Bärbel Vogel, Kyung Sik Woo, Ralf Grunewald, Roger Crofts and Gisela Stolpe (Eds.)

Global Geoheritage – International Significance and Biodiversity Values

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Global Geoheritage – International
Significance and Biodiversity Values

Proceedings of the Workshop of the IUCN-WCPA
Geoheritage Specialist Group and
the Federal Agency for Nature Conservation (BfN) at
the International Academy for Nature Conservation on
the Isle of Vilm, Germany, 4 - 7 April 2018

Edited by
Bärbel Vogel
Kyung Sik Woo
Ralf Grunewald
Roger Crofts
Gisela Stolpe

Federal Agency
for Nature
Conservation

Cover picture: Unicorn Cave in the Harz, with workshop participants (R. Grunewald).

Editors's addresses:

Bärbel Vogel	German Speleological Federation E-Mail: vorsitz@vdhk.de
Kyung Sik Woo	Chair, IUCN-WCPA Geoheritage Specialist Group E-Mail: happyman369@naver.com
Ralf Grunewald	Federal Agency for Nature Conservation (BfN) E-Mail: ralf.grunewald@bfn.de
Roger Crofts	Deputy Chair, IUCN-WCPA Geoheritage Specialist Group E-Mail: roger.dodin@btinternet.com
Gisela Stolpe	Federal Agency for Nature Conservation (BfN) E-Mail: gisela.stolpe@bfn.de

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Preface

When Graeme Worboys mentioned the necessity of new recognition of geoheritage sites of international significance a few years ago, I did not really follow his supportive enthusiasm for geoheritage recognition and conservation in the world. However, since then, I began to collect information on this topic with my graduate student (Miss Ju) and asked her to write a M.Sc. thesis on this topic. As we gained more information, I was very surprised that there are still quite a few countries that do not even have proper concepts for geoheritage conservation. Thus, I strongly feel that it is our present responsibility to conserve many precious geoheritage sites for future generations, and IUCN can certainly play a significant role to initiate this.

The international expert workshop of the Geoheritage Specialist Group at the International Academy for Nature Conservation Isle of Vilm hence tried to make a strong case for demonstrating the wider benefits of geoheritage and to explore global mechanisms and instruments that can help to conserve our precious geoheritage. I seriously considered what would be the best way to make this workshop successful. I came up with three necessary topics to be discussed at the workshop; 1) Linking geodiversity with biodiversity within IUCN WCPA and step-up of the Geoheritage Specialist Group in IUCN WCPA, 2) Re-establishment of Caves and Karst Working Group in Geoheritage Specialist Group, and 3) Recognizing geoheritage sites of international significance for future conservation in the world, hopefully followed by a proposal to IUCN of a new programme, 'Key Geoheritage Area'. The Vilm workshop nicely built upon the first international workshop in Huanjiang, China in 2015 and came up with very useful directions for the future work.

It was a great pleasure to organize this workshop and I would like to express my sincere gratitude to Baerbel Vogel of the German Speleological Federation and Dr. Ralf Grunewald and Gisela Stolpe of the Federal Agency for Nature Conservation for their tremendous efforts to make this happen. Special thanks also go to Dr. Friedhart Knolle for organising an excellent field trip into the Harz. Also thanks to all participants who were happily involved in presentations and constructive discussion during the meeting. Finally, my sincere thanks go to the German Ministry for the Environment, Nature Conservation and Nuclear Safety who generously supported the meeting financially.

Kyung Sik Woo

Chair, IUCN WCPA Geoheritage Specialist Group

Introduction

Roger Crofts

WCPA Geoheritage Specialist Group Deputy Chair; IUCN World Commission on Protected Areas Emeritus

The Second International Workshop of the IUCN World Commission on Protected Areas Specialist Group on Geoheritage was held at the International Academy for Nature Conservation on the island of Vilm in Germany. It was hosted by the German Federal Agency for Nature Conservation.

Two key themes were addressed during the workshop: increasing the currency of geoheritage conservation internationally and developing formative links between geoconservation and biodiversity conservation. In addition, the workshop addressed the development of the Geoheritage Specialist Group activities, particularly its future work programme, its organisational structure, its links with other geoconservation organisations and its membership. These latter subjects are not dealt with in these proceedings as they are internal matters within WCPA and IUCN.

There has been a great deal of concern that geoconservation does not have the international recognition accorded to biodiversity conservation. Both topics under discussion at the workshop addressed this issue in various ways. First, we recognised that progress was being made in raising geoconservation up the nature conservation agenda. We instanced the UNESCO Geoparks programme, the UNESCO World Heritage Site inscriptions, as well as many initiatives around the world at national level. And we welcomed the approval of motions at successive IUCN General Assemblies of the importance of geoconservation in the work of the Union. Second, we recognised the need for the geoconservation organisations to work more closely and collaboratively to provide specialist advice and guidance on geoconservation definitions and standards, and on making assessments of site designation proposals and their later management. Part of the discussion also recognised the fragmented and, so far, incomplete attempts at a general, globally applicable classification of geoconservation sites and areas. Third, we recognised the need for working collaboratively with biodiversity conservation colleagues to ensure that the concepts of ecosystem functionality and ecosystem services recognised the essential connection between the biotic and abiotic parts of nature. And, finally, with the presence of so many experts on cave systems and karst science, we had up dates of the scientific understanding of these hydromorphological and biological systems, leant about management issues which had to be addressed and identified the key elements of future work on caves and karst as part of the Geoheritage Specialist Group since the merger of the previously separate Caves and Karst Specialist Group into the GSG.

As always, the facilities and environment of the international centre and the delightful island, along with the customary attention of our hosts to our debates and our wellbeing, meant that we had a very productive and valuable workshop. Participants from around the world and from different specialisms and experiences added greatly to our discussions. I hope that all participants will take forward the ideas and issues we debated into their work and those others reading these proceedings will join with us in promoting geoconservation around the world.

Conclusions

Roger Crofts

WCPA Geoheritage Specialist Group Deputy Chair; IUCN World Commission on Protected Areas Emeritus

1 Developing geoheritage protection

Our frame of reference is that “geoheritage is inherited from the Earth, maintained in the present and bestowed for the benefit of future generations”. In discussing the need for improving the global systems of geoheritage sites we:

- recognised the importance of placing our programme within the framework of the Promise of Sydney the major outcome of the VIth World Parks Congress;
- recognized that various past global initiatives for geosite assessment and declaration had not been successful;
- acknowledged that WHS and GGpN were important initiatives but did not cover all of the subject matter and had obviously narrower criteria, but there was an opportunity particularly to have greater recognition of landforms to be pursued through thematic studies;
- considered that a systematic approach was needed with a framework embracing three components needed: geological and geomorphological setting, geoheritage inventory and specific criteria;
- identified rarity, representativeness, and integrity as critical criteria;
- agreed on the need for clear procedures for identification of sites/areas and for assessing their effectiveness;
- agreed that any system must have a scientific underpinning to give it rigour and credibility;
- agreed that a collaboration with IUGS Commission on Geoheritage was the most appropriate way forward on this topic, learning from past attempts;
- considered the need to develop a programme, labelled at present Key Geoconservation Sites, learning lessons from the establishment of Key Biodiversity Areas within IUCN;
- recognised the importance of embracing experience in community collaboration, interaction with economic development interests, and the need for promoting education;
- called for a review of the effectiveness of existing geoconservation laws as an effective legal basis was needed; and
- considered that international targets (as developed for biodiversity) should be developed.

2 Integrating Caves and Karst

We agreed that full and effective integration of the former WCPA Caves and Karst Group into GSG was a priority, welcomed the appointment of John Gunn as the chair of the Sub Group and as a GSG Deputy Chair, and recognised the need for approval of terms of reference for the sub group by the WCPA Executive Committee.

We welcomed the opportunity to hear presentations on recent development in caves and karst science and methodology. In particular we:

- recognised that caves and karst were complementary elements;
- recognised that hydrogeology was a fundamental process;
- noted new scientific approaches and discovery of more underground systems;
- Noted the discovery of new cave species and greater understanding of the natural environment;
- agreed the need for a comprehensive whole environment approach in research and protection of cave systems;
- noted the importance of linking nature and culture in caves;
- expressed concern about the human impacts in caves and the need for further assessment of how to combat increases in light intensity, changes in humidity and temperature, effects on bats, other species and their habitat;
- expressed concern about the external effects on caves and especially their hydrology from activities in their catchments;
- considered that Red Listing of caves species and natural processes should be discussed; and
- considered that reviews of caves and karst features and processes in international sites, specifically GGN, Biosphere Reserves and Ramsar sites, should be undertaken.

3 Developing links between geodiversity and biodiversity

This was a major topic of discussion given the recognition that geoconservation was way behind on local, national and international agendas of policy and action compared with biodiversity conservation. We:

- noted the recently published reviews by some of our members assessing the reasons and what we can learn from biodiversity conservation;
- recognised that the new thinking on ‘conserving nature’s stage’ reflecting the underpinning abiotic elements and process of nature (soil, water, air, tectonics, glaciation etc.) was fundamental to the variety, functioning and health of plants and animals at all levels; and welcomed the special issue of Biological Conservation journal devoted to this topic;

- noted that too frequently geodiversity was only considered if relevant to biodiversity not for its own sake. And noted that geoheritage was often ignored eventhough it was an important feature or process, as exemplified in the thematic study nearing completion on volcanic WHSs;
- recognised the need to provide and promote guidance on the management of geodiversity across all categories of protected area that highlights the value of geoconservation principles and 'working with nature and natural processes' and the benefits for both geodiversity and biodiversity;
- sought to develop the bio focused thinking by focusing on ecosystems, especially their functions and the link to nature's services and to natural capital, using the scientific underpinning, and opening minds beyond the narrower and anthropocentric ecosystem services approach. There may be merit in considering 'abiotic ecosystem services' to compliment the bio focused approach and to promote a more inclusive approach that emphasises the whole of nature, not just biodiversity, and its benefits for people;
- recognised the importance of relating abiotic processes to major environmental issues, such as extinctions and species evolution, past environments and their relevance to understanding the present and future (including climate change) and disaster risk reduction;

4 Mainstreaming geoconservation to major conservation issues

We recognised the need to relate geoconservation to the major conservation and environmental issues facing the world, partly to increase the relevance and credibility of geoconservation and partly in recognition that this element is underplayed in the work of geodiversity professionals. We determined that this topic should be a new programme element devoted to mainstreaming geoconservation. In particular, we:

- noted that key elements would have to be climate change, extinctions and the role of abiotic processes, connectivity between protected areas, connecting people with nature and making protected areas work more effectively;
- noted that we had made progress through Resolutions to the IUCN General Assembly and needed to ensure that these were fully implemented, hence a specific programme on this element;
- agreed the need to develop statements of our position on key issues in the form of briefing notes to promote greater understanding of geoconservation and promote its values and benefits to society, communities, economy and health. Also agreed to identify within our membership who were likely to be the most successful interlocutors;
- agreed that mainstreaming within WCPA and with the Global Programme on Protected Areas was a priority with Best Practice Guidline having a key role;

- agreed that linking with other parts of IUCN was essential, especially the relevant parts of the Species Survival Commission (including the Specialist Group on cave fauna) and the Commission on Ecosystem Management. Developing joint discussions and liaison was a key priority to be covered in a new programme of work;
- agreed that beyond IUCN, we needed to make better links with the geoheritage community, specifically ProGeo, the IUGS and its new geoheritage commission, IAG, IAVCEI, GGN, and IUS. Agreed to invite representatives of these bodies to be part of our steering/liaison arrangements;
- agreed the need to have better links with UNESCO, especially its Global Scientific Programme and the Global Geoparks Programme, and with MAB for Biosphere Reserves; and also, with UN institutions such as UNEP/WCMC for Planet Earth data base and the CBD; and
- agreed to develop our capability to respond to key consultations where geoconservation input was valid, preferably in consultation with colleagues in other geo organizations.

5 Developing our membership

We agreed the need to increase our membership and to ensure that it represented the range of specialisms, and skills and experience needed to deliver our new programme of work. In particular, we:

- agreed to appoint Regional Vice-Chairs to represent members interests in their region, to develop the network regionally, to act as the conduit for communication between the Steering Committee and the members. Names were identified so approaches could be made;
- agreed that the newsletter should continue as a means of disseminating news and other information;
- expressed concern that some nominations for membership of the GSG have been refused by WCPA without reasons being given. And agreed that this should be pursued with the WCPA Chair;
- agreed that once the membership issue had been resolved, a call for new members would be issued;
- agreed to investigate the use of social media for communicating with members.

A The Role of IUCN in Geoheritage

Current and future activities of IUCN WCPA Geoheritage Specialist Group and a proposal of the Key Geoheritage Sites in IUCN

Kyung Sik Woo

Chair, IUCN WCPA Geoheritage Specialist Group

Professor, Department of Geology, Kangwon National University, Chuncheon 24341, Korea

Geodiversity is defined as "the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, topography, physical processes) and soil and hydrological features. It includes their assemblages, structures, systems and contributions to landscapes" (Gray, 2013). Geodiversity refers specifically to the diversity or variety of geological and geomorphological features or characteristics in an area, including both those deserving conservation (geoheritage) and those not. It does not equate with those features and characteristics themselves, and so should not be used as a descriptive term for the geology and geomorphology of an area. Geoheritage comprises those elements of the Earth's geodiversity that are considered to have significant value for intrinsic, scientific, educational, cultural, aesthetic and ecological/ecosystem reasons and therefore deserving conservation. It constitutes a legacy from the past, to be maintained in the present and passed on for the benefit of future generations. Geoheritage is the cumulative story of the Earth preserved in the rock record, as in the pages of a book, albeit fragmentary and with pages missing. It is represented in special places (geological sites) and objects (specimens in situ and in museums) that are fundamental to our appreciation of the history of the Earth and the evolution of life. However, geoheritage is not only about the past. It enables a better understanding of the dynamic processes that continue to shape the world we live in today and contributes to human well-being through cultural and aesthetic values and other benefits for society (Diaz-Martinez and Gordon, in preparation for IUCN Best Practice Guideline).

IUCN Resolutions at Barcelona (2008), at Jeju (2012) and at Hawaii (2016) clearly recognised that geodiversity is part of nature and geoheritage is part of natural heritage. Formal recognition of the geodiversity component of protected areas was made in 2008 in the revised 'IUCN Guidelines for Applying Protected Area Management Categories'. All 6 of the IUCN Protected Area Management Categories are applicable to the protection of geosites and the wider landscape values of geodiversity. Recognising the wider values of geodiversity therefore provides opportunities to integrate geoheritage much more closely in protected area networks, as the approach advocated by the Geoheritage Specialist Group (GSG) of the IUCN World Commission on Protected Areas. The Geoheritage Specialist Group facilitates the conservation and effective management of protected area geoheritage and provides specialist advice on all aspects of geodiversity in relation to protected areas and their management. These roles recognise the concept of 'geo' as part of 'nature' in IUCN's 2008 definition of a protected area and the clear link between geodiversity and biodiversity in the conservation of nature. Although geoparks are not a protected area category as such and only includes some parts of protected areas as geosites, the UNESCO Global Geoparks Network also provides an international framework to conserve and enhance geoheritage values as UNESCO World Heritage sites has provided. IUCN WCPA GSG will pursue significant roles for geoheritage recognition, expansion, and conservation as follows: (1) Develop and publish a Best Practice Guideline, 'Geoheritage Conservation and Management Guideline in Protected Areas' for the WCPA Best Practice Guideline Series (Project Lead, Roger Crofts); (2) Support and advise on IUCN World Heritage Guidance for Criterion (viii) Outstanding Universal Values: (a) Support the update '2009 World Heritage Volcanoes' IUCN Thematic Study (Project Lead: Thomas Casadevall), (b) Support the update of '2005 Geological World Heritage: A Global Framework' IUCN Thematic Study (Project Lead, Tim Badman and Kyung Sik Woo as a GSG focal point). This mission is based the WHC resolution and the IUCN official requests as such. Recalling Decision 37 COM 8B.15 adopted at its 37th session (Phnom Penh, 2013), reiterates its request to IUCN to revisit and update its thematic study on "World Heritage Volcanoes" to clearly articulate a short and appropriately balanced list of the strongest remaining volcanic sites with potential for inscription on the World Heritage List, and also requests IUCN to revise its thematic study on geological sites, the "Geological World Heritage: A Global Framework" (2005) to refine the proposed 13 themes, articulate the threshold of Outstanding Universal Value, and clarify the difference between the criterion (viii) of the World Heritage and Geoparks status.; (3) Work with IUCN WCPA to discover feasibility and need for new programme, 'Key Geoheritage Sites' or 'Key Geodiversity Area', including recognition criteria for international significance of geoheritage sites and legal protection measures (Project lead, to be determined); and some others.

Geoheritage values can be represented by and categorized into the sites of international (global and regional) and national significance, which must be under proper protection measures. Unfortunately there is no international protection system for conservation of nature, thus they can be only protected by national protection laws if available and/or applicable. At present conservation and inventory of significant geoheritage sites are not well recognized with well defined guideline or criteria at international level in the world as well as national level (except for some state parties), compared to well managed ecological and biodiversity values in the world. Thanks to the international programs for recognizing geoheritage values, a number of nations have shown interests for UNESCO designations such as World Heritage Sites or Global Geoparks. However, both programs are geographically very limited because the World Heritage Sites should display 'the Representatives of the Best in the world' and Global Geoparks with geoheritage sites of international significance must be associated with local communities for geotourism and sustainable development to be endorsed and revalidated by UNESCO. Therefore, a new program called 'the Key Geoheritage Site' or 'Key Geodiversity Area' is suggested here to recognize and conserve the geoheritage sites of international significance in the world. Key Geoheritage Site is based and justified by geological values alone without considering educational and touristic values, whereas Key Geodiversity Area is based on the linkage between geodiversity and biodiversity. Clear definition and distinction of these two terms need to be clarified and preferred, and it is hoped that a new program can be suggested at this workshop. For effective designation and protection of the Key Geoheritage Site program, objective geological contexts with appropriate criteria should be developed considering representativeness, rarity and integrity. However, to accomplish the 'Key Geoheritage Site' program, proper protection measures for geological heritage sites in each nation should be encouraged and established. 'Key Geodiversity Area' should have a guideline to meet the necessary criteria to protect biodiversity area linked with geodiversity area. A new program in IUCN could contribute to conserve geoheritage sites worldwide and will help achieve the Aichi Target 11 if it can be adopted by IUCN in the future.

IUCN WCPA Best Practice Guideline on Geoheritage Conservation and Management in Protected Areas

Roger Crofts

This paper introduces the Best Practice Guideline on Geoheritage Conservation and Management in Protected Areas, sets out the rationale, identifies the target audience, lists the key contributors, assesses progress, describes what is still required and provides an estimated timetable.

1 Why Best Practice Guidelines?

They are designed to help those working in and on protected areas to do their job better by sharing knowledge and experience, exchanging good ideas and those that have not worked, and sharing best practice.

Over 20 BPGs covering all aspects of protected areas conservation and management have been published by the IUCN World Commission on Protected Areas:
https://www.iucn.org/theme/protected-areas/publications/best-practice-guidelines

2 Where does geoheritage fit?

The revised IUCN definition of a protected area, published in 2008, is as follows: "A clearly defined geographical space, recognised through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values". This replaced an earlier definition which focused on biodiversity. In other words, it ignored the importance of abiotic nature and specifically geodiversity. The new definition, by focusing on nature, is all embracing recognising both the importance of geodiversity in its own right and the interconnection between the bio and the geo elements. It includes the whole of ecosystem functions and the goods and services provided by them. This is best articulated by the 'conserving nature's stage' approach discussed in the paper by Gordon and Crofts at this workshop.

3 What is the Geoheritage Conservation BPG?

At present, none of the BPGs deal with the geoconservation so the intention is to fill this gap. The BPG will cover the following topics: Introduction; Geoconservation rationale, definitions and principles; Setting up a geoheritage conservation system; Establishment of geoheritage protected areas; Key issues in managing the geoconservation sites, identifying threats to geoconservation and how to deal with them; Communicating geoheritage conservation to the public and no specialists; and selected examples of different situations such as fossils and minerals, caves and karst, glacial and periglacial environments. General principles and key tools and approaches will be described. Case studies will be used throughout the text.

4 Who's it for?

The Guideline is intended to give a helping hand to all who are involved in protected areas - leaders, managers and staff, as well as advisors and consultants. It is being written for those with no technical expertise or knowledge of the role of the Earth sciences in protected area conservation and management and who are likely to find the language used quite incomprehensible.

5 Who's doing it?

Roger Crofts, WCPA Emeritus and Geoheritage Specialist Group Deputy Chair, is Editor and Coordinator: roger.dodin@btinternet.com

Section leads and other contributors are Enrique Díaz-Martínez, Nigel Dudley, John Gordon, Graeme Worboys, José Brilha, Margaret Brocz, Tim Badman, Patrick McKeever, Kyung Sik Woo, Murray Gray, Jonathan Larwood and Dan Tormey.

6 What progress?

The need for this BPG was first muted following the agreement of the revised definition of a protect area. The project specification was developed within the Geoheritage Specialist Group and has been agreed by the Publications and Executive Committees of WCPA. Section leads have been allocated and agreed. Drafts of 6 of the 8 sections have been received and the final two are expected in mid-summer 2018.

7 What's needed?

We are still looking for case studies from around the globe: on many subjects. A template is available, including 800 words text, photos and e links.

We are looking for text specifically on: legal and other effective measures; Geoparks, WHS and other international designations; culture & traditions; and monitoring.

And we are looking for Text on specific environments/subjects, for example fluvial, volcanic, tectonic, using the headings forms, features and processes of value, threats, management principles and guidelines.

8 What's next?

To complete the project, we are looking for funds and volunteers for translation into as many languages as possible.

We expect to have a substantive draft in the autumn fir preliminary vetting. We hope for publication in the latter half of 2019, but that depends on the labyrinthine IUCN vetting processes for all publications!

The foreseeable role of GSG in IUCN/WCPA

Enrique Díaz-Martínez

Geological Survey of Spain (IGME)

We are currently three members within IUCN dealing with geoconservation (the conservation of geodiversity and geoheritage) as our main objective: the Geological Society of Spain (SGE), the European Association for the Conservation of Geological Heritage (ProGEO), and the Spanish Society for the Defense of Geological and Mining Heritage (SEDPGyM). The first one was the SGE, in March of 2008. In 2004, after a strategic analysis of national and international regulations towards geoconservation, the Commission on Geoheritage of the SGE identified the IUCN as the international organization with the highest potential to influence national and regional European policies towards nature conservation, and in particular towards geoconservation. The process to become a member of IUCN took a few years, and our surprise in the meantime was to discover that IUCN had very seldomly and only very recently dealt with geoconservation. What was worse: when we looked at the programme of activities for the 4th World Conservation Congress, to take place in Barcelona that same year of 2008, we noticed that there was not one single slot within it where our specific subject (geoconservation, geodiversity, geoheritage) could fit without forcing or ridiculously stretching the concept of biodiversity. We figured out that the only way to achieve this properly was to induce a change by proposing a motion at the General Assembly in Barcelona, which was successfully approved as WCC-2008-Res-040. This allowed proposing a set of different geoconservation-oriented activities for the next congress in Jeju 2012, including a poster, a round table, an intensive course, a documentary, a conference, and a new motion to the General Assembly promoting geoconservation in the new IUCN programme for 2013-2016 (WCC-2012-Res-048). By then, ProGEO had become a member of IUCN in 2011, which meant stronger support for SGE and a backup from an international geoconservation organization. This resolution introduced some basic principles as well as recommendations towards the gradual proper consideration of geoconservation by IUCN members, officials and organic structure. An immediate result was the birth of the Geoheritage Specialist Group, which started its meetings towards the definition of its Terms of Reference and its formal recognition by WCPA.

It is important to be aware of this brief summary of circumstances and achievements taking place during the last decade (2008-2018) because it reflects a situation that is still suffering from the same weaknesses. Ever since its inception, the structure, personnel, members and activities in general of IUCN have been oriented towards biotic nature, resulting in “a peculiar forgetfulness” (to call it somehow) towards the abiotic part of nature, as if geodiversity and geoheritage were not part of natural diversity and natural heritage. This is still the situation in many ways, and there are many easy indicators at sight. For instance, the recent (February 2018) booklet on “Protected areas: challenges and responses for the coming decade”, says absolutely nothing about geodiversity or geoheritage. This was a surprise for us, as one of its authors (Nigel Dudley) had precisely 10 years ago been the first to introduce geodiversity and geoheritage in the consideration of IUCN categories for protected areas. This lack of holistic consideration of nature may also be observed in crucial IUCN strategic documents, such as (a) the Promise of Sydney, stemming out from the World Parks Congress (2014), and where our proposals were ignored, (b) the 2017-2020 programme adopted at the WCC2016 in Hawaii, or (c) the latest summary of IUCN strategy and objectives.

Nevertheless, some crucial achievements are also in sight. The IUCN "Protected Area Governance and Management E-Book" published in 2015 now includes a Chapter 19 on "Geoconservation in Protected Areas", and a synthetic review article was published in Parks, the journal of WCPA (http://parksjournal.com/parks-20-2/). Some of our most experienced colleagues with longer time in IUCN, such as Graeme Worboys and Roger Croft, have now become our most active promoters of geoconservation within IUCN, but they will not be at the front for many more years to influence IUCN from within. The task is large and we cannot be in all fronts, so the process of change is gradual, slow, and still with too many disappointments.

The strategic vision of WCPA, that protected areas are recognised and valued for conserving nature and as natural solutions to global challenges, includes the basic reference to nature, which includes both natural diversity and natural heritage, and thus also geodiversity and geoheritage. Let's continue our work in that direction, in all settings and contexts where we may influence within our range of action.

The IUCN General Assembly recently approved a third resolution addressing geoheritage (WCC-2016-Res-083 Conservation of moveable geological heritage), which urges the World Commission on Environmental Law and the World Commission on Protected Areas to prepare guidelines on the protection, conservation and management of this part of our geoheritage, in compliance with national and international regulations of its commerce.

For clarity and to avoid potential misunderstandings, it must be said here that the term geodiversity as used herein does not refer to the elements but just to their diversity, and the term geoheritage does not refer to all the elements, but just to those identified to be preserved for their higher value. Furthermore, the term geological and the prefix geo- as used herein refer to all abiotic elements and the processes forming them, including for instance sedimentary rocks (lithology, petrology, sedimentology, stratigraphy, etc.), landforms (geomorphology, glacial, karst, etc.) and fossils (paleontology, paleobiology, etc.).

Role of Geoconservation in IUCN WCPA

Tim Badman

IUCN Global Protected Areas Programme World Heritage and IUCN Geoconservation Focal Point

With the agreement of recent IUCN General Assemblies on the role of geoconservation with IUCN and the change in the definition of protected areas to embrace geo elements, the Union Secretariat is rethinking the role of geodiversity conservation. As a result, not only has the Geoheritage Specialist Group been recognised by the IUCN Council as a component of the WCPA programme, Tim Badman has been designated as the Geoconservation Focal Point in IUCN. These are significant steps forward.

Tim outlined the key components of geoconservation work: specifically, the preparation of the Best Practice Guideline, the review of volcanic component of World Heritage Sites and the development of the Global Geoparks network following approval by UNESCO.

He encouraged the GSG to engage in the broader environmental agendas. He specifically highlighted the linkage between geodiversity and biodiversity with the former as the non-living component of ecosystems as key functional units. He encouraged GSG to address key conservation issues, especially climate change, extinctions and species evolution, analysis of past environments to inform dealing with the future, and helping to improve the communication of nature to wider audiences.

He also encouraged to widen our network to make it more ethically, age and gender diverse.

Strategically, he encouraged GSG to focus on implementing the approved IUCN Resolutions on geoconservation, recognise the specific role we have in contributing to protected areas conservation and management as part of WCPA, and building on the Best Practice Guideline to explore within IUCN the Key Geodiversity Areas concept and its potential linkage to and relationship with Key Biodiversity Areas.

B International Significance of Geoheritage

The assessment of the international significance of geoheritage

José Brilha

University of Minho, Portugal (jbrilha@dct.uminho.pt)

The concept of geoheritage is strongly dependent on the scale factor. We may refer to the geoheritage of a small protected area with a few square kilometres, of a country like Australia or Brazil, or even of the whole Earth. Hence, the inventory method used to identify, characterise and assess geoheritage needs to be adapted to the working scale (BRILHA, 2016; 2018). In order to know if a geosite has international significance, it is necessary first to clarify what type of value is under assessment since geoheritage may have different types of values, such as the intrinsic, scientific, aesthetic, cultural, or educational (GRAY, 2013).

The project Global Indicative List of Geological Sites – GILGES was a first initiative to identify geoheritage of global significance (WIMBLEDON et al., 1999) established after a UNESCO request made in 1988. This multi-institutional project (IUGS, UNESCO, IGCP, and IUCN) tried to identify top-class geosites that could be proposed to the UNESCO's World Heritage List. By the end of the 1990's, GILGES was converted into the Global Geosites project, under the leadership of IUGS. Both projects never reached their goals but the latter has established the bases of a method to support a systematic inventory of sites with international significance. This method was later developed and used in many European countries under the coordination of the European Association for the Conservation of the Geological Heritage – ProGEO (WIMBLEDON & SMITH-MEYER, 2012).

Nowadays, there are several formal mechanisms to recognise the international significance of geoheritage (REYNARD & BRILHA, 2018). UNESCO is responsible for two of these mechanisms: the Convention Concerning the Protection of the World Cultural and Natural Heritage – WHC (since 1972) and the International Geoscience and Geoparks Programme (since 2015).

The criterion viii) of the WHC states that selected properties need "to be outstanding examples representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features." This criterion is clearly based on the scientific value of geoheritage. On the other hand, criterion vii) says that properties must "contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance." Therefore, in order to be recognized by UNESCO as having "outstanding universal value", geoheritage must have scientific and/or aesthetic values, despite the need of other requisites in order to be included in the World Heritage List but not directly focused on values. The assessment of geoheritage significance in WH applications is under the responsibility of IUCN. International experts are invited by IUCN to make desktop and field evaluations but the justification of whether a geosite has global significance or not has shown to be rather complex. In 2005, IUCN produced recommendations to UNESCO in order to set some standards related with the acceptance of geosites in the World Heritage List (DINGWALL et al., 2005). This report proposes 13 geological/geomorphological themes in order to help State Parties to prepare comparative analysis of sites to support their applications.

In 2014, the World Heritage Committee of UNESCO requested IUCN "to revise its thematic study on geological sites, the "Geological World Heritage: A Global Framework" (2005) to refine the proposed 13 themes, articulate the threshold of Outstanding Universal Value, and clarify the difference between the criterion (viii) of the World Heritage and Geoparks status." (Decision 38 COM 8B.11). This is a clear demonstration that the topic of the assessment of global significance of geoheritage is still unclear and unevenly accepted.

In 2015, UNESCO created the label "UNESCO Global Geopark" with the establishment of the International Geoscience and Geoparks Programme. According to the statutes of this programme to the "Operational Guidelines for UNESCO Global Geoparks", a "UNESCO Global Geopark must have a clearly defined border, be of adequate size to fulfil its functions and contain geological heritage of international significance as independently verified by scientific professionals". As stated in these documents, IUGS is responsible for the assessment of the "scientific value and international significance of the geological heritage" of aspiring Global Geoparks". So, it is clear that for UNESCO Global Geoparks the scientific value of geoheritage must have international significance. In order to help IUGS evaluators to make this assessment, in 2017 the new International Commission on Geoheritage has accepted the proposal made by several experts to constitute the Working Group on Geoheritage Assessment (WGGA). This group is now setting up the guidelines to support an objective assessment of the international relevance of the scientific value of geoheritage in new Global Geopark applications. This presentation will present more detailed information about the work that is being done in the WGGA.

A third initiative has been developed since the 1970's, and has been well-accepted in general by the scientific community. The International Commission on Stratigraphy of IUGS is responsible for the definition of stratigraphic standards like GSSPs, which are geosites of international scientific relevance approved after a long process of scientific evaluation and based on a rigorous internal method. Gray (2011) has already suggested that these geosites should be included in a new geoconservation network supported by UNESCO in collaboration with other organisations.

Recently, van Wyk de Vries et al. (2017) have proposed a global framework that could be used in the future to support a systematic international inventory of geoheritage. Such an inventory is essential to sustain a proposal such as the one made by Brocx & Semeniuk (2017) that "there is a critical need to develop a convention, similar to the Convention on Biological Diversity that recognises the importance of geology as a part of Nature".

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IUCN Volcano Thematic Study: Identifying the Strongest Remaining Candidates for Inscription on the World Heritage List

Thomas J. Casadevall[1]; Daniel Tormey[2]; Jessica Roberts[3]

[1] U.S. Geological Survey, Denver, Colorado, USA (tcasadevall@usgs.gov)

[2] Catalyst Environmental Solutions, Santa Monica, California, USA (dtormey@ce.solutions)

[3] University of Portsmouth, Portsmouth, UK (jessica.roberts@port.ac.uk)

Introduction and Objectives

Volcanoes are among the most easily-recognizable natural areas of the World Heritage Program, notable for their combination of geological, biological, cultural, and aesthetic values to communities on every continent. The global recognition of the heritage value of so many volcanic landscapes raises important questions for their representation on the List. As advisory body for natural sites, the IUCN prepares thematic studies in response to important and programmatic questions. In particular, UNESCO requested the IUCN:

"*to revisit and update its thematic study on World Heritage Volcanoes to clearly articulate a short and appropriately balanced list of the strongest remaining volcanic sites with potential for inscription on the World Heritage List*..." IUCN Decision 37 COM 8B.15 adopted at its 37th session in Phnom Penh, 2013

We have prepared a Volcano Thematic Study in response to this request, and summarize the methods and major findings in this paper.

The context for this Volcano Thematic Study is that UNESCO seeks a representative, balanced, and credible World Heritage list of sites (including volcanic sites) that demonstrate outstanding universal value: significance as exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. The World Heritage List is not a venue to collect a large number of sites representing very specific values; rather the List highlights the best of the best in the world. This context raises two key questions:

1) **What makes a volcanic terrain "the best of the best", truly iconic, and worthy of inscription on the World Heritage List?** Iconic is not necessarily the same as outstanding universal value, however, and is defined in this study to mean "so famous as to be an integral part of a broad culture". For example, there are many scientifically-important and aesthetically-pleasing oceanic islands, but the Galapagos Islands are an iconic volcanic terrain because they also host one of the world's most outstanding illustrations of how volcanic geodiversity supports unique biodiversity and that Darwin's development of the theory of evolution by natural selection was in part inspired here. Similarly, volcanic chains along the "ring of fire" surrounding the Pacific Ocean contain several exceptionally beautiful, spiritually uplifting, snow-clad cone volcanoes, but Mount Fuji is an iconic volcanic terrain because it has been represented in art and spiritual practice for millennia and is considered part of the world's shared patrimony. We make this distinction because many iconic volcanic terrains on the World Heritage list are also not included for their outstanding universal value of geological attributes (such as Mt. Fuji), while others are (such as the Galapagos).

2) **Are iconic volcanic terrains appropriately identified on the World Heritage List?** The Galapagos Islands were listed for geological, ecological, and aesthetic criteria. Therefore, the volcanic features were appropriately identified and recognized in the listing under

criterion viii. Mount Fuji, in contrast, was listed for a unique cultural tradition, and tangible association with traditions and artistic works of outstanding universal significance. Mount Fuji was neither nominated for, nor listed for, its volcanic features under criterion viii despite being one of the first “iconic volcanoes” many people, including most volcanologists, would name. Without the volcanic features identified in the listing, there is no assurance that the geological attributes will be adequately represented or protected, and that the host of volcanic risks will be addressed in the management plan.

Method

The Volcano Thematic Study begins by defining an approach to classifying volcanic landscapes for use in developing a balanced and representative World Heritage List for volcanic sites. The study then provides an analysis of existing listed sites using the classification system as an organizing principle, and identifies gaps in representation on the World Heritage List. The analysis first considers volcanic sites listed under criterion viii, and the degree to which the current List adequately represents the world’s volcanic estate. Next, the analysis considers those sites on the List that have volcanic features, but that are not listed for criterion viii. Many of these sites do not display outstanding universal value for their volcanic features, but several of them certainly do. We consider how representative the current List would be, with addition of these sites not currently listed under criterion viii but with a likelihood of qualifying. We then consider sites on State Parties Tentative lists, and consider representativeness of the List with the potential inclusion of these sites in the future.

Finally, we specify sites identified during the preparation of this Volcano Thematic Study, in order to identify remaining gaps that could be filled by new nominations. The systematic application of the method described in this Volcano Thematic Study leads to a list of the strongest remaining volcanic sites with potential for inscription.

The study also provides advice to State Parties on the application of criterion viii to volcanic sites. The advice includes the use of the classification system and feature identification presented in this study to nomination of volcanic sites under criterion viii, including a checklist that can also be used by the reviewers of the nomination. The advice also describes developing a comprehensive global comparative analysis to support the application for Listing. The global comparative analysis is central to the application and review process in establishing the potential for outstanding universal value.

Analysis

Volcanoes are a true wonder of the planet; they are central to formation, evolution, and sustaining of biological systems; they form some of our deepest and most significant cultural attachments to the land; and they attract large numbers of visitors for their aesthetic appeal. Brilha (2016) articulates that the values considered for geoheritage sites are properly only scientific values. However, the relative youth and dramatic aspect of active volcanic sites compared to other geological themes lends cultural, biological, and aesthetic importance to volcanic sites. The relatively rapid growth of new terrain, standing above surrounding areas, leads to an unusually high degree of micro habitats that lead to high levels of biodiversity and endemism. The growth rate of volcanic terrain is closer to the human memory scale, and this immediacy leads to a closer involvement with cultural development. Therefore in developing the classification for use in World Heritage Site listing, these related values, beyond scientific values, become important considerations in assessing both representativeness, and outstanding universal value among many possible choices in the world's volcanic estate.

Classification of volcanic landscapes

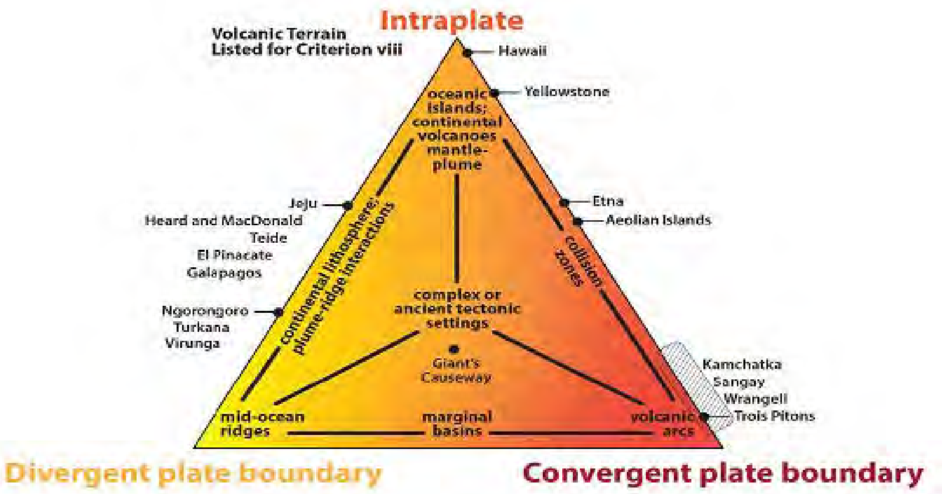
Classification of volcanic landscapes for world heritage must support dialogue among scientists, decision makers, local populations, and other stakeholders. The classification must address scientific values, heritage values, and regional diversity. Perhaps most important for a UNESCO program, classification for world heritage should itself be memorable and educational.

Classification must also recognize that the World Heritage List allows a limited number of sites with outstanding universal value. The components of the classification do not automatically require representation on the World Heritage List for each component: sites must also meet the conditions of outstanding universal value, site integrity, and management. Some components of the classification may be represented by very few sites, because even the best sites within a taxonomic component may not satisfy integrity and management criteria.

In addition to assessing outstanding universal value of volcanic properties, the classification system helps the IUCN address the question: how does the nominated property compare with other similar properties at the global level? The global comparative analysis that all nominated properties must provide (Operational Guidelines, Section III.A.3, paragraph 132.3) requires the application of a global classification system and a comparison of the nominated property with other World Heritage properties and protected areas within the same or similar global context.

Primary Classification System for Volcanic World Heritage: Plate Tectonic Setting

In surveying and considering the range of potential classification systems, we determined that landform-type classification systems such as proposed by Wood (2009) were too narrow for our purposes, and that genetic systems were too broad. Plate tectonic setting, however, provides an organizing principle that is readily understood, easy to communicate on maps and graphics, and neither too broad nor too narrow. Plate tectonics is the result a scientific revolution that completely transformed how geologists consider the dynamic earth, and volcanism is the visible evidence for many plate boundaries. As the primary classification component for volcanic world heritage, plate tectonic setting is certainly memorable and educational. The primary subdivisions of the classification system are based on the plate tectonic setting and include (see also Fig. 1):



1. Divergent
2. Convergent
3. Intraplate
4. Backarc basins
5. Subridge plume
6. Collision zones

Fig. 1: Diagram showing the plate tectonic settings of volcanoes, after Perfit and Davidson (2000, modified from Pearce 1996)

Regional representation is an important factor in providing a representative, balanced, and credible World Heritage List. For example, “textbook bias” can lead to overlooking volcanic sites with outstanding universal value, but not located in developed countries where most textbook authors reside and refer. On the other hand, we would not expect all regions to be represented equally, because active volcanoes are not uniformly distributed across regions. Therefore, those regions with the preponderance of activity are likely to have most of the listed sites. We classify regional representation using the following regions:

- Africa
- Asia
- Europe
- Latin America
- North America
- Oceania

The secondary subdivisions of the classification include consideration of specific values, including cultural and spiritual value (including whether the volcano is iconic), biological and ecosystem value, aesthetic value, and scientific value. Not every volcanic site recognized for outstanding universal value under criterion viii must have all secondary components. Rather, as with plate tectonic setting, one or more of the secondary factors listed here may be considered part of the measure of the outstanding universal value of the particular nomination. That is, among the many outstanding volcanoes associated with the Pacific ring of fire, those that have outstanding value for spiritual, ecosystem, aesthetic, and scientific value would be the strongest candidates to represent this component of the classification.

The primary classification of plate tectonic setting would identify gaps in the current World Heritage List. The secondary components would assist in determining which volcano or volcanic property would demonstrate outstanding universal value among the candidates to fill the gap. This procedure will lead to the selection of volcanic sites to the World Heritage List that display broad (as opposed to narrow) values for which volcanic terrain is known. In some cases, these secondary classification components may also display outstanding universal value and be listed as such, in addition to criterion viii.

Gap Analysis

In our application of the classification to volcanic sites on the World Heritage List, we find that the List is neither systematic in how it recognizes the volcanic theme in general, nor how it recognizes volcanic sites with outstanding universal value specifically. The List currently has 80 sites with volcanic features, but only 23 are listed under criterion viii (geological values). The others are listed for cultural (78), biological (67), and aesthetic values (36). Note that frequently individual sites are listed for multiple criteria.

The Geological World Heritage report (DINGWALL et al. 2005) recognizes that direct recognition of geological heritage through the use of criterion viii will ultimately recognize only a relatively small number of global sites, and that there is a benefit in recognizing the supporting value of geology within World Heritage properties inscribed for biological, cultural, or aesthetic values. However, the report notes that volcanic sites that are not listed for criterion viii are likely to be of regional or national importance only, not outstanding universal value.

Our analysis indicates, however, that several volcanoes on the World Heritage List do in fact have OUV for criterion viii, but are not listed under that criterion. Of volcanic sites on the World Heritage List that would generally be considered to have outstanding universal value by both volcanologists and the public, more than half are not listed under criterion viii.

In regard to the management of volcanic World Heritage properties, if a volcanic property is not listed for criterion viii, there is the potential that the risk of hazardous conditions (eruptions, gas emissions, hydrothermal activity, landslides, and other volcanic hazards) may not be adequately addressed in the site's management plan. The World Heritage List includes some notably dangerous volcanoes, and the monitoring of volcanic activity and risk contingency planning should be essential parts of the management process in all potentially active volcanic World Heritage properties. In addition, the site's key volcanic features may not receive adequate emphasis or protection by the managing authority.

There are currently significant gaps in representation of volcanic sites listed for criterion viii. western South America is the most prominent example of continental arc volcanism, and yet is poorly represented. The southwestern Pacific island arc settings, with several volcanoes with outstanding universal value, are unrepresented on the List. For divergent margin sites, the mid-Atlantic Ridge (including iconic volcanoes of Iceland), the Great Rift Valley of Africa, the Red Sea Rift, are poorly or not represented. Submarine volcanic systems are dominantly rift systems and are not represented. Volcanism in back arc basins is unrepresented, although there are outstanding examples in Argentina and the southwest Pacific. Collision zones are not represented. Ancient volcanic terrains contain no continental flood basalts, greenstone belts, ring-dike complexes, or komatiites, despite the importance of these terrains in remaking continental surfaces, and as components of most mass extinctions on the planet.

Filling the Gaps

The first place we consider for filling the gaps identified for those sites listed for criterion viii is World Heritage Listed sites that have volcanic features likely to display outstanding universal value, but were not listed for criterion viii. Most of these sites would not likely display outstanding universal value for their volcanic features because the level of significance is regional or local only. In other words, the omission of listing for criterion viii for the site's volcanic features is probably correct. However, many listed sites would almost certainly display outstanding universal value under criterion viii, and therefore would increase the representation of volcanic sites on the List for their geological values.

Among convergent margin plate tectonic settings, 5 of the 9 listings are considered iconic, yet they are not listed under criterion viii. These include Mt. Fuji, Japan, Pompeii and Vesuvius, Italy (although the volcano is not included in the boundaries of the listing), Joya de Ceren (buried by eruption from Loma Caldera in El Salvador), Popocatepetl, Mexico (although the volcano is not included within the property boundary), and Ujung Kulon. Indonesia (including Krakatoa). Therefore, inclusion of the volcanic sites not listed under criterion viii significantly expands representation of iconic convergent margin sites on the List, but would require some potential modifications to listings that might be suggested to the State Party. Considering convergent margin volcanic provinces, the inclusion of sites not listed for criterion viii still leaves the previously-identified gaps.

Divergent margins would also be better represented by including sites not listed for criterion viii. Three iconic sites, including Surtsey (Iceland) and two from the Great Rift Valley of Africa (Mount Kilimanjaro and Mount Kenya), could be listed for criterion viii and would enhance representation of divergent margins on the List. The lack of any submarine volcanic site, which contains approximately half the world's volcanic estate and most of the world's divergent margin volcanoes, leaves these sites unrepresented.

Continental Flood Basalts are represented by the Western Ghats of India (Deccan Traps), the Putorana Plateau of Russia (Siberian Traps), and the Iguazu National Park (Parana Basin Flood Basalts), Brazil/Argentina. All of these are considered iconic and likely to display outstanding universal value for criterion viii. Because the geology was not central to the listings for these sites, the best-preserved areas of those volcanic provinces are not included in the World Heritage Site Boundary. Although these provinces are likely to preserve areas that contain outstanding universal value for geological features, it is not clear that the boundaries as currently drawn include such areas.

State Parties are required to develop Tentative Lists of properties considered for nomination to the World Heritage List. These tentative lists represent current thinking of State Parties with respect to filling the gaps in representation. We followed the practice of Wood (2009) by also including an inventory of volcano properties listed in the World Heritage Tentative List. The current Tentative List contains 19 properties of high-quality volcanic areas including 15 that may be nominated for inscription under criterion viii, including several sites which would fill gaps in the World Heritage List.

In our opinion, the Tentative Lists include some iconic sites that are likely to demonstrate outstanding universal value. In particular, Payun Matru in Argentina would fill an important gap in back arc volcanism. Atitlan (Guatemala) and Masaya (Nicaragua) would improve representation in cordilleran arc magmatism. Changbai and Paedku (forming a common boundary of China and the Peoples Republic of Korea) would fill an important gap in tectonically complex areas of Asia. Banda (Indonesia), Mayon (Philippines), and Kermadec (New Zealand) would help fill the gap in southwest Pacific island arc volcanism. The Icelandic volcanoes would substantially add to representation of the marine divergent margin setting, although the subridge plume leads to these being subaerial.

Notably State Parties have begun to fill the important gap in submarine volcanism, which makes up roughly half of the world volcanoes but are practically not represented on the World Heritage List. Specifically the Commander Islands (Russian Federation) and Kermadec Islands and Marine Reserve (New Zealand) are on the Tentative List.

The results of this Volcano Thematic Study should be used by State Parties to evaluate their tentative lists and consider adding to them, and ultimately select sites for nomination that are currently underrepresented, and to support the nomination with a comprehensive Global Comparative Analysis.

It is up to State Parties to consider other factors, including stakeholder support for listing, conditions of integrity within proposed boundaries of the World Heritage site, and whether an appropriate management framework could be developed. Based on these other factors, State Parties may choose other related volcanic sites that fill the gaps identified in representation, and have suitable heritage value.

Based on the work conducted for this Volcano Thematic Study, including our own experience, knowledge of the scientific literature, and extensive outreach to professional societies and other experts in volcanic property, we have also identified several gaps in representation on the World Heritage List. We include them to emphasize their importance to improving the representativeness of volcanic sites listed under criterion viii.

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Linking geodiversity and biodiversity: an agenda for developing more integrated nature conservation and protected area management

John E. Gordon[1] & Roger Crofts[2]

[1] School of Geography & Sustainable Development, University of St Andrews, St Andrews, Scotland, UK

[2] IUCN-WCPA Emeritus, Edinburgh, Scotland, UK

Introduction and background

The links between geodiversity and biodiversity were recognised in the original definition of an ecosystem as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" (TANSLEY 1935), and subsequently in the Convention on Biological Diversity (1992). Nevertheless, and despite acknowledgement of the wider intrinsic, aesthetic, cultural and ecological values of geodiversity and geoheritage (IUCN 2008, 2012; CROFTS & GORDON 2015) and that geodiversity delivers or underpins many key ecosystem processes and services that deliver valuable benefits for society (Gray et al. 2013), geodiversity remains generally poorly integrated in nature conservation and protected area management, as well as more generally in environmental, social and cultural heritage policies and strategies (BRILHA 2002; CROFTS 2014, 2017; GORDON et al. 2018). This situation has arisen because: 1) biodiversity is more advanced as a conservation science, as a societal imperative and as an area for government action; and 2) the implications for protected area management of the fundamental interconnections between geodiversity and biodiversity are not yet fully recognised in nature conservation (CROFTS 2017; GORDON et al. 2018).

A number of priority themes in the current global conservation agenda offer opportunities for a more integrated approach: 1) incorporating geoconservation principles in protected area planning and management and in the sustainable management of natural systems; 2) supporting biodiversity conservation in both the terrestrial and marine environments, including adaptation to climate change, through the 'conserving nature's stage' approach; 3) integrating geoconservation into the ecosystem approach and the valuation of natural capital and ecosystem services; 4) normalising geoconservation in civil society, recognising the connections with people, place and human well-being and the ecosystem services and economic and social benefits provided by geodiversity and geoheritage; and 5) contributing to the achievement of the UN Sustainable Development Goals (GORDON et al. 2017, 2018). Here, we focus specifically on the links between geodiversity and biodiversity. We outline for discussion, within the scope of the IUCN/WCPA Geoheritage Specialist Group, the background and an agenda for more integrated nature conservation and protected area management that deliver benefits for all of nature.

Conserving nature's stage: why geodiversity is important for biodiversity

Geodiversity forms the foundation for ecosystems from global to local scales in both terrestrial and marine environments. This is reflected in the concept of 'nature's stage', that the physical environment is a stage that supports the actors - the species that are the primary target of biodiversity conservation (ANDERSON & FERREE 2010). Most species depend on the abiotic 'stage' on which they exist. First, there is a close connection between flora and fauna with the soil and underlying rocks, and the landform mosaics, water and nutrients on which they depend. Second, dynamic processes (e.g. soil formation, biogeochemical and water cycling, stream flows, erosion and sedimentation) maintain habitat condition and ecosystem health or provide disturbance regimes that support habitat and landscape diversity. In many environments, geodiversity in combination with climate provides the abiotic heterogeneity for high species richness, and areas of high geodiversity support high biodiversity from global to local scales. For example, global centres of vascular plants are located in mountain regions in the humid tropics where suitable climate conditions coincide with high levels of geodiversity (e.g. BARTHLOTT et al. 2005), while at a more local scale, mountain landforms and geomorphological processes support a diversity of habitats (e.g. KOZŁOWSKA et al. 2006). Also many distinctive habitats (e.g. limestone pavements and caves) support rare or unique biota adapted to particular abiotic conditions.

Nature's stage is not static. Terrestrial environments are episodically dynamic in space and time in response to geomorphological processes of different magnitudes and frequencies. Increased rates, occurrence, intensity and seasonality of flooding, slope failure, erosion, sediment supply and transfer, channel mobility and coastal change can all lead to changes in distributions of landforms and habitats. Extreme episodic events may also mean irreversible changes if geomorphological thresholds are crossed. Such geomorphological processes and disturbance regimes increase landscape heterogeneity and biodiversity. For example, river functional ecosystem processes are enhanced by habitat complexity at valley to reach scale, and biocomplexity is greater in functional process zones that are more hydrogeomorphologically complex because of greater habitat diversity and niche availability (THORP et al. 2010). Over longer timescales, past geological and geomorphological events (e.g. glaciation) and landform inheritance continue to influence present links between geomorphology and biodiversity, both in terms of providing refugia and influencing current slope processes that maintain habitat and species diversity, as in the Giant Mountains in the Czech Republic (ŠTURSA 2013).

Climate change and sea-level rise will lead to more dynamic landscapes that will provide challenges for biodiversity management. In planning for change, 'conserving nature's stage' is a coarse filter approach to enhance resilience and adaptation options for biodiversity. Areas that include a diversity of abiotic conditions will likely enable species to adapt or relocate through availability of suitable environmental mosaics, connections, corridors and elevational opportunities, as well as a range of potential macro- and micro-refugia, even if the climatic conditions and species in those areas change (ANDERSON et al. 2014). Geomorphological sensitivity to climate change will also impact biodiversity non-linearly, requiring consideration of the geological and geomorphological setting, past history, and process dynamics. Learning from the past (100s – 1000s of years) is also vital to inform restoration and adaptive management through opportunity mapping to help understand past ranges of natural variability and future trajectories of change.

'Conserving nature's stage' requires better integration of geodiversity in the selection, management and monitoring of protected areas as part of an ecosystem-based approach that recognises the value of both abiotic and biotic processes in nature conservation. Trying to manage biodiversity alone without understanding the underlying geodiversity/abiotic processes risks wasting time and resources. Combining abiotic and biotic targets can result in a system of protected areas that is more representative of a region’s natural diversity. Including geodiversity and making space for natural processes that enhance landscape heterogeneity can therefore help improve protected area design and delivering long-term biodiversity targets where communities are likely to change (ANDERSON et al. 2014). In some dynamic environments, as a consequence of the sensitivity of geomorphological processes, protected area status may no longer be justified since the interest has shifted, the site boundaries may need to be changed or conservation targets may no longer be viable.

An agenda for progressing interconnectivity

We identify 5 priority areas for discussion at the workshop to progress a more integrated approach that recognises the value of the links between geodiversity and biodiversity in protected areas. These are founded on the concept of 'conserving nature's stage'.

1. At a site level, improve advice on geoheritage conservation for ecologists and others through a Best Practice Guideline on Geoheritage Conservation in Protected Areas. This is already in preparation by the IUCN/WCPA Geoheritage Specialist Group, but the challenge will be to ensure wide adoption of the guidance. Good case studies will be critical in this respect.
2. At a system (landscape/biome) level, develop Key Geodiversity Areas to complement Key Biodiversity Areas. First, from a purely geoheritage conservation viewpoint, this would be of significant step since there is no existing systematic international network of geoheritage protected areas. Second, from the viewpoint of linking geodiversity and biodiversity, there are likely to be many overlaps in the respective Key Areas that would benefit from a joint management approach, while additional Key Geodiversity Areas should provide extra support for biodiversity and may enhance connectivity between Key Biodiversity Areas. Subsequent analysis should also enable better understanding of functional links between abiotic and biotic components of ecosystems and their potential responses to climate change.
3. Develop the relevant geoconservation ‘working principles’ (Table 1) in terms of more specific guidance to connect geodiversity with biodiversity, particularly in relation to protected area management. What do the principles mean in practical terms? Again, case studies will be critical to demonstrate the value to biodiversity conservation.

Tab. 1: Geoconservation working principles and consequences for protected area management (from Crofts & Gordon 2015; Gordon et al. 2017).

Working Natural Principle	**Consequence for management**
Manage natural systems by ‘working with nature’	Plan for space for nature to operate naturally
Manage natural systems in a spatially integrated manner	No artificial lines or barriers to conservation on the ground
Natural change is inevitable	Dynamic approach to conservation planning for future changes
Climate change & geomorphological responses impacts on condition of habitats & species	Dynamic approach to conservation planning for future changes
Sensitivity of natural systems should be recognised	Assess thresholds of change and moderate management accordingly
Understand physical processes and landscape evolution of active systems	Adapting species and habitat management accordingly

4. Develop specific guidance for key biomes e.g. grasslands, volcanic landscapes, coasts. What are the priorities?
5. Find ways to improve networking and communicating between geodiversity and biodiversity colleagues within IUCN. Possible actions might include:
   - gain agreement in the WCPA Steering Group for action to improve geo/bio linkages;
   - provide material to the WCPA/Species Survival Commission (SSC) Joint Task Force on Biodiversity & Protected Areas to broaden their remit and approach;
   - interact with the Commission on Ecosystem Management (CEM) Specialist Group on Ecosystem Function & Services;
   - ensure geodiversity input to other Best Practice Guidance;
   - arrange joint meetings/workshops with scientists and practitioners to progress the 'conserving nature's stage' approach in protected area management;
   - publish a paper in Parks journal on the interconnections between geodiversity and biodiversity after this workshop.

Conclusions

1. The interests of most protected areas for biodiversity depend on abiotic conditions and processes. In the face of climate change, protected area design and management that recognise these interconnections should enhance resilience and sustain key processes. This would benefit nature conservation from both a biodiversity and a geodiversity perspective.
2. The concept of 'conserving nature's stage' offers a promising way forward, but there is a need for wider engagement with the nature conservation movement and within bodies such as IUCN to present and develop both a practical framework and its scientific underpinning.
3. As first steps in an 'agenda for interconnectivity', we identify five priority areas for discussion to help progress the role of geodiversity in protected area management.

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Natural Capital, Ecosystem Services and Geodiversity: complexity and confusion

Murray Gray

Queen Mary University of London, UK

Geodiversity

Milton (2002, p.115) accepted reality in stating that “diversity in nature is usually taken to mean diversity of living nature”, but nature comprises both living and non-living elements: both biodiversity and geodiversity. Several definitions of geodiversity exist. Ruban (2011) saw geodiversity as referring to the diversity of geosite types, but most researchers have defined it as the diversity of abiotic nature itself. I have defined it as “the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, topography, physical processes), soil and hydrological features. It includes their assemblages, structures, systems and contributions to landscapes” (GRAY, 2013, p.12). In essence, this means that geodiversity involves three characteristics - material, form and process. Any analysis of nature/natural capital ought to recognize the existence of geodiversity and these characteristics.

Natural Capital

Several types of capital exist:

- financial capital – monetary wealth;
- produced capital – e.g. roads, buildings, machines, produce;
- human/social/intellectual capital – e.g. health, knowledge, culture, institutions;
- natural capital – the stock of natural assets.

The World Forum on Natural Capital defines natural capital as “the world’s stocks of natural assets which include geology, soil, air, water and all living things” (naturalcapitalforum.com). This definition has the advantage of being clear, concise and comprehensive, and it puts geology first, recognizing it’s place as the foundation of the planet. Most other definitions/descriptions do not share these advantages. For example, The UNEP Finance Initiative’s Natural Capital Declaration (2012) includes only “soil, air, water, flora and fauna” (naturalcapitaldeclaration.org). The UK is one of the only countries to have established a Natural Capital Committee. Its 2nd report (2014) includes a much longer list of natural assets – species, ecological communities, soils, freshwater, land, atmosphere, minerals, subsoil assets, coasts and oceans. The most interesting point here is what must be seen as the deliberate avoidance of the use of the term “geology” by introducing the term “sub-soil assets” and distinguishing these from “minerals”. Perhaps our subject should be renamed “sub-soilology”!! Dieter Helm’s (2015) book on Natural Capital is subtitled valuing the planet, yet the index has:

- no reference to “geology”;
- only one reference to “soil”;
- one reference to “geothermal power”;
- two references to “minerals”;
- several references to “oil” and “gas”.

So this is not a comprehensive assessment of abiotic nature or the benefits it brings to society. Dieter Helm is Chairman of the UK Natural Capital Committee. Finally, the World Conservation Monitoring Centre (WCMC) has a webpage (unep-wcmc.org) entitled Valuing Natural Capital that focuses entirely on biodiversity and illustrates this with a photograph of snow-capped, rocky mountains!

Ecosystem Services

As implied above, Natural Capital assets lead to goods and services that benefit human society. Gretchen Daily's (1997) seminal book on this subject that cemented this approach is entitled Nature's Services: societal dependence on natural ecosystems. But unfortunately, the approach has become generally known not as "natural services" or "nature's services" but as "ecosystem services". This is not very helpful to abiotic nature since ecosystems are predominantly associated with living nature. The Convention on Biodiversity, agreed at the Rio Earth Summit in Rio de Janeiro in 1992, defined an ecosystem as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" (my emphasis). But as we know and as described below, many services related to geology do not involve biotic interactions. So the problem is that the term "ecosystem services" is unhelpful, confusing but is now firmly established in the literature and in practice. For this reason the terms "geosystem services" has sometimes been used, including by myself (GRAY, 2011) to apply to services provided by geodiversity. Others have preferred the term "abiotic ecosystem services" (e.g. GORDON et al., 2012) in order to stay within the ecosystem services sphere.

The Natural Capital Protocol developed by the Natural Capital Coalition (naturalcapitalcoalition.org) shows "stocks" as being biodiversity, but "flows" as including both "ecosystem and abiotic services", though it says very little about the latter. Returning to the Natural Capital Committee's 2nd report, they list the goods derived from natural assets as – food, fibre (inc. timber), energy, clean water, clean air, recreation, aesthetics, hazard protection, wildlife and equable climate. This is a rather mixed list but it's unclear that any of these relate to either "sub-soil assets" or "minerals".

Summary of geodiversity within Natural Capital and Ecosystem Services

So the World Forum on Natural Capital is leading the way in promoting "natural capital" as including geology, but the "ecosystem services" approach is often trying to exclude it. For example, Diaz et al. (2015) state that "Non-living natural resources…are considered to be part of nature, but their direct benefits are not the focus of IPBES" (Intergovernmental Platform on Biodiversity and Ecosystem Services). And Brown et al. (2011) state that the UK National Ecosystem Assessment "does not provide an assessment of 'environmental services' that may be purely abiotic in origin…".

The serious global issue is that natural capital and thus the ecosystem services that depend on it are in decline as illustrated by Dearing et al (2012) study of the Lower Yangtze Basin in China. Consequently the aim of the international nature conservation community is to reduce or eliminate this decline and, if possible, reverse it.

Classification and Assessment

Further complexity emerges from the fact that three systems have been introduced in recent years to classify and assess ecosystem services:

- Millennium Ecosystem Assessment (MEA, 2005) – initiated by UN Secretary General Kofi Annan in 2000 and carried out between 2001 and 2005 by 1300 international scientists. It concluded that many services that ecosystems provide are being lost or degraded.
- Economics of Ecosystems and Biodiversity (TEEB, 2010) - commissioned by the G8+5, TEEB assessed the global problem of biodiversity loss and ecosystem degradation in quantitative economic and human welfare terms, and proposed solutions targeted at policy-makers, administrators, businesses and citizens.
- Common International Classification of Ecosystem Services (CICES, v5.1) (HAINES-YOUNG & POTSCHIN, 2018) – this system developed from the work on environmental accounting undertaken by the European Environment Agency (EEA). It supports their contribution to the revision of the System of Environmental-Economic Accounting (SEEA) that is currently being led by the United Nations Statistical Division (UNSD).

In this study, I have focused on the MEA, which classifies ecosystem goods and services as:

- Regulating services;
- Supporting services;
- Provisioning services;
- Cultural Services.

For example, provisioning services are listed as :

- Food (plants, animals);
- Fibre (wood, wool, cotton, etc.);
- Fuel (wood, etc.);
- Genetic resources;
- Biochemical & pharmaceuticals;
- Ornamental resources (shells, flowers);
- Freshwater.

Apart from freshwater, all these are biological services. For example, there is no mention of mineral fuels, construction materials, industrial minerals or gemstones. This simply reinforces the point that the “ecosystem services” approach, as currently practiced, is biologically based and does not do justice to the services provided by geodiversity. Because of these deficiencies, I have used the MEA classification as a basis for showing the goods and services related to geodiversity. I have however introduced a 5th category of “Knowledge services”, part of “Cultural Services” in the MEA classification. This is because of the importance of geodiversity in providing evidence for the history of Planet Earth and the evolution of life. The following 25 major services have been identified:

Regulating services

1. Atmospheric and oceanic processes;
2. Terrestrial processes;
3. Flood regulation;
4. Water quality regulation;

Supporting services

5. Soil processes;
6. Habitat provision;
7. Land and water as platforms;
8. Burial and storage

Provisioning services

9. Food and drink;
10. Nutrients and minerals for healthy growth;
11. Energy sources;
12. Construction materials;
13. Industrial minerals;
14. Ornamental products;
15. Fossils for commercial sale;

Cultural services

16. Environmental quality;
17. Geotourism and leisure;
18. Cultural, spiritual and historic meanings;
19. Artistic inspiration;
20. Social development;

Knowledge services

21. Earth history;
22. History of research;
23. Environmental monitoring and forecasting;
24. Geoforensics;
25. Education and employment;

Some Glimmers of Light

Despite the above discussion, a few current developments give some grounds for optimism;

- England's 25-year plan for the natural environment (2018) includes "geological assets" rather than "sub-soil assets". This follows a meeting that representatives of the English Geodiversity Forum had with staff preparing the plan;
- The journal Ecosystem Services has started publishing papers on geosystem/ abiotic services (VAN DER MEULEN et al., 2016; VAN REE AND VAN BEUKERING, 2016; VAN REE et al., 2017);
- The index to Mark Everard's book on Ecosystem Services has:
  3 references to geology;
  10 references to geodiversity;
  2 references to geomorphology;
  1 reference to the UK Geodiversity Action Plan;
  1 reference to Gordon & Barron's (2013) article on geodiversity and ecosystem services in Scotland.
- CICES (v5.1, HAINES-YOUNG & POTSCHIN, 2018) has an "abiotic extension" listing 35 abiotic services. This represents progress though it is regarded as an "extension" rather than an equal partner and is not comprehensive.

Conclusions

- Society is fortunate to live in a geodiverse world since this brings a huge range of benefits;
- Unfortunately, the current position of geology/geodiversity within the natural
- capital and ecosystem services approaches is complex, confused and inconsistent;
- This means that decision makers are undervaluing the benefits that the whole of nature brings to society and are therefore failing to promote a comprehensive and integrated approach to nature conservation.

International Recognition of Cave and Karst Geoheritage

John Gunn

School of Geography, Earth & Environmental Sciences, University of Birmingham, Edgbaston, Birmingham, B15 2TT, e-mail: J.Gunn.1@bham.ac.uk

Caves are found in many lithologies and settings. The majority are formed by dissolution of carbonate, evaporite or, more rarely, silicate rocks but there are also a substantial number of volcanic caves (also called lava caves) and littoral caves (also called sea caves). Less common forms include piping caves, developed by mechanical removal of sediment and tufa caves formed by deposition of carbonate minerals. Caves differ from all other landforms by their presence beneath the earth's surface which means that the global number, length and depth are unknown but increases year on year as a consequence of exploration by cavers. This poses particular problems for land managers and for those responsible for conserving geoheritage because new discoveries may totally change previous perceptions. An additional layer of complexity stems from some caves being clearly related to the landforms on the surface above them whilst others are totally independent of the cover rocks, receiving inputs of water, sediments, and in some cases pollutants, from thousands of metres away from the surface above them.

One of the most commonly cited definitions of karst is “terrain with distinctive hydrology and landforms arising from a combination of high rock solubility and well developed secondary (fracture) porosity.The distinctive surface and subterranean features that are a hallmark of karst result from rock dissolution by natural waters along pathways provided by the geological structure” (FORD & Williams, 2007, pages 1 & 2). This definition emphasises the landforms, and particularly the distinctive surface landforms, that many geoscientists equate with karst. However, it is important also the consider a hydrogeological definition which views karst as “an integrated mass transfer system in soluble rocks with a permeability structure dominated by conduits dissolved from the rock and organised to facilitate the circulation of fluids” (KLIMCHOUK & FORD, 2000, page 46). Most near surface carbonate and evaporite rocks meet this definition because they are soluble and groundwater is commonly discharged from them at springs fed by an integrated network of dissolutionally enlarged conduits. An important corollary is that karst may have no surface expression and evolution from a fluvial to a karst surface landscape is dependent on development of the conduit system.

These definitions are useful when considering how cave and karst geoheritage has been recognized under the two primary international designations - World Heritage Sites (WHS) and UNESCO Global Geoparks (GG). Caves and karst commonly also have high biodiversity value, as recognized by the addition of “subterranean karst and cave hydrological systems” to the Ramsar classification system for wetland type in 1996.

In 2008 the IUCN WCPA published a global review of karst World Heritage properties that was undertaken by Paul Williams. This provided a thorough assessment of the situation at that time and of future prospects and management requirements. In Table 1 of the review Paul identified 45 World Heritage properties with internationally significant karst features and in 27 of these the karst was classed as being of outstanding universal value (OUV). Subsequently Paul has updated the Table and as of 31 December 2017 he has 52 properties (in 33 countries*) with internationally significant karst features of which 28 were considered to have karst of OUV. One of these is the South China Karst, a serial site with seven karst clusters in four Provinces: Shilin Karst, Libo Karst, Wulong Karst, Guilin Karst (which has two separate sections), Shibing Karst, Jinfoshan Karst, and Huanjiang Karst. Williams noted that in addition to the sites on his list there are other World Heritage properties that contain caves or karst of national or regional significance. (*Two of the properties are cross-border, one shared between France and Spain and one shared between Hungary and Slovakia. As France has two other WH properties this is excluded from the count of countries).

In all of these properties it would be expected that there would be requirements for site integrity and management designed to protect the geoheritage but 5 of the 52 sites, including two identified by Williams as having karst of OUV, were inscribed on the WH list solely because of their cultural interest and it is not clear whether these sites have any requirements for protection of geoheritage.

The review was focussed on carbonate rocks but includes three 'non-carbonate' properties, one site with lava caves that contain carbonate speleothems, one with quartz sandstone fluviokarst and one with caves and a surface fluviokarst in quartzite. Eight of the carbonate properties are in a coastal or maritime setting.

As of 31 December 2017 there were 127 sites that had been recognized as UNESCO Global Geoparks (GG) of which 53 (in 18 countries*) include caves and / or karst as part of their geoheritage interest and two include caves in their title (Zhijindong Cave GG, China and Marble Arch Caves GG, United Kingdom and Republic of Ireland). (*Two of the GG are cross-border, one shared between Austria and Slovenia and one shared between the Republic of Ireland and the United Kingdom. As all of these countries have other GG the cross-border sites are not included in the list of countries). The countries with the highest number of GG with caves and / or karst sites were China (13), Spain (8) and Greece (5). The amount of geological information on the GG websites is very variable but at least two of the GG contain lava caves (Jeju GG (Republic of Korea) and Lanzarote and Chinijo Islands GG (Spain)) and one contains gypsum caves and karst (Central Catalonia GG). In the remainder the cave and karst interest is present in carbonates and metacarbonates. In total 37 of the GG contain at least one cave that is open to the public (based on information on their web-sites) with some having more than one tourist cave. It is to be expected that, as in WHS, the tourist caves in GG will be managed to the highest possible standards although the extent to which this is assessed during the four-yearly inspections is not clear. Perhaps more importantly it is not clear whether there are any measures in place to protect and manage the many other caves in each GG that are not open for tourists but which form an important part of the geoheritage. The European Geoparks Network, which is part of the GG network used to have a Cave and Karst Working Group but this is no longer operational (Kirstin Lemon, pers. comm.).

As of 31 January 2018 there were 98 Ramsar Sites in 47 countries with a combined area of 7,812,380 ha that were classified as "Wetland type: Zk(b): Karst and other subterranean hydrological systems". Of these 22 were in Mexico, 18 countries had 2-4 sites and the 28 other countries had only one site. For some sites the karst interest is immediately obvious and there is clear overlap with the geoheritage interest, for example Skocjanske Jame in Slovenia which is also a World Heritage Site. However, for others there is no apparent karst interest and in these cases it may be that the designation as a Ramsar Site is due to aspects of groundwater ecology in a non-karst context. Kalissaye in Senegal appears to fall in this category. There are also some sites that are quite simply puzzling. For example, the Grotte des Emotions in Belgium is clearly a small limestone cave "some 250 m by 100 m in overall extent but comprising a very complex network of chambers and passages more than 2000m long and with three main levels (45 m high). It presents a great variety of karst phenomena and features that are of important scientific interest. Little is known of any flora or fauna that may be present". With the latter in mind it would appear that this site is of importance primarily for its geoheritage interest. On the Ramsar web-site 36 of the sites are listed as having a management plan that has been implemented and it is assumed that the remainders have no management plan.

There is very little overlap between the WHS and GG designations but the Naigu Stone Forest Global Geopark forms the buffer zone for the three core zones in the Shilin cluster of the South China Karst WHS. There is more overlap between WHS and Ramsar sites as the Skocjan Caves WHS, the Baradla Cave system in the Caves of Aggtelek and Slovak karst WHS and the Puerto Princesa Subterranean River National Park WHS are also Ramsar sites. In addition, 22 of the 52 properties identified by Williams as having internationally significant karst features were inscribed on biological criteria (ix and x) as well as for earth heritage criteria (vii and viii) and there were five sites on Williams list where there were no WH earth science criteria and only biological criteria. This emphasises the fact that in karst there is commonly an overlap between geodiversity and biodiversity and this needs to be taken into consideration in any management plan and in the development of best practice guidelines.

In summary, this analysis has identified international recognition of cave and / or karst geoheritage at 203 sites in 66 countries. However, there is some duplication of sites and there are additional World Heritage properties that contain some cave and karst geoheritage features.The next stage will be to understand more about the nature of the cave and karst interest at each site, the extent to which that interest is taken into account in site management plans and how the condition of the interest is monitored.

A proposal of the Key Geoheritage Site program in IUCN

Seonok Ok Ju, Kyung Sik Woo

Department of Geology, Kangwon National University, Chuncheon, Gangwondo 24341, Republic of Korea

1 Introduction

Geoheritage can be defined as outstanding geological or geomorphological values, offering important information on geological phenomena, such as the evolution of the Earth and history of life, which should be conserved and inherited for future generations. Geoheritage sites with international geological significance (IGS) contain geo(morpho)logical features of global to regional values which can be accepted by Earth scientists, and that need legal protection for conservation. In some countries, these sites are protected by applicable national laws, however conservation of such significant geoheritage sites is not presently well-recognized even at national level when compared to significant ecological sites with high biodiversity. Thanks to the international programs that recognize geoheritage values, a number of countries have shown interests in UNESCO designation of World Heritage Sites or Global Geoparks. However, both programs have major geographic limitations because World Heritage Sites must be 'the representatives of the best in the world,' and Global Geoparks with IGS geosites require association with local communities for geotourism and sustainable development in order to be endorsed. Therefore, a new program is desperately required to promote the recognition and conservation of IGS geoheritage sites in the world.

2 Evaluation Assessment

2.1 Criteria (Representative, Rarity and Integrity)

The evaluation of geoheritage for IGS is based on the criteria (representativeness, rarity, and integrity) of a given geological context to reduce subjectivity. Representativeness is defined as a geological phenomenon that indicates the best representative example of stratigraphy, palaeontology, geomorphology, etc., and contributes to further understanding of geological concepts, processes, and features. Rarity can have two implications, including a uniqueness or as a special representative of an outcrop. The former is related to very rare and unique occurrences, such as the Burggess Shale fossil sites (lagerstätten) or the Niagara Falls that show the unique evidence of major events in evolutionary stages or the outstanding unique landform not common elsewhere. On the other hand, the latter is a special, exposed outcrop of normally hidden underground geological features, which could be geologically significant on a global scale. For example, a fold is a common geological structure, however when the outcrop of folds with globally significant tectonic implications is naturally exposed, it can be regarded as a rare geoheritage site.

Many valuable geoheritage sites are at risk of destruction by natural processes and humans, so they must be protected by proper protection measures. Integrity can be defined as a measure of the wholeness or an intactness of a geoheritage conservation state in World Heritage, however integrity here refers only to an intactness for geoconservation. Every geoheritage site should have a good management plan to maintain its best condition.

2.2 Geological Framework and Contexts

The geological framework is a list categorized according to the geological features of geoheritage. The framework is necessary to aid objective assessment and to conserve IGS geoheritage sites. Considering all the geological elements including geological sites and ongoing processes, this paper proposes the new geological framework including stratigraphy, palaeontology, paleoenvironment, tectonics/structural geology, mineralogy/petrology, marine geology, geomorphogy related to ongoing geological processes, and others. In addition, each geological context should contain some characteristics suggested here with applied criteria (representativeness, rarity and integrity) (Table 1) to justify its potential IGS. Eventually a comparative analysis is required within the same context in order to objectively prove IGS.

Tab. 1: An example of 'stratigraphy' in geological context with applied criteria. (REP/RAR=Representativeness/Rarity, O=Outcrop, S=Site)

Context	Characteristics	REP	RAR	Intergrity	
				O	S
Stratigraphy	Major boundaries of Geological time scale	○		O	
	Major event boundaries due to mass extinction or catastrophic events		○	O	
	Internationally accepted stratotypes of Geologic Era or Period(s)	○	○	O	
	Internationally accepted biozones based on macro- and microfossils	○		O	
	Internationally accepted chronostratigraphic sequences based on radiometric dating, paleomagnetism and geochemical data (stable isotopes, 87Sr/86Sr ratios, etc.)	○			S

2.3 Key Geoheritage Site

Only the parts of geoheritage sites with IGS have been designated as World Heritage Sites and Global Geoparks. Therefore, a new program 'the Key Geoheritage Site' is proposed to recognize and conserve all of the best representative geoheritage sites with IGS in the world. The Key Geoheritage Site should be justified by geological values alone, thus not considering its independent educational and touristic values. Thus, the concept of the Key Geoheritage Site is quite different from the geosites in Global Geoparks but can include the World Heritage Sites with criterion (viii) (Fig 1). Also for effective and suitable evaluation, recognition, designation and protection, objective geological contexts with appropriate criteria should be developed.

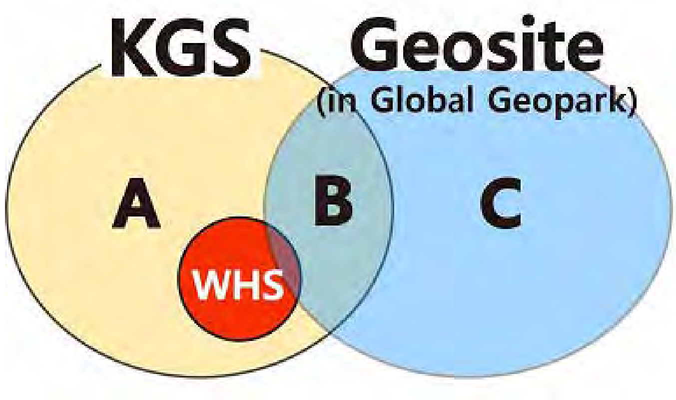

Fig. 1: The relationship between Key Geoheritage Site (KGS), geosites in Global Geoparks, and World Heritage Sites with criterion (viii) (WHS). A = Geoheritage sites with international geological significance. B = Geoheritage sites with international geological significance in Global Geoparks. C = Geoheritage sites without international geological significance, but with educational and/or touristic values.

3 Conclusions

Geoheritage site with IGS can be defined as a site with outstanding geo(morpho)logical values of regional to global scale. Therefore, a new program the ‘Key Geoheritage Site (KGS)’ is suggested to recognize and conserve the best representative geoheritage sites with IGS in the world, which can be justified by geological values alone. For effective assessment, recognition, designation and protection, objective evaluation methods using geological contexts with appropriate criteria should be developed. Comparative analysis of the proposed sites with proposed geological context and criteria should be carried out to justify their justification for IGS. We hope that this new program could contribute to conserve geoheritage sites worldwide if it can be adopted by IUCN in the future.

Recognizing landforms of international significance

Piotr Migoń

Institute of Geography and Regional Development, University of Wrocław, pl. Uniwersytecki 1, 50-137 Wrocław, Poland; e-mail: piotr.migon@uwr.edu.pl

Landforms – the subject matter of the science of geomorphology – are a key component of geoheritage and decisive for geodiversity of an area. The latter is due to the fact that in many contexts landforms (= surface relief) are the most evident block buildings of an environment, whereas rocks, soils and waters may be hidden under vegetation and land use. At the same time, landforms have a very special status within geoheritage as they combine inheritance and dynamics, unlike rock outcrops or fossil sites. Hence, landforms have various lifetimes, persist for different time intervals, and may be completely lost without any human interventions, by natural processes only. Landforms occur in a nested hierarchy of features, with minor landforms superimposed on the major ones (e.g. moraines within glacial troughs or waterfall steps within fluvial valleys) and with different clarity, which depends on the properties of the supporting rock/sediment itself, the density of vegetation and the magnitude of subsequent geomorphic processes. It is landforms which are among global landscape icons easiest to recognize (e.g. Sugar Loaf of Rio de Janeiro, Table Mountain in Cape Town, Uluru in Australia). However, most landforms are so obvious that non-geomorphologists hardly realize their existence, not to speak about their proper recognition and naming. In this respect, landforms – as rocks and soils – are ubiquitous; they are everywhere on land and in fact, build nearly 100 per cent of the global land surface (except highly urbanized and thoroughly modified areas).

Nonetheless and despite this ubiquity, landforms play an important role in the World Heritage Convention and many successful World Heritage nominations underlined the presence of specific landforms, usually outstanding due to their size and origin, within the boundaries of a property. Landforms as natural features of potentially outstanding universal values are explicitly addressed in the criterion no. (viii) which defines World Heritage properties as 'outstanding examples representing major stages of Earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features'. However, this statement raises several questions which seem not easy to be unequivocally answered. How to define 'significance' in the context of landforms and processes contributing to the development of landforms? How to define it in respect to various levels of inquiry, from local to international? Is it possible to evaluate 'significance' objectively, to avoid biased approach and minimize individual preferences? Are there thresholds of significance beyond which a truly international significance can be claimed?

It is argued here that 'significance' may be variously understood. Landforms may be significant for the science of geomorphology itself, playing an important part in our attempts to understand how the Earth's surface evolves. Particular reasons for significance may be manifold. For example, as rocks and fossils, albeit in a different way, landforms and their assemblages provide the record of the evolution of the Earth surface in different time spans, from the most recent past (e.g. history of deglaciation since the Little Ice Age, recorded in the assemblages of moraines and outwash sediments) through the Quaternary (e.g. evolution of dune fields in world's deserts or the origin of flights of raised marine terraces on oceanic islands and tectonically rising coasts), to longer periods, even back to the

Mesozoic as is the case of the Fennoscandian Shield. Some landform assemblages record the past better than others and those which do this best, are clearly of highest significance. Another, but closely related reason of significance resides in the role of a type locality played by a landform/landscape. Some landforms, due to their clarity, accessibility, size etc., became a subject of detailed studies which then, as the science of geomorphology evolved, gained the status of a ‘classic’. This is reflected in the common practice to draw parallels to such localities in subsequent studies carried elsewhere in the world. Examples of such ‘classic’ geomorphic features include the cockpit karst of Jamaica, star dunes of the Sonoran Desert, pingos of the Mackenzie Delta, raised coral reefs of Huon Peninsula (New Guinea), tors of Dartmoor (England), or the great escarpments of South Africa. Certain geomorphic localities are sites of ‘milestone’ discoveries in the history of Earth Science. Channeled Scablands of northwest US represent an area where the existence of glacial megafloods was realized for the first time, whereas the Meteor Crater in Arizona helped to understand the reality of extraterrestrial impacts. Often these ‘classic’ localities are more thoroughly researched than others and hence, better understood and presented as model examples of a certain type of landforms. The significance may also be associated with the sheer size of certain landforms. Huge size tends to be presented as natural curiosity but science helps to go beyond a mere fascination with grandeur, offering insights into the power of certain land-forming processes. Finally, an issue of uniqueness of certain landforms emerges. Generally speaking, processes that shape the surface of the Earth are universal and governed by basic principles of physics and chemistry. However, these processes are controlled by a multitude of factors such as rock type, air and ground temperature, amount of rainfall, type of vegetation, inclination of slope, crustal movements and many more, whereas the factors of time and external disturbance impair on the persistence of the resultant landforms. Since combinations of factors behind landscape evolution in any given place may be nearly endless, landscapes with no or little parallels elsewhere may indeed exist or they show certain features in an exceptional manner. Examples of such unique geomorphological landscapes may be found on the World Heritage List and include the sandstone spires of Wulingyuan in China or the quartzite mesas of the Canaima National Park in Venezuela.

Landforms may be also significant for reasons not directly related to geomorphology itself. In the context of biology, while not necessarily significant in their own right, landforms may crucially underpin the course of biological and ecological processes, contribute to the high degree of endemism, explain the mosaic of habitats and specific environmental adaptations among the living world. A good example to show how landforming and ecological processes go parallel is the Kvarken archipelago in Finland – an example of an emerging coastline due to glacioisostatic rebound. Likewise, in the cultural heritage context landforms are the necessary background of many cultural landscapes or inseparable components of sites of special cultural, religious, or historical significance. The spiritual significance of isolated hills and mountains is common to many cultures in the world and in specific instance the sacred status of a mountain goes hand in hand with scientific significance (Uluru in Australia is one example). Further examples of these linkages are provided by human modifications of extraordinary badland landscapes (e.g. Cappadocia, Turkey), military architecture which uses residual landforms (e.g. Hadrian’s Wall in England – a part of the Frontiers of Roman Empire property, numerous medieval castles on hilltops), caves and shelters with rock art or urban layouts guided by landform configuration.

Leaving science aside, landforms may be considered significant by the general public for reasons rather different than those named above although some common points remain. Grand examples of certain natural phenomena always attracted attention and the quest for 'World records' drives many people to particular localities. Many such records refer to landforms and for landforms difficult to measure unequivocally we even observe a sort of competition, fueled by tourism industry, which locality occupies no. 1 position (e.g. claims for the deepest canyon, the highest dune or sea cliff etc.). 'Record' landforms may be recognized at international, but also national and regional level. However, the best examples of a kind are not necessarily the biggest ones. Clarity of expression may be more important than size and one may think about situations where too big a size negatively impacts the ability to appreciate the whole landform in the context. For example, smaller tributary canyons to the Colorado canyon may be found to be more impressive examples of the power of fluvial erosion than the Grand Canyon, especially on a day with poorer visibility. Nonetheless, certain landform assemblages, even if fully recognized only by means of satellite imagery or digital elevation models, will remain highly significant for science. Another factor contributing to significance for general public is accessibility. Thus, for many the Niagara Waterfall would probably be more significant, and better recognized, than more remote examples even if the latter are bigger and their surroundings less altered anthropogenically.

Thus, 'significance of landforms' has many faces and it not easy to define. In the context of global initiatives to appreciate, protect and promote geoheritage, two issues emerge and have to be discussed. The first one is to address uncertainties connected with the use of 'significance' in wording of the criterion no. (viii) in the World Heritage Convention. Clear guidance which criteria have to be met by landforms and their assemblages (= 'geomorphic or physiographic features') to be considered significant for World Heritage would be welcome. Is scientific approach alone sufficient? Is it possible to express significance quantitatively? Simultaneously, a similar attempt should be made in respect to other geoheritage-oriented initiatives. The second issue is where and how the significance of landforms/ landforming processes crosses the 13 Earth Science Themes considered by IUCN as a framework to use in forthcoming nominations. Critical reading shows that they do not fit easily. Landforms are particularly relevant for volcanic systems, mountain systems, fluvial/lacustrine/deltaic systems, caves and karst systems, coastal systems, glaciers and ice caps, Ice Ages and arid and semi-arid desert systems. However, certain themes highly relevant to landforms are missing from the list such as permafrost-related features or rock-controlled landforms (which are not all necessarily mountainous), whereas some existing themes overlap (e.g. mountain systems in arid regions) or may be considered too broad for geomorphology (again, mountain systems). Therefore, it is worth reflecting on either revising the global framework for Earth Sciences to better expose the issue of 'significance of landforms' or work towards a parallel framework designed specifically for landforms and processes involved in their origin.

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World Cave Heritage

Trofimova, E.[1], Trofimov, A.[2]

[1] Institute of geography, Russian Academy of Science, 29, Staromonetny str., Moscow 119017 Tel.: +7 903 719 2759, eltrofimova@rambler.ru

[2] Russian Geographical Society, 10/2, Novaya Ploschad, Moscow 109012, RUSSIA

Abstract: For the first time the World Cave Heritage explorations are represented. The unique cave remarkable properties are divided into three groups by the types of heritage: cultural, natural and mixed, cultural-natural one. The distribution of the World Cave Heritage by the parts of the world and by the countries is given. The following outstanding cultural properties of the caves are considered: the objects of worship, caves decorated by the pre-historical paintings, conserving the archaeological materials, caves-mines and cave settlement. Caves of natural and mixed heritage are at the focus of separate attention. The World Cave Heritage map is represented.

Key words: caves, World Heritage, cultural properties, natural sights.

1 Introduction

"Cultural heritage refers to monuments, groups of buidings and sites with historical, aesthetic, archaeological, scientific, ethnological or anthropological value. Natural heritage refers to outstanding physical, biological and geological formations, habitats of threatened species of animals and plants and areas with scientific, conservation and aesthetic value" (World Heritage… 2008, p. 3). Some objects are characterized simultaneously by cultural and natural heritage, i.e. having mixed (cultural-natural) one.

Separate cave outstanding values were already considered by the colleagues-karstologues and speleologues (Dingwall et al 2005; Shivtiel 2016; Trofimov, 2015, 2016; Vermeulen, Whitten 1999; Williams 2008; Wong et al. 2001; Woo 2005; etc.), but this work is the first global analysis of the World Cave Heritage properties.

Currently, Cave Heritage of the mankind includes 43 properties, located in different parts of the globe (Tab. 1, Fig. 1): 19 – in Europe, 14 – in Asia, 5 – in America, 4 – in Africa and 1 – in Australia. The objects, describing exclusive cultural value, are dominating - 32 ones, eight natural ones of outstanding natural heritage and only two objects of mixed, cultural-natural heritage.

Fig. 1: World Cave Heritage: Cultural heritage: 1 – caverns as objects of worship, 2 – caves with the pre-historical painting, 3 – archaeological properties, 4 – cave-mines, 5 – cave settlement; Natural heritage – 6; Cultural and Natural (mixed) heritage – 7

2 Cultural heritage

Caves as objects of worship

The caves, nominated on the World Heritage List as the objects of worship, received the most support on the sessions of the World Heritage Committee: as for today 12 such sites were announced, three of which are disposed in Europe (3, 6, 19) (here and in the rest of the text the number (X) corresponds to that shown in Tab. 1 and Fig. 1), eight – in Asia (20-21, 23-26, 30, 32) and one that in Africa (34). All 12 cave sanctuaries represent a place of four religions pilgrimage: Buddhism, Hinduism, Jainism and Christianity, namely, its Eastern European branch. Cave temples of Ellora (25) devotes simultaneously to the gods of three religions: Hinduism /17 caverns/, Buddhism /12 ones/ and Jainism /5 ones/. Caverns of Mogao (20), Yungang (21), Longmen (23), Adjanta (24), Seokguram (30) and in Dambulla (32) are the Buddhism complexes. Elephanta Caves (26) are the Hinduism buldings and cave churches of Ivanovo (3), on the Island of Pátmos (6), in Kiev (19) and in Lalibela (34) are the Christianity ones.

With the exception of Apocalypse cavern (6), being the natural underground cavity, embedded in light-grey limestones and decorated for the religious ceremonies, all cave temples were created by “hands of the man”: both three cave complexes of China – Mogao, Yungang (20-21) and Longmen (23), hewn in the sandstones and limestones accordingly, and three cave monasteries of India – Adjanta, Ellora, Elephanta (24-26), cut in the basalt. Churches of Ivanovo (3), Golden Temple of Dambulla (32) and Churches of Lalibela (34) were hewed in the rocks in a similar manner. But caverns of Kiev-Pechersk Lavra (19) were dug in the weak kaolinite sandstones, and Seokguram Grotto and Bulguksa Temple (30) were built from the huge granite blocks, which were not fastened by building solution from within.

The earliest period of Buddhism cave sanctuaries appearance refers to 200 BC (24), but as for Christianity, the first Orthodox church was found in X century (6).

The most foremost techniques, created in an architecture, wall painting and stone carving, were used in course of cave temple complexes adorning. Moreover, the caves as the objects of worship are the remarkable illustration of recent art for the different epoch of human civilization development because all underground monasteries were re-built time and again during long period of its existence.

Caves with the pre-historical figures

At the present time the caves with the pre-historical figures were found in ten areas of the globe: in four regions of the Europe (1), (4-5), (14), in three ones in the America (38-40), in two sites of the Africa (35) and (37) and only one such object was revealed in the Asia (27).

With the exception of the Rock Shelters of Bhimbetka (27), where the figures are dated by the period from the Mesolithic to the Middle Ages, the all underground cavities images explored were created starting from the Upper Palaeolithic. But the most ancient cave masterpieces, adorning the walls and ceilings of the Cave Chauveux (5), treat on the Aurignacian culture: 33-29 thousands BP (PETROGNANI 2013).

The quantities of creations, arising from the titanic work of ancient people, are striking: so, in the World Heritage site “Serra da Capivara National Park” (39) approximately 30000 cave decorations are already described. The figures number exceeds 100 ones even in separate underground cavities: by example, in Lascaux (4) and Altamira (14). Besides, it is very difficult to estimate exactly the general quantity of cave images: on one hand, in consequences of the numerous, strictly conserved, areas inside of the caverns, and on the other hand, because of the complicity to identify, in some instances, the small, by the sizes, pictures.

By the subjects paintings in all underground cavities are distinguished both the zoomorphic masterpieces with images of local recent animals (horses, bisons, bears, etc.), and anthropomorphic paintings with the drawing of man “in full stature”. The panorama pictures indicate the situation scenes of hunting, harvest, ritual dances (1, 5, 37, 38, etc.). The considerable part of anthropomorphic figures in the Cave Chauveux (5), situated in Europe, are related with the images of the hands, but the name of the cave-site “Cueva de las Manos, Rio Pinturas” (38), disposed in the Southern America, is translated to English as “cave of the hands”: the hand imprints coloured were revealed in this underground cavity.

Caves as archaeological objects

Eventually there are four caverns of the UNESCO World Heritage List where the universal archaeological material was revealed: two in Europe (7) and (15), and one in Asia (22) and Africa (36). The expeditions are currently working in all the caves, and near to underground cavities the museums are opened, where the unique findings, found in the caverns, are exhibited. Two groups of such objects are distinguished: underground cavities, in which the unique outstanding artifacts are found, and the caves that hold the unique evidences of human habitation: shedding the light on the evolution of mankind.

The first group included six "Caves of the Ancient Art of the Ice Age" in the Swabian Jura (7), where the first art objects in the history of mankind, carved from the various materials, including mammoth ivory (more than 30 thousand years ago, the Aurignac culture) (Lobell 2012) were discovered: the famous statuette of a woman (The Venus of Höhle Fels), 6 cm high, the creature with a human body and a lion's head, as well as the numerous animal figurines (lions, mammoths, horses and bovids). The oldest musical (in particular, a flute) instruments are found here. Excavations in underground cavities considered were carried out since 1860.

The second group unites the following World Heritage sites. The rich fossil evidences of the earliest human presence in Europe have been discovered in the cave of Atapuerca (15): it is the largest repository of paleontological finds dating from the Middle Pleistocene. About 2000 bones belonging to 33 individuals of the species Homo beidelbergensis, which is an intermediate species between Homo erectus and Neanderthals, are described. All findings are well preserved (BERMÚDEZ DE CASTRO et al., 1997; GUNN 2004). The remains of Homo sapiens (18-11 thousand years BC) in the cave of Zhoukoudian (22) in Asia, the Beijing Sinanthropus pekinensis (Beijing), are dated from the Middle Pleistocene too (GUNN 2004). But the African caves (36) are the fossil deposits age record: in one of them, Sterkfontein, the famous Taung skull belonging to the Australopithecus africanus, who lived on Earth more than 2 million years ago (HERRIES, SHOW 2011), was found. More than 500 skeletal fossils were discovered here in course of archaeological excavations.

Cave-Mines

Cave-mines are being the World Heritage ones are distributed on the globe in the following manner: five properties are situated in the Europe: (2), (8), (12-13) and (17), and the one cave-mine is located in the Asia: (28). All the caves researched are currently closed for mining operations, but are used only for the touristic purposes. Stone quarries in the area of Spiennes (2), are the most ancient (dated from the Neolithic age - 4300-2200 years BC), spreading over 100 hectares, where a flint was mined. Two mining areas: (8) and (12), disposed in the Central Europe, are a unique monuments to the history of mining. They have a significant contribution to the global production of silver, lead, copper and zinc in the Middle Ages and are known by its technologically innovative underground water management systems. The beginning of salt exploitation in the town of Wieliczka-Bochnia (13) dates back to the 13th century: a salt mine in nine levels stretches underground for 300 km. In the 16th century, the mercury mining was established in the Europe in the Almagen and the Idrija (17), which became the world center for the production of this precious metal, and at the same time in another part of the world, in the Asia, in city of Iwami (Asia) (28), the extraction and smelting of almost a third of the world's silver volume were set up.

Cave settlement

Starting from the Palaeolithic the karstic relief is used in the most outstanding cave city of Sassi (11), where its historical center is represented by the caverns hollowed up in the limestones.

3 Natural Heritage

First of all, it should be noted that all 8 caves inscribed on the UNESCO World Natural Heritage List have a karstic genesis, moreover, they are distinguished both by outstanding speleosystems as a whole, and by their outstanding individual parts. So, the largest cave density in the world is observed in the area of Aggtelek karst and Slovak karst (9): here, 712 caves are concentrated on an area of 56 651 ha. Underground cavities are richly encrusted with drip-stone formations, among which is the giant stalagmite Observatory reaching a height of 32,7 m. In the same place, in the Europe, there is a unique complex of caves in Škocjan (16) by a total length of 5,8 km (Fig. 2), with its world's largest underground halls Martelov (its volume is estimated to 2,100,000 m^3) and Shumecha (870,000 m^3). The underground River Reka is known by the numerous waterfalls, as well as by the famous canyon with a depth of up to 100 m, through which the fragile Hanke bridge is thrown at a height of 65 m.

Cave Hang Son Dung (what is meant by Vietnamese as "cave of a mountain river"), located in the National Park "Phong Nha-Ke Bang" (33), is the largest cave in the world. Its four-kilometer underground gallery has a height of 240 m. Although the Mammoth Cave (42) is the longest underground cavity on the planet: its labyrinths are spread to 590 km. But the cave Puerto Princesa (29) is famous for its underground river, flowing directly into the sea of Sulu and being navigable over a length of 6 km under the ground, and subjected to the tides and ebbs.

The UNESCO List also includes the caves with unique karstic manifestations. Thus, the volcanic island Jeju is known by its lava tunnels (31) and the cave Geomunoreum, formed on the contact of carbonate rocks with frozen lava streams. The areas of carbonate karst are distinguished by a bright variety of colour shades (from brown to white), both the underground passages, and the speleothems observed in them. But Carlsbad Caverns (41) represent a speleological site of 81 underground cavities, among which the cave Lechugia (Lekugilla), having an unusual, sulfuric acid genesis, stands out by its charming beauty.

Australian Fossil Mammal Sites (Riversleigh and Naracoorte) (43) are worthy of the separate attention: the excellent illustration of the unique Australian fauna evolution main stages is reserved here.

4 Cultural and Natural Heritage

There are only two caves of World Heritage describing cultural and natural heritage simultaneously. The artefacts of five cultural epochs: from the Acheulian (500-200 thousands years ago) to Natufiy (12-9 thousand years ago), were found by the archaeologists (cultural heritage) in four natural caves of the Nahal-Mearot reserve (10) (natural heritage), located on the western slope of Mount Carmel. But the area of the Göreme National Park (18) is considered as the one of the most unusual places on the planet, often called the "museum under an air opened". On one hand, it is an astonishing landscape formed by the erosion processes (natural heritage), and on the other hand, numerous cave churches and monastic buildings, carved into volcanic tuff (cultural heritage), dating back to the beginning of IV century.

5 Conclusions

As shown above, currently the World Cave Heritage includes 43 sites located in different parts of the globe: 19 in Europe, 14 in Asia, 5 in America, 4 in Africa and 1 in Australia. 33 properties are characterized by the exceptional cultural value, of which there are 12 sites of worship, 10 properties with the caverns richly decorated by prehistoric drawings, priceless archaeological material is preserved in underground cavities of 4 areas, 6 caves reflect the different epochs of the mining industry formation and the center of 1 settlement is represented by the caves. 8 properties assumed a high status of the World Natural Heritage: at large, they are distinguished both by outstanding speleosystems as a whole or their outstanding individual parts, and by the universal peculiarities of its genesis. 2 objects are being a cultural and natural, that is, a mixed heritage: the historical evidences of different historical cultures are conserved in natural caves.

Tab. 1: World Cave Heritage

No	Country	Type of heritage		
		Cultural		Natural
		Natural cavities	Artificial cavities	
Europe				
1	Azerbaijan	Gobustan Rock Art Cultural Landscape: 2007*		
2	Belgium		Neolithic Flint Mines at Spiennes (Mons): 2000	
3	Bulgaria		Rock-Hewn Churches of Ivanovo: 1979	
4	France	Decorated Grottoes of the Vézère Valley: 1979		
5		Cave Chauveux: 2014		
6	Greece	Historical Centre (Chorá) with the Monastery of Saint John “the Teologian” and the Cave of the Apocalypse on the Island of Pátmos: 1999		
7	Germany	Caves and Ice Age Art in the Swabian Jura: 2017		
8			Mines of Rammelsberg and Historic Town of Goslar: 1992	
9**	Hungary-Slovakia			Caves of Aggtelek Karst and Slovak Karst: 1995, 2000
11	Italy		I Sassi di Matera: 1993	
12	Poland		Tarnowskie Góry Lead-Silver-Zinc Mine and its Under-ground Water Management System: 2017	
13			Wieliczka Salt Mine: 1978	
14	Spain	Altamira Cave: 1985		
15		Archaeological Site of Atapuerca: 2000		
16	Slovenia			Škocjan Caves: 1986
17**	Slovenia-Spain		Patrimoine du mercure Almaden et Idrija: 2012	

No	Country	Type of heritage		
		Cultural		Natural
		Natural cavities	Artificial cavities	
19	Ukraine		Kiev: Saint-Sophia Cathedral and Related Monastic Buildings, Kiev-Pechersk Lavra: 1990	
Asia				
20	China		Mogao Caves: 1987	
21			Yungang Grottoes: 2001	
22		Peking Man Site at Zhoukoudian: 1987		
23			Longmen Grottoes: 2000	
24	India		Adjanta Caves: 1983	
25			Ellora Caves: 1983	
26			Elephanta Caves: 1987	
27		Rock Shelters of Bhimbetka: 2003		
28	Japan		Iwami Ginzan Silver Mine: 2007	
29	Philippines			Puerto-Princesa Subterrane-an River National Park:1999
30	Republic of Korea		Seokguram Grotto and Bulguksa Temple: 1995	
31				Jeju Volcanic Islands and Lava Tubes: 2007
32	Sri Lanka		Golden Temple of Dambulla: 1991	
33	Vietnam			Phong Nha-Ke Bang National Park”: 2003, 2015
Africa				
34	Ethiopia		Rock-Hewn Churches, Lalibela: 1978	
35	Libia	Rock-Art Sites of Tadrart Acacus: 1985		

No	Country	Type of heritage		
		Cultural		Natural
		Natural cavities	Artificial cavities	
36	Southern Africa	Fossil Hominid Sites of Sterkfontein, Swartkrans, Kromdraai, and Environs: 1999, 2005		
37	United Republic of Tanzania	Kondoa Rock-Art Sites: 2006		
America				
38	Argentina	Cueva de las Manos, Rio Pinturas: 1999		
39	Brazil	Serra da Capivara National Park: 1991		
40	Mexico	Rock Paintings of the Sierra de San Francisco: 1993		
41	USA			Carlsbad Caverns National Park: 1995
42				Mammoth Cave National Park: 1981
Australia				
43	Australia	Australian Fossil Mammal Sites (Riversleigh, Naracoorte): 1994		

* - year when the object was inscribed at the List of World Heritage

** numbers 9 and 17 are concerned to the caverns of heritage mixed – natural-cultural one: 10 – Sites of Human Evolution at Mount Carmel: The Nahal Me'arot / Wadi el-Mughara Caves (Israel): 2012; 18 – Göreme National Park and the Rock Sites of Cappadocia (Turkey).

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C Case Studies of Geoheritage Conservation and Biodiversity Importance of Geoheritage

Challenges in the management of the Škocjan Caves, Slovenia

Rosana Cerkvenik

Park Škocjanske jame, Slovenija Škocjan 2, SI-6215 Divača, http://www.park-skocjanske-jame.si
rosana.cerkvenik@psj.gov.si

Škocjan Caves Regional Park

Škocjan Caves Regional Park is situated in the Kras Plateau of South-West Slovenia. The protected area of 413 ha conserves an exceptional limestone cave system which comprises one of the world's largest known underground river canyons, cut into the limestone bedrock by the Reka River. The river disappears into the karst underground, before passing through a vast and picturesque channel of up to 150 m in height and more than 120 m in width, often in the form of rapids and waterfalls. The canyon's most spectacular physical expression is the enormous Martel Chamber which exceeds two million cubic meters in volume. Like the canyon, the vast underground halls and chambers of the cave system expose stunning variations of limestone bedrock and secondary cave formations. It is no coincidence that karst research has its origin in this very part of Slovenia, referred to scientifically as "Classical Karst". The term "karst" itself is derived from the name of the plateau, one of many technical terms commonly used in karstology which have their origin in the region. Beyond its almost supernatural visual appeal, its scale and scientific importance, the regional park is also home to noteworthy species and species assemblages, namely in the distinct world of the underground environment and in the so-called collapse dolines, a form of karst sinkholes. The caves support many endemic and endangered species, including the Cave Salamander along with many invertebrates and crustaceans. The very particular environmental conditions of the collapse dolines provide habitat for rare and threatened flora and fauna. Furthermore, ongoing archaeological studies have been revealing ever more details of a very long history of human occupation since prehistoric times. There is strong evidence that our ancestors appreciated the area as a place for settlements. Archaeological research has also disclosed that the area was historically used as a burial ground and for rituals.

The Park is renowned not only for its rich natural features but it is also characterized by an interesting combination of unique cultural heritage features which are well-worth visiting in the villages of Škocjan, Betanja in Matavun. Very interesting from a historical point of view is the entire village of Škocjan, which together with the Church of Sv. Kancijan represents a settlement site.

The buffer zone covers 45.000 ha and encompasses the entire Reka River basin including its flow in the karst underground water accumulations, which forms a part of the contact karst.

Legal Framework for management of the Škocjan Caves

Škocjan Caves have been protected as a natural monument since 1980 and inscribed on World Heritage list in 1986. In 1996 the Škocjan Caves Regional Park Act was adopted, whereby a public service agency, in charge of managing the protected area was founded.

The caves were included in the Ramsar List of Wetlands of International Importance in 1999. Since 2004, the park has also been a member of the UNESCO's Man and Biosphere Programme as the Karst Biosphere Reserve.

Every activity undertaken by the Škocjan Caves Park Public Service Agency is based on a five-year management plan – the Škocjan Caves Park Protection and Development Programme. The programme is adopted by the Government and the National Assembly of the Republic of Slovenia. Every annual work programme is based on this document.

The mission of the Škocjan Caves Park is to manage and protect Škocjan Caves as a World Heritage Property, work with the local population to preserve the extraordinary natural properties and rich cultural heritage of this area and raise awareness in Slovenia and abroad of the importance of protecting the area. With this in mind, six operational objectives have been set for the coming five-year period:

1. Preservation of the Škocjan Caves and other subterranean areas.
2. Preservation of the favourable status of natural assets, animal and plant species and habitat types.
3. Cooperation in protecting cultural heritage.
4. The development of environmentally friendly park visits and raising awareness of the park – the sustainable development of tourism.
5. Greater involvement of the local population in developing activities in the park.
6. Greater role of the park manager in the wider park area (buffer zone and transitional area).
7. More effective management and international cooperation.

Škocjan Caves Regional Park Act lays down the protection regime for the area of influence, one of the main goals being to ensure the existing Reka River water regime and the favourable water status.

Challenges in the management of the Škocjan Caves

Škocjan Caves Regional Park is a protected area, well known in Slovenia and abroad. This is apparent from the number of visitors that grows every year (there were 52,000 visitors in 2000, 100,000 in 2008, 123,000 in 2015, and 178,000 in 2017). Data show that there are around 87 % of foreign visitors and 13 % of Slovenian visitors. Nature conservation is the absolute priority of the Škocjan Caves Public Service Agency. Therefore, planning and orienting their visit is crucial to protect this vulnerable area, including the Škocjan Caves and the entire regional park, from being overloaded.

The agency that manages this protected area and the World Heritage property recognizes today's challenges and those arising in the near future. The management takes various steps and measures to identify and meet the challenges.

These include mostly:

Managing the World Heritage property while the number of visitors increases

Managing a show cave that is also a World Heritage Property requires the assurance that the impact on the cave is minimised, that the cave is properly presented to the visitors, and that the safety of visitors and staff is well taken care for.

The agency tries to minimize the tourist impact on the cave environment by establishing different visitation protocols and especially by promoting off-season visits.

Between 2009 and 2015, with the help of the European Regional Development fund and the Ministry of Economic Development and Technology of the Republic of Slovenia, the main tourist infrastructure in the Škocjan Caves was renovated. The investment was worth 1,900,000 €. The main goal of renovating the infrastructure was to lower the energetic input and therefore helps protect the cave environment on the one side and to ensure the highest possible safety of both visitors and employees on the other side.

The entire tourist infrastructure of the cave was renovated. The path and the electrical installations were completely renovated and the lighting was replaced. According to the first results it is not allowing for more lampenflora to grow. Efficient and sectoral lighting along the walking paths, as well as ambient lighting in individual parts of the cave were introduced. The new installations include new, more environmentally friendly and effective technologies (LED lamps and reflectors) with a different colour spectrum, which does not allow for the lampenflora to grow as much and assures a 70 % lower electricity consumption. In addition, the micro-positioning of individual lights helped bring down the general load on the cave environment even more.

The cave also boasts IT equipment. The new communication infrastructure, especially the optical communication links, opened up new possibilities for monitoring and determining the influence of cave use on the cave environment. The data on various cave parameters are collected in different parts of the cave and can be monitored on-line through SCADA.

Recently, not only the cave infrastructure was renovated, but also the visitors centre and the parking area.

Together with the council of experts, the agency adopted a document for establishing the cave carrying capacity based on observation of the Škocjan Caves environment. The document contains monitoring guidelines for determining the tourist impact on the cave environment. On the basis of monitoring, it is possible to determine individual trends of deterioration or improvement that can be used as indicators for the cave carrying capacity. The monitoring indicators, the number of guides, the parking area capacity, and the length of time illuminating the cave route are crucial for managing the tourist visits. When the cave visits show negative trends (the conditions worsen), the cave carrying capacity is exceeded and it is necessary for the management to act in accordance with mitigation measures. The management of the Škocjan Caves must react in the event of negative changes or any kind of deviations from the natural state that assures smooth continuation of natural processes in the cave ecosystem, and especially before the damage becomes irreversible.

Understanding and researching the Karst

A precondition for good management, recognition of any kind of deviations and changes, and the basis for establishing possible measures is knowing the fundamental laws of such a complex system as the cave system. There were many fundamental and in-depth research studies conducted on the Škocjan Caves. Developing new skills and knowledge in the field of karstology and using new research technologies led to even more questions.

The IT technology established in the Škocjan Caves (see above) gives the possibility of monitoring various parameters that indicate the functioning of the system and the connections between different parameters.

The leading partner for the applied research project entitled "Karst research for sustainable use of Škocjan Caves as World Heritage Property" (2017-2020) is Karst Research Institute of the Slovenian Academy of Sciences and Arts. The research aims to determine the actual state of the karst in the Škocjan Caves and the surface from different aspects (non-living and living nature), perform system measurements (meteorology and hydrology), identify the current tourism impact, and determine the best methodology and measures for sustainable use of the show cave. To understand the origins and formation of the karst cave, it is also necessary to explore the surface above the cave system.

Strengthening the management role in the park's buffer zone

Conservation regimes for the park's buffer zone are defined in the Škocjan Caves Regional Park Act and refer mainly to the provision of the Reka River's water regime and the favourable water conditions.

According to the Slovenian Environment Agency the ecological and chemical status of waters in the buffer zone is good. Occasionally, water pollution and foam appear both on the surface current before the Reka River's ponor into the Škocjan Caves, as well as in the underground current including the Velika and Mala Dolina.

The most polluted area is the Ilirska Bistrica Basin, which includes the town of Ilirska Bistrica and the surrounding settlements. Industry is concentrated in this area, as well as many smaller industrial plants, transport providers, other businesses and farms. Industrial and domestic wastewaters flow to sewage system and the Ilirska Bistrica water treatment plant.

Settlements without a sewage system in the buffer zone are most often the source of pollution. Only Ilirska Bistrica and a few nearby villages have a sewage system.

Increased traffic loads of some roads sections, traffic accidents, and spills of oil and dangerous substances affect the quality of the Reka River. The main ecological wound from the past is the former Ilirska Bistrica chemical plant's industrial waste landfill.

The agency is actively involved in various educational and awareness-raising activities within the buffer zone, and encourages the resolution of old ecological issues and actions to prevent new pollution. In order to act in a case of oil or dangerous substance spill into the Reka River, the agency, together with the local voluntary fire brigade, bought the equipment needed for protection and rescue (in 2010 and 2014). Currently, the agency together with the Ministry of Environment and Spatial Planning and the local community is planning to rehabilitate the industrial waste landfill. In addition, some other projects are being implemented to improve the water status in the buffer zone.

Sustainable development of the wider area

The Škocjan Cave Regional Park plays an important role in the sustainable development of the wider area (tourism, agriculture and other services). Over the past years, the Škocjan Cave trademark has been developed especially for local providers of services and products. The agency also provides grants for the locals in the protected area who have new business ideas.

Some stakeholders already recognize the development opportunities, mainly in the accommodation and hospitality. However, there are still many opportunities left to explore. In this area, it is necessary to follow regional strategic documents, while private individuals deal with red tape and they wish the national law was more flexible.

Geoheritage interpretation

One of the agency's main goals is the adaptation of geoheritage presentations to different groups. At this point, the museum collections and the park's educational trails should be mentioned. They have changed over the years, both in terms of content, as well as tools for heritage interpretation. The Hanke Channel is planned to become a part of the guided tour, but this part of the cave (yet unopened to public) is intended only for experienced speleologists. In recent years, the park management tries to provide additional content that is more accessible to persons with disabilities. The regional park will also play an important role in the emerging geopark Kras – Carso as one of the key points in explaining contact karst.

Different challenges appear when explaining heritage, one of them is how to best present the Škocjan Caves' rich heritage to the visitors; not only the geological and geomorphological perspective but also the technical heritage.

Natuturingan cave (Puerto Princesa Underground River, Palawan, Philippine): how to preserve an astonishing ecosystem while improving tourism

Antonio De Vivo & Paolo Forti

La Venta Esplorazioni Geografiche & Italian Institute of Speleology

The Natuturingan cave, better known as Puerto Princesa Underground River (PPUR), is one of the largest subterranean estuaries in the world, where tides propagate over 7 km inside the cave. It actually consists of some 34 km of giant galleries and hosts a complex ecosystem mainly based on huge colonies of bats and swiftlets. Its natural uniqueness was recognized as World Heritage by UNESCO in 1999, while the first part of its navigable branch (some 2 kilometers) is used as a show cave since 1970 (Fig. 1).

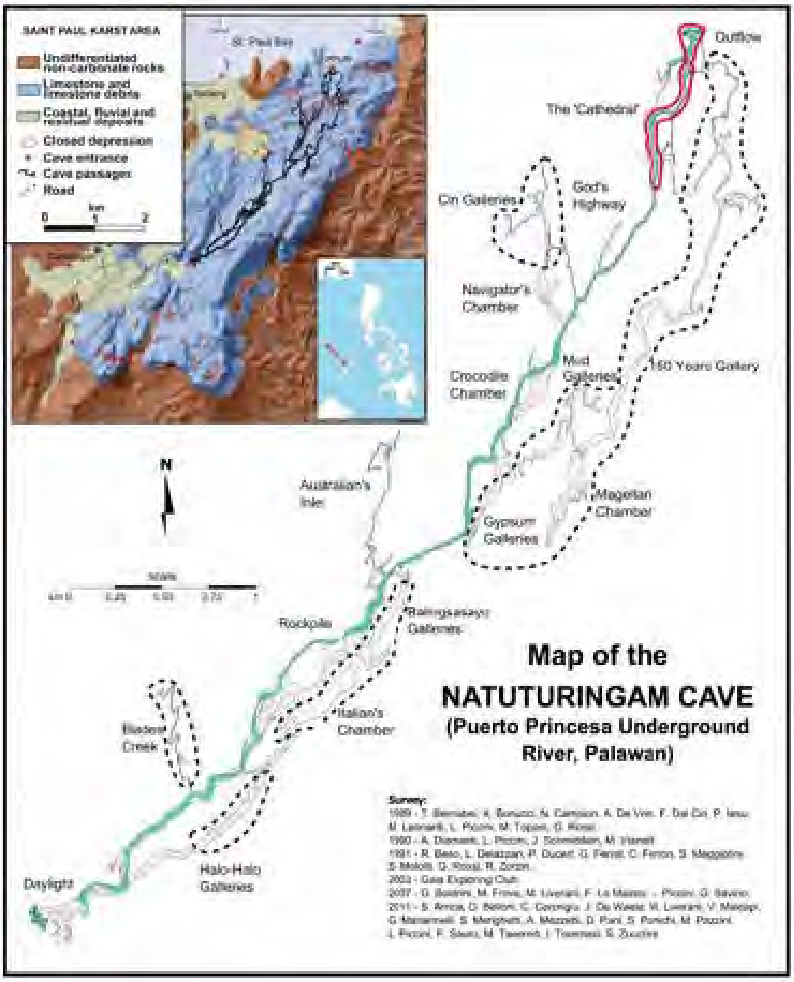

Fig. 1: Index map, geological sketch and present day development of the PPUR (modified after De Vivo & Piccini., 2013): the red area marks the sector actually open to tourism, while the dotted black ones those with thermostable climate.

But the most precious treasures of PPUR are hidden in the areas where tourist cannot reach. There, 5 different environmental host one of the most complex ecosystem of the whole planet (AGNELLI & VANNI, 2017) (Fig. 2).

In the same areas some new, and/or extremely rare types of delicate speleothems develop, the genesis of which is always related to the peculiar climate of this cavity (BADINO, 2017). In the upper series new cave minerals had the possibility to evolve while new corrosion forms related to the huge and widespread guano deposits and mud forms never seen before are also present.

Finally very rare and well preserved fossil remains are relatively common.

Among them the 20 million years sirenian fossil protruding from the cave wall along the God's Highway and the perfect preserved and relatively young (few hundreds of year) skeleton of a mountain cat in the 150 years gallery are worth of mention (Fig. 3).

All these peculiarities make the Natuturingam cave one of the most interesting karst not only of the Far East but of the whole planet.

A singularity of this cave is that, even though it is actually visited by more than 300.000 people/year, no one tourist fixed structure has been placed inside the cavity: not a single cement step, or a single steel footbridge, or an electric line. Therefore PPUR should be still considered as a totally pristine cave.

The ecological approach to the cave was, since the beginning, the most amazing: in fact PPUR, even being amongst the most visited show caves in the world is, at the same time, the least damaged.

This represents the true point of force of this tourist site, since the disturbance induced by the human presence has been kept to a minimum with proper policies.

Anyway, in the last few years, first evidences of ecological problems, mainly related to the diurnal resting of bats, have been noticed during the most crowded days. Therefore the Local Government, together with the Protected Area Management Board, decided to investigate how to manage the increasing tourism and limit the impact on the natural environment of the PPUR and its surrounding areas.

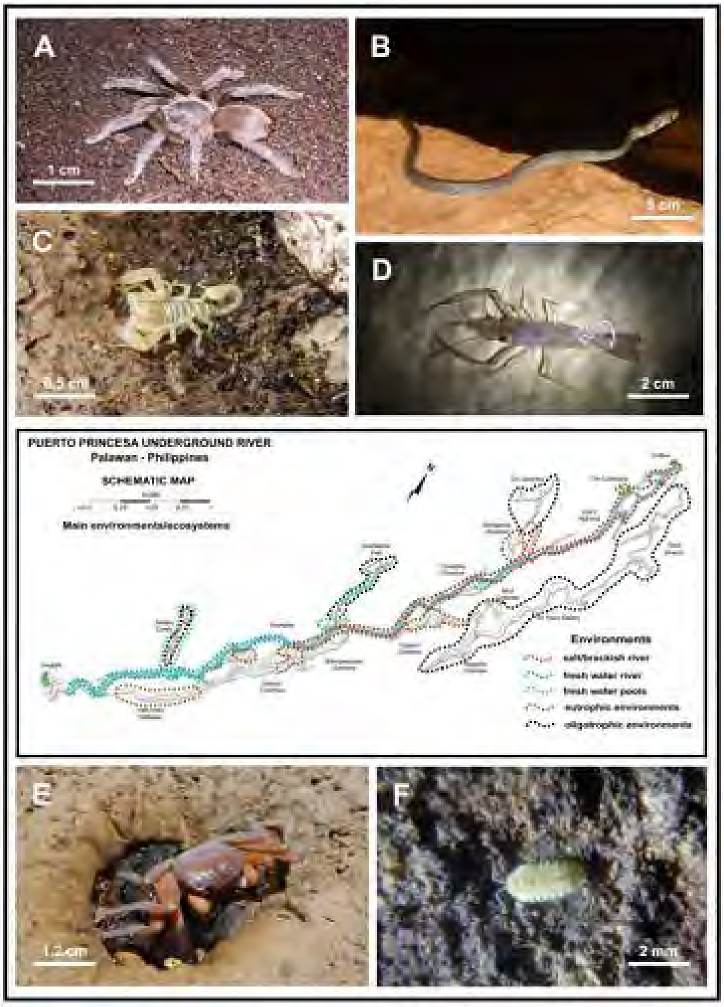

Fig. 2: PPUR schematic map with the locations of the five different ecosystems. A: a mygalomorph spider hunting over bat guano; B a snake (Coelognathus erythrurus) along the Underground river; C: a white scorpion; D: a freshwater shrimp; E: a sesarmid crab; F: a troglobitic isopod (Photo La Venta archive).

At the end of 2015, in the framework of the “Philippines-Italy Debt for Development Swap Program”, the “Support for Sustainable Eco-Tourism in the Puerto Princesa Underground River Area” Project was financed.

Thanks to this grant 2 big expeditions to PPUR were organized in 2016 and 2017 (De Vivo & Forti 2017, De Vivo et al. 2017a, b).The aims of the project were: 1- completing the multidisciplinary (mineralogical, biological, paleontological, hydrogeological, etc.). study, which started over 25 years ago; 2- defining the “carrying capacity” of PPUR; 3- searching for alternative and/or additional caves to divert at least a part of the incoming tourists.

As a matter of fact, the impact of tourism is definitely higher outside the cave, mainly due to acoustic noise produced by the motor bancas going back and forth from Sabang and by the vans carrying tourists from Puerto Princesa, which very often keep the engines running while waiting for the return of the people from the PPUR.

The analyses of the energetic impact of the tourism on the cave environment evidenced that the tremendous amount of energy naturally exchanged everyday between the PPUR and the external environment (sea tides, air currents, heat transfer from the huge bat and swiftlets colonies) is of a couple of factors higher than that brought inside by tourists (Badino, 2017). It is therefore evident that from this point of view the activity of the show cave is perfectly compatible with Natuturingam ecosystem safeguard.

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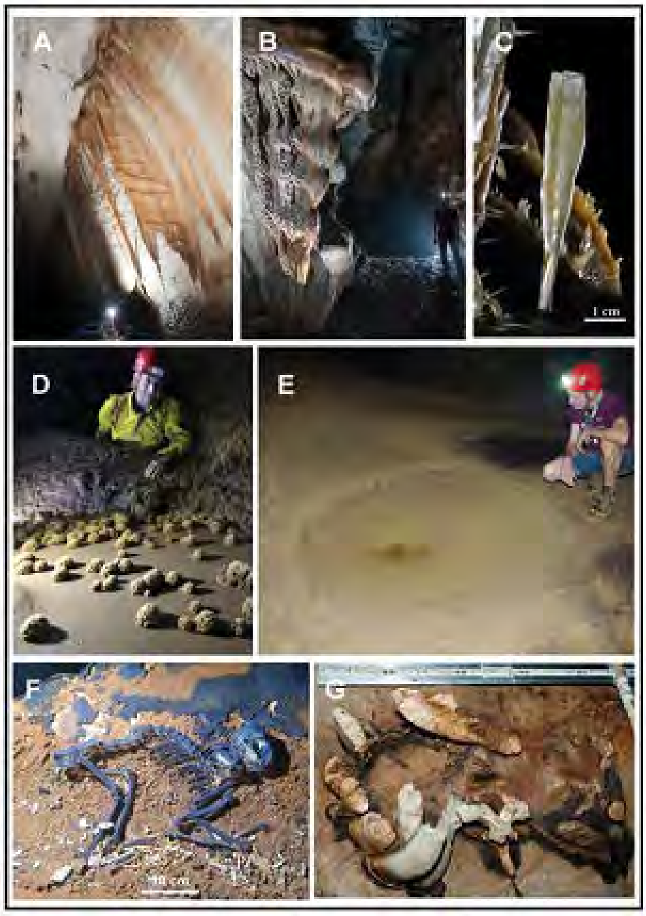

Fig. 3: Some of the most interesting new speleothems and fossil remains: A) the ribbed drapery; B) The giant jellyfish; C: the champagne flute; D: the sea urchins; E: a big mud ring the evident double darker rings consist of small organic particles; F) the sirenian bones exposed by the differential corrosion process; G) Carlita’s Branch: the perfectly preserved mountain cat skeleton; (Photos La Venta Archive).

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It is therefore evident that from this point of view the activity of the show cave is perfectly compatible with Natuturingam ecosystem safeguard. Anyway, even if the simple energetic data seems to support the theoretical possibility of a noticeable increase in the visitors number, more concerns exist about the sustainability of the cave tourism in the next years as a direct consequence of the continuously growing number of requests. In fact it will be impossible to increase the number of admitted tourists without seriously affecting the PPUR ecosystem, in particular that of the bat colonies living along the part of the Underground River up to the beginning of God's Highway (corresponding to the actual tourist path). In fact it has been already noticed in the most crowded days that bats stop their diurnal sleep and start flying around the bancas. Increasing tourism will necessarily not only increase the bat disturbance in the tourist sector of the cave, but also will affect the whole bats and swiftlets living inside the Natuturingam cave. This because this will require the expansion of the show cave's opening hours, thus interfering with the bats and swiftlets' activities (e.g. entering/escaping from the outlet each sunrise and sunset), which is absolutely to be avoided. Therefore, in order to further increase the tourist flow in the Sabang area without affecting the hosted ecosystems, one of the main targets of the Project was the selection of some substitutive &/or alternative tourist targets.

The attention was focused on the search and characterization of (hypogean &/or epigean) karst sites which can be already regarded as, or can become in the near future, new tourist targets easily reachable from Sabang (see Fig. 4). It is evident that none of these sites, though interesting from different points of view, has a tourist appeal similar to that of the Natuturingam cave. But when the PPUR cannot be visited due to meteorological reasons, or because it has already been completely booked, they should be proposed as alternative destinations to those tourists who have no possibility to wait for more favorable (weather or booking) conditions.

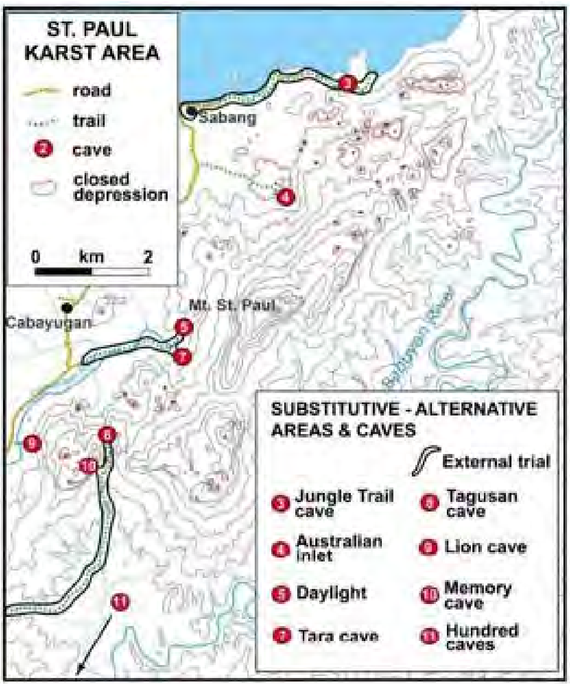

Fig. 4: Map of the Sabang surroundings with the possible substitutive/alternative tourist sites (after De Vivo et al. 2017b).

Moreover it is also important to use them as supplementary targets for all those who visit the PPUR. In fact, they may become fundamental as additional destinations for people coming to visit the PPUR and willing to stay for a couple (or even more) days in Sabang: as a matter of fact, actually less than 1 % of them spend the night there. An integrated offer of karst excursions will be the best and easiest way to fulfill the rather opposite requests of a strict environmental protection of the PPUR (and its surrounding park) and of a general increase in karst-related tourism in the Sabang area. The tourist must have the possibility to choose and book in advance, beside the always included PPUR visit, some (or even the whole) of the proposed excursions and the consequent lodging(s) in Sabang and in the surrounding area.

To reach this goal, different subjects (the Park, the managers of the other show caves, the hotels and resorts of Sabang etc., the tourist companies of Puerto Princesa and Manila etc.) must co-operate. This may be hard, at least at the beginning, but if all the involved entities will cooperate, the results will be extremely good. In fact, this kind of tourist (not necessarily linked to karst) exists since a long time in Europe, and all are successful.

In conclusion the fundamental challenge to be faced in the near future will be that of allowing a fast development of tourism, which is needed to improve the level of life of the local inhabitants, without depleting the PPUR pristine condition. In the past 40 years the strict rules imposed by the local Authorities were enough to achieve this goal, but in the next years a differentiation in the tourist targets is absolutely needed to avoid inevitable damages to the cave environment and most of all to the ecosystems hosted within Natuturingam cave.

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The Ocean on Shore: Combining Marine Sciences with Earth History – Highlights of a Project in Geo-Education: MOBI

Christof Ellger[1] & Simon Schneider[2]

[1] GeoUnion Alfred-Wegener-Stiftung, c/o Institut für Erd- und Umweltwissenschaften der Universität Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Christof.Ellger@geo-union.de
[2] Institut für Erd- und Umweltwissenschaften der Universität Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, simschne@uni-potsdam.de

Summary: A series of workshops for the German Science Year 2016*17, dedicated to the Marine Sciences, linked marine research issues with the presentation of geological features of marine origin in inland areas. The workshops, at the same time advanced training courses for educators in nature interpretation and environmental knowledge, were organized in cooperation with geoparks and other natural area institutions in Germany. They managed to ignite learning processes through the mutual stimulation of the two subject areas, which in the end produced a successful contribution to science communication for both marine sciences and geosciences.

Key words: Ocean Literacy, Earth History, Geo-Education, Nature Interpretation, Science Communication

The context: science communication and the "Science Year" in Germany

Since the year 2000, "Science Years", organized under the auspices of (and financed by) the German Federal Ministry for Education and Research, have presented various disciplines to the general public and established them as a major programme in science communication. In the Science Year 2016*17, dedicated to Marine Sciences, for the first time funding for smaller and specific projects in science communication had been made available. GeoUnion Alfred-Wegener-Stiftung, together with the Potsdam-based initiative 'GeoEducation (GeoEd)', devised a project in science communication to carry Marine Sciences to inland locations: MOBI – Meere und Ozeane im Binnenland ("Taking the ocean to inland areas"). In cooperation with institutions involved in nature and environmental education in different types of nature reserves – like e.g. geoparks, nature parks, biosphere reserves – a series of workshops on Marine Sciences and Earth History was set up, designed for people active as nature guides, rangers or interpreters in these conservation areas away from the coast.

The idea

The workshop series was meant to inform the participants about central issues in Marine Sciences and encourage them to look for links between marine topics and the inland environment – and use these in their own science communication concepts. In Germany, questions of ocean research and knowledge are rarely raised in those parts of country which are away from the coast.

To be successful, the project had to find thematic bridges between the sea and the inland locations. A number of ideas were discussed: water pollution, which starts inland and effects the ocean, the water cycle and the role of rivers as transport arteries and trade routes between coast and hinterland, in past and present. In the end, an earth history approach was used, i.e. marine formations in the earth history of the region where the workshop was held, their genesis and the evidence for these which can be found today, were combined with present-day topics of ocean science.

The partners

The majority of workshops were organized in cooperation with geoparks in Germany (see Table 1). But other types of nature reserves became interested too; one event took place in Bad Dürkheim in cooperation with the (European) Biosphere Reserve Pfälzer Wald-Vosges du Nord, and one workshop was held in Potsdam, as a special course for nature reserve rangers from all parts of the federal state of Brandenburg. A workshop in Bad Sachsa on the edge of the Harz mountains was welcomed as a chance to revive the long-standing tradition of the Southern Harz Karst Symposia. Another meeting was organized by the Nature Conservation Academy for Hesse, together with Lahn-Marmor-Museum and Geopark Westerwald-Lahn-Taunus. And, finally, one MOBI appearance was staged as part of a youth culture festival in Görlitz (Lower Lausatia, Brandenburg), where ‘music and party’ has been more and more complemented by a large programme of discussion of political and societal questions, including science.

Nature museums were involved, too. Especially Lahn-Marmor-Museum (Lahn Marble Museum) in Villmar, Hesse, was an excellent location to present marine sediments: The Devonian limestone of the region, which for centuries has been used as building material all over the world (e.g. in New York’s Empire State Building), is a fascinating product of marine origin, documenting paleozoic stromatoporoids reefs.

The format of the workshops

The workshops usually started with two lectures, one on marine sciences, either with a general introduction to ocean issues as a whole (e.g. “The role of the ocean in the earth system: climate, biosphere, biogeochemical cycles” – a very fine contribution by the director of the Potsdam branch of Germany’s Alfred-Wegener Institute for Polar and Marine Research, Professor Bernhard Diekmann) or with a more specific topic (like „Sirenia and other marine mammals“ oder „Sponges in the ecosystem of the Antarctic sea“), and the other one on marine aspects in the earth history of the region (e.g. “Wadden sea and reefs, Devonian dream beaches in Southern Laurussia”, “When Tharandt lay by the sea: paleontology and stratigraphy of Cretacious sediments in Saxony”, “Sharks in the Mainz Basin – marine phases in Palatinate’s earth history). This was followed by a groupwork programme for which material had been prepared on various marine science issues; this material had to be transformed into posters by the participants. Finally, these posters were presented and discussed, ending in a more general discussion on the topics raised during the day.

A number of workshops also included a short excursion to a special site of marine origin in the region: sediments of the Tertiary North Sea in the open-cast brown coal mines near Leipzig (Markkleeberg); Middle Triassic limestone rocks near Naumburg; Tertiary coastal sediments on the edge of the Rhine Rift Valley (Bad Dürkheim), the fossil Zechstein stromalites reef of „Westersteine“ (Bad Sachsa), a Middle Triassic limestone quarry and Eberstadt’s karst cave (Buchen im Odenwald), and the impressive karst cave Kluterthöhle in Ennepetal (Ruhr area).

Topic I: The ocean

Among the ocean issues it was primarily questions of the global energy balance which were focussed on: thermohaline circulation, sea level rise, the role of the ocean in climate change and the biogeochemical processes around CO2 in the ocean. A special emphasis was laid on the importance of the Arctic in global climate change dynamics. In addition, specific types of marine ecosystems were dealt with: coral reefs, mangrove coasts. And individual species were presented as examples for specific forms of life, relevance for food chains and also for hazard situations: the common mussel, Antarctic krill, porpoise. Central problems of ocean ecology were also addressed: overfishing, eutrophication, plastic waste in the ocean. Marine geology was represented by "the emergence of oceans, sea-floor spreading". For the selection of relevant topics the concept of "ocean literacy", developed by marine scientists and educationalists in the U.S., with its seven principles of ocean science to be communicated to everybody, was a great help (Carley et al. 2013). The material for the group work part was taken from various sources, ranging from present-day standard textbooks of marine sciences (e.g. Hempel et al. 2017, Latif 2017, Roberts 2012, Schröder 2010-2015) to Wikipedia articles.

Considering the thematic orientation of the organizing institutions, we expected a general interest in nature and environmental themes among the participants. As a matter of fact, the ocean issue in general appeared as largely unknown in the target groups involved. But this was an additional factor to make the workshops attractive; it definitely served as an element of change in the series of courses the participants regularly take part in. The attempt to structure the marine questions on the one hand and to highlight specific exemplary questions proved successful in the end. The workshop series was able to communicate essential elements of the Ocean Literacy Principles to this special audience.

Topic II: Earth history and marine formations

In addition, the MOBI project could not only deliver ocean research knowledge to new recipients, it was also able to communicate elements of the Geosciences and of Earth History to the participants of which a large share – trained more in the "bio" field of nature conservation – were not really familiar with the geo-aspects of landscape interpretation. Here, the combination with present-day marine issues in the presentation helped greatly to make understand the emergence of geological formations in the past and their change into today's landscapes. The idea of the Dynamic Earth with enormous changes in the planet's history, essential to Geosciences, could be transported. And a special attention was attributed to Paleontology, a discipline often followed by small highly specialized interest groups and neglected by many; in the combination of present-day marine sciences and Earth History, the context of the discipline's relevance was made evident, where fossils, especially index fossils, are vital in structuring and explaining earth historical evolution.

Conclusion

In the final discussions in the workshops and the online questionnaire afterwards the participants mentioned the multi-faceted conception of the workshops and the integrative focus on both marine and earth historical aspects as the central factors for the success of the workshops.

In the end, with its novel approach, MOBI was able to contribute to interdisciplinary and science-based nature interpretation and could also highlight a number of global ecological problems – climate change, marine pollution and protection, biodiversity, overexploitation and sustainability – using specific marine examples and convey essential elements of a science-based concept of Planet Earth to the participants.

The series of workshops will be continued. More workshops have already been arranged.

Tab. 1: The workshops and cooperation partners

05.05.2017	Korbach, Hessen	Geopark GrenzWelten
15.06.2017	Markkleeberg, Sachsen	Geopark Porphyrland, Stadt Markklee-berg
16.06.2017	Naumburg, Sachsen-Anhalt	Geo-Naturpark Saale-Unstrut-Triasland, Saale-Unstrut-Tourismus e.V.
23.06.2017	Bad Dürkheim Rheinland-Pfalz	UNESCO-Biosphärenreservat Pfälzer-wald Nordvogesen, Bezirksverband Pfalz; Pfalzmuseum für Naturkunde
12.08.2017	Bad Sachsa, Niedersachsen	Förderverein Deutsches Gipsmuseum und Karstwanderweg, Stadt Bad Sachsa
13.08.2017	Altdöbern, Brandenburg	Festival Wilde Möhre
14.09.2017	Villmar, Hessen	Naturschutz-Akademie Hessen; Geo-park Westerwald-Lahn-Taunus, Lahn-Marmor-Museum
23.09.2017	Buchen im Odenwald,Baden-Württemberg	Geo-Naturpark Bergstraße-Odenwald, Burghard-Gymnasium Buchen
12.10.2017	Potsdam, Brandenburg	Naturwacht Brandenburg
04.11.2017	Dorfhain, Sachsen	Geopark Tharandter Wald
17.11.2017	Ennepetal	Geopark Ruhrgebiet, Regionalverband Ruhr, Nordrhein-Westfalen Arbeitskreis Kluterthöhle e.V.

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The Evaporite karst and Caves of Emilia-Romagna Region: The first karst of this type officially inserted in the WH Tentative List of UNESCO

Paolo Forti[1]

[1] Federazione Speleologica Regionale dell'Emilia Romagna & Italian Institute of Speleology, Via Zamboni 67, 40126 Bologna: paolo.forti@unibo.it

Karst and caves are actually well represented in the UNESCO WH list, with over 50 sites spread over 5 continents, and it is evident that in the near future only a few more karst areas are expected to attain the status of World Heritage. Nevertheless, in 2016 the Emilia-Romagna Regional Speleological Federation, together with the Regional Government, decided to submit part of the regional karst (Fig. 1) to become the first natural World Heritage in evaporite rocks. At the beginning of 2018, during the official UNESCO meeting in Paris, they were inserted in the Tentative List and the document to be evaluated for the possible final inclusion in the WH list is expected to be ready in the next 18 months.

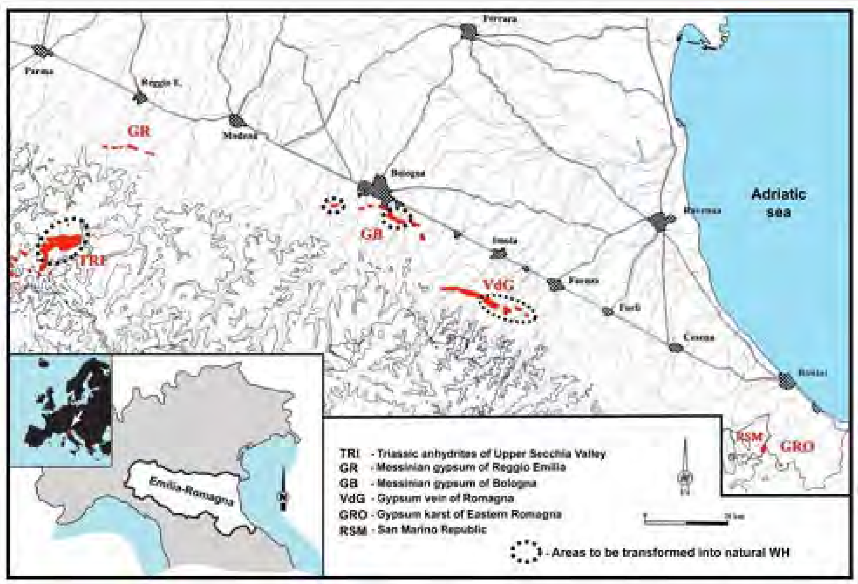

Fig. 1: Evaporite karst outcrops (red areas) of the Emilia-Romagna Region: areas within the dotted lines are those submitted to UNESCO.

The karst outcrops of the Emilia-Romagna Region, although relatively small (their total extension is about 50 km^2), consist of two different lithologies: Triassic anhydrites (~ 20 km^2) and Messinian gypsum (~ 30 km^2), corresponding to less than 0.5 % of the whole regional territory (Fig. 1).

Main characteristics of the Evaporite karst of Emilia Romagna

Despite their reduced dimensions, these areas (Fig. 2, A-B) host well developed and varied surface forms and over 700 caves have been explored and mapped so far (all data available at the following address: https://applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=grotte)

The outcrop of Triassic Anhydrites in the Upper Secchia Valley is a rare, perfectly preserved, example of evaporite, still partially active, diapir (Fig. 2A). Among the caves, the single epigenic ones in this lithotype actually known in the world, there is a completely new kind of cavity: the “hypogean bend”, the development of which is strictly controlled by the anhydrite hydration.

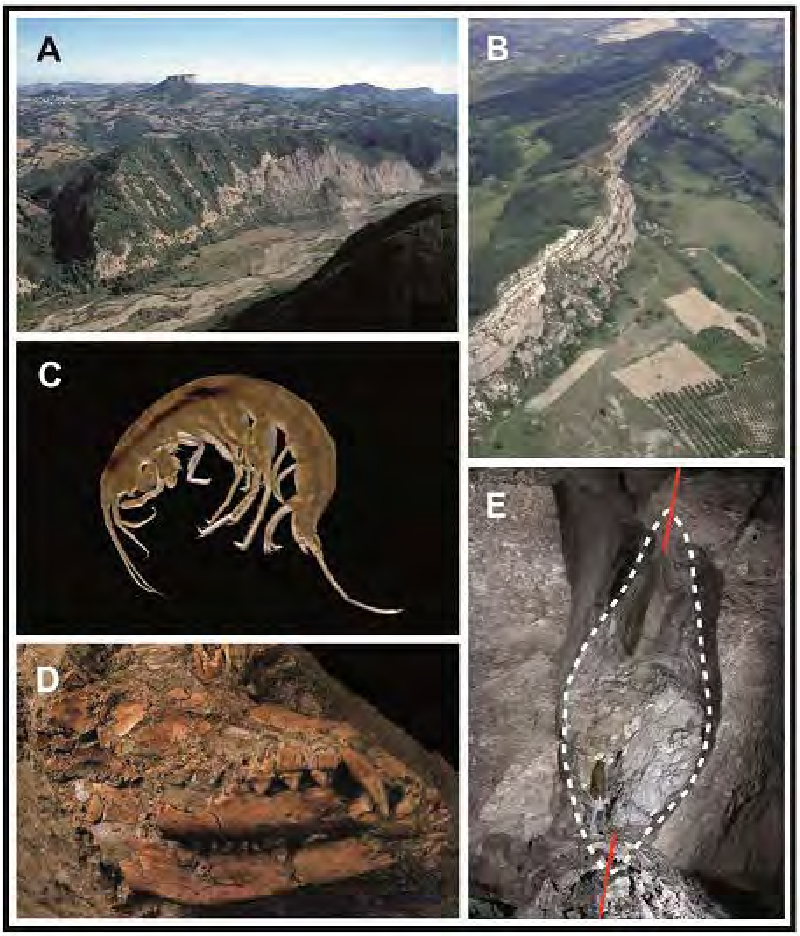

Fig. 2: A: aerial view of the Triassic anhydrites diapir in the Upper Seccha Valley; B: aerial view of part of the gypsum outcrop in the “Vena del Gesso Romagnola”; C: Niphargus poianoi a new endemic species from Poiano salt spring (Upper Secchia Valley); D: Skull of the Plioviverrops Faventinus trapped in the sediment of a fossil gypsum; D: a 70° tilted fossil karst, intra-Messinian in age, exposed within an abandoned gypsum quarry near Bologna

In these cavities peculiar solution-corrosion forms are also present together with some cave-minerals, presently restricted to them. The Anhydrite outcrop hosts also the largest karst salt karst spring of Italy: the Poiano spring with an average discharge of over 250 l/s. Gypsum outcrops exhibit spectacular monoclinal structure (Fig. 2B) which has been exposed by the differential erosion of the overlying impervious deposits. The gypsum outcrops underwent two different speleogenetic cycles: the first was intra-Messinian (Fig. 2E), while the second started over 500.000 years BP and is still going on today. Moreover gypsum karsts hosts several peculiar solution-corrosion forms, speleothems and cave minerals, important paleontological (Fig. 2D) and archeological remains, while some endemic organisms can be found only there (Fig. 2C).But lithological variety and richness in surface and deep karst morphologies are only some of the many reasons which suggest that they have a real chance to attain the rank of World Heritage. Evaporite karsts of the Emilia Romagna Region where the first to be studied (since the 16th Century): therefore many of the main classical gypsum and/or anhydrite karst features have been firstly studied and described from these territories.

Even today Emilia-Romagna evaporite karst is the best known from a morphological, speleogenetical, mineralogical and biological point of view. As a consequence the existing printed papers (over 2000) on these areas are more than those regarding all the other evaporite karsts in the world. Moreover, beside their natural peculiarities, they represent also extremely important archaeological, paleontological and historical sites.

Some of the caves are also important archaeological sites for the copper, bronze, and iron ages, during which they were used as places of settlement, burial or cultic sites, as well as for some perfectly preserved roman aged mine-caves of “Lapis Specularis”. From the Biological point of view the evaporite karsts of the Emilia-Romagna host peculiar on-going ecological and biological processes. In particular, it is worth mentioning the Poiano Springs in the Upper Secchia Valley and its related brackish aquifer, hosting several rare and/or new to science organisms like the endemic amphipod Niphargus poianoi (Fig. 2C). These organisms probably represent phylogenetic relicts, survived in an area where anhydrite karst aquifers are characterized by high sodium chloride content.Finally the Emilia-Romagna evaporite are extremely important biological shelters, hosting some of the largest and varied bat colonies of Europe, and several peculiar endemic troglobitic species, restricted to these environments. Moreover, the gypsum and anhydrite outcrops influence the local microclimate allowing the presence of rare botanic associations: over 500 of them have been detected in the Triassic Anhydrites of the Upper Secchia Valley, while some 1000 species have been detected in the Messinian gypsum, including Mediterranean Tortula revolvens nd the fern Cheilanthes (Notholaena) persica, single growing area of which in Western Europe is located just the Vena del Gesso Romagnola

The criteria met by the Evaporite karst and Caves of Emilia Romagna Region

As shortly outlined in the previous paragraph, the significant factors supporting the candidature of the Evaporite karst of Emilia Romagna may be summarized as:

1. the lithological variability;
2. the presence of two different speleogenetic cycles;
3. the richness of epigean and hypogean karst forms, sometimes restricted to these environments;
4. the huge dimensions of both anhydrite and gypsum caves;
5. the presence of peculiar ecosystems giving shelter to endangered species;
6. the evolution of unusual, ecological and biological processes;
7. the presence of rare cave minerals;
8. the existence of important and rare paleontological and archaeological remains;

In addition to them it must be stressed that these areas are by far the best explored, documented and studied evaporite karst in the world since 16th Century.

These characteristics, at least theoretically, allowed to submit the candidature under quite all the natural UNESCO criteria. Anyway, in order to make easier the analyses of the submitted official document, we decided submit it just under the VIII criterion:

“be outstanding examples representing major stages of earth’s history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features.”

Therefore all the remaining characteristics, related to other UNESCO criteria (III,VII, IX, X) were just used to support and strengthen the submitted candidature under the single criterion VIII.

Present day protection

In order to be taken into consideration, the UNESCO rules request that the submitted areas should have some kind of protection in order to avoid the possibility to their degradation or partial destruction in a more or less near future.100% of the proposed World Heritage is already fully protected being inserted within Natural Parks or Reserves. All the properties are geosites officially catalogued by Emilia-Romagna Region, thanks to the Regional Law n.9/2006 “Norme per la conservazione e valorizzazione della geodiversità dell’ Emilia-Romagna e delle attività ad essa collegate”.

Consequently, all the proposed properties are protected by law. Moreover, these three Parks and Reserves are still expanding their territories by acquiring new private areas and these acquisitions will be further enhanced if these properties will be nominated WH. Moreover all the proposed properties, from 2010 to 2016, were interested by LIFE 08 NAT/ IT/000369 project “Gypsum: protection e management of the habitats associated with the gypsum formations of Emilia-Romagna (http://www.lifegypsum.it)”, which increased protection and awareness of these areas.

Comparison with other similar karst areas of the world

UNESCO rules require that the submitted area should be the ”best of the best” of our planet and therefore a detailed comparative analyses must be done with the other potential competitors.

Gypsum, and to a lesser extent, anhydrite, outcrop in many places around the world (Fig. 3) and often lie buried at a shallow depth. Occurrences are particularly extensive in the Russian Federation, Ukraine and North America. Huge Messinian evaporitic, often well karstified, deposits are present all around the Mediterranean sea. Anyway, only few of them have been explored and studied yet and even less have a protection suitable to be considered for a WH application. Comparison has been made with one anhydrite karst and 11 (see Fig. 3) gypsum karsts: the analyses were always done not only on bibliographical documents but also on personal experience on the field. Presently the single Country in which caves in this lithotype are known and explored is Germany. Their genesis is hypogenic, while that of Emilia Romagna is epigenic and therefore the two karsts are hardly comparable. Anyway a single speleogenetic mechanism is responsible for their development thus the resulted forms are few and generally simple. By far Cave complexities and sizes, hosted speleothems and minerals, and hydrogeology make the Emilia Romagna Anhydrite karst much more interesting. Finally German Anhydrites exhibit no interest at all from the biological, paleontological and archeological point of view.

Among the 11 analyzed gypsum karst in the world, only the 4 most interesting ones are here briefly reported. The gigantic maze caves of Podolia, Ukraine, are by far the longest gypsum caves of the world and the most renown. They are hypogenic in origin. Anyway morphological varieties and hosted speleothems of the Podolia caves exhibit, by far, less variability with respect to those of Emilia Romagna, moreover in Podolia a single karst cycle is present. Nothing is actually known on the hosted ecosystems and their in time evolution and no paleontological or archeological remains at all are hosted in those caves. Finally Podolia gypsum karst still lacks of a suitable protection.

The Sorbas Karst, Spain is very similar to the gypsum karst of the Emilia-Romagna being developed in the same formations. The karst and caves are well documented. But their dimensions are smaller and only the actual karst cycle is represented.

Moreover they lack of several forms and speleothems as well as cave minerals. Their ecosystems are by far poorer and. no paleontological or archeological remains exist. Only a part of the area is protected.

Fig. 3: Location of the main evaporite karst areas actually known in the world. Anidrite: 1) Emilia-Romagna (Italy); 2) Central Germany. Gypsum: 1)Emilia Romagna (Italy); 2)Calabria (Italy); 3) Sicily (Italy); 4) Pinega (Russia); 5) Kungur (Russia); 6) Podolia (Ukraina); 7) Almeria (Spain); 8) Darhedi (Algeria); 9) New Mexico (USA); 10) Punta Alegre (Cuba); 11) Neuquen (Argentina).

Most of the karst forms and of the speleothems of the Santa Ninfa are similar to those of Emilia Romagna, being developed in the same formations, but they are smaller, less developed and exhibits a less variability than those of the Emilia Romagna. Extremely few is known on cave ecosystems, no paleontological and archeological remains are present and finally most of the gypsum outcrop have no protection at all. The huge Permian gypsum outcrop around the Kungur village hosts lot of sinkholes, several different small karst forms and a few caves, the most renown of which is the Kungur Ice Cave. The main characteristic of Kungur Ice Cave is given by the hosted huge ice deposits giving rise to formations and large crystals, while speleothems are restricted to few and small gypsum ones. This cave hosts also some ephemeral minerals segregated by the freezing lakes in the winter time. In any case its morphological and mineralogical interests are by far less and less interesting than those of the Emilia Romagna ones. Maybe that the underground lakes host peculiar ecosystems but they are still totally unknown. Moreover, the cave is open to the public with very few restrictions; therefore it is not well preserved. The other seven locations have even lower general interests and sometime they are still scarcely explored and documented, finally they normally lack of any protection

At the end of this recognition it is evident that the Evaporite karst and caves of Emilia Romagna, is by far the best, and therefore it should be considered for attaining the rank of WH.

Final Remarks

The inscription in the “Tentative List” is surely a first step, but several harder ones must be done in the near future before crossing the finish line to see the Evaporite karsts and caves of the Emilia Romagna Region included in the UNESCO World Heritage list. First of all the official candidature document should be prepared and presented in Paris at the General Assembly of UNESCO. All the needed data are already available and we are confident that its implementation will lasts no more than 24 months. Therefore its submission will probably occur in February 2020.The following steps will by sure result more complex and difficult to overcome. In fact it is well known that UNESCO want to accept in the WH list very few new sites, privileging, when possible, the transnational ones. Informal suggestions to present the candidature of the “Evaporite karst of Mediterranean area” were given to us in the last months. We perfectly agree with this idea from the scientific point of view, but unlikely it practical realization is absolutely unrealistic at least in the next decade or more. In fact many of the areas and of the Countries that should be involved are far to be ready to join this project.

Therefore we decided to go on with our proposal, restricted to the Emilia-Romagna evaporites, but we are ready to expand it by adding any other Mediterranean areas, when they will be interested and ready. In any case, we are confident to reach at least the minimum target of our proposal: that is to demonstrate that, if and when the UNESCO will insert an evaporite karst within its World Heritage list, the Anhydrite and Gypsum karst of the Emilia Romagna Region must be included being, without any doubt, the most complex and interesting of the whole planet.

Pre-Excursion South Harz Zechstein Karst Belt

Friedhart Knolle[1] & Bärbel Vogel[2]

[1] Editor, Verband der deutschen Höhlen- und Karstforscher VdHK, Grummetwiese 16, D-38640 Goslar, Germany, fknolle@t-online.de

[2] President, Verband der deutschen Höhlen- und Karstforscher VdHK, Hauptstr. 5, D-87484 Nesselwang, Germany, vorsitz@vdhk.de

Introduction

The landscape of the South Harz is dominated by gypsum karst, forming one of the largest continuous gypsum karst areas in Europe (Kempe 1996). It occupies a narrow belt extending through the States of Lower Saxony, Thuringia and Saxony-Anhalt (Federal Republic of Germany) from Osterode am Harz in the West to Sangerhausen in the East. This sulphate belt has developed a remarkable density and variety of karst phenomena throughout the Pleistocene and Holocene. Karstification occurs mostly in the gypsified anhydrite layers of the Upper Permian, i.e. the anhydrite members A1, A2, A3 of the Werra, Staßfurt and Leine Zechstein (Upper Permian) salinar series, respectively. Dolomite and limestone outcrops complement the karst area. This outstanding landscape is worthy of preservation and several important sections are legally protected. However, the area and its outstanding importance is not well known internationally.

Epikarst and Biodiversity Hotspot

The most pronounced features of the South Harz karst landscape are more than 20,000 sinkholes in addition to countless uvalas, ponors and karstic springs, periodic lakes, about 170 caves and other karst phenomena plus many archaeological sites. All are confined in the small spaces of the individual gypsum outcrops. These natural conditions are a vast mosaic of closely interconnected but diverse habitats, including dry meadows, beech forests on sulphate rocks and dolomite (Hordelymo-Fagetum lathyretosum), gypsum escarpments, stony terrain, spring bogs and water-filled fens. The South Harz gypsum karst area is also an important habitat for many bat species and the European Wildcat (Felis sylvestris).

The highly structured surface and its dry soils limits housing development, agriculture and forestry. Many parts of the karst are therefore in a semi-natural state. Calcareous beech woodlands are particularly worth protecting and dominate the flora together with dry calcareous grasslands. In addition, the north-western Atlantic and south-eastern continental climate zones overlap in the Lower Saxony part of the gypsum karst. The geological conditions, especially the diversity of different karst types and climatic conditions, allow a specific large biodiversity. This has been the main reason why the German Federal Agency for Nature Conservation (BfN) has added this area to a list of 30 biological hotspots under the name of "South Harz Zechstein Belt, Kyffhäuser and Hainleite". Even though, only parts of the landscape are protected.

Landscape History

The fens and lakes in the South Harz gypsum karst sinkholes are excellent archives for the reconstruction of vegetation, land use and emission rates over millennia. Pollen is preserved very well due to the anoxic conditions in bogs especially in the hypolimnion of lakes.

Studies of the varved sediments of the Lake Jues sinkhole in Herzberg provided a well-dated, continuous and highly sensitive environmental and climatic reconstruction of the Holocene for the mid-latitudes in Central Europe. The results serve as an important link between the better investigated neighbouring regions. This sinkhole is one of the largest of its type in Germany and collapsed during a Laacher See volcanic event ~ 13,000 BP. Tephra from this event was found at the base of Jues sinkhole (MEISCHNER & GRÜGER 2008).

Climate shifts, mainly in phase with those recorded from other European regions, are inferred from changing limnological conditions and terrestrial vegetation. Significant changes occurred at 11,600 yrs BP (Preboreal warming), between 10,600 and 10,100 yrs BP (Boreal cooling), and between 8,400 and 4,550 yrs BP (warm and dry interval of the Atlantic). From 4,550 yrs BP the climate became gradually cooler, wetter and more oceanic. This trend was interrupted by warmer and dryer phases between 3,440 and 2,850 yrs BP and probably between 2,500 and 2,250 yrs BP (VOIGT et al. 2008).

Palynological studies provide reconstruction of vegetation and settlement history from the Preboreal throughout the Holocene. Deciduous primeval forests dominated by oaks (*Quercus*) spread from the beginning of the Holocene at 10,020 a BP. From 7,600 a BP on in the Neolithic period first settlements and arable farming began to affect the forests. Floral change again took place during Bronze Age when the beech (*Fagus)* superseded the primordial tree species. This process bearing significant ecological effects. Biomass and biodiversity of arthropods declined in the forests, since the number and biomass of foliage-feeding invertebrates associated with oak exceed those associated with the beech (ALEXANDER et al. 2006).

Based on the landscape features and ecological qualities, there also exists a wealth of archaeological sites in the South Harz Zechstein belt. The Einhornhöhle cave near Herzberg-Scharzfeld, a cave bear site with Neanderthal tool findings has been known since prehistoric times. More recently the Lichtensteinhöhle cave near Osterode am Harz has become known. It can be dated to the Late Bronze Age by archaeological findings (FLINDT & HUMMEL 2015) and comprises among others, a rich bat fauna.

The beech declined in the Middle Ages when humans exploited large areas due to a demand for charcoal for mining. The extraction of metals started more than 4,000 years ago. Geochemical investigations of fens in karst sinkholes in the South Harz allow detection of the emissions produced by mining, as the high portion of low density organic material with very low background concentrations of heavy metals, and the near-neutral pH-values in most of these mires prevent migration of heavy metals. Emission of dust and other harmful elements can be correlated with changes in vegetation (after HETTWER et al. 2002).

Threats and Chances

Unfortunately, parts of this landscape have already been destroyed. In many places gypsum, anhydrite and dolomite is quarried predominantly by globally operating business groups. Every year, millions of tons are processed for construction materials, such as gypsum wallboards, plaster, etc., and karst phenomena with their characteristic flora and fauna are irreversibly lost. Valuable natural heritage and long-term development prospects for the region are sacrificed for short-term jobs and profits. But this must not happen any more, since natural gypsum can be substituted by synthetic, especially gypsum from flue gas desulphurisation (FGD) in nearly all fields of application. FGD gypsum is a waste product of smoke desulfurization. Not all of this gypsum is used for the building industry and must be locally stored or even deposited. Phosphogypsum also can be used as a substitute material for natural gypsum in different technical fields (YANG et al. 2015).

Gypsum karst areas, which are now being unnecessarily destroyed, developed over hundreds of thousands of years and represent geosites and biotopes with a significant ecological importance for biodiversity, groundwater systems and the defining landscape elements in Europe. Compensatory measures such as restoration can never substitute primary ecotopes that evolved over a geological and rather than a biological time frame. Restoration would take centuries and the geomorphological structure of this unique habitat and also the karst phenomena would be irrecoverably lost. Because of the current tempo of species extinction, due to climate change, ecological niches like the gypsum karst become indispensable. For this reason sustainable production in the case of utilisation of synthetic gypsum instead of natural gypsum is an economic advantage, resource efficient and above all a guarantee for the protection of biodiversity and landscape ecology in Europe (RÖHL 2003).

Protection by World Heritage Status?

The environmental and speleological NGOs in Lower Saxony, Thuringia and Saxony-Anhalt vigorously object to the issuing of new extraction permits. In order to ensure the long-term protection of the gypsum karst landscape they demand the establishment of a cross-boundary UNESCO Biosphere Reserve, designated "Karstlandschaft Südharz", and the nomination of more gypsum karst areas as Natura 2000 sites also in Lower Saxony and Thuringia. The environmental NGOs have lodged a complaint with the EU, because important gypsum areas comprising habitat types and species worth of protection have not been nominated for protection in the interest of the continued gypsum mining.

The South Harz gypsum karst is part of the Geopark Harz. Braunschweiger Land. Ostfalen since 2002, UNESCO Global Geopark since 2015 and was declared a German National Geosite in 2006. For more geo-tourist information see also http://www.karstwanderweg.de.

So far, Saxony-Anhalt has been the only German state to consistently protect its share of the gypsum karst belt as a Biosphere Reserve. Declared in 2009, it has an area of 30,034 ha and ranges from Stolberg in the West to Sangerhausen in the East. There is no other Biosphere Reserve in a gypsum karst area in the world.

Sulphate karst areas are massively under-represented in the global network of protected areas and sites. Following Guidelines 4 and 9 (IUCN 1997) and Recommendation 4 from IUCN (2008), parties whose territories include karst terrains situated on evaporite rocks should consider the potential of their sites for natural World Heritage recognition, and this consideration should be started for the gypsum karst landscape described above.

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Assessment of extinction risk of species as a tool for cave and karst conservation

Ana Komerički, Louis Deharveng

IUCN SSC Cave Invertebrate Specialist Group

Introduction

Karst is found throughout the word, where it occurs in different forms, creating various unique landscapes [1]. Hosting numerous geomorphological features like dolines, towers and caves, it attracts attention of geologists and hydrologist since late 19th century [2]. Such diversity of forms is groundwork for diversity of habitats, which are then further shaped by climatic conditions. Therefore, karst is considered highly important from biological point of view. Both surface and subterranean karst habitats host an array of adapted plant and animal species, ranging from tiny orchids and land snails to primates. Their connection to karst habitats is often restricting, especially in cases of isolated karst units and cave dwelling animals, resulting in a high rate of endemism [3]. Certain species are found to be restricted to a single cave or a karst hill, which makes them very vulnerable to threats, usually arising from human activities.

Numerous karst areas have been inhabited by humans since their early history, changing and shaping its landscape, leaving abundant and well preserved evidences in caves. But in more recent times, humans have an overall strong negative impact on karst, often resulting in heavy degradation and complete destruction of karst landscapes. Most important resources humans gather from karst landscapes are mineral resources, water and wood. Mining for resources often destroys whole hills, eliminating all of its important features [3]. Man made changes in hydrological regimes caused by damming and water pumping, as well as removal of vegetation cover from karst surface, cause various levels of degradation, which nature has no tools to recover from. Karst is also vulnerable to pollution, and is threatened by human activities on a non-industrial scale.

IUCN Red List of Threatened Species is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. It is produced and managed by the IUCN Species Survival Commission, IUCN Global Species Programme and the Red List Partnership [4]. It operates on efforts of numerous volunteers drafting and reviewing the assessments of species extinction risk, from both academia and conservation sectors, with a small core team, Red List Unit. The purpose of the Red List is to provide information and analyses on the status, trends and threats to species in order to inform and catalyse action for biodiversity conservation. The first pre-criteria for assessment of species extinction risk was set as early as 1950s, and were made available for general public in 1964, when the first comprehensive list of threatened mammals and birds was compiled and published. Since then the criteria have regularly been reviewed in order to improve and adjust them to fit the requirements of risk assessment for all living organisms. The revised Categories and Criteria which are now in use were adopted by IUCN Council in February 2000 and the revised system came into use in 2001. The criteria for threatened categories are based on population size, geographic distribution, habitat and ecology, threats and conservation actions. The categories are: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concerned (LC) and Data Deficient (DD). Species listed under the first three categories are regarded as species of elevated conservation concern, which may require conservation actions. It is updated regularly, with new assessments and reviews added twice a year [4]. According to latest update from December 2017, the Red List includes assessments for 91 522 taxa, of which 25 821 are species of elevated conservation concern [5]. In order to achieve a better insight into biodiversity conservation needs, one of the goals is having at least 160,000 assessments published on The IUCN Red List by the end of 2020 [6].

Cave and karst biodiversity and the IUCN Red List

Karst landscapes appear mostly in carbonate and gypsum bedrocks, as a result of chemical erosion caused by water [2]. With an internal water drainage system and numerous caves, cracks and fissures, the whole karst unit is interconnected. Within karst areas the boundaries of species distribution depend on natural barriers within the karst and the species distribution mechanisms. Although we can only penetrate into subterranean karst features as much as their and our size allows it, the smaller cracks provide a suitable habitat as well as a connection to other parts for invertebrate fauna [7]. The same applies to karst aquatic habitats, whose connection is even greater, due to the lack of self-filtration mechanism and the aquifer features of karst landscapes. Besides karst, caves in other substrates host the same kind of fauna, which displays similar adaptations as well as biodiversity and endemism patterns. Therefore, the cave and karst impact assessments studies should consider the wider context of potential interventions and take a holistic approach to their conservation where needed.

Due to the complexity of access to karsts and caves, and relative lack of interest from the scientific community, much is still unknown on karst ecosystems. The current knowledge already proves that karst holds a significant part of the world`s biodiversity, and most importantly of its endemic component. Still, its biodiversity, just like geodiversity, is undervalued or even omitted in scientific studies which feed into Environmental Impact Assessments (EIA), Biodiversity Management Plans (BMP), land use plans and international and national policies and regulations [3]. Lack of available data prevents quality desk studies, meaning most cases require a biodiversity research focusing on recording species, assessing the habitat and imminent and potential threats. Because of its high biodiversity and endemism, in cases of both flora and fauna, taxonomic studies usually involve identifications and descriptions of new species. The low number of available experts and the amount of time required for the above, means the studies are time-consuming, even for basic inventory data.

There is an opportunity to instigate preliminary conservation actions and further research of karst, by assessing the karst restricted species for the Red List. In order to include karst in biodiversity studies of infrastructure and land planning, since 1990s several documents have been produced by IUCN, World Bank and partnering NGOs. They serve as guidelines for management of karst landscapes for government and business sector, emphasizing the importance of biodiversity and ecosystem services. Within those guidelines, several criteria are considered more important in assessing the biodiversity value of the area; among them are conservation status of recorded species in the IUCN Red List and presence of caves in the area. While presence of caves as a criteria in this context initiates cave survey to further investigate its biodiversity, site presence of species of elevated conservation concern (categories CR, EN and VU) in development of Biodiversity Management Plans requires further research and conservation actions. Near Threatened (NT) and Least Concern (LC) do not trigger any action, but the Data Deficient (DD) category implies a need for further research [8]. Following the Red List criteria, which are still not the most suitable for invertebrates, many species restricted to caves and karst appearing in a low number of records will justifiably fall under this category. For most of them, systematic research is required in order to present a more informed assessment.

With this opportunity comes a responsibility of providing high quality assessments for the Red List, including scientific approach accompanied by peer-review. The assessment process itself is described in detail in IUCN Red List Categories and Criteria Guidelines Version 3.1. It includes involvement of certain roles; Assessor, Reviewer, Contributor, Red Listing Authority, each with its tasks. Although recently the role of the Assessor has been more often carried out by non-experts, there are numerous advantages to having a taxonomist or ecologist expert carry out the assessments. Most important role of the Assessor is to compile all available data on the species, evaluate their truthfulness and enter as many as possible while following the criteria, but with a critical mind. The ability to correctly assess the Extent of occurrence (EOO) and Area of occupancy (AOO), two important criteria on species distribution, depends on the assessor's success in recognizing karst units and familiarity with karst ecology. The Reviewer provides a peer-review, checking whether the data are correct and properly assessed and reviewing the importance of identified threats and proposed conservation actions. It is very important this role is carried out by an experienced specialist, increasing the quality and relevance of the assessment. Due to the fact all review work is on a voluntary basis, and most experts having a lot of work already, the expert availability is the only limiting factor. For some SSC expert groups, a Red List Authority role provides a long term expert reviewer, but for expert groups including a large array of species that does not replace the need for specialists. The quality of the assessment should be considered the most important aspect, as lack of it may result in erroneous conclusions on species, as well as habitat importance. A misleading species extinction risk assessment, resulting in a too low category, might lead to complete loss of the species and its habitat. In the opposite case, an over-rated category could cause wrong prioritisation of conservation actions. Both instances would corrupt the authority of the Red List, which is why the assessment quality must be kept at a high level.

Prioritizing actions

With 91 522 assessments currently in the Red List, of which many need revision , there is a long way ahead to populate the Red List with all discovered taxa. As time is an important factor in the process, with some assessments requiring from hours to days to complete, the key to meaningful use of the Red List is prioritizing. And in this process, a rule of threat as a criteria, should also be applied. Although it seems logical to start assessing karst restricted species for which we have the most data, we must also be aware of the impact of current and imminent threats. Certain areas of high importance for karst geodiversity and biodiversity are already under protection, properly managed, and assessing the extinction risk of its characteristic organisms would enhance their protection or initiate further studies. But some important karst areas are being destroyed by quarrying and damming, with little or no knowledge on what special features lay within. These areas, especially if proven to be diverse and rich in features and life, are the ones which could benefit the most from its biodiversity included on the Red List.

So far, assessing cave invertebrates for the Red List resulted in protection of caves within mining concession areas, development of management plans, initiatives for new protected areas, further cave fauna research, and in general, increasing karst visibility on the conservation maps. In recent decades successful attempts to mainstream karst biodiversity into conservation have been made. With the IUCN Red List categories now utilized as a crucial factor in biodiversity management, we are using the tool already developed and recognized, to protect the species, but through it the caves and karst as a whole.

Yet there is still much to do to protect the important karst landscapes. Several issues require addressing in order to construct proper conservation strategies for caves and karst. Biodiversity is still largely unknown in the majority of karsts and caves, and the current data show disproportion in research efforts worldwide, with certain areas having long research history, and numerous others never having been investigated. Sampling efforts often depend on funding, knowledge of caves, and personal interests, resulting in lack of systematic research and broader understanding of their biodiversity on a global scale. Investigations of ecology and population sizes remain unresolved, leaving numerous gaps in knowledge on these unique ecosystems. Evaluation of cave and karst biodiversity has only been done in a few cases, and establishing standard for their evaluation on a global scale would improve and provide guidance for their protection.

IUCN World Commission on Protected Areas (WCPA) Geodiversity Specialist Group (GSG), among other duties, facilitates the conservation and effective management of protected area geoheritage. It serves to promote geodiversity as an intricate part of nature, and recognizes the clear link between geodiversity and biodiversity in nature conservation [9]. Further work toward protection of karst landscapes would benefit from comprehensive collaboration of scientific and conservation communities working on geo- and bio- diversity of karst and caves, which could be achieved by cross-sector engagement. As these unique landscapes suffer from lack of recognition in conservation community, joint efforts would increase its visibility and promote its need for conservation.

New opportunities arising?

Without proper enforcement, international recommendations and guidelines hold little value to the lucrative business of resource extraction. The ever increasing human demand for resources will continue to pose a threat to some of the most breath-taking and important landscapes in the world. Future opportunities for karst conservation might largely lie in the IUCN Red List of Ecosystems, a tool which evaluates conservation status of ecosystems. Recognized by IUCN in 2014, it allows addressing different aspects of public policy from a global and national perspective, and aids countries to achieve international conservation goals [10]. The central goal of the IUCN Red List of Ecosystems Categories and Criteria is to support conservation in resource use and management decisions by identifying ecosystems most at risk of biodiversity loss. The Red List of Ecosystems is developed and implemented jointly by the IUCN Commission on Ecosystem Management (CEM) and the IUCN Ecosystem Management Programme (EMP), in collaboration with the IUCN Species Survival Commission (SSC) and the IUCN Global Species Programme (GSP). It will provide indicators used to assess ecosystem health and support arguments for non-degraded ecosystems as a core component of human well-being, land use management, governance and macroeconomic planning. (WEB) The criteria are: A) Reduction in geographic distribution, B) Restricted geographic distribution, C) Environmental degradation, D) Disruption of biotic processes or interactions and E) Quantitative analysis that estimates the probability of ecosystem collapse. These criteria trigger categories same as the ones in the Red List of species: CR, EN and VU as threatened categories, and NT, LC, DD and NE. An additional category (CO, Collapse) is assigned to ecosystems that have collapsed throughout their distribution, the analogue of the extinct (EX) category for species proposed by IUCN. Currently the first terrestrial assessments are being completed, and its goal is to have a complete assessment of all of the world's ecosystems by 2025 [10]. Its potential for cave and karst conservation should be thoroughly investigated.

Conclusions

- Tackling the complex issue of karst management requires a holistic approach, having in mind the different geological, biological and archaeological values it holds.
- Regarding biological issues, IUCN Red List has proven to be a useful tool for karst conservation, which can result in further research or conservation actions.
- To utilize conservation tools at current disposal, biodiversity can be used as a flagship value in conservation of caves and karst.
- Producing high quality assessments of species extinction risk for IUCN Red List with peer-review increases the impact of conservation actions and maintains the important role or the Red List in nature conservation.
- By investigating karst biodiversity and assessing species conservation status, we can protect karst landscapes and enable their informed management.
- Linking Red List assessments of subterranean species with conservation bodies in IUCN in charge of ecosystem assessments would increase efficiency of assessments as well as instigate collaboration with expert community on the process.

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The Importance of Geodiversity on Biodiversity near Al-Salman Depression, West Al-Samawa City, Southern Desert, Iraq

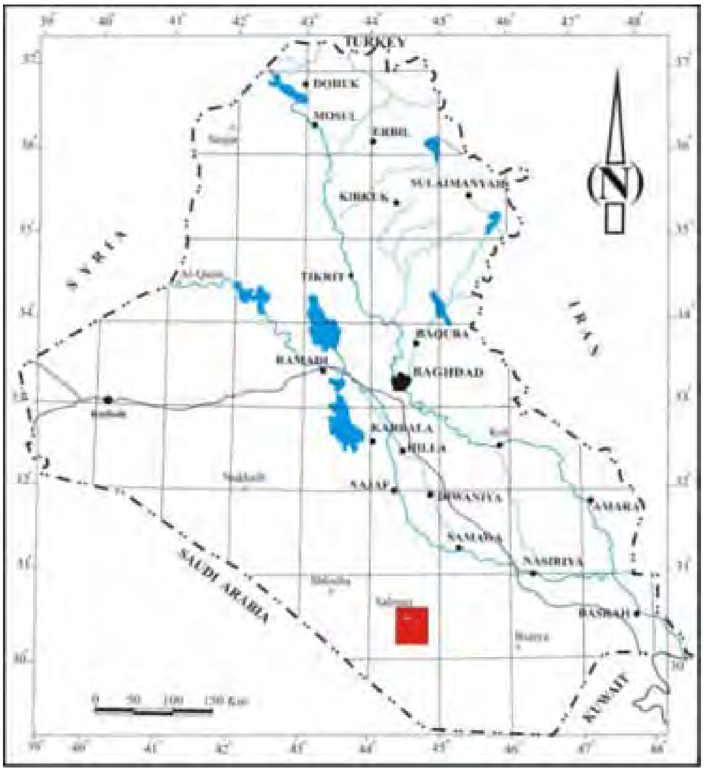
Mohammad K. Mohammad[1], Aqeel A. Al-Zubaidy[1] and Ali N. Al-Barazengy[2]

[1] Iraq Natural History Museum, University of Baghdad, Baghdad, Iraq

[2] Iraqi Ministry of Environment/Center of Sustainable Management for Natural Ecosystem-biodiversity unit

Key words: Geodiversity, biodiversity, habitats, southern desert, Al-Salman, Iraq

The study area is located at southern desert of Iraq, near Al-Salman Depression, about 130 kilometers south west of Al-Samawa City.



Conservation and management of natural resources need to take care on geodiversity and biodiversity. Geodiversity comprises geological factors: rocks, minerals and fossils; geomorphological factors: land forms and natural processes; type of soils; and water resources. The main exposed rock bed units of study area are carbonate of Dammam Formation (Eocene) underlain by interbedded of anhydrite and limestone of Rus Formation (Early Eocene). Many land form are found: plateau, sinkholes, wadis, caves, Hamada and hills. Three type of soils were recognized; clayey, silty clay and sandy soils. The main water resources are the ephemeral wadis, sinkhole well and hand dug wells. Geodiversity factors provide the framework on the earth for animal’s life and formed many habitats in the study area such as Wadi Al-Awaja, Faidhat, Plateau and sinkhole.

Fig. 1: Sand sediments trapped by plants

Fig. 2: Wadi Al- Owja after heavy rain

Fig. 3: Faidhat Hadania (karst depression)

The present study reveals that biodiversity components represented by 76 plants, 8 reptiles, 57 birds, and 18 mammals. Many kinds of invertebrates including insects, scorpions, ticks, spiders, centipedes etc. were present as well. Some species were restricted to limited habitat types in the studied area, while other species proved to be more generalists. The study contains also some notes on biology and ecology of certain species of plants, insects, reptiles, birds and mammals. Animals and plants associations with habitats:

A - wadi al-Awaja:

- Mammals: *Hystrix indica*
- Birds: black-eared wheatear, brown necked raven,
- Reptiles: *Eremias sp*.
- Plants: *Asteriscus pygmaeus*. Depending on moisture level, flora of Wadis varies from year to year.

B - Faidhat (Al-Hadaniya, Al-Shawiya, Al-Rifaeiya):

- Mammals:
- Birds: stilt, *grey hypocolius*
- Reptiles:
- Plants: the characterstic plants are *Ziziphus nummularia* and *Lycium shawii* and for lesser extent *Haloxylon salicornicum* at the faidhat surroundings.

C - Plateuae:

- Mammals:
- Birds: steppe eagle, kestrel
- Reptiles: *Meslaina spp*
- Plants: the dominant species is *Astragalus spinosus*

D - Sink holes (Al-Wajaja):

- Mammals: -
- Birds: rock dove, house sparrow
- Reptiles:-
- Plants:-

Al- Salman Depression host three species of global importance, such as:

(Asian Houbara) *Chlamydotis macqueenii*
Status: Vulnerable A4acd ver 3.1
Pop. trend: decreasing

Fig. 4: (Asian Houbara) *Chlamydotis macqueenii* (Vulnerable)

Hyaena hyaena (Striped Hyaena)
Status: Near Threatened ver 3.1
Pop. trend: decreasing

Fig. 5: *Hyaena hyaena* (Striped Hyaena), (Near Threatened)

Falco vespertinus (Red-footed Falcon)
Status: Near Threatened ver 3.1
Pop. trend: decreasing

Fig. 6: *Falco vespertinus* (Red-footed Falcon), (Near Threatened)

Faunal Biodiversity of the Jenolan Karst Conservation Reserve and the significance of endemic, relict and threatened species

Anne M. Musser[1 2]

[1] Jenolan Caves Reserve Trust, Jenolan, NSW Australia

[2] Australian Museum, Sydney, NSW Australia

ABSTRACT - Jenolan Karst Conservation Reserve (JKCR) is home to many rare, threatened, endemic and relict species, including iconic species like the Koala (*Phascolarctos cinereus*), Platypus (*Ornithorhynchus anatinus*) and Superb Lyrebird (*Menura novaehollandiae*). The caves support subterranean invertebrate communities that include both stygobitic and troglobitic species. However, the extent of Jenolan's true biological diversity is poorly understood. The work presented here represents nearly a decade of observations on biodiversity at JKCR, involving numerous person-hours spotting, photographing and recording species (presence, abundance, location, behaviour, habitat, distribution). Of particular interest: 1) the discovery of species not previously known from JKCR, some of which may be moving in response to climate change; 2) behavioural observations, especially of threatened species such as the Brush-tailed Rock-wallaby and the Sooty Owl; and 3) increased understanding of how different species use JKCR, both on and off the limestone as well as within the cave system. These records are to be included in the Atlas of Living Australia, a collaborative initiative by the Australian federal government that compiles biodiversity data on Australian flora and fauna from multiple sources in an online database freely accessible to all.

Introduction

Jenolan Karst Conservation Reserve (3,085 ha) is part of the Greater Blue Mountains World Heritage Area and is bordered by Kanangra-Boyd National Park, farmland and state forest. JKCR is located along Australia's Great Dividing Range (780-1250 m ASL) about 110 km due west of Sydney in New South Wales. The impounded karst within the Reserve is Silurian limestone, 11 km in length and up to 350 m wide, and is surrounded by Ordovician and Devonian rocks. The flora is comprised mainly of Southern Tableland Wet Sclerophyll Forest species. The vertebrate fauna includes monotreme, marsupial, bat and rodent species; raptors, owls, parrots and other birds; several reptile species, including snakes, lizards, and turtles; and a small but significant amphibian fauna. Invertebrate species include numerous insects, arachnids, crustaceans and worms, at least 136 known taxa of which are restricted to caves. This work is a summary of personal observations on the fauna of Jenolan made over past decade, conducted in an attempt to record and understand its biodiversity.

Methods

Most species sightings were recorded photographically. Identifications were made by referencing field guides; apps for bird, frog and spider identification; and through social media sites (e.g., Australian Bird Identification; Australian Amateur Entomology; Australian Mammal Identification). Taxonomists from the Australian Museum provided expert advice. Results were recorded in the Atlas of Living Australia (henceforth the Atlas), a freely available online initiative of the Australian Government that aggregates data about Australian flora and fauna compiled by scientists, institutions, 'citizen scientists' and others.

Results

Several rare, migratory or previously unrecorded species (i.e., new to the Atlas) were identified, including six waterbirds and one dove; 19+ butterfly species; moths, other insects, and several spiders. Some species rarely seen in temperate eastern eucalypt woodlands such as Jenolan were found (e.g., Diamond Dove and Plumed Whistling Duck). At least two species exhibited colour/pattern morphs more commonly seen in hotter, drier areas (a Bell's Form Lace Monitor, and northern form pale-bellied Red-bellied Black Snakes).

Blue Lake site study - the Blue Lake is a small lake formed when the Jenolan River was dammed in 1908 to produce hydro-electric power. It provides key habitat for rare, threatened or protected species like Platypuses, Spotted-tailed Quolls, Common Wombats and Rockwarblers, along with several reptile and bird species. Results of this study confirm that the lake serves as an important stopover point for migratory waterbirds. Six waterbird species not previously known to have used JKCR were recorded in this study, suggesting that small bodies of water like the Blue Lake may be of increasing importance as the climate becomes warmer and drier.

Threatened Species: Brush-tailed Rock-wallabies - The Brush-tailed Rock-wallaby (*Petrogale penicillata*) is a macropod that dens in rocky, sheltered areas like Jenolan's Grand Arch. All rock-wallabies are threatened as habitat has disappeared, and as introduced predators like the Red Fox decimated rock-wallaby populations. Success in controlling foxes has allowed release of Jenolan's rock-wallabies back on to the Reserve. Our Arch wallabies rely on the vegetation and fresh water of the Blue Lake area for sustenance. In this study, behaviours of the Grand Arch/ Blue Lake rock-wallabies were observed, including feeding, mating, rearing of young and inter/intra-specific interactions.

Butterflies: unexpected species richness - Prior to this study butterflies at Jenolan had not been systematically recorded, with just ten species in the Atlas. This study has identified at least a further 19 species, increasing the total number of butterfly species within JKCR to 29 or more (identifications, distributions and other data from Braby 2016 and Sands and New 2002). Of these 29+ species, 24 are endemic to Australia; three have a Pacific distribution; one has a global distribution (the Monarch Butterfly); and one species is introduced (the Cabbage White). Several of the newly recorded species are native to eastern New South Wales and neighboring states, with restricted distributions, low numbers and therefore high conservation significance. The rare Rock Ringlet (*Hypocysta euphemia*) is found only in southernmost Queensland and eastern New South Wales. Prior to this study JKCR did not have Atlas records for Rock Ringlets, and there are currently only 333 records in the Atlas Australia-wide. The Speckled Line-blue (*Catopyrops florinda*), found at Jenolan during this study, is a northern species that appears to be moving south. Its presence at Jenolan is outside of its known distribution as shown in the Atlas, representing the most westerly record for this species in the southernmost part of this expanding range.

Subterranean diversity - The rich invertebrate diversity within Jenolan's caves is one reason for the inclusion of JKCR within the Greater Blue Mountains World Heritage Area. Terrestrial troglobites include arachnids, collembolans, insects, molluscs, millipedes, centipedes and worms (EBERHARD et al. 2013). There are 238 stygobitic taxa, with amphipods, syncarids and hydrobiid gastropods being the most dominant and most widely distributed. Less than half of the taxa are assigned to species (EBERHARD et al. 2013).

Many of these subterranean taxa are relict species of great age. Collembola is an ancient group of Hexapoda with origins in the Silurian (at over 420 million years of age, close to the age of the Jenolan limestone). There are at least 33 species of Collembola known from Jenolan. Syncarids, the most primitive crustaceans known, are over 300 million years old. Jenolan's syncarids are in the family Psammaspididae, a cave-dwelling group restricted to caves in southeastern Australia (including Tasmania) (EBERHARD et al. 2013).

For this project, observations and photographs of cave invertebrates within the show cave system were made (mainly Collembola and other troglobitic insects, along with cave-dwelling spiders and mites). Molluscs, worms, millipedes and centipedes are normally not encountered in the show caves. Spider images and specimens are sent to the Australian Museum in Sydney for identification and curation.

Evidence for climate change?

As with weather, changes in distributions, behaviours and appearances may not implicate climate change. However, rising temperatures and declining rainfall are certain to affect the biota in many ways. The weather in southeastern Australia has been unusually warm and dry over the past three years. Two records from Jenolan are thus of interest.

The Lace Monitor (*Varanus varius*), normally grey-black with creamy spots, exhibits the yellow-banded Bell's Form in drier areas of Australia. Such a banded individual was seen at Jenolan in 2016 during a protracted warm, dry period. Although not excessively far from where Bell's Form occurs, the occurrence of this colour pattern at Jenolan is unusual.

The Diamond Dove (*Geopelia cuneata*), normally found in arid and semi-arid areas to the west of the Dividing Range, was recorded at the Blue Lake in December 2016 during an unusually hot, dry month (2.21˚C above the average of 18˚C), suggesting that even higher temperatures further west may perhaps have prompted eastward migration.

Conclusions

The rich and diverse fauna of JKCR is of great conservation value. As its biodiversity is catalogued and analysed, the role Jenolan plays in providing for present and future conservation needs will become ever more apparent. The Blue Lake is proving to be an important stopover site for migrating birds, butterflies and other species. JKCR is important habitat for butterfly species, including native species, Pacific region species and global species like the Monarch Butterfly (undoubtedly the case for other invertebrates as well). Revealing the full extent of Jenolan's biodiversity will be an ongoing work involving government, natural history institutions, database projects like the Atlas and involvement of 'citizen scientists', an essential part of the frontline for the challenges that lie ahead.

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Cave and Karst Protection and Management in Pakistan

Farzana Khan Perveen

Founder Chairperson and Associate Professor, Department of Zoology, Shaheed Benazir Bhutto University (SBBU), Main Campus, Sheringal Khyber Pakhtunkhwa, Pakistan

Office Phone: (092)-944-885529; Mobile: (092)-300-225387; Fax: (092)-944-885805
URL: www.sbbu.edu.pk; E.mail: farzana_san@hotmail.com

Abstract: In Pakistan, much of the caves and karsts have been explored since 1990 by British Cave Research Association (BCRA) with Pakistani cavers and mountaineers. The Pir Ghaib Gharra is the longest cave in Pakistan located in Baluchistan with 1275 m. The Kach Gharra Juniper Shaft is the 131 m deepest cave with 350 m long and over 1000 m thick. The Murghaghull Gharra, Baluchistan is the single chamber largest cave with 576 m. The cave city, Gondrani has 500 out of the 1500 caves. It is also known as Shehr-e-Roghan is located near Bela in Baluchistan. The beautiful Islamabad is home to famous caves of Shah Allah Ditta, an important archeological site are approximately 4000 years old, Khewra is famous for having the 2nd world's largest salt mines are located in district Jhelum of Province Punjab, and situated 200 km from Islamabad with 288 m above sea-level. It is part of mineral-rich mountain-range called Salt-Range with total length of 300 km and width varies 8-30 km, extending from Beganwala near River-Jhelum to Kalabagh near River-Sindh. In Pakistan, caves and karsts are importance for tourism perspectives and place to practice cannibalism, home for bats, crickets, millipedes, many other insects, birds, animals, plants and for practicing black magic. In August 1997, the Pakistan Caves Research and Caving Federation (PCRCF) was formed for cave and karst protection and management. It has mystic elements to attract people for exploring, awareness, education and research.

Key words: Caves and Karts, Kach Gharra Juniper Shaft, Pakistan, Pir Ghaib Gharra, Salt-Range

Introduction

The term cave is commonly applied to natural openings, usually in rocks, that are large enough for human entry (FORD, 1988). The karst represents a subset of groundwater, whose chemical composition is controlled fundamentally by climate, the type of source materials being dissolved, and resident for long time (FORD AND WILLIAMS, 1989). Cave and karst landforms are widely distributed around the world. They have many values and are an integral component of the biodiversity (ANDERSON AND SWABEY, 2013). Some are habitats for a wide range of endemic species of fauna and flora, while others house for endangered and wild species. Numerous animals colonize in them by developing entirely new behaviors such as echo-location (e.g., bats and the nocturnal oilbird, Steatornis caripensis (HUMBOLDT, 1817), bioluminescence (e.g., the New Zealand glow-worm, a fly larva, Arachnocampa luminosa (SKUSE, 1890), or hibernation (e.g., a carp from China, Varicorhinus macrolepis (BEDDOME, 1862). However, these types of behavioural modifications are the exception, not the rule. Most of the species can be grouped into one of the following categories: feeding, reproduction, social behaviour (including: aggregation, responses to alarm substances, and antagonistic behaviour), photo responses, circadian rhythms, and acoustic behaviour (PARZEFALL, 2000).

Still other caves and karsts are the sources of rare minerals and some are important for resources such as groundwater, while some are recognized as sites for religious, spiritual and cultural importance (GAMS, 1993). Internationally, the karst landscape has great significance on a number of levels, most important is its role as a water resource, however, the hydrology of karsts is important for a number of other relationships, including biodiversity (GUNN, 2004). Considering special places, cave and karst landforms require special management, as they are considered as protected areas (WATSON et al., 2018).

Pakistan is home of 14 ranges of mountains including Karakoram, Himalayas, Hindu Kush, Nanga Parbat, Sulaiman mountains, Safēd Kōh, Spin-Ghar mountains, Margalla hills, salt-range mountains etc. It has many known caves and karsts found around and in rocks of such mountainous ranges. The Baluchistan (one of the provinces of Pakistan) is very rich in caves and karsts. It have more than 130 caves, including the longest, largest chamber, natural decorated, deep descending shaft, largest opening, and longest pillar caves. In Southeast Asia, they have been widely used by man since prehistoric. Buddhism is the dominant religion in the region and makes use of many caves as hermit retreats, underground temples, and places for worship (BURDON AND SAFADI, 1963).

The Pakistan Caves Research and Caving Federation (PCRCF) was established in August 1997, which is a sports federation and non-profit governing body. Its head quarter is located in Quetta, Baluchistan. It is affiliated with International Union of Speleology (UIS), London, United Kingdom (UK). It is working with National Universities, Geological Survey of Pakistan, Pakistan Sports Board, Pakistan Sports Climbing Federation (PSCF), Social Welfare Department (SWD), International Speleological Communities (ISC) etc for caves and karst protection and management. It has numinous fundamentals to fascinate publics for the sentience, education and research for caves and karsts. It is also working for their protection and management.

Materials and Methods

The information provide in this review was collected from personal field survey of caves and karsts in Pakistan by the author, available literature including published research papers, and encyclopedia of caves and karst science, and internet. Direct contacts, discussions, cross conversation, interviews with experts PCRCF administration, related-local people, and communities were made. During survey, binocular, GPS (Global Positioning System) meter and digital camera were used. Every effort was made to locate caves and karsts for protection and management in Pakistan.

Results and Discussion

The longest stalagmite and stalactite cave, the Pir Ghaib Gharra is located in Harnai District of Baluchistan, surrounded by a stunning waterfall with 1275 m length (Fig. 1i).

The deepest cave, the Kach Gharra Juniper Shaft is situate near Ziarat, Baluchistan, the 131 m deep with 350 m long and over 1000 m thick, at an altitude over 2200 m near top of the limestone. It is first ever most difficult deep descending vertical shaft cave on mountains of Kach in Pakistan (Fig. 1ii).

The single chamber largest cave, the Murgha Ghull Gharra (Juniper Shaft) cave is located in Harnai (Bats valley), Baluchistan with 576 m length. It was second longest cave of Pakistan in 1997. The initial exploration of karsts of limestone was found on it (Fig. 1iii).

The cave city, the Gondrani is also known as Shehr-e-Roghan or Mai Pir with dating back to 700 A.D. It is located in Bela, Baluchistan. During British rule, around 1500 caves were reported, but now only 500 are remained. It is an important archeological site, believed to be carved by Buddhists and represents old cave civilization with house of the great spirits and mysteries. It is locally known as puraney-ghar (old houses) are carved into solid conglomerate rocks at several levels, and are connected by pathways. All the caves have small rooms with hearths and wall niches for lamps, along with verandahs and front porches. They are in poor condition and are slowly eroding. No conservation efforts have been made to protect them, because of poor accessibility and lack of knowledge of the archaeological site (Fig. 1iv and v).

The beautiful capital city, Isalamabad of Pakistan is home to famous caves of the Shah Allah Ditta, date-back to stone-age an important archeological site ca. 4000 years old. It was formed in the Ghandara civilization with murals on walls denoting Buddhism and Hinduism (Fig. 1vi).

The highest altitude cave, the Saiazgai Pot is located in Baluchistan, Pakistan. Its window entrance is lighted with daylight, however, it is dark inside with flow fresh and clear water. It is beautiful cave for recreation (Fig. 1vii).

The Pooai cave is found in Baluchistan, Pakistan. Its entrance is comparatively round and its inside is not much darker, but have comparatively dim light (Fig. 1viii).

The Khuzdar cave is a short and deep cave near Khuzdar, Balochistan, Pakistan. It is very beautiful cave with fresh and clear water flowing inside it. Outside of it, many herbs, shrubs and grasses are found (Fig. 1ix).

The natural decorated cave is found in Kalat District of Baluchistan. It is decorate with speleothems, the precipitate of limestone builds dripstone, however, water drips from the ceiling of the cave. Initially, it forms a delicate hollow tube called a soda straw, where calcite precipitate is deposited around and outside of the drips. But finally, the soda straw fills up, and water migrates down the margin of the cone to form a more massive structure, solid icicle-like cone called a stalactite. At this point, the drips hit the floor, the resulting precipitate forms an upward-pointing cone called a stalagmite (Fig. 1x).

The Ghwa cave is located in Loralai, Baluchistan, Pakistan. It is another much smaller cave is present in dolomite of probable Paleozoic (early Cambrian) age on the east side of the road. This smaller cave apparently is remarkably beautiful. Because, it is decorated with karsts, which are found around it (Fig. 1xi).

The Kaan Ziarat cave is situated at an altitude of about 2,400 m in Ziarat, Baluchistan, Pakistan. It is made up of pinkish brown stones. Its entrance is bright with daylight, however, inside is darker. It is mostly plane with no or very rare fauna (Fig. 1xii).

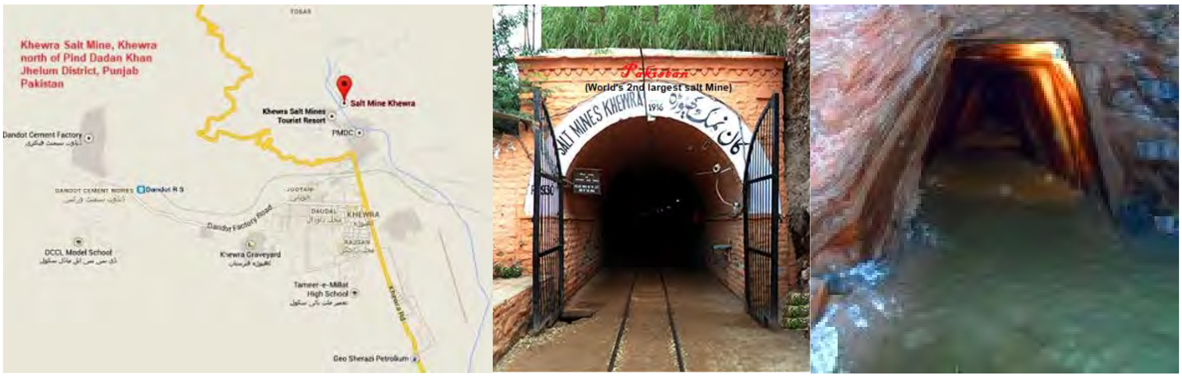
The Amarnath cave, Kashmir, Pakistan is made up of gay-stone. It is a Hindu shrine, located in Jammu and Kashmir. The cave is situated at a high altitude of 3,888 m and about 141 km from Srinagar. The shrine forms an important part of Hinduism, and is considered to be one of the holiest shrines in Hinduism. The cave mountain are covered with snow during the most of the year except for a short period of time in summer, when it is open for pilgrims. Hundreds of thousands of Hindu devotees make an annual pilgrimage (Fig. 1xiii).

The caves are located at the Kai valley, Sindh, Pakistan about 40 km from Sehwan, is the Kai valley, which offer scenic vistas on both sides of the road. It seems as if the hills were once below sea level because there are visible signs of erosion from water waves. A narrow and difficult track leads to 2 cave sites. The lower site, locally called Satt Ghariyoon (seven caves). The upper sites lies to the south of the village, at top of the hill (Fig. 1xiv).

The Sanghao cave is a Paleolithic site, located near the village of Sanghao, Parkho dara, northeast of Mardan in Khyber Pakhtunkhwa, northern Pakistan at an altitude of 600 m (2,000 ft). The cave is often called as Parkho-darra. Excavations from the site yielded evidence of human activity from the Middle Paleolithic period, over 30,000 years ago.The cave was excavated by Ahmad Hasan Dani in 1963. Chipped stone, bones, scrapers, quartz tools, blades, flakes etc were found during the excavation (Fig. 1xv).

Fig. 1: The famous caves in Pakistan: i): The Pir Ghaib cave in relatively round, Bolan mountains, Baluchistan (the longest cave); ii): The Kach Gharra Juniper Shaft cave lies near Ziarat in Baluchistan (the deepest cave) with 131 m deepest with 350 m long and over 1000 m thick; iii): The Murghagull cave Harnai, Baluchistan is the largest single chamber cave with 576 m; iv and v): The Gondrani caves (Shehr-e-Roghan or Mai Pir), Bela Baluchistan is dating back to 700 A.D., an important archeological site carved by Buddhists; vi): The Allah Ditta cave, Islamabad, archeological site is ca. 4000 years old, to stone-age and were formed in the Ghandara Civilization; vii): The window entrance of the highest altitude cave, Saiazgai Pot, Baluchistan; viii): The Pooai cave, Baluchistan; ix): A short cave near Khuzdar, Balochistan; x): The Natural Decorated Cave, Baluchistan; xi): The entrance of the Ghwa Cave, Loralai; xii): The Kaan Ziarat cave, Ziarat; xiii): The entrance of Amarnath cave, Kashmir; xiv): The caves at Kai valley, Sehwan, Sindh; xv): The Sanghao Cave located near the village of Sanghao, Parkho dara, northeast of Mardan, Khyber Pakhtunkhwa

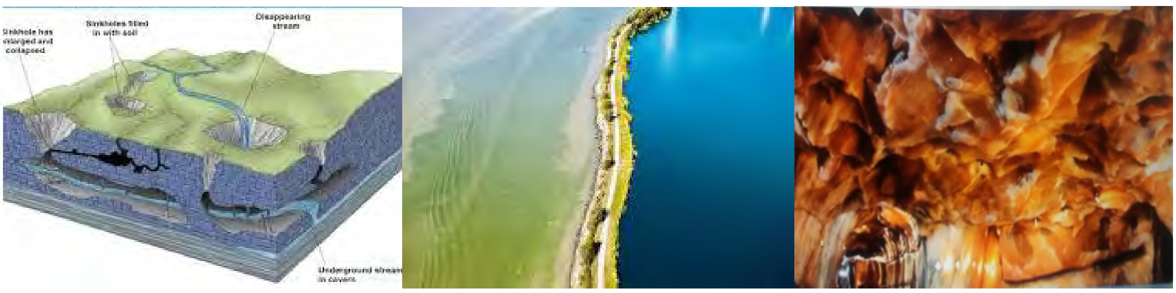
The Khewra Salt Mine is Pakistan's the largest, the world's 2nd largest and the oldest salt mine in the world. It is located in the Khewra, north of Pind Dadan Khan, an administrative subdivision of Jhelum District, Punjab, which rises from the Indo-Gangetic Plain. It is located 200 km from Islamabad with 288 m above sea-level and total length of 300 km and width varies 8-30 km. It is extended from Beganwala near River-Jhelum to Kalabagh near River-Sindh. It is the part of the mountain-range of mineral-rich called the Salt-Range (Figure 2a, b, c).



a) b) c)

Fig. 2: Khewra salt mines: a): Map of Khewra salt mines; b): Entrance Khewra salt mines; c): Internal view of Khewra salt mines

The karst is a landscape underlain topography eroded by dissolution of soluble rocks such as limestone, dolomite, and gypsum producing ridges, towers, fissures, sinkholes, circular depressions that form either when the ground collapses into an underground cave below or when surface bedrock dissolves in acidic water on the floor of a bog or pond. In cases where the ground collapses over a long, joint-controlled passage, sinkholes may be elongate and canyon-like. Ridges or walls between adjacent sinkholes tend to be steep-sided. Over time, the walls erode, leaving only jagged, isolated spires a karst landscape dominated by such spires is called tower karst. Such karst can be seen in Pir Ghaib Gharra, Kach Gharra Juniper Shaft, Murghaghull Gharra caves, Balochistan, and in others caves in Pakistan.



a) b) c)

Fig. 3: The Karsts in Pakistan: a): Karst topography features; b): carbonated rock formations develop cavities where groundwater can circulate. The dissolution of carbonated rocks can lead to underground collapses and structural damage to the site or building; c): karst in the Khewra Salt Mine, Khewra, north of Pind Dadan Khan, Jhelum District, Punjab

Conclusion and Recommendations

It is concluded that caves and karsts are rich natural resources in Pakistan. PCRCF is doing its efforts for safety, security and management of caves and karsts with other organizations. Caves and karsts are significance for tourism aspects. They provide home for birds, bats, wild animals and insects etc. They provide environment for flourishing plants and for practicing black magic and cannibalism.

The recommendations are as following: Further proper protection and consultation for the assessment and management of caves and karsts is required in Pakistan; other organizations should be participated and played their role in protection and management of caves and karsts.

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The dark side of human contamination: hidden impacts in subterranean ecosystems, legal framework and how to monitor subterranean biodiversity

Ana Sofia P.S. Reboleira

Natural History Museum of Denmark, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen, Denmark. Email: sreboleira@snm.ku.dk

An important part of the world's biodiversity is found below the ground and constitute one of the last frontiers for the biological research. In unique environmental conditions of the subterranean environment rises an habitat composed of species with peculiar morpho-physiological adaptations. These are known by their lack of eyes and pigment and extreme body elongation, but surprisingly little is known about how the subterranean ecosystems are being affected by human activities.

The occurrence and distribution of subterranean adapted species is intimately linked with the lithology of the terrain. It is now more 30 years that our perspective of the distribution of animals in caves has changed. The so called cave-adapted organisms live in a wide diversity of subterranean ecosystems ranging from the small spaces between the soil to the deepest and largest caves of the world, passing through a large extension of the so called MSS, a matrix of non-aggregated rocks close to the surface.

The infiltration of contaminants to the subterranean ecosystems is fast, making them excessively vulnerable to impacts of pollution.

While there are an array of EU regulations concerning the ecological conservation of surface freshwater biodiversity in place, the legal framework protecting groundwater biodiversity is arguably deficient. The EU Water Framework Directive or the Groundwater Directive solely refer to the chemical status (i.e. physic-chemical parameters of the groundwater), neglecting its ecological status Similarly, the Habitats Directive pays almost no attention to subterranean-adapted organisms in the terrestrial subterranean compartment, which is intimately linked with the groundwater cycle.

Despite worldwide recognition of the importance of subterranean ecosystems as the most important sources of freshwater for human consumption and also recognized as critically endangered, the array of EU legislation stresses only the need to achieve a good physico-chemical status of groundwater, neglecting its endemic biodiversity, as well as the biotic relations among them and their surrounding ecosystems. Subterranean species plays a key role in regulating the whole suite of ecosystem functions directly related to groundwater dependent ecosystems, as springs and rivers. A complete evaluation of the condition of subterranean ecosystems should consider not only abiotic parameters but also their biological components.

One of the main challenges for future research in subterranean ecosystems is to understand the impact of anthropogenic activities in subterranean ecosystems. This talk will present a framework for future ecological assessment of subterranean ecosystems, ensuring its sustainability.

Postojnska jama - a cave of exceptional geoheritage and biodiversity; 200 years of tourism

Nadja Zupan Hajna

Karst Research Institute ZRC SAZU; Postojna, Slovenia and International Union of speleology-UIS

Introduction

Postojnska jama (Postojna Cave) is the biggest show cave in Slovenia and in Europe. It is located in the central part of so called Classical Karst, in SW part of Slovenia. Classical Karst, as we understand it today, is the karst landscape between springs of Ljubljanica River in Ljubljana Basin (Slovenia) and Trieste Bay (Italy) well known due to its remarkable speleological, hydrological and morphological phenomena researched and studied since 17th Century. From the wider area also scientific term karst originates (from local toponym "kras") which denotes a rocky landscape with typical karst forms and subterranean water drainage. In the 19th Century this area contributed to the emergence and development of karstology, speleology and speleobiology as scientific disciplines.

Cave is important because of natural features, because of 200 years of tourist development (since 1818) and especially because of the first scientific research done in the cave in the world at all. Famous natural scientists such as Valvasor (1683) and Hacquet (1778) described the cave in their works from the 17th and 18th centuries. Extensive surveys and discoveries have continued in the early 19th century and were described by Hochenwart in 1832 and Schmidl in 1854. The first discoveries of cave-dwelling animals in the world were in Postojnska jama: in 1797 the cave salamander (*Proteus anguinus)* was first time found in the cave; and in 1831 a beetle (*Leptodirus hochenwarti*) was found there and in 1832, recognized and scientifically described by Ferdinand Schmidt as a true cave-dwelling animal.

Location and geology setting

Postojnska jama is about 25 km long cave with many entrances; some of them were originally known as separate caves (Črna jama, Pivka jama, Magdalena jama, Otoška jama). The cave passages were formed by the river Pivka in the karst area between Pivka Basin and Planinsko polje. The karst surface, at elevations between 600 to 650 m. a.s.l., is dissected with numerous solution dolines and sixteen large collapse dolines developed above cave passages and blocking some of the passages.

Pivka River recent ponor is at 511 m a.s.l. at the edge of impermeable Eocene flysch rocks of Pivka Basin and the first sump in Pivka jama is at 477 m a.s.l.; while several old ponors are located up to an altitude of 529 m. After newly discovered passages is about 500 m of unexplored galleries before the river re-appears in Planinska jama at 460 m a.s.l. The cave passages were formed on two levels, upper is dry and through the lower level river Pivka flows. The average water discharge is 5.2 m^3/s. During floods, the water in passages can raise up to 10 m. The cave shows a network of hydrologically and morphologically very different passages that differ in terms of formation and enlargement. Active water passages are on average smaller than the passages in the dry sections. The biggest chamber is Velika gora (Great Mountain) has a volume of approx. 100,000 m^3; the highest point in the hall is 40 m above the level of the cave entrance and 60 m above the ponor of Pivka River. The thickness of bedrock above the cave passages is from about 30 to 120 m.

Surface geology of the Postojna karst terrain between caves Postojnska jama and Planinska jama bases on studies of Buser et al. (1967), Gospodarič 1976, Čar & Gospodarič (1984), Placer (1996, 2014), Rižnar (1997) from which results compiled geology map presented on figure 2 (ZUPAN HAJNA 2015). The cave is developed in the Upper Cenomanian and Turonian to Senonian limestone sequence, which is about 800 m thick. Carbonate beds of various thicknes are overthrusted, folded and faulted due to regional tectonics. Cave passages were mostly formed following inter-bedded slips (ŠEBELA 1998) in the limestones of the Postojna anticline, which is oriented in the NW–SE direction (GOSPODARIČ 1976). The cave is intersected by several fault zones in the Dinaric and Cross-Dinaric direction.

Cave sediments and their age

Cave contains diverse sedimentary fill, ranging from speleothems to allogenic fluvial sediments of different ages. The river Pivka is recently bringing and was brought in the past alogenic sediments into the cave; most of them are younger than 780 ka while the oldest are over 3 Ma old (ZUPAN HAJNA et al. 2008, 2010). The cave is known for its huge amount of speleothems and their diversity (great variety of shapes, colors). Some of speleothems were dated by different dating methods; and obtained ages were from recent to 500 ka. The oldest known speleothem is from Pisani rov; its core was dated by using ESR and U/Th methods to approximately 530,000 years (IKEYA et al. 1983; ZUPAN 1991). Dated speleothems from the Velika gora (Mihevc 2002) uncover periods of growth in warmer climes and the time of the ceiling collapses in colder climes.

Speleobiology

Postojnska jama is known after the first discoveries of cave-dwelling animals (troglobionts) in the world; in 1797 founding of *Proteus anguinus* (Cave salamander or human fish) and in 1831 of first cave beetle *Leptodirus hochenwartii* (the Slenderneck beetle). With these first discoveries the new explorations were done in the cave and many new species were found and described from the cave: e.g. the cave spider (*Stalita taenaria*), the Postojna Cave pseudoscorpion (*Neobisium spelaeum*), the cave amphipod (*Niphargus stygius*), the giant cave trichoniscid (*Titanethes albus*), the cave snail (*Zospeum spelaeum)* and the cave centipede (*Lithobius stygius*); consequently, Postojnska jama is known also as cradle of speleobiology as a science. Postojnska jama is a hot-spot regarding biodiversity as 114 species of cave-dwelling animals (ZAGMAISTER et al. 2015) have been discovered and described in the cave, for 84 of them the cave is the type locality (Locus typicus).

Discoveries and tourism

Parts of the cave were known already in Paleolithic, one of the signatures on the cave walls is known from 13th century and its first scientific descriptions are known from 17th century. The Veliki dom (Great Dome) is the entrance chamber that had been known to Postojnska jama visitors even before the inner parts were discovered.

Its worldwide fame was achieved through 200 years of intensive tourist development: guided tours since 1819, railway since 1872, permanent electric lighting since 1884.

Postojnska jama is one of the World's most prominent show caves, visited by over 500000 (in last years over 700.000) tourists a year, 90 % of them from abroad. Sustainable management is a big challenge in show caves. While direct physical impact of the touristic infrastructure on cave environment can be relatively easily assessed, the assessment of indirect impacts of tourism is a difficult task. Chemical and physical parameters of percolation water and allogenic recharge to the cave system has been monitoring for decades. Since 2007 the Decree of the Government of the Republic of Slovenia provides the conditions for granting a concession for the use of natural values of Postojnska jama and thus also a mandatory monitoring carried out by the Karst Research Institute ZRC SAZU from Postojna. To this extend, long term monitoring and the analysis of the environmental parameters are performed: e.g. T, Q, EC of percolating water and sinking river, air T, CO2 and radon concentrations, dust monitoring, lampenflora, epikarstic fauna and microbiological monitoring (e.g. GREGORIČ et al. 2012; ŠEBELA & TURK 2014; GABROVŠEK et al. 2014). Besides activities related to sustainable management, in Postojnska jama, different karstological studies are currently going on: e.g. sediment dating, speleogenetic studies, CO_2 dynamics, biospeleological and structural geological studies. All these make Postojnska jama a prominent research site, which is a necessary element for sustainable tourism.

Scientific interpretation for tourism

In 2012 new concessionaire Postojnska jama, d.d. decided to invest in interpretation of Postojnska jama story. Prior to that, Postojnska jama was historically well known show cave with various, numerous and famous visitors from all over the world, but without any permanent exhibition or interpretation on the cave. Leading idea was to present cave regarding natural and tourist development and its significance in space and time (ZUPAN HAJNA et al. 2015) with the use of innovative technologies and interpretation. There was a big challenge how to provide enough information for average visitor, without over-simplifying or overloading; to avoid this problem multi-leveled exhibition was set up. Exhibition was opened in 2015 by marketing name “EXPO Postojna Cave Karst” and in 2017 exhibition got the award for most creative and exciting achievements in Slovenian tourism “Sejalec 2017” from Slovenian Tourist Board.

Conclusion

Without a doubt Postojnska jama is a cave with exceptional geoheritage and biodiversity values. But there is an open question whether it's a way of managing of such an outstanding natural site through the concessionaire satisfactory for the cave itself, the State and the local community?

Annex

Vilm Declaration on Geodiversity and Geoheritage Conservation

We the members of the IUCN WCPA Geoheritage Specialist Group meeting in Vilm Germany in April 2018 on Global Geoheritage – international significance and biodiversity values.

Consider that

- conservation, understanding and promotion of sites and areas of geoheritage significance is fundamental in its own right
- geodiversity is part of nature and a fundamental component of natural capital and is intrinsically linked to ecosystem functions, goods and services
- geodiversity and geoheritage conservation underpins biodiversity conservation, human wellbeing, economic prosperity and contributes to sustainable development
- geodiversity is significant at all scales from the local to the global

We are determined to work in a focussed way to deliver our revised programme for the period 2017-2020. The programme comprises 7 goals with associated work programmes identifying outcomes, target audiences, leads, contributors, partners, funding and timescales.

To achieve our ambitions, we recognise the vital importance of working in partnership within IUCN and with the geodiversity and geoheritage community.

Agreed by participants of Vilm Workshop of International Union for Nature Conservation World Commission on Protected Areas Geoheritage Specialist Group.

Workshop Agenda

Expert workshop

IUCN/WCPA GSG Workshop Germany: Global Geoheritage - International Significance and Biodiversity Values

2nd – 7th of April 2018

at the

International Academy for Nature Conservation
Isle of Vilm, Germany

organised by the

German Federal Agency for Nature Conservation (BfN) in cooperation with IUCN-WCPA Geoheritage Specialist Group

Monday, 2nd of April 2018

Pre excursion to gypsum karst in Harz

	Arrival at hotel „Der Achtermann Goslar“
16:00	Guided city tour (optional); meeting point: lobby at hotel “Der Achtermann” FRIEDHART KNOLLE (German Speleological Federation)
19:00	*Dinner at hotel „Der Achtermann“*
20:00	**Welcome** (venue: at hotel “Der Achtermann”) RALF GRUNEWALD (Federal Agency for Nature Conservation) BÄRBEL VOGEL (German Speleological Federation, VdHK EICK VON RUSCHKOWSKI (Director of Lower Saxony State Academy on Nature Conservation)
21:00	The South Harz Gypsum Karst Landscape - an Introduction FRIEDHART KNOLLE (German Speleological Federation)

Tuesday, 3rd of April 2018

09:00	Bus excursion Goslar, gypsum karst around Herzberg am Harz FRIEDHART KNOLLE
12:00	Einhornhöhle show cave visit and short lunch
13:30	Gypsum karst around Osterode am Harz and back to Goslar
20:00	*Dinner at restaurant „Weite Welt Goslar“*

Wednesday, 4th of April 2018

09:00	Bus excursion Goslar, Vienenburg and travel to Vilm Island FRIEDHART KNOLLE
18:10	**Arrival** at Lauterbach Mole
18:30	*Dinner*
19:30	Welcome KYUNG SIK WOO*,* GSG Chair
19:50	Introduction to the venue and logistic announcements RALF GRUNEWALD, BfN

Thursday, 5th of April 2018

07:30 *Breakfast*

General Introduction

08:30 Introduction
KYUNG SIK WOO (GSG Chair, South Korea)

09:40 Future directions on geo-heritage in IUCN
TIM BADMAN (IUCN, Switzerland)

10:10 Geoheritage, conservation and the role of the International Commission on Geoheritage (ICG) within IUGS
KEVIN PAGE (IUGS, UK)

10:40 *Coffee break*

11:00 Past, current and future activities of IUCN WCPA Geo-heritage Specialist Group and a proposal of the Key
Geoheritage Sites in IUCN
KYUNG SIK WOO (GSG Chair, South Korea)

11:30 Geoconservation of Global Geoparks in Germany
WOLFGANG EDER (IUGS, Germany)

12:00 UNESCO Global Geoparks Network and a fruitful
collaboration with UNESCO WHS
MARIE-LUISE FREY (Welterbe Grube Messel GmbH, Germany)

12:30 *Lunch break*

Session 1 - The Role of GSG in IUCN WCPA; Exploring the links between geodiversity and biodiversity

14:00 The foreseeable role of GSG in IUCN/WCPA
ENRIQUE DIAZ-MARTINEZ (Geological Survey of Spain)

14:30 Natural capital, ecosystem services and geodiversity: complexity and confusion
MURRAY GRAY (University of London, UK)

15:00 *Coffee break*

15:20 Linking geodiversity and biodiversity – progressing best practise guideline on geoheritage conservation
ROGER CROFTS (IUCN/WCPA Emeritus, UK)

15:50 Linking geodiversity and biodiversity – the value of developing a more integrated approach to nature conservation and protected area management
JOHN GORDON (University of St. Andrews, UK)

16:20	Assessment of extinction risk of species as a tool for cave and karst conservation ANA KOMERIČKI (IUCN SSC Cave Invertebrate Specialist Group, Cambodia)
16:50	Discussion
18:30	*Dinner*
19:30	Guided tour Vilm island RALF GRUNEWALD (BfN)
20:00	GSG steering committee meeting

Friday, 6th of April 2018

07:30	*Breakfast*

Session 2 - Conservation of Caves and Karst

08:30	The dark side of human contamination: hidden impacts of in subterranean ecosystems, legal framework and how to monitor subterranean biodiversity SOFIA REBOLEIRA *(*IUCN SSC Cave Invertebrate Specialist Group, Denmark)
08:50	International Union of Speleology: Postojnska jama - a cave of exceptional geoheritage and biodiversity; 200 years of tourism NADJA ZUPAN HAJNA (Karst Research Institute, Slovenia)
09:10	Challenges in management of the Skocjan Caves, Slovenia ROSANA CERKVENIK (Skocjan Caves Park, Slovenia)
09:30	Natuturingan cave (Puerto Princesa Underground River, Palawan, Philippine): how to preserve an astonishing ecosystem while improving tourism PAOLO FORTI (Italian Institute of Speleology, Italy)
09:50	Discussion
10:30	*Coffee break*
11:00	CKWG meeting
12:30	*Lunch break*

Session 3 - Recognition of Key Geoheritage Sites

13:30	Key Geoheritage Sites KYUNG SIK WOO *(*GSG Chair, South Korea)
13:40	The assessment of the international significance of geoheritage JOSE BRILHA (University of Minho and ProGEO)
14:10	International Recognition of Cave and Karst Geoheritage JOHN GUNN (University of Birmingham)

14:40	*Coffee break*
15:00	The IUCN Key Biodiversity Areas Standard TIM BADMAN (IUCN, Switzerland)
15:30	Recognising the landforms of international significance PIOTR MIGON (Univ. of Wroclaw, Poland)
16:00	Protected Volcanic Landscapes and the IUCN Volcano Thematic Study (TOM CASADEVALL (US Geological Survey, USA)
17:00	Discussion
18:00	Poster presentation
18:30	*Dinner*
20:30	Farewell party

Saturday, 7th of April 2018

07:30	*Breakfast*

Session 4 – Conclusions, future directions & next steps

08:30	Discussion
10:30	*Coffee break*
10:45	Evaluation
11:30	Closure
12:00 12:20	 Departure of ferry with packed lunch

Post excursion to chalk cliffs on Rügen

12:30	optional guided bus tour to chalk cliffs on Rügen *starts in Lauterbach, ends in Sassnitz*
17:00	Sassnitz train station: train back to Berlin

List of Participants

No.	Name	Institution	Country
1.	Dr. Al- Zubaidi, Aqeel	Natural History Research Center and Museum, University of Baghdad	Iraq
2.	Brilha, José	University of Minho Pro GEO	Portugal
3.	Casadevall, Thomas	U.S. Geological Survey	USA
4.	Cerkvenik, Rosana	Skocjan Caves Park, Slovenia	Slovenia
5.	Prof. Crofts, Roger	Deputy Chair of Geoheritage Specialists Group, IUCN-WCPA	United Kingdom
6.	Dr. Díaz-Martínez, Enrique	Geological Survey of Spain (IGME)	Spain
7.	Dr. Eder, F. Wolfgang	Geoscience Centre, Göttingen University	Germany
8.	Dr. Ellger, Christof	GeoUnion Alfred-Wegener-Stiftung	Germany
9.	Dr. Frey, Marie-Luise	Welterbe Grube Messel gGmbH	Germany
10.	Dr. George, Klaus	Regionalverband Harz	Germany
11.	Prof. Gordon, John	School of Geography & Sustainable Development, University of St Andrews	United Kingdom
12.	Dr. Gray, Murray	Queen Mary University of London	United Kingdom
13.	Dr. Grunewald, Ralf	Bundesamt für Naturschutz, INA	Germany
14.	Prof. Gunn, John	School of Geography, Earth & Environ-mental Sciences, University of Birming-ham	United Kingdom
15.	Dr. Hadi, Afkar	Natural History Research Center and Museum, University of Baghdad	Iraq
16.	Dr. Haryono, Eko	University of Gadjah Mada	Indonesia
17.	Hill, Wesley	IUCN/WCPA GSG Secretary	USA
18.	Ju, Seongok	Department of Geology, Kangwon National University, Korea	Republic of Korea
19.	Komericki, Ana	Fauna & Flora International Cambodia	Cambodia

No.	Name	Institution	Country
20.	Prof. Migon, Piotr	University of Wroclaw, Institute of Geography and Regional Development	Poland
21.	Dr. Musser, Anne	Jenolan Caves Reserve Trust	Australia
22.	Dr. Page, Kevin	Plymouth University	United Kingdom
23.	Dr. Perveen, Farzana	Department of Zoology, Shaheed Benazir Bhutto University (SBBU), Main Campus	Pakistan
24.	Reboleira, Ana Sofia	University of Copenhagen	Denmark
25.	Dr. Trofimova, Elena	Institute of Geography, Russain Academy of Sciences	Russian Federation
26.	Vogel, Bärbel	German Speleological Federation	Germany
27.	Wang, Meng	Young Earth Scientists (YES) Network, IUCN / WCPA Geoheritage Specialist Group, President / Member	China
28.	Prof. Woo, Kyung-Sik	IUCN WCPA Geoheritage Specialist Group, Chair	Republic of Korea
29.	Dr. Zupan Hajna, Nadja	Karst Research Institute ZRC SAZU and International Union of Speleology	Slovenia
30.	Zupanc Hrastar, Suzana	Ministry of the Environment and Spatial Planning	Slovenia