

Geodiversity of pseudokarst caves as the reason for their scientific importance and motive of protection

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Abstract. Pseudokarst caves occur in various - magmatic, metamorphic and sedimentary - rocks and represent many genetical types. They have been lately a frequent subject of registration and scientific studies. The development of these caves is closely related to processes of rocks formation or postdiagenetic reconstruction, mainly denudation (erosion, weathering). Consequently the studies of these caves often provide wider information on processes controlling geological or morphological development of the area. Thus, the scientific criteria should be more often applied in the caves evaluation and selection for legal protection. In Poland the number of protected pseudokarst caves has been increasing for the last years and now legally protected caves represent more than 25% of the caves number and more than 40% of their total length.

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Introduction

Caves do not occur in karst rocks only. They are frequent in many other types of rocks and exist in regions devoid of karst rocks. Different terms and classifications are applied in their descriptions, and the problem of definition of "pseudokarst caves" (and wider - "pseudokarst forms") is still a matter of discussion and consideration. Occurrence of many polygenetic and transitional forms (between karst and non-karst) does not make this discussion easier (vide Kunsy, 1957; Otvos, 1976; Panoš, 1978; Vitek, 1983; Rubin, Balatka, 1986; Bosák, 1988; Sjöberg, 1989a; Bella, 1995a; Striebel, 1995; Self, Mullan, 1997). In the present paper "pseudokarst caves" are defined - according to Ford, Williams (1992) - as caves produced by processes other than solution or solution-induced subsidence and collapse. In this meaning the term "pseudokarst" is referred only to forms, not to processes and does not determine the type of rocks (pseudokarst caves might be formed in karst rocks by non-karst processes) and their genesis except, of course, karst-corrosional (solutional) origin. It allows to include to the group of "pseudokarst caves" very differentiated forms, among them caves commonly occurring in places as

well as rare and unique ones. Some authors mentioned above suggest a more restricted sense of the term "pseudokarst", but apply quite different criteria and methods of "pseudokarst forms" distinction; thus, it is impossible to combine their opinions in other way than acceptance a very wide but rather well precised definition.

State of pseudokarst caves registration in Central Europe

The registrations and studies of the pseudokarst caves are advanced in some Central European countries. The results are usually published in national languages in local speleological journals and inventories. Rather seldom the studies on pseudokarst are presented in publications of international importance except for international meetings proceedings. This is why the cited bibliography represents mainly the papers presented during international conferences on pseudokarst. Draft information on the state of the registrations in Poland and neighbouring countries is presented hereafter.

About 500 pseudokarst caves have already been listed in Poland (Urban, 1996a). They occur predom-

inantly in sandstones (flysch) of the Outer Carpathians, Southern Poland (430 caves). In the Polish Outer Carpathians, 12 pseudokarst caves longer than 100 m are registered; the largest one - Jaskinia w Trzech Kopcach - is 913 m long (Klassek, Mleczek, 1997; Pulina, 1997). The Pieniny Klippen Belt, Inner Carpathians, represents the example area of occurrence of the non-karstic caves in carbonate rocks (Amirowicz et al., 1995). The second large mountain range, the Sudetes, South-Western Poland, is also abounding with caves which occur in sandstones as well as in magmatic and metamorphic rocks. Non-karst caves are scattered in uplands of Central Poland, too. In the Góry Świętokrzyskie (Holy Cross Mts), Central Poland, some 40 short caves are related to sandstone tors (Urban, Gubała, Kasza, 1997). A few clastokarst caves developed in Quaternary silts and lithified sands have been discovered in North-Polish lowlands, too (Urban, 1996a).

In the Czech Republic - where the studies of pseudokarst caves have a very long tradition (Kunsky, 1957) - several hundred caves have been registered. A great number of them occurs in sandstones of the Bohemian Cretaceous Basin. The longest one - Teplická jeskyně - is 1065 m long. Numerous caves in other geological units (the Sudetes, Carpathians etc.) and magmatic and metamorphic rocks have been noted, too (Vitek, 1983; Wagner et al., 1990; Kopecký, 1995; Demek, Kopecký, 1996). Various types of non-karst caves are listed in Germany: more than two hundred caves in Cretaceous sandstones of the Sächsische Schweiz (and similar massifs), mainly erosional forms in the Northern Bavaria, caves in granites of the Harz, "mysterious" pipeshape caverns in the Pfalz, etc. (Börner et al., 1988; Kamann, 1988; Knust, 1988; Bothe, Winkelhöfer, 1989; Striebel, 1995). Not less morphologically or genetically differentiated pseudokarst caves - more than 100 - have been registered in Slovakia. The most interesting Slovak caves occur in the Cerova vrchovina, Southern Slovakia (Gaál, Bella, 1994; Bella, 1995b). In Ukraine - gravitational caves in the Outer Carpathians are frequent, some are longer than one hundred metres (Turchinov, 1990).

Pseudokarst caves as a subject of scientific studies

Pseudokarst caves represent the great diversity of morphological and genetical types and occur in almost all kinds of rocks. The main factors stimulating their development are usually closely related to processes of rock formation, their postdiagenetic reconstruction or denudation - erosion, weathering. The pseudokarst caves reflect these processes in many cases better than karst caves. Studies of caves' shape,

their position (location on the slopes, elevation, etc.), the structures of cave walls, types of sediments filling the caves often enable recognition of essential data on rock formation, age and type of tectonic/gravitational movements or significant features of relief and its development.

Two main groups of pseudokarst forms are usually distinguished: primary forms developed parallel to rock formation and secondary - produced after the rock diagenesis mainly by exogenous, morphogenic factors. The most common pseudokarst caves in Central Europe are secondary forms, which represent crevices widened due to gravitational mass movements on the slopes. They occur usually in hard, rigid rocks: sandstones, limestones, granites, volcanic rocks, etc. These "crevice type" caves (according to classification of Vitek, 1983) are particularly frequent in the mountains and apparently related to slopes development, often to landslides (Vitek, 1983; Klassek, 1994; Klassek, Mikuszewski, 1997). Therefore the studies of the caves (or in the caves) deliver data on the state of fragmentation of rock massif, position of the main splintery planes in it as well as the directions and size of blocks translation (rotation). Occurrence of organic sediments in caves allows to determine the age of mass movements by radiocarbon dating (e. g. Janiga, 1974; Self, 1985; Hebert, Börner, 1988; Puczejda, 1989; Wagner et al., 1990; Demek, Kopecký, 1996).

Some of the crevice type and boulder (talus) type caves (voids among the large boulders and blocks) formed in magmatic and metamorphic rocks of Scandinavia are supposed to represent neotectonic forms. Investigations of them give arguments for discussion on neotectonic movements in Northern Europe (Sjöberg, 1989b; Isacson, 1989).

The second big group of pseudokarst caves represent empty spaces produced by selective weathering and/or subsurface erosion (especially water erosion) as well as cryogenic processes. These caves, belonging mainly to fissure type and bedding type in Vitek's (1983) classification, are usually shorter than crevice type ones, but not less significant for geomorphological studies. They are very often related to the crags, tors and klippens. The recent studies proved that in many cases factors responsible for these caves' development are the essential agents triggering or stimulating the formation of the rock relief. One of the best example represent Piekło pod Niekłaniem sandstone tors in the Góry Świętokrzyskie (Holy Cross Mts), Central Poland. They were formerly considered to be produced exclusively by eolian corrosion but the detailed observations of two small, previously neglected caves developed along the main joints in the massif lead to conclusion that the main factor controlling the fragmentation of the massif has been the subsurface water erosion (Urban, 1996b). Cryogenic processes were responsible for development of

the large chamber of Komoniecki cave in the Polish Outer Carpathians (Waga, 1993).

Interesting studies of relation between lithostratigraphy of Cretaceous sandstones of the Bohemian Basin and marginal basins and occurrence of pseudokarst forms (erosional and gravitational) were performed by Czech and German authors (Börner, 1988; Bothe, Winkelhöfer, 1889; Kalvoda, Zvedebil, 1989). Specific, unique forms in this area represent large pseudokarst cavities filled with fluorite deposits of hydrothermal origin in Jilove near Dečín (Fengl, Lysenko, Slacik, 1988; Fengl, 1995).

Numerous abrasional caves situated on the sea coasts in Scandinavia represent a specific type among erosional forms. Horizontal zones of these kind of paleocaves now situated on different elevations above the sea level are the evidences documenting the phases of the Scandinavia uplifting in the Pleistocene and Holocene (Schröder, 1989; Sjöberg, 1988, 1989b).

Significant group of pseudokarst caves, although not very often found in Central Europe, represent primary voids formed in volcanic rocks - gas and steam bubbles, tunnels in lava streams, voids remaining after decomposition of organic matter covered by lava, etc. Studies of this type of caves provide data on the original features of volcanic rock: lava viscosity (liquidity), former morphology and lava stream generations, primary and secondary minerals, etc. The most interesting, but very seldom found, are primary gas bubbles in deep magmatic rocks (Schröder, 1989; Kolev, Shopov, 1990; Eszterház, Gaál, Tulucan, 1996). Another primary type of the caves represent unique forms in travertine.

Pseudokarst caves as a subject of protection - examples from Poland

Recently developed studies of the pseudokarst caves have caused the change of approach to these phenomena as subject of nature conservation. Short time ago they were perceived as the unique peculiarities of nature (impressive "nature wonders") and aesthetic features, their size as well as cultural traditions were the only reasons for their protection. Currently non-karst caves have become appreciated as the subject of research, and scientific criteria have been more often applied for their evaluation. Besides geological and geomorphological features also biological reasons (fauna - bats, invertebrates, flora - root stalagmites) as well as historical and cultural aspects are taken into account as motives of their protection (Gaál, 1995).

The number of legally protected pseudokarst caves has increased in Poland for the last a few years and scientific criteria have been used, among others,

for their selection. It should be emphasized that among the protected ones are: 1) different types of caves, 2) caves of difficult/none access for tourists (e.g. narrow, difficult for exploration), 3) forms devoid of commonly accepted aesthetic values (e.g. small, without speleothems or picturesque chambers and passages).

Currently in the Polish Outer Carpathians 17 caves, mainly of crevice and talus types (predominating in this region), are protected as nature monuments. At least 65 caves, among them a few caves longer than 100 m are also situated within nature reserves and national parks. They represent about 20% of total number of these objects, but some 40% of their total length. About 20 crevice type caves developed in carbonate rocks are protected in the Pieniny National Park, Inner Carpathians. In the Sudetes still not known, but rather big number of pseudokarst caves are situated in the Karkonosze National Park and the Góry Stołowe National Park. Five caves situated in other mountain ranges of this region are protected as nature monuments. In the Góry Świętokrzyskie (Holy Cross Mts) 38 pseudokarst caves - 90% of total number, 89% of total length - are protected as nature monuments or in nature reserves. They represent various genetical and morphological types. In the vast area of Central and North-Polish lowlands all registered caves are legally protected.

Recent accomplishment of the speleological inventories in some regions abounding with pseudokarst caves in Poland makes a good opportunity for the examination and assessment of the scientific values of these objects as well as the analysis of protection necessity.

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