

A REVIEW OF KARST TERRAINS STUDIES IN ROMANIA AND BANAT MOUNTAINS AND FUTURE APPROACHES

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Abstract: *A review of karst terrains studies in Romania and Banat Mountains and future approaches.* Karst relief has been an attraction for human being, especially for what caves meant in human evolution. The aim of this paper is that to do short presentation of most important studies made in karst relief research in Romania and in Banat Mountains. Karst relief, as independently term, has its origin in the Slav word “kras” after the name the karstic plateau located between Trieste Golf, Istria Peninsula and the West part of Julian Alps. The name of “karst” is present for the first time on a map in 1585. That map was created by Mercator and published in Amsterdam. In scientific karst research, Romania has a global figure, naming here Emil G. Racoviță, the great scientist. This scientist is recongnized as the founder of Biospeleology as science, but also as the founder of the first speleological institute. This institute was founded in Cluj, in 1920. Considering that in this vast field of Romanian karstic regions research there are needed many systematic studies and analyzes, we propose that in the years to come with new results obtained by use of modern research, applied in Anina karst area of the Banat Mountains.

Rezumat: *O recenzie privind studiul reliefului carstic în România și Munții Banatului, și abordări viitoare.* Relieful carstic a atras întotdeauna omul, în special prin ceea ce au însemnat peșterile pentru evoluția umană. Scopul acestei lucrări este acela de a face o scurtă relatare a celor mai importante studii efectuate de-a lungul timpului în România și în Munții Banatului cu privire la cunoașterea reliefului carstic. Relieful carstic, ca și termen de sine stătător, își are originea în topicul slav “kras” după cum este denumit platoul calcaros situat între golful Trieste, peninsula Istria, și extremitatea vestică ale Alpilor Iulieni. Numele de “karst” apare pentru prima dată pe o hartă în 1585, aparținând lui Mercator și fiind publicată la Amsterdam. În peisajul științific al cercetării carstului, România are la nivel mondial una dintre cele mai mari personalități, numind aici pe marele om de știință Emil G. Racoviță. Aceste este recunoscut ca fiind cel care a întemeiat biospeologia ca știință, dar și ca fondator al primului institut speologic din lume, pe care l-a înființat la Cluj, în anul 1920. Considerând că în vastul



domeniu al cercetării regiunilor carstice românești mai este loc de numeroase studii și analize sistematice, ne propunem ca în următorii ani să venim cu noi rezultate obținute prin utilizarea mijloacelor moderne de cercetare, aplicate în carstul din zona carstică Anina, din cadrul Munților Banatului.

Key words: karst study, limestone, caves, Anina, Romania

Cuvinte cheie: studiul carstului, calcar, peșteri, Anina, România

1. INTRODUCTION

Karst topography is regions very complex and interesting from geologic, geomorphologic and hydrologic perspectives due to limestone, the rock that permits water to build two subtypes of landforms, the surface landforms and the underground landforms. These two subtypes of landforms have a high interdependence which makes difficult to study these karstic areas, but also the obtained results are very interesting sometimes. The aim of this paper is to present an overview of the most important researches in the field of karst terrains in Romania and in Banat Mountains, with emphasis on the Anina Mining Area.

First it is presented the origin of “karst” term. Second it provides a short history of karst terrains research in Romania and the next section is a summary for karst studies in Banat and Anina Mining Area. After that is presented on overview for karst studies in Romania. Finally, this paper discuss about some perspectives of future karst research in Romania, especially in Anina Mining Area and the also the limits of karst studies in Romania. Karst relief, as independently term, has its origin in the Slav word “kras” after the name the karstic plateau located between Trieste Golf, Istria Peninsula and the West part of Julian Alps. The name of “karst” appears for the first time on a map in 1585. This map was made by Mercator and it was published in Amsterdam. The name of this map was *Karstia, Carniola, Histria et Windorum Marchia* (figure 1).

First the geomorphologists used the term of “karst” for the dissolution processes in pure limestone, to describe the landforms resulted from these processes at surface and underground (Sharma, 2010).

The importance of karst dissolution by water from rain was recognized by James Hutton since 1795 and the first quantitative research in karst dissolution started at the beginning of 19th century. Gams (2003; quated by Ford & Williams) mentions that at the end of 19th century and at the beginning of 20th century appeared a division as a consequence of karst study in the following branches almost separate, naming here geomorphology and hydrogeology (Ford & Williams, 2011).

The person who gave a scientific layout for the field of karstology was Jovan Cvijic (1865 –1927). As Geography professor at the University of Belgrade, he started his studies of limestone areas in 1888 in Serbia. He continued his studies in Slovenia, Croatia and Montenegro. After he published some results of his studies, Cvijic published in 1893 the first synthesis regarding karst terrains called *Das Karstphänomen*. This paper may be considered as the birth work of a new scientific field, *karstology*. Limestone is the unique rock for which was named one type of relief, and for this rock were born two scientific disciplines: *karstology* and *speleology* (Bleahu, 1982)



Figure 1: Mercator's Map (Amsterdam, 1585) called "Karstia, Carniola, Histria et Windorum Marchia"

(Source: <http://www.wildernis.eu/chart-room>)

Karstology is the discipline which studies the relief formed on soluble rocks, naming here limestone and dolomite. The main agent which is modelling the landforms studied by this science is dissolution. Karstology is studying both exokarstic and endokarstic landforms. **Speleology** is the science that is studying all natural underground cavities. The term of 'speleology' was formed at the beginning of the 20th century from two words of Greek origin, and the meaning of joining these words to be "word about caves" or "the science of underground voids" (Racoviță, 1963).

2. BACKGROUND: KARST TERRAINS RESEARCH IN ROMANIA

In the karst terrains scientific studies, Romania has one of the world's greatest personalities, naming here the scientist Emil G. Racoviță. Starting from the period when Emil G. Racoviță has founded the first speleological institute in Cluj-Napoca (1920), in Romania has started the "boom" of cave discovers and exploring.

Due to the large areas covered by karst relief Romania is an active country in the field of karst research activities. These research studies are developed mainly by the public

institutions, funded by the Romanian budget. As example we can mention “Emil Racoviță” Speleological Institute or Romanian Geological Institute (Gilkes et. al, 2007).

Ilie (1970) said that research *of karst processes and landforms in Romania has great traditions*, and these studies cover many aspects such as foundation of geomorphology as a science with contributions from authors as Gr. Cobălceanu, Gh.M.Murgoci, E.G. Racoviță, G.N. Ionescu, Emm. de Martonne, I. Moisil, but also works with descriptive approach realized by true writers as Al. Vlahuță, Calistrat Hogaș, A. Pann, M. Sadoveanu.

The period starting from 1920 when Racoviță was professor at the University of Cluj meant the beginning of an extremely favorable karst research in Romania by numerous scientific research: exploring new caves, research living conditions of many creatures cave, studing systematic development of karst forms, presentation of research findings in Romanian caves and karst science through national and international publications in scientific meetings and forums (Ilie, 1970).

A significant contribution to knowledge, explain and popularize karst in Romania brought the geologist Marcian Bleahu. It examines in particular the Apuseni Mountains and South-West of Romania. Other authors having karst terrains as the main field of study were V.Sencu, who mainly studied karst in Banat Mountains, V.Trufaș who especially studied karst in the North and West of Sebeș Mountains and Șureanu Mountains. Following studies and synthesis papers appear, overview of karst, works of the following authors: M. Bleahu-T. Rusu (1965), Ilie I. (1966 and 1970), V. Sencu (1968). Another novelty is given by combining theoretical and applied exploration of karst areas. In this way appear legends of karst forms submitted by M. Bleahu, T. Rusu, V. Trufaș, V. Sencu. Also start researching to harness water limestone karst and other resources, and promotion of nature protection and karst forms. As shown karst studies begins with a close connection with the practical applicability of studies on karst topography and its specific forms.

Area occupied by limestone in Romania is about 4500 km² (**figure 2**), but, despite being a small percentage of the rocks in Romania, *it is a karst rich and varied, with many caves* (Orghidan et al., 1984).

If on karst research generally works mainly occurred in the 20th century, research in caves is much older, even having *an outstanding tradition* (Bleahu et. al, 1976). First caves appeared in world geographical and speleological literatures were those of Transylvania, which is mentioned in the early of 18th century and were made by J. Fridvalsky in *Mineralogy magni Principatus Transsilvaniae*, published in Cluj in 1767. There are made the first descriptions of a number of caves; some are just mentioned, these caves are Cave from Porcești, Cave from Runc, Cave from Pasul Vulcan, Cave from Merești. Also in this book is mentioned for the first time a cave in Muntenia, Dâmbovicioara Cave (Bleahu et. al, 1976).The year of 1788 is a memorable one because it is one of the first plans published cave in the world, a plan that was published for Veterani Cave, located in the Danube Gorge (**figure 3**). This plan was a strategic goal since the cave was a hardened and plays an important role for Austria in fighting against Turkey (Bleahu et. al, 1976).

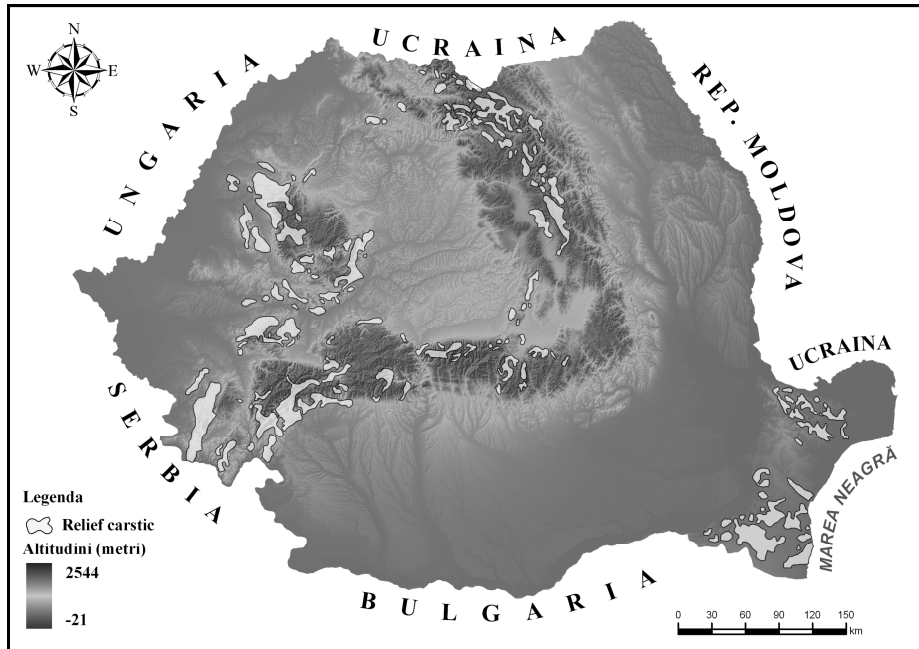


Figure 2: Surfaces occupied by karstic areas in Romania (modified after Bleahu, 1976)

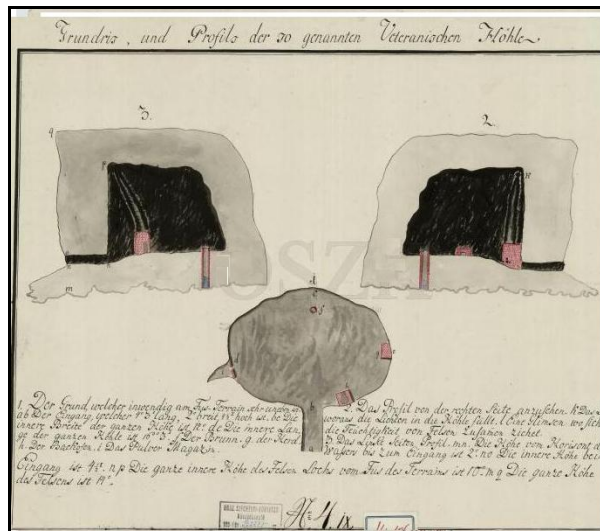


Figure 3: Veterani Cave. Plan and cross section, 1788 (Széchenyi National Library, Budapest)

(Source: <http://asztrorege.blogspot.ro/2010/07/pestera-lui-veterani.html>)

The knowledge of caves in another historical region of Romania, namely the Romanian Principalities is about the same length as in Transylvania. For this region there are many legends about the caves. For example the Bat Cave from Bistrita Monastery is mentioned in 1633, and in 1793, is described a very old chapel from Ialomita Cave by I. Kleinlauf. In Oltenia, in 1894 was described Muierii Cave from Baia de Fier by Al. Ștefulescu (Bleahu et. al, 1976).

The first monograph of some caves occurs in the late of 19th century. Fr. Kraus, during 1885-1886 wrote a monograph of the Great Cave at Merești (Alma Cave), containing a detailed plan. The first monograph of a cave, written in Romanian language in 1897 belongs to V. Popovici-Hațeg and I. Singiorzan. Presented in this monograph is a detailed plan of that cave. Also, during this period of the late 19th century appears tourism in the underground. Visiting caves is due to the promotion of these new discoveries in the field of natural beauty. Among the numerous caves that have attracted visitors were Dâmbovicioara Cave, Polovragi Cave. Even if these caves were undeveloped from the visitor's facilities perspectives, were often visited, *as shown in the travel notes of different visitors* (Bleahu et. al, 1976).

After the 1st World War, speleological research on Romanian territory will move from sporadic, random and disorganized research, to systematic research, based on a predetermined plan and specific goals. This change of view and attitude in speleological research is based on the establishment of the Institute of Speleology in Cluj; this institute is the oldest scientific institute of fundamental research in Romania. "Founder" of this institution is the great naturalist Emil G. Racoviță (**figure 4**), who won worldwide renown through his dedicated work life in Antarctica, made after the return from the expedition "Belgica", in which he took part as a naturalist (1897 -1899), due to the study of oceanographic fauna performed as a subdirectory of Arago Laboratory in Banyuls-sur-Mer (1900-1920), and as the founder of biospeology as science, in 1907.

On 26th April 1920, King Ferdinand enacted the *Law regarding the creation of an Institute of Speleology at the University of Cluj*, and this action meant that Romanian caving moved from sporadic actions to the systematic ones (Racoviță, 1999).



Figure 4: Emil G. Racoviță (1868-1947)

(Source: <http://www.iser-cluj.org/ISER/History.html>)

On the organization of this institute caving, Racoviță George (1999) states that this institution was born *in an atmosphere of wide and deep spiritual refreshment, being founded on very solid legal basis, even unique in its own way as any other Romanian scientific establishment not benefited by then so thoroughly regulated status* (Racoviță, 1999).

The World War II seriously disrupts the work of the Institute, and after the war its creator, Emil G. Racoviță dies. Speleological research activity persists and it is continued by young people who grew up with the great naturalist. From this team we may mention M. Șerban, D. Coman, I. Viehmann and M. Bleahu who studied Apuseni Mountains.

After 1956, the Institute of Speleology is reorganized by C. Motaș, and in Cluj remains only a section of the Institute. With this reorganization, speleological activities are increasing and bring new areas investigated from speleological point of view: in Banat and Poiana Rusca activated a team formed of L. Botoșăneanu, Alexandrina Negrea and Ștefan Negrea. In Oltenia worked a team formed by Decu V. and M. Bleahu, in the Cerna Valley worked Dance D., E. Șerban, I. Tabacaru, Ștefania Avram and Ilinca Juvara-Bals and in Pădurea Craiului Mountains worked a team with I. Viehmann, Th. Rusu and C. Pleșa as members (Bleahu et. al, 1976).

Contemporary period comes with publications of the Institute of Speleology "Emil Racovița", for example *Theoretical and Applied Karstology* where are published several papers on karst topography in Romania and not only. Among authors we may mention: Alexandru Bulgăr, Diaconu, V., Oancea, V. (1984), who performed work on modern research methods to karst topography, with applications in some karst systems in Carpathians; Adrian Iurkiewicz, Mariana Voica, Alexandru Bulgăr (1996) in a paper on karst system of Izvarna; Iancu Orășeanu (1996) with a thesis on the hydrogeology of karst areas in Bihor-Vlădeasa Mountains; Bogdan-Petroniu Onac, Stein-Erik Lauritzen (1996) in a paper on climate information retrieval using speleothems.

Other works on karst in Romania belong to Onac et. al (2009) with an article on the topic of the relationship between mineral and thermal water cave of the Cerna Valley; Perșoiu et. al (2011) conducted a study on the relationship between air temperature and changes in glacier mass in Scărișoara Cave; Kayleigh et. al (2007) published as a results of the field applications in some of the most interesting and beautiful caves in Romania a brief overview of karst landscape in Romania; Onac, Pedersen and Tysseland (1997) conducted a study on the presence of rare elements that are covering a part of the sands in Wind Cave.

Another karst region studied is the Piule-Iorgovanu Mountains, research conducted in several publications and a doctoral thesis by Mircea Ardelean. He presents a detailed study of this area, introducing karst topography studies of geophysical methods and data processing techniques of Geographic Information Systems.

After the year 2000 comes to the attention of Romanian karst researchers the need to address the issue of protection of karst areas. Such works appear in publications of the Institute of Speleology "Emil Racoviță" and their topic is, for example, on karst groundwater vulnerability having authors as Vlaicu M. and Muntean C.M. (2008).

3. CONTRIBUTIONS OF STUDIES IN BANAT KARST AREA AND ANINA MINING AREA

The karst terrains from Banat Mountains belong to Locvei Mountains, Almăj Mountains, and Anina Mountains. In the Banat Mountains we meet the most compact area of carbonate rocks in Romania, known as Reșița - Moldova Nouă Synclinorium (Orășeanu, Iurkiewicz, 2010). On the geology aspect of a part of this synclinorium, namely the median part, a study was developed by Vasile Mutihac (1959); this study is detailed one for the geological central compartment of Reșița - Moldova Nouă Synclinorium. Later, Mateescu (1961) conducted a study with the aim to reveal the connection between geology and geomorphology in the area of Anina Mountains, called in that period Caraș Mountains. Another study was made by Răileanu et. al (1964) and the goal of this study was to present the sedimentary rocks from Mesozoic and Paleozoic in the South-West of the Getic Nappe in the Southern Carpathians.

A recent detailed paper on the geology of Reșița - Moldova Nouă Synclinorium is developed by Ioan I. Bucur (1997), a work in which all the geological formations of this Synclinorium are presented. His work is based on previous studies, mentioned in the above paragraph. Scientific studies regarding Banat Mountains karst have been made by Botoșăneanu, Ștefan Negrea, Alexandrina Negrea, Vasile Sencu. These studies involved mainly underground cavities, but Vasile Sencu was dedicated to the survey of karst water. All these researchers have published in their papers many touristic information, which showed enormous tourism potential offered by Banat karst areas.

Among the above mentioned works and other contemporary authors of the period include: Negrea et. al (1965) with a work on the caves explored with Banat Mountains in 1963; Botea Francisc and Botoșăneanu Lazăr (1966) with a thesis on the elements of the fauna of caves in Banat; Negrea et. al (1967) published a paper on the subject of fossils of mammals from caves in Banat Mountains; then Orghidan (1972) provide an overview of the activities carried out under the auspices of the Institute of Speleology "Emil Racoviță"; more recent Greece and Vilceanu (2012) conducted a paper on geomatic use as a solution for environmental management, with the case study Semenice - Caras Gorge National Park; Eugene Nitzu, Ionuț Popa and Andrei Giurgincă (2011) published a paper on the invertebrate fauna of karst areas Anina Mountains and Locvei Mountains. Among the authors who have seen karst topography of Banat region through the eyes of tourists, Lazăr Botoșăneanu and Ștefan Negrea said: *karst landscape is responsible for several features of the Banat mountains, especially limestone, it immediately strikes traveler, as the researcher* (Botoșăneanu, Negrea, 1968).

One of the main karst units of Banat Mountains is represented by Anina Mountains and the main researcher of karst these mountains was Vasile Sencu. As a result of many studies in the field, Sencu has written numerous papers on karst terrains in Anina Mountains, and he stated that these mountains *have characteristic morphological features, as a result of their geological composition* and due to the fact that the predominant rock is limestone the relief consists of *ridges, parallel valleys and vast plateaus limestone, "riddled" of sinkholes* (Sencu, 1978). Vasile Sencu has taken a lot of exploration, mapping, hydrogeological studies, reaching also touristic approaches for this area. Sencu's study was focused heavily on Anina mining area, which he called "Anina Mining Field" or "Anina Mining Basin". One

of his publications concern even included in karst mining field of Anina (1977). But, before making a presentation of limestone area around the town of Anina, Sencu published other works in which he detailed parts of this "mine field area", works on the caves located in the basins of Buhui and Anina rivers (1963); then he published a paper regarding the caves located in the basins of Steierdorf and Ponor streams (1964). It also performs the Karst Map of Anina Mining Field (1977). This map shows that carbonate rocks are predominant in this area and there are many conditions for future studies in this region where after the 1990s geomorphological research is almost missing.

The same Vasile Sencu propose various studies on karst in Banat Mountains area such as a work of sinkholes in karst valleys Banat Mountains (1970); another material presents research results of chemical erosion in Anina Mountains (Sencu, 1986) and a study of karst denudation in the river basin of Caraș (Sencu, 1990). Other works on karst area Anina unfortunately remained unpublished in the form of manuscripts. These works belongs to Vasile Sencu and Dragos Buga, the two having an unpublished paper on geography of Anina area, and also of Anescu Dumitru, who produced a report on the geology of the area Anina as mine geologist. Some others papers on karst regions of Banat appear in *Theoretical and Applied Karstology* under the auspices of the Institute of Speleology "Emil Racoviță". Thus, Adrian Iurkiewicz, Gigi Dragomir, Aurel Rotaru, Bogdan Bădescu (1996) published a paper on karst systems in the Banat Mountains, specifically in the Reșia-Nera region, a work showing hydrogeological studies in Caraș Basin, Miniș Basin and Lăpușnicul Mare Basin. Also Iurkiewicz Adrian, Bogdan Bădescu, Elisabeta Marinică (1996) published another paper on karst processes intensity as a function of carbonate formations in the northern part of Reșia-Moldova Nouă Synclinorium, work which details information on karstification indices and statistics of the karst phenomenon.

Recently, in the literature on the study of karst landscape in Romania have appeared studies regarding karst vulnerability and these studies also refer to Banat Mountains. Such works have appeared under the auspices of the Institute of Speleology "Emil Racoviță" having as research topic the karst management in the northern region of Caraș Gorge, with authors such as Cristian-Mihai Munteanu, Vlaicu Marius, Constantin Marin and Alin Tudorache (2010).

5. DISCUSSIONS AND PERSPECTIVES

Karst landscape has always attracted man, especially through what they meant caves in human evolution. First, people have found a refuge in caves, the first "roof over their head". With the evolution and emergence of communities, caves have remained extremely interesting to human. Caves were used as space for hiding in times of wars and persecutions, and in modern times have these natural features become points of extremely frequently visited attractions.

Karst research in Romania appeared after the appearance of the first research institutes and universities. It is true that the first references to some caves are older, but they had a less scientific purpose. Studies of Romanian karst practically starts somewhere in 1890, when it starts the first systematic research of karst areas. It may be noted that most studies in the past refer to endokarst, and less to exokarst. In Romania, after the year of 2000 began studies of karst aquifers and pollution, studies regarding dating based of cave signs.

Recently were discovered the oldest human traces in a cave in Anina Mountains. Also began studies that analyze the impact of tourism in some caves. Other studies are regarding cave fauna and their distribution. Some studies related to karst that were made in Romania, even in the Banat Mountains refers to the study of karst vulnerability. In future studies we consider necessary to include karst terrain studies regarding general infrastructure development and analyzes of carbonate rocks, analysis of urban activities on karst environment. Also we consider extremely important in future work to develop integrated management of karst areas, changing management plans of protected areas or administrative unit to management plans of some karst areas taken as a whole, from geomorphological perspective.

Although Romania has some special elements in regional and continental karst topography, unfortunately attention to these karst regions is insufficient in our opinion. Karst areas may represent areas with high economic potential that can increase the level of local communities that can move from ignorance and lack of seriousness of environmental pollution in karst ecological recovery based on the principles of sustainable development. But to get there must be involvement of researchers, authorities and institutions that are managing elements of karst topography, especially involvement in development processes of karst environment protection of the inhabitants of these regions.

In our opinion the study of karst landscape in Romania and Anina area can offer many interesting results to be exploited later. We think that environmental research in Romanian karst is far from reaching its peak. A more depth and systematic analysis can bring Romanian as an important member in karst research at regional, European and, why not, even globally. I believe that Romania and Romanian researchers could better harness the "testament" left by Emil G. Racoviță and those who helped him during that period. We believe that the reputation of this great scientist was not valued as it should have.

Future geomorphological studies that will be developed in the Anina Mining Field may be the fundamental study from which to start the decision making plans for these regions, regarding karst management, karst vulnerability, touristic strategies, infrastructure development and development directions. We hope that in the next 3-4 years we may come with new ideas and new proposals regarding karst areas development strategies, based on the geomorphological studies connected with geological previous works which represents our starting point in future approaches.

Summarizing, the works presented above, we can say that research karst landscape in Romania has existed for just over 100 years, but the first mentions on various karst regions are much older, dating back over 250 years. Some particulars of elements of Romanian karst represented worldwide premieres, such as for example one of the first plans cave in the world and the first institute in the world caving. Considering that, we believe that in the vast field of Romanian research in karst regions there are many systematic studies and analyzes that we should conduct. We propose that in the next years, based on field research and laboratory work we may bring new results obtained by use of modern research such as GIS techniques and geophysical methods, applied in the karst area of Anina Mining Field.

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