



List of the most representative geosites of Lithuania

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Abstract. The list of most representative geosites of Lithuania has been compiled. The geosites could be subdivided into the three major groups: the landforms and landscape features, Quaternary type sections and pre-Quaternary type sections. The following criteria for selections have been identified: scientific value, educational meaning, historical-ethnographical meaning, aesthetic value, touristic attraction and relevance for practical use. Taking into account the peculiarities of geological structure — thick Quaternary cover, formed during glacial and interglacial stages, and bedrock formed by sedimentary rocks — the most representative geosites demonstrate typical geological and geomorphological features of Lithuania.

Key words: geoconservation, network of European geosites, Lithuania.

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Streszczenie. Zestawiono listę najbardziej reprezentatywnych geostanowisk Litwy. Wybrane geostanowiska można podzielić na trzy główne grupy: formy rzeźby i typy krajobrazu, stratotypowe profile czwartorzędowe i stratotypowe profile przedczwartorzędowe. Przy wyborze uwzględniono następujące kryteria: wartości badawcze, dydaktyczne, historyczno-etnograficzne, walory estetyczne, atrakcyjność turystyczną i znaczenie praktyczne. Biorąc pod uwagę specyfikę budowy geologicznej — miąższa pokrywa czwartorzędowa utworzona w okresach glacialnych i interglacialnych, podłoże zbudowane ze skał osadowych — najbardziej reprezentatywne geostanowiska obrazują typowe cechy geologiczne i geomorfologiczne Litwy.

Słowa kluczowe: geochrona, sieć europejskich geostanowisk, Litwa.

The pre-Quaternary bedrock is presented by sedimentary rocks of Palaeozoic, Mesozoic and Tertiary age, continuously covering the pre-Cambrian crystalline bedrock, which occurs at depth of 300–400 metres in eastern and at the depth 2000–2500 metres in Western Lithuania. The pre-Quaternary rocks — starting with Devonian sediments could be observed in a day light in a few natural outcrops in river valleys or in artificial outcrops made due to exploitation of Devonian dolomite, Permian limestone, Triassic clay or Neogene quartz sand. Outcrops with blocks of pre-Quaternary rocks, glacially dislocated, are known there as well as in several river valleys of Lithuania.

The territory of Lithuania could be regarded as one of classical regions with Quaternary cover formed during continental glaciations. The geological maps in a regional scale display distribution of Quaternary deposits covering continuously the whole territory of Lithuania. The thickness of this cover is 130 metres on the average and varies from 10–30 m in

the northern part of the country — area of prevailing glacial erosion — up to 200–300 m in ice marginal highlands and the ancient buried valleys or paleoincisions. Through the Quaternary period Lithuania was covered by continental ice-sheets originating in Fennoscandinavia which correspond to all glaciations known so far in Eastern Europe (Gaigalas, 1995). That caused a very complicated structure of the Quaternary cover. Processes of accumulation and erosion during the glaciations as well as interglacial intervals created the wide genetical variety of sediments and landforms. These processes also had the great impact on the present morphology of the pre-Quaternary surface.

The sediments and landforms of at least 6 glacial stages and 8 ice-free periods could be revealed and observed in stratigraphic cross-section of Quaternary of Lithuania. Due to this, the territory of Lithuania has served as a key region in solving of many stratigraphical problems of Quaternary of the whole Eastern Baltic area (Kondratiene *et al.*, 1993; Gaigalas, 1995). So, the territory of Eastern Lithuania, especially the area of the border of Weichselian ice maximum extension, could be considered as stratigraphic archive, providing very important knowledge on glacial history for all continentally glaciated territories of northern hemisphere.

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Geoconservation network

The official list of legally protected geological monuments of Lithuania contains now 162 objects: 99 erratic boulders, 26 outcrops (mainly of Quaternary deposits), 25 hydrogeological objects and 12 geomorphological objects. Besides 20 geological reserves, there are established for conservation assemblages of erratic boulders, outcrops and fossiliferous sites and particular landforms (Lincius, 1994). The geological objects of Quaternary age there predominate in the list of protected geological monuments and reserves. The protected sites comprise most of particular geological structures or their evidences like large erratic boulders, picturesque landforms such as kames and eskers, springs etc., having a significant national natural heritage value. In most cases, the protected geological objects have particular historical, cultural and ethnographical value as well.

The landscape features, including the geological phenomena, are protected in 5 national parks, 30 regional parks, 30 geomorphological reserves, 61 landscape reserve and 35 hydrographic reserves. Besides that, the landscape elements are protected in numerous reserves, established for protection of animate nature. So generally, the landscape, relief together with subsurface features, are legally well protected in Lithuania and are regarded as a part of national natural heritage with implication for culture, science, education and tourism.

Draft candidate list of geosites

In order to compile the top list of geosites the following criteria have been used: scientific value, educational meaning, historical-ethnographical meaning, aesthetic value, tourist attractiveness, relevance for practical use (Baltrunas *et al.*, 1997). Taking into account the peculiarities of geological structure — thick Quaternary cover, formed during glacial and interglacial stages, and bedrock formed by sedimentary rocks — the most representative geosites should demonstrate typical geological and geomorphological features of Lithuania. Therefore, the scientific value and representativeness of the geosites was the main criteria defining the value of the particular object. The geosites selected could be subdivided into 3 groups: landforms and landscape features, Quaternary type sections (outcrops) and pre-Quaternary type outcrops (Fig. 1).

1. The Kuršiu Nerija (Curonian Spit), peninsula of the Baltic Sea (67.4 m a.s.l.; geographical co-ordinate of the northern point: 55°43'22"N/21°05'41"E).

Main features: active dunes, lacustrine marls.

The Curonian Spit area is the 10,000 ha, it is a 100 km long and narrow (0.4–4.0 km) peninsula. The active dunes (58.4–67.4 m high) cover the surface of the peninsula.

The Curonian Spit is known due to the largest in Eastern Europe eolian active dunes, the lagoon marl (clayey gyttja) outcrops, exposed below the eolian deposits and the deposits of amber.

The Curonian Spit (its Lithuanian part) belongs to the national park, which has been founded in 1991. Three separate

dunes and one exposure of lacustrine marl were declared as geological monuments in 1964 and 1968.

2. The Biržai karst area is located in the Northern Lithuania (50 m a.s.l.; geographical co-ordinate in the centre: 56°13'14"N/24°38'58"E).

Main features: sinkholes, notches, outcrops, cavities, springs.

The Biržai karst area is spread on the area of about 1000 km² (environs of Biržai and Pasvalys towns).

Lithuanian karst — it is mantled sulphate karst. Total area — 146,494 ha (the most active karst process affects 29,416 ha area). The karst develops in fractured gypsiferous rocks of Tatula Formation of Upper Devonian Frasnian Stage. There, both the surface and underground karst forms are found. Surface karst forms include sinkholes, depressions and notches, underground ones — widened fractures, canals, cavities, caves, etc. Sinkholes are most widespread among surface karst forms (Fig. 2). More than 8500 of them are found. In some places more than 200 of sinkholes are concentrated in one square kilometre. Most of sinkholes are dry, some of them are partly filled up with water and turned into small karst lakes or peat bogs. In cases when sinkholes reach artesian water, in favourable geomorphological conditions springs arise with mineralised water. In valleys of rivers karst notches, outcrops and cavities are found (Marcinkevicius & Buceviciute, 1997).

All these features make particular landscape, which is protected in the Biržai Regional Park (1992) and 4 geological reserves. Selected sinkholes, notches, outcrops, springs, erratic boulders are declared as geological monuments since 1964.

3. The Šeškinė esker is situated in Vilnius territory (180 m a.s.l.; 54°42'58"N/25°16'01"E).

Main feature: esker.

Šeškinė esker is a typical 1.16 km long, 18 m high, 50 wide radial esker, formed under glacial conditions. This classical esker denoting maximum advance of the Weichselian Glaciation is known since end of 19th century.

The Šeškinė is declared as geological monument since 1964 and is very popular place for recreation.

4. The Velnio Duobe (Devils Hole) is located in South-Eastern Lithuania (200 m a.s.l.; 54°36'42"N/24°31'02"E).

Main feature: hole.

Velnio Duobe is situated in a picturesque vicinities of Aukštadvaris town. The diameter of this hole (kettle) is 200–220 m, depth 40 m (9.5 m under the bottom surface). This form is located within the area of marginal moraines of the Late Weichselian. Its genesis is disputable, some scientists regards this hole as impact crater, due to its typical morphology. However, other researchers declare its thermokarstic origin.

The Velnio Duobe is declared as a geological monument since 1964.

5. The Puntukas is situated in north-eastern part of

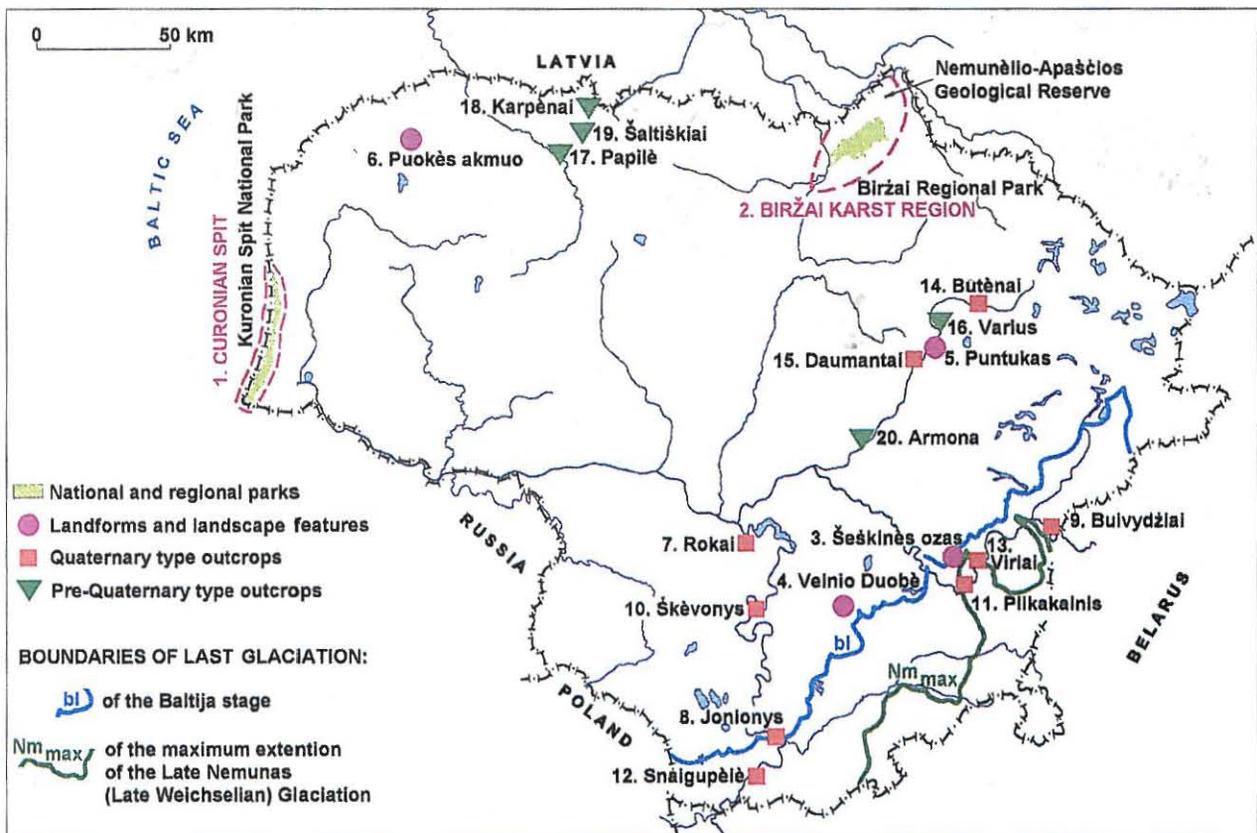


Fig. 1. Location of the most representative geosites of Lithuania

Lithuania Anykščiai district (80 m a.s.l.; 55°29'02"N/25°03'44"E).

Main feature: erratic boulder.

The Puntukas is second in Lithuania according to size (height is 5.7 m, length — 7.54 m, width — 7.34 m, horizontal size — 21.39 m) typical erratic boulder of Fennoscandinavian origin.

The Puntukas is a geological monument since 1964 and a monument of culture and art since 1972.

6. The Puokės Akmuo (The Puokės Stone) is located in north-western part of Lithuania Skuodas district (90 m a.s.l.; 56°11'32"N/21°53'55"E).

Main feature: erratic boulder.

The Puokės Akmuo is the largest erratic boulder, known so far in Lithuania. Its height is 3.6 m, length — 13.35 m, width — 7.53 m, horizontal size — 32 m.

This boulder is a geological monument since 1964.

7. The Rokai on the right bank of the Jiesia river (left tributary of the Nemunas river) near Kaunas (70 m a.s.l.; 54°50'35"N/23°56'42"E).

Main features: Quaternary stratotype, lacustrine deposits.

The surrounding topography is a flat, till plain covered with varved clays. The section is 34 metres high and from top to bottom displays 8 beds of deposits of different age and genesis

(Fig. 3). The section is particularly interesting due to the presence of lacustrine deposits attributed to the Middle Weichselian stage. The upper part of the section is composed of four Late Weichselian till units. In the lowermost part of the outcrop, close to the present-day river level, a layer of grey silty/clayey till of the Medininkai (Saalian) Glaciation occurs.

The outcrop is included into the Jiesios landscape reserve.

8. The Jonionys site in Southern Lithuania (30 m a.s.l.; 54°09'41"N/24°06'25"E).

Main features: sequences of the Eemian Interglacial and Weichselian (Vistulian) interstadials.

The Jonionys outcrop is situated in the valley of river Nemunas, 3 kilometres downstream from the town Merkine. The height of Nemunas terrace is 1113 m above the water level. The Jonionys area is dissected by a deep valley of a small tributary stream Didžioji Jonioniu Griova (The Big Ravine of Jonionys). The organic interglacial and interstadial sediments at the site form the basement of a fluvial terrace of the river Nemunas and are overlain with alluvial fine sands and gravel, together 35 m thick.

The deposits exposed in outcrops at Jonionys belong to the Merkine (Eemian) Interglacial and Early Nemunas (Weichselian) stages. As the interglacial sediments comprise and represent the whole Merkine Interglacial, the Jonionys site has been established as stratotype for the Merkine (Eemian) Interglacial in Lithuania (Kondratiene *et al.*, 1993). Most recent data indicate (Satkunas & Grigienė, 1997) presence of three independent

interstadials (Brørup, Odderade and Oerel) above the Eemian deposits in the Jonionys section. So, the section of the Jonionys palaeo-lake represents a continuous sedimentation and vegetation history starting with the Eemian Interglacial and ending with the mid of the Middle Weichselian.

The site is included in the Dzukija National Park, besides that, the Big Jonioniu Ravine is a geological monument since 1974.

9. The Buivydžiai in Eastern Lithuania near state border with Belarus (140 m a.s.l.; 54°52'02"N/25°44'37"E).

Main features: Upper Pleistocene sequence, interglacial gyttja.

The Buivydžiai outcrop is located on the right slope (35 m height) of the valley of the Neris river.

General thickness of Quaternary in the Buivydžiai site is 70–80 m. Within its structure, 4 layers of tills have been recorded and attributed to Dainava, Zemaitija, Medininkai and Gruda glacial units.

The Buivydžiai is known due to the presence of a gyttja layer attributed to the Snaigupele Interglacial (Kondratienė & Vishnevskaya, 1974). This layer so far has a meaning as parastratotype of the Snaigupele Interglacial (Kondratienė *et al.*, 1993). Besides the interglacial gyttja, the exposure presents a very interesting section of Middle- and Late Pleistocene, characteristic for the area of a maximum extent of last glaciation (Satkunas, 1997).

The outcrop is not officially protected.

10. The Škevonys Site in Southern Lithuania in vicinities of Birštonas town (75 m a.s.l.; 54°36'18"N/25°00'20"E).

Main feature: section of Pleistocene deposits.

The Škevonys is located on the right slope of the Nemunas river valley. The outcrop is 24 m high and displays Middle Pleistocene (Medininkai) and Upper Pleistocene tills (6 separate units) separated by a crust of weathering, formed during the Eemian Interglacial.

The site is a geological monument since 1984 and belongs to the Nemuno Kilpu Regional Park.

11. The Plikakalnis on the right bank of the Neris river in Vilnius city (120 m a.s.l.; 54°41'07"N/25°13'33"E).

Main features: section of Pleistocene deposits, postglacial landscape.

The outcrop is 60 m high and the section exposed comprises the following stratigraphic units: Elsterian (Dainava) Glaciation, Holsteinian (Butenai) Interglacial, Early Saalian (Zemaitija) Glaciation, Snaigupele Interglacial, Late Saalian (Medininkai) Glaciation. The section is composed of tills, lacustrine, glacialfluvial and glaciallacustrine sediments.

The outcrop is a geological monument and belongs to the Karoliniskiu Landscape Reserve.

12. The Snaigupele in Southern Lithuania in vicinities of Druskininkai town (100 m a.s.l.; 54°02'07"N/24°00'04"E).

Main feature: section of Pleistocene deposits.

The Snaigupele is the stratotype section of the Snaigupele Interglacial is located in the valley of the Snaigupele river (small tributary of Nemunas), 2.5 km NE of the Druskininkai town.

The Snaigupele gyttja (1 m), exposed in this section, is covered with brown till 2.5 thick. The site is well investigated, however, the stratigraphic position of the Snaigupele Interglacial is problematic and is an object of scientific discussions (Baltrunas, 1995). Palynological data indicate that the deposits of the Snaigupele Interglacial are younger than the beds of the Butenai (Holsteinian) Interglacial and older than the Merkinė (Eemian), however, the conditions of occurrence of the interglacial layer do not support this conclusion.

The outcrop is a geological monument since 1974.

13. The Viriai in South-Eastern Lithuania in vicinities of Vilnius (165 m a.s.l.; 54°45'38"N/25°18'58"E).

Main feature: glacitectonic structure.

The Viriai is located in the Neris river valley, northern suburb of Vilnius. The section is 30 metres high and particularly steep.

It displays a large glacitectonic structure of the Middle Pleistocene age and is composed of till with few lenses of dislocated sand. The section is evidence of the Major Saalian Glaciation.

The outcrop has no protected status, however, this site belongs to the Verkiu Regional Park.

14. The Butenai in North-Eastern Lithuania, north of Utena town (80 m a.s.l.; 54°38'49"N/25°20'29"E).

Main feature: stratotype of Holsteinian Interglacial.

The Butenai is located in the valley of Šventoji river.

This outcrop is the stratotype of the Butenai (Holsteinian) Interglacial. The outcrop is only 2–4 m high, however, it represents typical vegetational development, determined by pollen and spores data, during the Holsteinian Interglacial in Lithuania.

The Butenai outcrop has no protected status.

15. The Daumantai in North-Eastern Lithuania, southward of Anykščiai town (70 m a.s.l.; 55°27'12"N/24°56'15"E).

Main feature: Neogene/Quaternary boundary.

The stratotype for the Daumantai Preglacial Formation was suggested a 25 m high outcrop of the Šventoji river valley at Daumantai village (Kondratienė *et al.*, 1993), where the Daumantai Formation overlays the Anykščiai (Upper Pliocene) Formation and a boundary between Quaternary (the Daumantai Formation) and Neogene (Anykščiai Formation) is presented. This Quaternary/Neogene boundary was established by pollen and lithological criteria. Besides, the Upper Devonian sandstone is exposed and makes the basement of the outcropping sequence. The section is unique as displaying the Neogene/Quaternary boundary in terrestrial sediments.

The Daumantai Stage comprises the oldest Quaternary deposits known in Eastern Baltic region.

The outcrop has no protected status, however, this site belongs to the Anykščiu Regional Park.



Fig. 2. A karstic sinkhole — characteristic feature of a karstic landscape (The Biržai karst area). Photos 2 and 4 by V. Mikulenas



Fig. 3. The Rokai outcrop is 34 m high section of Quaternary deposits. Photo by J. Satkunas

16. The Varius in North-Eastern Lithuania, northward of Anykščiai town (90 m a.s.l.; 55°34'42"N/25°06'47"E).

Main feature: Lower and Upper Neogene deposits.

The Varius outcrop is located in Stakiu village and represents a 9 m high section of the Lower and Upper Neogene. Sediments are composed of very fine quartz sand. This sand is attributed to the Anykščiai Formation of Upper Pliocene. The sand is being excavated near Anykščiai town.

The outcrop is a geological monument since 1987 and belongs also to the Anykščiai Regional Park.

17. The Papile in North Lithuania, small town Papile (85 m a.s.l.; 56°08'52"N/22°48'27"E).

Main feature: Late Jurassic deposits rich in fossils.

The Papile outcrop is located in the valley of Venta. The section is 10.4 m high and is composed of black clay with mica and siderite concretions, limestone, brown sandstone, clay and sand of Late Jurassic (Callovian Stage). This sequence is

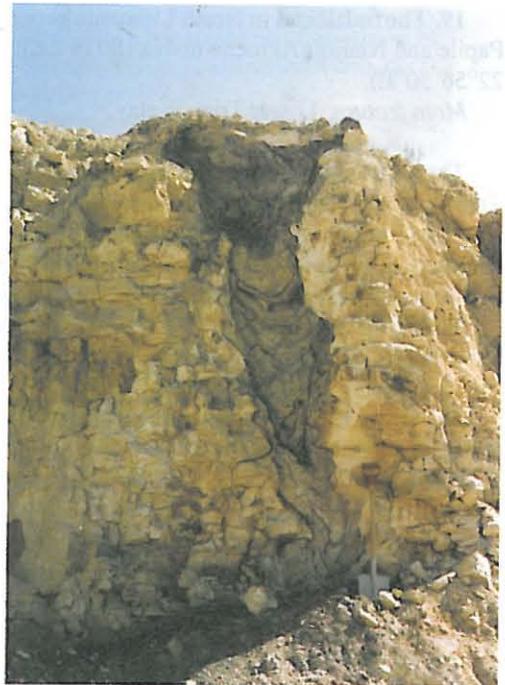


Fig. 4. Section of Karpenai deposits, with characteristic paleokarstic developed in Upper Permian limestone

covered with a 15 m thick Quaternary till. Characteristic fossils (Grigelis, 1994): *Oxytoma inaequivalvis* (Sow.), *Chlamys (Aequipecten) fibrosa* (Sow.), *Protocardia cognata* (Phill.), *Trigonia (Trigonia) zonata* Ag., *Myophorella undulata* (Ag.), *Astarta sauvagei* Lor. and *Astarte trembrazensis* Lor., *Cosmoceras jason* Rein., *Cosmoceras castor* Rein., *Cosmoceras obductum* Buck., *Cosmoceras transitionis* Nik., *Cosmoceras cf. compressum* Quenst.

The exposure has been known to scientists since 1825, and collections of fossils from the Papile are available in many European universities since the last century. The largest collections of fossils are at Vilnius University and Institute of Geology in Vilnius.

The Papile is the most widely known among the number of Jurassic exposures.

The site is a geological monument since 1964, and also belongs to the Ventos Regional Park.

18. The Karpenai in North Lithuania near state border with Latvia (90 m a.s.l.; 56°18'38"N/22°58'29"E).

Main features: Upper Permian limestone, paleokarstic forms.

The Karpenai is located in a deep and big quarry of limestone of the Naujoji Akmene Formation (Upper Permian). The section exposed in the quarry is 20 metres high and represents typical section composed of three layers: lower clayey limestone, middle — limestone, upper — dolomite with high content of limestone. Paleokarstic phenomena could be observed in the section (Fig. 4).

The site has no protected status.

19. The Šaltiškiai in North Lithuania between mentioned Papilė and Naujoji Akmenė towns (80 m a.s.l.; 56°12'55"N/22°56'50"E).

Main feature: Lower Triassic clay.

The Šaltiškiai is located in the quarry of clay of the Lower Triassic. The sections there displays upper part of the marine clay layer, which is up to 96 m thick. The clay is differently coloured, contains lenses of silt, quartz sand or even gravel. The clay has practical meaning and is used for cement production.

The sections are not officially protected because they occur in the quarry, where clay extraction is still ongoing.

20. The Armona in Central Lithuania, Ukmergė District (90 m a.s.l.; 55°10'55"N/24°38'25"E).

Main feature: Upper Devonian deposits rich in ichthiofauna.

The Armona outcrops occur in the Armona river valley. The Upper Devonian Šventoji Member deposits occur under a thin Quaternary cover. The visible sections 2.5–6.2 m high, display sand, sandstone and siltstone.

The outcrops are well known and valuable due to fossils of ichthiofauna: *Asterolepis radiata* Rohon, *Psammolepis undulata* Ag., *Laccognathus panderi* Gross, *Glyptolepis baltica* Gross, *Panderichthys rhombolepis* (Gross), *Dipteris* sp.

Five outcrops make the Armona geological reserve.

Conclusions

The selection of the most representative national geosites is an activity initiated by the ProGEO — European Association for Conservation of Geological Heritage. That was a driving force for reconsideration and revision of the protected sites, comparing them with the list of the most scientifically significant geosites.

In order to compile the top list of geosites, the scientific representativeness of the geosites was the main criteria defining the value of a particular object. The analysis performed from this point of view shows that in spite of comprehensive list of legally protected sites and areas in Lithuania, some of most significant sites are not listed among protected geological

monuments and reserves. The stratotypes, as sites of special scientific importance, in most cases have a great international, scientific meaning, which could be evaluated much more higher than value of a particular erratic boulder or esker, having only a local value. The stratotypes must be well documented, mapped and catalogued. The information about scientific value of certain outcrop should be available and accessible not only for scientific community, but it also should be provided for local people and authorities, expecting public awareness. The information on most valuable geosites is also very important for elaboration of plans of environmental protection, landscape planning, geotourism and education.

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