



Sustainable mineral resource management in karst areas -Report on NATO advanced research workshop 26th September - 1st October, 2000, Portorož, Slovenia

Trajnostno gospodarjenje z mineralnimi surovinami na kraških ozemljih - poročilo z NATO delavnice, Portorož 2000

Slavko V. ŠOLAR¹ & Deborah J. SHIELDS²

¹Geological Survey of Slovenia, Dimičeva 14, 1000 Ljubljana, Slovenia
e-mail: Slavko.solar@geo-zs.si

²USDA Forest Service - Research and Development, Rocky Mountain Research Station, USA
e-mail: dshields@lamar.colostate.edu, dshields@fs.fed.gov

Workshop objectives, scientific programme and organization

The main objectives of the Advanced Research Workshop (ARW) were to:

- Review the state of science with respect to the biophysical, geo-technical, economic, institutional and social aspects of extraction in karst areas;
- Investigate the applicability of sustainable development principles to mineral resource management in karst areas at multiple scales;
- Identify relevant research needs;
- Foster international cooperation.

The specific science areas to be addressed were:

- Geologic, hydrogeologic and environmental features of karst systems;
- Mining and mineral resource management in karst systems; and
- Economic and social dimensions of mining in karst systems.

The Scientific Programme comprised keynote science presentations, roundtable discussions, and three concurrent, discipline-specific working groups. Cross-discipline synthesis was discussed in Roundtable sessions. Working groups were asked to: identify and prioritize open scientific issues

in their discipline, recommend potential approaches for addressing these issues, and identify further steps, including future co-operation. Working group sessions also included time for additional participant contributions. In total there were 19 keynote science presentations (30 minutes long) and 18 participants' contributions (10 minutes), covering the topics/themes of the workshop.

The meeting began with a Welcoming Reception at which self-introductions and a discussion of participants' expectations took place. The next morning Opening Addresses and formal Welcomes were made in Plenary Session by the then incumbent Slovenian State Secretary for Science and State Secretary for Space and Waters, the ARW Co-Director (D. Shields) on the behalf of the NATO Science Programme, and the Director of Geological Survey of Slovenia (B. Ogorelec). The first Working Session followed the Opening Plenary Session. Topics relevant to the ARW were introduced: sustainable development, mineral resources, mining, and karst systems.

The second Working Session took place during the morning of the second day and focussed on karst system features. In the afternoon participants were taken on a half-day technical field trip: Karst - Environ-

ment and Society. The purpose of the trip was to create a common understanding of science in karst among the representatives of the diverse disciplines present at the ARW. Participants were taken by bus to: a) an active limestone aggregate quarry in the karst region of Slovenia (for an overview of mining in karst); b) the karst cave Škocjanske jame - a UNESCO World Heritage Site (to observe the results of karst-water interactions in cave systems and to learn about the natural heritage aspects of karst); and c) the Idrija Mercury Museum Mine (to learn about the local-scale cultural and social aspects of mining and mine closure). During travel time presentations were made on the geology, and the environmental and social characteristics of the karst region. Technical presentations and guided tours were provided at each stop by local experts. The day ended with a dinner of typical Slovenian foods, a concert of traditional songs, and displays of locally-made lace.

The third Working Session focused on mining; science presentations were supplemented by roundtable discussions and concurrent working group sessions. The final working day started with science presentations on economics and mineral policy. Much of the rest of the day was dedicated to on-going concurrent sessions. Working groups completed their assigned tasks and presented their conclusions during the final Plenary Session. The technical part of the ARW ended with a Summary of Accomplishments by the Co-Directors and final thoughts from each participant. A Closing Banquet was held that evening, during which each individual contribution was recognized.

Scientific content

The purpose of this ARW was to bring together experts in a variety of fields to review the state of science with respect to the geo-technical, environmental, social, and economic aspects of karst processes and extraction in karst areas, to identify gaps in knowledge, and determine how science can support sustainable resource management in karst areas.

Because of the multi-disciplinary nature of the conference, it was necessary to provide an initial common basis of understand-

ing. Therefore, the ARW started with introductory lectures on sustainable development principles, karst features and systems and mining related issues. Workshop participants then focused on the state of science in three specific areas: I - Karst System Features (geology and hydrogeology), II - Sustainable Mining in Karst (mine design, management, environmental impacts, and reclamation), and III - Creating a Framework for Sustainable Development in Karst Areas (sustainable economic and resource management policies). Examples from all over the world (Europe, Asia, the Pacific area, and North America) were presented.

Applying Sustainable Development Principles to Karst Systems (presenter in bold print)

- Applying Principles of Sustainable Development to Mineral Resources, **D. Shields**, Forest Service, USA and S. Šolar, Geological Survey of Slovenia, SLO

- Karst as a Complex Ecological, Economic and Social System, **A. Mihevc**, Karst Research Inst., SLO

- Distinguishing Features of Karst Systems, **J. Gunn**, University of Huddersfield, UK

- Ecological Problems in the Subtropical Karst of South China, **Daoxian Yuan**, Institute of Karst Geology, Guilin, PRC

- Mining and Karst: the Asian-Pacific Experience, **E. Hamilton-Smith**, IUCN, AUS

- Hierarchical Systems Analysis in Karst Terrains: Part I. Approaches and Applications to Environmental Characterization, **K. Kolm**, Colorado School of Mines, USA and W. Langer, US Geological Survey, USA

Content - Karst, originally a Slovenian word, denominates an area with water-soluble, mostly-carbonate rocks, and specific settings, landforms and hydrogeology. Karst areas can be found in all climate types and this reality, combined with karst's geological features, results in an enormous variety of landscapes, hydrology, land use and grades of human impacts. Karst areas are important sources of both mineral resources and water, but in many countries the character and functioning of karst systems are being altered due to the impacts of quarrying, ground water removals, settlements, agriculture, etc. The incidences of sinkhole

creation, ground water resource losses, and ground water pollution due to hazardous waste disposal in active karst areas are increasing. To date it has been difficult to identify appropriate and publicly acceptable resource management policies, due to the multi-disciplinary nature of the problem. The sustainable development (SD) paradigm offers an effective framework for addressing these issues in a comprehensive manner.

The fundamental principles of SD are: economic prosperity, environmental integrity, and social equity. SD requires that economic, environmental and social issues be integrated in decision-making. In all decisions, the long-term effects on resources and capital, as well as the capacity for future creation of benefits, should be considered. Decision-making should be broad, participatory, and also interdisciplinary. Thus, commitment to SD principles necessitates integration of resource management, environmental policies and development strategies so as to satisfy current and future human needs, improve the quality of life, and protect resources. Accomplishing the goals of SD will require public policies with sound scientific basis.

I - Karst System Features

- Morphology, Hydrogeology and Human Impact in Karst Geo-ecosystems of the Southern Alps: Problems of Management of the Water Resources, U. Sauro, University of Padova, IT and **A. Borsato**, Museo Tridentino di Scienze Naturali, IT

- Extraction of Water in Karst Areas, **B. Paukstys**, Vilnius University, LT

- Environmental Indicators of Sustainable Development in a Karstic Area, **A. Fabbri**, ITC, NL; P. Napolitano, Studio Tecnico Napoli, IT; L. Recatala Boix, CIDE, ES; and A. Cendrero, Universidad de Cantabria, ES

Content - Keynote speakers used case studies to illustrate the relationship among human exploitation of karst, the auto-depuration of the karst aquifer capacity, and pollution in karst water systems. Other case studies illustrated the result of excessive human water extraction, karst acceleration, which in turn causes additional environmental damage (sinkholes and more agricultural pollution). It was agreed that the basic geological and hydrogeological conditions in karst

systems are similar, suggesting that fundamental lessons learned in one area can be applied in others. Conversely, each karst system has unique features, and natural processes functioning in one area may not be present in others. While it is not appropriate to apply the details of one specific karst system to others, existing environmental indicators for karst can be adapted to most systems. International efforts should focus on what is similar and where differences could be significant. The group identified the following research need: more complete numerical ground water flow models for karst systems.

II - Sustainable Mining in Karst Systems

- Applying ISO Standards as a Framework for Sustainable Mine Management, **S. Olivero**, CEPAS, IT

- Spatial Prediction Models for Sustainable Development of Nonrenewable Resources in Environmentally Fragile Areas, **C-J. Chung**, Geological Survey of Canada, CA and A. Fabbri, ITC, NL

- Anthropogenous Pseudokarst - Hydrogeological Conditions of Exploitation of Underground Mines from the Environmental Protection Point of View, **A. Grmela**, Technical University of Ostrava, CZ

- Impact of Quarrying Gypsum in a Semidesertic Karstic Area, **A. Pulido Bosch**, University of Almeria, ES; J. M. Calaforra, U. Of Almeria, ES; and P. Pulido-Leboeuf, U. Of Almeria, ES

- Landscape Reconstruction after Quarrying, **J. Gunn**, University of Huddersfield, UK

- Risk Perception and the Acceptance of Extraction, **P. Dowd**, University of Leeds, UK

- Hierarchical Systems Analysis in Karst Terrains: Part II. Analysis of Environmental Impacts of Aggregate Mining, **W. Langer**, US Geological Survey, USA and K. Kolm, Colorado School of Mines, USA

Content - Mining or quarrying have the potential to cause immense damage to karst; therefore, it was agreed that methods are needed to facilitate exploitation while simultaneously protecting the natural heritage of karst areas. Management based on sound principles will be crucial to mitigating negative impacts, as well as optimizing economic benefits. Many useful tools have

been developed to serve this purpose, including models of environmental systems and models that connect multiple systems (such as economic, social, technological). For example, hierarchical systems analysis (HSA) has been designed to characterize environmental system components, identify impacts to those systems and evaluate the extent of those systems. Spatial prediction modeling can be used to demonstrate the relations among exploration, development, environmental impacts and sustainability. Landform Replication can be used in reclamation efforts to assure that the post-mining landform-vegetation assemblages resemble natural areas in the vicinity of the quarry. There was agreement that mining in karst should follow Best Environmental Practices and that corporate management tools such as ISO 9000 and 14001 could support this effort. However, it was also agreed that some tools (e.g., computer-based expert systems for karst management), data (e.g., interferometry and satellite), and standards (e.g., international standards of best practice) are missing. Further, it will be necessary to develop methods to quantify the risk associated with alternative management actions and find a way to communicate that information to the public. And finally, a coherent system to integrate available tools is badly needed, as is a way to share this information.

III - Creating a Framework for Sustainable Development in Karst Areas

- Economic Instruments for Sustainable Mining in Karst Systems, **J. Sejak**, Czech Environmental Union, CZ
- State Mineral Resource Policies, **V. Gasiuniene**, Geological Survey of Lithuania, LT
- Utilizing Indicators of Sustainability in a Mineral Resource Management Policy, **S. Šolar**, Geological Survey of Slovenia, SLO and **D. Shields**, Forest Service, USA

Content - As with karst systems, the social and political systems of the countries where karst is found have much in common, but each country has its own legal system and culture. This suggests the existence of a rich diversity of potential solutions to resource management issues in karst areas. The details of one country's sustainable resource management plan may not apply in

other countries, but there are general concepts that can be applied broadly. It was agreed that information sharing and multi-stakeholder participation would be essential components of a successful management plan. The former requirement implies a need for indicators of social, economic, environmental and karst system condition. The indicator set will need to be science-based, believable and acceptable to both decision makers and the public. For example, it is possible to develop monetary measures of environmental values for use in the evaluation of anthropogenic impacts in karst. Given that resources are limited and populations continue to expand, there is a need for tools to support analysis of »tradeoffs« between utilizing karst to fulfill human needs (water, food, minerals) and protecting fragile karst systems. Further, participants identified a need for more detailed social assessments of communities in karst areas.

Conclusions and Recommendations

Reviewing the state of science with respect to karst areas led the participants to several final conclusions. First, neither mineral demand, water use nor human activities in or near karst areas will decrease in the foreseeable future. As a result, anthropogenic impacts on karst are expected to intensify. Second, although more needs to be learned about karst systems as noted above, the state of science is such that the management of karst could be greatly improved. Third, if negative human impacts are to be reduced, a multi-disciplinary approach will be needed. Fourth, participants agreed that an effective approach would be based on the principles of SD, a paradigm accepted by societies, governments and industries worldwide. Finally, science can contribute to this process by communicating current and emerging knowledge and understanding to all segments of society, including policy and decision makers, stakeholders, and mineral resource professionals. One aspect of their contribution should be the development of valid, relevant, unbiased, science-based indicators of sustainability.

Suggestions for workshop follow-up included: a) publication of a second, extended edition of ARW abstracts; b) production of a CD-ROM containing the abstracts, Power-

Point presentations, short versions of some papers, concurrent sessions group reports, photographs and other workshop materials; c) a book on workshop topics, which should be designed as a text on managing mining in karst; d) further networking among participants; e) a multi-discipline case study on social preferences with respect to mineral extraction in karst and; and f) organization of a similar event focused on sustainable karst water management.

Planning and administration

This Advanced Research Workshop was an outgrowth of a preceding NATO Advanced Study Institute (ASI), »Deposit and Geoenvironmental Models for Resource Exploitation and Environmental Security,« which was held in Mátraháza, Hungary, in Sept. 1998. The ASI Working Group on Resource Policy identified the need to extend the paradigm of sustainable development to the management of earth resources. The NATO Member Country and Partner Country leads of that Working Group (D. Shields (USA) and S. Šolar (Slovenia)) undertook the organization of an ARW on the selected topic. They were joined on the Organizing Committee by Andrea Fabbri (Netherlands, Co-Director of the preceding ASI), Vyda Elena Gasiuniene (Lithuania) and Sergio Olivero (Italy), both participants in the ASI, and Dragomir Skaberne (Slovenia). An initial organizing meeting was held in Ljubljana, Slovenia, in June 1999. Thereafter the Org. Committee utilized the internet to hold real-time electronic meetings.

Committee members utilized their personal experience and professional contacts to identify leading scientists in ARW research areas. Those individuals were personally invited to participate in the workshop. In addition, the ARW was widely publicized and other interested scientists were invited to submit applications. An ARW website (http://www.geo-zs.si/angl/nato_workshop/nato_workshop.htm) was created and hot linked to many other websites. A logo was designed and used on the ARW brochure, poster, abstract booklet, and meeting materials, including a rucksack and notebook. Extensive mailings of the brochure (in both electronic and paper form) were made

by organizers, including to all participants in the previous ASI. The ARW was also promoted through national newspapers (science pages), on local Slovenian radio and TV, in the Croatian quarry magazine and the Slovenian Quarry Manager's Newsletter.

Keynote speakers, participants and observers came from NATO countries (Canada, Czech Republic, Greece, Hungary, Italy, Netherlands, Poland, Spain, Turkey, United Kingdom, United States), NATO partner countries (Albania, Croatia, Estonia, Lithuania, Russia, Slovak Republic, Slovenia, the former Yugoslav Republic of Macedonia and Ukraine) and 3 other countries (Australia, Bosnia and Herzegovina, and PR China). All together there were 47 attendees. The Org. Committee worked with the leading scientists to ensure that their keynote presentations were focused, relevant, and not duplicative, and with the other participating scientists to ensure that they were prepared to review the work presented, and contribute to the discussions.

Prior to the meeting, all participants were provided with logistic information. Participants arrived on or before September 26. They were met at their point of debarkation (airport or train station in Ljubljana, Slovenia, or Trieste, Italy) and driven to the conference venue, the »Hoteli Morje« in Portorož, Slovenia, either by a Geological Survey car or by hired bus. The ARW office was set up in a hotel conference room and was well equipped. It was staffed by two Administrative Assistants, Ms. Kristie Maczko (MATCOM for US Forest Service) and Ms. Irena Trebusak (Geological Survey of Slovenia). The Administrative Assistants were available to answer questions, help participants with tasks such as meeting registration, document editing and PowerPoint presentation development, and also to assist with any changes in air or rail reservations and coordinate the transportation back to the train stations and airports on October 1. Each participant received a special ARW rucksack containing the book of ARW abstracts, (Šolar, Skaberne & Shields) the Final Scientific Program, background information, and meeting supplies, upon registration. Participants were reimbursed, by check (in US dollars), for their transportation expenses upon presentation of receipts.

Lodging and full board were provided for all.

The ARW was sponsored by the NATO Science Programme. Major support was also provided by the United States Forest Service and the Geological Survey of Slovenia. The following organizations provided additional support and publicity: the United Nations Environmental Programme (UNEP), the United Nations Educational Scientific and Cultural Organization Division of Earth Sciences (UNESCO), the World Conservation Union (IUCN), and the Slovenian Ministries for Science and Technology, Economic Affairs, Foreign Affairs, and Environment and Spatial Planning. Support was also provided by the Slovenian Chamber of Commerce and Industry and the following Slovenian companies: Ruda, Marmor, Gradis, Kraški zidar, Vinakoper and Adria Airways.

Trajnostno gospodarjenje z mineralnimi surovinami na kraških ozemljih

Geološki zavod Slovenije in Gozdarske službe ZDA (USDA Forest Service) sta med 26. septembrom in 1. oktobrom 2000 organizirala v Portorožu mednarodno posvetovanje - delavnico z naslovom »**Trajnostno gospodarjenje z mineralnimi surovinami na kraških ozemljih**«. Mednarodno delavnico, katere glavni sponzor je bil NATO oziroma njegov program za znanost, so podprle številne mednarodne organizacije, posamezna ministrstva republike Slovenije ter del slovenske industrije.

Delavnico so uradno odprli predstavniki države (državna sekretarja z MŠZŠ-ja in MOP-a) ter organizatorja. Program delavnice je potekal večitirno; z vabljenimi 30 minutnimi predavanji in skupnimi diskusijami ter 10 minutnimi predavanji ostalih udeležencev in diskusijami v delovnih skupinah. Oblikovali smo tri delovne skupine (A - okolje-kras, B - rudarjenje in mineralne surovine ter C - družboslovje). Skupno je bilo 19 vabljenih predavanj ter 17 drugih predavanj oziroma predstavitev, ki so pokrile teme delavnice. Osnovni nameni delavnice so bili: (1) pregled raziskav geološkega, geo-tehničnega, okoljskega, družbenega in ekonomskega vidika pridobivanja mineralnih surovin na kraških ozemljih, (2) raziskati uporabnost principov trajnostnega

razvoja pri gospodarjenju z mineralnimi surovinami, (3) identifikacija smotrnih ciljev prihodnjih raziskav. S tem smo krepili (4) mednarodno raziskovalno sodelovanje in tudi razpoznavnost Slovenije.

Prvi dan so bile predstavljene teme delavnice: 1) paradigma trajnostnega razvoja, temelječega na ravnotežju med naravo/okoljem, gospodarstvom ter družbo za sedanje in prihodnje rodove, 2) značilnosti kraškega sveta in življenja na njem, 3) gospodarjenje z mineralnimi surovinami vključno z rudarjenjem. Drugi dan delavnice je bil razdeljen na predavanja o oblikah kraškega sveta ter s terenskim ogledom a) kamnoloma apnenca Črni Kal-Črnotiče b) Škocijanskih jam ter c) muzeja rudnika živega srebra v Idriji. Na ekskurziji smo videli primere dobre prakse varovanja okolja (tako narave kot mineralnih surovin), uspešnega pridobivanja mineralnih surovin ter tudi primer uspešnega porudarskega razvoja kraja (Idrija). Tretji dan delavnice je bil namenjen različnim vidikom rudarjenja na kraških ozemljih. Zadnji dan delavnice pa je bil poudarek na razvojnih usmeritvah držav in privatnega sektorja, industrije s področja pridobivanja mineralnih surovin. Poleg tega so delovne skupine pripravile povzetke diskusij, kjer so se izpostavile prioritete razvoja sektorja, potrebe po večji uporabi znanja, več povezanosti med strokami (multidisciplarnost) ter med strokami in javnim ter privatnim sektorjem.

Slovenski strokovnjaki so na delavnici prikazali stanje na področju razvoja in raziskav na krasu, z ozirom na več dimensionalnost gospodarjenja z mineralnimi surovinami, z več predavanji (A. Mihevc: Kras kot kompleksni ekološki, ekonomski in družbeni sistem, L. Zadnik-Štirn: Tvorba alternativ trajnostnega gospodarjenja z uporabo metode večih kriterijev, A. Barbič: Lokalno prebivalstvo kot ključni faktor gospodarjenja z viri na Krasu, B. Salobir: Slovenska rudarska zakonodaja in rudarjenje v občutljivih območjih, S. Šolar: Uporaba kazalcev trajnostnega razvoja v razvojnih usmeritvah gospodarjenja z mineralnimi surovinami).

References

- Šolar, V. S., Skaberne, D. & Shields, D. J. 2000: Sustainable Mineral Resource Management in Karst Areas. - Book of Abstracts, USDA Forest Service & Geological Survey of Slovenia, 85p., Portorož, Slovenia