The significant objects of the Quaternary formations studied by A. K. Giedraitis (1848-1909) and their changes over time

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Proceedings of the 47th INHIGEO Symposium, Les Eyzies, France, 2022
Special issue of the *Travaux* of COFRHIGEO
T. XXXVI[BIS], 2022

The significant objects of the Quaternary formations studied by A. K. Giedraitis (1848-1909) and their changes over time

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Abstract. Duke A. K. Giedraitis (1848–1909) – a geologist with a renowned professional career, evidenced by his extensive inquiry reports and publications in German, Polish, and Russian (Duke..., 2023). He is well known in Lithuanian and neighbouring countries' scientific history. A. K. Giedraitis created the first geological map of such a large region by international standards, well understood the characteristics of Quaternary deposits, and took at that time an audacious position that previously the area had been covered by two or three glaciations. A standard label and an authorized stratigraphic chart, as well as his observations were used to create the M 1:420 000 geological map. A. K. Giedraitis's summary publication with the map, however, did not appear until 1895 (Гедройц, 1895).
The objects of his investigations were relief, outcrops, springs, boreholes, and mines. All of them have undergone different changes over time. Some outcrops significant for Quaternary geology have been destroyed or overgrown with trees, or entered the Cultural Heritage System, and others have become stratigraphic standards, etc.

Keywords: A. K. Giedraitis – Quaternary – Polyglacialism – Geological mapping – Lithuania

Introduction

Antanas Karolis Giedraitis (1848–1909) was the first to create a geological map of a such wide region based on the international requirements of geological mapping, using the internationally accepted conventional legend and ratified stratigraphic scheme recognized at that time. In 1895, he compiled all the research and described the results of the study on the Nemunas, Neris, Šventoji, and other river valley outcrops, where he discovered and identified numerous new Cretaceous and Tertiary formations (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.

In the second half of the 19th century, the theory of continental glaciation was published. It was found that boulders found on the surface of the Earth were brought in by the continental glaciers. The first knowledge about it appeared during the study of the Alpine mountains. At first, it was thought that there was only one glaciation (monoglacialism), later, it was found that there were many glaciations (polyglacialism). A. K. Giedraitis was well-acquainted with and was a supporter of the newly formed theory of polyglacialism (Dalinkevičius et al., 1969).

Today a look at the objects investigated by A. K. Giedraitis shows that they have much changed during the last 130–140 years. Some of them have been transformed into vast quarries, others are now hidden by scree on their slopes or by advancing forests. Some have become items of natural and cultural heritage or served as inspiration for the creation of artists.

We present several geological objects explored by A. K. Giedraitis, whose studies enriched the knowledge of Lithuanian geology.

Materials and Methods

The research in this study is supported by new findings from numerous archives and literature sources. The authors drew on the research and writings of A. K. Giedraitis as well as information on his studies from other scientists. The study material for the work was gathered by the authors themselves from the Upper Pleistocene till complex in the Jiesia River (Rokai outcrop and other) and the distribution zones of chalk and Jurassic system slabs (blocks) in southern Lithuania (Akmuo Village and other)

Results

Among the explored outcrops, mention should be made of Grodno and Nemunaitis (outcrop by the Nemunas River), Pamerkiai (outcrop by the Merkys River), Rokai (outcrop by the Jiesia River), Plikakalnis (outcrop by the Neris River), Bekešas Hill (outcrop by the Vilnia River), and many other outcrops, as well as drinking water springs and the first artesian boreholes in Vilnius (Fig. 1). According to recent studies, many of A. K. Giedraitis's conclusions reached more than a century ago, are confirmed.

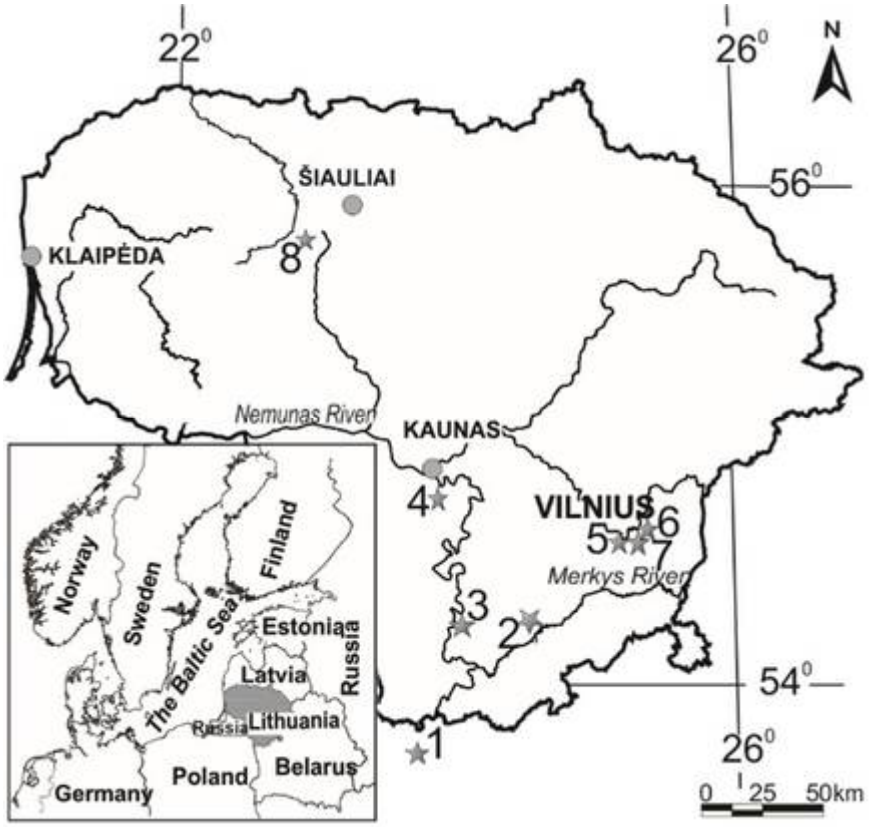

Fig. 1. Study site: 1 – The Grodno Chalk Quarry; 2 – the outcrops with chalk layers not *in situ* at the villages of Pamerkiai and Akmenis; 3 – the limestone tuff (spring limestone) outcrop at the Nemunaitis Village; 4 – the Jiesia River outcrops; 5 – the Plikakalnis outcrop; 6 – the Bekešas Hill outcrop; 7 – the "Pogulianka" borehole; 8 – the Venta-Dubysa Channel

The Nemunas River outcrops

A. K. Giedraitis researched the area around Grodno (Belarus) and described of the Nemunas River outcrops with chalk layers. The Cretaceous rocks that A. K. Giedraitis described were eventually mined and then transformed into a sizable industrial quarry. Its extensive extraction of chalk didn't start until after World War II and hasn't stopped until today. The portion of Grodno's exploited chalk quarries has been transformed for recreational use (Fig. 2).

Fig. 2. The Chalk Mine in Grodno,1959 (https://www.ksm-grodno.by/pictures/virtua-ksm/index.html)

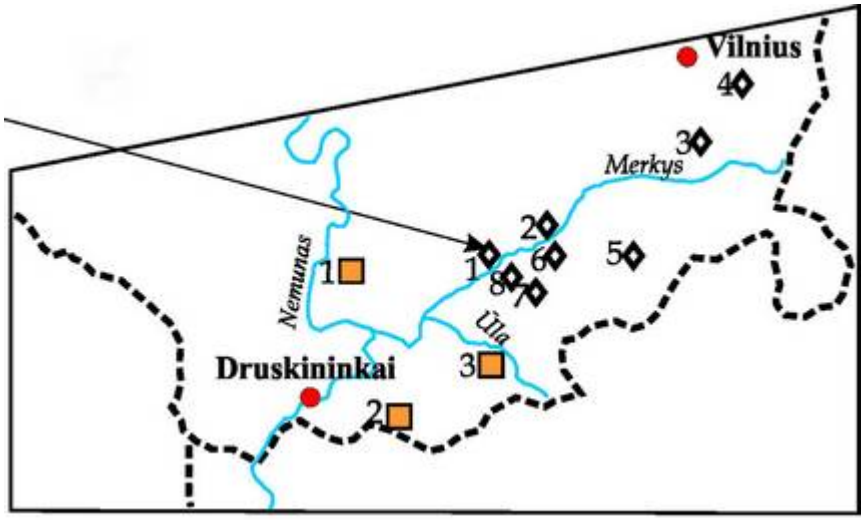

Fig. 3. Distribution of the chalk deposits and the Flint Mines in southern Lithuania. The chalk deposits: 1– Akmuo, 2 – Kuktiškės, 3– Juodžiai, 4– Naujoji Vilnia, 5– Tetėnai, 6– Mielupis, 7– Šarkiškės, 8– Matuizos. The Stone Age Flint Mines: 1– Ežerynas, 2– Margionys, 3– Titno ežeras (Baltrūnas *et al.*, 2006)

One of the most interesting and one of the largest outcrops in Lithuania (Alytus district) that formed during the Holocene – the Nemunaitis outcrop (Fig. 4). This is a sediment of mineral springs – limestone tuff (spring limestone). These deposits typically range in size from a few hundred to a few thousand cubic meters and are smaller than lake limestone. The limestone deposit at the Nemunaitis Springs was discovered to be composed of three lenses of calcareous tuff that can occasionally reach thicknesses of 6 to 8 meters through the examination of boreholes (Fig. 5) (Lietuvos geologija, 1994).

This Holocene-aged rock is heterogeneous and porous, includes plant impressions and remnants, and is tinted yellow or brown by iron compounds. It is nearly a kilometer long and dips into the abrasive sand along the Nemunas shore. A. K. Giedraitis found 11 mineral water springs nearby during the investigation, but only one of them still exists now.

The Merkys River outcrops

The first chalk system deposits were discovered and reported by A. K. Giedraitis in South Lithuania in 1895 at Merkys River outcrops close to the villages of Pamerkiai and Akmuo. But the mining of chalk there never took place – World War I put a stop to plans to mine the chalk in Pamerkiai Village. Before World War II, geologists from Vilnius University were interested in these deposits. After this war, studies on them continued (Paškevičius, Baltrūnas, 1978), and with the help of recent studies, it is better to understand the sinking character and occurrence of the slabs of the Jurassic and Cretaceous systems and according to the palaeontological data to know more about their stratigraphic dependen-

cy. The studies of the fossils from the carbonated rocks (chalk and marl) allowed us to identify layers. Foraminifera Gaudryina laevigata Franke, Textularia turris d'Orb, bivalve mollusks (Inoceramus cardiformis Sow.), sea urchins (Terebratulina striatula Mant), and sea urchins (Cidaris vesiculosus Gold et al.) testified the deposits from the Konjac and Santon levels of the Cretaceous system near Akmuo Village (Paškevičius, Baltrūnas, 1978). It is interesting that between the stratigraphic units of the Cretaceous system, there is a fixed rock formation, the stratotype of which is in the Žiogeliai borehole near Druskininkai (The Formation…, 1999).

A. K. Giedraitis' conclusion about the subsidence of chalk layers *not in situ* (*i.e.*, glaciodislocations) was confirmed by all later investigations. Interestingly, subsequent research revealed that chalk flints were already exploited in South Lithuania at prehistoric times too (Fig. 3) (Akmens amžius..., 2001).

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

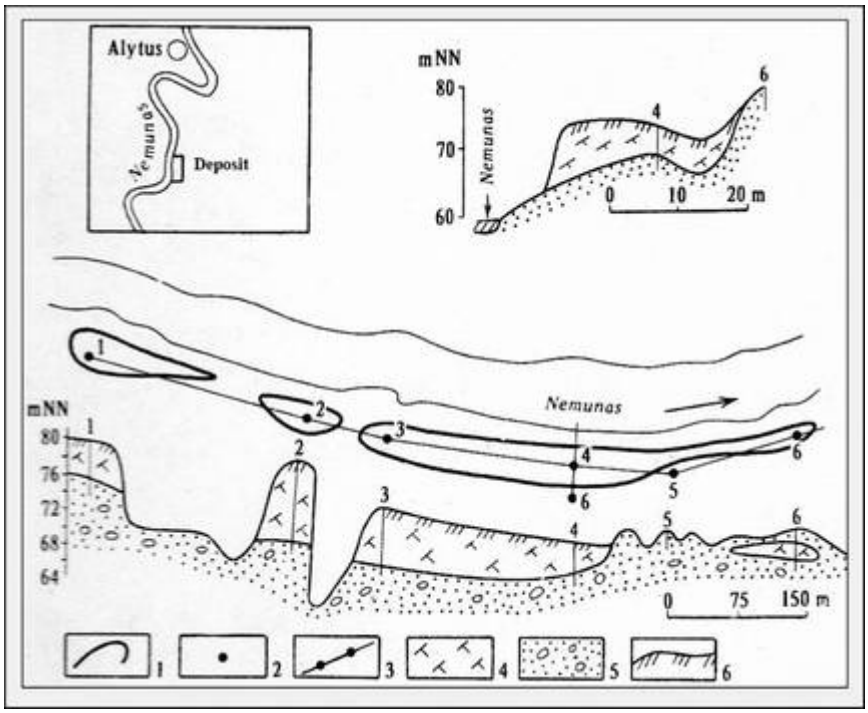

Fig. 5. The limestone tuff deposits of the Nemunaitis outcrop. 1– limit of deposit; 2– borehole; 3– cross-section; 4– limestone tuff; 5– sand with pebble; 6– soil (Lietuvos geologija, 1994)

The Jiesia River outcrops

There were many outcrops in the Jiesia River during the time of A. K. Giedraitis' investigation and up to 1958 when the Kaunas hydroelectric power plant was built. Only a few outcrops, which are crucial for understanding Upper Pleistocene stratigraphy, are left today. At the present river level, rocks from the Cretaceous period are also visible. Data about the investigation of the Jiesia River may be found in the "account" of the geological expedition carried out by the University of Lithuania in 1925–1926 (Kaveckis, 1928) and the summary of the geological research of 1927–1930 (Kaveckis, 1931) (Fig. 6).

They also provide the initial findings about the distribution and chemical composition of chalk deposits. The following number of components (%) were found in the intervals 0.65–7.6 m and 7.6–11.0 m of drilled well No. 1 (1926): heating loss: 38.11 and 32.78; CaO: 46.10 and 38.40; Al2O3 + Fe2O3: 3.52 and 8.99; SiO2: 11.33 and 18.9; MgO: 0.92 and 0.73. This information about the chalk under study indicated that it was fit for usage (Kaveckis, 1931). Above the often disintegrated (dislocated) chalk sediments there are the deposits of the Quaternary system, which have been visually described by A. K. Giedraitis in 1895. Remained his description of the 40-meter outcrop of the Jiesia River.

At the end of the 20th century and the beginning of the 21st century, the Quaternary sediments of the Jiesia River outcrops were evaluated in palaeogeographic, stratigraphic, and geochronological aspects using various analytical methods (petrographic, lithological, palynological, and geochronological, OSL, C14) (Baltrūnas, 1995; Gaigalas, 2001; Gaigalas et al., 1994; The Rokai..., 1996; Гайгалас, 1971; etc.) (Fig. 7). They showed the structure of the Middle and Upper Pleistocene deposits in the valley of the Jiesia River at Rokai locality and allowed us to substantiate the stratigraphy of the Upper Pleistocene in Lithuania. A large column of the Nemunas limno-fluvial deposits got the OSL dates from 63 000±6 000 to 32 000±4 000 years (Gaigalas et al., 1994). These OSL dates correlated well with the radiocarbon dating stated. According to these dates, the maximum of the Late Pleistocene Glaciation took place in South Lithuania in the Late Nemunas (Late Weichselian) stadial. Normally, the till of the Late Nemunas covers the deposits of the Rokai Mega-interstadial (Gaigalas et al., 1994; The Rokai..., 1996) (Fig. 8).

Fig. 6. The high Jiesia River outcrops, 1925: a– marl; b– clay (Kaveckis, 1928)

Fig. 7. The Jiesia River outcrop today. Photo by V. Baltrūnas

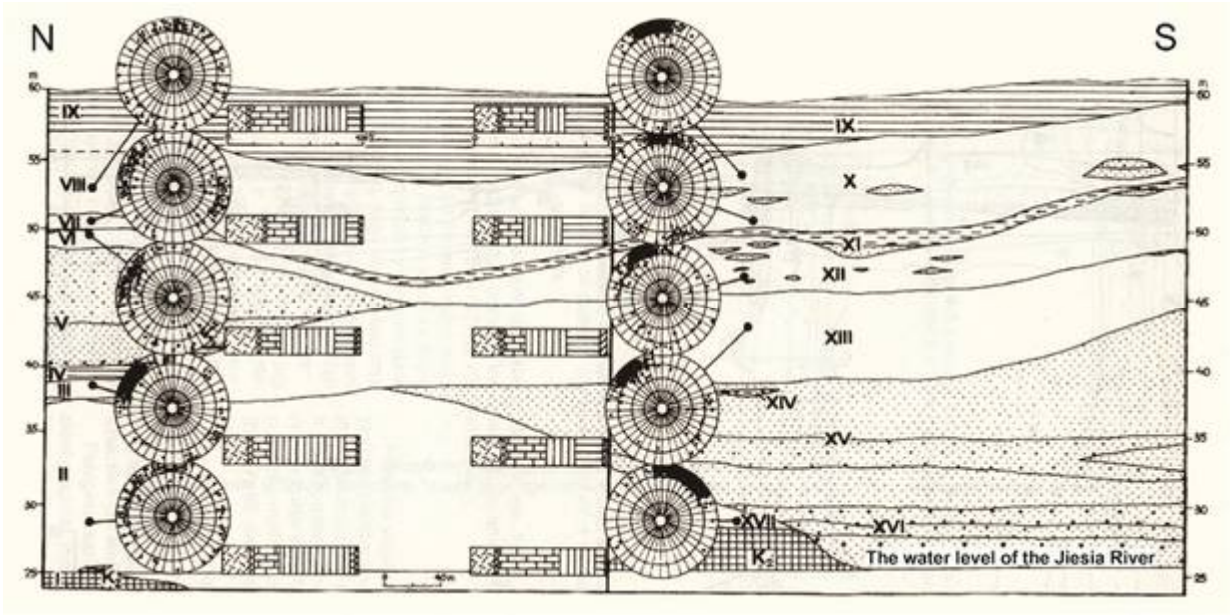

Fig. 8. Structure of Middle and Upper Pleistocene deposits of the Jiesia River near Rokai Village. The stereograms of orientation and inclination of macro-clast in till and diagrams of petrographic composition of macro-clasts by A. Gaigalas and V. Baltrūnas. I– marl and chalk (K_2); II, XVII– Middle Pleistocene till; III, XIII– Upper Pleistocene Grūda till; IV– clay; V– fine and various sand; VI, VII, XII– Upper Pleistocene Baltija till; VIII, X– South Lithuania Phase till; IX– varved clay; XI– silt and fine sand; XIV– soil; XV– fine and various sand; XVI– gravel (Baltrūnas, 1995)

The Neris River Plikakalnis outcrop (Bare Hill)

It is known as Lysa Gora (*in Polish*) in literature too. A. K. Giedraitis described it in detail and a cross-section of this outcrop (height – 204.5 feet or 60 m) from top to bottom (with corrected sediment names): till (red) – 8.5 m; silt – 0.46 m; sand – 8.2 m; till (grey) – 7.3 m; sand, with interlayers of silt – 21.3 m; sand (claying) – 8.5 m; sand (very fine) – 5.2 m (Гедройц, 1895). In the section of the outcrop, can be seen the till (glacial deposits) of two glaciations and below them the thick layers of sand, that are typical of Vilnius City and can also be seen in other outcrops. Scientists from Vilnius University, notably A. Halicka (Antonina Jaroszewicz-Kyszyska-Halicka), examined this outcrop in the interwar period (Fig. 9)) and these investigations earned her the M. S. degree.

To make studying numerous samples simpler, A. Halicka applied B. Rydzewski's petrographic method (Kosmowska-Ceranowicz, 1986; Passendorfer, 1946). She examined petrographically the coarse-grained part of all three till layers that were distinguished by A. K. Giedraitis too. The four layers have the same index values, so they were defined by the author as the bottom of oscillating moraines belonging to one glacier. Detailed studies of the Plikakalnis outcrop were carried out by A. Gaigalas and his colleagues (Гайгалас *et al.,* 1984). Two moraines of the Middle Pleistocene Age (Žemaitija and Medininkai) were identified (Fig. 10). The Medininkai moraine complex consists of two layers. In the lower layer, there are interlayers formed by two receding lobes of one glacier (Гайгалас *et al*., 1984).

The outcrop is now heavily overgrown, and difficult to access. It belongs to the landscape reserve. Geological research can no longer be conducted there.

Fig. 9. The Plikakalnis outcrop. Photo by J. Wojciechowski (Jaroszewicz-Kłyszyńska, 1938)

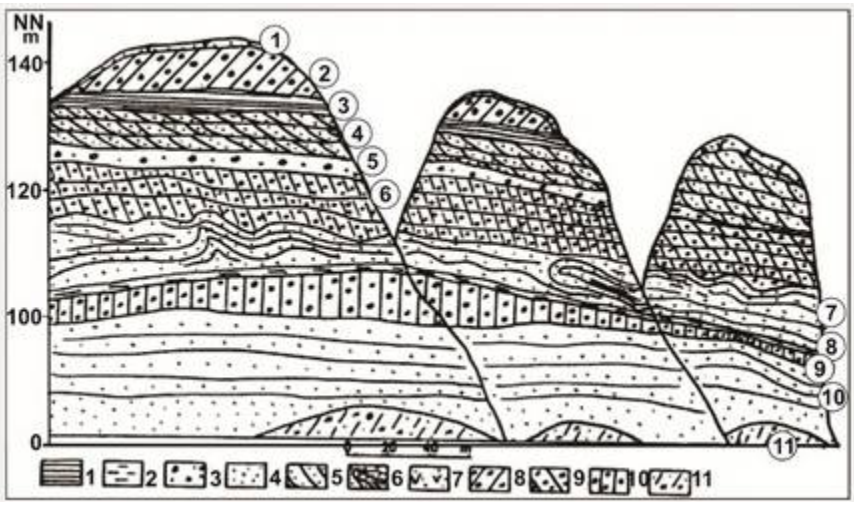

Fig. 10. The cross-section of the Plikakalnis outcrop.
1 (in the scheme) and 7 (in legend)– soil (pd IV); 2 and 8– Medininkai till (g II md); 3 and 1– clay (lg II md); 4 and 5– fluvioglacial sand (f II md), gravel and pebble; 6 and 9– Medininkai till (g II md); 7 and 6– sand of Snaigupėlė Interglacial (II sn); 8 and 2– glaciolacustrine silt (lg II žm); 9 and 10– Žemaitija till (g II žm); 10 and 4– sand of Butėnai Interglacial (II bt); 11 and 11– Dainava till (g II dn) (Gaigalas, Melešytė, 1993)

The Vilnia River outcrop – Bekešas Hill

This outcrop was constantly exposed to severe erosion. It was given the name Bekešas after the Hungarian military leader Gáspár Bekes (1520–1579). He was buried atop the hill because he practiced Arianism faith and would not be allowed in Vilnius City's cemeteries. An octagonal tower served as a monument to his burial. The Bekešas Hill outcrop's cross-section reveals two glacial till layers as well as the distinctive Vilnius City sand layers in the lowest half of the section. The 143 feet (about 43 m) outcrop from top to bottom (with corrected sediment names): sand, with interlayers of clay – 14.6 m; gravel – 1.2 m; till (red) – 1.8 m; sand (various) – 1.2 m; clay – 1.8 m; sand (various) – 3.4 m; till (grey) – 8.5 m; sand (fine) – 0.6 m; sand (greenish grey), with glauconite – 10.4 m (Гедройц, 1895).

Currently, the remains of the Bekešas Hill outcrop are covered with trees and is not accessible for direct investigation and it belong to the Cultural Reserve of Vilnius Castles (Fig. 11).

Fig. 11. The Bekešas Hill outcrop, 1873–1881. Photo by J. Czechowicz

The artesian boreholes

At the end of the 19th century, the natural springs that had previously supplied Vilnius City with water were replaced with artesian wells, one of which was investigated by A. K. Giedraitis in 1883 ("Pogulianka" borehole in Vilnius) (Fig. 12). It was equipped for the needs of the Russian tsarist army. "Pogulianka" was the first borehole in Vilnius that reached the deep layers of the Earth (D2), which are sinking under the cover of glacial deposits. Sections of borehole (from top to bottom): 0–12.78 m – sand (various) [Q3]; 12.78–24.50 m – till (grey) [Q2]; 24.50–51.32 m – sand (fine) [Q2]; 51.32–59.74 m – till [Q2] (without samples); 59.74–71.32 m – sand, with gravel [Q2]; 71.32–75.90 – till (grey) [Q2]; 75.90–78.18 – sand glauconitic [K1]; 78.18–79.55 – sand, with interlayers of carbon [K1]; 79.55–106.07 – sand glauconitic [K1]; 106.07–117.65 – clay (grey), with interlayers of sandstone [D2] (Гедройц,

Fig. 12. The "Pogulianka" borehole in Vilnius. Photo by V. Baltrūnas

1895). The geological data of this borehole entered the “Gold Fund“ of Lithuanian geology. Based on these data, the creators of geological science, A. K. Giedraitis, P. Jodelė, M. Kaveckis, and J. Dalinkevičius explained the regularities of the geological structure of eastern Lithuania and the history of geological development.

The place of “Pogulianka“ borehole is marked by the octagonal tower and today it is included in the Cultural heritage system.

The Venta-Dubysa Channel

It is another interesting object studied by A. K. Giedraitis. First, in a few words about one significant fact of our country's history. In 1569 one of the largest countries in Europe Polish–Lithuanian Commonwealth was formed, which united the Kingdom of Poland and the Grand Duchy of Lithuania. It ended its existence in 1795 when three countries – Prussia, Austria, and Russia third (last) time divided Commonwealth among themselves. The Polish–Lithuanian Commonwealth had been completely erased from the map of Europe (Poland and Lithuania re-established their independence, as separate countries, only in 1918 after World War I). After partition Lithuania fell into the clutches of the Russian Empire, which wished to increase its power in international trade and seize control of the ports. The Nemunas River was the sole route from Lithuania to the Baltic Sea, but at that time, the mouth of the Nemunas River was controlled by Prussia. As a result, the concept of creating channels to connect the Nemunas River Basin with the Baltic and Black Seas emerged in Russia (Fig. 13). The Venta-Dubysa Channel was one such, and work on it started in 1824. However, the building was halted in 1831 when a rebellion occurred in Lithuania. Many years later, A. K. Giedraitis researched the abandoned channel and paid a lot of attention to the possibilities of using peat from the drained swamp. Channel mining works resumed in the 20th century, but the outbreak of World War I put an end to them. Currently, almost all of it belongs to Kurtuvėnai Regional Park, but only the remains of the channel and several locks (Fig. 14).

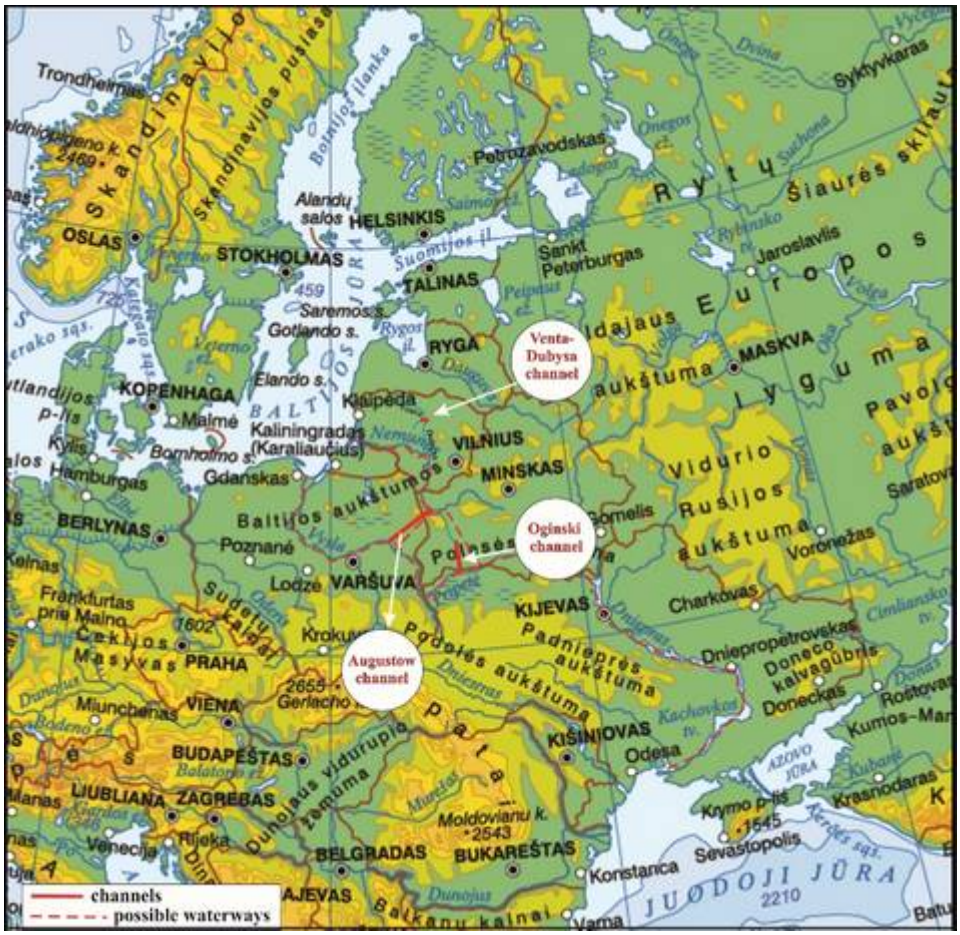

Fig. 13. The channels connecting the Nemunas River Basin with the Baltic and Black Seas on the map of Europe (https://lt.wikipedia.org/wiki/Ventos%E2%80%93Dubysos_kanalas#/media/Vaizdas:VentosDubysoskanalas1.JP)

Fig. 14. The Venta-Dubysa Channel near Žadvainiai Village (Kurtuvėnai Regional Park, Šiauliai district)

Generalization and Conclusions

In this overview of the Quaternary objects studied by A. K. Giedraitis, we wanted to show the primary investigations, facts, and observations made 130–140 years ago and their significance of obtaining for future research. A. K. Giedraitis himself wrote about this purpose of his research in the introduction to his work, emphasizing that he aims to <<*publish his observations to facilitate the work of future researchers*>> (Гедройц, 1895). Based on this overview of the A. K. Giedraitis geological works on the territory of Lithuania and other neighbouring countries and on the conclusions that he presented, it is safe to say that A. K. Giedraitis is the first modern Quaternary researcher in Lithuania, who used the theory of continental glaciation in Quaternary studies (Paškevičius, 2023). In the Merkys River Valley, he skillfully recorded the phenomenon of the deployment of Cretaceous and Jurassic system rocks *not in situ*, *i.e.*, recorded the phenomenon of their deployment during glaciations – glaciodislocations. His observations were supported by further research. In Lithuania, several of the outcrops he repaired and investigated later served as supporting sections for Quaternary sediments, enabling him to recreate the palaeogeographical circumstances that led to sediment production and associated geochronology.

Acknowledgments

The authors thank the organizing committee for the mention of the 175th anniversary of A. K. Giedraitis in 2023, which encouraged us to take a deeper look at the Quaternary research works of geologist Duke A. K. Giedraitis.

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