

CEILING EROSION IN CAVES: EARLY STUDIES AND ZDENĚK ROTH AS AUTHOR OF THE CONCEPT

STROPNA EROZIJA V JAMAH: ZGODNJE RAZISKAVE IN ZDENĚK ROTH KOT AVTOR KONCEPTA

Pavel BELLA^{1,2} & Pavel BOSÁK³

Abstract

UDC 551.435.84(437.6)

Pavel Bella & Pavel Bosák: Ceiling erosion in caves: early studies and Zdeněk Roth as author of the concept

Ceiling channels belong to specific geomorphological forms occurring only in caves. Their origin has been commonly connected with the paragenesis. According to review articles, the terms of ceiling channel and paragenesis were defined by Philippe Renault (1958) for the first time. Nevertheless, Zdeněk Roth in his study of morphology and geomorphological evolution of the Domica Cave (southern Slovakia) published in 1937 (in Czech with long French summary) not only described ceiling channels, but he presented also their definition. Roth and other authors used the term later in describing features of several caves in Slovakia and Hungary. Based on original Roth observations, Josef Kinský defined the term generally in his textbook (1950 in Czech, 1956 in Polish and 1958 in French). The description of paragenetic ceiling channels by Renault (1958) can be considered as the first one only in Western European karstology literature.

Key words: ceiling channel, paragenesis, antigravitativní erosion, definition, Zdeněk Roth, Domica Cave, Slovak Karst.

Izvleček

UDK 551.435.84(437.6)

Pavel Bella & Pavel Bosák: Stropna erozija v jamah: zgodnje raziskave in Zdeněk Roth kot avtor koncepta

Stropni žlebovi so jamske skalne oblike, katerih nastanek najpogosteje povezujemo s paragenezjo. V večini preglednih člankov je kot prvotni vir, ki uvede pojma stropni žleb in parageneza, navedeno delo Philippea Renaulta iz 1958. Pri tem pa je spregledana starejša študija Zdeněka Rotha iz leta 1937, ki obravnava geomorfološki razvoj jame Domica na Slovaškem. Roth v tem delu, ki je v češčini s francoskim povzetkom, stropne kanale opiše in definira. Pred Renaultom, poleg Rotha, término pri opisu različnih jam na Slovaškem in Madžarkem uporabljajo tudi drugi avtorji. Na osnovi izvornih Rothovih opazovanj je Josef Kinský término definiral v učbeniku, ki je v češčini izšel leta 1950, v poljščini leta 1956 in v francoščini leta 1958. Renaultov opis paragenetskih stropnih žlebov iz leta 1958, je torej prvi le v naboru zahodnoevropske krasoslovne literature.

Ključne besede: stropni kanali, parageneza, antigravitativna erozija, definicija, Zdeněk Roth, jama Domica, Slovaški kras.

INTRODUCTION

Ceiling channels belong to specific geomorphological forms occurring only in fluvially modelled caves. Their origin has been connected with the paragenesis. Pasini (2009) in his review of ceiling channels and antigravita-

tion theory in caves explains that the process of erosion of the rocky ceiling from below up due to water stream flowing under pressure as a consequence of deposition of sediments was described by Philippe Renault (1958) for

¹ State Nature Conservancy of the Slovak Republic, Slovak Caves Administration, Hodžova 11, 031 01 Liptovský Mikuláš, Slovakia, e-mail: pavel.bella@ssj.sk

² Department of Geography, Faculty of Education of the Catholic University, Hrabovská cesta 1, 034 01 Ružomberok, Slovakia

³ Institute of Geology of the CAS, v. v. i., Rozvojová 269, 165 00 Praha 6–Lysolaje, Czech Republic, e-mail: bosak@gli.cas.cz

Received/Prejeto: 12.3.2014

the first time. Also Farrant & Smart (2011) reported, that the paragenesis concept has been known since innovative study of P. Renault from sixties of the 20th century.

Nevertheless, the Czech geologist Zdeněk Roth already in 1937 studied and described ceiling channels in the Domica Cave (Slovak Karst, southern Slovakia). In spite of fact, that the Czech study was followed by prolonged French summary, the study and the primary knowledge on ceiling channels were not attracted the interest of foreign karstologists. Although the study was published some 80 years ago, its general importance has to be stressed. Our study of archives and literature indicate, that the geomorphology analysis and interpretation of ceiling channels from the Domica Cave represented the primary description of this kind of speleogens not only from the territory of past Czechoslovakia, but in

general. This concept was followed also by other Czech and Slovak geomorphologists and karst students.

The origin of *ceiling channels* has been generally explained by so-called paragenesis (Renault 1958, 1968, 1970; Lauritzen & Lauritsen 1995; Lauritzen & Lundberg 2000; Farrant 2004; Farrant & Smart 2011 a. o.) or by antigravitation erosion (Pasini, 1967, 1975, 2009, 2012). The ceiling channel is formed by subterranean water flow, which presses fluvial sediments up to rocky ceiling contributing to its enlargement from below up. Nevertheless, *false ceiling channels* represent different speleogen. They represent upward deepened parts of proto-channels at the contact of overlying non-soluble and underlying soluble rocks, e. g., in the intrastratal gypsum karst (Sorbas, southern Spain, see Calaforra & Pulido-Bosch 2000).

PRIMARY STUDIES OF CEILING CHANNELS IN THE DOMICA CAVE

The Domica Cave at the southwestern margin of the Silická planina Plateau (Slovak Karst) is developed in Wetterstein Limestone (Middle Triassic) of the Silica Nappe by corrosion and mechanical erosion by occasional water

streams entering the karst from nearby part of the Bodvianska pahorkatina Upland (Droppa 1961, 1972, a. o.). The principal corridor continues crossing the Slovakia/Hungary state boundary into the Baradla Cave (Aggtelek Karst, northern Hungary) genetically forming the uniform cave system. Ceiling channels represent the most expressive morphologies in the Domica Cave. Aggradation of fluvial sediments in vadose conditions caused the complete filling of passages in places, especially in the upstream (near ponor) cave segments as a consequence of allogenic drainage loaded by big amounts of gravel and loamy sediments in passages with low dips (Ford 2000).

In the study of morphology and geomorphology evolution of the Domica Cave, Zdeněk Roth (1937) not only described the ceiling channels, but he defined them: in the Czech text on page 131, and in the French summary as *auge de plafond* on p. 39–40 (165–166). He illustrated them on his Figs. 1–4 on Tabs. I and II (Fig. 1). He defined the ceiling channel as special form preserved on ceilings of passages and more extensive cave spaces – broad upwards vaulted speleogen eroded by subterranean water flow in rocky ceiling; it is similar to fluvial channel, it can be traced for relatively long distances and it is usually meandering. Roth followed by statement,

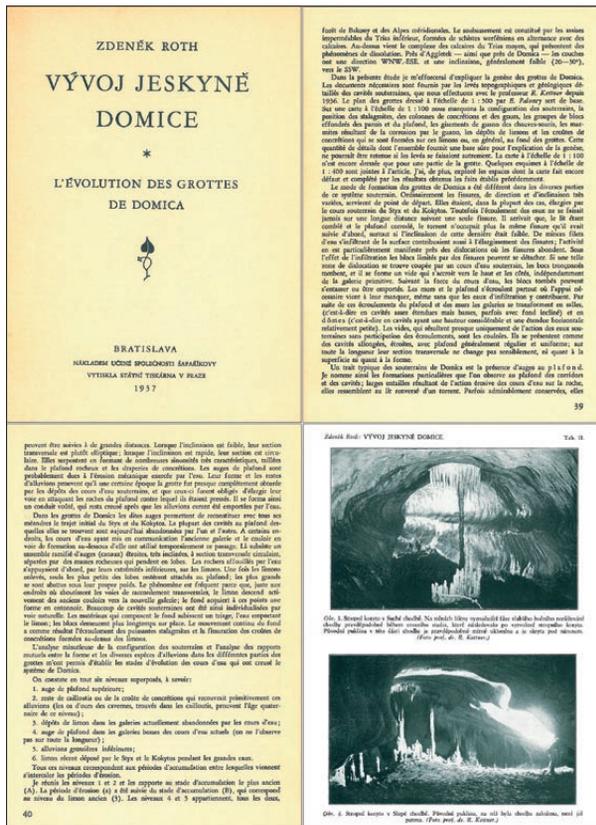


Fig. 1: Facsimile of a part of Zdeněk Roth paper on the Domica Cave from 1937; the title page, pages with the definition of ceiling channel in the French summary and photo plate No. II.

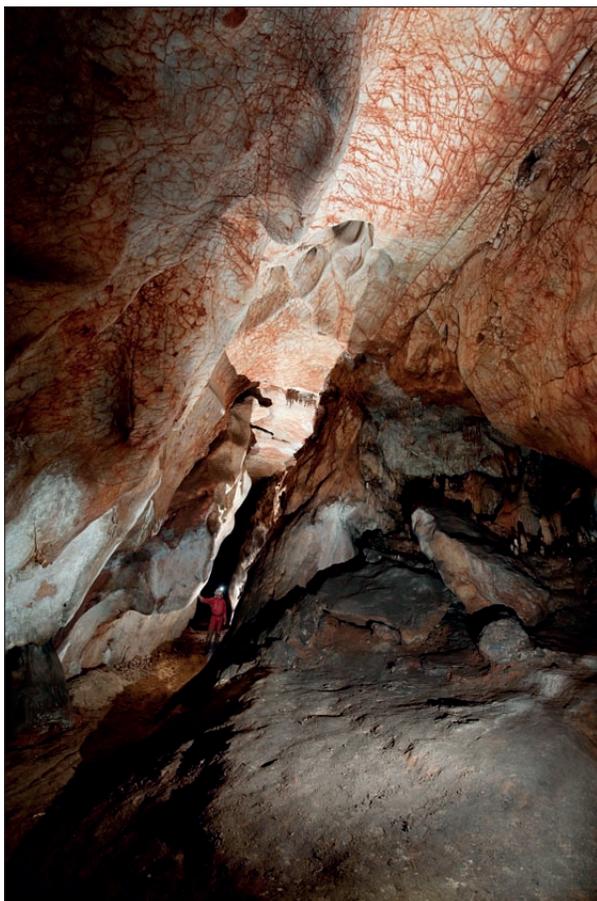


Fig. 2: Ceiling channel in the Dome of Mysteries, Domica Cave (Photo: Pavol Staník).

that the evolution of ceiling channels is mostly dependent on mechanical erosion by flowing water rather than limestone dissolution (according to recent studies, the rocky forms representing the paragenesis developed by rock dissolution; e. g., Slabe 1995; Farrant & Smart 2011). Based on the forms of ceiling channels and rest of river deposits, Roth (1937) expected that the Domica Cave was once nearly completely filled by alluvial deposits loaded by allogenic streams. The water stream pressed up to the ceiling “has to enlarge its way up by rock erosion in cave ceiling” forming “the passage with vaulted cross-section” remaining after the exhumation of cave sediments (p. 131 in the Czech text, p. 39–40 in the French summary; Figs. 2 and 3). Ceiling channels in the Domica Cave developed in two levels and served as the principal argument in the interpretation of Domica Cave evolution.

Z. Roth (1937) introduced the term of ceiling channels and formulated principles of their origin and evolution on the basis of his original field observations, any older references dealing with the topics are missing.



Fig. 3: Ceiling channel in the Meander Passage, Domica Cave (Photo: Pavel Bella).

More we reviewed cave studies of his professor, Radim Kettner, from the same region and other karst areas and we did not find any use of this term. The Domica Cave at that time was the best geomorphologically studied cave in the whole Czechoslovakia and probably also in the broader Central European region.

In his following study, Roth (1940) compared the morphology of the Domica and Baradla caves. He described ceiling channels also in the Baradla Cave and correlated them with ones in the Domica Cave. Meandering ceiling channels were somewhat later identified by Mann *et al.* (1949) in the lower level of the Domica Cave.

Based on Z. Roth studies from Domica and Baradla caves (1937 and 1940), Josef Kunský described conditions and processes leading to origin of ceiling channel in the textbook *Karst and Caves* (1950 in Czech, 1956 in Polish and 1958 in French). He described two ways of ceiling channel origin: (1) if water flow is renewed after the filling of cave passage up to ceiling, the flowing water erodes sediments and mechanically affects the ceiling by loaded gravels, the upward vaulted channel is then formed, and (2) ceiling channel can form when water flow is pressed against the ceiling, which erodes.



Fig. 4: Zdeněk Roth at cores from borehole Krásná 1, 1975 (Photo: archive Czech Geological Survey).

Ceiling channels were later recognized also in the Jasovská Cave (Sekyra in Ložek *et al.* 1956) and Drienovská Cave (Seneš 1956) from the Jasovská planina Plateau (eastern part of the Slovak Karst).

Zdeněk Roth (Assoc. Prof., RNDr., DrSc.; 1914–2009; Fig. 4) prepared this unique and important study as young researcher at the Institute of Geology and Paleontology, Charles University in Praha (Czech Republic) with the support of his professor, academician Radim Kettner, Institute director. The geomorphology investigations were carried out within the frame of the activity of the Karst Commission belonging to the Club of Czech Tourists and founded in 1933 for the research of the Domica Cave and its surrounding. Univ. prof. dr. Kettner served also as the Commission President. R. Kettner and Z. Roth carried out detailed geomorphology mapping of the principal cave segments in 1936–1938 – four map segments were published in Roth (1937) study, two segments were presented by Kettner (1948) and two colored sheets are deposited in cave map collections of the Slovak Museum of Nature Conservation and Speleology in Liptovský Mikuláš city (Lalkovič 1997, 2001).

CONCLUSIONS

The geomorphology description of the Domica Cave by Zdeněk Roth (1937) belongs to the oldest studies describing the morphology and evolution of ceiling channels. In spite of the age of the study, its importance has to be stressed especially due to primary description of this speleogen. Because the study was published in local journal *Bratislava* (issued by the Šafárik's Learned Society in 1927 to 1937 and printed studies from Slovakia and Transcarpathian Ukraine) and it was focused primarily to Slovak and Czechoslovak community, the primary knowledge on ceiling channels did not attract foreign karst students in spite of prolonged French summary.

Ceiling channels were described later also by Roth (1940) in Baradla Cave (Hungary), Mann *et al.* (1949) in

lower level of the Domica Cave, Sekyra (in Ložek *et al.* 1956) in Jasovská Cave and Seneš (1956) in Drienovská Cave (both in the Slovak Karst). Based on Z. Roth studies from Domica and Baradla caves (1937 and 1940), Josef Kůnský generally defined ceiling channels in his textbook *Karst and Caves* (1950 in Czech, 1956 in Polish and 1958 in French).

Recently, there are not known older studies of ceiling channels than the study of Roth (1937). Therefore the text of Philippe Renault (1958), which has been expected as the oldest study dealing with the problem of paragenetic evolution (antigravitation erosion) in caves for long decades, represents the primary text only for the Western European karstological literature.

ACKNOWLEDGEMENTS

We acknowledge the help of Mrs. Václava Škvorová, librarian of the Institute of Geology ASCR, v. v. i., for the search of original and primary literary sources. We are grateful to Mr. Marcel Lalkovič, former director of the Slovak Museum of Nature Conservation and Speleology, for consultations on maps of the Domica Cave. The

study was compiled within the frame of the Institutional Financing of the Institute of Geology of the CAS, v. v. i., No. RVO6798531 and it was supported by the Slovak Research and Development Agency under contract APVV-0625-11.

REFERENCES

- Calaforra, J. M. & A. Pulido-Bosch, 2000: Cave Development in Vadose Settings in a Multilayer Aquifer – The Sorbas Karst, Almeria, Spain.- In: A. B. Klimchouk, D. C. Ford, A. N. Palmer & W. Dreybrodt (eds.) *Speleogenesis. Evolution of Karst Aquifers*. National Speleological Society, pp. 382–386, Huntsville, Alabama, U.S.A.
- Farrant, A., 2004: Paragenesis. In: J. Gunn (ed.) *Encyclopedia of Caves and Karst Science*.- Fitzroy Dearborn, pp. 569–571, New York – London.
- Farrant, A. R. & P. L. Smart, 2011: Role of sediment in speleogenesis; sedimentation and paragenesis.- *Geomorphology*, 134, 1–2, 79–93.
- Ford, D. C., 2000: Caves Branch, Belize, and the Baradla-Domica System, Hungary and Slovakia.- In: A. B. Klimchouk, D. C. Ford, A. N. Palmer & W. Dreybrodt (eds.) *Speleogenesis. Evolution of Karst Aquifers*. National Speleological Society, pp. 391–396, Huntsville, Alabama, U.S.A.
- Kettner, R., 1948: O netopýřím guanu a guanových koroších v jeskyni Domici.- *Sborník Státního geologického ústavu Československé republiky*, 15, 41–64, Praha.
- Kunský, J., 1950: *Kras a jeskyně*.- Přírodovědecké nakladatelství, 163 pp., Praha.
- Kunský, J., 1956: *Zjawiska krasowe*.- Państwowe Wydawnictwo Naukowe, 207 pp., Warszawa.
- Kunský, J., 1958: *Karst et grottes*.- Service d'Information géologique du B.R.G.G.M., 107 pp., Paris.
- Lalkovič, M., 1997: Zbierka jaskynných plánov a máp Slovenského múzea ochrany prírody a jaskyniarstva v Liptovskom Mikuláši.- In: M. Kováčová (ed.) *Historické mapy*. Zborník z vedeckej konferencie, Bratislava 24.–25. 4. 1997. Kartografická spoločnosť SR, Slovenský národný archív, pp. 30–39, Bratislava.
- Lalkovič, M., 2001: Detailné mapovanie jaskyne Domica v rokoch 1936–1938.- In: M. Kováčová & M. Hájek (eds.) *Historické mapy*. Zborník z vedeckej konferencie, Bratislava 26.–27. 4. 2001. Kartografická spoločnosť SR, pp. 149–156, Bratislava.
- Lauritzen, S.-E. & A. Lauritsen, 1995: Differential diagnosis of paragenetic and vadose canyons.- *Cave and Karst Science*, 21, 2, 55–59.
- Lauritzen, S. E. & J. Lundberg, 2000: Solutional and erosional morphology.- In: A. B. Klimchouk, D. C. Ford, A. N. Palmer & W. Dreybrodt (eds.) *Speleogenesis. Evolution of Karst Aquifers*. National Speleological Society, pp. 408–426, Huntsville, Alabama, U.S.A.
- Ložek, V., Sekyra, J., Kukla, J. & O. Fejfar, 1956: Výzkum Velké Jasovské jeskyně (Die Durchforschung der Grossen Jasover Höhle).- *Anthropozoikum*, 6, 197–282. (Dtsch. Zusammenfassung, 266–282).
- Mann, K., Pouba, Z. & P. Šantrůček, 1949: Nová speleologická studia v Domici (New Speleological Studies in the Domica-cavern).- *Sborník Československé společnosti zeměpisné*, 54, 2, 99–106, Praha. (Engl. summary, 105–106).
- Pasini, G., 1967: Osservazioni sui canali di volta delle grotte bolognesi.- *Le Grotte d'Italia*, 4, 1, 17–74.
- Pasini, G., 1975: Sull'importanza speleogenetica dell' „erosione antigraavitativa“.- *Le Grotte d'Italia*, 12, 4, 297–326.
- Pasini, G., 2009: A terminological matter: paragenesis, antigraavitative erosion or antigraavitational erosion?- *International Journal of Speleology*, 38, 2, 129–138.
- Pasini, G., 2012: Speleogenesis of the “Buco dei Vinchi” inactive swallow hole (Monte Croara karst sub-area, Bologna, Italy), an outstanding example of antigraavitative erosion (or “paragenesis”) in selenitic gypsum. An outline of the “post-antigraavitative erosion”.- *Acta Carsologica*, 41, 1, 15–34.

- Renault, P., 1958: Eléments de spéléomorphologie karstique.- *Annales de Spéléologie*, 13, 1–4, 23–48.
- Renault, P., 1968: Contribution à l'étude des actions mécaniques et sédimentologiques dans la spéléogénèse. Les facteurs sédimentologiques.- *Annales de Spéléologie*, 23, 3, 529–596.
- Renault, P., 1970: *La formation des cavernes*.- Presses Universitaires de France, 127 pp., Paris.
- Roth, Z., 1937: Vývoj jeskyně Domice (L'évolution des grottes de Domica).- *Bratislava*, 11, 129–163 (Res. Franç., 163 –168 paginated as 38–42).
- Roth, Z., 1940: Vývojový vztah jeskyně Baradel k jeskyni Domici v Jihošlovanském krasu (Das genetische Verhältnis der Baradla-Höhle zu der Domica-Höhle in Südslovakischen Karste).- *Věstník Královské české společnosti nauk, třída mat.-přírodověd.*, 1–9. (Dtsch. Zusammenfassung, 5–9).
- Seneš, J., 1956: Výsledky speleologického výskumu Drienovskej (Šomody) jaskyne v Slovenskom krase (Ergebnisse der speleologischen Erforschung der Höhle Drienovská jaskyňa (Šomody) im Slowakischen Karst).- *Geografický časopis*, 8, 1, 16–28. (Dtsch. Zusammenfassung, 27–28).
- Slabe, T., 1995: *Cave Rocky Relief and its Speleogenetical Significance*.- *Zbirka ZRC*, 10, SAZU, 128 pp., Ljubljana.