MORPHOMETRIC CHARACTERIZATION OF KARSTIC ZONES AND INDICATIVE WATER EROSION SENSITIVITY. CASE STUDY LEBANON

C. Abdallah[1], R. Bou Kheir[1]

[1]National Council for Scientific Research/Remote Sensing Center, P.O. Box: 11-8281, Beirut, Lebanon. Tel: +961-4-409845/6; fax: +961-4-409847; E-mail: raniabk@cnrs.edu.lb

Abstract
In Lebanon, the sensitivity of different landforms to water erosion is not yet clearly identified, notably when the water flow regime is not sufficiently understood. This is the case of karstic terrains, which occupy a big portion of the country (70% of its area). These terrains are distributed in localities having various lithologic and soil properties and they are characterized by different responses to carbonate dissolution. In this study, a full typology of the Lebanese karstic terrain is developed. Four karstic zones have been identified, i.e. the dolines zone, the lapies zone, the covered karst zone, and the open karst zone. They vary in topographic form, in dissolution response due to the impact of the climate, and in geographic location altitudes over 2000; between 1000 and 1500 m; between 500 and 1500 m; and between 500 and 2000 m. Field observations reveal that different soil properties characterize these zones as well as various water flow regimes.
The statistical interpretation of field erosion data (earth pillars, linear channels, soil etching, soil drift) indicates that the karstic terrain can be considered as having a relatively low level of water erosion. In fact, the median volumes of soil losses are equal to 0.91, 0.08, 2.89 and 0.02 tons/ha/year in the dolines zone, the lapies zone, the covered karst zone, and the open karst zone.

Keywords: morpho-pedology, karstic terrain, field erosion indicators, Lebanon, Mediterranean environments.

KARST WATER MANAGEMENT AND PROTECTION IN ARID AND SEMI ARID ZON

Dr. Ahmad Afrasibian

Pars International Karst Company, Falamak North St. Faz, 4 - Shamrak - Gharb, Junction of Zarafshan, 7th Alley, No. 12, Tehran, Iran, E-mail: ahmadafrasibian@hotmail.com

Abstract
Ground water in karstic formation is one of the important potable water resource specially in arid and semi arid zone where due to limitation of ground water in alluvium resources. There exist a great need and demand for exploration and withdraw from karstic formation. Without hesitation conquence to as such the vulnerability of karst and share of future generation is not much taken into consideration.
Due to vulnerability and high sensitivity to pollution, there fore the karst water management and protection which is a part of sustainable development scheme is one of important measure which has to be observed in karstic region.
In this paper as case study the management of karst water in Maharlu kasrt basin in S.W. Iran has been presented and recommended dimension for its degree which is mainly around pumbing field (10×10MM) as well second and third degree protection has been defined in the basin which has been selected as Iran karst pilot basin.
It is finally concluded that there exist a lot of unsolved problem and defination for preparation and defaination of code of specification for sustainable development in karstic region and as such a need for international collaboration and research is suggested in the paper.

KARSTIC CULTURAL LANDSCAPE (3KCL PROJECT) IN FRANCE

Philippe Audra

Equipe Gestion et valorisation de l´environment UMR 5651 du CNRS "ESPACE", Department de geographie, Universite Nice-Sophia-Antipolis, 98 Bouldevard Edouard Herriot - BP 20, Nice, France, E-mail: audra@unice.fr, audra.philippe@wanadoo.fr

Abstract
The project "3KCL – Karstic Cultural Landscape", teamed up Montebelluna Museum (It., leader), Padova University (It.), Postojna Karst Inst. (Slov.), and Nice University (Fr.) to study three karstic areas in respective countries. The research was carried out in an interdisciplinary way, concentrating on a variety of aspects relating to the relationship between man and his environment, and how this has changed through time. The Karst landscape represents an important part of our national heritage both from the point of view of the natural beauty of our landscapes and for the relationship between man and his environment.
The Annot-Méailles area is at the South of the French Alps. Caves where used by Prehistoric Man. In the Saint-Benoît Cave, a 1574 date is engraved, one of the most ancient recorded in French caves. In the XVIIth century, scientist, like astronomer Gassendi and humanist Peiresc described hydrodynamic and airflow. Caves are found in 3 lithological units; 1) Fissure pseudokarsts in Annot sandstone; 2) The Cretaceous limestones give origin to the main rivers, the Vaïre and the Coulomp, which is the largest spring of the Var catchment; 3/ most of the caves are in Nummulitic limestone and conglomerates. The perched parts of the karst display cave systems at the contact of limestones overlying marls, originating sussessively from karst solution along fissures then from erosion of the marls basement. In dammed karst, cave are of epiphreatic type with looping tube and 3D underflow mazes.
These data where presented through conferences and field excursion to Primary schools. On their turn, pupil designed the panels of the exhibition to local people, which was presented simutaneously with a book combining all scientific results.

THE ROLE OF CONVECTION-CONDENSATION PROCESSES IN HYPOGENIC SPELEOGENESIS. STUDY OF THERMAL SULFIDIC CAVES OF AIX-LES-BAINS AND DALUIS, FRANCE

Philippe Audra[1], Fabien Hobléa[2], Jean-Yves Bigot, Jean-Claude Nobécourt

[1]Equipe Gestion et valorisation de l´environment UMR 5651 du CNRS "ESPACE", Department de geographie, Universite Nice-Sophia-Antipolis, 98 Bouldevard Edouard Herriot - BP 20, Nice, France, E-mail: audra@unice.fr, audra.philippe@wanadoo.fr
[2]University of Savoy.

Abstract
The study of two sulfidic caves, an active and thermal one in Aix-les-Bains (Chevalley shaft and Snake Cave) and a dry one in Southern Alps (Cat Cave in Daluis) put in evidence the role of convection airflows and condensation processes. They appear to play an important speleogenetic part in the development of conduits during the period of hydrothermal flow, and also during the late genetic phase, when cave is abandoned by thermal water but still under thermic influence. The distribution of cave popcorn perfectly reflects the dynamic and activity of thermic-driven airflow processes.

SHOW CAVES IN CROATIA – PRESENT CONDITION AND PERSPECTIVES

Neven Bočić[1], Aleksandar Lukić[2], Vuk Tvrtko Opačić[3]

[1] Department of Geography, Faculty of Science, University of Zagreb, Marulićev trg 19 /II, 10 000 Zagreb, Croatia & Commission for Show Caves, Croatian Speleological Federation, Nova Ves 66, 10 000 Zagreb, Croatia, nbocic@geog.pmf.hr
[2] Department of Geography, Faculty of Science, University of Zagreb, Marulićev trg 19 /II, 10 000 Zagreb, Croatia, alukic@geog.pmf.hr
[3] Department of Geography, Faculty of Science, University of Zagreb, Marulićev trg 19 /II, 10 000 Zagreb, Croatia, vtopacic@geog.pmf.hr

Abstract
Touristic valorisation of caves has long tradition in Croatia. Research has been conducted in order to: identify show caves in Croatia (13), make an overview of their basic geomorphologic characteristics and study their role as tourist attraction. Among others, ownership relations and management have been recognized as an important factor for touristic valorisation of show caves. These elements as well as linkages of show caves with local economy have been examined in more details in case studies. Paper concludes with overview on current tourist development of show caves in Croatia and proposes some future actions in that respect.

POSSIBILITIES OF TOURISM VALORISATION OF THE CAVE GVOZDENICA NEAR KARLOVAC (CROATIA)

Neven Bočić[1]

[1] Department of Geography, Faculty of Science, University of Zagreb, Marulićev trg 19 /II, 10 000 Zagreb, Croatia & Commission for Show Caves, Croatian Speleological Federation, Nova Ves 66, 10 000 Zagreb, Croatia, E-mail: nbocic@geog.pmf.hr

Abstract
The cave Gvozdenica is located in the area of the village of Brebornica near Krnjak, some 21 km south from Karlovac. The cave is 661 m long and -41 m deep. It is a branching and level morphologic type, without recent hydrologic function and significant quantities of water. A special scientific (geomorphologic, geological, biological and archeological-paleontological), esthetical, educative and recreative significance has been determined. On the basis of the traffic position and defined importance of the cave and its surroundings, a possibility of their tourism valorisation has been noticed, as well as that of the cave`s wider surroundings valorisation. The attention was also paid to the combination of the tourism valorisation of the Gvozdenica cave and its surroundings with the other tourism resources of wider surrounding area.

KARSTERO: A SPECIFIED QUANTITATIVE MODEL FOR PREDICTING SOIL-EROSION PROCESS IN KARST MEDITERRANEAN LANDSCAPES USING REMOTE SENSING AND GIS, CASE STUDY LEBANON

R. Bou Kheir[1], C. Abdallah[1], J. Chorowicz[2]

[1]National Council for Scientific Research/Remote Sensing Center, P.O. Box: 11-8281, Beirut, Lebanon. Tel: +961-4-409845/6; fax: +961-4-409847; E-mail: raniabk@cnrs.edu.lb

[2]Université Pierre & Marie Curie, Laboratoire de Tectonique, case 129, 4 place Jussieu, F 75252 Paris cedex 05, France. Tel: +33 1 44 27 50 89; fax: +33 1 44 27 50 85; E-mail: jean.chorowicz@lgs.jussieu.fr

Abstract
Over the last three decades, there has been a growing awareness of the gravity of problems related to land degradation in Mediterranean environments. Though a lot has been done and achieved in water erosion research, there is no emphasis on predicting erosion on specific environments, i.e. the peculiar and attractive karst landscapes commonly distributed in the Mediterranean region (e.g. 70% of the total area of Lebanon). The general objective of this work is to define and conceptualize in the frame of remote sensing and GIS a regional quantitative empirical model named "KARSTERO", specified to predict erosion in dynamic karst landscapes at a scale of approximately 1:100,000, over a representative region in Lebanon. The built model integrates, in addition to several common geographical factors such as soil erodibility, topography, etc. considered by all previous erosion models, a new factor "*Rock infiltration*" which is considered as a relatively static parameter allowing a better prediction of the dynamic soil-water erosion process. This factor is determined using GIS through the combination of lithology, lineaments frequency density, karstification and drainage density. Statistical validation, depending on visual indicators observed on about 160 field sites, proves a good overall correspondence between the obtained erosion risk map and field observations (i.e. total precision ~ 88%). The model used seems to be applicable to other areas of the Mediterranean region, constituting a tool for soil conservation planning and sustainable management.

Keywords: karst environments, erosion, land degradation, GIS, remote sensing, rock infiltration.

MODERN TOOLS FOR ASSESSING, MONITORING AND PREDICTING NATURAL ATTENUATION OF CONTAMINANTS IN KARST

Traian Brad

Romanian Academy, Institute of Speleology "Emil Racovita", Clinicilor 5, P. O. Box 58, Cluj – Napoca, Romania, E-mail: traian99@yahoo.com

Abstract
Groundwater pollution is an apparent and unfortunate phenomenon in karst. Surface contaminants are continuously driven in the karstic system polluting the groundwater, the most important drinking water resource all over the world. However, the groundwater ecosystem has an intrinsic capacity of natural attenuation of many pollutants by the presence and activity of degrading microorganisms. The identification of the potential for contaminant biodegradation of the groundwater ecosystem requires information on the identity and activity of groundwater dwelling organisms.
Classical identification of groundwater organisms, either prokaryotic (e.g. bacteria) or eukaryotic (e.g. protozoa, fungi, metazoa), is difficult, time consuming and involves the presence of taxonomists for each group of organisms. We propose here the application of modern tools for studying the community structure and composition in relationship with the environmental factors and the process of natural attenuation of contaminants in karst. Culture-independent molecular techniques of DNA fingerprinting are useful tools for determining the community structure in environmental samples. PCR-amplified rRNA gene fragments are subjected to molecular fingerprinting methods such as DGGE (denaturing gradient gel electrophoresis). DGGE gel images can be analyzed statistically and the community structure, as obtained in DGGE profiles, can be related to environmental characteristics (e.g. pollution). By identifying functional genes involved in biochemical pathways of contaminant biodegradation, one can determine the potential for pollutant natural attenuation of the (karst) groundwater ecosystem. By cloning and sequencing of phylogenetic markers, such as ribosomal or mitochondrial genes, groundwater inhabitants can be identified without the need of culturing approaches in case of microorganisms, and without dissection procedures and morphological identification of groundwater metazoa, respectively.

Integrated knowledge on the community structure and hydrogeochemistry of polluted groundwater in karst ecosystem, as well as information on how the community is affected by the polluted environment and vice versa, may well help in the development of tools for assessing, monitoring and predicting natural attenuation, as natural attenuation appears the least expensive mean of bioremediation.

THREATS TO KARST GEO-HERITAGE SITES IN UNDEVELOPED REGIONS OF SERBIA

Jelena Ćalić

Geographic Institute "Jovan Cvijic" of the Serbian Academy of Sciences and Arts, Djure Jakšića 9, Beograd, Serbia and Montenegro, j.calic@sezampro.yu

Abstract
Greatest part of Serbian karst is situated in economically undeveloped regions of the country. In the background of the wide-spread claims for modalities of future prosperity and development of those regions by means of tourism industry, there are serious threats to the environment in general and to some particular karst geo-heritage sites which are often being considered as the potential tourist attractions. Rushing into partial investments without the appropriate management and conservation strategies is conspicuously in disagreement with the principles of sustainable development. The paper gives the analysis of three various examples of inadequate karst sites management, suggestions for improvement of the situation, as well as some other briefly mentioned cases of misuse and erroneous valorization.

A FIRST ATTEMPT IN EVALUATING THE HUMAN DISTURBANCE TO ITALIAN KARST ENVIRONMENTS.

Fabiana Calò

National Research Council of Italy (CNR), Via Amendola 122-I, Bari, Italy, E-mail: fabianacl@libero.it

Abstract
Karst environments are extremely vulnerable to degradation and pollution because of their peculiar geological and hydrogeological features. In these environments, any anthropogenic activity should be carefully managed in order to reduce as much as possible the likely negative effects on both surface and subsurface karst. To evaluate the human disturbance to a typical karst environment of Italy, some areas have been selected in Apulia, a mostly carbonate region in the south-eastern part of the country. The effects deriving from anthropogenic activities are being assessed through a combined use of direct experience and field surveys, and the critical evaluation of data available in different branches of the scientific literature, from botanics to biology, hydrogeology, etc. Even law issues have been considered, due to the recent foundation of a national park in the area.
By applying a recently developed karst disturbance index (KDI), the human disturbance to the karst setting in Alta Murgia is determined and discussed in this contribution. KDI is a hierarchical index based upon the definition of different categories (covering physical, biological, and social aspects), and the evaluation of a number of indicators for each category. Scores are attributed to the indicators, to assess how much the human activity has impacted the karst environment. In the study area, the most dangerous activities for natural caves and karst surface landforms are quarrying and stone clearing practices, both extensively diffuse and that are heavily changing the original karst landscape. In addition, many natural caves have been partially or totally destroyed because of these activities.

The results so far obtained for the study area represent a preliminary evaluation of the human disturbance to karst in Apulia, but have to be necessarily integrated by further applications in other karst areas of the region, aimed at a better understanding of the potentiality of the approach and its feasibility in different karst settings.

HYDROGEOLOGY OF THE COASTAL KARST IN MONTENEGRO

Tijana Danilović

Geoprojekt, Podgorica, Hydrogeological/geotechnical research Institute, Studentska 4, Podgorica, Srbija in Črna gora, E-mail: danilovic_tijana@yahoo.com; geoprojekt@cg.yu

Abstract

Karst of Montenegro belongs to Dinaric karst, which is considered to be classical model of specific morphology and hydrogeology on a world's scale.

Coastal karst of Montenegro is characterised by very complex hydrogeological relations and phenomena, which are conditioned by high degree of karstification and tectonic rupture of carbonate rocks, as well as by a position of flysch barriers. That enables specific relation of fresh and salt water and establishment of a transitional zone between them, whose position changes, depending on the hydraulic gradient of the background aquifer.

As a consequence of all stated above, there are many coastal saline springs and vruljas of extremelly high capacity oscillations, which limits a possibility of quality water supply using local watersouces.

In order to prevent marine water penetration into watersources, it is necessary to study structure of carbonate rocks and flysch sediments, position and dimensions of karstic channels, directions of movement and conditions of groundwater circulation.

A short presentation on some characteristic and interesting hydrogeological relations and phenomena, as well as on some research projects related to groundwater tapping and protection is given in this paper.

THE DISCOVERY AND PROTECTION OF ONE OF THE MOST IMPORTANT ANCIENT METROPOLITAN CAVE SITES OF THE MIDDLE EAST: HOQ CAVE ON SOQOTRA ISLAND, YEMEN

Pierre De Geest

Vrije Universiteit Brussel, Department of Geology (DGLG-WE), Pleinlaan 2, Brussels, Belgium, E-mail: Pierre.De.Geest@vub.ac.be

Abstract

The arid tropical island Soqotra (Yemen), is situated between the Horn of Africa and the Arabian Peninsula in the Indian Ocean. Soqotra has a geodiverse karstic landscape, as more than half of its surface consists of outcropping limestone deposits. Seepage of monsoonal rains has, over the millennia, created many cave systems. Since 2000 the Soqotra Karst Project (SKP) mapped more than 30 km of underground galleries, in about as much different cave systems. Most caves are of international climatological, archaeological and biodiversity importance and some also provide precious water resources.

Hoq Cave, situated in Socotra's northeastern limestone cliffs facing the sea, surprised all. A systematic inventory revealed ancient relics: such as calcified pottery, mural paintings, epigraphs, charcoal fragments, footprints and a wooden tablet with an inscription from the 3rd century CE. Most of the epigraphs refer to merchants arriving from East Africa (Abyssinian), Southern Arabian (pre-Arabic), actual Syria (Palmyrian), but mostly West India (Brahmi) and up to Pakistan, making Hoq cave one of the most metropolitan cave site of the region during the first centuries CE.

Small populations of bats and troglobitic endemic species offer a glimpse into the biogeographical evolutionary perspectives of the biodiversity in the region.
These unique assets are increasingly threatened by unmanaged tourism, including an increase in uncoordinated 'ecotourism'. Although the SKP-team installed a well defined walking pathway up to a certain area inside the cave, vandalism by less careful visitors is now recognizable in previously pristine areas. Some of the most important archaeological features, most of which unstudied, are missing, displaced or visibly damaged.
Currently protection measurements are taken in collaboration with Yemeni Ministries and national and international NGO's. A proposal to include the island in the World Heritage list of UNESCO is currently reviewed. Because there is a high national pressure to develop the site as a show cave, not only the preservation and sustainable management is at stake, but also the ancient cultural hot spot data could be lost in a split second! Therefore the need for support and the following up of an equilibrated action plan is of the up most importance.

TOURISM AND PRESERVATION POLICIES IN KARST AREAS: COMPARISON BETWEEN THE SKOCJAN CAVES (SLOVENIJA) AND THE ARDECHE GORGE (FRANCE)

Melanie Duval

Laboratoire EDYTEM UMR 5204 - CISM - Université de Savoie Institute, Campus scientifique, Le Bourget-du-Lac, France, E-mail: melanie.duval@etu.univ-savoie.fr; melanie_duval@yahoo.fr

Abstract
This aims of this communication is to specify which are the various modes of management of karstic areas in France and Slovenia. On the basis of the natural reserve "les gorges de l'Ardèche" and the Skocjan Caves Regional Park, it will be question to observe which are measurements taken to manage the karstic resource, in particular in comparison with the development of tourism.
Initially, a historical background will specify which are been various times of the installation of a protection system as well as different the stages from the development of tourism.
The second part of this presentation will be interested in current management of these two areas. How karstic areas are considered in comparison with the French and Slovenien laws? Which measurements are actually taken to manage the karstic resource on the level of these two areas? How is the development of tourism thought in comparison with the safeguarding of this karstic resource?
In a last point, this comparative will make it possible to open a more general reflexion on the interactions between karstic natural heritage and tourist development. On this point, the question of the adequate space scales to manage such phenomena will be discussed.

THE JEITA CAVE (LEBANON): AN EXAMPLE OF SUSTAINABLE DEVELOPMENT OF A TYPICAL KARSTIC RESOURCE

Sandrine El Nawwar and Fadi H. Nader*

Department of Geology, American University of Beirut, P.O. Box11-0236/7136 Beirut – Lebanon
*Spélé-Club du Liban, P.O. 70-923, Antelias – Lebanon, E-mail:sce02@aub.edu.lb

Abstract
The Jeita cave, with its subterranean river and long history of exploration, is the most famous cave in Lebanon. Its entrance is situated at some 18 Km from north of Beirut (capital of Lebanon). Although it was documented since 1836, the complete exploration and survey of the Jeita cave network (about 9km) was not achieved before

1958. This cave is entirely within the Lower-Middle Jurassic strata (locally, the Keserouane Formation) which has a stratigraphic thickness of 1000m and consists of dolostone and micritic limestone. During the Late Jurassic-Early Cretaceous, a local uplift occurred in Lebanon resulting in aerially exposing the Keserouane Formation. This led to an initial karstification affecting the Kesrouane strata before burial in the Cetaceous times. In the Neogene, upon the final uplift of Mount Lebanon, this early karstification phase was reactivated.
One of the east-west valleys cross cutting the western flanks of Mount-Lebanon is the Nahr el Kalb valley, which intersects the Lebanese western flexure. There, the impervious Upper Jurassic volcanics and Lower Cretaceous sand are dipping almost vertically. This constitutes a hydrogeological barrier, forcing the outlet of the Jeita underground river to the surface (at the northern side of the valley). This barrier could be the reason for the westernmost, large cave chambers with heights exceeding 60m. The annual precipitation over Lebanon (more than 1200mm) and the steep topography of the area have intensified the observed karstification. The Jeita river, an important regional groundwater resource (discharge ~2.3m^3/s) feeds a million inhabitants in the Beirut city. The Jeita cave follows a sinuous line and the river flows in a westward direction. A ratio of total slope gradient of 1/100 is calculated between the entrance of the cave and its inland extremity. This shows its smooth flat course even though it is sometimes interrupted by several small cascades and rapids. From the west, the Jeita cave starts with large halls and meanders. Through some rapids, the dimension becomes narrower. Going forth, it is spacious with the Thompson's cavern (250m long and 60m wide), Grand Chaos (500m long) and Mroueh's Hall (200m long and 50m wide). The latter two are floored with collapsed blocks. The cave ends with a Y-shaped pattern, where, each branch ends with a siphon.
The western extremity of the Jeita cave hosts momentous halls decorated with huge and delicate speleothems, in two superposed galleries (a lower water-gallery and an upper dry gallery). The cave was considered of a touristic interest; hence it was turned into a show cave in 1969. In the early 1970's, the Lebanese conflict has started and the show cave was closed. In 1995, it was reopened, and currently it receives around 280,000 visitors per year. Visitors are transported in the Lower Gallery by electric boats for a distance of 500m. The Lower gallery is located 60m below the Upper Gallery which consists of 800m of a walking-path. Some conservation measures, such as closing the show cave for a month per year are being applied. The Jeita cave provides a full time job for around 115 residents from the nearby area, where 30% of them are female personnel.
This contribution aims to shed light on the exploration history of the Jeita cave and its socio-economic impact on the Lebanese community. The Jeita cave is considered as an important national karstic resource. Its proper sustainable development is a necessity for optimizing groundwater resources, scientific research and prosperous tourist attraction.

"PEŞTERA URŞILOR DE LA CHIŞCĂU" CAVE – THE IMPACT OF TOURISTIC ACTIVITIES UPON THE CAVE CLIMATE

Ioana Feier

Al. I. Cuza University, Faculty of Geography - Geology, Department of Geography, B-dul Carol I Nr. 22 (corp B), Iasi, Romania, E-mail: ioanafeier@yahoo.com

Abstract
"Peştera Urşilor de la Chişcău" Cave, located in the SE part of Beius Depression, at 482 m a.s.l., is the most important Romanian show cave.
The presence of an important number of Ursus Spelaeus fossils and speleothems, the horizontally of the fossil level and the cavernament's large dimensions, made possible the touristic arrangement of the cave, started in 1976. In this respect, in the superior level of the cave a touristic pathway and two artificial openings (closed by doors) were constructed, and also a complex illuminating system was installed.
At the moment of discovery (1973), the only exchanges with the exterior were possible trough the fissure network of the calcareous rock and the underground river located at the lower level of the cave; a consequence of it the existence of a very stable cave climate.
After 20 years of touristic use, in the touristic part of the cave an increase of temperature and relative humidity was noticed, as well as the presence of a unidirectional air circulation (missing at the moment of discovery) at the superior galleries level, as a consequence of the artificial openings.

In this paper we report the results of a daily monitoring of air temperature and number of tourists, performed between January and October 2003. The analysis of these time series shows a good correlation between the air temperature in different parts of the cave and the outside environment, and also between the air temperature and the number of tourist.
This study is the first of its kind in a Romanian show cave, the obtained results contributing to the understanding of the response of the cave environment to antropic impact and giving a useful tool for those involved in the management of this (and other) caves.

SUSTAINABLE MANAGEMENT OF BRACKISH KARST SPRING PANTAN (CROATIA)

Ivana Fistanić

Građevinsko-arhitektonski fakultet Sveučilišta u Splitu, Hidrologija, Matice Hrvatske 15, Split, Croatia, E-mail: ivana.fistanic@gradst.hr

Abstract
Brackish karst spring Pantan is situated in the vicinity of town Trogir. It is a permanent and abundant coastal spring of the ascending type. The opening of the spring is located in the contact zone between the limestone and flysch layers while the catchment area is formed of highly permeable limestone rocks. Flysch zone presents incomplete barrier towards the sea resulting with sea water intrusion into the spring aquifer. Therefore, the main characteristic of the spring is periodical salinity during the year with the highest salinity during summer months. The other particularity of this spring is swampy area which presents unique area on the eastern Adriatic coast mostly characterized by dry karst areas.
During the past period water from Pantan spring was used for irrigation as well as for the purposes of fish-farm situated in the vicinity of the spring. In the same time extensive water investigations have been taken for the purpose of finding solution of spring desalinization and taking fresh water for the purposes of water supply. Though these investigations gave some assumptions about spring functioning concrete solution of spring desalinisation has never been achieved. Meanwhile, due to bed watershed management water quality of Pantan spring is permanently devastated. Close to the spring main road is located as well as waste deposits. Today salinity of the water is not the main problem comparing to the other parameters of water quality.
Unfortunately Pantan karst spring presents an example of not preserving balance between natural resources on karst and human interventions in watershed area. Human pressure and bad spatial planning made serious consequences on Pantan water quality. It is not possible to use water for the watersupply but it still possible to use it for other purposes as for irrigation, fish-farm and as tourist attraction. All further measures should be directed on further protection of karst environment. Pantan spring is unique area and social and economic development should not have the advantage over environment protection. This paper will present state of the spring as well as further measures of sustainable management directed to the preservation of this distinct karst ecosystem.

HERITAGE AND PATRIMONIAL RESOURCES IN A KARSTIC MOUNTAIN: THE PROTECTION OF THE CAVES OF CHORANCHE (VERCORS, FRANCE)

Christophe Gauchon

Laboratoire EDYTEM, Université de Savoie, E-mail : Christophe.gauchon@univ-savoie.fr

Abstract
In January 2006, the French ministry of Ecology launches the procedure of classification of the caves of Choranche and the massif of Coulmes (North-west Vercors, French Préalpes). Within the framework of the preparation of a file for UNESCO "World Heritage" relating to 18 sintered cavities, it is necessary to furnish the proof that the goods proposed with the inscription are indeed protected by the State carrying the file. However, until now, the karstic network of the caves of Choranche does not profit from any lawful protection. They are arranged for tourism since 1967 and this exploitation is completely compatible with the conservation of the site. So, if no direct threat weighs actually on this karstic unit, one of the villages of the plate a long time planned to collect the underground river of Gournier, which would have serious consequences on the formation of the tuffs to the downstream of emergence. The file of classification must thus meet three aims: 1°, to establish the scientific, picturesque, historical, artistic or legendary interest of the site, because such are the five criteria envisaged by the law of 1930 which governs the protection of the natural sites in France. In the case of the caves of Choranche, the artistic and legendary interests are hardly concerned; it is thus on the three other registers which work carries. 2°, to define the perimeter of classification, which is an extremely delicate task because part of the plate is populated by farmers who fear for their activity. 3°, to propose a book of management of classified space, by taking into account all the activities present, as much economic than of leisures. It was thus necessary to initially identify the many and various patrimonial resources which could justify the protection measure. To the first rank speleothems come, and especially the straw stalactites ones of Coufin, which won the site of Choranche to appear in file UNESCO. Everyone agrees on the value of these speleothems, but their necessary protection immediately brings interests into conflict as soon as the discussion is about the delimitation of the competent protection area: is it enough to classify the piece under which it opens? Or the scientific expertise must try to identify all the zone of supply of speleothems? Second resource, water: the North-West of Vercors constitutes a forest karst of medium mountains, abundantly sprinkled, but the communes of the plate have very little of water resources. Moreover, the networks are in bad condition. If water does not miss, it constitutes a very coveted resource. But the scientific study made also emerge other patrimonial resources. On the scientific level, it is the karst of Coulmes as a whole which deserves to be protected: three large underground rivers run indeed under the plate of Coulmes and form a whole of penetrable emergences, perched 400 meters above the bottom of the valley of Bourne. The explored speleological networks (> 40 km) present all the panoply of the endokarstic forms, whereas on the surface, it is spectacular a karst with hillocks which is preserved, with many unroofed caves. The waterfalls of Gournier present also a complex of tuffa, with several tens of produced tons each year. This diversity of the forms is translated on the picturesque level because the landscape formed by the circus of Choranche, dominated by high limestone ochres cliffs, is imposing. These landscapes are marked by a whole series of violent one contrasts between the inside and the outside, the vertical one and the horizontal one, the mineral and the plant… Lastly, the historical interest, more discrete, is not less real, with at the same time archaeological layers under the porch of Coufin, important paleontological layers in several cavities (Coufin, Pré L'Etang) and the traces of old tourist visits, especially in the cave of Balme Etrange (years 1830). The patrimonial interest of the site is thus easy to show. All becomes complicated when they are to convince the actors of the good founded the protection measures to be taken. Indeed, if the professionals of tourism support this project of classification, the same does not apply for from there farmers, hunters and of part of the owners who do not approve this measure. One sees by there that the patrimonial management of the resources of the karst remains a delicate problem, especially if a true teaching work did not precede launching by these procedures.

COMPARISON OF LANDSCAPE CHANGES ON KARST AREAS IN HUNGARY AND CHINA

Horváth Gergely[1], Móga János[1], Leél-Őssy Szabolcs[1],
Zámbó László[1]

Institute of Geography and Earth Sciences, Faculty of Science, Eötvös Loránd University, 1117 Budapest, Pázmány sétány 1/C.

Abstract
Having investigated the impacts of changes on the landscapes caused by the nature and the society it can be stated that on karstic landscapes – which are very sensitive ecological indicators – very negative, moreover irreversible processes take place, anthropogeneous and natural-anthropogeneous processes result considerable degradation. These processes are especially dominant in China, where agricultural activities, deforestation, enlarging of the settlements, demands on building materials, and increasing landscape loading caused by the tourism result considerable landscape degradation. First of all the great population density and, as its consequence, the increasing demand for the land use, in addition, the irregularity of this expansion and the priority of the economical growth (surpassing all other factors), and the unsettled attitudes toward the landscape protection have crucial importance in the landscape degradation. In contradiction, the situation is better in Hungary, where karst areas are not the main spaces of the economical activity, apart from some mining areas in the Transdanubian Hills. Moreover, due to the nature conservancy some karst areas – like the Aggtelek Karst Area and the Bükk Mts. – have been luckily preserved in relatively good condition. On the other hand a special situation is in Hungary that there are towns settled above especially vulnerable karst areas. Beyond these aspects, as a consequence of the political changes of the past decades nowadays the aggressive attack of the private interest, which thrusts the public interest into the background, is the most dangerous tendency on the landscape forming.

A PAN-EUROPEAN APPROACH TO MAPPING GROUNDWATER VULNERABILITY AND CONTAMINATION RISK FOR THE PROTECTION OF KARST AQUIFERS

Nico Goldscheider

University of Neuchâtel, Centre of Hydrogeology (CHYN), Rue Emile- Argand 11- CP 158, Neuchâtel, Switzerland, E-mail: nico.goldscheider@unine.ch

Abstract
Carbonate rocks, most of which are karstified, cover one third of the land surface of Europe. Karst aquifers hold important groundwater resources that contribute significantly to the drinking water supply, e.g. 12–36 % in Belgium, Croatia, France, Spain, Switzerland and the UK, and 50 % in Slovenia and Austria. Some big cities, like Vienna, depend nearly entirely on this resource. At the same time, karst aquifers are particularly vulnerable to contamination due to their particular characteristics. Contaminants can easily enter the subsurface, either diffusely through shallow soils or point-like via swallow holes. Inside the aquifer, they can be rapidly transported over large distances, while attenuation processes operate less effectively than in other aquifers. Therefore, the European COST Action 620 proposed a comprehensive approach to "vulnerability and risk mapping, for the protection of carbonate (karst) aquifers". The project was given impetus by the European Water Framework Directive, which is intended to provide a common framework for water resource policy and management.
The pan-European approach includes methods of intrinsic and specific vulnerability mapping, hazard assessment, risk mapping, and validation. The maps can be prepared for resource and source protection. The methodology is based on an origin-pathway-target model. The origin is the point of potential contaminant release; the pathway comprises all compartments between the origin and the target, which might be the groundwater table (resource) or a particular spring (source). The intrinsic vulnerability only takes into account the hydrogeological properties of the aquifer system, such as overlying layers and flow concentration. The specific vulnerability additionally considers the interactions between particular contaminants and the hydrogeological system. Hazards are defined as potential contamination sources. The risk map is obtained by overlaying the vulnerability and hazard maps. Different techniques, including the use of natural and artificial tracers, can be used to validate the vulnerability and risk assessment. The new methodology was successfully tested in different European karst areas, and a simplification has been proposed for the application in developing countries.

MICROBIAL CONTAMINATION IN KARST GROUNDWATER: FUNDAMENTALS AND MONITORING STRATEGIES

Nico Goldscheider

University of Neuchâtel, Centre of Hydrogeology (CHYN), Rue Emile- Argand 11- CP 158, Neuchâtel, Switzerland, E-mail: nico.goldscheider@unine.ch

Abstract
Microbial pathogens are among the most problematic contaminants in karst groundwater. The detection of faecal bacteria in a water sample indicates the possible presence of pathogenic bacteria, protozoans and viruses. Faecal bacteria often originate from domestic wastewater and agricultural activities, like cattle pasture or liquid manure spreading. Karst aquifers are particularly vulnerable to contamination. In recharge periods, contaminants from the land surface can easily enter the aquifer, either diffusely by infiltration through the soil or concentrated via swallow holes, and are rapidly transported in the conduit network without significant attenuation. Karst aquifers are characterised by strong variations of spring discharge, physicochemical and microbiological water composition in response to hydrologic events. Monitoring the bacteriological water quality requires sterile water sampling and subsequent laboratory analyses, whereas various physicochemical properties can be measured continuously and online. These easy-to-measure parameters could consequently be used as indicators for the presence of microbial pathogens. Detailed spring monitoring in a karst aquifer system near Yverdon (Switzerland) and other test sites made it possible to better understand the variability and complex interaction between spring discharge, physicochemical parameters, suspended mineral particles (turbidity), organic carbon and faecal bacteria. On this basis, innovative monitoring techniques and protection strategies can be designed.
The abstract should be concise and should present aim of the work, essential results and conclusion. It should be typed in Times New Roman, 10, single spaced, fully justified.

WHEN IS A KARST RESOURCE FEATURE DAMAGED OR RENDERED INEFFECTIVE?: A CONCEPTUAL APPROACH.

Paul Griffiths[1], Carol Ramsey[2]

[1]Cave Management Services/KarstCare, 544 Springbok Road, Campbell River, British Columbia, Canada V9W 8A2, E-mail pgriff@island.net
[2]206 – 1501 Richmond Avenue, Victoria, British Columbia, Canada V8R 4P7, E-mail: sciurus46@yahoo.ca

Abstract
British Columbia (BC) is Canada's most ecologically diverse province and home to some of the nation's finest karst resources including a significant percentage of the world's globally-rare temperate rainforest karst. BC's coastal karst areas support highly productive forests; the surface and subsurface elements of associated karst systems can be especially susceptible to modification by timber harvesting activities. Beginning in 1997, the province adopted an ecosystem-based approach to managing cave and karst resources in forest lands. The *Forest and Range Practices Act* (FRPA), a results-based regulatory framework for forest practices, was introduced in January 2004. Under FRPA, orders can be made to identify categories of karst resource features that will be subject to a legal practice requirement (i.e., a result). Once these orders are established, the onus will be on forest companies to meet the practice requirement of "*not damaging or rendering ineffective a resource feature*". What is meant by "damaging or rendering ineffective" has not yet been established and remains subject to

widely differing interpretations. This paper presents a conceptual approach to determining when karst resource features are damaged or rendered ineffective.

SUSTAINABLE MAPPING OF CAVES

Philipp Häuselmann

Haldenstr. 32, Bern, Switzerland, E-mail: praezis@speleo.ch

Abstract
Mapping of caves is prerequisite for any other scientific or touristical work. However, mapping is often incomplete, thus the need to remap a cave arises, impacting the fragile cave environment. The present article aims to show what types of data have to be acquired in order to have a complete and informative cave map. With a complete map, the cave environment is protected, time (and money) is saved, and all necessary information is available.

HYDROLOGICAL AND HYDROGEOCHEMICAL COMPARISON OF BASINS WITH DIFFERENT GEOLOGICAL BASEMENT IN SLOVAKIA

Oliver Horvát[1], Zuzana Makišová[2]

[1]Slovak University of Technology, Faculty of Civil Engineering, Department of Land and Water Resources Management, Radlinského 11, 813 68 Bratislava, Slovak republic, E-mail: horvat@svf.stuba.sk
[2]Comenius University, Faculty of Natural Sciences, Department of Hydrogeology, Mlynská dolina, 842 15 Bratislava, Slovak republic, E-mail: makisova@fns.uniba.sk

Abstract
One of the main goals of our project was to obtain the influence of geological basement on hydrological cycle, especially in karst environment. Subbasins located in karst were compared with subbasins located in different types of geological structures. Our rainfall-runoff model FRIER (Water Distribution (Flow, Routing, IUH) Model with Accent to Evapotranspiration and Radiation Methods) was used to calculate water balance and simulation of discharge. FRIER is physically based hydrological model and simulates hydrological processes in vertical and also horizontal direction for which the water and energy balance are maintained on each raster cell in GIS interface.
The parameters of chemical composition of groundwater from selected springs, wells and boreholes from the area of interest were gained from the archive materials and by sampling in field. The reactions which are creating the chemical composition were characterized. The quality of groundwater, the character and sources of groundwater pollutions were determined.

Keywords: karst, water balance, hydrological model FRIER, geographical information system - GIS, geological basement, dissolution of carbonates.

EXPLOITATION OF NATURAL RESOURCES AND THEIR ENVIROMENTAL IMPACTS IN INDIA

Vinod Kumar Jena

Pt. Ravishankar Shukla University, School of Studies in Chemistry, Amanaka, Raipur, India, E-mail: patelsing@satyam.net.in

Abstract

The natural resourced materials (NRMs) i.e. coal and minerals contain the toxicants i.e. arsenic (As) at trace levels. Their huge exploitation in unsustainable order results in deposition of the arsenic in the environment. Their contamination to water, soil and food are detected in various sites of the country. Their sources, extents and toxicities in various of the country are discussed. Arsenic contamination is a global problem now. It virtually appears on all continents. Arsenic contamination of groundwater is a global environmental problem affecting a large number of populations, especially in developing countries. In several Asian countries, i.e. India, Bangladesh, Cambodia, China, Nepal, Pakistan, Taiwan, Thailand, Vietnam, etc., the situation of arsenic toxicity is alarming with reports of severe health problems among the populations. In Bangladesh, high arsenic concentrations are suspected to exist so far in 53 districts out of the total 64 and people of 34 districts have been found to be suffering from various affections caused by arsenic pollution. The West Bengal State of India, which surrounds Bangladesh's west and north border, is also an Arsenic-affected zone because of the geological similarity. But the situation in Bangladesh is more alarming compared to West Bengal. It occurs as results of geological processes and human activities which include agriculture, manufacturing, mining, smelting, coal burning, etc. The arsenic cycle has broadened as a consequence of human interference and due to this, large amounts of arsenic end up in the environment and in living organisms. The Arsenic pollution has been creating serious social problems for the affected people. Plants absorb arsenic fairly easily, so that high-ranking concentrations may be present in food. The concentrations of the dangerous inorganic arsenics that are currently present in surface waters enhance the chances of alteration of genetic materials of fish. Exposure to inorganic arsenics can cause various health effects, such as irritation of the stomach and intestines, decreased production of red and white blood cells, skin changes and lung irritation. It is suggested that the uptake of significant amounts of inorganic arsenic can intensify the chances of cancer development, especially the chances of development of skin cancer, lung cancer, liver cancer and lymphatic cancer. A very high exposure to inorganic arsenic can cause infertility and miscarriages with women, and it can cause skin disturbances, declined resistance to infections, heart disruptions and brain damage with both men and women. Finally, inorganic arsenics can damage DNA. Organic arsenics can cause neither cancer, nor DNA damage. But exposure to high doses may cause certain effects to human health, such as nerve injury and stomachaches.

Recently, the arsenic contamination of water in several states (i.e. Best Bengal, Bihar, Utter Pradesh, Andhra Pradesh, Chattisgarh, etc.) of India was reported. The spreading of arsenic pollution and their causes, accumulation in common food and health impact are discussed.

Remnant hydrothermal karst activity in light of hydrochemical studies of springs in the Cracow-Czestochowa Upland (S Poland)

Agata Koptyńska, Andrzej Tyc

Department of Geomorphology, University of Silesia, ul. Bedzinska 60, 41-200 Sosnowiec, Poland

Cracow-Czestochowa Upland is an example of relict or denuded karst. One of the significant feature of this region is that carbonate massif built by the Triassic and Jurassic limestone is situated in the zone of very active tectonic faulting in the past. The contact zone of two large tectonic blocks (Małopolska and Upper Silesian) influenced sedimentation, tectonic structure and later karst evolution Mesozoic carbonate massifs. Great part of relict karst features of the central Cracow-Czestochowa Upland are effects of hydrothermal processes, associated by dolomitization, silification and Zn-Pb or Fe mineralization of carbonates. Almost all terrain is covered by Pleistocene sandy or loamy sediments which can suppress possible present day remnant processes related to this tectonic activity. Authors presents results of hydrochemical regime studies of this possible contemporary traces of hydrothermal processes or gaseous emanations of CO_2 realized by springs discharge. Based on long term investigations (almost 20 years of observations), two years of special hydrochemical studies of several springs with stable discharge, the traces of remnant hydrothermal karst processes were found. Results of hydrochemical researches and karst morphology were connected with the geologic and tectonic structure of the contact zone between mentioned two tectonic blocks in the base of karst massive using GIS methods.

MALI DOL - A DRY VALLEY IN KRAS (CLASSICAL KARST)

J. Košutnik

Department of Geography, Faculty of Arts, University of Ljubljana, E-mail: jurekosutnik@gmail.com

Abstract
In Kras we can find at least two uncharacteristic valley-like oblique, which were interpreted by older geomorphologiests as river valleys which are now dry, from the so called prekarstic fluvial faze of geomorphologic development. With the new knowledge of denudated caves theory I thoroughly studied the valleys for my thesis. I was especially careful about finding non-carbonate pebbles and autochthonous flowstone. Mali dol (Little dry valley) has it's bottom from 50 to 75 meters above the karstic plane, it is 10 kilometers long, runs in the perpendicular to the dinaric direction and meanders heavily. In the bottom of the dry valley deep, elliptic dolines, thickly covered with read karstic soil, have been formed.
We can say that Mali dol is a polygenetic form. After the planation of Kras in the heights of the piezometric level a river was running from at that point elevated Vipava valley. Before the river sinked into the underground of now tectonically elevated Kras it made a relatively deep valley. Proof of that are rare silica pebbles which are mixed with the red karstic soil. Soil derives from Paleocene, from tropical climate. It was sedimented into the valleys later. Because of the thick soil cover the lateral corrosion made deep dolines inside the basic valley-like form. Some dolines may be of collapse origin. Local faults and thick soil cover allow water to flow above ground into the valley. Deep and steep erosion gullies were made, which were formerly interpreted as alohtonous tributaries of the main river.

KARST WATER MANAGEMENT IN SLOVENIA IN THE FRAME OF VULNERABILITY MAPPING

Gregor Kovačič[1], Nataša Ravbar[2]

[1] University of Primorska, Faculty of Humanities Koper, Glagoljaška 8, SI-6000 Koper, Slovenia & University of Primorska, Science and research centre of Koper, Garibaldijeva 1, SI-6000 Koper, Slovenia, e-mail: regor.kovacic@fhs-kp.si
[2] Karst Research Institute, ZRC SAZU, Titov trg 2, SI-6230 Postojna, Slovenia, e-mail: natasa.ravbar@zrc-sazu.si

Abstract
Slovene karst sources are of great national importance for drinking water supply. Since karst aquifer systems are very susceptible to contamination, these sources require appropriate and careful managing. Unfortunately, in the acts of Slovene legislation, the special characteristics of water flow within karst regions are not very seriously taken into consideration in the frame of determining the criteria for karst water sources protection. In opposite, in some of the countries, the concept of groundwater vulnerability mapping has been successfully used for protection zoning and land use planning in karst. Regarding the differences between particular karst aquifer systems, data availability and economic resources, different methods of karst water vulnerability assessment and mapping have been developed, which have been implemented and many times tested in different test sites worldwide.
However, experiences on application using different methodologies for vulnerability mapping of karst aquifers are very modest in Slovenia. In the present article stress to potential methodological problems that might arise while applying the most commonly used methods for karst water vulnerability assessment to Slovene karst regions, the advantages and disadvantages of each are subjected and described.

Keywords: karst water management, karst sources protection, drinking water, vulnerability assessment and mapping, Slovenia.

VULNERABILITY OF THE KARST – FISSURE HYDROGEOLOGIC STRUCTURES SOUTH–FACING SLOPES OF THE LOW TATRAS MTS.

Erika Kováčová

Geological Survey of Slovak Republic, Hydrogeology and Geothermal Energy, Mlynská dolina 1, Bratislava, Slovakia, E-mail: kovacova@geology.sk

Abstract

The concept of groundwater vulnerability is based on the assumption that the physical environment may provide some degree of protection to groundwater from anthropogenic and natural impacts, and that the degree of vulnerability is a function of hydrogeologic settings. Understanding the groundwater flow system enables to determine the potentially important factors controlling the "intrinsic vulnerability" of a ground water resource. For this study, an "intrinsic vulnerability" for any contamination in general is considered using Kullman´s method (2000), that is based on the assessment of the degree of groundwater vulnerability depending on the rock disruption and karstification. The spring depletion hydrograph enables to assign the individual laminar and turbulent sub-regimes that occur in the karst-fissure rock environment. Differences in character of individual depletion hygrograms enable assessment of the anticipated possibility of absorption, attenuation and self-purification processes during the groundwater penetration through the rock environment. The method was applied on the Mesozoic rock environment in the southern slopes of the Low Tatras mountains. In total, 292 recession curves from 32 gauged springs were analyzed.

The result of this study is, that the carbonate rock environment reach only lower half of the complete 10 degree range of the Kullman´s vulnerability scheme (2000) adjusted by Malík (2005), with maximum of a 5,5 degree. Lowest vulnerability is recognized in Ramsau dolomites, Choč dolomites and limestones, dolomites and cherty limestones. Only a laminar groundwater flow is present here, usually combination two or more sub-regimes characterized by different discharge coefficient. The risk of extensive groundwater contamination is very low. Medium vulnerability rating can by find in carbonatic Vajsková conglomerates, where combination of two or more regimes with laminar flow is present. Rock environment is characterized by irregularly developed fissure network, with majority of open macro-fissures. The risk of more extensive groundwater contamination is low. The highest vulnerability rating is linked to Gutenstein limestones, Hauptdolomites and rauwackes. Regime of groundwater flow is created by superposition of sub-regimes with turbulent flow and sub-regimes with laminar flow. Substantial role in groundwater discharge has a sub-regime with laminar flow. Rock environment is characterized by prevalence open karstic and non-karstic fissures in the waterlogged karst-fissure. The risk of more extensive and also limited point groundwater contamination is high, with limited possibility of its retention, fixation, but mainly dilution. A surprising presence of turbulent subregimes was discovered for two outflows of mine water in non-karstic rock environment. Three hydraulic systems of groundwater flow were recognized by Kullman (1984) in the most important hydrogeological structure in the southern slopes of the Nízke Tatry Mts. between Podbrezová, Krpáčovo, Jasenie and Lopej. The second one – an open fault zone crossing the Vajskovská valley, is characterized by sub-regimes with turbulent flow and sub-regimes with laminar flow. The vulnerability of groundwater is higher than a vulnerability of the third hydraulic system, where only single laminar sub-regime was found. The first hydraulic open fault system could not by evaluated because of insufficient data. The daily and weekly observed data on groundwater discharge and temperature, obtained from Slovak Hydrometeorological Institute (SHMI) were used for this groundwater vulnerability assessment. Daily data are more representative and enable more sensitive hydrograph analyses and even more correct estimates of a groundwater vulnerability to pollution by this undemanding method.

PREVENTION AND PRESENTATION OF KARST PHENOMENA – EXAMPLES OF GEOLOGICAL EDUCATIONAL TRAILS FROM BIOKOVO NATURE PARK AND UČKA NATURE PARK IN CROATIA

Damir Lacković

Hrvatski prirodoslovni muzej, Demetrova 1, 10000 Zagreb**,** E-mail: damir.lackovic@hpm.hr

Abstract
Isolated elements of karstic heritage are usually stored and presented in the natural history museums and collections. However, integral karstic phenomena in their original environment can be preserved and presented only in nature (in situ). Geological educational trails in Biokovo Nature Park and Učka Nature Park in Croatia are examples of this approach. On this site visitors can touch and feel karst phenomena in direct contact with the environment. Through educational boards they learn how to appreciate the significance and value of karst phenomena, which is a first step towards the successful protection. Presented effect of chemical weathering of carbonate rocks are karren, kamenitzas, limestone column, dolines, shafts and caves.
Such "open exhibition" of karst phenomena also enriches the tourist offer.

Keywords: Karst Phenomena Prevention and Presentation, Biokovo Nature Park, Učka Nature Park, Geological Educational Trail, "Open Exhibition".

Picture 1, 2 and 3
Sketch presentation of limestone weathering and erosion during geological time, from "Geological educational trail Vela draga", Učka nature park, Croatia.
Sketched By Trpimir Vedriš.

KARSTOLOGICAL MONITORING OF OBJECTS AS A MEANS OF SUSTAINABLE DEVELOPMENT OF KARST TERRAINS

Mikhail Leonenko

Antikarst and River Bank Protection, 33 Mayakovsky Street, Dzerzhinsk, Russia, E-mail: karst@kis.ru

Abstract
Establishment and operation of chemical plants in karst terrains is associated with a potential risk of pollution. Karst sinkholes developing beneath environmentally hazardous industrial constructions can cause their destruction. As a result chemicals can penetrate into the rock and pollute the ground water. Development of karst caverns in covered karst is accompanied by gradual changes in overburden physical characteristics. At the stages immediately followed by collapses these changes become significant enough to be registered by instrumental methods. Geophysical and geodetic monitoring of the subterranean environment at the sites of chemical plants location can be used for prediction of catastrophic collapses. Management of karst collapse development is aimed to prevent negative impacts through implementation of protection programs in due time. Karstological monitoring practice on an industrial enterprise in Dzerzhinsk is considered.

QUATERNARY PALAEONTOLOGY OF BIOKOVO

Kazimir Miculinić[1]& Siniša Radović

[1]Zavod za paleontologiju i geologiju kvartara HAZU, Ante Kovačića 5, Zagreb, Croatia, E-mail: miculinic@hazu.hr

Abstract
Mountain of Biokovo is situated in the south coastal part of Croatia, and major part of it is under management of Nature Park Biokovo. During recent paleontological researches of the two caves, remains of Pleistocene fauna were found in their sediments as well as traces of devastation of cave and fossil contain. Collected skeletal remains are scientifically valuable as a marker of faunal associations at mountain Biokovo in the Upper Pleistocene. Beside their scientific character the remains are interesting as a possible educational and exposal examples of animals that inhabit that area in the past.

CONTRIBUTION OF SIMPLY HYDROGEOLOGICAL INDICATING METHODS IN BY CONTAMINATION IMPACTED ENVIRONMENTS

Slavomír Mikita

Department of hydrogeology, Faculty of Natural Sciences, Comenius University Bratislava, Mlynská dolina, Slovakia, E-mail: mikita@fns.uniba.sk

Abstract
The requirements for water treatment in sensitive karsts system with its incline area have a very high priority. Contamination must be detected, considered and predicted and also it's necessary to know how we can control and minimize the contamination.
In the project of Environmental Government of Slovak Republic during 4 years period the influences of different contaminant sources on water environment was monitored and assessed. The localities were situated in various geological settings of Western Carpathians.
The knowledge from the project confirms that the source of the contamination and zone of interaction with impacted area are variable in space and time.
An amount of objective and efficient information is necessary to fulfill the requirements for water treatment.

Huge complex of land field methods is therefore essential. The possibility how to minimize the amount of expensive and intricate methods for investigation is to connect them with simply indicating methods. The correlated relations distinguished between contaminant and physical characteristic of water allow using the obtained local information in larger area and repeating them in higher frequency. The economical benefit is relative to increasing demands on space and time.
Although the investigations and control of contaminated local sources interactions in water environment assessment were simple, they were effective and operative enough. *Indicating hydrogeological methods (IHM)* were applied. The base was built on the water electrical conductivity (EC) and water temperature measurements set in situ. Obtained information was processed basically and was added with other field methods results to be amplified.
The basic processing came from screening all waters accessible in solvent area and it does recur in different time in the same positions. It's so possible to assess the relative differences of water features, to map the mass transport paths of contamination, to consider the effects of climatic and hydrological factors on the change of measured dates, to estimate the trends of the data changes development.
The amplified processing follows the basic processing by distinguishing the relations between EC and typical chemical parameter – macrocontaminant which is characteristic for studied area and which we are considering to represent the physical attributes in the selected environment. For that purposes the inert chloride affirm very well. Described procedure allows developing the 3D models of selected contaminated components distribution. It's so possible to monitor the dynamic changes of contamination influences in space and time with relatively dense data net. The achieved information are after the settings of impacted environment *good assumption for various purposes:* to assess of the climatically and hydrological influences on potential contamination spreading from source, to conceive the contamination limitations in space and time, to monitor relative extent of natural degradation and attenuation processes with increasing distance from contaminated source, to predict the trends of contamination spreading.
In general the application of IHM methods in contamination impacted environment is conditioned by water presence and field accessibility, by contrast of different water characters and by anisotropies of geological conditions.

MONTELLO KARST WATERGROUND. CHANGING ITS PERSPECTIVE FROM THE PERCEPTION OF DROUGHT TO A STRATEGICAL WATER RESOURCE

Francesco Ferrarese[1] & Marta Modesto[2]

[1] Universita degli Studi di Padova, Dipartimento di Geografia, Via del Santo 26, Padova, Italy
[2] Museo Civico di Storia Naturale e Archeologia di Montebelluna, Via Piave 41, Montebelluna, Italy

Abstract
The need of water for the inhabitants of the plain situated on the north of the province of Treviso is, with no doubts, connected with the management of the water, as a local natural resource. Thanks mainly to its position, the Montello hill can be considered and analysed as an area of a possible water supply for the surrounding plain.
From an historical point of view, for long time water has been a critical resource for life on the Montello hill. The specific rock formation and the geomorphological structure that characterize this very distinctive low hill, cause the almost total absence of surface water courses, reduced mainly to seasonal events. These tend to be principally streams which flow, in the presence of a clay covering, along the bottom of some little valleys, many of which have been eroded by these self-same water courses. But another typical aspect of Montello's area - and also connected with karsism's processes - is the presence of water springs. There's a total of a hundred of those natural springs at least, and they are widely distributed throughout the surface of the hill. However, since evidence of human settlement has been found on the Montello hill, water sources were surely used and their management was accurate in order to preserve a good quantity of very pure water into the numerous well and storage tanks placed around the springs. By 1960 the connection to the municipal waterworks provided all houses on the hill with water; thus ceased every reason to maintain the natural springs and they were quickly abandoned and neglected.

Regarding this important natural resource, it can be interesting to make a comparison between the past use and the present state of abandon; but it can be even more useful to analyse how they could be used and managed in the future. For example monitoring a certain number of springs, it can be interesting to analyse the hydrological natural balance and the artificial one, taking in account the effective contribution of the water provided by aqueduct.

ECOTOURISM DEVELOPMENT OF THE WHITE DESERT " A KARST TOWER LANDSCAPE" IN THE WESTERN DESERT OF EGYPT

T. Nassar, M. I El Anbaawy

Geology Department, Faculty of Science, Cairo University, Giza 12613, Egypt, E-mail: nassar@ndara.com

Abstract
The White Desert protectorate (the name derived from the snow white colour of chalk covering its floor) is located at the northern periphery of the Farafra Depression in the central part of the Western Desert of Egypt, it resample a large Tower Karst Landscape with numerous other karst features (pedestals, karst bridges, caves and cave deposits); it is bounded by the eastern, western and northern scarps and sand sheets from the south.
The area declared as a national park by the EEAA (Egyptian Environmental Affairs Agency) in 2000 for its unique geomorphologic features. It takes the number 20 in the UNESCO map of Egypt's protected areas (2004).
The White Desert is of great importance for the future development in the New Valley as it is a virgin area for geo-environmental tourism (ecotourism).
Based on geologic, geomorphologic and water resources data; a plan for new tourist routes has been designed, with the aid of landsat images and field check up, to reach the environmental friendly tourism.

GYPSUM KARST AS GROUNDWATER RESOURCE IN NORTHERN CYPRUS

Mehmet Necdet

Geology and Mines Department, Turkish Republic of Northern Cyprus (Mersin 10 Turkey), E-mail: mehnec@kktc.net

Abstract
Cyprus is a semi – arid country and located at the eastern most Mediterranean Region. The main water resource – for irrigation and household use – is the groundwater basins of the island. There is a big demand on water for irrigation but the capacity of groundwater basins are very limited . The pumping rate from gypsum aquifers are limited due to the ionic quality of the water. They occur in seven different areas and the size of these aquifers differs side by side in the northern part of Cyprus. The salinity of the water in gypsum is related with the distance of the pumping point where the gypsum deposit occurs. Moderate saline groundwaters are used to irrigate only selected crops. Groundwater extraction from gypsum aquifers creates sinkhole problems around the pumping areas.

PSEUDO COUNTRY AND SUSTAINABLE MANAGEMENT ON KARTS – CASE OF BOSNIA AND HERZEGOVINA

Dr. Jasmina Osmanković, Mr. Jasminko Mulaomerović

Ekonomski fakultet Sarajevo, Trg oslobodjenja 1, 71000 Sarajevo, BiH, Tel: 387 33 27 59 19, Fax: 387 33 27 59 94

Abstract

Nearly half of Bosnia and Herzegovina's territory consists of karst regions. These are mostly to be found in the Dinaric Alps, with some karst pockets in the north and northeast of the country.

As early as the consolidation of Austro-Hungarian rule at the end of the nineteenth century the issue of managing the karst regions, especially the karst fields, was addressed. This continued, off and on, up until the beginning of the last war. Especially important in this respect has been the development of large power-supply projects in Eastern Herzegovina (in the upper regions of the River Trebisnjica) which coincided with the development of speleology and multi-disciplined research into the BiH karst regions.

During the war, and then after the war in the pseudo-state that was created by the Dayton Peace Agreement, there has been a wholesale destruction of the karst regions, and a general failure of any kind of conservation regime. Demographic processes, which are having a clearly negative impact, will only add to the further degradation of the natural and cultural heritage of BiH' karst regions. The speed of social change does not promise any improvement in this situation in the future.

DIFFICULTIES IN THE PROTECTION OF KARST PHENOMENA IN CROATIA: EXAMPLE OF CAVE IN DEBELJAČA QUARRY AND CAVE IN TOUNJ QUARRY

Dalibor Paar[1,4], Petra Ujević[4], Darko Bakšić[2,4], Damir Lacković[3,4], Ana Čop[4]

[1]Faculty of Science, University of Zagreb, Croatia, E-mail: dpaar@phy.hr
[2]Faculty of Forestry, University of Zagreb, Croatia, E-mail: petraujevic@yahoo.co.uk
[3]Croatian Natural History Museum, Zagreb, Croatia, E-mail: damir.lackovic@hpm.hr
[4]Speleological Section Velebit, Zagreb, Croatia

Abstract

In the poster presentation we shall present difficulties in the protection of two important karst phenomena in Croatia. The Cave in Debeljača quarry was discovered in 2004. while mining in the quarry near Lovinac in Lika region. The Cave in Tounj quarry was discovered in 1983. when the mining it the quarry opened a hole on the top of a large cavern. Both caves are not adequately protected from devastation. The scientific and natural values of these caves will be presented, and the measures for their protection will be analyzed.

SUSTAINABLE MANAGEMENT OF NATURAL AND ENVIRONMENTAL RESOURCES IN THE KARST OF ASPROMONTE (CALABRIA, SOUTHERN ITALY)

Mario Parise [1, 2] Angela Rizzi [3] & Antonio Trocino [2, 3]

(1) CNR-IRPI, Sezione di Bari, Via Amendola 122-I, Bari, Italy, E-mail: m.parise@ba.irpi.cnr.it
(2) Gruppo Puglia Grotte, Castellana-Grotte (BA), Italy
(3) Explora, Italy

Abstract
The Aspromonte Massif, in the southernmost part of Calabria region (southern Italy), hosts a National Park that was founded in 1994 because of the remarkable naturalistic and environmental richness of the area. Several rare species of animals (including wolf, hawk, and eagle-owl), and wide areas forested with beeches, firs, black pines, holm oaks, and chestnuts characterize the inland areas of the massif, where elevations over 2,000 meters above sea level are reached at the highest peaks. Even though a portion of the National Park includes karst, with diffuse outcrops of carbonate rocks, and many surface and subsurface karst features, the actions of safeguard and management of the natural resources carried out so far have not fully considered the peculiarity of such a setting. This is partly due to the scarce knowledge of the Aspromonte karst, as regards explorations of the caves, and the scientific research as well. The present contribution is a first attempt in partly covering the issues above, by describing the topographic and hydrogeological characters of an area in the municipalities of Canolo and Agnana Calabra, in the province of Reggio Calabria. The main activities likely to produce negative effects to the natural environment are examined, starting with mining and quarrying, and the changes they cause in the karst ecosystems. Then, the Zagaria cave at Canolo is dealt with: it is a natural cave that, together with some artificial cavities (old coal mines) at Agnana Calabra, are on the way to be exploited as tourist caves. To this aim, and the ensure the safeguard and conservation of the natural resources, the main instruments adopted by the Aspromonte National Park in managing the area are examined and critically discussed.

THE ORIGIN OF GRAND SHAFT IN THE WIELKA SNIEZNA CAVE (TATRA MOUNTAINS, POLAND)

Patrycja Pawlowska-Bielawska

Univesity of Silesia, Department of the Earth Science, Sosnowiec, Poland, ppwlows@wnoz.us.edu.pl or genpaton@wp.pl

Abstract
The Grand Shaft, which is the part of the greatest cave system in the Tatra Mountains (Poland), the Wielka Sniezna Cave System, is a particular form of regular cross-section. It is 66 m deep, and its volume is estimated for 5100 m3. It developed vertically among the levels 1510-1575 m a.s.l. in the massif, and is well modeled in the hydraulic conditions. The measurements of physio-chemical properties of the water circulating in this cave showed that pure corrosion was not able to create such huge dimensions of pits and galleries of this cave in the conditions similar to actual. Therefore it is obvious, that among the most important factors in the process of that shaft formation, one must take into consideration the factor of effective mechanic erosion as well as significant abundance of water. The sources of rock pebbles for mechanical erosion and the role of extreme events in the shaft's origin is discussed in contribution. The existence of insufficiently effective channel draining the water from the shaft in the evolutionary stage of Sniezna Cave System speleogenesis is taken into consideration for explanation of the shape and dimensions of the Grand Shaft. Some conclusions for the origin of cave pits in general are proposed, too.

DYNAMICS OF AIR TEMPERATURE IN A SHOW CAVE FROM APUSENI MTS., ROMANIA

Aurel Perşoiu

"Emil Racoviță" Institute of Speleology, Geospeleology, Clinicilor 5, PO BOX 58, Cluj-Napoca, Romania

Abstract
In this paper we present the results after two years of air temperature monitoring in Focul Viu Ice Cave, Apuseni Mts., Romania. Focul Viu Ice Cave is a small, descendent cave in the central part of the Bihor Mts., Romania. It is located at an altitude of about 1165 m, in the upper part of a limestone ridge. A small entrance is giving access to a large chamber ("Big Hall", 68x46 m), followed by a smaller one ("Small Hall", 20x5 m). The floor of the Big Hall is fully occupied by a massif ice block (25.000 m3), while the second room is missing this feature. The ceiling of the Big Hall is open to the sky through a large shaft, located at a higher level than the entrance of the cave.
In March 2004 a number of 3 temperature data loggers were installed in the cave: in the Big Hall, in the Small Hall and in the shaft, while a fourth one was measuring the temperature in the outside of the cave, near to the entrance.
The results so far show a strong correlation between the external and the internal air temperature as long as the outside temperatures are below 0ºC, with a general inflow of cold air in the cave through the entrance shaft, while during summer there is no dynamic connection between the two environments, the heat exchange being only of conductive type. As the touristic route is restricted to the entrance shaft, no antropic influence upon air temperature can be recognized.

POSSIBLE CONTAMINATION WITH HEAVY METALS IN KARST SEE LAKE OF ROGOZNICA

Irena Ciglenečki[1*], Srđan Pichler[1], and Božena Ćosović[1]

[1] Department of Marine and Environmental Research, Ruđer Bošković Institute, Bijenička 54, 10000, Zagreb, Croatia

Abstract
Geochemical, mineralogical and sedimentological analyses were carried out to contrast two different sites (respectively characterized by permanently oxic and anoxic conditions) in a small, meromictic, seawater Lake of Rogoznica. Rogoznica Lake has delicate connection over crack system in Karst. Due to relatively high organic matter content, and reduced water exchange, the Rogoznica Lake has almost permanent anoxic conditions below the depth of 12 m, where sediment can be considered an anoxic-sulphidic sedimentary environment. Different water column and sediments redox conditions affect the distribution of major redox-sensitive metals (Fe, Mn, Mo), heavy metals Cu, Cr and Pb, reduced sulphur species (RSS) and dissolved organic C (DOC). Trace metals, especially those that accumulate in anoxic-sulfidic environments (Fe, Mo) showed a marked enrichment in the solid phase, whereas the low solubility of sulphides leads to low pore water concentrations.
For all analysed metals only Cu, Cr and Pb had high concentration in sediment (oxic and anoxic samples), which show on possible anthropogenic beringing. Lead comes from Pb-petrol which is by combustion connected as aerosol in atmosphere, and like that is deposited in Lake sediment.

Keywords: anoxia, geochemistry, heavy metals, Fe, Mn, Mo, pore water, sediment, Karst, Rogoznica Lake.

ESTIMATING TOTAL SPECIES RICHNESS OF EPIKARST COPEPODS (CRUSTACEA, COPEPODA) IN A »HOTSPOT« IN SLOVENIA

Tanja pipan[1] & David C. Culver[2]

[1]Karst Research Institute, ZRC SAZU, Titov trg 2, 6230 Postojna, Slovenia, Europe;
[2]Department of Biology, American University, 4400 Massachusetts Ave. NW, Washington, DC, USA;

Abstract
The epikarst zone is the karst layer closest to the surface. It is the interface zone between soil and rock characterized by small fractures and solution pockets. Although epikarst harbors a rich copepod fauna, it has been little studied quantitatively. Epikarst copepods from 35 drips in six caves from the Dinaric karst of Slovenia were sampled where a total of 37 species were found. Based on species accumulation curves and Chao estimates of total diversity, we established rules for sufficient sampling of at different geographic scales. As long as drips sampled are less than 200 m apart, five drips are sufficient to sample most of the fauna. Compared to other components of the stygofauna, relatively few caves are needed to establish regional diversity patterns. The epikarst copepod fauna is a significant part of the aquatic cave fauna, contributing about 30 percent at the local and 15 percent at the regional level.

Keywords: Accumulation curves, caves, Copepoda, epikarst, Slovenia, species richness.

THE USE OF GROUND PENETRATING RADAR TO INVESTIGATE THE EPIKARST IN AN ALPINE SETTING

L. Plan[1] , M. Meissl[1], M. Andert[2], B. Grasemann[1], K.-H. Roch[2]

[1]University of Vienna, Department for Geodynamics and Sedimentology, Althanstr. 14, 1090 Vienna, Austria.
[2]Vienna University of Technology, Institute of Geodesy and Geophysics, Gußhausstr. 27-29, 1040 Vienna, Austria.

Abstract
The epikarst is the uppermost zone of a karst system and the interface between soil and rock. Water movement and storage in small voids, which characterize the epikarst zone, appear to play an important role in the hydrologic regime and vulnerability of karst aquifers (Klimchouk, 2004).
Ground Penetrating Radar (GPR) is a geophysical method using very short electromagnetic pulses that are radiate into the ground and reflect from heterogeneities. It is a non destructive method that produces a cross-sectional or 3d image of subsurface structures. Studies with GPR in Mediterranean karst showed promising results (e.g. Al-fares et al., 2002). The aim of our feasibility study is to investigate if it is possible to derive information on the thickness and storage capability of the epikarst in an alpine setting using GPR.
The area of investigation is situated 80 km south of Vienna (Austria) on the Schneeberg karst plateau which is the catchment area for the 1st Viennese water supply pipeline. At this plateau there are several types of karst landscapes: e.g. zones with high doline density, karren fields, and areas with glacial overprinting versus palaeo-landscapes. Eight profiles were surveyed with a GSSI SIR 2 device in combination with antennas with different main frequencies (40 – 500 MHz) and processed with REFLEX Software. Using different frequencies enables to explore different depths from some meters down to about 40 meters with changing resolution. Measurements were realized at different weather conditions. Furthermore one area was measured in order to model a 3D block.
First results show that structures like fractures and cavities can be clearly detected by GPR up to a depth of 40 m. Data acquisition under different weather conditions reveal that humidity saturation is an important parameter when subsurface features on the karst plateau are imaged. Profiles measured at wet conditions show more significant reflections in the upper part of the record, whereas measurements at dry conditions show more reflections in the lower part.

KARST SPACE PRODUCTION. THE TERRITORIAL STAKE.

Pierre C. Provost

Université du Québec, Montréal, 6655 18e Avenue, Montréal, Canada, E-mail: pierre.provost@ekarst.com

Abstract
As the world population growths up rapidly, the inner environmental constraints are actively influencing social structure. This is obviously true in karst terrain. Actually, many world renowned authors discuss about human impact in karst and there geotechnics solutions. However, one of other important consideration in reducing and prevent those constraints is public education on the territorial stake of living with karst. It appears that the social interface between science and state karst ordinance is a key achievement in that realization. This research situating the karst as a conceptual product of science involvement in understanding earth surface. This production of karst science as a corollary in the social production of karst space. If some local parts of the world as proceed of this dialectical production of karst, some's not. This social production of karst environment is important in population preparation for karst related ordinance project. With the theory of Lefebvre space production and is dialectical approach in analyzing social history, we are presenting new result coming from the Kentucky Karst Plain region.

UPPER PLEISTOCENE FAUNA OF CAVES PEĆINA NA BREHU (ĆIĆARIJA) AND BABA (BIOKOVO) - CROATIA

Siniša Radović, Kazimir Miculinić

Institute for Quaternary Paleontology and Geology, Croatian Academy of Sciences and Arts
Ante Kovačića 5, Zagreb, Croatia

Abstract
Caves and pits, as examples of endocarstic phenomena, are numerous in the karstic regions of Croatia. Different sedimentary processes caused accumulation of sediment especially in caves. They are mostly of Pleistocene age and may contain fossil remains of the fauna that lived in caves or in their vicinity.
During excavations of two caves on Ćićarija and Biokovo, Pećina na Brehu and Baba, the bones and teeth of Upper Pleistocene fauna were collected, and paleontological analyses enabled a partial understanding of fauna in that area. In the caves being studied the most abundant remains are those of cave bear (*Ursus spelaeus*), but the presence of other mammals and birds has also been confirmed. On the basis of the obtained data it has been possible to reconstruct the paleoenvironment.
The results presented here, apart from their scientific relevance, may be used for popular science purposes.

HYDROGEOLOGICAL CHARACTERISTICS OF THE BOKAKOTORSKA BAY (SERBIA AND MONTENEGRO)

Milan Radulović

Geoprojekt, Podgorica, Hydrogeological/geotechnical research, Studentska 4, Podgorica, Serbia and Montenegro.

Abstract
Directions of groundwater flow and conditions of groundwater discharge in the Boka Kotorska bay are examined in this paper. There are many vruljas and saline springs in this area, characterised by typical karstic regime of groundwater outflow, i.e high amplitude of capacity fluctuation.
On the basis of complex geological explorations performed so far, a presentation is given on hydrogeological characteristics of the terrain with special emphasis on the possibilities of groundwater tapping for water supply needs.

Keywords: Karstic aquifer, directions of groundwater movements, vruljas.

FRACTAL DIMENSIONS OF SUPERFICIAL KARST OF MIDDLE ATLAS (MOROCCO)

Mohamed Rouai

Engineering Geology Laboratory, Meknes University, Morocco, PO Box 11201 Zitoune, Meknes Morocco,
E-mail: mrouai@fs-umi.ac.ma

Abstract
The karst structure of Middle Atlas (Morocco) is investigated by fractal analysis using a 1:100,000 scaled geomorphological maps obtained from aerial photographs at scale 1: 40,000. Six karstic surfaces were selected to test the fractal character of karst, and to perform frequency-size distribution analysis. Using the popular box-counting algorithm, the fractal dimension D_b in the region ranges from 1.11 to 1.44. These results show that karst spatial distribution is fractal, and D_b tends to increase with density of karsts. Fractal dimension thus provides a tool for quantifying spatial clustering of karsts. The area-perimeter plots of digitised data from the six karst surfaces show that perimeters appear to be fractal with contour fractal dimension D_c ranging from 1.06 to 1.29, which may reflect a karst evolution degree. The size-number distributions of karst areas and perimeters exhibit power-law behaviour with characteristic exponents for this region. The Mandelbrot-Korçak law for karst areas distribution is: $N(>a) \propto a^{-0.92}$. This work supports that karstification process is a self-similar phenomenon; it is well known that many geological processes like fracturing and fragmentation are fractals. A fractal driving processes with combination of rainfall and other fractal climatic factors will lead to the fractal structure of karst. Fractal or scaling properties characterize the hierarchical and spatial organization of karsts. It may be encouraging that the fractal analysis can be used to compare structural variations in karstic areas and to follow the maturity level of karstification.

Keywords: Karst, fractal geometry, fractal dimension, Middle Atlas, Morocco.

CHANGES IN THE NATURAL RESOURCES USE AND HUMAN IMPACT IN THE KARST ENVIRONMENTS OF THE VENETIAN PREALPS

Ugo Sauro

Dipartimento di Geografia dell'Università di Padova, Via del Santo, 26, Padova, Italy, E-mail:
ugo.sauro@unipd.it

Abstract
During the last three centuries, and especially the last 50 years dramatic changes in the natural resources use have taken place in the karst environments of the Venetian Prealps.
During the past centuries, in most of the prealpine environments the traditional resources use was trending to an equilibrium with the natural dynamic. In others words, compatible development models were realized by the local human communities. The price to pay not to alter such equilibrium was the emigration of the surplus of the human population.
The most common types of land uses were: forest for wood and charcoal production, meadow for hay production, pasture for sheep and cattle grazing, oasized agriculture, garden-culture for the production of vegetables. Also the quarrying activities were important in some areas for the commerce of both stone and lime.
The human landscape consisted in a mosaic of land plots differently managed according with environmental variables and cultural traditions. The scarcity of some resources as the surface water has been partly solved with ingenious systems.
Only in some particular areas and in specific political situation the human activities have strongly interfered with the natural equilibria creating strong impacts and environmental changes. During the XVIII Century a significant example of strong impact has been the surcharge of the upper Sette Comuni Plateau by seasonal sheep grazing induced by the common property and the "Pensionatico" law of the Repubblica di Venezia.
During the XX Century the first event of strong impact in large prealpine areas has been represented by the battles of the first world war.
But it is especially after the second world war that rapid changes in the resources management have taken place according with the new economic styles promoted by the urban and industrial development.
Cattle breeding, hog farming and poultry farming have assumed an industrial dimension with introduction from outside of most of the fodders. Many of the old settlements have been abandoned and new urban areas have arisen also linked with the explosion of the mass tourism. Quarrying and ornamental marble cutting have become major industries, with destruction of the landscape and impact on the natural environment.
The big problem of the future development is to individuate a strategy capable to modify the local economic mechanisms, governing them towards better sustainable development models.

TURLOUGHS: A MOSAIC OF BIODIVERSITY AND MANAGEMENT SYSTEMS UNIQUE TO IRELAND

Dr. Micheline Sheehy Skeffington

National University of Ireland, Department of Botany, University Road, Galway, Ireland, E-mail: micheline.sheehy@nuigalway.ie

Abstract
Turloughs are seasonally flooded karst wetlands that are almost unique to Ireland. As priority habitats under the EU Habitats Directive, many have been designated as Special Areas of Conservation in Ireland. They flood seasonally, usually from October to April, but may fill at any time of year if rainfall is excessive. Most fill and empty through swallow-holes that drain to the underlying limestone. Almost all of them occur in Ireland on well-bedded pure Carboniferous limestone.
Since turloughs are usually shallow basins that are covered in vegetation, unlike more permanent water bodies, they are excellent feeding areas for over-wintering wildfowl, such as ducks, geese and swans, hosting numbers of international importance, especially of whooper swans *Cygnus cygnus*.
Turloughs are almost all grazed by domestic stock in the summer months and the central basins are often owned and managed as commonage. They support relatively low-intensity farming due to their marginal nature and inaccessibility for much of the year. The vegetation depends to a large extent on the flooding regime and on soil type and may comprise small-sedge communities or grass-dominated swards. The former may be less intensively managed, but the type of management varies considerably, not only between but within turloughs. This gives rise to a diversity of sward composition and structure that increases both plant and invertebrate diversity.
Whereas drainage was a large threat to turlough conservation in the past, eutrophication of flood waters is gaining in importance. However, the single greatest threat to turloughs in the future may be the cessation of farming within their basins, resulting in the development of a uniform sward within each flood zone. It is

important to develop a strategy for turlough conservation that involves the land-owners and takes into account local socio-economic factors, since turloughs are an integral part of the Irish cultural landscape.

KARST PROTECTION AND CONSERVATION IN VENEZUELA; INVENTORY OF CAVES IN NATURAL PARKS AND PROTECTED AREAS USING GIS TECHNIQUES

Crisanto Silva Aguilera

Technische Universität Darmstadt, Institut für Angewandte Geowissenschaften, Schnittspahnstr. 9, 64287 Darmstadt, Germany, E-mail: crisantosilva@yahoo.com
Venezuelan Speleological Society, Apartado 47.334, Caracas 1041-A, Venezuela.

Abstract
Venezuela presents a considerable karst areas development and with more than 600 caves reported. Cave and karst system are important besides other reasons by the source of fresh water resources and groundwater until now unexploited in Venezuela. The protection and management of these vital water resources are critical concerning the public health and to sustainable development. Actually there are two figures of natural protection in Venezuela: the 43 natural parks and 36 natural monuments. National parks in Venezuela cover a total area of 13.6 ha and naturals monuments 4.3 ha which represents 19 % of the country surface. Until the present is not clear the amount of caves located within the area of the National parks and most of these are not considered inside the inventory of the features of the park. A data base of the Venezuelan caves was created using the information of the Venezuela Society of Speleology and others speleological group like Speleo-USV and GEO-UCV besides others. A review literature a source of information about National parks, Digital Elevation Models and geology, thematic map were created and processed using GIS techniques. The results show that 252 caves are within the protected areas mentioned, from these only few are considered within the Park features. Some actions for included this caves in the Natural Parks are proposed and discussed.

Keywords: Karst protection; Karst conservation; GIS, Venezuela.

ALUVIAL FANS ON KARST (EXAMPLE FROM CONTACT KARST OF MATARSKO PODOLJE, SLOVENIA)

Uroš Stepišnik[1], Mateja Ferk, Petra Gostinčar, Luka Černuta, Karmen Peternelj, Tomaž Štemberger, Urša Ilič.

[1]Univerza v Ljubljani, Filozofska fakulteta, Oddelek za geografijo, Aškerčeva cesta 2, Ljubljana, Slovenia, urosstepisnik@hotmail.com

Abstract
There are many various types of contact karst on Slovenian karst. The most common type of contact karst is the ponor type, which appears between flysch and limestone. The longest contact of this type is in western Slovenia in the area of Matarsko podolje, where a variety of typical - concave contact karst features can be found. In north western part of Matarsko podolje is the limestone bedrock covered with material of active and fossil alluvial fans. Geomorphologic features and processes on alluvial fans and the influences of alluvial fans on development of local karst have been investigated in details.

A REVIEW OF THE FOREST MANAGEMENT HISTORY AND PRESENT STATE OF THE HARAGISTYA KARST PLATEAU (HUNGARY)

Eszter Tanács

University of Szeged, Department of Climatology and Landscape Ecology, Egyetem u. 2, P.O.Box 653, Szeged, Hungary, E-mail: nadragulya@geo.u-szeged.hu

Abstract
Vegetation is one of the karstecological factors. As such it directly affects microclimate and soil and thus indirectly the whole system. Due to their geographical position, the potential vegetation of Hungarian karsts is mixed-stand deciduous forest so forest management methods in the past and present are a key issue in today's karst surface development.
In this study we attempt to provide a complex review of the relationship between the forest management history and the recent state of the karst plateau called Haragistya, situated in the northern part of Aggtelek Mountains at 400-600 m above sea level. Historical data and geographical names hint that the area was intensively used over the centuries, mainly for wood production and grazing but at some point probably even as arable land. In the 20th century, non-native coniferous forests were planted in the northern and western parts in order to increase wood production. Since the area was designated strictly protected zone and a smaller part forest reserve, its forests have been left unmanaged. Investigating patterns in the resulting dynamic changes in the context of land use history provides useful information on the interactions and processes of the karstecosystem.
For the analysis we used an integrated GIS consisting of historical data (18th-19th century military maps, old forest management plans, aerial imagery etc.) forest structure data and the results of recent and past soil investigations in the area.

DISCHARGE REGIME OF KARSTIC SPRING FOR ESTIMATION OF GROUNDWATER SENSITIVITY TO POLLUTION IN THE DOLNÝ VRCH AREA, SLOVENSKÝ KRAS MTS., SLOVAK REPUBLIC

Peter Malík [1] & Silvia Vojtková [2]

[1] Geological Survey of Slovak Republic, Mlynská dolina 1, 817 04 Bratislava, Slovak Republic, E-mail: malik@gssr.sk
[2] Comenius University, Faculty of Natural Sciences, Department of Hydrogeology Mlynská dolina G, 842 15 Bratislava, Slovak Republic, E-mail: wiesengangerova@fns.uniba.sk

Abstract
Hydrograph analyses of groundwater depletion process in the spring were used for estimation of karstification degree and groundwater sensitivity to pollution in the whole catchment's area. Differences in character of individual depletion hydrographs enable assessment of the anticipated extent of absorption, attenuation and self-purification processes during the groundwater penetration through the rock environment, between its infiltration and its outflow in the spring. The method was applied in the S part of the Slovensky Kras Mts., Dolny vrch / Alsohegy hydrogeological structure. In total, 66 individual recession curves from 9 gauged springs were analyzed. Depending on characteristic groundwater depletion hydrograph with independent sub-regimes, categories groundwater sensitivity to pollution was defined. Mean values of sensitivities to pollution were also linked to litostratigraphical units in the area.

LONG RESIDENCE TIME OF WATER IN UNSATURATED ZONE OF MORAVIAN KARST: CONSEQUENCES FOR TEMPORAL BEHAVIOR OF NITRATE CONTENT IN SEEPAGE WATERS AND KARST SPRINGS (^{18}O, ^{3}H)

Helena Vysoká[1] & Jiří Bruthans[2] & Ondřej Zeman[2]

[1]Department of Hydrogeology, Engineering Geology and Applied Geophysics. Faculty of Science, Charles University, Albertov 6, Praha 2, CZ 12843
[2]Geological Institution of Czech Academy of Sciences, Rozvojová 135, Praha 6 CZ 165 02

Abstract

The residence time of water in unsaturated zone of karst was studied on many localities. Individual studies brought very different residence times. It is believed that this is result of very complex nature of exokarst and large diversity of environments and other factors as well.
Studied area is situated 16 km northeast of Brno, Czech Republic, in protected landscape area "Moravian Karst". Seepage waters are studied in the Ochozská Cave in the southern part of the Moravian Karst. Intensively karstified Devonian limestones occur in the area. Soil layer is mostly less than 0,5 m deep; unsaturated zone above cave is 60 m thick. Locality is covered by forest.
Conductivity, temperature, flow rate are continually measured in the seepage water. Soil zone above cave is equipped by tensiometers and lysimeters for taking samples from soil zone for and study of the hydraulic head propagation through the unsaturated zone.
Three different localities of waters percolating from the unsaturated zone to the cave were sampled in the years 2001 to 2005 (dripping waters). Precipitations were sampled as well. The results of study showed relatively long residence time in the unsaturated zone: About 25% component has residence time several years, about 15-25% component was infiltrated in 60. or 70. (30-40 years ago), the rest 50% has residence time of several months. The content of event water is low (less than 10%) even after intensive melting of thick snow cover.
The long residence time fits well with high nitrate content in seepage waters in other parts of Moravian Karst, where crops were intensively cultivated in the past (before year 1989). Thanks to long residence time in unsaturated zone of karst the content of nitrates will decrease relatively slowly in seepage waters and karst springs.
This study was realized with the financial support HeidelbergCement, Mokrá (cooperation with Czech Academy of Sciences).

POSSIBILITIES OF THE DIGITAL PHOTOGRAMMETRY IN THE MAPPING AND MANAGEMENT OF THE KARSTS

Z. Zboray, I. K. Bárány

University of Szeged, Department of Climatology and Landscape Ecology, 6722 Szeged, Egyetem u. 2. Pf. 653., Hungary, E-mails: zzboray@geo.u-szeged.hu, keveibar@earth.geo.u-szeged.hu

Abstract
Photogrammetry is the basis of preparing maps. Photogrammetry produces high precision maps with the help of aerial photos, which make field work easier, detection and analyze of changes, time of mapping can be reduced. Most often much of the maps reflect the general topographic aspect, which are often unprecise depending on the

size of forms and the scale. For the mapping of surface of karsts and the accurate description of forms you need further field work and measure with surveying (GPS and/or total station), or a brand new survey.
Digital photogrammetry approaches the surface with triangular irregular network (TIN mesh) from the aspect of high scale aerial photos measured with stereo workstations, and produces surface (contours and grids). On the karst with the assistance of facade you can analyse karsthills and landforms (karst cones, mapping of dolines), morphometric parameters (measure distance, area).
Beside measuring the karst surface, from the aerial photos you can produce ortophotos, which show the actual condition in contrast of the existing maps. Ortophotos made on different occasions can be contrasted with each other easily in GIS environment, changes are detectable, which in handling the area (e.g. national parks or process of authority) has great importance.

GROUNDWATER VULNERABILITY ASSESSMENT AND PARAMETER SENSITIVITY ANALYSIS - APPLICATION OF EPIK METHOD IN THE NATIONAL PARK "TARA"

V. Zivanović, Z. Bjelivuk, I. Jemcov

[1]Institute of Hydrogeology, Faculty of Mining and Geology, Đušina 7, Belgrade, Serbia, E-mail: v.zivanovic@rgf.bg.ac.yu, zocahg@gmail.com, igor@jemcov.com

Abstract
National park Tara is a karstic groundwater system in western Serbia. The aquifer is a karstified limestone of Triassic and Cretaceous age. Although the National Park is under protection of the state, there are many violations of the natural balance. This is partly due to the usage of old methods of protection, especially for protection of the groundwaters.
This paper describes application of the EPIK method whose final aim is to assess the intrinsic vulnerability of groundwaters and to ensure sustainable development of the whole region. This method already has long tradition in applying when it comes to groundwaters vulnerability of karst terrains. In order to evaluate the influence of each parameter on the vulnerability assessment, parameter sensitivity analysis was done.

Keywords: Karst aquifer, vulnerability assessment, EPIK, sensitivity analysis.