



Recent sinkholes in an area of intensive karst development in northern Lithuania

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The karst of northern Lithuania is developed in gypsumiferous layers of the Pasvalys and Nemunėlis beds of the Tatula Formation of the Upper Devonian (Frasnian) stage. The new sinkholes formed during the last ten years in around Biržai and Pasvalys indicate recent karst activity. 84 recent sinkholes appeared around the villages of Karajimiškis, Mantagailiškis in the Biržai district from 1995 to 1999. The three biggest sinkholes occur in Pasvalys. Karst processes and phenomena are particularly dangerous in urban areas. The sudden appearance of sinkholes and ground subsidence have often caused building damage. New sinkholes indicate a very sensitive engineering geological environment.

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The new sinkholes formed during the last ten years in the Biržai and Pasvalys districts point to recent karst activity. The karst of northern Lithuania is developed in gypsumiferous layers of the Pasvalys and Nemunėlis beds of the Tatula Formation of Upper Devonian (Frasnian) stage. Soluble deposits of the Nemunėlis and Pasvalys beds of the Upper Devonian Tatula Formation — gypsum, dolomitic gypsum, gypsumiferous dolomite with interbeds of dolomite and dolomitic marl — occur near the land surface (10–20 m deep) there. The thickness of the Nemunėlis beds reaches 20 m, and the Pasvalys beds are up to 25 m thick. The Kirdonys beds, formed of dolomitic marl and clay, are 4–8 m thick and separate the Nemunėlis and Pasvalys beds. The Tatula Formation occurs on an undulose surface of the Upper Devonian Kupiškis Formation. Deposits of the Tatula Formation are covered by Quaternary morainic loam, sandy loam, and rarely by dolomite of the Upper Devonian Istras Formation, lying under Quaternary deposits.

The rocks of the Tatula Formation are fractured and affected by karst phenomena. The groundwater circulates in fractures and cavities of various size. In the karst region of North Lithuania both surface and underground karst features are widespread. Surface karst forms include sinkholes (most widespread), depressions and notches, while underground ones include widened fractures (through dissolution), canals, cavities, caves, and so on. More than 8500 sinkholes have been found. Using the number of sinkholes per square kilometre, the karst region of North Lithuania is subdivided into areas of different karstification degree (Marcinkevičius and Bucevičiūtė, 1986) (Fig. 1). In northern Lithuania sinkholes of different forms, size, depth and morphological type occur. Sinkholes of oval forms, medium size, shallow and flat are most frequent. The depth of recent sinkholes reaches 20–25 m. Most sinkholes are dry, some are partly filled with water as small karst lakes (Marcinkevičius and Bucevičiūtė, 1997).

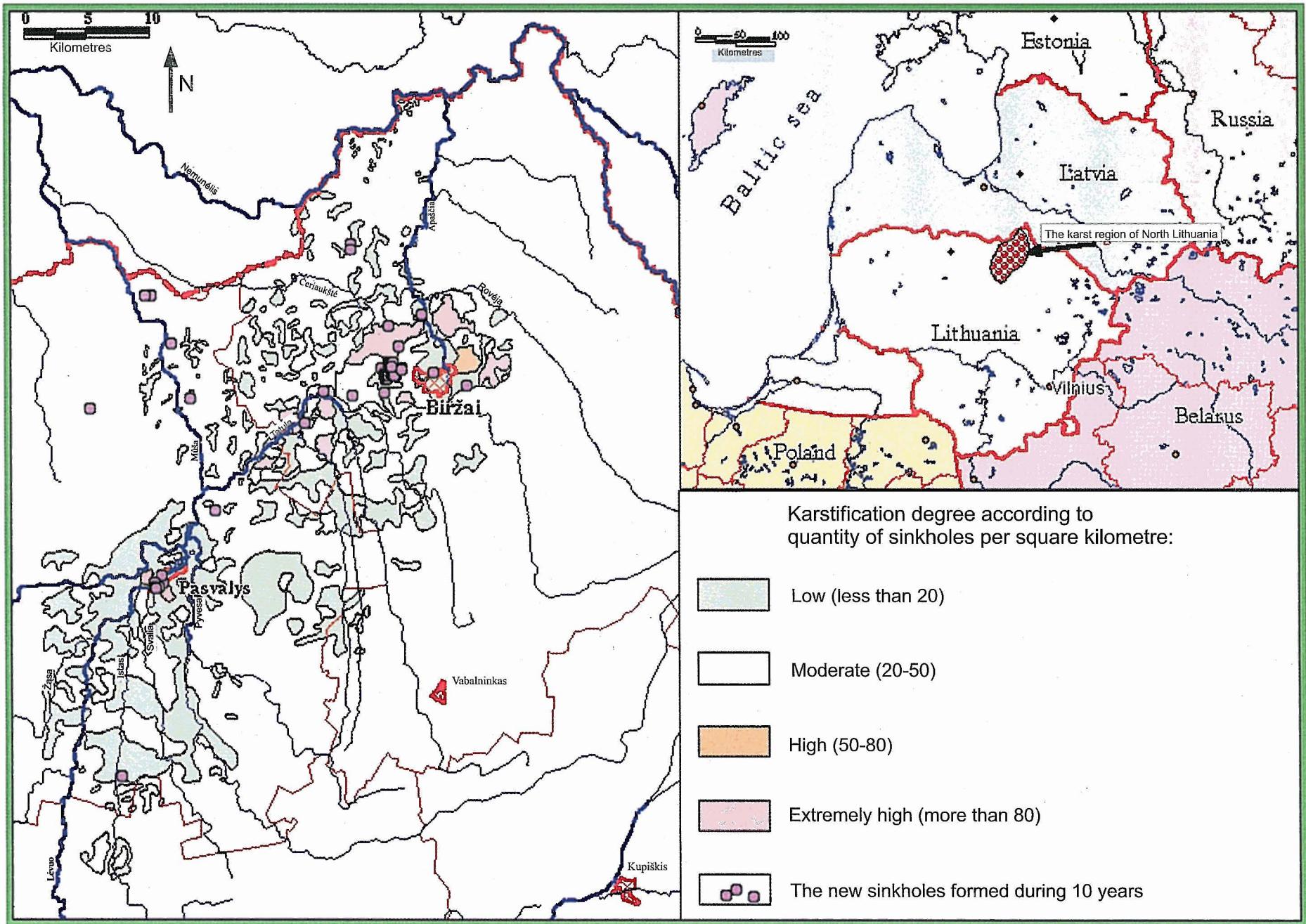


Fig. 1. The karst region of North Lithuania subdivided according to karstification degree (after Marcinkevičius and Bucevičiūtė, 1986)



Fig. 2. The new sinkhole which suddenly opened on the Panevėžio Street, Pasvalys on March 5, 1997



Fig. 3. Sinkhole appearance, with consequent damage to two buildings on June 15, 1999



Fig. 4. The tilted water-supply tower in Kirdonis village, Biržai district

Karst phenomena are particularly dangerous in urban areas. The towns of Pasvalys and Biržai occupy 25 km² (7.2 and 17.8 km² respectively) of heavily karsted areas in the karst region of North Lithuania. In Pasvalys, engineering investigations for construction indicate that karst cavities are the most widespread of underground karst forms, occurring throughout the Upper Devonian Tatula Formation of 2–15 m depth below the ground surface. The diameter of underground cavities varies from 1–5 to 11 m. Sinkholes occur across the northwestern part of the town with a density of more than 50 sinkholes per square kilometre. In Biržai, underground karst cavities are distributed through more than 15 m of the lower part of the Tatula Formation gypsumiferous rocks. The diameter of cavities varies from 0.5 to 3.6 m. Sinkholes in the western and northeastern part of

Biržai have a density of more than 50 sinkholes per square kilometre.

The new sinkholes have been catalogued during fieldwork on the project "Database of karst and slope collapse phenomena of Lithuania", carried out since 1996 by the Lithuanian Geological Survey. This project collects geological, hydrogeological and engineering geological data on karst process development of the karst region of North Lithuania and compiles a database on the physical and mechanical parameters of karstic rocks. Compilation of a package of special geological maps is foreseen.

During fieldwork, new sinkholes were located and their geographical co-ordinates plotted by the Global Positioning System equipment with an accuracy of 0.5 to 5 m. The morphological parameters, lithological composition and recent environmental state were described.

The most recent sinkholes are visible at the land surface around the villages of Karajimiškis, Mantagailiškis villages and near Biržai. 53 new sinkholes occurred in Karajimiškis from 1997 to 1999; and 31 in Mantagailiškis from 1995 to 1999. Sinkholes of oval form, small and of medium size (1–7 m wide and up to 0.5–2.5 m deep), shallow and flat are most common. Single sinkholes occur around Juodeliai, Kirkilai, Šlepščiai, Nociūnai and Kojeliškiai villages in the Biržai district, and Pumpėnai, Poškonys, Kurpalaukis, Saločiai and Manikūnai in the Pasvalys district. They are oval or round, of medium size (3.0–14.5 m wide and 0.8–4.5 m deep), shallow and flat. Most of the sinkholes are dry and open.

The biggest sinkholes occurred in Pasvalys in 1995, 1997 and 1999 (Marcinkevičius and Taminskas in: *Geoindicators*, 1999). The first of them opened near the Vilnius Street in the centre of the town. It was 6 m wide and 21 m deep. The next sinkhole of 7–7.5 m wide and 7 m deep suddenly opened on Panevėžio Street in March 5, 1997 (Fig. 2). The third sinkhole, 15 m wide and 14 m deep, opened near Žalioji Street. The latter caused serious damage to two buildings (Fig. 3). The water-supply tower was tilted one side (deviation from the vertical axis reaching 55 cm) in Kirdonis, in the Biržai district. Waterlogged dolomitic sediment was found under the foundations, this possibly being the immediate cause of differential settlement (Fig. 4).

These new sinkholes have produced a very sensitive engineering geological environment (Fig. 5). Data on the average number of sinkholes appearing every year are needed to assess the stability of the territory for construction and engineering. The sudden appearance of sinkholes and rapid ground subsidence may cause building failures requiring considerable finance for restoration work. The acceleration of karst processes in recent years may have been exacerbated by intensive economic activity (ground water exploitation, static and dynamic loading and so on).

The Lithuanian Geological Survey has initiated geoenvironmental investigations of the cities and largest towns



Fig. 5. Part of a house, after falling into a sinkhole 3–4 m wide and 5 m deep in Naciūnai village in April 11, 1997

of the Lithuania, relating to this problem. The karst will be monitored closely for its effect on human settlements and built structures, with plans to map the territories of Biržai and

Pasvalys in the karst region of North Lithuania from the engineering geological point of view at a scale of 1:5000 in 2001–2005.

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