
Theoretical and Applied Karstology Symposium

*** Program – Abstracts ***

Simpozionul de Carstologie Teoretica si Aplicata

*** Program – Rezumate ***

Symposium de Karstologie Théorique et Appliquée

*** Programme – Résumés ***

XVIII

Băile Herculane — Romania
May 24–28, 2002

The XVIIIth International Symposium on Theoretical and Applied Karstology

Baile Herculane — Romania

May 24–28, 2002

Organized by:

The “Emil Racoviță” Institute of Speleology

and

The Romanian Society for Speleology and Karstology

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The Romanian Academy

The International Geographical Union

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SCHEDULE / PROGRAM

24.05.2002

Opening of the Symposium/Deschiderea simpozionului

9.30–10.30 Opening addresses / *Alocuțiuni de deschidere*

10.30–11.30 Welcome cocktail

11.30–13.00 Scientific sesion # 1/ *Sesiunea științifică nr. 1*

Moderator: dr. Costin RĂDULESCU

John GUNN (Great Britain)

Progress in cave and karst conservation (*keynote speech*).
Progrese în conservarea peșterilor și carstului.

Viorel HOROI (Romania)

A new approach on the relationship between limestone petrography and dissolution (*keynote speech*).
O abordare nouă a raportului dintre petrografie și procesul de disoluție a calcarelor.

15.00–17.00 Scientific session # 2/ *Sesiunea științifică nr. 2*

Moderators: dr. Bogdan ONAC
dr. John GUNN

Ioan POVARA (Romania)

A multi-tracing experiment in boreholes from pseudo-karst deposits: the loess from the area of SIDEX Galați, Romania.
Experiment multi-trasor în foraje din depozite pseudocarstice: loess-urile din zona SIDEX Galați.

Haji KARIMI, Siamak Mahmoudi SIVAND, & Ezzat RAEISI (Iran)

Determination of the catchment area of karstic Alvand aquifers, Iran.

Determinarea bazinului de alimentare al acviferelor carstice din zona Alvand, Iran.

Aurel ROTARU (Romania)

Hydrodynamic behavior assessment of the Motru Sec – Baia de Arama karst system and its implications on the tectonic and structural model.

Evaluarea comportamentului hidrodynamic al sistemului carstic Motru Sec – Baia de Aramă și implicații asupra modelului tecto-structural.

Mahmood Sadeghi BOJD & Farid MOORE (Iran)

Application of Fry analysis in the spatial distribution of thermal karst springs, South of Iran.

Aplicații ale analizei Fry asupra distribuției spațiale a izvoarelor termale carstice din sudul Iranului.

17.00–17.30 Coffee break / *Pauză*

17.30–19.00 Scientific sesion # 3/ Sesiunea științifică nr. 3

**Costin RĂDULESCU & Alexandru PETCULESCU
(Romania)**

Comparative studies on Pleistocene small mammal associations from karst deposits of Central Dobrogea and Oltenia, Romania.

Studii comparative asupra asociațiilor Pleistocene de mamifere mici din depozite carstice din Dobrogea Centrală și Oltenia.

**Margarita ERBAJEVA, Fedora KHENZYKHENOVA, &
Nadja ALEXEEVA (Russia)**

Small mammalian faunas from the caves of the Lake Baikal region.

Fauna de mamifere mici din peșteri din zona lacului Baikal.

Emil STIUCA & Răzvan ARGHIR (Romania)

The representatives of *Martes* genus in the Würm of Romania.

Reprezentanții genului Martes în Würmul din Romania.

Elena V. TROFIMOVA (Russia)

L'humidité de condensation dans les grottes de la région d'Olkhon (la côte occidentale du lac de Baïkal, Russie).

Umiditatea de condensare în peșterile din regiunea Olkhon (malul vestic al lacului Baikal, Rusia).

20.30–22.30 Slide & video shows / Proiecții dia și video

Colin BUNCE & John SWEENEY (Ireland)

Evolution of landforms and caves of the Burren, Ireland (slide show).

Siamak Mahmoudi SIVAND (Iran)

Kathale-Khore Cave, Iran (video tape).

Elena TROFIMOVA (Russia)

The Argarakan Cave (Irkutsk, Russia) (video tape)

25.05.2002

09.30–11.00 Scientific sesion # 4/ Sesiunea științifică nr. 4

Moderators: dr. Cristian GORAN
dr. Andrzej TYC

John GUNN (Great Britain)

Comparative hydrogeology and geochemistry of two potable water springs at Buxton, England.

Hidrogeologia și geochimia comparată a două izvoare de apă potabilă din Buxton, Anglia.

Augustin ȚENU, Florin DAVIDESCU, Răzvan PETRE^a & Lăcrămioara COARNĂ (ROMANIA)

Long-term survey of the karstic system in South Dobrogea (Romania) by environmental isotopes.

Observații pe termen lung asupra sistemului carstic din Dobrogea de sud pe baza izotopilor de mediu.

Irina TUDOSE & Răzvan ARGHIR (Romania)

Therapeutics efficacy of the microclimate from salt mine and caves – a case study from Praid Salt Mine (Romania).

Eficiența terapeutică a microclimatului din saline și peșteri — studiu de caz al salinei Praid.

Kyung Sik WOO, D. W. CHOI, R. KIM (S. Korea)

Geological investigation of the speleothems in limestone caves, Korea.

Cercetări geologice asupra speleotemelor din peșteri din Coreea.

11.00–11.30 Coffee break / Pauză

11.30–13.00 Scientific sesion # 5/ Sesiunea științifică nr. 5

Bogdan P. ONAC & Paul DAMM (Romania)

Mineralogy of skarn-hosted caves at Bâița (Bihor county, Romania): implications for speleogenesis.

Mineralogia pe țiterilor dezvoltate în skarne de la Bâița (jud. Bihor): implicații speogenetice.

Bogdan P. ONAC & Daniel VERE^a (Romania)

Mineralogy of Rastoci Cave (Someș Plateau, Romania).

Mineralogia Pe țterii Râstoci (Podișul Someșan).

Cristian PANAIOTU, Emilia-Cristina PANAIOTU & Silviu CONSTANTIN (Romania)

Paleomagnetism and rock magnetic properties of a flowstone core from Cloșani Cave (Mehedinți Mountains, Romania).

Paleomagnetism și proprietăți magnetice ale unei carote de planșeu stalgmitic din Pe țtera Cloșani (Munții Mehedinți).

15.00–16.30 Scientific sesion # 6/ Sesiunea științifică nr. 6

Moderators: dr. Andrej KRANJC
dr. Viorel HOROI

Jelena CALIC-LJUBOJEVIC & Vladimir LJUBOJEVIC (Yugoslavia)

Karst of the ridge Dzevrinska Greda — caves, fluvial influences, groundwater circulation.

Carstul din zona crestei Dzevrinska Greda — pe țteri, influențe fluviale, circulație subterană.

Loredana BĂRBU^a (Romania)

Evolutional aspects of the karstic valleys from Padiș–Cetățile Ponorului plateau (Bihor Massif, Romania).

Aspecte evolutive privind evoluția văilor carstice din platoul Padiș-Cetățile Ponorului (Munții Bihor).

Mircea ARDELEAN (Romania)

Some considerations on the glacial aspects in Piule-Iorgovanu Mountains (Romania).

Considerații asupra reliefului glaciar din Muntele Piule-Iorgovanu.

Heinz Charles KOHLER & Joachim KARFUNKEL (Brazil)

The Quaternary morphogenesis of Lagoa Santa tropical karst, Minas Gerais State, South-Eastern Brazil.

Morfogeneza cuaternară a carstului tropical din Lagoa Santa, Minas Gerais, sud-estul Braziliei.

17.00–17.30 Coffee break / *Pauză*

17.00–19.00 Scientific session # 7 / *Sesiunea științifică nr. 7*

Ilona BÁRÁNY-KEVEI & Edit HOYK (Hungary)

Morphometrical parameters of Hungarian dolines.

Parametrii morfometrice ai dolinelor din Ungaria.

Andrzej TYC (Poland)

Contribution to karst evolution in the area of Cracow-Wielun Upland (South Poland).

Evoluția carstului din zona Cracovia-Wielun, sudul Poloniei.

Călin GHEMIS (Romania)

Archaeological reseraches in Ungurul Mare and Mișid caves (Pădurea Craiului Mountains, Romania).

Cercetări arheologice în peșterile Ungurul Mare și Mișidului (Munții Pădurea Craiului).

Iosif VIEHMANN (Romania)

Man and cave environment.

Omul și mediul de cavernă.

20.30–22.30 Slide shows / *Proiecții dia*

Iosif VIEHMANN (Romania)

Man and cave environment.

Andrzej TYC (Polonia)

Karst of the Irkutsk Platform and Baikal region.

John GUNN (UK)

Aragonite caves in the South of France.

26.05.2002

09.30–11.00 Scientific sesion # 8/ *Sesiunea științifică nr. 8*

Moderators: dr. Heinz Charles KOHLER
dr. Iosif VIEHMANN

Marco MENICHETTI (Italy)

Speleogenesis of the Frasassi karst system in Central Italy.
Speleogeneza sistemului carstic Frassasi (Italia centrală).

Ioana FEIER (Romania) & Marco MENICHETTI (Italy)

Environmental aspects of the Grotta Grande del Vento
(Frasassi Gorge - Central Italy).
*Aspecte microclimatice în Grota Grande del Vento (Frassasi,
Italia centrală).*

Andrej KRANJC (Slovenia)

The history of karst resources exploitation — an example of
iron industry in Slovenia.
*Istoricul exploatării resurselor din carst — exemplul industriei
extractive din Slovenia.*

11.00–11.30 Coffee break / *Pauză*

11.30–13.00 The annual meeting of the IGU Karst Comission /
*Sedința anuală a comisiei de carst a Uniunii Internaționale de
Geografie.*

15.00–16.00 Poster session/ *Sesiunede prezentări poster*

Evelyne CREGUT-BONNOURE, Alain ARGANT, Jacqueline ARGANT, Daniel BILLIOU, Hervé BOCHERENS, Evelyne DEBARD, Bernadette DONAT-AYACHE, Philippe FOSSE, Catherine HÄNNI, Frédéric LAUDET, Cécile MOURER-CHAUVIRE, Christine OBERLIN, Ludovic ORLANDO, Michel PHILIPPE, & Michel THINON (France)

Les avens pièges du Mont Ventoux (Vaucluse, France): découverte de la plus grande accumulation européenne de restes d'ours brun (*Ursus arctos* L.) et données sur l'environnement holocène en milieu d'altitude.

Avenele-capcană din Mont Ventoux (Vaucluse, Franța): descoperirea celei mai mari acumulări europene de resturi de urs brun (Ursus arctos L.) și noi date asupra mediului de altitudine în Holocen.

Tudor TÂMĂ^a (Romania)

New data on the mineralogy of Iza cave (Rodnei Mts, Romania).
Date noi asupra mineralogiei peșterii Iza (Munții Rodnei).

Ognjen BONACCI & Slobodan SESTANOVOIC (Croatia)

Catchment of the Dinaric Karst River Cetina.

Bazinul de recepție al râului Cetina, din carstul dinaric.

16.30–19.00 Field trip to the karst springs in Băile Herculane and the Cerna Valley.

Excursie la izvoarele carstice din stațiunea Băile Herculane și de pe Valea Cernei.



ABSTRACTS / REZUMATE

A new approach on the relationship between petrography and dissolution

Viorel HOROI

“Emil Racoviță” Institute of speleology, Bucharest, Romania

Limestone dissolution is absolutely necessary for the development of karst features. The role of the petrography during this process is not obvious all the time. We can control all the parameters during a dissolution experiment, based on the theoretical models developed so far. The only parameter that we cannot quantify is the rock fabric. In this paper we propose a new method to quantify the limestone petrography. The measured variables were used in comparison with the results of a dissolution experiment in order to identify the influence of the rock petrography in the dissolution process.

We begin by briefly reviewing some of the important results obtained in this field. Generally, these works can be divided in two categories. The first one includes the physico-chemical approaches that intend to identify the physico-chemical factors acting in the dissolution process, their importance and the laws guiding the process. Generally, the results of the dissolution experiments are confronted with the predictions of a theoretical model.

In this model, the influence of the petrography on the dissolution process seems to be insignificant. The sole parameter that can play a role is the rock surface area exposed to dissolution, when the ratio V/A controls the process kinetics

and the conversion of CO_2 from atmosphere into solution became a limiting factor.

When the kinetics of the dissolution process is controlled by the reactions at the interface rock-solution (that means, a turbulent flow regime and a sufficiently large V/A ratio), the dissolution rate can be described by two empiric formulas:

$$F = k_{n_1} (1 - c/c_{eq})^{n_1} \quad \text{for} \quad c < c_{sw} \quad \text{and}$$

$$F = k_{n_2} (1 - c/c_{eq})^{n_2} \quad \text{for} \quad c \geq c_{sw}$$

Above a concentration $c_{sw} \sim 0,8 c_{eq}$, the kinetics of the process change from a non-linear law with $n_1 \sim 2$ to a law of superior order with $n_2 \sim 4$ (DREYBRODT, 1997). A more subtle influence of the rock petrography can consist in the variations of the n_1 and n_2 . For the 16 marbles and 19 limestones analyzed, SVENSSON & DREYBRODT (1992) obtained values in the range 1.2–2.5 for n_1 and, in the range 2.5–4.9 for n_2 , respectively.

The second group of studies of interest, come from the field of karst geomorphology. Measurements of karst denudation, by means of tablets or micrometer method, yield valuable information on how the different types of limestones respond to the action of external factors. In this respect, we can outline the following conclusion: (a) in nature, limestone dissolution is associated with a segregation process, the micritic fabrics being more easily attacked than the sparitic ones, and (b) a heterogeneous petrography favors the alteration process.

In the relationship between the rock petrography and the dissolution process we may distinguish a quantifiable variable – the dissolution, and a nominative one – the petrography. In order to make a comparison and to define more explicitly this relationship, we will try to quantify the nominative variable.

If we will consider the limestone as a monomineral rock, the different varieties of the limestone derive from the micrite/sparite ratio and the spatial distribution of these elements. Their optical properties make possible the recognition of the rock petrography on greyscale images or photographs.

He have used two types of images: one obtained directly on thin sections (real surface — 1 cm^2) and another one obtained from the microscope photographs on the same thin sections (real surface — 1 mm^2). These images were treated by means of specialized software (image treatment, GIS system, 3D-representation) in order to obtain series of numerical variables, which allow, as large as

possible, a quantitative description of the rock petrography. They were obtained 16 variables. The multivariable analysis (analysis of principals components) allows us to distinguish which variables are important in defining the different analyzed rocks and how to discriminate and regroup different petrographies. In order to have a more complete description of each rock, chemical composition analyses were made and the content in CaO and MgO were added in the multivariable analysis.

In order to obtain the second member of the relation petrography – dissolution, we performed a dissolution experiment: six limestone tablets were exposed to the water flow during a long period time, in the same hydrodynamic conditions. For each experience we tested two different hydrodynamic conditions. The first experience was made at the Mangalia Laboratory (Romania) during 86 days, and the second one was made in the Moulis Cave (The Subterranean Laboratory, France) during 148 days. The standard tablets were different for the two experiments, and they come from the same blocks from which we cut the thin sections. The samples come from the Arbas Massif (France) and Obârșia Cloșani – Piatra Mare Massif (Romania).

The quantitative variable — the dissolution rate — is estimated, for each rock type, as percent of the weight loss from the initial weight of the standard tablet during the dissolution experiment.

The relationship between petrography and dissolution is analyzed by means of the already mentioned multivariable analysis, where the percent of weight loss is added to the already used petrography variables.

Conclusions

Concerning the quantification of petrography, the analysis show that the first axis (F1), which explain more than 40% of the total variance, can be denominate as the “heterogeneity” factor. The F2 axis reflect the “crystallization degree” and the F3 axis regroup the variables which control the “crystallization dispersion”. On the main plane (F1 – F2) in the space of statistical units we can see that the first two factors allow a good discrimination of the different rock types. We maz conclude that this method can be successfully used for the quantification of the limestone petrography.

Considering the relation petrography – dissolution, the analysis show a relatively weak correlation between the petrographic variables and the dissolution rate. This correlation is much more evident for the weak water flow regime. The petrographic variables which impose this correlation depend on the rocks’ heterogeneity and its crystallization state. It seems that the more significant

variables in this relation come from the treatment of the microscope photographs of the thin sections images.

The practical conditions and the long period of the dissolution experiment did not allowed the use of much more statistical units. We are convinced that we cannot extrapolate these results at a general scale and, thus, their significance is restricted to the studied examples. Despite these restrictions imposed by the strict rules of the statistical analysis, we find these results encouraging. We consider this study like a first approach which will allow the fine tuning of a new method. Future experiments must cover a more wide range of petrographic variety and include a meaningful population of statistical units.

Determination of the catchment area of Alvand karstic aquifers, Iran

Haji KARIMI, Siamak Mahmoudi SIVAND & Ezzat RAEISI
Geology Department, College of Science, Shiraz University, Iran

The Alvand basin, with an area of about 2700 square kilometers, is part of the Zagros Mountain Ranges, located in Kermanshah province in the west of Iran. The study area is situated in the Zagros thrust zone (High Zagros) and in the Zagros simply folded zone. Elevations range from 360 to 2400 m above mean sea level. Geological formations in decreasing order of age consist of the Miocene Fars group mainly consisting of marl and gypsum, Oligo-Miocene Asmari limestone, Cretaceous Pabdeh-Gurpi, mainly made of marl and marly limestone, and Cretaceous Illam limestone. The Alvand basin is composed of seven anticlines. The core of the anticlines is composed of Karstic Asmari Formation which is sandwiched between the two impermeable Pabdeh-Gurpi and Fars groups. The karstified Illam Formation is exposed in the core of one of the anticlines. Five of these anticlines seem to be hydrogeologically independent based on the geological map. The karst water discharges from 16 main karstic springs and 23 minor springs. Major ions, electrical conductivity, temperature and pH of the 8 main springs were measured once every two weeks during the period of September 2000 to September 2001. The discharge, electrical conductivity and temperature of the 8 main springs were measured daily during the wet season. The physico-chemical characteristics of the other springs were measured seasonally. The mean annual discharges of the main springs range from 100 ls^{-1} to 2600 ls^{-1} and the mean annual discharges of the small springs are less than 60 ls^{-1} . The type of groundwater is calcium- magnesium bicarbonate.

The catchment area of each spring was determined by the water balance method. Water balance calculations indicate that the area of karstic formations in some of the anticlines, is not sufficient to provide the discharge of the related spring(s). Therefore, the deficit must be provided by the adjacent anticline(s). Geological setting, geomorphology, topography, lithology of the karst aquifer and surrounding formations, specific conductances and chemical characteristics of the springs, hydrographs of springs, and elevations of anticlines were used to determine the probable boundary of the catchment area of the springs. The most probable catchment area of most anticlines was determined using the above criteria. In one case, further study such as dye tracer, should be used to determine a more reliable catchment area. It may be concluded that in the first step, the mentioned parameters may be used to determine the most probable boundaries of the catchment area. If the method is not applicable in some parts of the study area, then expensive methods such as dye tracer, isotope tracer and/or isopotential maps may be used.

Hydrodynamic behaviour assessment of the Motru Sec – Baia de Arama karst system and its implications on the regional tectonic and structural image

Aurel ROTARU

Institute for Meteorology, Hydrology and Water Management, Bucharest,
Romania

The Motru Sec-Baia de Arama karst system is a complex system with a recharge both diffuse by precipitations and organized from the Motru Sec river swallet. The outlet is a line of sources in the Baia de Arama zone. Labelings have proved the continuity of both the Danubian Unit carbonatic deposits and the karst system, beneath the Getic Nappe.

The analysis performed for the registered hydrographs of tree most important sources have provided the system's complexity. The hydrodynamic behavior is characterized by the existence of two components of discharge. The first one is the fast component which gives the system its vulnerability to pollution. The second is a slow component which gives the system good storage capacity.

The existence of a fast component as well as the short mass transfer time between Motru Sec swallet and Baia de Arama sources are strong arguments for a new tecto-structural image of the area which displays a smaller thickness of the Getic Nappe deposits than initially thought.

Application of Fry analysis in the spatial distribution of thermal karst springs, South of Iran

Mahmood SADEGHI BOJD & Farid MOORE

Dept. of Geology, Shiraz University, Iran

Point data on the spatial distribution of thermal karst springs can be analyzed spatially by a plot on which distance and direction from each data point are recorded by a point at that distance and direction from the origin.

Fry analysis can operate manually by placing a sheet of tracing paper on which a series of parallel reference line (typically north pointing on a map) have been drawn and the location of each data point is recorded. On a second sheet of tracing paper with a center point (or origin), a set of marked parallel lines are kept parallel to those on the first sheet. The origin of the second sheet is placed on the data points on the first sheet and the second sheet marked with all the positions of points on the first. Then the origin of the second sheet is placed on the different data point on the first and the positions again recorded on the second sheet. This is continued, maintaining the same orientation, until all points on the first sheet have been used as the origin on the second. For n data points there are $n^2 - n$ translations. The resulting Fry plot may be further analyzed by construction of a rose diagram recording joint frequency versus directional sector.

About 33 thermal karst springs are reported in Fars, Bousher and Koh-kiloh BoirAhmad provinces in south of Iran. Most of the springs are sulphatic to chloritic in composition. The temperature of water ranges from 22°C to 52°C . In this paper, the distribution of springs and their relation to lithologic and structural characteristics are evaluated using Fry analysis when the springs are plotted on the map, and three categories are realized. A rose diagram is provided for each group. The main direction of springs is $130\text{-}150^{\circ}$, but the majority is concentrated between $130\text{-}140^{\circ}$.

So far several mechanisms have been proposed by different authors to explain the presence of thermal karst springs on the south of Zagros mountain range of which deep circulation of ground water along the dextral Qatar-Kazeron major fault, and exothermic change of anhydrite to gypsum have are more popular among regional geologist. However, the present Fry analysis clearly indicate that the main trend of thermal karst springs in NW-SE, that is, the same trend as zagros main thrust. It is believed that Qatar-Kazeron fault can only play a minor role in the orientation of thermal karst springs in the studied provinces.

Comparative studies on Pleistocene small mammal associations from karst deposits of Central Dobrogea and Oltenia, Romania

Constantin RĂDULESCU & Alexandru PETCULESCU

“Emil Racoviță” Institute of Speleology, București, Romania

Fossiliferous karst and cave deposits in central Dobrogea and Oltenia supplied abundant remains of small mammals from middle Pleistocene to the Holocene. Climatically distinct, not only at present but also during the time interval concerned, the two investigated areas were characterized by a stock of species in common (*Sorex*, *Crocidura*, *Talpa*, *Erinaceus*, *Clethrionomys*, *Arvicola*, *Microtus* ex gr. *arvalis/agrestis*, *Chionomys nivalis*, *Cricetulus*, *Ochotona* etc.) on the one hand and by the presence of particular taxa with local significance on the other.

Fossil faunas of Central Dobrogea reflected a predominant open environment (abundant occurrence of steppe lemmings of the genera *Lagurus* and *Eolagurus*; presence of *Ellobius* and *Scirtopoda*). In contrast, the faunas from Oltenia were connected with forests (interglacial/interstadial) (*Sciurus*, *Glis*, *Muscardinus*) or with sylvo-steppe (glacial/stadial) (*Mezocricetus*, *Cricetulus*, *Ochotona*) environments.

Biostratigraphy and ecological aspects of the small mammal assemblages from the principal fossil localities are discussed.

Small mammalian faunas from the caves of the Lake Baikal region

Margarita ERBAJEVA, Fedora KHENZYKHENOVA & Nadja ALEXEEVA

Geol. Inst., Siberian Branch, Russian Academy of Sciences, Russia

The Baikalian region associated with world-famous Lake Baikal, is located in the center of Asia, on the territory of two states – Russia and Mongolia. The territory stretches from South to North between 47° and 58° N. From West to East, it extends between 102° and 114° E. It is situated on the south-eastern borderland of the Siberian platform, one of the stable blocks of the Asiatic

continent and a part of the Central-Asian fold belt formed during the long geological evolution of the Paleoasian Ocean. The Baikal region is spread within the Central-Asian mountain belt and it is characterized by the alternation of large tectonically-determined relief forms grouped into three longitudinal ranges. This region has drawn the attention of investigators due to the unique region named as the “ancient crown of Asia” and the Baikal Rift system (KHAIN, 2001).

The studied area includes the territory of Russia, namely south of the Eastern Siberia - Predbaikalia and Western Transbaikalia. This region has more than 70 recorded caves distributed unevenly across the territory in a variety of climate, geologic, physiographic hydrologic regimes. The classification of these caves was provided by FILIPPOV (1993a; 1993b).

Systematic studies of caves had arisen to the end of 19th century. The geologists P.Kropotkin and I. Tschersky were early investigators reported the first data on the caves in the western shore of the Lake Baikal. From the beginning of the 20th century some caves were studied mainly by archaeologists such as outstanding explorers B. Petri, G. Debets, I. Veselov, P. Khoroshikh, G. Vologodskiy and others.

Around the 80's of the last century detailed multidisciplinary studies of the most caves of the Prebaikalian National Park were provided by different specialists – speleologists, geologists, paleontologists, biologists, climatologists, archeologists etc. (GORYUNOVA *et al.*, 1996).

Many fossil-bearing caves are known in the region, the faunas of which have provided significant information on biotic and climatic changes. As a usual the bone deposits of the most caves are the result of the activities of predators, either animals or birds, or both.

The presentation deals with the small mammalian faunas of several cave sites located in the mid of western part of Lake Baikal coast and three sites known on Olkhon Island which is placed opposite. They are: *Uzurskaya*, *Shamanskaya*, *Boro Khukhan* (Olkhon Island) and *Aya*, *Bol'shaya Baidinskaya*, *Tonty*, *Khurganskaya*, *Sarminskaya*, *Sluchainaya*, *Shida*, *Kurtinskaya* and *Kurtun-1*.

The oldest site with small mammal faunas is *Aya Cave*, the only Miocene cave known in East Siberia. It is situated on the Priolkhon plateau about 240 m above of Lake Baikal surface in Aya bay about 15 km east of Yelantsy village and more than 30 km southwest of the Olkon Island. It is a phreatic cave developed in graphite marbles of Upper Archean-Early Proterozoic age. The length and depth of this cave are 550 m and 40 m respectively. In this site eight layers of Late Cenozoic deposits were established by Filippov (ERBAJEVA & FILIPPOV,

1997). The uppermost two layers are of the Late Pleistocene dated on the base of sediments and faunas, including fish, amphibians, bats and rodents. Moreover, molluscs *Anisus* (*Gyraulus*) sp. was found here. In the next, Middle Pliocene redeposited dark-brown soil containing grit and rock debris grouting with black colour loam cement the remains of fishes, bats and undetermined small mammals were collected. Abundant fossils were found in the next three layers – 4, 5, 6, containing turtles, amphibians, birds, seven fish taxa belonging to five families and mammals (FILIPPOV *et al.*, 2000).

The small mammals are represented by:

Lagomorpha Brandt, 1855

Family Palaeolagidae Dice, 1929

Subfamily Amphilaginae Gureev, 1953

Genus *Eurolagus* Lopez Martinez, 1977

Eurolagus cf. *fontannesi* (Deperet, 1887)

Rodentia Bowdich, 1821

Aplodontidae gen. indet.

Dipodidae Fischer, 1817

Subfamily Lophocricetinae Savinov, 1970

Genus *Heterosminthus* Schaub, 1930

Heterosminthus erbajevae Lopatin, 2001

Cricetidae Fischer, 1817

Gobicricetodon Qiu, 1996

Gobicricetodon sp. nov.

In the lowermost three layers – 7, 8 and 9, no fossil remains were found. On the base of vertebrate faunas, the geological age of Aya Cave site is recognized as Middle Miocene.

Three Caves are situated on Olkhon Island. They are Uzurskaya, Shamanskaya and Boro Khukhan. The first one is located on the eastern part of Island near the village Uzur. The cave is developed as well in graphite marbels of Archean-Early Proterozoic age. It is not a big cave (length, width and depth: 5×1.5×2 m, respectively), filled with grey sandy loam 30 cm by thickness.

It includes the next small mammals: *Lepus* sp., *Ochotona* cf. *hyperborea*, *Spermophilus* sp., *Cricetulus* sp., *Alticola* sp., *Lagurus lagurus*.

The fauna is characterized by the predominance of the steppe inhabitants among which *Lagurus lagurus* was the most abundant form.

The sites Shamanskaya and Boro Khukhan are located in the mid of Olkhon Island not far from each other. Fossil-bearing deposits are not deep in the last site (around 0.2 m) and rather thick in Shamanskaya cave (1.1 m). The Boro

Khukhan fauna includes: *Lepus timidus*, *Spermophilus undulatus*, *Cricetulus barabensis*, *Clethrionomys cf. rutilus*, *Alticola cf. olchonensis*, *Microtus oeconomus*, *Microtus cf. fortis*.

The fauna of Shamanskaya cave includes all mentioned above taxa and in addition *Lagurus lagurus* and *Clethrionomys rufocanus*.

Small mammal associations of these last two sites show that open landscapes were distributed widely, however forest biotopes existed as well. The climate was rather cold and dry.

The other eight mentioned above caves are located on the western coast of Lake Baikal. Almost all of them are developed as well in graphite marbels of Archean-Early Proterozoic age. Fossil remains were collected from different layers referred to the latest Pleistocene and Holocene. All caves contain small mammal faunas including the same taxa. However the number of remains in each cave differ much. A great number of specimens (more than 900) were collected in Kurtun-1 site, around 500 specimens in Kurtinskaya and Tonty caves each, 25 — in Bol'shaya Baidinskaya, 42 — in Sluchainaya, 70 — in Khurganskaya and others (FILIPPOV *et al.*, 1995).

The general list of small mammals are:

Sorex sp.

Lepus timidus L.

Ochotona hyperborea Pall.

Pteromys volans L.

Tamias sibiricus Laxm.

Spermophilus (Urocitellus) undulatus Pall.

Apodemus sp.

Micromys cf. minutus Pall.

Clethrionomys rutilus Pall.

Clethrionomys rufocanus Sundev.

Myopus sp.

Alticola cf. argentata Severtz.

Alticola sp.

Lagurus cf. lagurus Pall.

Cricetulus sp.

Arvicola cf. terrestris L.

Microtus (Stenocranius) gregalis Pall.

Microtus (Microtus) ex gr. arvalis Pall.

Microtus (Alexandromys) aff. fortis Buechn.

Microtus oeconomus Pall.

The species composition given above show, that all these caves contain mainly the recent taxa that inhabited in Prebaikalia nowadays except of *Lagurus lagurus* whose closest area of distribution is Mongolia in the south and Khakasia and Kazakhstan in the west.

In total the faunas of these caves demonstrated that in the region the forest inhabitants (*Ochotona hyperborea*, *Clethrionomys rutilus*, *C. rufocanus*, *Alticola argentata*) were predominance at that time. However the representatives of typical steppe such as *Lagurus*, *Spermophilus* and *Cricetulus* existed too but they were scarce. This work was supported by RFFI grant no. 01-05-97239.

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The representatives of *Martes* genus in the Würm of Romania

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Remains of various mustelides (*Martes martes*, *M. faina*, *Mustela nivalis*, *Putorius putorius*) have been recovered from the Cave no. 4 in Scocul Scorotei (Retezat Mountains, Hunedoara County, Romania). The new fossil site of the Southern Carpathians may be located during the Late Pleistocene (Middle

Würm). Allometrical and morphological study of the skull and dentition indicate a climate warming corresponds to layers 3 and 2, followed by a cooling that corresponds to the layer 1, as well as the existence, during the Würmian of two different types of *Martes*.

L'humidité de condensation dans les grottes de la région d'Olkhon (la côte occidentale du lac de Baïkal, Russie)

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L'humidité de condensation joue un rôle important à l'augmentation d'écoulement souterrain, à l'accroissement du volume des vides karstiques et à la formation des spéléothèmes. Pour évaluer la grandeur de l'humidité de condensation qui se forme dans les cavités souterraines de région karstique d'Olkhon nous avons organisé pendant cinq années des observations microclimatiques synchrones (à l'extérieur et à l'intérieur) à deux grottes – Mechta et Bolchaïa Baidinskaïa. Les cavités souterraines se trouvent dans les marbres d'Archéen. Le réseau de Mechta possède un développement connu de 823 m, la dénivellation totale est de 52 m, pour Bolchaïa Baidinskaïa conformément à 45 et à 11 m.

Les processus de condensation d'humidité se passe dans les grottes si

$$e_{\text{ex}} - e_{\text{in}} > 0,$$

et devant $e_{\text{ex}} = e_{\text{in}}$, il y a lieu si

$$t_{\text{ex}} - t_{\text{in}} > 0,$$

où $e_{\text{ex}}, t_{\text{ex}}$: l'humidité (en millibar) et la température d'air ($^{\circ}\text{C}$), $e_{\text{in}}, t_{\text{in}}$: le même dans la cavité souterraine.

Selon nos observations la condensation d'humidité se voit dans les grottes considérées d'juin à juillet (Table 1) :

Table 1: L'humidité d'air en mb.

L'objet	Mois											
	1	2	3	4	5	6	7	8	9	10	11	12
La surface	1.2	1.2	1.9	3.2	5.5	9.4	12.9	12.1	7.9	4.8	2.4	1.7
Les grottes : Mechta	6.7	6.7	6.6	6.7	6.6	6.5	6.7	6.6	6.7	6.7	6.7	6.7
Bolchaïa Baidinskaïa	6.2	6.1	6.2	6.1	6.1	6.1	6.3	6.3	6.2	6.2	6.2	6.2

Les calculs de l'humidité de condensation sont s'effectués en utilisant la formule suivante:

$$Q = V I T (e_{ex} - e_{in}),$$

avec :

Q = la quantité d'humidité de condensation (en g) ;

V = le volume de cavité souterraine (en m³) ;

I = le coefficient d'intensité d'échange d'air: la grotte – la surface (nombre de fois à vingt-quatre heures) ;

T = la durée de période de la condensation (en vingt-quatre heures).

Par nos estimations, dans le région d'Olkhon la grandeur de l'humidité de condensation de saison chaude est de 7.5 % de précipitations moyennes annuelles qui ne dépasse pas ici en 280 mm.

Comparative hydrogeology and geochemistry of two potable water springs at Buxton, England

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The thermo-mineral springs of Buxton in the Derbyshire Peak District, England, were known to the Romans who named the town *Aquae Arnemetiae* (water of the goddess of the grove). In mediaeval times the spring was given the name "St Anne's Well" and the first recorded observations on the water were made in 1557 by a Dr. Turner. The first analyses were reported by a Dr. Pearson in 1784, with subsequent analyses in the 19th and 20th centuries. Taking into account improvements in analytical techniques it would appear that the

hydrochemistry has remained essentially constant over that time. Since the early 1990s part of the discharge has been tapped at source and piped to a factory where it is bottled as “Buxton Mineral Water” which has become one of the leading brands in the UK. The spring has been studied in some detail but with the exception of the temperature (27°C) and major ion analyses the only published details are in BARKER *et al.* (2000) and form part of a series of hydrogeothermal studies in the UK. BARKER *et al.* argue that flow from the spring is not driven by gravity but is primarily a thermodynamic mechanism of geothermal origin. They also suggest an age of *c.* 5000 years for the emergent waters on the basis of ¹⁴C dating. As part of a larger study of karst groundwater evolution and the origin of thermal waters in the Derbyshire dome the water from the spring was analysed for major ions, strontium, and the isotopes of sulphur (³⁴S, ³²S), carbon (¹³C, ¹²C), oxygen (¹⁸O, ¹⁶O) and strontium (⁸⁷Sr, ⁸⁶Sr). The results will be presented along with a new model that suggests that the chemistry and temperature of the Buxton thermal water is best explained by topographically deep flow through Namurian sandstone aquifers with the Dinantian limestone providing a higher permeability pathway for discharge at Buxton which is in a local topographical low.

Rockhead Spring, which has also been known as Cow Dale Spring and Pig Tor Spring, is some 3 km eastsoutheast of St Anne’s Well on the western bank of the River Wye. Until the mid 1970s water from the spring was pumped by a hydraulic ram to Cowdale village, where it formed the potable supply. The hydrochemistry of the spring was studied by CHRISTOPHER (1981) from 1977 to 1979 and by RAPER (1989) from 1986 to 1988. Both found the chemistry to be remarkably stable and Christopher suggested that it is “a site whose chemistry is so stable that any changes can be attributed to random error.” Christopher also suggested that it should be recognised as a type site for Derbyshire limestone percolation water. In 1997 the owner of the spring commissioned further research that led to a successful application for recognition of the spring as a natural mineral water and the granting of an abstraction licence. A pipeline linking the spring to a new bottling factory was completed in the autumn of 2001 and production commenced early in 2002. The spring was sampled as part of the same larger study as St Anne’s Well and analysed for the same parameters. In addition, the spring emits a continual stream of bubbles as a series of periodic bursts, each burst comprising a few ml of gas. These were sampled and analysed for N₂, Ar, O₂ and CO₂ by mass spectrometry. Methane was also analysed but was below detection (<0.05 vol. %). Carbon dioxide was quantitatively extracted from a known volume of each gas sample and purified for carbon isotopic analysis. The spring water chemistry and flow regime appear to indicate that the Rockhead Spring water is derived from more

than one source and on the basis of a detailed study of the geology three potential sources were identified: (a) *Relatively young water from a c. 1.11 km² local surface catchment*; (b) *Fault guided water from underlying dolomite beds driven into the spring area under hydrostatic pressure from more distant areas* and (c) *Deep anticlinal water*. The chemical and carbon isotopic composition of the gas bubbles suggest a soil gas source, probably derived close to the spring. However, there is an equilibrium isotopic fractionation between CO₂ gas and dissolved bicarbonate, of the order of 8 to 10 ‰ and in the correct sense to account for the difference between TDIC and CO₂ gas at this site. Since the bubbles and water are not in chemical equilibrium with respect to carbon species it is impossible to calculate exactly what fractionation should apply, but it remains a possibility that CO₂ in the bubbles results from degassing of TDIC into bubbles of CO₂-free gas introduced into the spring water.

Long term survey of the karstic system in South Dobrogea (Romania) by environmental isotopes

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South Dobrogea (Romania) represents, due to its natural and anthropic features, a very interesting area especially for hydrogeologists. Two superposed calcareous aquifers — the upper aquifer (Sarmatian) and lower aquifer (Barremian - Jurassic) — there are in the region and form the so-called “karstic system” of strategic importance. The isotopic monitoring (³H, ¹⁴C, ¹³C, D, ¹⁸O) was performed over the last 25 years by an integrated research of all natural types of waters in order to improve the knowledge of hydrogeological parameters and the regional pattern flow. The main isotopic characteristics of meteoric and surface waters are briefly described in the paper. As karstic system, the stress is on the lower aquifer for which, by a correlated interpretation of all hydrodynamic and isotopic information, was carried out an up-to-date regional conceptual model.

Therapeutics efficacy of the microclimate from salt mine and caves – a case study from Praid salt mine

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Despite the speleotherapy being used in Romania since more than 30 years in the treatment of chronic and allergic respiratory disorders, it is not still fully accepted as an effective method.

Although the caves have been mostly used, silver and salt mine are effective too. The karst aerosol has been most extensively studied — it is generally cold with high humidity, calcium and magnesium content, absolutely free of germs, yeasts, and aggressive allergens.

The mutual parameter for all kinds of speleotherapy (salt, mine, etc.) is the alpha-radon ionization of the cave aerosol and its sequent electro-negativity. This negative charge of the aerosol has substantial healing effect to cillial border of the respiratory mucosa improving the clearance capacity and closing the gates for infection and sesitization.

Cave environment, with its high humidity and low temperature, hydrates the damaged epithelium, and improves mucous viscosity. The absence of bacteria, yeasts, and allergens avoids inflammatory irritation.

The patients followed a speleotherapeutic cure during the course of a treatment of 14 days, including 1 & 14 descents in SD, depending on the form of the disease and the state of patients. As a result of speleotherapy we note a considerable improvement of clinical symptoms (the fit of asthma, coughing, crepitation in lungs are decreasing, the character of expectoration is changing). Speleotherapy influences the function of external respiration, and improves the main indicators (VC, FVC).

Geological investigation of the speleothems in limestone caves, Korea

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There are more than 1,000 limestone caves in South Korea. The caves are mostly distributed in the lower Paleozoic carbonate rocks (Joseon Supergroup) of the central part of the peninsula. Textural and geochemical investigation of the speleothems has been carried out in order to understand the original mineralogy, formation processes and carbonate diagenesis, using coordinated textural, isotopic and elemental data.

Among the speleothems studied, curtain (also bacon sheet), fried-egg stalagmite, cave shield, and rimstone are solely composed of calcite, and anthodite is composed of aragonite. However, cave coral, stalactite, stalagmite, flowstone are composed of aragonite and/or calcite. Based on the textural observations of more than 500 speleothem samples, five types of aragonitic and ten types of calcitic texture could be categorized.

The aragonitic speleothems show higher Sr and lower Mg contents than calcitic ones. All the speleothems from different caves show their distinctive Sr and Mg compositions, indicating that the fluids responsible for the formation of the speleothems had the different Sr and Mg contents according to locality.

The $\delta^{18}\text{O}$ values range from -9.4 to -4.0 per mil (PDB) and those of cave water and adjacent stream water range from -10.7 to 9.3 per mil (SMOW), suggesting that most of the speleothems formed in oxygen isotopic equilibrium, except for some enriched aragonitic speleothems. These enriched aragonitic speleothems may indicate that they were formed by evaporation rather than degassing of carbon dioxide.

The $\delta^{13}\text{C}$ values are quite variable from -10.0 to -5.0 per mil (PDB). These values are between the carbon isotopic compositions of the measured organic carbon in overlying soils and those of the carbonate rocks surrounding the limestone caves. Based on the mass balance calculation about 10 to 25% of the carbon in speleothems studied were from the organic carbon in overlying soils.

Some of the originally aragonitic speleothems such as cave coral, stalactite, and flowstone in a few caves have been calcitized. The neomorphic calcite crystals contain relics of the original aragonite crystals and growth laminae. The presence of these relics in neomorphic calcite as well as the similar elemental contents to the original aragonite suggests that the calcitization processes took place in a semi-closed system via a thin-film alternation front.

Mineralogy of skarn-hosted caves at Băița (Bihor county, Romania): implications for speleogenesis

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The Băița (Bihor County, Romania) metallogenic district is genetically connected to a deep-seated Upper Cretaceous granitic pluton. Within this district several skarn bodies host economic concentrations of Mo, W, Bi, Cu, Pb, Zn, B, wollastonite, marble etc. During skarn mining, numerous karst cavities were encountered. Minerals such as *wittichenite*, *antimonian luzonite*, *natrolite*, *quartz*, *rosasite*, *glaukosphaerite*, *aurichalcite*, *azurite*, *malachite*, *norsethite* and more commonly calcite, aragonite, hydromagnesite, and goethite were found within these skarn-hosted caves as crusts, corraloids, minute crystals, aggregates, and earthy masses. It is concluded that some of the minerals are of hydrothermal origin, whereas other are considered to have formed during hydrothermal or vadose alteration processes. A third group consists of minerals that were precipitated from low-temperature karstic waters. Although most skarn-hosted cavities exhibit the classical features of meteoric water caves, their mineralization, morphology, and position within the skarn support a hydrothermal and/or mixed hydrothermal/vadose origin.

Mineralogy of Răstoci Cave (Someș Plateau, Romania)

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Răstoci Cave hosts a diverse and interesting assemblage of minerals. The phosphatization of argillaceous material leads to the generation of the *francoanellite-taranakite* assemblage of minerals. In addition, *brushite*, *ardealite*, *hydroxylapatite*, *carbonate-hydroxylapatite*, and *monetite* were also documented from this cave. These minerals formed under different pH conditions on either wet and/or dry environments due to reactions between phosphate-rich solutions leached from guano deposits and limestone bedrock. Among them, two phosphates, *francoanellite* and *phosphammite*, and one sulfate mineral, *cesanite*, are very rare species that have been previously reported from a restricted number of caves in Italy, Australia, and San Salvador (Bahamas) respectively.

Paleomagnetism and rock magnetic properties of a flowstone core from Cloșani Cave (Mehedinți Mountains, Romania)

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A 40-cm long sub-vertical core was collected from a flowstone at the entrance of Cloșani Cave. U-Th dating revealed an age exceeding TIMS methods, thus older than 500 ka. Half of the core was cut in 1-cm segments, parallel with the lamination, which yielded 40 samples (around 3 cm³ per sample). For every sample, the structure of natural remanent magnetization was determined by stepwise alternating field demagnetization. Following the demagnetization, we measured the magnetic susceptibility, anhysteretic remanent magnetization (50 mT bias field, 100 mT peak AC field) and isothermal remanent magnetization

at 200 mT and 1000 mT for the whole collection. Based on rock magnetic data the core can be divided in two parts. The upper 20 cm have larger values for all parameters than the lower 20 cm and it shows several pulses of magnetic minerals which are absent in the lower part. Also the microstructures and the growth rate are different between the two parts: the upper part correspond to a finely laminated flowstone rich in clay minerals suggesting a slow growth rate and including several hiatuses, while the lower part is characterized by dendritic fast-growing and more pure calcite. Reliable paleomagnetic directions could be determined only in the first half. Even though the core was not collected oriented, magnetic polarity could be unambiguous identified, taking into account the component of magnetization parallel to the core. All samples have normal polarity except the samples cut at 15 cm depth which show a negative inclination. Since these samples are located in a fast growing area, they probably correspond to a warmer and more humid climate, and this reversal can be correlated with a reversal excursion during Brunhes which took place around 560–570 ka.

Karst of the ridge Dzevrinska Greda — caves, fluvial influences, groundwater circulation

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Dzevrinska Greda is an elongated and narrow ridge of Upper Jurassic limestone, situated next to the Danube Gorge (Iron Gates) in Eastern Serbia. It is uplifted along the conspicuous Dževrin fault of N-S direction, and is surrounded by non-carbonate rocks on the East (Cretaceous flysch) and the West (Palaeozoic schists).

Taking into account that the limestone surface is quite small (less than 5 km²), total length of all cave passages explored so far (more than 6300 m; when 32 caves are summed up) can be considered as an indicator of the significant karst development. One of the reasons for that certainly lies in the strong influence of allogenic water input (thanks to the petrologically different surroundings), which gives to this area an attribute of contact karst and/or fluviokarst. As this kind of water input is combined with the favourable tectonic conditions next to the Dževrin fault, the great density of cave passages per surface unit is quite comprehensible.

The behaviour of the fluvial network in contact with the narrow limestone ridge is varied: some of the streams sink at the contact, the larger of them entrench across the ridge, or even make tunnel caves. Dominant direction of karst groundwater flow is from the South towards the North, along the limestone belt. Thanks to the intensive tectonic activity, groundwater is capable of reaching considerable depths. The presence of lukewarm springs and springs of stable discharge throughout the year, strongly points to deep groundwater circulation.

It is important to mention that the northern part of Dževrinska Greda reaches the Danube as a sharp peak named Dževrin (434 m a.s.l.), about 7 km downstream from Tekija. The limestone belt is continuing on the other bank of the Danube, in Romania, stretching further as the Mehedinti Plateau. Considering that some of the major geological conditions in this area are quite similar at both sides of the Danube, it can be expected that more detailed comparison would perhaps give answers to some of the questions on the evolution of this karst area.

Evolutional aspects of the karstic valleys from Padiș– Cetățile Ponorului Plateau (Bihor Massif, România)

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The Bihor Massif (Apuseni Mountains) hosts one of the most interesting karstic plateaus in Romania: *Padiș–Cetățile Ponorului*. The paper presents some evolutionary aspects of karstic valleys from this region, which developed along several stages; each stage is represented by a certain type of valley. Thus, depending on the present flow and morphology, in Padiș–Cetățile Ponorului closed basin one can distinguish: permanent active valleys, temporary active valleys, dry valleys (sohodols) and doline valleys. The categories of karstic valleys also includes blind and rebound valleys. The morphology of the discharge and recharge points shows that such valleys witnessed several evolutionary stages.

Some considerations on the glacial aspects in Piule-Iorgovanu Mountains, Romania

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Piule-Iorgovanu Mountains are a small unit of Southern Carpathians, located on the western side of the range. They are mainly formed by Jurassic and Cretaceous limestone which belongs to the Danubian tectonic unit. The paper presents the glacial features of the limestone area of Piule-Iorgovanu Mountains under a morphological and morphometrical perspective. The aspects of the glacial morphology are compared to those from the neighbouring units in order to show the difference between the two manners of glacial activity.

The Quaternary morphogenesis of Lagoa Santa Tropical Karst, Minas Gerais State, South-Eastern Brazil

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The tropical karst region of Lagoa Santa is located approximately 30 km north of the state's capital Belo Horizonte, on a mountain plateau in the northern peripheral urban area developed over an interfluvial block at altitudes between 650 and 850 m above sea level. Up to date it is the oldest karst feature studied in Brazil, comprising karstological, paleontological, arqueological and speological aspects.

This karst region is outstanding due to its extension and geoeconomic and ecologic importance. The climate presents a pluviometric annual average index of 1 381 mm, whereas the average temperature is 20.8 °C. Geologically it is situated at the southern portion of the São Francisco Craton, composed of low to medium grade metamorphic pelites and calcitic/siliceous limestone of precambrian age (\pm 600–500 Ma).

The task of the present study is to elaborate a precise morphological and morphogenetical analysis of the exokarst scenery, aiming to elucidate the morphodynamic evolution of the area.

The exokarst scenery is characterized by closed depressions (e.g. dolines, uvalas, poljes), that turn in temporary lagoons when the aquatic karst level emerges, as a consequence of the reloading during maximum rainfall periods. Thus it can be classified as a typical karst of intermittent lagoons.

The geologic map (1:500.000) displays the Lagoa Santa karstic region as an enclosed open window incised in the precambrian metapelites. Outstanding is a narrow mountain range, lined in NW–SE direction, representing remnants of the “*Sul Americana*” surface, as well as the course of the Córrego da Mata, flowing to the south, contrasting the general direction of the hydrographic system.

Studying the region in a larger scale (1:50.000) four geomorphologic compartments have been identified (from SW towards NE): (i) a higher area (up to 850 m) lodging a fluviokarst with blind valleys and dolines; (ii) a semicircular belt comprised of dolines and uvalas; (iii) a lower plateau consisting of a complex system of sinkholes of different ages, aligned along ancient, precambrian structural trends; and (IV) the lowermost compartment with its poljes at approximately 650 m, next to the main river, the Rio das Velhas.

Massive walls, up to 40 m show at a 1:1.000 scale systems of horizontal (*Schichtenkarren*) and vertical (*Rund-Rillenkarren*) systems as a consequence of dissolution dynamics of pluvial water. Morphogenetic features have been imposed by sedimentary facies transitions, hence mineralogically the depressions (dolines, uvalas) represent areas of calcitic limestones, while topographic positive relief (e.g. humes, towers) are composed of siliceous carbonate rocks. Cave systems (endo-karst) developed at the bottom of the walls near the sinkhole level. Several halls are coated with travertines, that can fill, in some cases, ancient conduits. Under the stalagmitic floor most of the extinct mega-fauna has been discovered.

Geomorphological, geological and paleontological data indicate some interesting anomalous hydrological features in the Lagoa Santa region. The karst scenery developed mainly during Quaternary time, however its origin is remote and probably related to the breakdown of Gondwana during the late Jurassic. The proto-Rio das Velhas, situated at that time approximately 10–20 km towards the south-west, gave rise to erosional processes, that started to sculpture the enclosed window in the precambrian metapelites. Due to Plio-Pleistocene neotectonic processes the Rio das Velhas bed has been dislocated to its present site creating in its former location the Corrego da Mata, draining to the opposite direction. This evolution scheme is based on the amount of corroded limestones of the enclosed actual window, as well as on paleoclimatic conditions (glacial/interglacial) and neotectonic processes, among others.

The following morphogenetic sequence, postdating the Jurassic/Cretaceous origin, has been established: Cenozoic pediplanation (South American Surface, hot and humid climate, lateritic soils); Lower Pleistocene surface dissection due to climatic alternance (cold and dry, hot and humid); Middle Pleistocene beginning of exokarstification processes; Upper Pleistocene (> 22 000 ka BP) maximal karstification; Between 22.000 and 13.000 KyBP — a maximal chemical corrosion with formation of speleothems and stalagmitic floor (climate cold and dry); Holocene maximal karstification (humid climate), with periodic flooding of dolines, uvalas and poljes, that characterize the actual Lagoa Santa karst of intermittent lagoons.

Morphometrical parameters of Hungarian dolines

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Introduction

Dolines provide very sensitive monitoring points for the environment in a karst region. The morphology of the dolines may indicate the aspects of doline-development that arise from exogenic influences. After and during the formation of the dolines, the exogenic ecological factors modify the dolines.

The reason for the **asymmetry of dolines** is the difference in microclimate, soil and flora on different slopes. BÁRÁNY-KEVEI (1992; 1995; 1996) has previously investigated the ecological relations of dolines and found the following: different slopes receive different quantities of radiation and build up different microclimates, which have an effect on chemical and biological processes in doline soils. The types and activities of soil bacteria depend on microclimate hence in the soils covering the bedrock in the dolines they control the nature and the order of magnitude of corrosion processes necessary for solution.

Morphometrical characteristics of the analysed dolines

Micro- and meso- forms of the karst areas in Aggtelek-, Bükk- and Mecsek Mountain - the conjointly extending doline is undoubtedly the most characteristic feature of the karst topography. Dolines are located at different heights. Morphometry of dolines is an important indicator of their mode of development (WILLIAMS, 1975, SAURO, 1991, BÁRÁNY-KEVEI & MEZŐSI, 1991). The central feature of our studies is the surface forms in various lithologic, tectonic, orographic situations. Our analyses permitted the identification of the

doline types belonging to the most important morphogenetic units an estimation of their ecological state.

Dolines in the Aggtelek karst are in an advanced stage of development, characterised by siltation of the bottom of the dolines and their lateral extension. Opposite to this the Mecsek dolines are in a primitive stages of their development, shown by the large steepness of their sides and their ongoing deepening. Between the Mecsek and Aggtelek types the Bükk dolines represent a transition, since the deepening is already not too intensive there, siltation and lateral extension are also under way.

Karstification of the Triassic limestones in *Aggtelek Karst* happened in several phases. The present surface shoes remains of these processes (e.g. a tropical cone karst in the depression of Redlake). At the end of the Tertiary, an intensive karstification took place, which was able to form canyon-like valleys in the mountain where clay slate was close to the surface. One part of dolines is situated in valleys.

Dolines of Aggtelek Karst are located at heights of 270-300 m (basin dolines), 300-350 m (valley dolines) and around 500 m (plateau dolines).

Valley dolines at 300- 350 m are situated in rows and display NE-SW and W-E strikes. A typical filling is the dark red terra rossa. The layer thickness is 5-15 m on the doline bottoms. The doline side and bottoms protected by the terra rossa exhibit definite tropical tower karst microforms. Such forms absent from the ridges and doline side not covered by terra rossa. As a result of secondary surface karst denudation processes is shaping the relief.

Basin dolines are small dolines. The clay fill is 2-5 m thick. The subsoil rock forms are characterised by corrosion karren with the presence of fissure karren.

Plateau dolines have generally steeper side than the dolines at intermediate heights. This may well be connected with the fact that they contain little fill, which favours the expression of the morphology of the rock surface. These dolines are filling black humus, their soil is rendzina soil.

Morphometrical parameters of some typical dolines in Aggtelek Mountain are the following:

Doline	1	2	3	4	5	6	7	8
Elongation ratio	1,80	1,09	2,25	2,19	1,08	0,86	1,08	1,48
Area/Depth ratio	0,98	1,40	0,98	0,98	0,99	0,88	0,98	0,87
Peripher./Depth ratio	0,84	0,83	0,80	0,81	0,86	0,78	0,58	0,87

The elongation ratio, extents and depths of dolines depend on variations in geological and ecological elements of landscape. The tectonic movements of the Tertiary preformed the recent directions of the surface forms. Dry valleys, formed along the EW and NE-SW tectonic lines, influencing the placement of solution dolines.

The *Mecsek Mountain* is rich in karstic forms. There is a karstic plateau of approximately 14 km² extension to the South-East of Orfű, divided into 3 smaller plateau's. During collecting data 64 out of 1540 dolines found on the 14 km² area were analysed. In the morphometric study slope angles were measured on the basis of which depth, maximal, minimal and average diameter, protracting ratio, relief ratio, area and doline density were calculated. Taking into account these parameters dolines in the Mecsek territory are less developed than in the karstic areas of Bükk and Aggtelek.

The doline density is extremely high: 110 dolines per km² on average. The minimal doline density is 50-60/km², the maximal one can reach even 380/km². Even the minimal values exceed significantly the maximal values of Bükk plateau, where doline density varies between 5-30/km². This extremely high doline density can be explained on one hand by the fact that the whole territory is covered by forest that leads to more intensive microbial activity and thicker soil layer. On the other hand the rock of the base is highly fissured.

The morphometry of the Mecsek dolines differs significantly from that of the Bükk and Aggtelek area. Concerning depth the difference is not significant but the average diameter differs considerably. 2/3 part of the Mecsek dolines has a diameter below 30 m, while dolines in the Bükk and Aggtelek territories exceed this value significantly. Similar ratios can be found concerning the areas. Area of the dolines examined in the Aggtelek-karst and in the Bükk was always over 10000 m², while in Mecsek only very few dolines can be found in this category.

Examining the relief ratio the maximal values (over 0.3) appear in Mecsek, while in Aggtelek and in Bükk the relief ratio of the majority of dolines does not reach 0.2.

Higher protracting ratios are characteristic of dolines in Bükk and Aggtelek. In Mecsek most of them has a small protracting ratio (0.7-1.29). On average it is similar to those of Bükk, but in Aggtelek there are much higher values, most of the dolines belong to the over 1.5 category.

On the basis of the morphometrical comparison it can be concluded that despite the existing differences the Mecsek dolines are more similar to those of Bükk. As a result of the comparison a kind of sequence can be established

which shows the differences between the developmental stages of the 3 sampling territories.

The most part of the geological structure of the sampling area in Mecsek Mountain is made of middle Triassic, Anizussic limestone. Among these the Lapsi limestone is the major rock-forming constituent which is strongly fissured. This circumstance plays a significant role in the development of the numerous dolines in the area.

Summarising our analysis we can say that from a morphometric point of view the dolines of Mecsek Mountain are significantly different from those in karst areas of Bükk and Aggtelek. The difference can be clearly seen in their smaller size, small area, and big depth in relation to size and funnel-like form. The big relief ratio is reflected by the vegetation, since species characteristics of ravine forests appear also.

Conclusion

The dolines in the Mecsek territory are less developed than in the karstic areas of Bükk and Aggtelek. From a morphometric point of view these dolines are significantly different from those in karst areas of Bükk and Aggtelek. The difference can be clearly seen in their smaller size, small area, and big depth in relation to size and funnel-like form. The big relief ratio is reflected by the vegetation, since species characteristics of ravine forests appear also.

Dolines in Mecsek plateau are characterised by a natural state, the territory can be considered as more or less free from antropogenic influences. This state close to its natural condition is a great value of the landscape. Nowadays it is an important task to conserve the natural conditions of the environment, especially those of karstic regions. The karst is a highly vulnerable natural system that reacts with great sensitivity to antropogenic influences, so it requires an increased protection.

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Contribution to karst evolution in the area of Cracow-Wielun Upland (South Poland)

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Cracow-Wielun Upland, with about 2500 km² of area and more than 1700 known caves, is the largest individual karst region in Poland and whole Central Europe. Karst developed in limestone of Upper Jurassic age is unique on European scale and usually classified as relict karst, even palaeokarst. Several phases of karstification are distinguished in the evolution of the region. According to new geologic, mostly tectonic data some contributions to knowledge of karst evolution are presented in the paper. Detail researches of residual hills, mentioned in older geomorphological literature of the region as mogotes, are additional bases of new ideas.

Primary matrix for karst development is influenced and impacted by coexistence in the geological profile and structure of three different in solubility limestone facies - rocky (the most karstifiable, main part of bioherms), bedded and chalky. Cracow-Wielun Upland is located in significant Cracow-Hamburg fault zone influencing tectonic pattern of Palaeozoic background as well as Mesozoic platform. Due to monoclinical pattern of the platform it is possible to recognise different stages of karst evolution within the Upper Jurassic carbonates. According to evolutionary types of karst western part of the region represents exhumed karst and in the eastern part carbonates are buried by Cretaceous marls and sandstone. Exhumation processes are active in present stage of karstification.

The influence of Sanian and Odranian ice sheet in Pleistocene as well as interactions between ice sheet and hydrothermal activity connected with mentioned fault zone play an important role in the karst evolution of the Cracow-Wielun Upland. Special attention is dedicated to this phase of karstification of the region.

Archaeological researches in Ungurul Mare and Mișid caves (Pădurea Craiului mountains, Romania)

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The researches from the cave of Ungurul Mare yielded a very rich archaeological material. The oldest remains belong to the Middle Neolithic; they are followed by artifacts dated as the final Bronze Age. The stratigraphic profile has recorded several levels of settlements as well as a small deposit of bronze pieces (Sunceius III).

The researches started two years ago in Mișid cave have yielded a cultic complex belonging to the Dacian Epoch, which is unique through its complexity. Silver coins, iron and bronze pieces and an impressive amount of ceramics have been retrieved from this cave. The complex has been dated between the IInd Century B.C. and the Ist Century A.D and represents a unique ritual complex for the Dacian world.

Man and cave environment

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The paper deals with the effects of the cave environment on the human organism. The author takes a historical approach on the energizing and therapeutical effects of the cave, followed by considerations on the ‘beyond time’ experiments performed in caves beginning with the ‘60s. In the end, the experiments performed in 2001 and 2002 in Romania are presented. Medical experts and laboratories have performed a series of observations and analyses before and after these experiments. The subjects were two males (33 and 77 years old) and a woman (21), isolated in different caves and places. The experiments aimed to the knowledge of human reactions to absolute silence, darkness, low temperatures, high humidity and total separation to the surface.

Speleogenesis of the Frasassi karst system in Central Italy

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The Frasassi Caves are located in Central Italy, on the Adriatic side of the Apennine mountains, 40 km from the coast. Karst systems consist of more than 100 caves, developed on both sides of a deep gorge, cut by the Sentino river in the Jurassic carbonate bank. The Grotta Grande del Vento, the most popular show cave in Italy, is visited every year by approximately 300.000 tourists.

The caves consist of a maze system of more than 25 km of solutional passages and at least four main levels are developed, related to the evolution of an external hydrographic network. The karst system is mainly horizontal and has a ramiform pattern; several big rooms with wide ceilings end abruptly in narrow passages or fissures; phreatic and often anastomotic passages, are also spread over large parts of the cave, where they constitute some network zones. Common underground morphological features are large rooms (the Abisso Ancona is one million of cubic meters), cupolas, bubble trails, roof pendants, and knife edges. The lowest parts of the cave reach the phreatic zone, where a cold sulphide-sodium-chloride mineralized ground water and carbonatic meteoric circulation occur. The sulfide can reach concentrations of up to 0.4 mMol l⁻¹ in the mineralized aquifer.

Two end-types of groundwater are found in the Frasassi Cave. Carbonate waters from the infiltration and seepage of the surface meteoric waters through the limestone with about 500 mg/l of TDS; the catchment of this aquifer, extending for about 5 km² with an overall base flow, discharge of 22 l sec⁻¹ km⁻². The mineralized waters, with an average temperature of 13.3°C and more than 2000 mg/l of TDS rise from the depth, through Triassic anhydrite rocks in a complex underground regional flow path. The groundwater flow in the vadose zone is controlled by a conduit system along faults and fissures, with a transfer time of a few weeks. A network of tectonic fractures leads the water movement in the phreatic zone with recharge times of many months. The hydrodynamics of the springs is regulated primarily by the base flow, but occasional quick flows and seepage occur from the vadose zone.

The main cave-forming processes of the Frasassi karst system are related to the H₂S oxydation, in the groundwater as well as in the atmosphere where the

oxido – reduction reactions involve bacterial activity. The bedrock corrosion produce sulphate ions in the phreatic zone and gypsum replacement in the limestone walls of the vadose sectors of the cave.

Large carbonate speleothems are diffuse features in different passages of the caves and in the Grotta Grande del Vento their age in the lower levels, dated by the uranium-series method, reaches 200.000 y B.P. Gypsum deposits are common at different altimetric levels with white, finely graded or massive floor deposits. The macro and micro crystalline gypsum formation occurs on the cave walls above the water-table, owing to the oxydation of H₂S vapours. Other minerals in the caves are brown clay, mainly illitic with associatd montmorrillonite and jarosite, hallosite. Clastic breakdown rocks and debris are very diffuse, especially in the larger rooms.

Environmental aspects of the Grotta Grande del Vento (Frasassi Gorge - Central Italy)

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The Grotta Grande del Vento in the Frasassi Gorge in Central Italy was discovered in the early seventies. The opening of an artificial access tunnel and the construction of a pathway, has permitted the visit of more than ten million of tourists since 1974 with an average of 1,000 visitors each day. In the touristic branch of the cave, an environmental monitoring network with more than fifty sensors for air and water temperature, air humidity, velocity of the air, CO₂ concentration, atmospheric pressure, conductivity and rain has recorded at 30 minute- intervals since 1989.

The average air temperature in the cave varies between 12 to 14°C. In the touristic part, the temperature increases of a few degrees during the summer season as a consequence of the influx of warm surface air, through the artificial tunnel and due to the large number of tourists visiting the cave (in the month of August an average of 3.000 persons visit the cave each day). Only in the early autumn the underground air temperature recover the original values of the colder months. These cyclic temperature variations progressively decrease from the entrance to the deeper section of the cave.

The airflow in the cave is characterized by a «chimney effect»: in winter, when the external air temperature is lower, the air enters the cave through the lower entrance and exits the cave through the upper entrance. The circulation is reversed during the warmer season and the switch in the direction air flow depends on the general external weather condition. The difference of the air temperature and the atmospheric pressure control the air velocity in the entrances of the cave. In the upper small natural cave entrance the flow may reach more than 6 m³/sec-1, while in the lower artificial tunnel the air flux can exceed 10 m³/sec-1, especially when the tight doors remain completely opened for the high number of the tourist.

The CO₂ concentration in the cave atmosphere, has both a natural and an anthropogenic component. The natural background, which varies from 600 to 1.400 ppm, is related to the rising of mineralized water and to the external biological seasonal cycles. Tourists' breath has a small contribute in the increasing and to storage of CO₂, while the opening of the tight doors in the artificial tunnel contribute significantly to the decreasing of the CO₂ concentration in the cave atmosphere. The CO₂ level shows seasonal variations with a maximum in summer when it exceeds 2000 ppm and with a minimum of about 400 ppm in winter. Daily and hourly fluctuations of up to 1.100 ppm are correlated with the number of visitors and the opening of the sliding door. The cave atmosphere sometime takes a few days for to recover a severe increase in the carbon dioxide concentration, caused by anthropogenic factors.

The heat flow, generated by the tourists and by the artificial lights installed along the visitors' path, accounts for 86% of the total energy input into the cave. The energy output is mainly represented by cooling convection and radiation through the limestone walls (19%) and through the exchange of air (67%) through the natural and artificial entrances. The total estimated energy input is of 574 GJ, while the energy output represents 566 GJ, leaving a substantial balance in the overall energy budget.

The history of karst resources exploitation — an example of iron industry in Slovenia

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For a long time karst was an important source of iron ore in modern Slovenia. During several prehistoric and historic periods iron industry was the most important economic activity. On our territory it has a very long tradition, starting

in the Older Iron Age (Hallstatt) and was in full bloom in the 8th century BC already. There were two main karst regions with developed iron industry: the valley of Bohinj with Triglav Massif in the Alps and the karst of Notranjska (Inner Carniola) and Dolenjska (Lower Carniola) with Bela Krajina. Easily accessible iron ore deposits were located there. Iron ore appears in the form of limonite pieces or oolitic concretions of iron hydroxides, so-called “*broad bean ore*” (Bohnenerz in German), which contains 30–50 % of iron.

The position of our territory lying on the crossroad of two main directions was very important for the development of the iron industry. The first direction leading along the Danube transmitted the influence from the East while the other one transmitted the influence from Mediterranean and Italy across the Adriatic. The oldest iron object (an imported one, however), which had been found on the territory of Slovenia was excavated in the cave Mušja jama near Škocjan. It dates to the 10th century BC. During the Hallstatt period (750–300 BC) the inhabitants collected iron ore mostly on the surface. The ore was melted in the so called “*shaft type*” blast furnace — clay cone 2 m high — with the fireplace in the ditch. Combustible was beech tree charcoal and, in order to reach higher temperatures, the wind was used. In that period the mentioned karst parts of Slovenia became densely populated giving rise to cultural landscape. The “Dolenjska” and “Notranjska” group of Hallstatt inhabitants reached the “protourban” degree of development.

The iron industry became an important branch of economy again at the end of the Middle Age. From the “simple forest iron melting” complex ironworks developed, using the energy of running water. Ironworks concentrated in the valleys, on karst land near big karst springs. Their impact on karst environment was double. The first was the direct one: mineshafts and galleries scattered throughout the country, large consumption of wood for the charcoal (the so-called Slovene blast furnace needed 50-60 % more of charcoal than iron ore), and water pollution (washing of ore). At Železniki for example there were two melting furnaces, seven ironworks and 110 smith’s fireplaces, employing about 2000 people altogether. Nowadays Železniki is a local centre having little more than 3100 of inhabitants. In Slovenia, the iron industry is much less important today as it was during the past and no ironwork plant exists on karst.

Nowadays, there are practically no visible traces of the impact of iron industry which pressed on karst during centuries, even millenaries, and the most heavily between the 15th and 19th century. In the region Kras which was the most barren and has become a historical synonym for “karst desert”, there had been no iron industry at all.

**Les avens pièges du Mont Ventoux (Vaucluse, France):
découverte de la plus grande accumulation européenne
de restes d'ours brun (*Ursus arctos* L.) et données sur
l'environnement holocène en milieu d'altitude.**

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La présence de restes d'ours brun (*Ursus arctos* L.) n'est pas exceptionnelle dans les cavités karstiques européennes, mais l'espèce y est toujours connue par des restes épars. Dans le cadre de l'inventaire des cavités karstiques du flanc nord du Mont Ventoux (Vaucluse, France), le Groupe Spéléologique de Carpentras a localisé 14 avens situés entre 1.300 et 1.600 mètres d'altitude. D'une profondeur variant entre 3 à 40 mètres, une dizaine d'entre eux a fourni des restes d'au moins 500 ours qui, d'après l'analyse phylogénétique de

séquences partielles de l'A.D.N mitochondrial, peuvent être inclus dans le clade balkanique.

Le site le plus important est celui du René-Jean, petite galerie de 3 mètres de long aboutissant à un puits de 17 mètres de profondeur. Une fouille a été réalisée à la base du puits. Le remplissage est composé de trois unités stratigraphiques formées en totalité par un éboulis de type cryoclastique, plus ou moins ouvert, et dont la stratification reconnue est horizontale. La sédimentation s'est effectuée par gravité depuis les parois de l'aven. Le gisement a livré 15.000 ossements d'*U. arctos* représentant un minimum de 190 individus avec prédominance de jeunes de 3–5 mois (70 %) et de femelles parmi les 28 adultes. Ces données révèlent une occupation de la galerie d'accès en hiver ainsi que le rôle de piège de ces sites d'hibernation. Les dates du ^{14}C de l'ensemble des cavités indiquent un fonctionnement sur une longue période : de –7500 avant Jésus-Christ à + 900 après Jésus-Christ. Quatorze espèces de grands mammifères (dont cinq au René-Jean), huit espèces de rongeurs (dont sept au René-Jean), trois espèces d'insectivores, trois espèces de chiroptères et au moins neuf espèces d'oiseaux (dont six au René-Jean) ont pu être aussi identifiées attestant d'une biodiversité importante de la grande faune du Ventoux en comparaison de la faune moderne. De nombreux charbons de bois ont aussi été récoltés. Leur analyse montre une évolution de la représentativité des arbres au cours du temps, liée à l'ouverture artificielle du milieu par l'Homme (pastoralisme et feu). La palynologie corrobore la transformation du milieu et confirme l'existence d'un paysage plutôt ouvert, avec des zones boisées formant une sorte de mosaïque. La découverte de restes humains (MV2, MV6) ou de traces de leur activité (armature en silex au René-Jean, flèche en Bronze dans le sternum d'un chamois au MV9, tessons de poterie au MV6) confirment la présence humaine. Parmi les grands mammifères, chien, mouton, chèvre attestent d'une activité pastorale d'altitude. Les analyses isotopiques effectuées sur les herbivores récoltés dans l'ensemble des cavités du Mont Ventoux sont révélatrices d'un milieu ouvert fréquenté par les ovicaprins, le chamois et les cerfs. La signature isotopique des ours adultes montre qu'ils ont consommé de la chair de ces herbivores d'altitude. Enfin, il faut signaler une proportion non négligeable (8–10%) d'os rongés au sein des assemblages osseux trouvés au fond des puits, qui démontrent que des individus ont survécu quelque temps à leur chute en consommant des portions de cadavres. Cette étude sur la consommation d'os par les ours bruns constitue un référentiel remarquable pour les études taphonomiques sur les assemblages pléistocènes créés ou modifiés par les Ursidés (ours des cavernes principalement).

New data on the mineralogy of Iza cave (Rodnei Mts, Romania)

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Several cave mineral deposits, consisting of crusts and flowstones, have been recently investigated in Iza Cave (Rodnei Mountains, Maramureş county, Romania), developed at the contact between Eocene limestones, conglomerates and crystalline rocks (sericite-chlorite schists and marbles).

Previous studies carried out in Iza cave reported a large clay-like deposit, consisting of muscovite, illite, kaolinite, dickite, quartz and possibly rutile, formed by subaerial weathering of schists in the cave environment.

Our work describes secondary deposits including aragonitic crusts, gypsum crystals and crusty nodules of hydronian jarosite ($(\text{H}_3\text{O,K})\text{Fe}_3(\text{SO}_4)_2(\text{OH})_6$) deposited over goethite flowstone. They were investigated by XRD, SEM and EDS.

Magnesium resulted from the alteration of chlorites is supposed to be responsible for aragonite deposition, while goethite and the two sulfates formed through the action of percolating water over pyrite, present as accessory mineral in the crystalline schists.

Catchment of the Dinaric Karst River Cetina

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The Cetina River is a typical karst watercourse in the deep and well developed Dinaric karst. The total length of the Cetina River open streamflow from its spring to the mouth is about 105 km. Estimated mean annual rainfall is 1380 mm. The Cetina catchment is built of Triassic, Jurassic and Cretaceous carbonate strata. The western part of the catchment by the Cetina River is referred to as "direct" or topographic catchment. It was defined based on surface morphologic forms, by connection between mountain chain peaks. This part of the catchment is almost entirely situated on the territory of the Republic of Croatia.

Eastern part of the catchment is referred to as “indirect” catchment, which is mainly situated on the territory of Bosnia-Herzegovina. Water from “indirect” catchment inflows the western “direct” catchment through the underground. Water emerges to the surface in the form of numerous permanent and temporary karst springs. Since 1960, numerous hydrotechnical works have been carried out on the Cetina River and within its catchment. Five hydroelectric power plants (HEPP), four reservoirs, three long pipelines, etc. were built. Their operation significantly altered natural hydrological regime. With regard to hydrogeology and hydrology, the Cetina River is divided into two sections. In the upstream one, in the length of 65 km, hydrological regime was redistributed within the year. Low flows had increased and high flows had decreased while mean discharges remained the same. Part of the Cetina watercourse downstream from the Pranèeviaèi Reservoir lost the main quantity of its natural water. The mean annual discharges dropped from $100\text{m}^3\text{s}^{-1}$ in natural state to less than $10\text{m}^3\text{s}^{-1}$.

This paper emphasizes the fact that power supply authorities are disregarding ecologically acceptable flow of $8\text{m}^3\text{s}^{-1}$ (in Croatia referred to as “biological minimum”) that shall be released from the Prancevici Reservoir.

Numerical modeling of hydro-mechanical fracture behavior

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The movement of fluids through rock fractures is important in many engineering areas of practical interest such as petroleum and mining engineering. One of the most investigated and complex subject is the effect on well productivity due to changes in hydraulic conductivity both of the rock matrix and of the main fractures presented in it. A numerical approach for modeling coupled Hydro-Mechanical fracture behavior in 2D and in 3D is presented in this paper. This approach accounts for the strong dependence of the flow characteristics on fracture apertures and offers an anisotropic description of the flow propagation in the fracture.

A finite element code is developed to predict the influence of the variation of normal stresses in the soil on the distributed hydraulic conductivity field. The introduced mathematical model combines the cubic law with a non linear deformation function (hyperbolic) suggested to describe the stress-closure/opening curves of the joints, and allows coupling between hydraulic and mechanical fracture behavior (BART, 2000).

Due to the complexity of the different fractures dimensions and to the impossibility for a numerical code of a simultaneous, convenient and detailed description of all of them, the choice was made in this work to study the evolution of a fractured oil reservoir, where only the main fractures were reproduced.

In order to validate the applicability of the model to general geomechanic problems, a first simulation was performed of a 2D oil reservoir containing one horizontal fracture. The results show the good application of the mathematical model in a fractured reservoir context and the fundamental hydraulic role played by the fracture.

Comparison between the proposed non linear model and the one governed by Darcy fluid flow equation and linear stress-closure/opening relation shows the importance of describing the phenomena, by taking into account the coupled hydro-mechanical behavior of the fractures.

Finally a 3D simulation of a fractured oil reservoir sected by three main fractures was conducted to test the new features of the finite element code in 3 dimensions and to offer a more realistic representation of the evolution of the reservoir during an exploitation.

