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Highlights of Romanian Caves and Karst

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Abstract

Romania with an area of 238,391 km2, located in Southeastern Europe, has a karstifiable area of about 5,500 km^2 (approx. 2.3%). A website, www.speologie.org, was set up to collect and centralize all cave-related data within the Romanian karst. It is an online searchable database of 8,645 identified caves with 1,042 km of surveyed passages. The web page was started by cavers and is open for community contributions. The data structure extends the systematic catalogue started by Cristian Goran in 1981. The diverse spectrum of Romanian caves is briefly presented in this paper.

Keywords: karst, caves, catalogue, recreational caving

Introduction

Romania, with an area of 238,391 km^2, is located in Southeastern Europe and is surrounded by the Black Sea and Moldova in the east, Serbia and Hungary in the west, and Ukraine in the North. The Danube (Dunărea) River forms most of the southern border with Serbia and Bulgaria.

The karstifiable rocks (limestones, dolomite, salt, gypsum) occupy about 5,500 km^2 (Onac and Cocean, 1996; Onac, 2000) of the Romanian territory (approx. 2.3%), and are Paleozoic, Mesozoic and Neogene deposits (Figure 1).

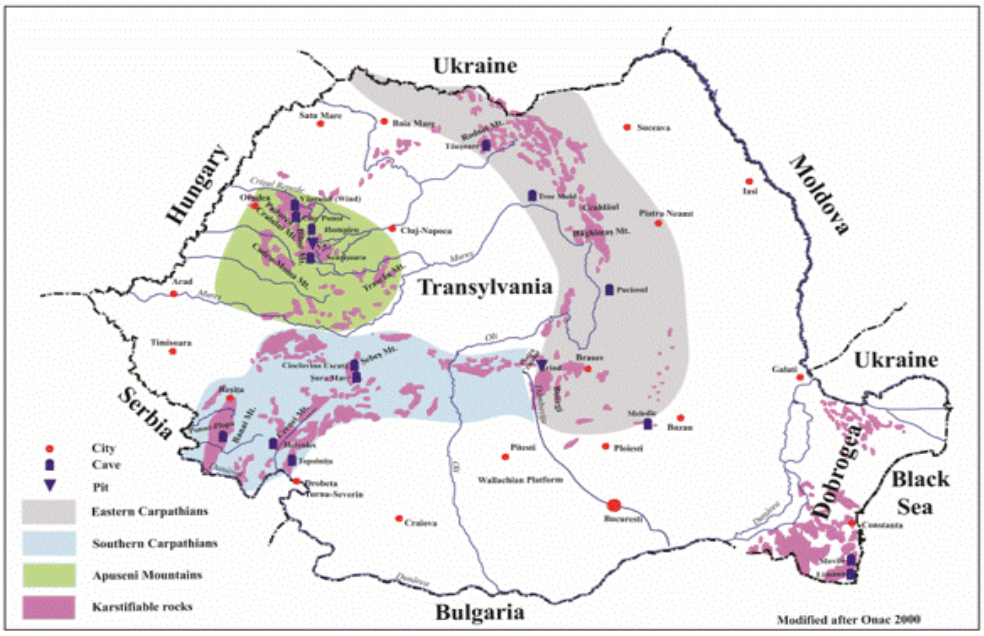

Figure 1. Karstifiable rocks of Romania (from Ponta and Ursu, 2017, with permission)

Romania has a temperate-continental climate, with four seasons, with average annual temperature ranging between 8 °C to 11 °C and precipitation between 600 mm to 1,010 mm per year. The temperature ranges from −25°C in January to 31°C in July.

The first cave explorations and scientific research in Romania date back to 1,767, when J. Fridvaldszky, in his book dedicated to the mineralogy of the Principality of Transylvania published in Cluj, mentions six caves. In 1774, A. Nedeczky published in Vienna the description of the cave at Fânaţe, followed by those published in 1778 by J. Benkő in Haarlem (Holland) and J.E. Fichtel (1780) in Nuremberg (Germany), which present the caves known until that date in Transylvania (Damm & Lascu, 2008). The nineteenth century is marked by an increase in exploratory activities driven by greater scientific interest devoted to cave exploration.

In 1836, I. Fekete published in Cluj the map of Mereşti Cave (Vârghişului Gorges), his initiative being followed by J. Wastler who in 1863 mapped Fânaţe, Scărişoara, Onceasa, Ferice and Meziad caves (Damm & Lascu, 2008). F. Posepny – one of the precursors of the hydrothermal theory in the genesis of caves in 1871 published the maps of the caves in the Băiţa Bihor area and Roediger in 1880 Igriţa's Cave map (Damm and Lascu, 2008). In 1887, G. Hazai mapped Măgura Cave and G. Téglás in 1891 published the maps of the caves in the Hunedoara region. A special mention must be given to Balázs Orbán who, in his Description of the Szekler Land (1868 – 1873) presents geological, geographical, archaeological and historical aspects related to the caves in the region. The leading work of the nineteenth century, however, is undoubtedly the study carried out by the famous Austrian geographer Adolf Schmidl: Das Bihargebirge an der Grenze von Ungarn und Siebenburgen published in 1863 in Vienna. The material presented in the book was obtained between 1858 and 1862 during a large-scale multidisciplinary expedition, organized by the Vienna Academy of Sciences in the Bihor Mountains, Pădurea Craiului and Codru Moma.

As a result of these investigations, at the end of the nineteenth century, according to the inventory made by E.A. Bielz (1884), the number of caves in Transylvania was 81. Starting at the end of the nineteenth century, the touristic interest in caves increased substantially. Czárán Gyula (1903), a wealthy lawyer in love with nature, spends almost his entire fortune on exploring and developing show caves and opening new tourist tracks in the Bihor Mountains. In 1903 the Vadu Crişului Cave was explored, and subsequently opened for tourism (Czárán, 1905).

Beginning in 1920, when the Institute of Speleology" Emil Racoviţă" (ISER) was established in Cluj-Napoca, the collection of documents and maps related to the caves of Romania started, and a depository established. Between 1920 and 1956, over 300 caves were recorded, the majority of them being documented in the ISER's publications.

Shortly after 1956, when the ISER was reorganized, with offices in Bucharest (București) and Cluj-Napoca, the recreational caving movement began, the first grottos/caving clubs began their activities in late fifties and sixties in several major cities in Romania: Cluj-Napoca, Reşiţa, București, Arad, etc. In 1965, the map of Romanian Karst Areas was published by ISER, which included about 1,000 caves (Goran, 1981).

The first Catalogue of Romanian Caves was compiled by Marcian Bleahu and Ioan Povară in 1976, and recorded about 2,000 caves, including the early discoveries of the recreational cavers. In the same year, The Central Committee of Sportive Speleology (CCSS) was formed as a subsidiary of Romanian Federation for Tourism and Alpinism, which up to 1989 was the largest organization in Romania with about 500 members and 40 to 50 grottos/caving clubs. For almost 15 years, CCSS with ISER promoted speleology, organizing short courses/camps for caving/climbing technique (SRT), cave survey, biology, and cave photography, through the National School of Speleology. The main sponsor of caving activities between 1969 and 1989 was Biroul de Turism pentru Tineret/Youth Bureau for Tourism (BTT).

CCSS had its own publication (Buletin FRTA; later becoming Buletin Speologic) and several caving clubs published new discoveries and trip reports in their bulletins and newsletters. Between 1972 and 1994, CCSS (after 1994 Romanian Federation of Speleology) organized annual conventions (Speosport), and sponsored survey camps to validate the maps of the main Romanian caves. In 1994 Speosport became the National Congress of Speleology. As a result of these activities, in 1981, The Systematic Catalogue of Romanian Caves/Catalogul Sistematic al Peşterilor din Romania (Goran, 1981) was published and included data about 6,816 caves. By 1989, the number of caves discovered and surveyed reached 12,000. Based on the Romanian Federation of Speleology's (FRS) web page (www.frspeo.ro), the number of known caves today in Romania is 12,600. The database related to these caves is hosted by ISER (official depository); a copy was at CCSS/after 1994 FRS, and the grotto/caving club who made the discovery and survey held a third one.

After 1989, the caving activity decreased due to better opportunities to travel outside Romania, and many experienced cavers abandoned the activity. Permission to access the cave database was allowed to the author/s of the discovery, or by others with his/their permission. The new generation of cavers found it difficult to get permission to view the cave-related maps and documents, and the database became obsolete and restricted.

In these circumstances, the webpage www.speologie.org, was started, where with cavers contributions, a new database was generated and made available on the web. The web page follows the same structure as the catalogue designed by Cristian Goran in 1981. The discrepancy between the 8,645 records available on the website and the approximately 12,600 caves reported by the Romanian Federation of Speleology suggests either incomplete data transfer or the presence of duplicate records.

Geology

Romania consists of four major geological areas: The Eastern Carpathians (Carpaţii Orientali), The Southern Carpathians (Carpaţii Meridionali), Apuseni Mountains, and Dobrogea. The Carpathians Mountains arcs have been shaped around an old rigid central structure in the alpine cycle.

The Eastern Carpathians with 1,062 caves are located between the Tisa River in the North and Dâmbovița River in the South and consist of numerous karstifiable rocks (limestones and dolomites of Triassic through Miocene age) scatters across this mountain range, overlaying a crystalline zone of Paleozoic and Precambrian age, and a flysch zone (Mesozoic rocks). The longest caves (e.g. Tăușoare) in Eastern Carpathians are located in the Rodnei Mountains and are developed in Eocene (Priabonian) limestones.

Miocene salt deposits located at the south end host a unique karst landscape, with sinkholes and closed depressions (Ponta, 1984-1985). Neogene volcanoes exist in the central part of the Eastern Carpathians, contain tree-mold caves, lava caverns with opal, and others formed by the underground erosion of tufa layers of cemented agglomerates (Naum & Butnariu, 1967).

Dâmbovița River in the East, the Danube River in the West, and Mureș River and Transylvania in the North, defines the Southern Carpathians with 4,131 caves. The Southern Carpathians consists of three structural units: the Danubian terrane, the Severin nape, and the Getic terrane. The Danubian and Getic terranes consist of Mesozoic rocks that overlie Paleozoic and Precambrian sedimentary and crystalline rocks (Burchfiel et al., 1974). The majority of these caves are located in Jurassic-Cretaceous limestones. One of the longest underground streams in the country (Șura Mare) (Ponta, 1991) with a large bat colony, and a cave rich in minerals (Cioclovina Uscată) (Onac, 2000) was identified in this area. Ardealite (name comes from Ardeal, another name used for Transylvania) is a phosphate mineral found in Cioclovina Uscată and described for the first time by Halla in 1931.

In the Jurassic and Cretaceous limestones of Banat, karst platforms developed, with numerous caves and potholes. In one of the caves, Peștera cu Oase/Bones Cave, one of the oldest remains of a modern human (c. 40 ka) that shows evidence of admixture with Neandertalians was found (Trinkaus et al., 2013).

Hydrothermal karst is present within the Cerna Valley in southwestern Romania (e.g. Hercules Cave) in the Jurassic and Cretaceous limestone with air temperatures as high as 40°C, due to the presence of thermal water flowing through the caves (Povară, 2012).

The Apuseni Mountains with 3,234 caves are located between Mureș River in the south and Crișul Repede River in the North. Most of the limestones are in the northern Apuseni Mountains, which consist of Mesozoic sedimentary rocks overlying Paleozoic and Precambrian sedimentary and metamorphic rocks. The longest caves in the country (Wind/Vântului, Humpleu caves, and Ciur Ponor) (Ponta et al., 1991), the second deepest pothole (V5 Pit), and biggest perennial ice cave in Romania (Scărișoara) are located in these mountains. In Humpleu Cave 80 cm long single crystals were found, and in Valea Rea Cave 37 minerals were identified. In Ciur Izbuc Cave, about 400 footprints in mud, several thousand years old, and in Vârtop Cave three footprints preserved in a calcite crust were found, dated 62 ka (Onac et al., 2005). Also, the Bears Cave (Peștera Urșilor) is known for several cave bear skeletons.

The Dobrogea area comprises a group of low mountains, where 99 caves were identified. Upper Jurassic and Barremian limestones and dolomites, Senonian chalk and Sarmatian limestones occur in this area. Here is the location of Movile cave with its groundwater ecosystem rich in hydrogen sulfide and carbon dioxide, and Limanu cave with 4,000 meters of passages formed by solutioning with several man-made enlarged passages.

Karst

The Romanian karst landscape was generated in the Quaternary and can be classified into three categories, characterized by the hydrodynamic conditions of the karst aquifers and the relationship between karst aquifer and land surface (Ponta, 1998):

1. Deep Karst type features (paleokarst) occur in the sedimentary rocks underlying non-soluble bedrock and overlain by aquicludes or aquitard deposits. These confined aquifers are typical to the Wallachian Platform. The Carbonate Deposits of Malm-Barremian Ages are 1,500 m thick and can be found at a depth ranging between 1,800 m to 2,000 m in the Wallachian Platform (Ponta, 1998).
2. Shallow Karst type features are in sedimentary rocks overlain by unconsolidated sediments. The thickness of the overburden range between 10 m to 50 m. This type of karst has the greatest extension in Dobrogea, where the overburden is formed mainly by loess (Ponta, 1998).
3. Bare/exposed karst occupies approximately 5,500 km^2 (Onac, 2000) on the Romanian territory (approx. 2.3% of the Romania's surface). The most karstified deposits belong to the Jurassic-Cretaceous sedimentary cycle. In the Southern Carpathians, the largest exposed carbonates region is Banat (800 km2) and the most karstified area is in the Bihor Mountains (Apuseni Mountains) (Bleahu & Rusu, 1965).

Recrystallized Paleozoic carbonate deposits represent about 16% of the total bare karst. The Mesozoic deposits belong to two sedimentary cycles (Triassic 17. 8% and Jurassic-Cretaceous 47.3%), and the Neogene deposits to a third cycle (Eocene, Tortonian and Sarmatian 16.8%) (Bleahu & Rusu, 1965).

Based on the geomorphological and structural aspects, there are three types of karst landscape specific to the Romania's territory:

1. Plateau type karst is characterized by large dolomite or limestone plateaus with surface karstic features like karrens (lapiés), dolines (sinkholes), closed depressions, dry valley and streams with elevation range between 600 m to 2000 m and covers areas between 20 km2 and 120 km2. The thickness of the carbonate deposits ranges between 200 m and 600 m and alternates with non-carbonate rocks. The most important plateaus are in the Bihor, Pădurea Craiului, Codru Moma, Sebeș or Banat Mountains (Bleahu, 1972).
2. Bar/Ridge type karst is ridges derived from carbonate deposits approx. 200 m thick, which dip at over 450. As in the previous case, generally the carbonate rocks alternate with non-soluble rocks. Due to the differentiated erosion processes very prominent limestones-dolomite ridges appear. The strike or these is controlled by longitudinal faults with regional extension and are cut by transverse faults, on which the karst aquifer is opened and emerges to the surface through springs. The most representatives' ridges are in the Hăghimaş, Piatra Craiului, Vânturariţa, and Trascău massifs (Bleahu & Rusu, 1965).
3. Isolated massifs are an intermediate type between the previous two, being less extended plateaus such as the Ceahlău or the Dâmbău in the Metaliferi Mountains or olistoliths on the limestones in the Piatra Mare and Bucegi Mountains (Bleahu & Rusu, 1965).

Results and Discussion

While the extension of karstifiable rocks represents only 5,500 km^2 scattered across Romania, a diverse range of caves are present:

Limestones and Dolomite caves

From the total of 8,645 caves, 97% are developed in limestones and dolomites rocks, only 3% being hosted in other rocks. The largest numbers of caves are located in Bihor Mountains (1160), which represents 13.4%, followed by Pădurea Craiului with 1059 (12.2%) and Vâlcan Mountains 813 (9.4%). The total length of surveyed passages is 1,042 km. There are 164 caves over 1 km long, 110 caves with vertical development higher than 100 m, 24 caves in salt, and 132 caves protected by law (Moldovan, 2019). The longest cave is Peștera Vântului (approx. 50 km) and the deepest one is Avenul din Colții Grindului with -815 m. 80 caves are totally submerged being accessible only by divers. The deepest sump is in Izbândiș Cave (-129 m), and the longest one is Sifonul Negru (Black Sump) in Isverna cave, almost 700 m long. In the database, elevation of the entrances is known for 4,408 caves, of which 3,697 ranges between 300 to 1200 m. The intervals with the highest number of caves (at 100 m increments) are 400-500 with 718 caves, followed by 500-600 interval, with 574 caves, and 1,100-1,200 m interval with 448 caves.

Evaporates/salt karst

The karst formed on evaporite rocks represents 5% of the Romania's bare type karst and is in the lowland hills of Eastern Carpathians. The largest zone is Săreni - Trestioara situated between Slănic Valley, Sării Valley and Meledic Valley, known under the name of Meledic plateau. The average altitude of the area is 600 m, and presents caves, deep valleys, karren and sinkholes (50 m in diameters) (Ponta, 1998).

Volcanic caves

Puciosul cave (Peștera din Muntele Puturosul) located in the central part of the Eastern Carpathians is 14 m long, with sulfur deposits on the walls as a result of hydrogen sulfide and carbon dioxide released by volcanic activity. Carbon dioxide (CO2) is heavier than air, so operating below the CO2 /air interface is fatal. Tree Mold caves are located on the upstream section of Mureș River, in the Topliţa-Deda gorges. The caves were formed when the Călimani - Gurghiu volcano was active, and its lava flew out and covered the forest, trapping trees. In time, the trees were washed away, leaving behind the tree mold/shape caves (Moreh, 2009).

Thermal Caves

Thermo-mineral karst (thermal waters) is present in the Băile Herculane, Mangalia and Geoagiu areas (Bleahu and Rusu, 1965). The largest hydrothermal karst reservoir is in Băile Herculane within the Cerna Valley, in southwestern Romania, where the longest thermal water cave, Hercules (82 m long) is traversed by a stream with temperatures as high as 28°C to 30°C.

Ice Caves

Several ice caves are known in Romania as: Focul Viu, Avenul cu Zăpadă, and Scărişoara. Scărişoara cave previously known to host a 3,000 to 5,000 years old deposit of perennial ice with a volume estimated at 100,000 cubic meters (Onac et al., 2010). Perșoiu in 2017 and 2018, determined that the ice block is over 10,000 years, exceeding 100,000 cubic meters in volume and an average thickness of 22 meters, being one of the largest known underground ice bodies worldwide and a unique paleoclimatic archive (Perșoiu et al., 2017, Perșoiu, 2018).

Mineralogy

Minerals were identified in several caves in Romania. Cioclovina Uscată and Peștera din Valea Rea Cave are characterized by remarkable mineral diversity. Ardealite (name comes from Ardeal, which is another name for Transylvania) is a phosphate mineral found in Cioclovina Uscată and described for the first time by Halla in 1931.

Sulfuric Acid/Hypogene Speleogenesis Caves

Movile Cave (Peștera Movile) is known for its groundwater ecosystem rich in hydrogen sulfide and carbon dioxide. Life in the cave is sustained by microbial mats (bacteria) on the cave walls and the surface of pools, based on chemosynthesis (Sarbu et al., 1996).

Historical and Anthropological Caves

Paintings were found in Cuciulat and Coliboaia Caves. Marin Cârciumaru estimated that the Cuciulat cave paintings were completed in the Upper Paleolithic, about 12,000 years ago (Cârciumaru & Bitiri, 1983). The oldest cave paintings in Central Europe, estimated at between 23 000 and 35 000 BP (Gravettian or Aurignacian) have been discovered by a team of Romanian speleologists in the Coliboaia Cave, Bihor Mountains (Clottes et al., 2012). In Peștera cu Oase/Bones Cave, one of the oldest remains of a modern human (c. 40 ka) that shows evidence of admixture with Neandertalians was found (Trinkaus et al., 2013). In Ciur Izbuc cave about 400 footprints in mud several thousand years old, and in Vârtop Cave three footprints preserved in a calcite crust were found.

Biospeleology

Romania is one of the best-investigated European countries for biospeleology. In 1920 Emil Racoviţă founded world's first Institute of Speleology in Cluj-Napoca. Romania has a rich cave fauna with many endemic elements. There are 31 bat species found in seven caves that are considered shelters of major importance (Coroiu, 2017). Bone remains belonging to the Upper Pleistocene cave bear (Ursus spelaeus) were found in numerous caves, as Peștera de la Vadul Crişului or The Bears Cave (Peștera Urşilor).

The longest caves in Romania

1. Peștera Vântului	50,000 m
2. Peștera Mare din Valea Firii (Sistemul Humpleu)	36,600 m
3. Sistemul Vărăşoaia (V5-V24)	30,500 m
4. Peștera din Pârâul Hodobanei	22,142 m
5. Peștera Topolnița	20,500 m
6. Sistemul Ciur Ponor-Topliţa de Roșia	20,150 m
7. Peștera din Valea Rea	16,357 m
8. Sistemul Zăpodie-Peștera Neagră	12,048 m
9. Peștera Șura Mare	11,694 m
10. Peștera Polovragi	10,350 m

The deepest caves in Romania

1. Avenul de sub Colţii Grindului	815 m
2. Sistemul Vărăşoaia (V5-V24)	690 m
3. Peștera de la Izvorul Tăuşoarelor	461 m
4. Peștera Şura Mare	425 m
5. Avenul din Dealul Secăturii	390 m
6. Peștera din Valea Rea	372 m
7. Avenul din Stanul Foncii	339 m
8. Peștera Mare din Valea Firii (Sistemul Humpleu)	314 m
9. Peștera Jgheabul lui Zalion	303 m
10. Avenul de Rezervă	300 m

The stories of these explorations are extensively presented in a book series entitled ″10,000″, the first volume being published in 2019 (Bleahu et al.2019), followed momentarily by volumes 2 and 3 (Aldica et. al, 2021; Perlik et al., 2023). A collection of scientific papers can be found in ″Caves and Karst Systems of Romania″ edited by Ponta and Onac and publish in Springer's series ″Caves and Karst Systems of the World″.

Conclusion

The Conclusion section presents the outcome of the work by interpreting the findings at a higher level of abstraction than the Discussion and by relating these findings to the motivation stated in the Introduction. Papers without conclusion won't be accepted.

Competing interests

The authors declare that they have no competing interests.

Authors' contribution

All authors provided critical feedback and helped shape the research, analysis and manuscript.

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