose was to create a geological map of these territories (Dalinkevičius *et al*. 1969).

The first route in the meridian direction – from the headwaters of the Venta River through the Kaunas, Gardinas governorates and Suvalkai, the second – from Vilnius along the Poliesė (Ukr. *Полісся*, Blrs. *Палесьсе*, Pol. *Polesie*, Russ. *Полесье*) railway to the city of Rivne in the Volynė (Ukr. *Волинь*, Pol. *Wołyń*) governorate. The third route in the latitudinal direction continued through the governorates of Minskas, Gardinas, Suvalkai, and Lomža (Pol. *Łomża*) to Varšuva (Pol. *Warszawa*). Later A.K. Giedraitis completed several routes along the banks of the Nemunas, Neris, Šventoji, Dubysa, Jura, and other rivers too, and explored the river valleys of the territories of Lithuania, Belarus, and Poland. (Гедройц 1895).

On the order of the Russian Geological Committee, he continued these works in 1883–1887 and conducted new geological surveys of Poliesė. Geological material from these territories A.K. Giedraitis used for making the fifth sheet of the 10-versts scale (M 1:420 000) geological map in 1887, based on a conventional legend (Гедройц 1895; Satkūnas, Žalūdienė 2023a, b). But the full summary included a geological map compiled by him was published also in 1895 (Гедройц 1895). The material from this map was used for geological map of the European part of Russia, which first time was presented at the International Geological Congress held in St. Petersburg in 1897.

The objects of his research were: outcrops, slopes of valleys, upper reaches of ditches, railway lines, springs, boreholes, and mines. Among the explored outcrops, mention should be made of Gardinas (outcrop by Nemunas River, the Republic of Belarus), Pamerkiai (outcrop by Merkys River), Nemunaitis (outcrop by the Nemunas River), and many others. He paid the most attention to the research of the cities of Vilnius and Kaunas, and described the banks and outcrops of the Jiesia, Nemunas, Vilija (Neris), Vileika (Vilnia) rivers. It is necessary to highlight A.K. Giedraitis studies at Rokai (outcrop by the Jiesia River), Plikakalnis (outcrop by the Neris River, Vilnius City), Bekešas (Bekesh) Hill (outcrop by the Vilnia River, Vilnius City), as well as drinking water springs and the first artesian boreholes in Vilnius (Pukelytė, Rudnickaitė 2023).

A.K. Giedraitis investigated the surroundings of Gardinas (now the Republic of Belarus) and described the chalk outcrops near the Nemunas River. The object he explored turned into a large-scale industrial quarry, but the intensive exploitation of chalk began only after the 2nd. World War and continues to this day **(**Fig. 1).

A.K. Giedraitis found chalk blocks in South Lithuania too, at the outcrops of Merkys River near

the villages of Pamerkiai and Akmenis, but there the chalk mining was not performed. The project to exploit the chalk near Pamerkiai was stopped by the 1st World War. A.K. Giedraitis' conclusion about its occurrence not *in situ* (i. e., glaciodislocations) was later confirmed (Fig. 2). Interestingly, chalk flints were already exploited there in prehistoric times too (Baltrūnas 2001).

One of the most interesting outcrops in Lithuania – Nemunaitis (Alytus district) – limestone tuff outcrop of Nemunas River. Limestone tuff is a sediment of mineral springs, formed during the Holocene. During the research, A.K. Giedraitis discovered 11 mineral water springs near this outcrop, of which only one remains today (Figs 3, 4).

A.K. Giedraitis investigated some sections significant for stratigraphy. During the time of A.K. Giedraitis and until 1958, when the Kaunas hydroelectric power was built, there were a lot of outcrops in the Jiesia River Valley (Baltrūnas, Pukelytė 2021; Pukelytė, Rudnickaitė 2023). Now only a few outcrops remain, which are of great importance for Upper Pleistocene stratigraphy. Remained A.K. Giedraitis description of one 176-feet (54 m) high Jiesia outcrop (Гедройц

Fig. 1 The old chalk quarry in Gardinas adapted for recreation (https://birstonas.lt/wp-content/uploads/2016/02/Dvira-tininko-gidas-LT.pdf)

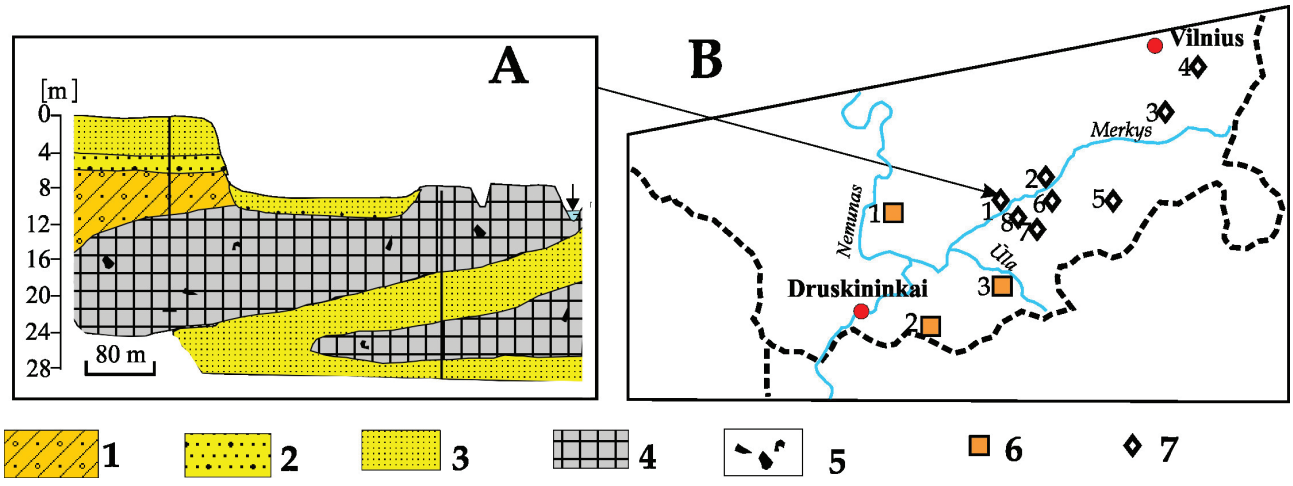

Fig. 2 Subsidence of chalk slabs near Akmenis Village, Varėna district (A), and distribution of chalk shale and flint mines in South Lithuania (B). A: 1 – moraine loam, 2 – various sand, 3 – fine sand, 4 – chalk block, 5 – flint concretions. B: 6 – former flint mines, 7 – discovered chalk slabs. Localities: 1 – Akmenis, 2 – Kuktiškiai, 3 – Juodžiai, 4 – Naujoji Vilnia, 5 – Tetėnai, 6 – Mielupis, 7 – Šarkiškiai, 8 – Matuizos; prehistoric flint mines near: 1 – Ežerynas, 2 – Margionys, 3 – Lake Titnas (Baltrūnas 2001; Baltrūnas *et al*. 2006)

1895). Using names of rocks that are not always understood today (often repeated "marl", etc.), he writes that the outcrop consists of (from the top): sandy marl (25.6 m), sand and marl with interbeds of glacial marl (22 m), red till layers of pebbly marl (2.4 m), gray till marl (3 m) and decomposed white chalk (0.6 m). Today there is no longer such a high exposure, but the 40 m Rokai outcrop is well investigated (Baltrūnas 1995; Gaigalas 2001, and others) (Figs 5, 6). The rocks of the Cretaceous period are also recorded at the level of the river now and you can see the structure of Middle and Upper Pleistocene deposits in the valley of the Jiesia River at Rokai locality in nowadays investigations. The current studies of this outcrop – lithological, petrographic, palynological, geochronological, optically stimulated luminescence (OSL), and other methods made it possible to substantiate the stratigraphy of the Upper Pleistocene in Lithuania.

The Plikakalnis (Pol. *Łysa Góra*) Neris River outcrop (Fig. 7) has a long history of geological research and remains important for studies of Pleistocene stratigraphy. True, it is currently heavily overgrown and difficult to access, which makes direct research difficult. A.K. Giedraitis described in detail the section of the 204-feet-high (about 60 m) outcrop at that time, where you can see the till characteristic of the city of Vilnius and found in other outcrops, as well as layers of sand, siltstone, and clay. Its schematic description (with corrected sediment names) from the top is as follows: pink till loam (8.5 m), silt-

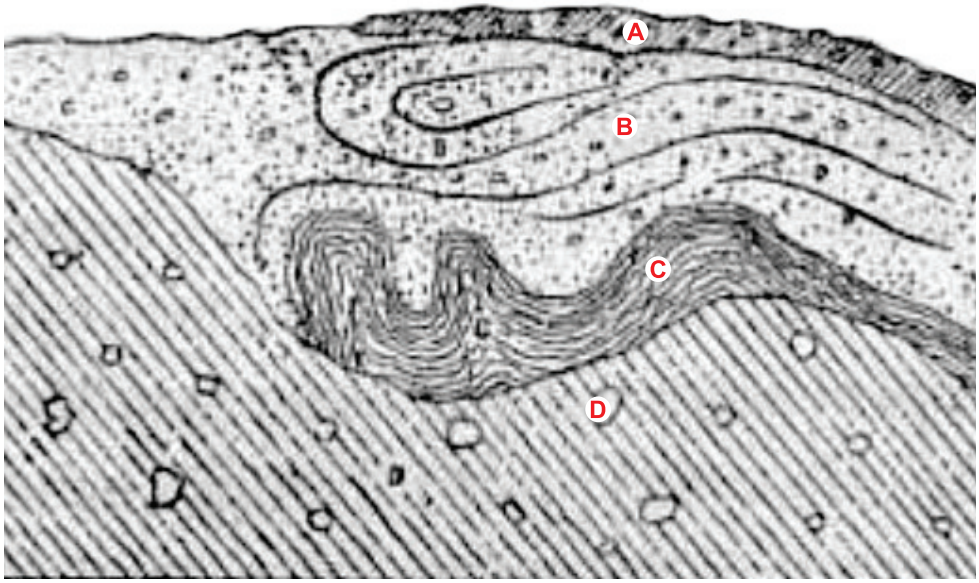

Fig. 3 A section of the limestone tuff outcrop of Nemunaitis compiled by A.K. Giedraitis. A – red clay; B – fluvioglacial sand; C – marl (calcareous tuff); D – moraine loam (Гедройц 1895)

Fig. 4 Nemunaitis outcrop today. Photo by R. Šečkuvienė

stone (0.46 m), sand (8.2 m), gray till loam (7.3 m), sand with siltstone interlayers (21.3 m), clayey sand (8.5 m) and fine sand (5.2 m) (Гедройц 1895).

It is difficult to compare this one 130–140-year-old description of the section made with the current ones, but the general structure of the section remained similar. Although the subsidence elements of the Quaternary layers changed, because more than a century the outcrop of Plikakalnis was eroded, flattened out considerably, and became heavily overgrown with trees and bushes (Pukelytė, Rudnickaitė 2023) (Fig. 8).

The outcrop of the Bekešas Hill of the Vilnia River does not have a long research history. Since ancient times, it has been destroyed by erosion little by little every year. In the literature, we find records of the huge landslides of 1838 and 1843 that significantly changed the banks of the river in this place. The Hill and its outcrop are immortalized in a painting a photo (Pukelytė, Rudnickaitė 2023) (Fig. 9).

The height of the Bekešas Hill outcrop described during A.K. Giedraitis's research was 143 feet (about 43 m above the level of the Vilnia River). It consisted of the following layers (from the top): sand with clay interlayers (14.6 m), gravel (1.2 m), moraine loam (1.8 m), sand (1.2 m), clay (1.8 m), sand (3.4 m), gray moraine loam (8.5 m), fine sand (0.6 m), greenish gray micaceous and watery sand (10.4 m) (Гедройц 1895). The tills of two glaciations were recorded in the outcrop section, and in the lower part, a thick sand layer characteristic of the entire territory of the city of Vilnius was revealed, which is an aquifer of groundwater resources. Currently, the outcrop of Bekešas is covered with trees and is no longer visible. It belongs to the Cultural Reserve of Vilnius Castles and is no longer accessible for direct geological research (Pukelytė, Rudnickaitė 2023) (Fig. 10).

Springs and their use

Among the objects of A.K. Giedraitis' research, the mineral Springs of Nemunaitis has already been mentioned, but the Vingriai Springs of Vilnius also attracted a lot of attention (the Springs of Misionieriai (Žiuproniai) he only mentions). The use of spring water

Fig. 5 High outcrops of Jiesia River (Kaveckis 1931)

Fig. 6 Jiesia outcrops are covered with forest today. Photo by V. Baltrūnas

to supply the inhabitants of Vilnius with drinking water was written about already in 1501 when the Grand Duke of Lithuania Alexander gave a plot of land to the Dominican monks (Jurkštas 1990). In 1536 the Grand Duke of Lithuania Žygimantas Augustas instructed the Dominican monks to hand over the Springs of Vingriai to the city council of Vilnius. For several hundred years, the people of Vilnius used the water of Vingriai and Misionieriai Springs, which drains from the Quaternary sedimentary aquifer. While describing the outcrops of the slopes at the former Springs of Vingriai, A.K. Giedraitis found a layer of sand interlayered with pebbles and pieces of clay, and a reddish morainic loam (clay with stones) sinking South of them (Гедройц 1895). He emphasized the importance of the aquifer in supplying the city with drinking water. But already in the 19th century the water of Vingriai Springs was significantly polluted due to the intensive expansion of constructions next to them. For the past half-century, water from these springs has been used for other city purposes (Fig. 11).

At the end of the 19th century, the springs were replaced by drilled artesian wells in Vilnius City. In 1883 A.K. Giedraitis initiated and described a borehole named "Pogulianka" (Гедройц 1895). It was the first deeper (116.95 m) borehole in Vilnius, reaching the deeper layers of the Cretaceous and Devonian systems covered by glacial sediments. Lower Cretaceous glauconitic sand was found at a depth of 75.90 m and from 106.07 m – Middle Devonian clay, sand, and sandstone (Гедройц 1895). Good groundwater was expected during drilling, but unfortunately, the hopes did not come true, as the water in the Devonian layer was strongly mineralized. This delayed further attempts to find good-quality drinking water in the Devonian strata for almost 30 years. But the data of this borehole were very valuable, because later creators of Lithuanian geological science relied on them in their works (Jodelė, 1922; Kaveckis, 1931; Dalinkevičius, 1940, etc.). During the Soviet time, the above-ground well equipment was dismantled, the mouth of the borehole was sealed, and the floor of the building was concreted. Today the

Fig. 7 Plikakalnis outcrop in the first half of the 20th century. Photo by J. Čechavičius. Funds of the National Museum of Lithuania (https://www.15min.lt/media-pasakojimai/fotografas-juozapas-cechavicius-gidas-po-xix-a-pabaigos-vilniu-1064)

Fig. 8 Plikakalnis outcrop today. Photo by V. Baltrūnas

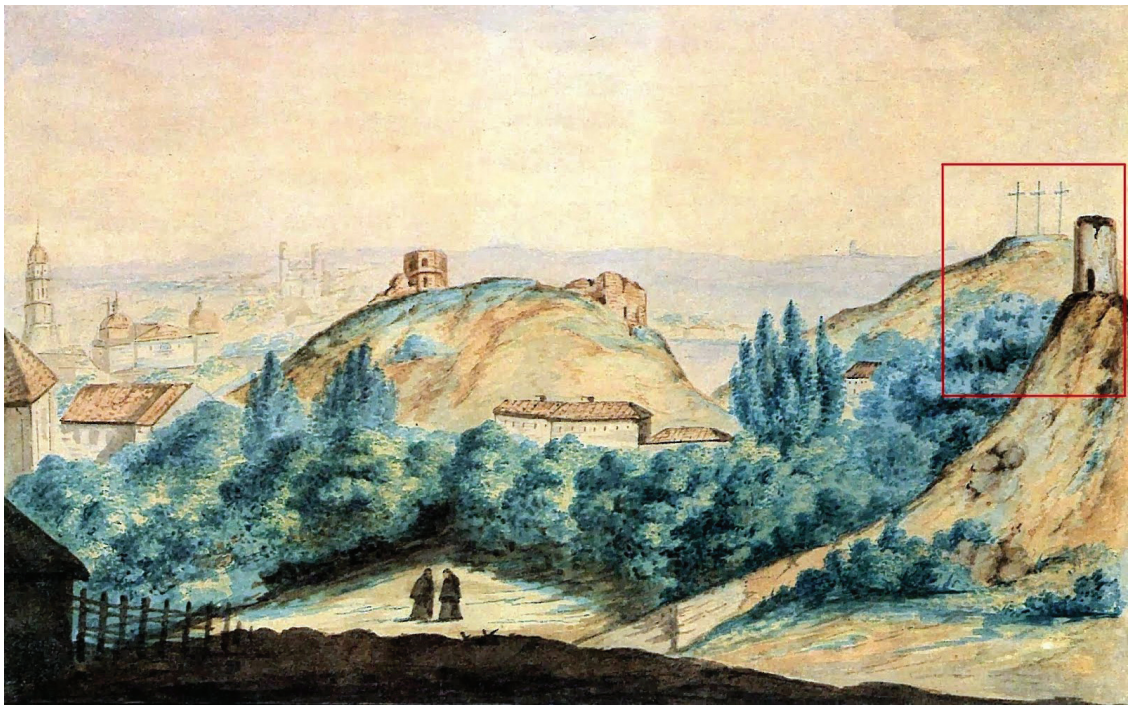

Fig. 9 Bekešas Hill in Marcelinas Januševičius (Marcin Januszewicz) artwork, 1846 (https://www.facebook.com/photo.php?fbid=2100828463262020&set=p.2100828463262020&type=3)

octagonal tower of red and yellow bricks has been left as a cultural heritage object.

A.K. Giedraitis described and summarized his research data obtained by studying the relief, composition, and structure of glacial formations, stratigraphy, soil formation, and mineral raw materials. In the 1884 report, he claimed that in glacial formations it is often possible to find slabs of Tertiary, Cretaceous, and Jurassic formations, in for example, Druskininkai, Kaimelis, Gelgaudiškis, etc. areas (Гедройц, 1895). Very interesting are the drawings of his outcrops, illustrating the nature of glacial accumulation and the structure of compressed tills (Dalinkevičius *et al*. 1969). When describing clays of glacial origin, A.K. Giedraitis distinguished layered and non-layered clays. According to him, there are layered or banded clays in many areas (Tauragė, Nemunaitis, near Ukmergė, etc.) (Гедройц, 1895). He rightly assumed that it was the sediment of preglacial lakes. Unstratified clays are widespread at the margins of stratified clay basins. Peats A.K. Giedraitis called brown coal and studied them in the vicinity of Gardinas, where they occur under a red moraine loam. The scientist concluded that the periods of warm and humid climate that existed during the Ice Age were favourable for the formation of peat (Giedroyc, 1886a, b, 1887).

After collecting a lot of factual material, the scientist concluded that two separates till horizons (layers) are spread on the territory of Lithuania, and even three till clay horizons are found in Vilnius. The author indicates the number of past glaciations very carefully – the till loam horizons differ only in colour, while the

Fig. 10 Current view of the flattened slope of Bekešas Hill. Photo by H. Giedrys

composition is very similar. The colour of till loams depends on the rocks that the glacier scratched as it moved because it is precisely from them that the Ice Age formations were formed. By studying the composition of till loams and boulders, according to the author, it is possible to trace the composition of the pre-Quaternary rocks of the areas through which the glacier moved. Thus, boulders and slabs of the main layers are indicators of a pre-Quaternary bed.

CONCLUSIONS

All these studies A.K. Giedraitis summarized in 1895 and described the results of research of the Nemunas, Neris, Šventoji, and other river valleys outcrops, where he found and described many new formations of the Cretaceous and Tertiary systems (Гедройц 1895). The results of the observations and research show that A.K. Giedraitis had a good understanding of the properties of sediments in Quaternary deposits. He was very familiar with and was a supporter of the newly formed theory of continental glaciation, whose scheme of the chronology of the old glaciers was created in 1880.

A.K. Giedraitis used all accumulated geological knowledge, and long-term research of various geological objects in Lithuania and the surrounding territories to create a geological map. Today's assessment of the condition of the research objects of A.K. Giedraitis during the last 130–140 years testifies to their different development and fate. Some of them now are covered by the sediments of the slopes or by forest, others turned into large quarries, objects of natural and cultural heritage, and some of them became a source of inspiration for artists and got into works of art (Pukelytė, Rudnickaitė 2023). The most important work of a geologist – a geological map at first was published in 1895. A.K. Giedraitis was the first who compile a geological map of a large region, based on the international requirements of geological mapping, according to international conventional legend and stratigraphic scheme recognized of that time (Satkūnas, Žalūdienė 2023a, b).

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Fig. 11 The territory of Vingriai Springs in 2022. Photo by V. Baltrūnas

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