TOURISM AND KARST AREAS

Formally/Formalmente “Pesquisas em Turismo e Paisagens Cársticas”

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Caverna Casa de Pedra (Iporanga SP - Brasil) - Com uma altura aproximada de 220 metros é um dos maiores pórticos do mundo.
Stone House Cave (Iporanga SP - Brazil) - With a height of 220 meters (720 ft) is one of the major cave entrance of the world.
photo/foto: Lalo de Almeida - see page/vide página: 34.

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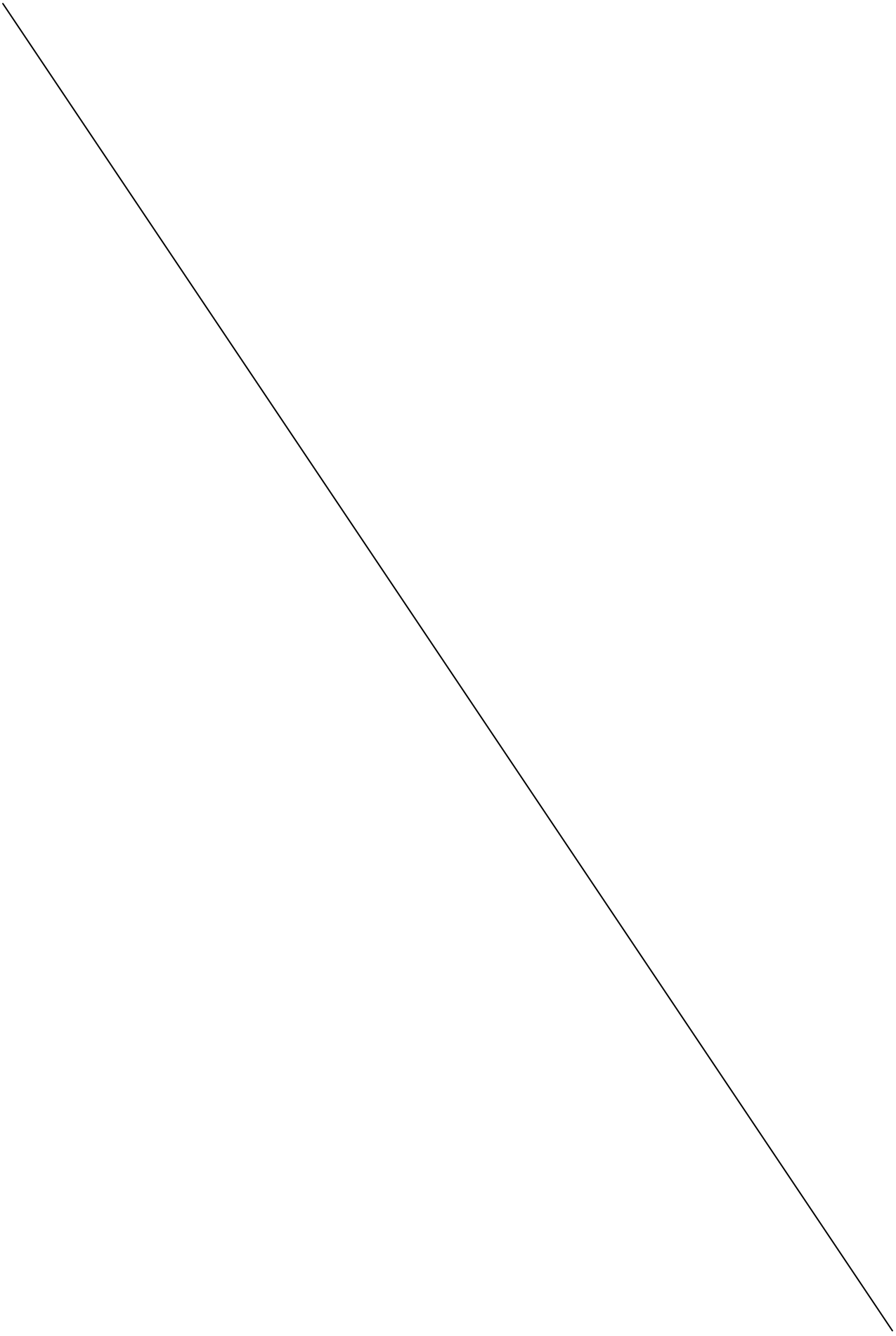

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TOURISM AND KARST AREAS

(Formalmente/*Formally*: Pesquisas em Turismo e Paisagens Cársticas)

SUMÁRIO
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EDITORIAL

Worldwide speleotourism: approaches for economic and heritage sustainability

Caves are important and singular examples of **Geodiversity** (Gray, 2004). Generally speaking, karstic areas are a significant part of distinctive Geological Landscapes, which require a holistic and integrated management because they constitute unique natural archives, important sources of paleoclimate, paleontological and archeological sources of information for the comprehension of the Earth History.

Thus, caves may be part of the **Speleological Heritage** as a sub domain of the Geological Heritage which, besides the representativeness and/or singularity of the cave systems and hydrogeological processes, the richness and diversity of speleothems, may also include cavernicolous biodiversity. As habitat, and the evolutionary record, of many species of well adapted or outsider organisms, caves have been used by Man across biological and cultural/technologic evolution as home and sacred site, places of fascination, mystery, dynamic culture, science and leisure. They are territories of discovery, of education and adventure, existing almost all over the world intimately related with geodiversity and the diversity of geomorphological processes. Some remarkable examples are the Mammoth Cave National Park, in USA, with 643,7km is the longest limestone cave in the world; the Kazamura Cave, in Hawaii, the world's longest lava tube with 65,5km; in quartzite rocks, the Charles Brewer cave system, in Venezuela, with 17,8km already mapped is the longest one; as the Gobholo Cave, in the granites of Swaziland.

As any other, Speleological Heritage needs specific measures of **protection, conservation and use**, right in accordance with the rate of importance and vulnerability. To find the right measures inventorying and technical-scientific studies of caves at a national level, developed by responsible institutions and easily available for territorial management bodies and local communities, are fundamental as tools for the definition of geoconservation and valuing approaches.

Caves, as territories of discovery, are the earliest tourist attractions, and nowadays one of the most appreciated **geotourism destinations** in the world. The concept of **Geotourism** was originally defined by (1995; see also Newsome and Dowling, 2010) as the offer of interpretation services and equipments enabling tourists to acquire knowledge and understanding of geology and geomorphology of a place (including the contribution for the development of Earth Sciences), beyond a level of esthetic appreciation. According to this definition, the Baumannshöle Cave, in Germany, already had guided visits in 1648, as well as a conservation and a controlled number of visitors management plan as early as 1668 (Erikstad, 2008). Geotourism is a **segment of Nature Tourism** with a great potential of affirmation in the international trade (Neto de Carvalho et al., 2009; Farsani et al., 2011). In the Portuguese language, the earliest reference for Geotourism may be reported to Barbosa et al. (1999).

Geotourism may have its background in the caves. The Niaux cave, in the French Pyrenees, is a labyrinth of passages and halls extending for kilometers. Here many footprints in different cavities were found in 1906, 1949 and between 1970 and 1972, showing repeated visits of Human groups during the Pleistocene (Pales, 1976). In one such cavity small footprints attributed to two young children were found showing a linear, distinct and recurring pattern, indicating that these children were drawing in the mud of the cave bottom, and developing artistic creations comparable to the more sophisticated and ritual-related rock art presumably made by adults on the walls of this same cave. These Pleistocene children were having fun and playing, and at the same time learning, while visiting the cave…

One may say that during those times visit to caves were just for contemplative appreciation of an underground dimension unfamiliar and therefore esoteric and mystic. Not surprisingly, it still is nowadays for the majority of tourist caves. In present times, tourist caves may be defined as natural or artificial caves which, by being specially habilitated, become accessible to a broad public interested in the underground environment in its whole diversity (Brandão, 2009). As tourism attraction, this can be a very important resource for regional economies that might have exponential results if correct measures of **geoconservation and interpretation** are taken (Moreira, 2011). It is necessary adequate social and economic viability plans, presentation of the tour, accessibilities, visitor services, charge capacity, environment control and

information/interpretation for different levels of public. Moreover, sustainable development of tourist caves fosters educational tools ad activities for local communities thus favoring local involvement in the management and an increasing number of speleologists and other researchers prone to contribute for cave's knowledge and valuing.

New ways for sustainable use of tourist caves are being developed. One of such innovative approaches is included in a territory of wider Geodiversity and Geological Heritage of international relevance, to which is associated a heritage's management body and a strategy for bottom-up local social and economic development based on the value of the Geological Heritage, the **Geoparks recognized by UNESCO** (see Farsani et al., 2011). According to the Feasibility Study of a UNESCO Geoparks Programme (2000), the former Division of Earth Sciences of UNESCO since the beginning of this worldwide movement (Patzak and Eder. 1998), has defending that geoparks may become an important factor for local economic development. They may generate employment and new economic approaches related to (geodiversity-related) specific subjects. The development of new trends in tourism and hadcrafting may be favored (geotourism, geoproducts)". In the most recognized UNESCO "**World Heritage**" Programme, from the 1560 Sites inscribed in the List and located in 172 countries, only 15 include caves by its exceptional Geological Heritage, such as Mammoth Cave or Škocjan, at Slovenia.

In this special issue of *Tourism and Karst Areas* dedicated to **Geoparks and other approaches for territorial management and tourism in karst areas**, Cigna and Forti introduces the importance of caves as tourism attraction, their fundamental importance for the history of global Geotourism and for the regional economies of many countries. The authors show also that scientific relevance of caves and the fragility of cave environments require specific approaches for geoconservation. Recommendations for the opening of tourist caves compiled from discussions in international scientific meetings are also presented here. In Brazil, with 17 geopark proposals selected by the Brazilian Geological Survey as the most promising ones at this moment, Nascimento & Mantesso-Neto analysed the presence of elements of speleological heritage in these proposals. In Asia, Rachmawati and Sunkar develop a market study based on public preferences, in a regional from the Island of Java (Indonésia). This kind of approaches complementing geoconservation and valuing studies already referred by previous authors is essential for any sustainable project related to the tourism value of karstic areas. On the other part of the world, Ulloa and Goicoechea report a synthesis of the geotourist potential of Costa Rica, in a national plan of sustainable use of abundant speleological resources.

In Brazil, Tourism as priority follows two worldwide trends: tourism diversification focused on the growth of interest about nature; and the preference (and request) for a better preserved environment (Moreira and Bigarella, 2010). The Brazillian Geological Heritage of international reference, vast and diverse where many other geotourist resources besides caves are included, has an enormous potential for generating social and economic opportunities and employment. Geoparks under the auspices of UNESCO and the sustainable-based tourist caves may be innovative opportunities for local communities and to burst local economies (Neto de Carvalho et al., 2009) that progressively deserve greater attention and appreciation of the various sectors of Brazilian society.

Jasmine Cardozo Moreira
Carlos Neto de Carvalho
Guest Editors

EDITORIAL

O espeleoturismo no mundo: abordagens de sustentabilidade económica e patrimonial

As grutas e cavernas constituem elementos importantes e singulares da Geodiversidade (Gray, 2004). Em geral, as áreas cársticas são uma parte significativa de uma Paisagem Geológica distinta, que requere uma gestão holística e integrada porque constituem arquivos naturais únicos, importantes fontes de informação paleoclimática, paleontológica e arqueológica para a compreensão da História da Terra.

Assim, as grutas e cavernas podem fazer parte do ***Património Espeleológico*** *enquanto subdomínio do* ***Património Geológico****, o qual, para além da representatividade e/ou singularidade das cavidades subterrâneas, da riqueza e diversidade dos espeleotemas, pode incluir a biodiversidade. Além de constituírem o habitat e o registro evolutivo de numerosas espécies de organismos, perenes ou episódicos, as grutas têm sido utilizadas pelo Homem ao longo da sua evolução biológica e cultural/tecnológica como abrigo e como lugar de culto, espaços de fascínio, mistério, cultura dinâmica, ciência e lazer. São territórios de descoberta, de educação e aventura, que ocorrem por todo o mundo particularizando-se com a geodiversidade e com a diversidade de processos geomorfológicos. Alguns exemplos notáveis são a Mammoth Cave National Park, nos EUA que possui 643,7km e é uma das maiores grutas carbonatadas do mundo, A Gruta Kazamura, no Havai, um dos maiores tubos de lava do mundo, com 65,5km; Já em rochas quartzíticas, o Sistema de Cavernas Charles Brewer, na Venezuela, com 17,8km cartografados; e a Gruta Gobholo, nos granitos da Suazilândia.*

Como qualquer outro, o Património Espeleológico necessita de medidas ***de protecção, conservação e usufruto****, na justa medida da sua importância e grau de vulnerabilidade. Para tal, é fundamental um estudo técnico-científico e inventariação detalhada das grutas a nível nacional, desenvolvidos por organismos com responsabilidades para tal e disponibilizado às entidades com responsabilidade no ordenamento e gestão do território, quer junto das comunidades locais, como instrumentos essenciais para a definição de estratégias de geoconservação e valorização.*

As grutas, enquanto territórios de descoberta, são certamente os mais antigos atrativos turísticos, e sem dúvida ***um dos destinos geoturísticos*** *preferidos no mundo. O conceito de* ***Geoturismo*** *foi definido originalmente por Hose (1995; veja-se também Newsome & Dowling, 2010) como a oferta de serviços e equipamentos interpretativos que permitam aos turistas adquirir conhecimentos e compreensão da geologia e da geomorfologia de um lugar (incluindo o seu contributo para o desenvolvimento das Ciências da Terra), para além de um nível de mera apreciação estética. Neste sentido, a gruta de Baumannshöle, na Alemanha, já possuía visitas guiadas em 1648, assim como um plano de conservação e controle do número de visitantes, em 1668 (Erikstad, 2008). Este é um segmento do Turismo de Natureza com grande potencial de afirmação nos mercados internacionais (Neto de Carvalho* et al.*, 2009; Farsani* et al.*, 2011). Na língua portuguesa, as primeiras referências ao Geoturismo deverão reportar-se a Barbosa* et al. *(1999).*

O geoturismo terá os seus ***antecedentes*** *nas cavidades subterrâneas. A gruta de Niaux, nos Pirinéus franceses, constitui-se como um labirinto que se estende por quilómetros. Aqui foram descobertas numerosas pegadas em distintas cavidades, em 1906, 1949 e entre 1970 e 1972, mostrando repetidas visitas de grupos humanos durante o Plistocénico (Pales, 1976). Numa destas cavidades foram encontradas pequenas pegadas, atribuídas a duas crianças, que mostram um padrão retilíneo, distinto e recorrente, indicando que estes jovens estariam criando desenhos e padrões na lama do fundo da gruta, desenvolvendo criações artísticas comparáveis com a arte rupestre mais sofisticada e ritual feita presumivelmente por adultos nas paredes dessa mesma gruta. Estas crianças do Plistocénico divertiam-se assim e brincavam no interior da gruta…*

Poderia dizer-se que naqueles tempos a visita às grutas teria como objetivo a apreciação contemplativa de um mundo subterrâneo estranho à luz solar e, portanto, esotérico. Infelizmente, ainda hoje assim é, na maioria das grutas turísticas. Nos tempos modernos, as cavernas ***turísticas*** *podem ser definidas como cavidades naturais ou artificiais que, tendo passado por um processo de habilitação, se tornam acessíveis a visita pelo público, interessado pelo ambiente subterrâneo, em toda a sua diversidade (Brandão, 2009). Como atrativo turístico, este pode ser um recurso muito importante para as economias regionais, que pode ser exponenciado se aplicadas correctas* ***medidas de geoconservação e de interpretação*** *(Moreira,*

2011). É necessária uma apresentação da caverna e informação/interpretação adequadas aos tipos de visitantes, apostar nas grutas turísticas enquanto ferramentas educativas para as comunidades locais, favorecendo o envolvimento destas na gestão e a participação de um número crescente de espeleólogos e outros investigadores que contribuam para a sua valorização.

Surgem diferentes formas de exploração sustentável de grutas turísticas. Uma delas inclui-se num território de Geodiversidade mais vasta e de Património Geológico de relevância internacional, ao qual se associa uma estrutura de gestão do Património e uma estratégia de desenvolvimento socioeconómico tendo por base a valorização do Património Geológico, que são os ***Geoparques sob os auspícios da UNESCO*** *(Farsani* et al.*, 2011). De acordo com o Estudo sobre Exequibilidade de um Programa UNESCO de Geoparques (2000), a então Divisão das Ciências da Terra da UNESCO, desde o início deste movimento em todo o mundo (Patzak & Eder. 1998), defende que os geoparques "podem tornar-se um importante fator de desenvolvimento económico local. Eles podem gerar emprego e novas estratégias económicas ligadas aos seus temas (de geodiversidade) específicos. O desenvolvimento de novas orientações no turismo e artesanato podem ser favorecidos (geoturismo, geoprodutos)". No Programa "****Património da Humanidade****" da UNESCO, dos 1560 Sítios inscritos na Lista, existentes em 172 países, 15 destes incluem cavernas pelo seu Património Geológico excepcional, como Mammoth Cave ou Škocjan, na Eslovénia.*

Neste número especial da **Tourism and Karst Areas** dedicada aos ***Geoparques e outras abordagens para a gestão territorial e turismo em áreas cársticas****, Cigna e Forti começam por apresentar a importância das grutas enquanto atrativos geoturísticos, de importância fundamental para a história do Geoturismo global e para a economia de muitos países. Os autores mostram ainda que a relevância científica das grutas e a fragilidade dos ambientes cavernícolas requerem medidas de geoconservação específicas. Recomendações para a abertura de grutas turísticas, resultantes de encontros científicos internacionais, são ainda aqui apresentadas. No Brasil, com 17 propostas de Geoparks selecionadas pelo Serviço Geológico do Brasil como as mais promissoras neste momento, Nascimento & Mantesso-Neto analisaram a presença de elementos do patrimônio espeleológico nestas propostas. Ainda na Ásia, Rachmawati & Sunkar estruturam um estudo de mercado baseado nas preferências do público, numa região da ilha de Java (Indonésia). Este tipo de abordagens, em complementaridade aos estudos de geoconservação e valorização já referidos pelos autores anteriores, é fundamental em qualquer projecto sustentável ligado ao aproveitamento turístico de áreas cársicas. No outro lado do mundo, Ulloa & Goicoechea fazem uma síntese do potencial geoturístico da Costa Rica, numa perspectiva nacional de utilização sustentável dos abundantes recursos espeleológicos.*

No Brasil, a priorização do Turismo segue duas abordagens globais que acompanham a tendência internacional: o aumento da diversificação turística focado num incremento do interesse pela natureza; e a preferência (e exigência) por um ambiente bem conservado (Moreira & Bigarella, 2010). ***O Património Geológico*** *brasileiro de referência internacional, vasto e diverso onde se incluem inúmeros outros recursos geoturísticos para além das grutas, tem um potencial enorme enquanto gerador de oportunidades socioeconómicas e de criação de emprego. Os geoparques sob os auspícios da UNESCO e as grutas turísticas que apostam na sua valorização sustentável são oportunidades para as comunidades locais (Neto de Carvalho* et al.*, 2009) que merecem cada vez mais a atenção dos mais diversos setores da sociedade brasileira.*

Jasmine Cardozo Moreira
Carlos Neto de Carvalho
Editores Convidados

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CAVES: THE MOST IMPORTANT GEOTOURISTIC FEATURE IN THE WORLD

CAVERNAS: RECURSOS GEOTURÍSTICOS MAIS IMPORTANTES NO MUNDO

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Abstract

Natural caves started to be opened to tourism over 400 years ago and presently quite all the Countries of the world hosts at least one, but often dozens, of show caves. Some 500 major show caves with over 50.000 visitor/year exist in the world and over 250 million visitors pay yearly a ticket to visit them. If all the activities related to the existence of a show cave (transportation, lodging, etc.) are considered, some 100 million peoples take, directly or indirectly, their income from show caves: these figures may be at least doubled taking into consideration surficial and deep karst within geoparks. It is therefore evident that show caves are presently the most important geotouristic target all over the world and they represent an important economic resource for many of the still developing Countries. But caves have also an exceptional scientific value due to the fact that they represent the best archive for all the Quaternary and allow for extremely accurate paleo-environmental and paleo-climatic reconstructions. Moreover they are truly fragile environments, which may be easily destroyed when the cave is transformed into a touristic object. It is possible to maintain the aesthetic and scientific values of a cave when transforming it into a show cave; but to reach this goal it is important to follow strict rules before, during and after their tourist development. Guidelines aiming to supply a recommendation to be endorsed for the development of show caves were drafted in the last years and received strong recommendations from the UIS Department of Protection and Management at both the 14th International Congress of Speleology held in Kalamos, Greece, in August 2005 and the 15th International Congress of Speleology held in Kerrville, Texas, in July 2009.

Key-Words: Show caves; Geotourism; New materials and frontiers.

Resumo

Cavidades naturais começaram a ser abertas para o turismo mais de 400 anos atrás e atualmente quase todos os países do mundo abrigam pelo menos uma, mas muitas vezes, dezenas de cavernas turísticas. Cerca de 500 grandes cavernas turísticas com mais de 50.000 visitantes/ano existem no mundo e mais de 250 milhões de visitantes anualmente pagam um ingresso para visitá-las. Se todas as atividades relacionadas com a existência de uma caverna turística (transporte, hospedagem etc.) fossem consideradas, os resultados seriam de cerca de 100 milhões de pessoas cuja renda depende, direta ou indiretamente, de cavernas turísticas. Estes valores podem ser pelo menos o dobro, levando em consideração áreas cársticas dentro de geoparques. Portanto, é evidente que as cavernas turísticas são, atualmente, o atrativo geoturístico mais importante em todo o mundo e representam um importante recurso econômico para muitos dos países ainda em desenvolvimento. Mas cavernas têm também um valor científico excepcional, devido ao fato de que eles representam o melhor arquivo para todo o Quaternário e permitem a precisa reconstrução paleoambiental e paleoclimática. Além disso, elas são ambientes verdadeiramente frágeis, que podem ser facilmente destruídos quando a caverna é transformada em um atrativo turístico. É possível manter os valores estéticos e científicos de uma caverna quando esta é transformada em uma caverna turística, mas para alcançar este objetivo, é importante seguir regras e premissas adequadas, antes, durante e após o seu desenvolvimento turístico. Orientações com o objetivo de fornecer uma recomendação a ser aprovada para o desenvolvimento de cavernas turísticas foram elaboradas nos últimos anos e receberam fortes recomendações do Departamento de Proteção e Gestão da União Internacional de Espeleologia (UIS), tanto no 14 º Congresso Internacional de Espeleologia realizada em Kalamos, Grécia, em agosto de 2005 e do 15 º Congresso Internacional de Espeleologia realizada em Kerrville, Texas, em julho de 2009.

Palavras-Chave: *Cavernas turísticas; Geoturismo; Novos materiais e fronteiras.*

1. INTRODUCTION

Our ancestors often visited caves since the far prehistory, but at that time their interest was mainly quite practical: they searched for a shelter, or a burial place or also looking for minerals impossible to be found outside. There is no evidence at all of an early "touristic" interest toward caves, which arose fairly later.

Even if seldom touristic visits of a cave are documented since over 3000 yr BP, natural cavities started to be opened to tourism over 400 years ago and presently quite all the Countries of the world host at least one, but often dozens, of show caves. Actually some 500 major show caves with over 50.000 visitor/year exist in the world and over 250 million visitors pay yearly a ticket to visit them. If all the activities related to the existence of a show cave (transportation, lodging, etc.) are considered, some 100 million peoples take, directly or indirectly, their income from show caves: these figures may be at least doubled taking into consideration surficial and deep karst within geo-parks. Another considerable implement in cave economy comes from religious and health care tourism.

Beside their economic importance show caves are fundamental tools for the protection of peculiar cave environments (e.g. archaeological and paleontological remains, peculiar biocoenosis etc.) and privileged places where to perform research in many different fields.

But caves are extremely fragile environments and transforming them into a touristic object may strongly affect their pristine state. Therefore it is important to follow strict rules before, during and after their tourist development.

After a short outline of the development of cave tourism in the last three thousand years, the present paper is focused on the best way to plan, implement and manage a show cave.

At the end the UIS (International Union of Speleology) Guidelines for the development of show caves are also attached.

2. A SHORT HISTORY OF THE CAVE TOURISM

Caves always attracted the attention of humans since the prehistory, but at that time the interest was mainly quite practical, i.e. to have a shelter, a sanctuary or a burial place therefore these human activities cannot be considered touristic.

The very first documented tourist visit of a cave took place in Mesopotamia where, not far from its source, the river Tigris flows through a natural rock tunnel. Tiglath Pileser, King of Assyria had his portrait carved at the entrance together with an inscription in 3100 BP (Optiz D., 1929). A subsequent Assyrian King , Shalmaneser, in 853 or 852 BC had his men exploring three caves near by the stream cave. The event is also reproduced in a bronze band of the gate of his royal palace in Balawat, now exhibited in the British Museum (Fig. 1). Anyway the best monument of an Assyrian king visiting a cave (Fig. 2) is just at the entrance of Shapur Cave not far from Persepolis in Iran (Forti, 1993).

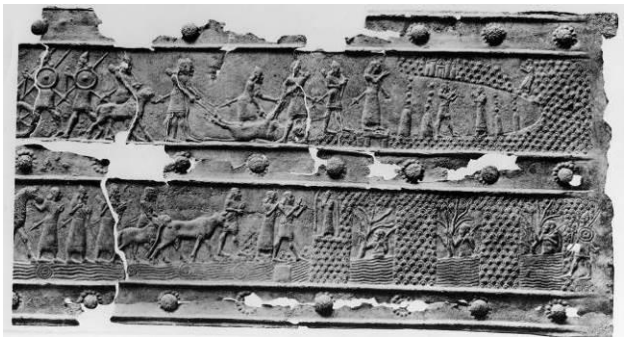


Fig. 1 – The bronze band of the gate of the royal palace in Balawat, now exhibited in the British Museum in which the visit to a cave (note the dripping over stalagmites) is represented

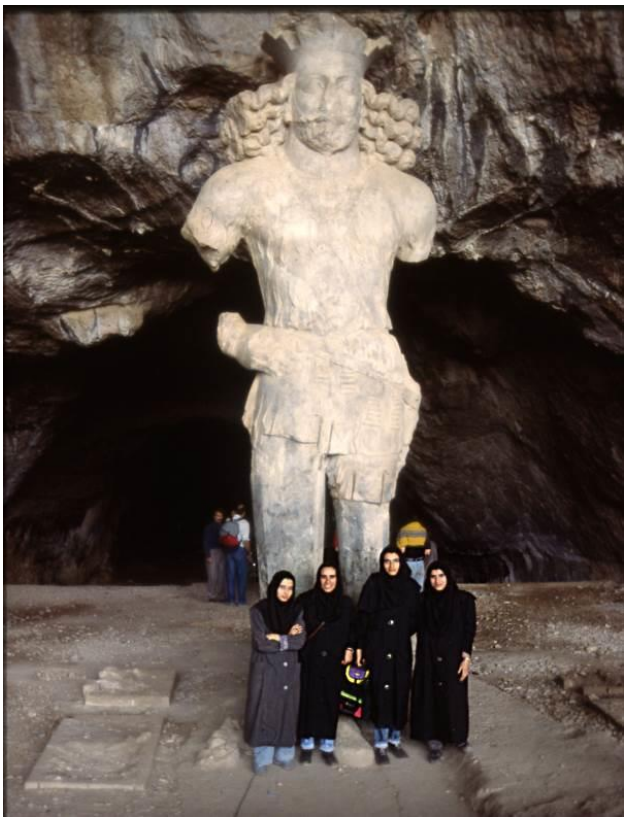


Fig. 2 – The entrance of Shapur Cave not far from Persepolis (Iran) in which a giant statue of the Assyrian king was carved

Later, about 2000 year ago Plinius (77), a Roman writer, described the "Dog's Cave" near Naples, Italy, being visited by several peoples because of the peculiar release of carbon dioxide close to the floor, which killed small animals (hence its name) while standing people was not affected (Fig. 3).

Fig. 3 – The "Dog cave" in a copper engraving of the XVII Century

In the same period, several hot caves were transformed into *Thermal baths*, like the Sciacca cave in Sicily (Fig. 4), moreover in many country of the world, caves were visited for religious purposes. Later, until the Middle Age, caves were often associated with the devil or hell in general, and people avoided getting into for fear.

Even if cave tourism started with King Tiglath Pileser in 1100 BC and a few other visits to caves are variously reported since that time up to the X Century, only a few centuries later a true cave tourisms started to develop.

In Postojna Cave (Slovenia), on the walls of the so called "Passage of the Ancient Names" on account of the old signatures left by occasional visitors, the most ancient ones date back to 1213, 1323 and 1393 according some authors of the 19th Century (Fig. 5). Around 1920 such signatures were scarcely visible on account of the seepage; presently the oldest signature, which can be read easily, dates 1412 and from the 16th Century onward they became rather abundant. This means that from the 16th Century many persons attracted by the underground world visited the cave more frequently.

Anyway, if a show cave is defined as a cave where a fee is paid in order to have access and visit it, then the oldest one is the Vilenica Cave in Slovenia, where an entrance fee was paid since the beginning of 17thCentury. The cave is close to the village of Sežana, just a few kilometers from the Italian border. At the beginning of the 17thCentury the Count of Petač began to invite the people of Trieste and some noble friends to visit the cave. On certain holidays, at a hundred meters from the entrance, an area for the orchestra and a dance floor were set up and the entire dripstone passage was illuminated with torches and candles. Probably already in 1633 the Count Benvenut Petač charged the admission to visit the cave. Part of the money was donated to the local church of Lokev where masses were dedicated to "greater safety" of the people in the cave (Puc, 2000)

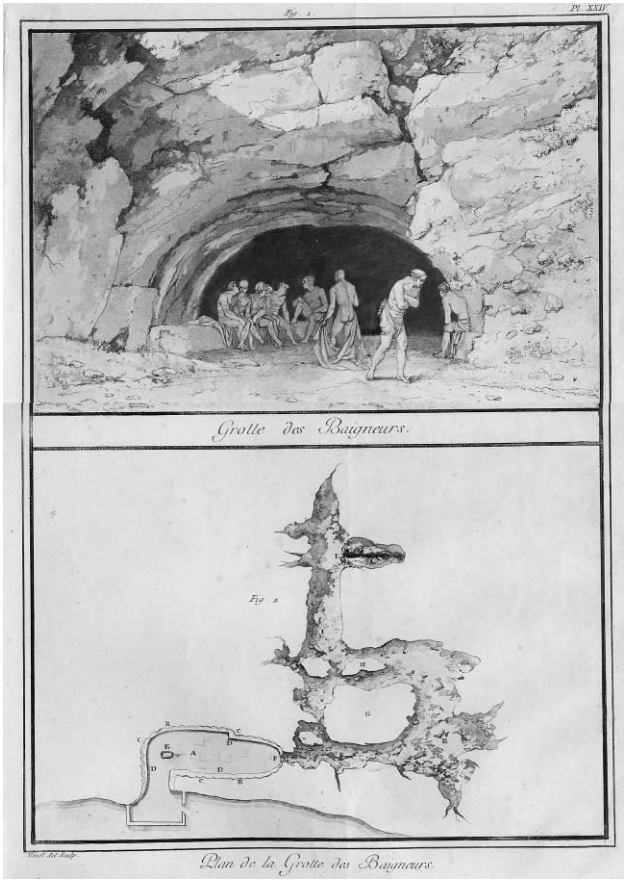


Fig. 4 – The Sciacca Thermal Bath in a copper engraving of the XVIII Century

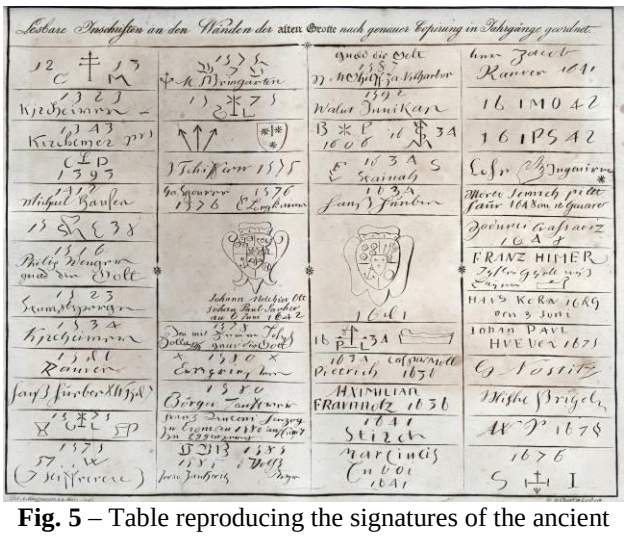


Fig. 5 – Table reproducing the signatures of the ancient visitors of Postojna cave from Hohenwart (1830)

In reality, only during the 18th Century cave tourism became popular in Europe: several caves become world renown and visited by hundreds persons/year and therefore a tourist organization grew around them: most of these early show caves are still important nowadays being visited by several hundred thousand visitors per year.

The Cave of Antiparos in Cyclades, Greece, became a great attraction as results by the many prints reproducing the cave (Fig. 6). Also at the same time in the Ural Mountains some 100 km SE of Perm, the Kungur Cave, a gypsum cave filled by ice speleothems, was normally inserted in the "Big Tour of Russia" by rich and noble persons (Fig. 7). On 13th August 1772 the scientist Joseph Banks landed on Staffa Island and in November he wrote in the "Scots Magazine"*: ...there is a cave in this island which the natives call the Cave of Fingal*. Since that time this cave became one of the best-known caves of the world, inspiring poets and musicians. Its fame was so great that it became the natural cave most represented in paintings and engravings all over the world (Fig. 8).

At the end of the 18th century cave tourism starts developing also outside Europe: the Cango Cave (Oudtshoorn, South Africa) was discovered around 1780 and the first recorded visit was made in 1806 (Craven, 1987; Faure 1824). A few years later a farmer bought the land around the cave with the exclusion of the entrance. The Governor included into the deeds the condition that the farmer was obliged to leave perfectly free and undisturbed the entrance of the cave, to be considered as public property, with a road in his land to reach the cave. This document has a historical importance because it is probably the first attempt in the world to legislate for cave protection (Craven 1999; 2004).

The Mammoth Cave (Kentucky) was already known in prehistory and in the late 18th Century the cave was mined for saltpeter to make gunpowder. Officially opened to tourism in 1816, it has been shown as a tourist attraction some tens of years before (Gurnee, 1990;1993).

The success of cave tourism was also testified by the fact that at the end of the XVIII and at the beginning of the XIX Century rather popular caving books became the tourist guides of the most world renown caves (Lang 1806, Hohenwart 1830, Bullit 1845) (Fig. 8).

At the beginning of the XX Century hundreds of show caves already existed, even if they were mainly located in Europe, where they were each year visited by a constantly growing number of tourists.

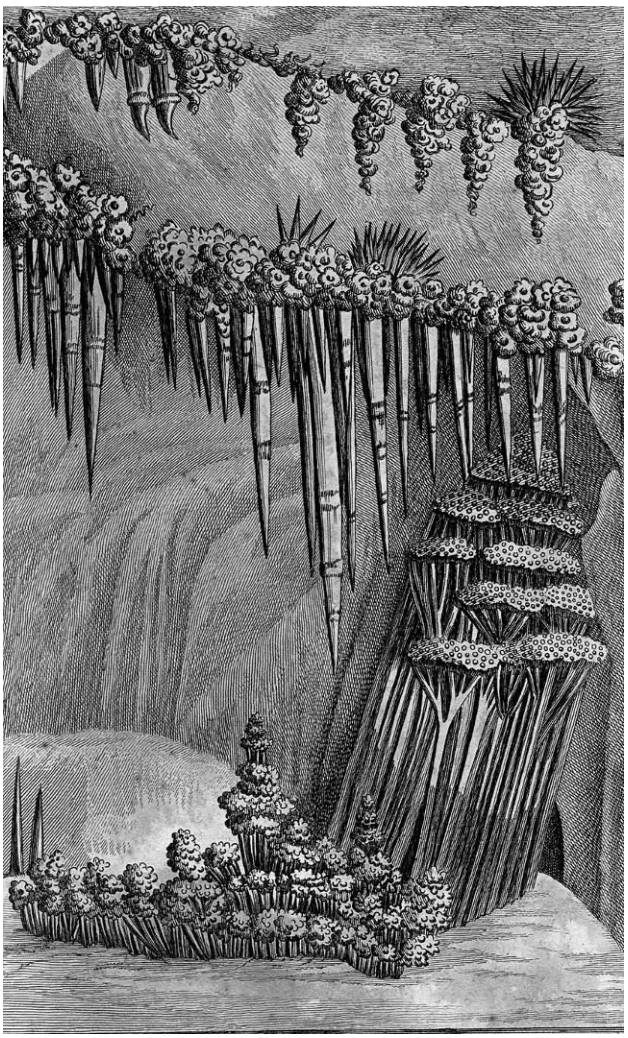


Fig. 6 – Speleothems in the main chamber of Antiparos Cave in an engraving of the XVIII Century

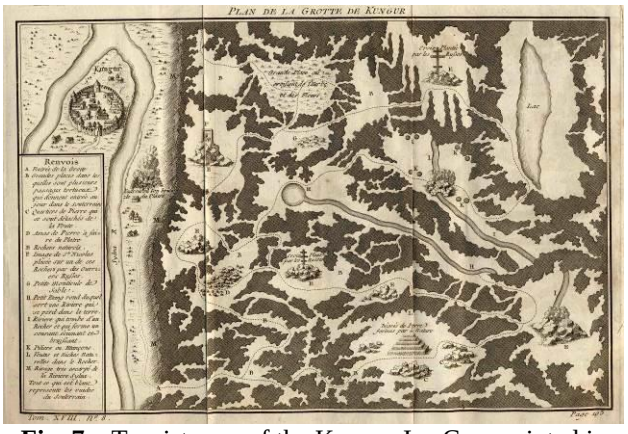
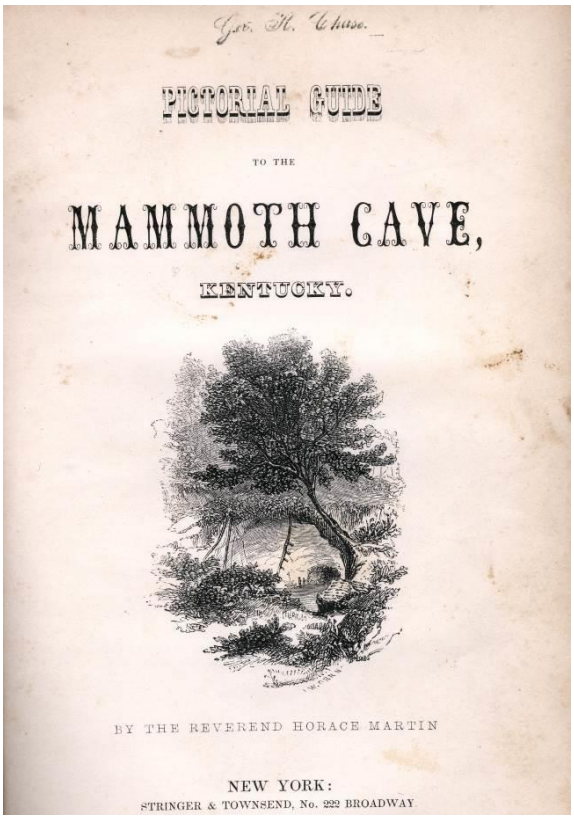


Fig. 7 – Tourist map of the Kungur Ice Cave printed in the XVIII century

But the real explosion of the cave tourism started after the Second World War when the possibility of travel became cheaper and easier even in the middle class and the so-called mass-tourism became a matter of fact.

At the end of XX Century and at the beginning of the third millennium the importance of

cave tourism grew rapidly mainly in the still developing Countries, where hundreds of new show caves are developed each year: presently practically each Country in the world has at least one, but often dozens of show caves.


Geo. H. Chase.

PICTORIAL GUIDE

TO THE

MAMMOTH CAVE,

KENTUCKY.

BY THE REVEREND HORACE MARTIN

NEW YORK:
STRINGER & TOWNSEND, No. 222 BROADWAY.

Fig. 8 – Frontispiece of an tourist book (1851) on Mammoth cave, Kentucky

It is rather impossible to exactly define the cumulative economic budget of the whole show caves of the world due to lack of available and reliable data of their visitors and even fewer data on the business automatically induced by the presence of a tourist cave (transportation, lodging, feeding, etc). A rough evaluation was made in the past (Cigna & Burri 2000, Cigna e Forti 2004, Cigna et al. 2000). On that basis it is realistic to state that today several thousand show caves are active in the world and over 500 of them are visited by more than 50.000 visitor/year. As a consequence over 250 million visitors pay yearly an average ticket of 5 U.S. $ to visit them, scoring a total of 1.25 billion/year. But much higher is the budget of all the activities strictly related to the existence of a show cave (transportation, lodging, feeding, etc.): if they are taken into account, the result is that some 100 million peoples take, directly or indirectly, their income from show caves.

3. FROM SHOW CAVES TO KARST-GEOPARKS

For centuries caves were the single geologic objects interested by huge touristic flow. But in the last tens of years the idea of enlarging the content of a touristic attraction in order to take into account any possible aspects of the area considered took gradually more attention. This change of view was also due to economical reasons leading to a better integration among the different tourist targets.

Therefore in the last 20-30 years geoparks started to be implemented all over the world, and several of them include karst features and/or show caves. The "Geo-mining park of Sardinia" (Pani, 2005) with the world renown Santa Barbara Cave (Fig. 9) and the "Geopark of Hong Kong" with huge basaltic sea caves (Fig. 10) are typical examples of geoparks hosting important show caves inside them.

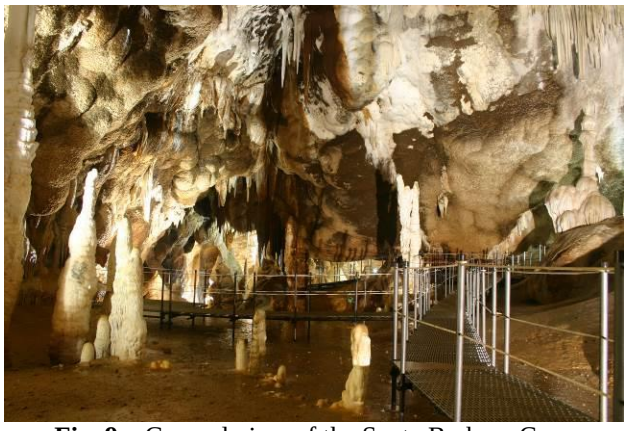


Fig. 9 – General view of the Santa Barbara Cave (Sardinia, Italy)

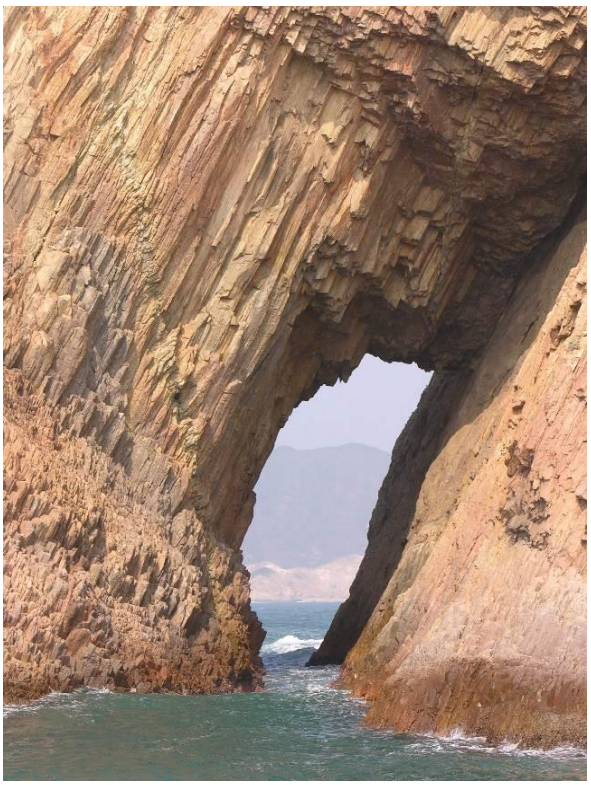


Fig. 10 – One of the largest basalt caves of Hong Kong

In the third millennium geopark tourism grew in exponential manner and nowadays several millions of tourists visit at least one geopark each year.

Taking into consideration that at least 1/3 of the existing geopark host karst features, the touristic budget related not only to show caves but also to karst geoparks should be probably doubled in respect to that restricted to show caves.

4. OTHER REASONS MAKING CAVES A TARGET FOR HUMAN FREQUENTATION

Presently two other human uses of caves generate huge touristic flows: the first related to religion and the second to health care.

Probably the first time in which men started to consider caves as a peculiar place was only some tens of thousands years ago (30,000-10,000 years BP) (Shaw, 1992), and the first reason to go caving was to perform religious rites, as testified by scores of caves spread in France, Italy, Spain etc. (Fig. 11). Anyway a deep interest into caves was maintained in all the different religions developed later, as testified by sacred caves spread all over the world. Among them the Induist and Buddhist caves from India Nepal, Myanmar etc. (Fig. 12) and the Maya caves from Mexico (Fig. 13) are here worth of mention.

Fig. 11 – Paintings in the Cervi Cave (Puglia, Italy)

Even today the three largest monotheistic religions (Jewish, Christian and Muslim) are deeply involved in caves and some of these sacred caves are visited by millions of pilgrims every year (Fig. 14).

Thus it is reasonable to evaluate that presently the cumulative budget of the sacred tourism in caves may correspond to 15-20% of that of the normal show caves and the total employed peoples should be increased by the same amount.

The second activity for economic importance, actually performed in caves is that related to health care: in the antiquity thermal caves have been used as *Thermae* (Verde, 2000), but it is was from the first half of the XX century onwards that thermal caves started to become important from the economic point of view. In the second half of the last century the cold caves also started to be widely utilized for speleotherapy, mainly in the Countries of Eastern Europe (Sandri, 1997). Actually speleotherapy is normally used against several diseases like allergenic asthma, arthrosis etc. (AA.VV., 1997).

Fig. 12 – Thousands of Golden Buddha fill the Pindaya cave in Myanmar

Fig. 13 – Votive potteries in Lol Tun cave (Mexico)

The number of Countries, in which health care in caves is active, is still scarce, being practically restricted to Europe. Thus the number of persons actually involved in such a kind of health-tourism are of course much less than those involved in the sacred or normal cave tourism: in fact they maybe a few millions yearly all over the world; anyway their number is growing fast and this activity stats spreading outside Europe.

But even if the health care in cave represents no more than 3-5% of the total cave tourism, its economic importance is by far higher due to its high costs. Thus the budget of the Spas and speleotherapic caves may be evaluated up to 10-15% of that of the normal show caves, while in this

case the employed persons should be considered no more than 2-3% of the total.

Fig. 14 – A ivory reproduction of the Amarnat cave in the Himalaya: this cavity is a sacred shrine to the Hindu' because just there onside the God Shiva explained to his wife Parvati the problems related to immortality and metempsychosis

In conclusion the two types of peculiar cave tourism, just outlined, contribute up to 35-40% to the total budget of the show caves of the world (see Tab. 1).

Tab. 1 – Different worldwide uses of show caves

Use of show caves	Visitors (%)	Economy (%)
Tourism	77-83	40-50
Religious	15-20	15-20
Health	2-3	35-40
Total	**100**	**100**

5. THE SCIENTIFIC IMPORTANCE OF SHOW CAVES

At the end of the second millennium it was already clear that caves are perhaps the best place of the world to perform research in many different scientific fields (Forti, 2002; 2009). This is because caves are low to very low energy sites, with scarce "noise" coming into from the outside, thus allowing extremely accurate experiments impossible to perform outside. Moreover, cave environment acts as perfect accumulation traps over extremely long span of time (Fig. 15): most of the knowledge we actually have about our ancestors will never be available to us without caves. Their physical and chemical deposits proved to record practically any event occurring in the cave area during their growth, thus allowing accurate palaeo-climatological, palaeo-environmental and palaeo-seismical reconstructions (Fig. 16).

Fig. 15 – The Men of Altamura is the best preserved old skeleton in Europe dating back to over 100.000 yr BP

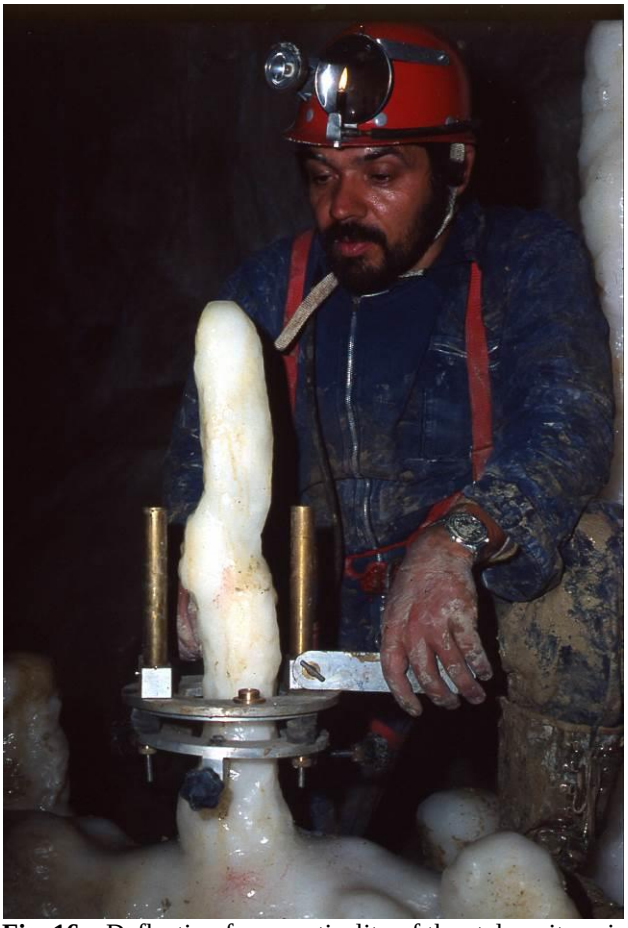


Fig. 16 – Deflection form verticality of the stalagmite axis may record strong earthquakes of the past

All these characteristics make caves perfect experimental laboratory in fields like physics, biology, geology, engineering, medicine etc.

Even if, theoretically, all natural cavities are suitable for research, in practice only few if them may be transformed into laboratories: in fact scientists require that a cave meets a few of common characteristics, which can be summarized as:

- To be in a condition as pristine as possible
- To be easily accessible
- To be safe
- To have power supply

The request of the scientists perfectly fit the common characteristics of any show cave, which are always the best site where perform any kind of research**:** this is the reason why several experimental laboratories have been located just within them.

Anyway, until now, sometimes the show cave managers may have scarce interest or, even worse, they totally disagree in having in their cave a scientific laboratory because they consider the research only as a waste of their money and a hinder to the normal tourist activity.

Of course they are right when saying that scientific research need space, time and money, but they do not consider the fact that scientists may greatly help the management of a show cave in two fundamental fields: the conservation of the cave equilibrium and the increase of its touristic appeal.

It is well known that tourism may induce negative changes in the cave environment: dust, lint (Fig. 17) and lampenflora degrading the cave formations and cave heating being the most frequent ones. It is evident that the presence of a laboratory, where cave parameters are constantly monitored, may help to prevent these undesirable consequences of the tourist activity.

Even more important is the second effect of the presence of scientific activities (Fig. 18) within a show cave: in fact researchers may easily supply suggestions and materials for the environmental education of the visitors, satisfying also their request of clear answers about scientific questions related to the show cave itself, or karst and caves in general. Hopefully scientists may also train the tourist guides in order to improve their knowledge and ability to explain the cave to the visitors.

Fig. 17 – Dust and lint cemented inside a stalagmite close to the tourist paths inside the Frasassi show cave (Italy)

Fig. 18 – Scientists performing research inside a cave

6. THE WAYS TO PLAN, IMPLEMENT, AND MANAGE A SHOW CAVE

The fundamental criteria to be adopted are the protection of the cave environment, the safety of the

visitors and a correct profit from the cave management. All such criteria must be taken into account otherwise the development would have very negative effects. As Summers (2012) stated, the worst fate that can befall a cave is for it to be developed as a show cave, then for it to fail as a business entity, and be closed. The cave becomes very vulnerable to misuse. Therefore the show cave must not be profitable for the short term, but perpetually.

The view that a show cave is a golden goose laying golden eggs implies that the goose must be properly fed and protected. This means that is necessary to having all of the knowledge and awareness regarding the physical needs of the cave to ensure that its environment is preserved and conserved.

Hundreds of wild caves are yearly transformed into show caves sometimes resulting only in a waste of money and wilderness. To avoid this possibility, before to start the development a new show cave, the following questions must be positively answered:

1. Is there a real request of cave tourism in the region?
2. The cave and the karst environment may host the supposed tourism without major problems?

In fact if even only one of this two questions has a negative answer, it is practically sure that the show cave will be unsuccessful and in few years it will be closed with noticeable loss of money and its pristine state.

Thus, in order to be sure that a wild cave may become a good show cave it is necessary to perform a multidisciplinary study to highlight not only all the cave characteristics but also those of the country in which the cave is developed and the social and economic problems which will arise during and after its transformation into a tourist object.

Therefore a good Environmental Impact Assessment for the Development and the Management of a Show Cave must be subdivided in three different steps, where specific studies and analyses must be performed (Fig. 19):

1. Before starting
2. During Transformation
3. During management

Due to the extreme differences existing from cave to cave it is impossible to list all the studies to be performed when a new show cave will be developed. In fact they will change time-by-time depending on the specific characteristics of the cave itself and/or of its environment.

Anyway some of the most important points related to the three steps of the Environmental Impact Assessment of a Tourist cave will be shortly outlined.

6.1. BEFORE STARTING

In this period all the positive possible points of interest for tourists (scenic points, speleothems and cave minerals, biologic inhabitants, archaeological remains etc.) should be described. In the same time also all the negative points (hazards, like boulders sliding or breakdown, flooding, or other problems limiting or avoiding the tourist fruition of the cavity, like cave climate and microclimate) must be clearly defined and studied. But the investigations must be extended also outside the cavity, taking into consideration not only the cave area, its problem of access and infrastructures etc., but also the whole region, analysing the already existing touristic flows and the possibility to drive tourists in a fast and easy manner to the show cave.

In any case the most important factor to decide if the show cave implementation is economically sustainable is the *visitor carrying capacity*, which define the maximum number of tourists that may enter the cave in a given time interval.

As it is well known, caves may be classified into widely different energetic categories. Heaton (1986) proposed three categories: high-energy, moderate-energy, and low-energy levels. In order to avoid any permanent change in the environmental equilibrium it is necessary to avoid the introduction of energy beyond the intrinsic cave capacity. Such a constraint implies a limitation of both electric power supply for the cave lighting and the visitors' flow, i.e. the visitors carrying capacity.

This limit may be evaluated according different methods and specialists only are entrusted to carry out the whole procedure according the best choice to be applied to each local situation (e.g.: Mangin & d'Hults, 1996; Lobo et al., 2013).

6.2. During Transformation

If the first step gave a positive support to the tourist implementation of the cave then the tourist project must be defined in detail on the basis of the data collected during the previous step.

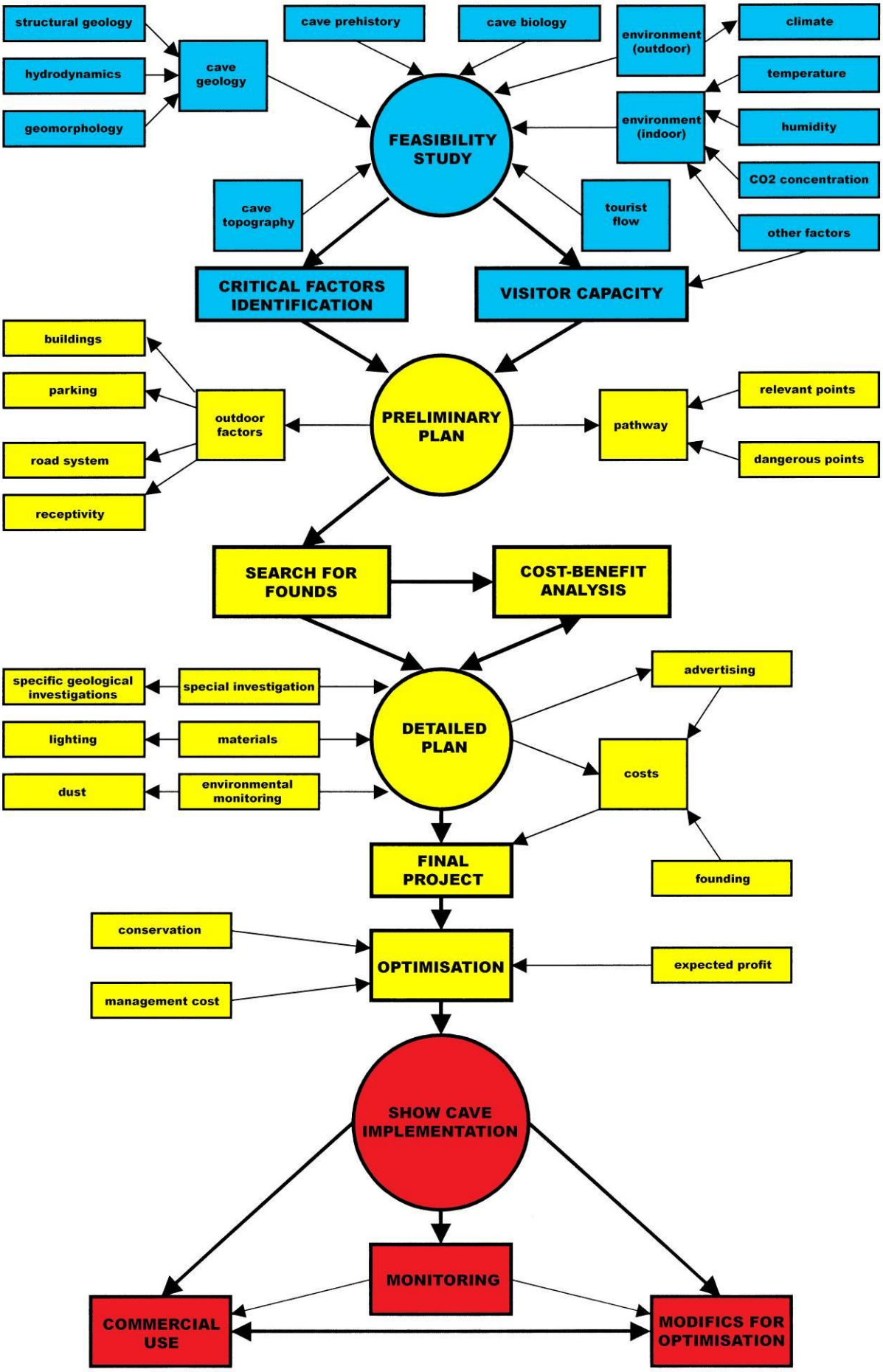


Fig. 19 – Flow chard for a correct planning implementing and managing a show cave

Of course the structure of the tourist pathways should be consistent with the visitor carrying capacity and must be designed to a safe approach of peoples as close as possible to the already defined scenic points, but avoiding the possibility to damage them.

Moreover the siting of the above ground facilities must be well planned by avoiding that these features be built over the cave itself, or relevant parts of it. In particular any intervention, such as the watertight surface of a parking area, must be avoided. Any change in the rainwater seepage into a cave, as well any change to the land above the cave, may have a negative influence on the cave and the growth of its formations.

Later, particular care has to be addressed to the techniques and materials utilized to transform the wild cave into a show cave in order to optimize costs and scenic effects while keeping the loss of its pristine state to a minimum. Recently an astonishing improvement and renovation occurred in the materials to be used in a show cave implementation (Cigna, 2013). Here are shortly described only the most important ones, those related to pathways and lighting.

6.2.1. Pathways

In the last tens of years new material were develop incredible advantages with respect to the past. In particular the pathways can be built entirely with plastics.

The material used for the pathways, including the handrails and kickplates, are manufactured by a pultrusion process. It is a continuous molding process whereby reinforcing fibers are saturated with a liquid polymer resin and then carefully formed and pulled through a heated die to form a part. Pultrusion results in straight constant cross section parts of virtually any shippable length, where continuous fiberglass roving and mat is covered by resin. The resin used for handrails is, isophtalic polyester and the resin used for other components is vinyl ester. Both have a low flame spread rating of 25 or less. These materials are delivered in various colors, avoiding, e.g., the brightness of the stainless steel that is not aesthetically agreeable.

These components have about one-third the weight of steel allowing easy an installation using standard hand saws. Stainless steel bolts connect the different parts. Such pathways may be easily repaired or modified to adapt to new layout, if necessary. Since the mechanical properties of this materials are very close to steel's properties it is evident the advantage because also long sections can be easily transported inside a cave, while the different parts can be easily worked out with simple instruments.

The design of fiberglass pathways needs a detailed survey of the strip where the pathway itself will be installed, because each element can be prepared in advance according the design. During the assembly of the pathway the legs require only small adjustment that can be easily obtained with sliding feet.

6.2.2. Lighting

Nowadays very efficient light sources have been developed (see Tab. 2). The most useful in caves are the LEDs and the cold cathode lamps (CCL). Both are characterized by a very long life of 50,000 hours and longer. The LEDs cost from 20% to 100% more than CCLs for the same results.

Tab. 2 – Indicative comparison of the overall luminous efficiency per input power for different lamps (lm/W).

Lamp	**lm/W**
Incandescent (IL)	15
Light emitting diodes (LED)	45
Cold Cathode Lamps (CCL)	67

In Table 2 a comparison among the overall luminous efficiency per input power (as lumen/watt) for incandescent lamps (ILs), LEDs and CCLs is reported.

The advantage of the new light sources is evident both for the cost of lighting and the long life of the lamps. But these new sources have specific qualities of their own: LEDs are point sources while CCLs are linear. LEDs may be chosen with different temperature color, i.e. warm (with a red component) or cold (more white). CCLs may be produced with a negligible contribution of their emission spectrum in the regions (around 430-490 nm and 640-900 nm), which mostly contribute to the chlorophillian process. In this way the proliferation of lampenflora is reduced.

The emergency lighting can be obtained at a very low cost with the "rope light" i.e. a flexible plastic polymer rope with lights inside that can be cut at a convenient length and placed along the pathways (Fig. 20). In particular such emergency lights can be divided into two sections distributed alternatively and connected to two different power lines in order that, in case of a failure of one section, there will always be another one in operation.

Such a kind of lighting can also supply enough light to the pathways in normal conditions, and special scenic features only, must have additional light sources.

The power supply must comply with both the country rules, which at present are in general rather severe, and the aesthetic requirements. The plastic pathways may host below the platform and along the legs, pipes with the cables of the power supply (Fig. 21). The cable network may be somewhat more complex than in the past because in general only the parts of the cave occupied by visitors should be switched on. The power supply of the emergency light should be split into at least two independent sections as reported above.

Fig. 20 – The emergency lights placed along the edge of the pathway in the Grutas de Bustamante, Mexico

Fig. 21 – The pathway in the Grutas de Bustamante, Mexico, with visitors. The cables of lighting and monitoring are placed under the walkway

6.3. During management

Surely, the "health" care of a show cave during its tourist exploitation is the most important of the three steps, but still now is normally the neglected one by cave managers. This because they wrongly think that a well-planned show cave will experience non-problem and they do not want to "waste money" in activities they consider not connected to the direct cave management. As already outlined in a previous paragraph, the tourism may affect the cave environment in a strongly negative manner both in the short and long period of operation.

Therefore it is really a necessity to control constantly at least the most sensitive cave parameters in order to correct immediately the cave management as soon as the very first bad effects could appear, avoiding the possibility to seriously damage the show cave itself

It is evident that the presence instruments constantly monitoring cave parameters, may help to prevent such undesirable consequences. But any data collection might be of little or no use at all in the absence of persons who have the capacity to take advantage of the data themselves. Probably a good Scientific Committee abreast of the management is the most important tool to assure a good development of a show cave. In any case the members of such a committee must obviously have not only a deep competence in their specific fields of interest but also a good knowledge of the cave environment.

In the past a complete network to supply environmental data to a central computer was considered the best solution to be achieved. But it was experienced that such a network might be convenient for larger caves only. The main problems being a relatively high cost (installation and maintenance) and the danger of damages due to lightning, which may discharge high tension peaks on the line connecting the sensors with the main computer.

A less expensive solution, which is also more robust, is obtained with a number of stations whose data are download, e.g. once a month, and the elaboration is carried out in a computer outside the cave without any hardware connection.

Recently, in addition to the usual parameters (temperature, relative humidity, etc.) radon became a relevant issue due to the regulation in some countries requiring a monitoring of its concentration in air on a yearly basis. The scope is the evaluation of the yearly average dose to cave guides to be kept below a given value, otherwise this personnel would be classified as professionally exposed and implying a number of constraints for the cave managers (Cigna, 2005).

The most suitable detector is the etched track detector because it is unaffected by humidity, may be kept to record the average concentration up to one

year and its cost is very low. Other detectors do not comply with such characteristics and, in general, should be avoided.

Finally to improve visitors' safety, a special network enabling a guide to talk with the outside office from any point of the cave would be strongly advisable.

7. FINAL REMARKS

Caves were the first and, for a long period, the single geologic item for tourism. In the last few tens of years, with the creation of "Geo-Parks", new geomorphological items started to become touristic targets. Anyway show caves are still now by far the most important geologic tourist attraction from the economic point of view and, in the last 20 years, their interest grew very rapidly and actually show caves and karst tourism supply, directly or indirectly, the income for over 100 million peoples, many of them living in the still developing Countries.

Often show caves are the best or even the single way to protect delicate speleothems and rare minerals, to avoid spoliation of archaeological and/or paleontological deposits, and to protect rare biocoenosis.

Thanks to their facilities, show caves may result a powerful tool for scientific research and environmental protection, which in turn may enhance the touristic appeal of the show cave itself.

Therefore the transformation of a wild cave into a show cave should be regarded, at least in theory, a good thing for caves and karst in general. But it must be clear that, if not well planned and implemented, such a transformation will result the most efficient and the fastest method to destroy a wild cave and its treasures.

Planning, implementing and managing a show cave is very complex and needs interdisciplinary studies during the whole process, which can be performed only by a specific "scientific committee", which should always be present in any show cave of the world.

The International Union of Speleology (UIS) is aware of the fundamental importance of a correct process to open a new show cave, thus worked hardly in order to produce a generally accepted guidelines aiming to supply a recommendation to be endorsed for the development of show caves.

The UIS Management Guidelines for Show Caves (see Annex) are very useful recommendations, if not a list of the least requirements, for a good development and management of a show cave. But such guidelines do not include the principle that it is imperative to keep oneself always up-to-date with the advancement of technology.

The UIS Guidelines are the result of wide cooperation between the International Show Caves Association (ISCA), the Union Internationale de Spéléologie (UIS) and the International Union for Conservation of Nature and Natural Resources (IUCN). The intention was to create commonly accepted guidelines that all show cave managers can work toward, taking into account both the protection of the environment and socio-economical constraints. Many recommendations and suggestions have been received in the course of nearly twenty years, and therefore the document reported here can be considered as the result of an active cooperation among many specialists involved in this matter. At present an agreement among such interested organizations was found aiming to rewrite a new text to assure anyway the best possible protection of the cave environment.

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ANNEX

UIS Management Guidelines for Show Caves

Those guidelines received strong recommendations from the UIS Department of Protection and Management at both the 14th International Congress of Speleology held in Kalamos, Greece, in August 2005 and the 15th International Congress of Speleology held in Kerrville, Texas, in July 2009. Such guidelines are here reported.

1 DEVELOPMENT OF A WILD CAVE INTO A SHOW CAVE

The development of a show cave can be seen as a positive financial benefit to not only itself, but also the area surrounding the cave. The pursuit of these anticipated benefits can sometimes cause pressure to be applied to hasten the development of the cave.

Before a proposal to develop a wild cave into a show cave becomes a physical project, it is necessary to carry out a careful and detailed study to evaluate the benefits and risks, by taking into account all pertinent factors such as the access, the synergy and possible conflict with other tourism related activities in the surrounding area, the availability of funds and many other related factors. The conversion should only take place if the results of the studies are positive. A wild cave that is developed into a show cave, and is subsequently abandoned, will inevitably become unprotected and be subject to vandalism in a very short time. A well managed show cave assures the protection of the cave itself, is a source of income for the local economy and also may contribute to a number of scientific researches.

A careful study of the suitability of the cave for development, taking into account all factors influencing it, must be carried out, and must be carefully evaluated, before physical development work commences.

2 ACCESS AND PATHWAYS WITHIN THE CAVE

In many caves it has been found to be desirable to provide an easier access into the cave for visitors through a tunnel, or a new entrance, excavated into the cave. Such an artificial entrance could change the air circulation in the cave causing a disruption of the ecosystem. To avoid this, an air lock should be installed in any new entrance into a cave. On the other hand it must be mentioned that in some very exceptional cases a change in the air circulation could revitalize the growth of formations. A decision not to install an air lock must be only taken after a special study.

2-1 Any new access into a cave must be fitted with an efficient air lock system, such as a double set of doors, to avoid creating changes in the air circulation within the cave.

Caves are natural databases, wherein an incredible amount of information about the characteristics of the environment, and the climate of the cave, are stored. Therefore any intervention in the cave must be carried out with great care to avoid the destruction of these natural databases.

2-2 Any development work carried out inside the cave should avoid disturbing the structure, the deposits and the formations of the cave, as much as possible.

When a wild cave is developed into a show cave, pathways and other features must be installed. This invariably requires materials to be brought into the cave. These materials should have the least possible impact on both the aesthetics of the cave and its underground environment. Concrete is generally the closest substance to the rock that the cave is formed in, but once concrete is cast it is extremely expensive and difficult to modify or decommission. Stainless steel has the distinct advantage that it lasts for a long time and requires little, to no, maintenance but it is expensive and requires special techniques to assemble and install. Some recently developed plastic materials have the advantage of a very long life, are easy to install and are relatively easy to modify.

2-3 Only materials that are compatible with the cave, and have the least impact on the cave, should be used in a cave. Cement, concrete, stainless steel and environmentally friendly plastics are examples of such materials.

The environment of a cave is usually isolated from the outside and therefore the introduction of energy from the outside will change the equilibrium balance of the cave. Such changes can be caused by the release of heat from the lighting system and the visitors and also by the decay of organic material brought into the cave, which introduces other substances into the food chain of the cave ecosystem. In ice caves, the environmental characteristics are compatible with wood, which is frequently used for the construction of pathways, as it is not slippery.

2-4 Organic material, such as wood, should never be used in a cave unless it is an ice cave where, if necessary, it can be used for pathways.

3 LIGHTING

The energy balance of a cave should not be modified beyond its natural variations. Electric lighting releases both light and heat inside the cave. Therefore high efficiency lamps are preferred. Discharge lamps are efficient, as most of the energy is transformed into light, but only cold cathode lamps can be frequently switched on and off without inconvenience. Light-emitting diode (LED) lighting is also very promising. As far as possible, the electric network of a cave should be divided into zones to enable only the parts that visitors are in to be lit. Where possible a non-interruptible power supply should be provided to avoid problems for the visitors in the event of a failure of an external power supply. Local code requirements may be applicable and these may permit battery lamps or a network of LEDs or similar devices.

3-1 Electric lighting should be provided in safe, well-balanced networks. The power supply should preferably be non-interruptible. Adequate emergency lighting should be available in the event of a power outage.

Lampenflora is a fairly common consequence of the introduction of an artificial light supply into a cave. Many kinds of algae, and other superior plants, may develop as a result of the introduction of artificial light. An important method to avoid the growth of green plant life is to use lamps that do not release a light spectrum that can be absorbed by chlorophyll.

3-2 Lighting should have an emission spectrum with the lowest contribution to the absorption spectrum of chlorophyll (around 440 nm and around 650 nm) to minimize lampenflora.

Another way to prevent the growth of lampenflora is the reduction of the energy reaching any surface where the plants may live. The safe distance between the lamp and the cave surface depends on the intensity of the lamp. As a rough indication, a distance of one meter should be safe. Special care should also be paid to avoid heating the formations and any rock paintings that may exist.

3-3 Lighting sources should be installed at a distance from any component of the cave to prevent the growth of lampenflora and damaging the formations and any rock paintings.

The lighting system should be installed in such a way that only the portions of the cave occupied by visitors are switched on, leaving the lighting in the portions of the cave that are not occupied switched off. This is important from the aspects of reducing the heating of the cave environment and preventing the growth of lampenflora, as well as decreasing the amount of energy required and its financial cost.

3-4 Lighting should be installed to illuminate only the portions of the cave that are occupied by visitors.

4 FREQUENCY OF VISITS AND NUMBER OF VISITORS

The energy balance of a cave environment can be modified by the release of heat by visitors. A human being, moving in a cave, releases about 150 watts – approximately the same as a good incandescent lamp. Consequently, there is also a limit on the number of visitors that can be brought into a cave without causing an irreversible effect on the climate of the cave.

4-1 A cave visitor capacity, per a defined time period, should be determined and this capacity should not be exceeded. Visitor capacity is defined as the number of visitors to a given cave over a given time period, which does not permanently change the environmental parameters beyond their natural fluctuation range. A continuous tour, utilizing an entrance and another exit, can reduce the time that visitors spend in a cave, compared to the use of a single entrance/exit.

In addition to the normal tours for visitors, many show caves have special activities, sometimes called "adventure tours", where visitors are provided with speleological equipment for use in wild sections of the cave. If such a practice is not properly planned, it may cause serious damage to the cave.

4-2 When visits to wild parts of a cave are arranged, they must be carefully planned. In addition to providing the participants with the necessary speleological safety equipment, the visitors must always be guided by a guide with good experience in wild caves. The pathway, where visitors are to travel along, must be clearly defined, for example with red and white tape, and the visitors should not be allowed to walk beyond this pathway. Special care must be taken to avoid any damage to the cave environment, and the parts beyond the pathway must be maintained in a clean condition.

5 PRESERVATION OF THE SURFACE ECOSYSTEM WHEN DEVELOPING BUILDINGS, PARKING, REMOVAL OF SURFACE VEGETATION AND WASTE RECOVERY

It is important that the siting of the above ground facilities, such as the buildings, parking and waste recovery, be well planned. There is a natural tendency to try and place these development features as close as possible to the cave entrance. Sometimes these features are built over the cave itself, or relevant parts of it. The hydrogeology above the cave must not be modified by any intervention such as the watertight surface of a parking area. Any change in the rainwater seepage into a cave can have a negative influence on the cave and the growth of its formations. Care should be exercised also when making any change to the land above the cave, including the removal of the vegetation and disturbance of the soils above the bedrock.

5-1 Any siting of buildings, parking areas, and any other intervention directly above the cave, must be avoided in order to keep the natural seepage of rainwater from the surface in its original condition.

6 MONITORING

After the environmental impact evaluation of the development, including any other study of the cave environment, it is necessary to monitor the relevant parameters to ensure that there is no deviation outside acceptable limits. Show caves should maintain a monitoring network of the cave environment to ensure that it remains within acceptable limits.

6-1 Monitoring of the cave climate should be undertaken. The air temperature, carbon dioxide, humidity, radon (if its concentration is close to or above the level prescribed by the law) and water temperature (if applicable) should be monitored. Airflow in and out of the cave could also be monitored.

When selecting scientists to undertake studies in a cave, it is very important that only scientists who have good experience with cave environments be engaged for cave related matters. Many, otherwise competent scientists, may not be fully aware of cave environments. If incorrect advice is given to the cave management, then this could result in endangerment of the cave environment. Cave science is a highly specialized field.

6-2 Specialized cave scientists should be consulted when there is a situation that warrants research in a cave.

7 CAVE MANAGERS

The managers of a show cave must never forget that the cave itself is "the golden goose" and that it must be preserved with great care. It is necessary that persons involved in the management of a show cave receive a suitable education, not only in the economic management of a show cave, but also about the environmental issues concerning the protection of the environment at large.

Cave managers should be competent in both the management of the economics of the show cave and its environmental protection.

8 TRAINING OF THE GUIDES

The guides in a show cave have a very important role, as they are the "connection" between the cave and the visitor. Unfortunately, in many instances the guides have not been trained properly and, not withstanding that they are doing their best, the overall result will not be very good. It is very important that the guides receive proper instructions about the environmental aspects of the cave as well as dealing with the public. It is important that guides are skilled in tactfully avoiding entering into discussions, which can have a detrimental effect on the overall tour. The guides are the guardians of the cave and they must be ready to stop any misbehaviour by the visitors, which could endanger the cave environment.

Cave guides should be trained to correctly inform the visitors about the cave and its environment.

I. Information on show caves in the world

There are many books published in different countries providing guides to the local caves. On one hand they report a rather large amount of information but, on the other hand, they are fully reliable for a short time only after their publications. In fact show caves have a certain turnover with changes of the visit details, etc. or, sometimes, on very existence of the show cave itself.

Recently a rather useful way to obtain up-to-date information became available. "Showcaves of the World" is a website, which can be found at http://www.showcaves.com/. This site changes and grows continually, so on the web the latest version may be always seen.

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(*formely*/formalmente: Pesquisas em Turismo e Paisagens Cársticas)
Brazilian Speleological Society / Sociedade Brasileira de Espeleologia (SBE)
www.cavernas.org.br/turismo.asp

SPELEOLOGICAL HERITAGE IN BRAZIL'S PROPOSED GEOPARKS, AS PRESENTED IN THE BOOK "GEOPARQUES DO BRASIL: PROPOSTAS"

PATRIMÔNIO ESPELEOLÓGICO BRASILEIRO APRESENTADO NO LIVRO "GEOPARQUES DO BRASIL: PROPOSTAS"

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Abstract

Brazil, with its vast territory, rich geodiversity, and terrains representative of all geologic eras, has a large potential for the implementation of geoparks. The country's geological service (Serviço Geológico do Brasil/CPRM), in its role of promoter of the creation of geoparks, issued in printed version in 2012, and also posted on the Internet the book "Geoparques do Brasil: propostas" (Geoparks of Brazil: proposals), vol. 1, with 17 geopark proposals, selected by CPRM as the most promising ones at this moment. In this paper, after an overview of geoparks worldwide, an analysis is made about the presence of elements of speleological heritage in this publication. Based on data presented for each proposal, tables and graphs were created, relating these elements to the local geology and particularly petrology. This analysis showed that 54% of the caves and other natural underground cavities listed are concentrated in sedimentary siliciclastic rocks (mostly sandstones), 38% in carbonatic rocks (essentially limestones and marbles) and 8% in rocks of the crystalline basement (orthogneisses and granites). The study also showed that despite the enormous potential, both in quantity and in quality, for the use of these cavities in future geoparks, they represent only a small portion (about 15%) of the proposed geosites.

Key-Words: Geopark; Geosite; Speleology; Cave.

Resumo

O Brasil, com seu vasto território, rica geodiversidade e terrenos representativos de todas as eras geológicas, tem um grande potencial para a implantação de geoparques. O Serviço Geológico do Brasil/CPRM, no seu papel de indutor da criação de geoparques no país, lançou em versão impressa em 2012, e disponibilizou também na Internet, o importante volume "Geoparques do Brasil: propostas", vol. 1. Nele são apresentadas 17 propostas que a CPRM selecionou como as mais promissoras no momento atual. Neste trabalho, após uma visão geral dos geoparques no mundo, é feita uma análise sobre a presença de elementos do patrimônio espeleológico nessa publicação. Com base nos dados apresentados para cada proposta, foram montadas tabelas e gráficos que dão uma visão geral dessa presença, relacionando-a com a geologia e particularmente com a petrologia locais. Constatou-se que 54% das cavernas e outras cavidades subterrâneas naturais inventariadas concentram-se em rochas sedimentares siliciclásticas (particularmente arenitos), 38% em rochas carbonáticas (essencialmente calcários e mármores) e 8% em rochas do embasamento cristalino (ortognaisses e granitos). Constatou-se também que apesar do enorme potencial, tanto em quantidade, quanto em qualidade, de aproveitamento dessas cavidades nos futuros geoparques, estas representam apenas uma pequena parcela (cerca de 15%) dos geossítios propostos.

Palavras-Chave: *Geoparque; Geossítio; Espeleologia; Caverna.*

1. INTRODUCTION

Brazil is a vast country endowed with a rich geodiversity, with terrains representative of all the geological eras, and thus presents a large potential for the creation of geoparks.

Geoparks, which include a new model of territorial management, represent a successful worldwide initiative. In the year 2000, just four geoparks, one in each of four European countries, formed the European Geopark Network. As of late 2013, 92 geoparks spread in 28 countries around the world make up the Global Geopark Network (GGN), with UNESCO's seal of approval. According to GGN, a geopark covers a geographical area with a geological heritage represented by geosites with a

unique scientific, educational or touristic value, which are integrated into a holistic concept, including protection, education and sustainable development. In this area, various mechanisms are created for the promotion of educational actions aiming at the popularization of Geosciences, the spreading of scientific knowledge, and the conservation of the geological heritage, but also at the creation of income-generating jobs. One of the results of these actions is the development of the practice of Geotourism, which helps in bringing means of sustainable economic growth.

According to Schobbenhaus & Silva (2012a), the Brazilian Geological Service/CPRM could not be absent from this initiative. Being the most important generator and holder of the geological knowledge about Brazil, CPRM has also the role of stimulating the proposition of new areas with adequate potential for future geoparks. Based on that premise, CPRM launched the Projeto Geoparques do Brasil (Project Geoparks of Brazil) in 2006, and, as one of its results, in 2012 published the book "Geoparques do Brasil: propostas - Vol. 1" (Geoparks of Brazil: proposals - Vol. 1) (SCHOBBENHAUS & SILVA, 2012a), which presents 17 geopark proposals already evaluated, currently under the process of evaluation, or that will in the near future be evaluated by CPRM itself or in partnership with other institutions.

In these proposals a number of specific types of geological interests are presented, being classified into nine categories: stratigraphic, geomorphological, tectonic, paleoenvironmental, metallogenetic, paleontological, igneous, mineralogical and, of course, speleological. Based on this last category, the present paper aims at giving a panoramic set of information about geosites related to the speleological heritage, represented by caves formed in different kinds of rocks, creating unique geomorphological features. Another goal of this paper is to emphasize the presence of examples of speleological heritage in Brazilian proposed geoparks.

2. GEOPARKS IN THE WORLD

Aiming at the reinforcement of projects of conservation of the geological heritage, UNESCO, after its 29th General Conference in 1997, started the development of its Geoparks Program, based on four European units. In that year, according to MOREIRA (2011), an important European financing program, Leader +, allowed the initial materialization of the geopark concept, in cooperation with UNESCO, in four countries: the Natural Geological Reserve of Haute-Provence (France), the Petrified Forest in Lesvos (Greece), the Vulkanaifel Geopark (Germany) and the Maestrazgo Cultural Park (Spain).

The Geoparks Program was presented to the international scientific community in 1999, with the characteristic of addressing the specific need for acknowledgement and conservation of the geological heritage, with the same kind of approach that the Biosphere Reserve Program applies in its dedication to the biological heritage. The program deals with a series of locations with worldwide geological interest based on the philosophical approach expressed in the "Declaration of the Rights of the Memory of the Earth" issued in Digne-les-Bains, France, in 1991.

In 2000, the four areas that started the program founded, under UNESCO's assistance, the European Geopark Network. However, in 2001, UNESCO decided "not to pursue the development of a UNESCO geoparks programme, but instead to support *ad hoc* efforts within individual Member States as appropriate". In this new context, in 2004, during the 1st International Conference on Geoparks, in Beijing, China, the Global Geopark Network (GGN) was officially launched (Martini, 2010). This network was created to establish, with UNESCO's endorsement, a common platform for cooperation and exchanges between specialists and all those interest in the geological heritage. According to UNESCO, "A geopark is a territory with well-defined limits that has a large enough surface area for it to serve local socio-economic development. It comprises a certain number of geological heritage sites (on any scale) or a mosaic of geological entities of special scientific importance, rarity or beauty, representative of an area and its geological history, events or processes. It may not solely be of geological significance but also of ecological, archaeological, historical or cultural value. A geopark serves to foster socio-economic development that is culturally and environmentally sustainable. This has a direct impact on the area by improving human living conditions and the rural environment, thus strengthening identification of the population with their area and triggering cultural renaissance."

The Global Geopark Network, assisted by UNESCO, has been spreading throughout the world, reaching many countries where there is an interest in the conservation and valuation of the geological heritage. In its beginning, it had only four geoparks; when officially created, in 2004, they were already twenty. Presently (late 2013) it congregates 92 geoparks distributed in 28 countries (Figure 1),

namely, in alphabetical order: Austria (2); Brazil (1); Canada (1); China (27); Croatia (1); Czech Republic (1); Finland (1); France (4); Germany (5 geoparks + 1 binational with Poland); Greece (4); Hungary (1 + 1 binational with Slovakia); Iceland (1); Indonesia (1); Ireland (2 + 1 binational with Northern Ireland); Italy (8); Japan (5); Malaysia (1); Northern Ireland (1 binational with Ireland); Norway (2); Poland (1 binational with Germany); Portugal (3); Romania (1); Slovakia (1 binational with Hungary); South Korea (1); Spain (8); United Kingdom (6); Vietnam (1).

There are 54 geoparks in 23 countries in Europe, 36 in 6 countries in Asia, and 2 in the Americas (http://en.globalgeopark.org/), being 1 in Brazil, the Geoparque Araripe*, the first in the American continent and also the first in the Southern hemisphere (http://geoparkararipe.org.br/).

* NOTE: the names of the one existing geopark and of the proposed ones in Brazil, as well as the names of the geosites in all of them, **will not be translated**, so as to allow searches, both in the book "Geoparques do Brasil: propostas" and on the Internet.

According to Brilha (2012), the Global Geoparks Network has defined as main goals for the geoparks which participate in it:

1. Conservation of the geological heritage;
2. Provision of education about geosciences and environmental issues to the common citizen;
3. Sustainable socio-economic and cultural development;
4. Multicultural cooperation;
5. Promotion of scientific investigation; and
6. Active participation in the network by means of the development of common activities.

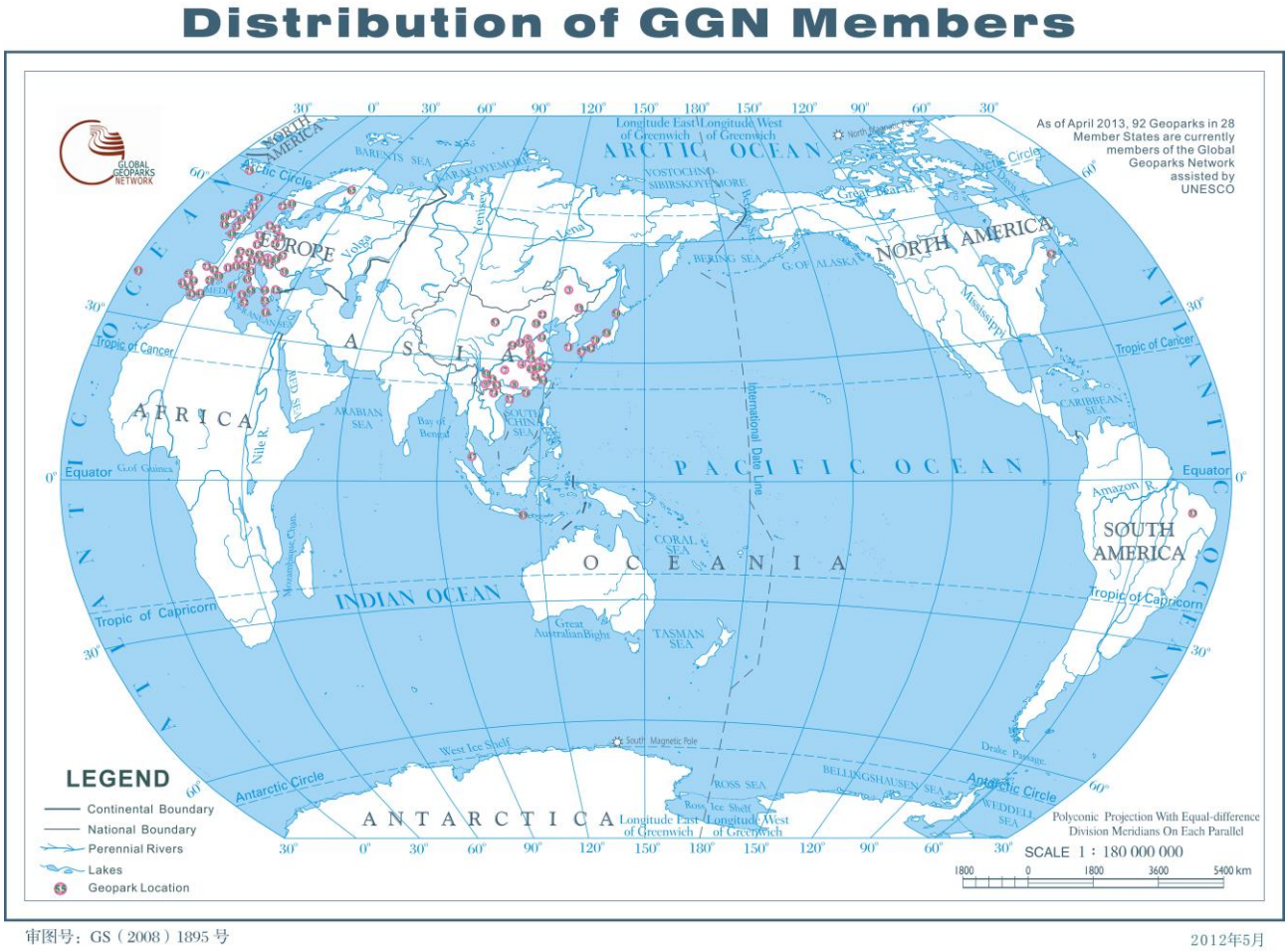

Fig. 1 - Map of the members of the Global Geoparks Network. Source: http://en.globalgeopark.org/UploadFiles/2012_5_7/GGN%20Distribution%202013.04.23.jpg

3. GEOPARKS IN BRAZIL

The Brazilian Geological Service/CPRM, through its Departamento de Gestão Territorial (Department of Territorial Management), launched in early 2006 the Projeto Geoparques do Brasil (Project Geoparks of Brazil) (SCHOBBENHAUS, 2006; SCHOBBENHAUS & SILVA, 2010; SCHOBBENHAUS & SILVA, 2012a), under the executive coordination of the geologist Carlos Schobbenhaus and the regional coordination of the representatives of the various regional offices of CPRM. This project plays an important role as inducer of the creation of geoparks in Brazil, and has as its main objectives to identify, classify, describe, catalog, georeference and publicize areas potentially prone to become geoparks, as well as to contribute to the definition of guidelines for their sustainable development. According to SCHOBBENHAUS & SILVA (2012a) the wealth of geological surveys existing in the country and the experience accumulated by the company's technical body, as well as the contribution of studies and proposals by the geoscientific community, favor the development of this project. In some cases, this inducing activity in carried out in conjunction with researchers from universities and other federal, state or municipal organisms.

Brasil has an enormous potential for the proposition of geoparks, because in its large territory, a rich geodiversity - including representatives from practically the whole geologic history of the planet - can be found, plus non-geologic sites of ecological, archaeological, historical and cultural value. Important records pertaining to all of these aspects, some absolutely unique, represent part of the nation's heritage, and even of mankind's heritage, and clearly deserve being preserved (SCHOBBENHAUS; SILVA, 2012a).

Various proposals of geoparks have already been evaluated, some are under evaluation, and others are scheduled to be evaluated in the future as part of the Projeto Geoparques (Geoparks Project). These proposals are indicated in the map in Figure 2 and in the list presented as Table 1. The technical report of some of these proposals can be found in digital form (in Portuguese) at http://www.cprm.gov.br/publique/cgi/cgilua.exe/sys/start.htm?sid=134. Such activities have been carried out partly in partnership with federal, state or municipal institutions, or with universities or private institutions. Besides those mentioned in that list, other proposals for geoparks exist: Campos Gerais (Universidade Estadual de Ponta Grossa e Minérios do Paraná-Mineropar - Ponta Grossa State University and Mineropar, the Paraná state geological service); Ciclo do Ouro (Prefeitura de Guarulhos, São Paulo - Municipality of Guarulhos, state of São Paulo); and Costões e Lagunas do Rio de Janeiro (Serviço Geológico do Estado do Rio de Janeiro - Diretoria de Recursos Minerais - Rocky shores and lagoons of the state of Rio de Janeiro - State of Rio de Janeiro Geological Service - Department of Mineral Resources).

It is worth pointing out that in this initial stage (Table 1) there are already proposals of geoparks in which speleology appears as a main category, particularly the following: 01. Cachoeira do Amazonas; 06. Bodoquena-Pantanal; 07. Chapada dos Guimarães and 15. Alto Vale do Ribeira.

The practice of presenting geopark proposals has been very well received in the academic community, as well as in government offices at the federal, state and municipal levels, in the private sector of the economy, and by local populations. These positive reactions allow this community, as well as other interested groups, to believe that there will be new geoparks established in Brazil in the near future.

4. SPELEOLOGICAL HERITAGE

Speleological heritage can be defined as per Artigo (Article) 5° (5th), inciso (item) I, of the Brazilian Decreto (Decree) n° 99.556/90 as *"the array of biotical, abiotical, socio-economic and historic-cultural, subterranean or surficial, elements represented by natural subterranean cavities or associated to such cavities"*. In its abiotical components, this kind of heritage is associated to the geological heritage and usually refers to those cavities that occur mainly in limestones and marbles, but occasionally also in banded-iron formations, sandstones, quartzites and granites.

According to CECAV/ICMBio (2011) the most commonly used definition for cave is "a natural opening formed in rock below the terrain's surface, large enough to allow a person to enter". This definition is adopted by the International Union of Speleology - UIS, the international body that congregates the various national institutions dedicated to speleology and caving. The Brazilian Decreto (Decree) n° 6.640/08, which partially modifies the above mentioned Decreto (Decree) n° 99.556/90, theoretically eliminates the expression "speleological heritage", but this same expression in used in its own text. It is clear, then, that there exists a legal incongruence; that incongruence will not be discussed here, as it is beyond our goals. As far as this paper is concerned, since the expression

"speleological heritage" is of general use by the scientific and speleologic communities, and is maintained in the most recent decree, it is considered by the authors as acceptable. It will be used here, not in a legal sense, but in the sense that it is normally used in those communities, meaning, in broad terms, "elements of speleological environments that deserve being preserved".

This same Decreto (Decree) n° 6.640/08 defines natural underground cavities as "any and all subterraneous spaces, with or without an identified opening, accessible to a human being, known by the population as *caverna*, *gruta*, *lapa*, *toca*, *abismo*, *furna* or *buraco* [*], including its environment, mineral and water content, fauna and flora therein found, and the rocky body in which they are located, provided they have been formed by natural processes, regardless of their size or type of rock in which they occur". [* these are various Brazilian non-technical terms used to name natural underground cavities].

Such cavities tend to be found mostly in soluble rocks (carbonatic rocks, both sedimentary and metamorphic), where they are generated precisely by dissolution by water of some of the rock components. Most typically, they are formed in limestone (sedimentary rock) and marble (metamorphic rock), in whose masses they generate the karstic morphology. However, nowadays there is a tendency to include siliceous rocks, particularly quartzites (metamorphic) and sandstones (sedimentary) in the group of karstifiable rocks. Such a trend is the result of recent studies that show that silica, until recently considered as a mineral of low solubility, has played a more important role than previously acknowledged in the generation of surficial and subterraneous, typically karstic, morphologies (CECAV/ICMBio, 2011). The landscape generated in a karstic environment has a number of characteristic features, some unique to this environment. Along with the caves proper, large exposed rock masses, walls, cliffs, valleys, towers, depressions, dolines, sinkholes, lagoons, speleothems (stalactites, stalagmites, helictites, cave pearls, among others) make up a very scenic, beautiful context.

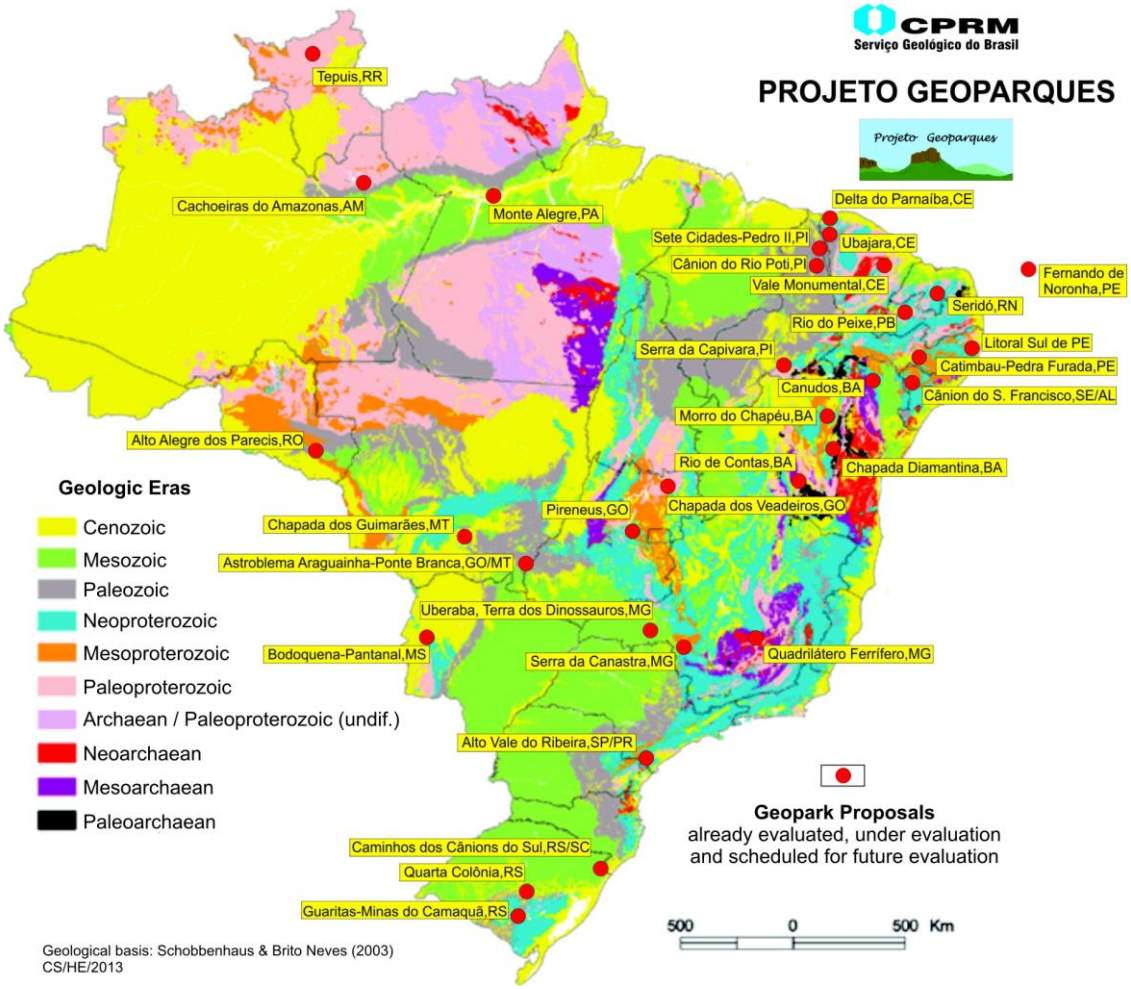

Fig. 2 - Map with the geopark proposals already evaluated, under evaluation and scheduled for future evaluation by the Projeto Geoparques. Based on Schobbenhaus; Silva (2012a)

Table 1. List of proposals already evaluated, under evaluation and scheduled for future evaluation by the Projeto Geoparques. Based on Schobbenhaus; Silva (2012a).

	Geopark proposal	**State**	**Main Category(ies)**
1	Cachoeira do Amazonas*	AM	Stratigraphic, Speleological, Archaeological
2	Morro do Chapéu*	BA	Stratigraphic, Geomorphological, Historical-Cultural
3	Pireneus*	GO	Stratigraphic, Tectonic, Geomorphological, Historical-Cultural
4	Astroblema Araguainha-Ponte Branca*	GO/MT	Astroblem (structure formed by a meteorite impact)
5	Quadrilátero Ferrífero*	MG	Stratigraphic, Paleoenvironmental, History of Mining, Geomorphological, Metallogenetic
6	Bodoquena-Pantanal*	MS	Speleological, Paleoenvironmental, Geomorphological, Paleontological, Metallogenetic
7	Chapada dos Guimarães*	MT	Geomorphological, Paleontological, Speleological, Scenic Beauty
8	Fernando de Noronha*	PE	Igneous, Scenic Beauty
9	Seridó*	RN	Stratigraphic, Igneous, Geomorphological, Metallogenetic, Historical-Cultural
10	Quarta Colônia*	RS	Paleontological, Stratigraphic
11	Caminhos dos Cânions do Sul*	RS/SC	Scenic Beauty, Geomorphological, Igneous, Stratigraphic
12	Serra da Capivara*	PI	Stratigraphic, Archaeological
13	Catimbau-Pedra Furada	PE	Stratigraphic, Paleoenvironmental, Geomorphological, Igneous, Archaeological
14	Sete Cidades-Pedro II	PI	Geomorphological, Paleoenvironmental, Mineralogical, Scenic Beauty
15	Alto Vale do Ribeira	SP/PR	Speleological, Paleoenvironmental
16	Chapada Diamantina	BA	Geomorphological, Paleoenvironmental, Scenic Beauty, Historical-Cultural
17	Uberaba, Terra dos Dinossauros do Brasil*	MG	Paleontological
18	Litoral Sul de Pernambuco*	PE	Igneous, Stratigraphic, Scenic Beauty, Historical-Cultural
19	Rio de Contas	BA	Stratigraphic, Geomorphological, Historical
20	Monte Alegre	PA	Stratigraphic, Geomorphological, Tectonic, Archaeological
21	Alto Alegre dos Parecís	RO	Stratigraphic, Geomorphological, Scenic Beauty
22	Serra da Canastra	MG	Scenic Beauty, Geomorphological
23	Chapa dos Veadeiros	GO	Geomorphological, Stratigraphic, Scenic Beauty
24	Canudos	BA	Petrological, Stratigraphic, Igneous, Geomorphological, Metallogenetic, Historical-Cultural
25	Cânion do São Francisco	SE/AL	Geomorphological, Scenic Beauty
26	Rio do Peixe	PB	Paleontological, Stratigraphic
27	Vale Monumental	CE	Geomorphological, Igneous, Scenic Beauty
28	Tepuis	RR	Geomorphological, Stratigraphic, Paleoenvironmental, Scenic Beauty

The asterisk after the name – * – indicates proposals of national geoparks published in the first volume of the book "Geoparques do Brasil: propostas".

In Brazil there are a number of karstic areas with caves that show a peculiar landscape. According to AULER & ZOGBI (2005), the country is also very favorable to the discovery of new caves. These authors state that there are more than 4.000 caves already registered, but the country's potential is at least ten times bigger. This statement is confirmed by CECAV/ICMBio (Centro Nacional de Pesquisa e Conservação de Cavernas do Instituto Chico Mendes de Conservação da Biodiversidade - National Center of Research and Conservation of Caves of the Chico Mendes Institute for the Conservation of Biodiversity), which, in its database, shows a little more than 10.000 caves already registered (details can be found, in Portuguese, at http://www.icmbio.gov.br/cecav/projetos-e-atividades/inventario-anual-do-patrimonio-espeleologico-brasileiro.html). According to CECAV/ICMBio (2011) about 90% of the caves known in the world are in carbonatic rocks. In Brazil however, due to peculiarities not yet well understood, but certainly related to geomorphological and climatic factors, sandstones and quartzites are also very liable to generate caves. Furthermore, it has recently been discovered that iron ore and canga (laterite, surficial or subsurficial limonite-cemented unstratified rock, mainly related to the banded-iron formations, a metamorphic rock) are extremely prone to the formation of caves, thus

adding a new component to Brazil's already complex speleological matrix. There are also, albeit in a lesser scale, caves in granites (igneous, plutonic rocks), gneisses (metamorphic rocks) and other metamorphic rocks such as micaschists and phyllites, and even in soils. Table 2 shows, in a preliminary version, the number of caves hitherto identified in each lithology and the probable speleological potential (caves not yet identified, but considered as probably existent).

Figure 3, based on CECAV/ICMBio (2011), shows the vast variety of rocks in which caves occur in Brazil. Black represents main carbonatic areas and orange main quartzitic areas; yellow triangles represent minor carbonatic areas, red stars represent iron ore areas, and green squares represent other lithologies (mainly sandstones) where caves also exist. The apparently larger concentration of rocks hosting known caves in the eastern part of the country may be related, at least partially, to the fact that this area has been subject to more detailed geological mapping.

Table 2. Estimate (order of magnitude) of Brazil's speleological potential in relation to known caves and lithology. Based on CECAV/ICMBio (2011) and Jansen *et al*. (2012).

Lithology	**Number of known caves**	**Probable potential (caves not yet known)**	**Percentage of known caves**
Carbonates	7.000	> 150.000	< 5%
Quartzites	510*	> 50.000	< 1%
Sandstones	510*	> 50.000	< 1%
Iron Ore	2.000	> 10.000	< 20%
Other lithologies	200	> 50.000	< 0,5%

*approximate numbers, compiled from CECAV/ICMBio's database on June 1, 2012.

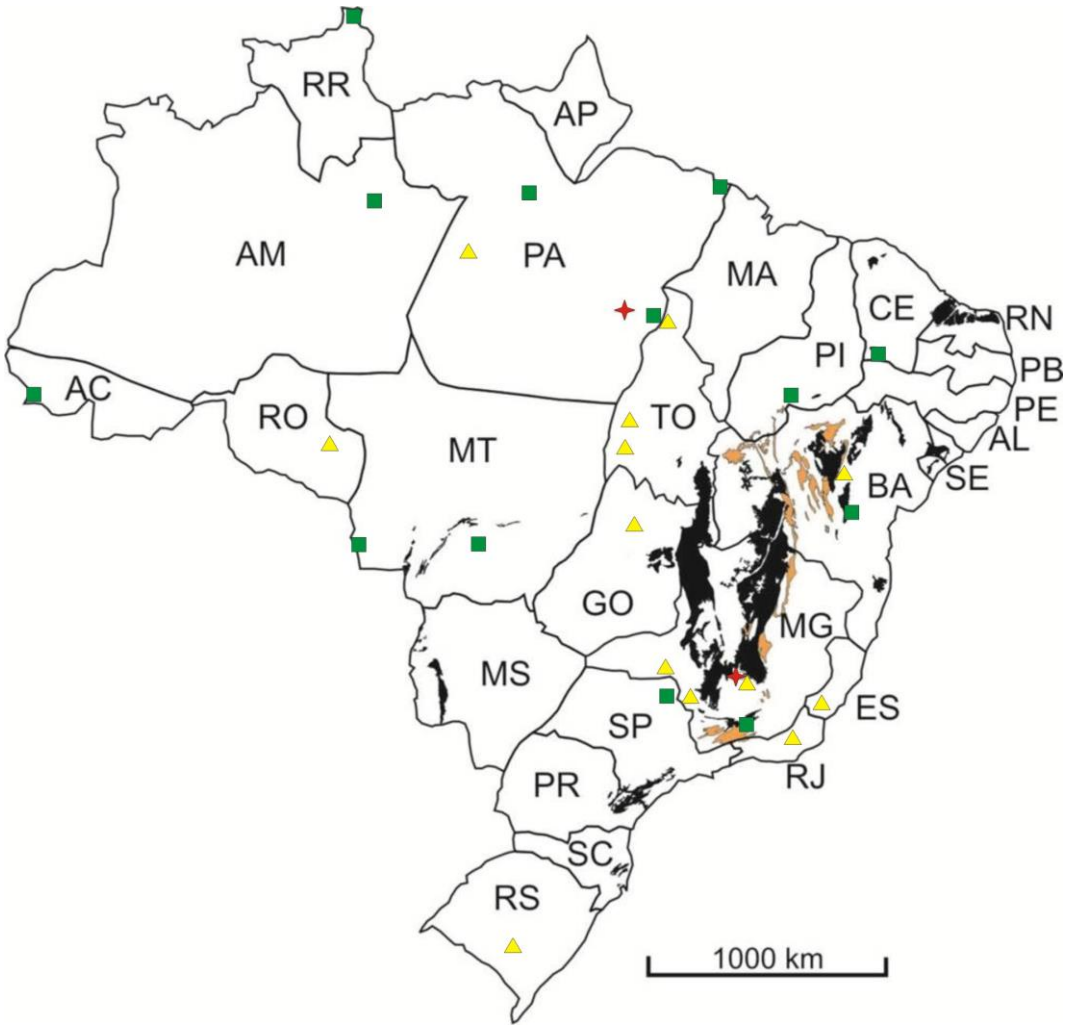

Fig. 3 - Map showing the main lithologies hosting natural cavities. Main carbonatic rocks (sedimentary and/or metamorphic) are represented in black. Main quartzitic rocks (metamorphic) are represented in orange. Minor carbonatic (sedimentary and/or metamorphic) areas are represented by yellow triangles. Iron ore areas are represented by red stars. Other lithologies are represented by green squares. Based on CECAV/ICMBio (2011).

It can be clearly seen that Brazil's potential speleological heritage is enormous. The main cave-bearing areas are situated in an oblong zone, running from NE to SW, parallel to the coast, with a higher concentration covering center-W Bahia, eastern Goiás and two branches running N-S crossing the central portion of Minas Gerais. These areas are mostly covered by limestones and dolomites of the Bambuí Group (Auler & Zogbi, 2005; CECAV/ICMBio, 2011). One of the most important clusters, with more than 700 caves already registered, is the region of Lagoa Santa (MG), which can be considered as the cradle of Brazilian speleology. The state of Bahia hosts the five longest caves in the country (Table 3). Crossing the easternmost boundary dividing the states of São Paulo and Paraná there is another important cluster, with more than 300 caves, formed in limestones and dolomites of the Açungui Group. Most of those in the state of São Paulo are situated inside the PETAR (Parque Estadual Turístico do Alto Ribeira - Alto Ribeira Touristic State Park), including Caverna (Cave) Santana, one of the most famous caves in the country, and Casa de Pedra (Stone House), the tallest natural rock opening known in the country (Figure 4); the caves in this region represent a meaningful portion of the geological heritage of the state, and of the country (MANTESSO-NETO *et al*. 2013).

In the NE region of the country, also corresponding to the NE tip of the above mentioned oblong zone in which are concentrated the main cave-bearing areas, many caves exist, but really big ones haven't been found yet. In the state of Ceará one of the best known is the Gruta de Ubajara, situated in one of the country's oldest national parks. In Rio Grande do Norte, most caves are concentrated between Felipe Guerra and Apodi; among them, Casa de Pedra de Martins (Martins' Stone House), considered one of the biggest marble caves in the country.

The map of potentiality of occurrence of caves in Brasil, in the scale 1:2.500.000 was published in 2012 (JANSEN *et al*. 2012). It is based in a new methodology, in which, according to the lithology, five classes of degree of potentiality are established: Very high; High; Medium; Low; and Occurrence unlikely (Table 4).

These classes were identified by the use of the following criteria: a) data about emplacement of the main karstic areas in Brazil; b) geological map of Brazil, scale 1:2.500.000, by the Serviço Geológico do Brasil/CPRM (Brazilian Geological Service), with emphasis in the fields Litologia1 (Lithology1), Litologia2 (Lithology2) and Nome da Unidade (Name of Unit), of the "Tabela de atributos" (Table of Attributes); c) geospatialized data from de caves furnished by CECAV/ICMBio (on June 1st, 2012); and d) bibliographical revision about the main lithological formations of the cavities registered in CECAV/ICMBio's database.

Fig. 4 - Reaching a height of approximately 220m (720') and essentially corresponding to the collapsed descending limb of a metamorphic limestone fold, Casa de Pedra (Stone House), is the tallest natural rock opening known in the country, and is possibly among the tallest in the world. It is situated in the southern portion of the state of São Paulo, in the PETAR Parque Estadual Turístico do Alto Ribeira - Alto Ribeira Touristic State Park. Photo by Lalo de Almeida.

Table 3. The 10 longest known caves in Brazil, according to CECAV/ICMBio (2011).

By order of length	Municipality	km / mi
1. Toca da Boa Vista*	Campo Formoso (BA)	106,50 / 66.6
2. Toca da Barriguda	Campo Formoso (BA)	33,30 / 20.8
3. Lapa Doce II	Iraquara (BA)	16,50 / 10.3
5. Gruta do Padre	Santana e Santa Maria da Vitória (BA)	16,40 / 10.3
5. Boqueirão	Carinhanha (BA)	15,17 / 9.5
6. Lapa do Angêlica	São Domingos (GO)	14,10 / 8.8
7. Gruna da Água Clara	Carinhanha (BA)	13,88 / 8.7
8. Lapa do São Mateus III	São Domingos (GO)	10,61 / 6.6
9. Lapa de São Vicente II	São Domingos (GO)	10,13 / 6.3
10. Lapa Doce I	Iraquara (BA)	10,00 / 6.3

*The Toca da Boa Vista is considered to be the 18th biggest cave in the world.

Table 4. Degree of potentiality of occurrence of caves in Brasil according to the lithology. Based on Jansen et al. (2012)

Lithotype	**Degree of potentiality of occurrence**
Limestone, Dolomite, Evaporite, Banded-Iron Formation, Itabirite and Jaspilite	Very high
Calcrete, Carbonatite, Marble, Metalimestone and Marl	High
Sandstone, Conglomerate, Phyllite, Shale, Fosforite, Greywacke, Metaconglomerate, Metapellite, Metasiltstone, Micaschist, Mylonite, Quartzite, Pellite, Rhyolite, Rhythmite, Calcosilicatic Rock, Siltstone and Schist	Medium
Remaining lithotypes (Anorthosite, Arkose, Augen Gnaisse, Basalt, Charnockite, Diabase, Diamictite, Enderbite, Gabbro, Gnaisse, Granite, Granitoids, Granodiorite, Hornfels, Kinzigite, Komatiite, Laterite, Metachert, Migmatite, Monzogranite, Olivine Gabbro, Orthoamphibolite, Syenite, Syenogranite, Tonalite, Trondhjemite, among others)	Low
Alluvium, Sand, Clay, Gravel, Pellite, Lignite, other sediments, Peat and Tuff	Occurrence unlikely

The studies showed that 78,4% of the cavities are situated in areas with degrees of potentiality of occurrence "Very high" and "High", meaning that they occur basically ln carbonatic rocks (sedimentary and/or metamorphic) and in the banded-iron formations (metamorphic). Classes of "Medium" potentiality, including sandstones (sedimentary) and quartzites (metamorphic) held 12,8% of the cavities, and only 8,7% of the total number were located in the "Low" and "Occurrence unlikely" degrees. It was thus possible to produce the map of potentialities of caves in Brazil, offering to the country an estimate of its potential in terms of speleological heritage (Figure 5).

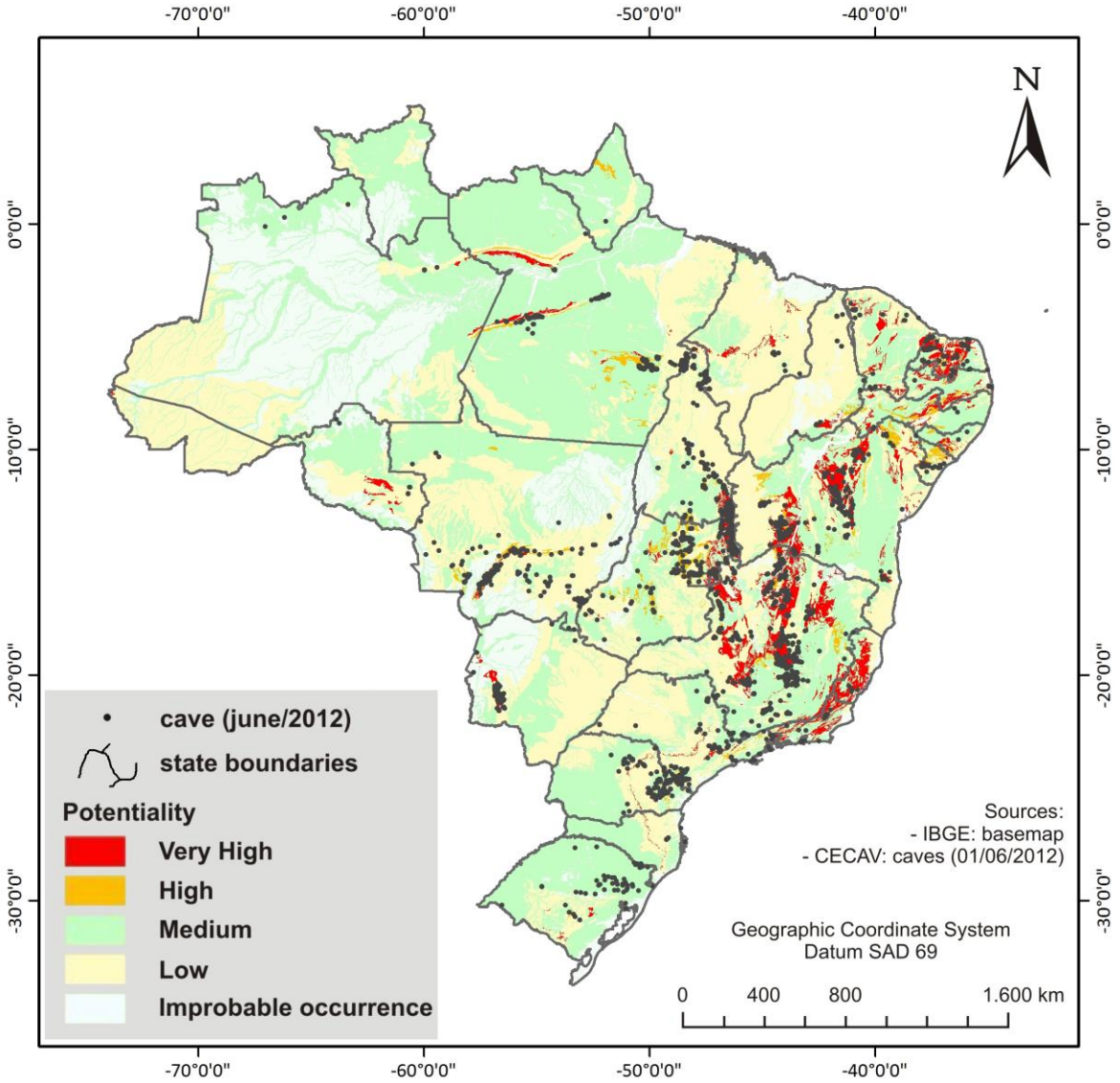

Fig. 5 - Map of potentiality of occurrence of caves in Brasil, by Jansen *et al*. (2012)

5. THE PRESENCE OF THE SPELEOLOGICAL HERITAGE IN THE PROPOSALS OF BRAZILIAN GEOPARKS

In late 2012, the Serviço Geológico do Brasil/CPRM (Brazilian Geological Service) published the first volume of the book "Geoparques do Brasil: propostas" (Schobbenhaus; Silva, 2012a - Geoparks of Brazil: proposals) which presents a meaningful set of information about 17 geopark proposals spread throughout the country. Beside CPRM's technical staff, these proposals include among their authors university researchers and members of other institutions. Some external proposals were invited by CPRM to participate in the book, and are also included. Besides the chapters describing the proposals, there are also two initial chapters about "O papel do Serviço Geológico do Brasil na criação de Geoparques e na Conservação do Patrimônio Geológico" (SCHOBBENHAUS & SILVA, 2012b - The role of the Geological Service of Brazil in the creation of Geoparks and in the Conservation of the Geological Heritage) and "A Rede Global de Geoparques Nacionais" (BRILHA, 2012 - The Global Network of National Geoparks).

As mentioned in our Introduction, the aim of this paper is to present the speleological heritage present in these 17 different geopark proposals, pointing out their respective characteristics (rock types, degree of conservation, abundance or rarity, among others).

The 17 proposals include the description of 362 geosites, with an average of 21 geosites per proposal. A total of 12 kinds of geological interests (Astroblem, Geomorphological, History of Mining, Igneous, Metallogenetic, Mineralogical, Paleoenvironmental, Paleontological, Petrological, Stratigraphic, Tectonic, and, of course, Speleological) are represented, plus the Archaeological, Historical-Cultural, and Scenic Beauty interests. Among the geosites, 54 are related to speleological heritage, represented by caves and other natural underground cavities, thus corresponding to an average of 3 speleological geosites per proposal. Table 5 shows the total number of geosites and the number of those related to speleological heritage for each proposal, while Figure 6 presents, in graph form, the total number of geosites for each of the 17 proposals.

Focusing specifically on the number of geosites related to speleological heritage, the Geoparque Serra da Capivara (PI) is the one with the largest quantity of them: 21; next comes Geoparque Bodoquena-Pantanal (MS) with 12 geosites, and in the third place Geoparque Morro do Chapéu (BA) with 5 geosites (Figure 7).

In terms of percentage of geosites related to speleological heritage compared to the total number of geosites, the Geoparque Serra da Capivara (PI) proposal maintains its lead, with 57% (of its 37 geosites, 21 are related to speleological heritage); next comes Geoparque Bodoquena-Pantanal (MS) with 27% (45 geosites, being 12 related to speleological heritage); in third place comes the Geoparque Cachoeira do Amazonas (AM) proposal, with 25% (out of a total of 8 geosites, 2 are related to speleological heritage) (Figure 8).

Table 5. Number of Geosites and Number of Geosites of Speleological Heritage in the 17 proposals. In parentheses, the percent value of the latter in respect to the former.

Geopark Proposal	Number of Geosites	Number of Geosites of Speleological Heritage
1. Cachoeira do Amazonas (AM)	08	02 (25%)
2. Morro do Chapéu (BA)	24	05 (21%)
3. Pireneus (GO)	20	00 (00%)
4. Astroblema de Araguainha-Ponte Branca (GO/MT)	15	01 (07%)
5. Quadrilátero Ferrífero (MG)	19	01 (05%)
6. Bodoquena-Pantanal (MS)	45	12 (27%)
7. Chapada dos Guimarães (MT)	16	03 (19%)
8. Fernando de Noronha (PE)	26	00 (00%)
9. Seridó (RN)	25	02 (08%)
10. Quarta-Colônia (RS)	20	01 (05%)
11. Caminhos dos Cânions do Sul (RS/SC)	20	03 (15%)
12. Serra da Capivara (PI)	37	21 (57%)
13. Ciclo do Ouro, Guarulhos (SP)	14	00 (00%)
14. Uberaba – Terra dos Dinossauros do Brasil (MG)	06	00 (00%)
15. Campos Gerais (PR)	14	00 (00%)
16. Litoral Sul de Pernambuco (PE)	23	00 (00%)
17. Costões e Lagunas do Estado do Rio de Janeiro (RJ)	30	03 (10%)
Total	**362**	**54 (15%)**

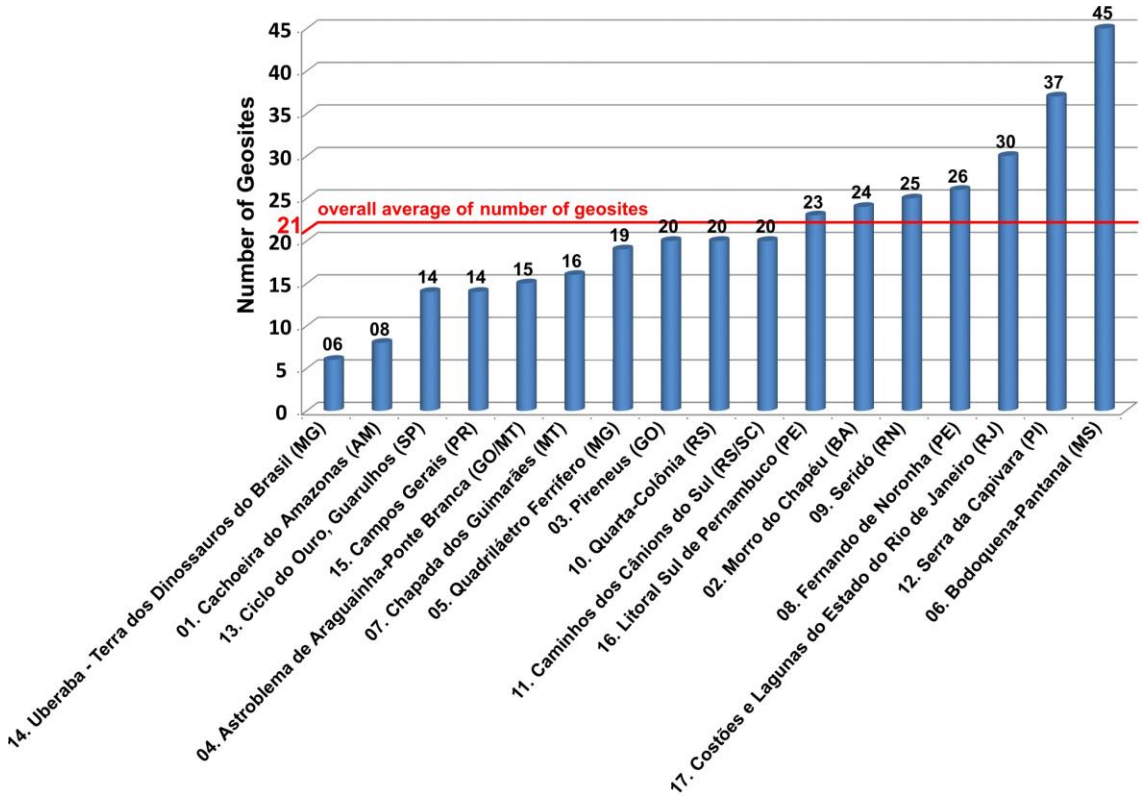

Fig. 6 - The proposals of geoparks and their respective number of geosites. Overall, 362 geosites were described, yielding an average of 21 geosites per proposal. The Geoparque Bodoquena-Pantanal (MS) proposal is the one with the largest number of geosites (45), whereas the Geoparque Uberaba-Terra dos Dinossauros do Brasil (MG) proposal has the smallest number, 6.

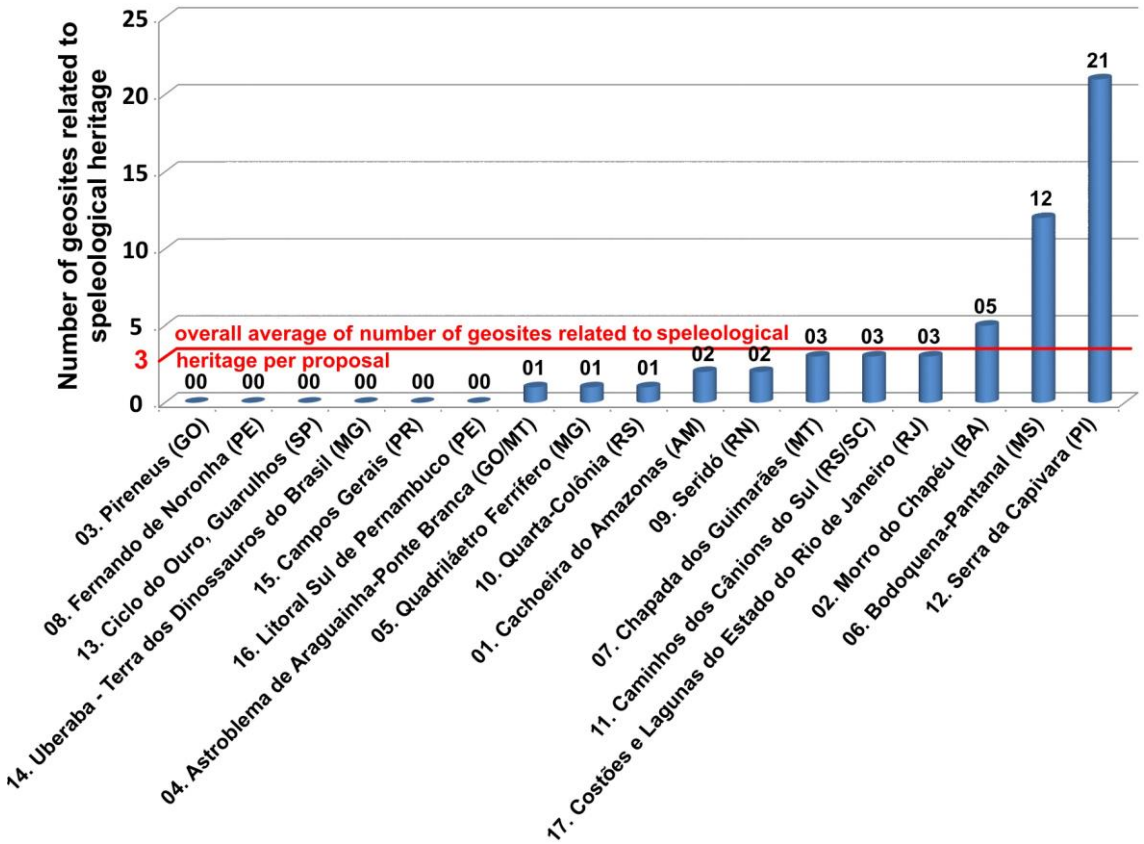

Fig. 7 - The proposals of geoparks and their respective number of geosites related to speleological heritage. There are 54 geosites with this characteristic, yielding an average of 3 geosites related to speleological heritage per proposal. The 3 proposals with largest number of such geosites are Serra da Capivara (PI) with 21 geosites, Bodoquena-Pantanal (MS) with 12 and Morro do Chapéu (BA) with 5.

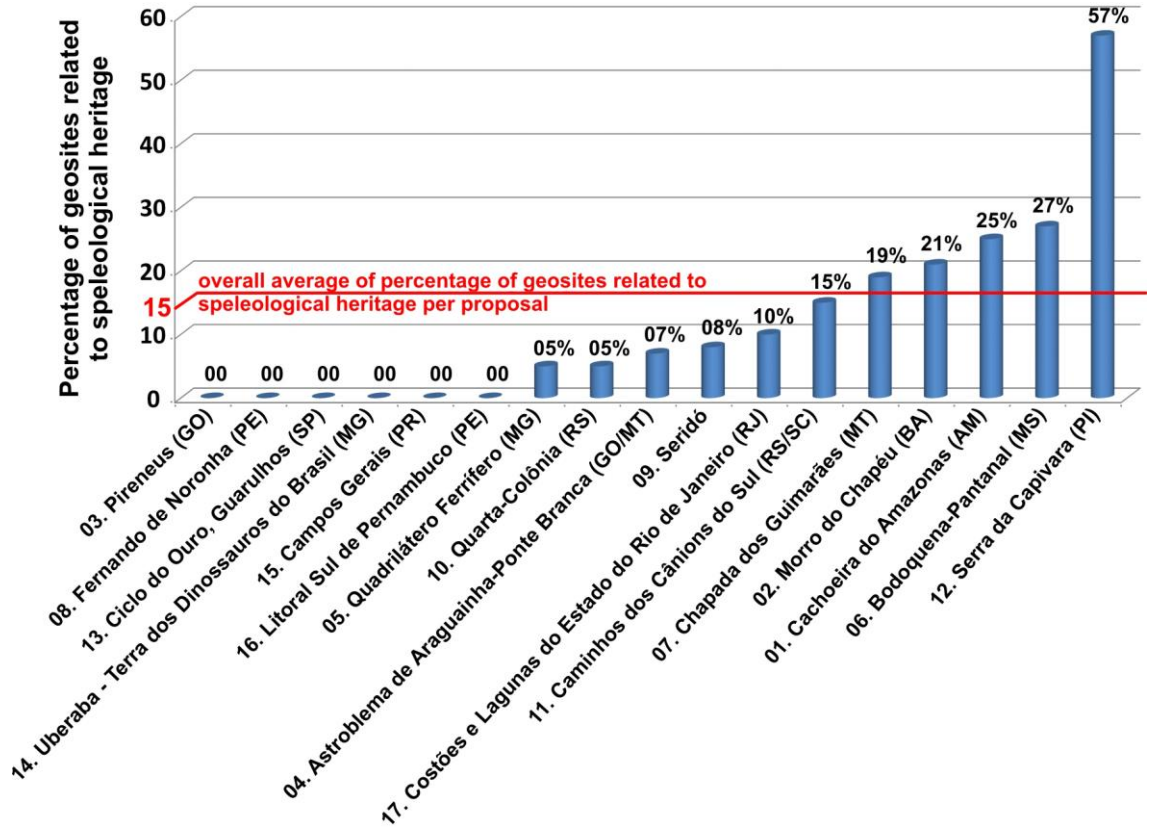

Fig. 8 - The proposals of geoparks and their respective percentagens of geosites related to speleological heritage. Out of a total of 362 geosites, 54, or 15%, are related to speleological heritage. The 3 proposals with the largest percentages of geosites related to speleological heritage are Serra da Capivara (PI) with 57% (21 geosites), Bodoquena-Pantanal (MS) with 27% (12 geosites) and Cachoeira do Amazonas (AM) 25% (2 geosites).

In most cases a word in the name given to the geosite indicates the presence of an item of the speleological heritage, or is related to it (Table 6); in some cases, however, the name of the geosite does not indicate that relationship. In such cases, it is necessary to read the description of the geosite or to check its characteristics in one of the tables herein, in order to establish its scientific value.

In lithological terms, it is easy to identify the predominance of sedimentary siliciclastic rocks (siltstones, sandstones and conglomerates, with a major participation of sandstones) and carbonatic rocks (limestones) (Figure 9). In a lesser scale, metamorphic carbonatic rocks (marbles), metamorphic rocks of initially igneous origin (orthogneisses), and igneous rocks (granites) are also present. Tables 6 and 7 show which lithotypes are associated to each proposal of geopark (and its respective geosites). They allow us to verify that the Geoparque Serra da Capivara (PI) proposal is the one with the largest variety of geological units hosting natural underground cavities, namely: sandstones of the Cabeças Formation of the Canindé Group; siltstones, sandstones and conglomerates of the Ipú Formation of the Serra Grande Group; and limestones of the Barra Bonita Formation of the Casa Nova Group. A second proposal with a rich variety of lithologies is Bodoquena-Pantanal (MS), with sandstones of the Aquidauana Formation of the Itararé Group and limestones of the Cerradinho and Bocaina Formations, both of the Corumbá Group. Some proposals have just one lithological unit hosting the natural underground cavities: Cachoeira do Amazonas (AM), sandstones; Astroblema de Araguainha-Ponte Branca (GO/MT), sandstones; Quarta-Colônia (RS), sandstones; and Quadrilátero Ferrífero (MG), limestones.

Of the 54 geosites presenting natural cavities, 29 are associated to sedimentary siliciclastic rocks (being 1 to siltstones, 27 to sandstones and 1 to conglomerates); these represent 54% of the total number of geosites. Carbonatic rocks (limestone and marbles), host 21 geosites, representing 38% of the total number. The remaining 8% are associated to rocks of the crystalline basement (orthogneisses and granites), which together add up to 4 geosites with speleological interest (Figure 9).

Table 6. Names of geosites related to speleological heritage in the 11 proposals of national geoparks in which there is (are) one or more natural underground cavity(ies).

Geopark Proposal	**Name of Geosite = type of rock to which it is associated**
1. Cachoeira do Amazonas (AM)	Geosite 03 – Cachoeira da Iracema = sandstone Geosite 08 – Gruta do Maroaga = sandstone
2. Morro do Chapéu (BA)	Geosite 07 – Buraco Possidônio = limestone Geosite 08 – Gruta Barrocão = limestone Geosite 09 – Buraco do Alecrim = limestone Geosite 13 – Gruta do Cristal = limestone Geosite 21 – Gruta dos Brejões = limestone
4. Astroblema de Araguainha-Ponte Branca (GO/MT)	Geosite 09 – Caverna da Gota Santa = sandstone
5. Quadrilátero Ferrífero (MG)	Geosite 18 – Gruta Nossa Senhora da Lapa = limestone
6. Bodoquena-Pantanal (MS)	Geosite 11 – Gruta do Lago Azul = limestone Geosite 12 – Gruta Nossa Senhora Aparecida = limestone Geosite 13 – Gruta São Miguel = limestone Geosite 14 – Abismo Anhumas = limestone Geosite 15 – Grutas do Mimoso = limestone Geosite 16 – Lagoa Misteriosa = limestone Geosite 17 – Buraco das Araras = sandstone Geosite 34 – Buraco das Abelhas = limestone Geosite 35 – Gruta do Urubu Rei = limestone Geosite 41 – Nascentes e Grutas Ceita Corê = limestone Geosite 42 – Buraco do Japonês/dos Fósseis = limestone Geosite 43 – Gruta e Nascente do Rio Formoso = limestone
7. Chapada dos Guimarães (MT)	Geosite 03 – Casa de Pedra = sandstone Geosite 14 – Caverna Aroe Jari = sandstone Geosite 15 – Caverna Aroe Jari – Lagoa Azul = sandstone
9. Seridó (RN)	Geosite 01 – Serra Verde = granite Geosite 13 – Gruta da Caridade = marble
10. Quarta-Colônia (RS)	Geosite 08 – Gruta do Índio = sandstone
11. Caminhos dos Cânions do Sul (RS/SC)	Geosite 01 – Furnas de Sombrio = sandstone Geosite 04 – Furnas Índios Xocleng = sandstone Geosite 06 – Morro dos Conventos = sandstone
12. Serra da Capivara (PI)	Geosite 05 – Toca do Sítio do Meio = siltstone Geosite 08 – Toca da Entrada do Pajaú = sandstone Geosite 09 – Toca do Pajaú = sandstone Geosite 10 – Toca do Barro e Toca do Inferno = conglomerate Geosite 11 – Toca da Entrada do Baixão da Vaca = sandstone Geosite 12 – Trilha do Boqueirão e Toca do Paraguaio = sandstone Geosite 17 – Toca do Caboclinho = sandstone Geosite 18 – Toca do Vento, Capim, Dedo e Castiçal = sandstone Geosite 19 – Toca do Cabloco da Serra Branca = sandstone Geosite 20 – Toca da Extrema = sandstone Geosite 21 – Toca da Passagem = sandstone Geosite 22 – Toca do Olho D´Água da Serra Branca = sandstone Geosite 23 – Toca da Mangueira do João Paulo = sandstone Geosite 25 – Toca do Estevo ou da Onça = sandstone Geosite 26 – Circuito da Pedra Caída/Toca da Invenção = sandstone Geosite 27 – Toca do Alexandre = sandstone Geosite 28 – Toca da Ema do Sítio do Brás I = sandstone Geosite 29 – Toca da Roça do Sítio do Brás I = sandstone Geosite 30 – Toca da Janela da Barra do Antonião = limestone Geosite 31 – Serrote do Tenente Luiz = limestone Geosite 32 – Toca dos Pilões = limestone
17. Costões e Lagunas do Estado do Rio de Janeiro (RJ)	Geosite 01 – Costão de Ponta Negra = orthogneisse Geosite 03 – Promontório Igreja de N.S. de Nazaré = orthogneisse Geosite 07 – Ilha do Cabo Frio = granite

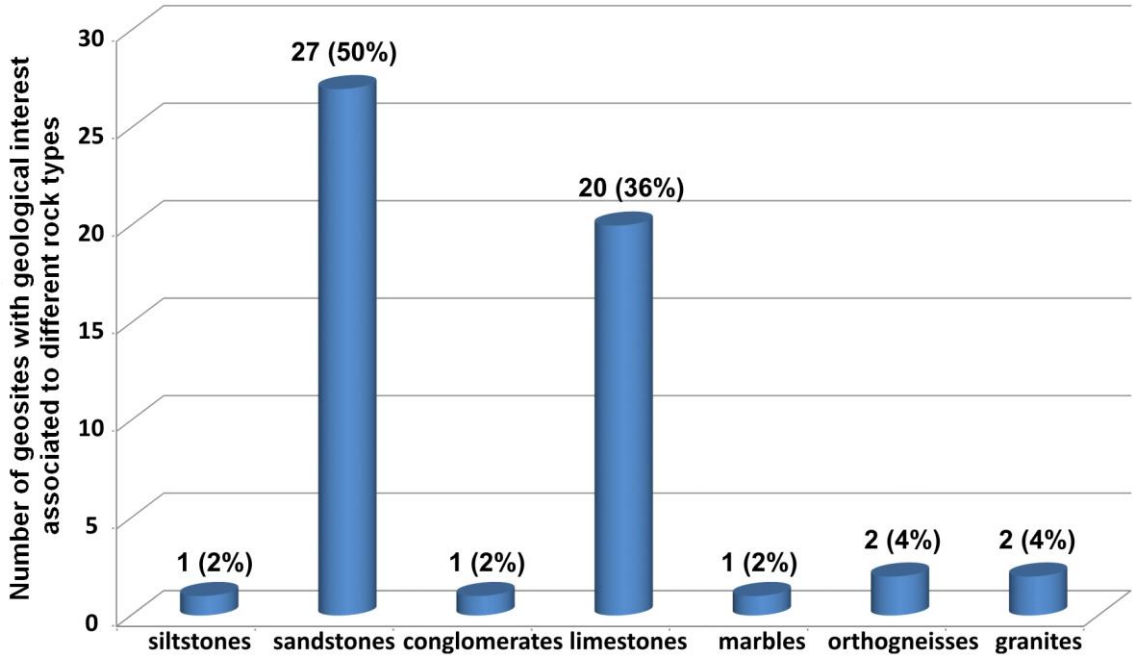

Fig. 9 - Number of geosites with geological interest associated to different rock types in the geopark proposals (total of 54 geosites inventoried). The predominance of geosites in siliciclastic rocks (conglomerates + sandstones + siltstones), with 29 geosites, representing 54% of the total, is clearly visible.

Table 7. Identification of the lithological units for each geopark proposal.

Geopark Proposal	**Lithologies**
1. Cachoeira do Amazonas (AM)	Sandstones of the Nhamundá Formation of the Trombetas Group.
2. Morro do Chapéu (BA)	Limestones of the Salitre Formation of the Una Group. Siltstones and limestones of the Caboclo Formation of the Chapada Diamantina Group.
4. Astroblema de Araguainha-Ponte Branca (GO/MT)	Sandstones of the Aquidauana Formation of the Itararé Group.
5. Quadrilátero Ferrífero (MG)	Limestones of the Gandarela Formation of the Itabira Group.
6. Bodoquena-Pantanal (MS)	Sandstones of the Aquidauana Formation of the Itararé Group. Limestones of the Cerradinho e Bocaina Formations of the Corumbá Group.
7. Chapada dos Guimarães (MT)	Sandstones of the Furnas Formation of the Paraná Group. Sandstones of the Alto Garças Formation of the Rio Ivaí Group.
9. Seridó (RN)	Granites of the Dona Inês Intrusive Suite. Marbles of the Jucurutu Formation of the Seridó Group.
10. Quarta-Colônia (RS)	Sandstones of the Serra Geral Formation of the São Bento Group.
11. Caminhos dos Cânions do Sul (RS/SC)	Sandstones of the Botucatu Formation of the São Bento Group. Sandstones of the Rio do Rastro Formation of the Passa Dois Group.
12. Serra da Capivara (PI)	Sandstones of the Cabeças Formation of the Canindé Group. Silstones, sandstones and conglomerates of the Ipú Formation of the Serra Grande Group. Limestones of the Barra Bonita Formation of the Casa Nova Group
17. Costões e Lagunas do Estado do Rio de Janeiro (RJ)	Granites of the Alcaline Complex. Orthogneisses of the Região dos Lagos Complexo.

6. FINAL REMARKS

The importance of a Geopark project, which allows the association of conservation and use of geologically significant sites (geosites) to the socio-economical and cultural development of the population of its territory is, in many countries, a well-established fact. The Geopark fosters the deployment of various lines of environmental education which include the physical basis (the geodiversity) and point out the close association between biodiversity and geodiversity, the latter supporting the former.

Brazil has a rich geodiversity, and could not let pass this opportunity to become engaged in this new trend. In fact, a number of federal, state and municipal organisms, plus universities and other institutions are already promoting a series of actions aimed at the establishment of geoparks in its territory. Besides CPRM – Serviço Geológico do Brasil, some examples are the Universidade Estadual

de Ponta Grossa and Minérios do Paraná-Mineropar; Prefeitura de Guarulhos, São Paulo; and Serviço Geológico do Estado do Rio de Janeiro - Diretoria de Recursos Minerais.

The geosites in the geopark proposals address different interests: stratigraphic, geomorphological, tectonic, paleoenvironmental, metallogenetic, paleontological, igneous, mineralogical and speleological. Focusing on this last interest, an analysis shows that out of the 17 proposals, at least 11 of them have one or more geosite(s) related to speleological heritage. Among those, a few stand out, like the Serra da Capivara/PI (with 21 geosites related to speleological heritage, in a total of 37 geosites), Bodoquena-Pantanal/MS (12 in a total of 45) and Morro do Chapéu/BA (5 in a total of 24). Percentagewise, Serra da Capivara/PI is the leader, with 57% of geosites with speleological interest, followed by Bodoquena-Pantanal/MS with 27%, and in third position comes Cachoeira do Amazonas/AM, with 25%. Of the total of 362 geosites listed in the 17 geopark proposals, about 15% are related to speleological interest. This is a low percentage, brought about mainly by the fact that six proposals - Pireneus/GO; Fernando de Noronha/PE; Ciclo do Ouro, Guarulhos/SP; Uberaba-Terra dos Dinossauros do Brasil (MG); Campos Gerais/PR e Litoral Sul de Pernambuco/PE - do not have any geosites of this kind. Overall, with 54 geosites of speleological interest in 17 proposals, the average comes to a little more than 3 geosites related to speleological heritage per proposal, a low value if the enormous potential that Brazil has in this kind of heritage is taken into account.

Regarding the lithological type to which these cavities are associated, in the 17 proposals, and limiting the analysis to those 54 geosites related to speleological heritage, 29, or 54% of them are related to sedimentary siliciclastic rocks (mainly sandstones); 21, or 38% are related to carbonatic rocks (limestones and marbles), and the remaining 4, or 8%, to the crystalline basement (orthogneisses and granites).

It must be pointed out that the speleological potential presented in these geopark proposals, according to the Brazilian law, must be initially protected by strategic actions for conservation. Only after these actions are implemented, can these areas be used for tourism and educational activities.

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GEOTOURISM POTENTIAL OF UNDERGROUND SITES IN COSTA RICA

POTENCIAL GEOTURÍSTICO DE LUGARES SUBTERRÂNEOS NA COSTA RICA

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Abstract

Although tourism is presently the main source of income of the Republic of Costa Rica, making an analysis of the offer and demand of the topic of "underground sites as tourist attractions", it is evident that in our country this activity is minimal, with percentage figures that are not even taken into account in the statistics. At government level, there's only one National Park whose focus is caves (Barra Honda); in this aspect, there's also very little and ambiguous legislation. At a private enterprise level, there are only five karstic underground sites worthy of mention, of which only two can qualify as 'business operations'. The other 3 are underground sites to which occasionally and informal visits are launched, but it is still difficult to find references, even in the web.

Key-Words: Caves; Underground tourist; Karst; Limestone; Tunnels, Costa Rica.

Resumo

Embora o turismo seja atualmente a principal fonte de renda da República da Costa Rica, fazendo uma análise da oferta e da demanda do tema de "lugares subterrâneos como atrações turísticas", é evidente para os autores que na Costa Rica esta atividade é mínima, com percentuais que não são sequer tidos em conta nas estatísticas. No âmbito governamental, só há um parque nacional cujo foco é cavernas (Barra Honda). Neste aspecto, há também pouca legislação, e também ambígua. Ao nível privado, há apenas cinco lugares subterrâneos cársticos dignos de referência, dos quais apenas dois podem ser qualificados como operações comerciais. Os outros três são lugares subterrâneos com visitas ocasionais e informais, sobre as quais ainda é difícil encontrar referências, mesmo na rede mundial.

Palavras-Chave: *Cavernas; Turismo subterrâneo; Carste; Calcário; Túneis, Costa Rica.*

1. INTRODUCTION

Costa Rica, despite its small land area (51,100 km^2) offers great biological and geological diversity, presenting attractions such as active volcanoes, sandy beaches, waterfalls, reefs, islands, caves and mine tunnels. Some of these attractions are quite exploited by tourism in general (i.e., volcanoes and sandy beaches), others as "adventure tourism" (i.e., caves), while others are potentially exploitable for rural tourism (i.e., mine tunnels). This article focuses on the underground tourist attractions (caves and tunnels) that are currently exploited or could be exploited in the future, which may have a high scenic, geological, historical or educational value.

One of the main economic activities in Costa Rica is tourism, reaching 9,1% of the Gross National Product during 2012 (La Nación, 2013). Tourists who come to Costa Rica are looking mainly for adventure, ecological and nature tourism. Although many of the country's tourist attractions have strong geological component (i.e., Poás, Irazú, Rincón de la Vieja volcanoes), it is considered that there is insufficient information available as to geotourism in the country and very few studies have addressed these issues (Campos; Astorga, 2010; Ulloa et al., 2011; Bundschuh et al., 2007).

The first National Park in Costa Rica (Poás Volcano National Park) was created in 1971 and since then, gradually an extensive protection system has been established, initially and fundamentally for the protection and conservation of the unique biodiversity that characterizes this small country.

Afterwards, the option of making the Parks available to tourism aroused an activity that, in this specific aspect, still continues to be a function of second instance. According to the National Institute for Biodiversity today approximately 25,1% of the territory of Costa Rica consists of National Parks,

Biological and/or Forest Reserves, Wetlands and other forms of protection, including two parks declared "World Heritage" by UNESCO. Forty four percent (44%) of that total is in the hands of private enterprises, especially in categories such as buffer zones, forest reserves and refuges. For its better management, 11 Protected Areas have been established, which break down to 162 Protected Areas (INBIO, 2013).

1.1. General geological aspects

Costa Rica corresponds to an island-arc caused by subduction, a phenomenon that occurs since the Upper Cretaceous. The recent volcanic arc has a NW-SE axis, with active volcanoes from the North part of Costa Rica to the Turrialba volcano. Between Turrialba and Barú (in Panama) volcanoes exists a gap in the recent volcanic activity; these area corresponds to the Talamanca Range. Also Tertiary volcanism is present (Aguacate Group, Sarapiquí Formation), that presents some ore, with presence mainly of gold and silver (figure 1). These mineralizations has been exploited (principally as underground mining) since colonial times (Ulloa, 1979).

During the geological evolution, different episodes of carbonate deposition have presented in the forearc, intra-arc and back-arc basins, which led to the deposition of limestone from the Cretaceous to Recent (Figure 1), in which karst occurs (Ulloa et al., 2011).

This geological diversity present in Costa Rica has led to the existence of several underground sites with geotourism potential. Undoubtedly, the most important are caves of karstic origin, but also some volcanic caves have been recognized (none currently exploited for tourism), as well as tunnels (mainly for mining), which have a geotourist and archeological potential. In Costa Rica, approximately 2000 km^2 correspond to karstic regions (Figure 1) and contain many caves that have been explored since the late 1960's by national and international speleological groups.

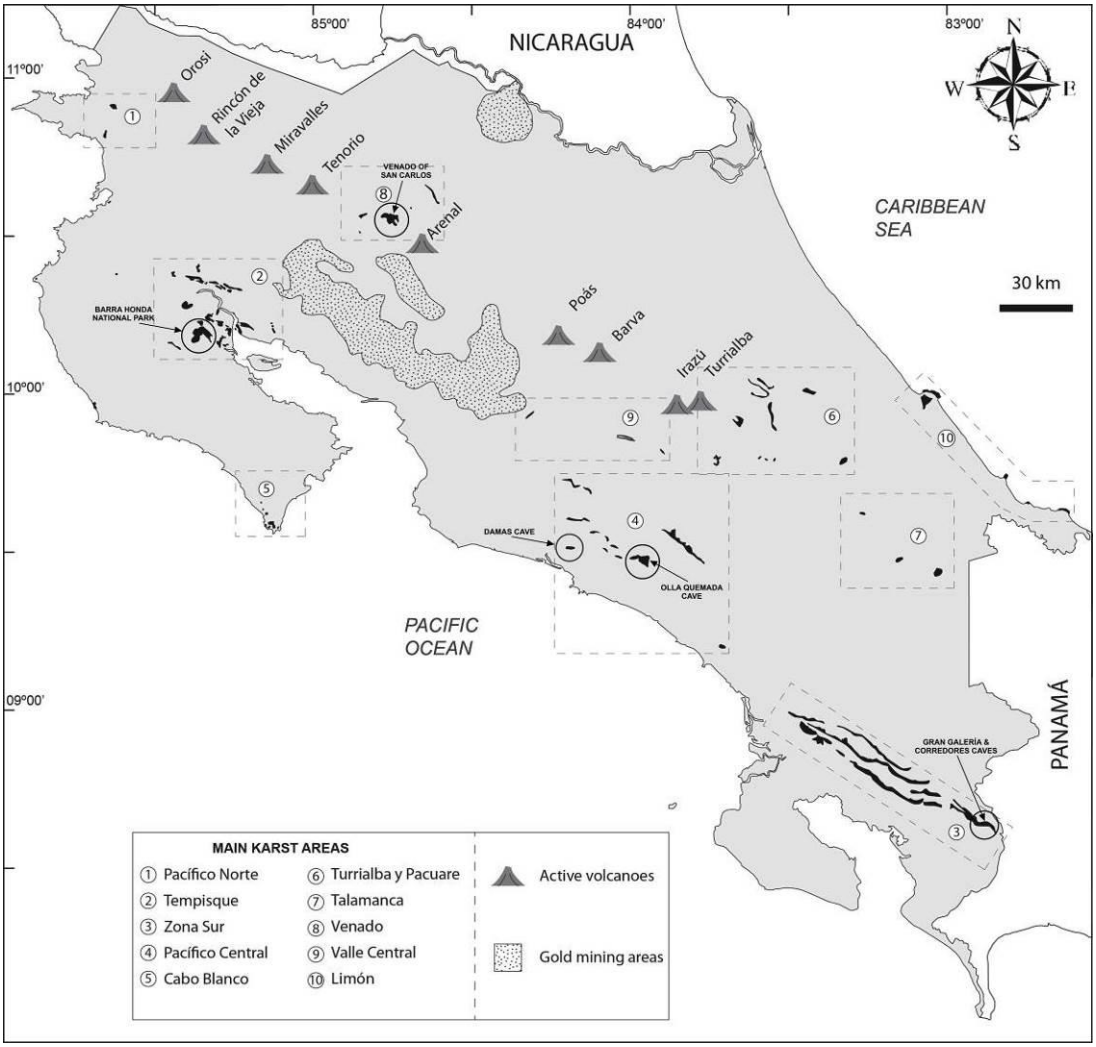

Fig. 1 - Map of Costa Rica showing the different limestone-karst areas, cave sites, active volcanoes and gold mining areas. Modified from Denyer; Alvarado (2007), Ulloa et al. (2011).

1.2. History of speleology in Costa Rica

There are reports of known caves in Costa Rica since the early 17th Century, but it is only after the early 60's that exploration of the caves of Costa Rica begins, with the arrival to the country of renowned French caver Robert Vergnes, who performed the first speleological recognition in Venado cave (a.k.a. Gabinarraca, Venado of San Carlos, Alajuela). During 1967, with the arrival of Catalan caver Juliá González Mateus, the Grupo Espeleológico (GE) is founded, as part of the Mountaineers Club of Costa Rica.

The first karst area that was explored in detail in the country was the Tempisque region (Ulloa et al., 2011), specifically the Barra Honda hills. Both national groups (The GE) and international (Cave Research Foundation, National Speleological Society) participated in these explorations, that led to the creation of the Barra Honda National Park in 1974 (Goicoechea et al., 2009).

Starting in the early 90's, there were important explorations in the south section of the country as well as in Barra Honda: Société Suisse de Spéléologie (SSS), Gruppo Grotte Carlo Debeljak (GGCD) and others (Hapka et al., 1992). In 1995 the Anthros Speleological Group (GEA) is created, which has carried on extensive speleological research, is in charge of the National Cave Register (Speleobase) and has extended its activity to other Central American nations.

The designation of the caves of Barra Honda as National Park marks the beginning of tourism in the caves in Costa Rica, at an enterprise level, with facilities that allow safe visiting for the tourists and for the site. Starting in 1976, cave tours are offered at Gabinarraca Cave (Venado), with a fairly simple infrastructure and gradually, all the others that will be referred-to in this paper.

1.3. Summary of the mine tunnels in Costa Rica

Costa Rica owes its name to the fact that when it was discovered in 1502 by Christopher Columbus, the natives wore many gold ornaments; that was associated by the Spaniards with a wealth that came from placer gold fields, possibly at Costa Rica's South Pacific region (Ulloa, 1979; Durango, 1961). According to Ulloa (1979), there were some mines near the Central Valley that were exploited by the Spanish. Ulloa also indicates that the first accidental discovery of mineral deposits of gold was by the Nicaraguan bishop Fray Nicolás García, in the Montes del Aguacate, Alajuela. Afterwards several other mining spots were opened (mainly underground mining), in different parts of the country (Abangares, Guacimal, Miramar and Aguacate), primarily for gold extraction (Figure 1). Besides Gold, there are other mineral manifestations that have been studied that required tunneling, such as Manganese (steel manufacturing, exploited during World War I), Silver (near the Central Valley and Cartago), Lead and Zinc (Central region and Monteverde) and Copper (mainly in the Talamanca Range & foothills) (Ulloa, 1979; Castillo, 1997). This mining activity led to the creation of several mine tunnels (for exploration and exploitation); according to Ulloa (1979), more than 186 mines and mine shafts were recorded by 1979. Most mining tunnels are in the Aguacate Mountains, Abangares, Miramar, Guacimal and some isolated ones around the Central Valley, Talamanca and Santa Rosa of Monteverde.

2. PRESENT SITUATION OF TOURISTIC CAVES IN KARST AREAS

The main tourist activity in subterranean sites of Costa Rica corresponds to tourist caves. These are distributed throughout the country, in different karst areas (Figure 1). In this section we discuss all the natural sites having tourism in Costa Rica, detailing each one of them, and in a summary. Table 1 shows the main tourist caves of Costa Rica by karst region.

Table 1. Major tourist caves of Costa Rica.

Karst region	Place	Tourist caves	Province
Tempisque	Barra Honda National Park.	Terciopelo and La Cuevita	Guanacaste
Venado	Venado of San Carlos.	Gabinarraca	Alajuela
Central Pacific	Damas of Parrita.	Damas and	Puntarenas
Central Pacific	Piedras Blancas of Pérez Zeledón.	Olla Quemada	San José
Southern region	Ciudad Neily	Gran Galería and Corredores	Puntarenas
Central Valley	Fossil Land, Patarrá.	Abismo Oscuro	San José

2.1. Barra Honda National Park

The Barra Honda National Park (2,295 hectares) is located in the province of Guanacaste. It was created in September of 1974 for the protection of the karst land and corresponds to the only region that has a karst protection status. The park presents some karst features as *mogotes*, karren, travertine waterfalls, sinkholes, springs and more than 50 caves (Wells, 1974; Mora, 1981; NSS, 1989; Ulloa, 2009; Ulloa et al., 2011). This karst area is located in the Barra Honda Formation, and consists of a carbonate platform (Mora, 1981, Calvo & Bolz, 1987) with Upper Paleocene age. Only 29 caves (58%) have been properly cataloged and surveyed. Caves present mainly vertical passages (deepest cave is 125 m); because of this reason, they are difficult to offer as a tourism activity.

The Park has two touristic caves: Terciopelo and La Cuevita. Terciopelo cave (Figure 2) was discovered by the Grupo Espeleológico (the GE.CMCR) on February 23 1969, as part of an exploratory cycle initiated by the Group in 1967, which lasted until 1974. In 1973, these hills and the immediate surroundings were studied by the Cave Research Foundation (CRF) and in 1982, the National Speleological Society (NSS) continued with the work. *La Cuevita* was discovered by the GE in 1971. It is located in the central and western part of the plateau of the hill.

Terciopelo Cave is the principal tourist cave in the park. It is a small cave (41 m depth, 92 m length; Figure 2). This cave has a vertical shaft, enabled by a rigid ladder (installed by the *Grupo Espeleológico Anthros* -GEA- in 2004) to facilitate the descent into the cave. The GE also conditioned properly the internal tour trails, which included installing another small internal staircase (Quesada et al., 2006). Climbing equipment is needed (provided), as well as an Official Guide and the Park's Service permission (in advance). The groups are around 10 visitors and the tour lasts about an hour; the attractions are speleothems, the vertical shaft and a small chamber, as well as observing the cave fauna.

La Cuevita (the Little Cave) is a very small cave (5 m depth, 17.2 m length). Consists of a single room handsomely decorated, suitable for the visitation of children and 'slim' persons, because its entrance is quite narrow, even after it was extended a bit. As in all of the caves in the Park, the visitors need to enter in the company of an official guide.

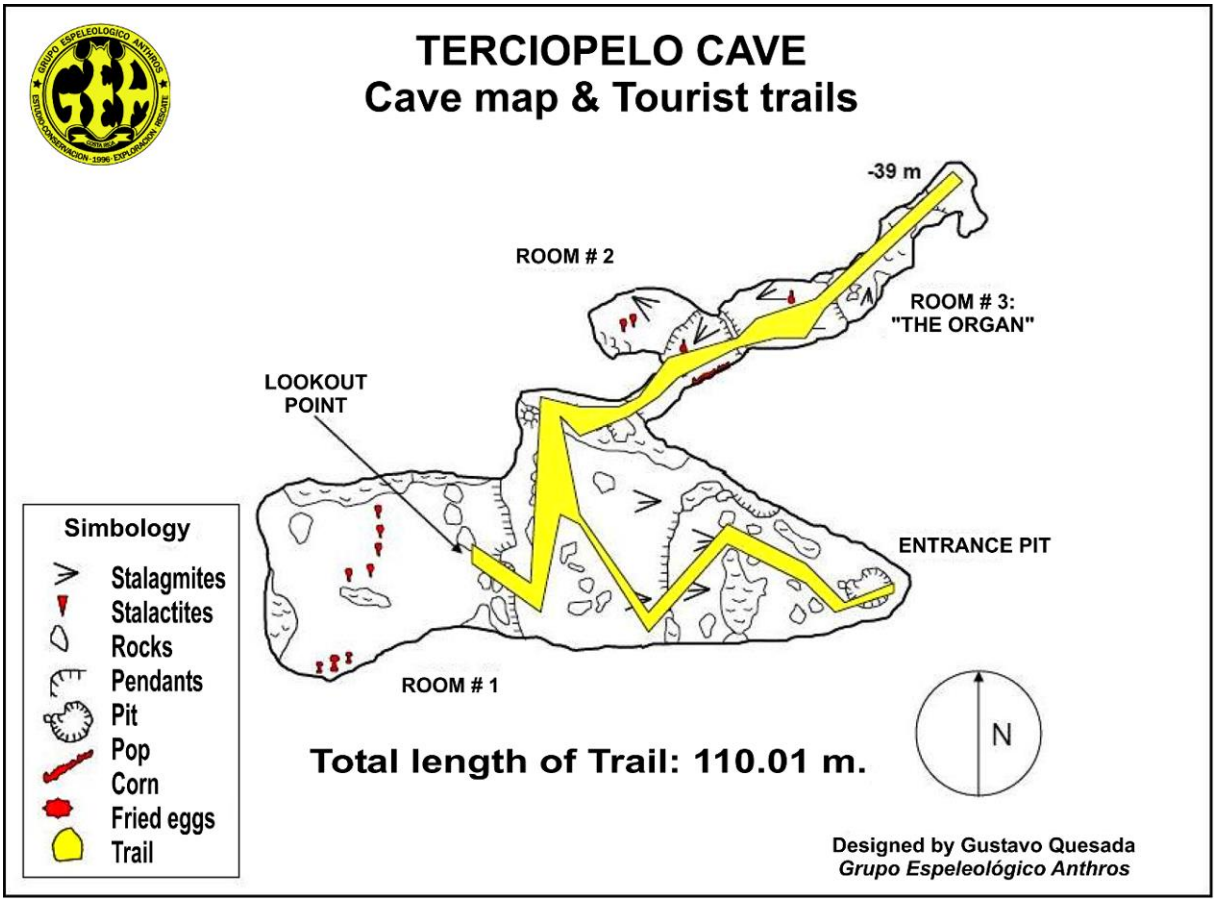

Fig. 2 - Map showing the re-conditioning in Terciopelo cave (GEA, 2003).
The use of this path, allows the visitors to fully appreciate its beauty, without causing major damage.

Barra Honda National Park also offers hiking trails through the tropical dry forest (mostly secondary) and spectacular views of the Tempisque Valley and the Gulf of Nicoya. There are cabins and camping area with drinking water and sanitation. Climate is warm and dry from December through April and then hot and humid for the rest of the year. Any time of year, it can be expected to see howler monkeys (*Congos*), deer, raccoons, peccaries, marten, agoutis and anteaters. Also to observe are 'Rimstone dams' on the East side of the Barra Honda hill, surrounded by secondary forest. The Barra Honda National Park is part of the Tempisque Conservation Area, is open from 8:00 a.m. to 3:00 p.m. and the entry fee is $ 10 per person (Foreign visitors).

2.2. Venado of San Carlos

The town of Venado is located in the northern-central region of Costa Rica, 180 km from San José. Near to this area are located other geological attractions like Arenal Volcano, hot springs, waterfalls, rivers and lakes. This zone has a karst area of approximately 21 km^2 and a total of 39 caves have been recognized in it (Speleobase, GEA, 2013). The limestone belongs to the Venado Formation, is stratified and associated with a carbonate sand bar system (Obando, 1986; Calvo & Bolz, 1987). This formation has an age of Middle to Upper Miocene (Malavassi & Madrigal, 1970; Sem Gupta et al., in Obando, 1986). Some karst features are conic karst, springs, sinkholes, dry rivers, blind valleys and caves systems (Ulloa et al., 2011).

In this region the main economic activities in the area include dairy farming and the production of sugar-cane, pineapple, oranges and tubercles. Cave tourism is one of the main attractions; one can visit Gabinarraca Cave or as it is popularly known, Venado Cave. This cave seems to have been known by the Guatuso aborigines that inhabited the area; however, so far no evidence has been found associated as to them visiting or using the cave. The cave was re-discovered around 1948 and its technical exploration started in 1968, by the *Grupo Espeleológico*. This cave was also explored in the 80's by geologists looking for oil and coal in the area, by the NSS on an expedition in 1991 and by *Grupo Espeleológico Anthros* cavers, starting in 1996 till the present day.

Gabinarraca cave is the biggest cave of Costa Rica (2741 m length and 41 m of height difference). It is a cave with five entrances, with passages that have an interlocking pattern, with dry and wet sections. It has at least three vertical levels, the lower generally corresponds to the wet sections (Figure 3). The main attractions are speleothems (stalactites, stalagmites, columns, flowstone, curtains, etc), large colonies of bats, underground fish, amphibians and insects, such as spiders and crickets. The average temperature inside the cave is 22 º C.

Tour operations were formally launched in 1976, reaching in 1996 a peak close to 500 visitors per week. Derived from a problem with some tourists becoming infected with Histoplasmosis in October 1998 (61 children and 14 adults), the cave was closed for a couple of months. From that date on, the number of visitors dropped to about 500 visitors per month. Presently, the owners provide and recommend the use of paper masks. The site counts with adequate infrastructure, such as toilets, showers and a large saloon that serves as lounge and restaurant (meal services have to be previously requested).

The Administration usually keeps 2 or 3 permanent guides, but in case of tours with many participants (reservations required), they summon additional guides. The duration of the tours is approximately 2 hours, with a maximum of 10 to 12 individuals. Regular tours do not cover the entire cave, but a just a selected portion. Signs indicating where the exits are have been posted, in case of an emergency evacuation. As part of the entry fee a clinical type mask is included, to cover nose and mouth, in order to avoid possible infection by Histoplasmosis. Its use is optional. All visitors, at the conclusion of the tour, are advised to take a shower and change clothes. The schedule is every day from 7 a.m. to 5 p.m. Camping is allowed on the property. There are also several informal restaurants in the town of Venado, just 2 km away.

2.3. Central Pacific: Damas and Olla Quemada caves

The Central Pacific karst region (Figure 1) presents 57 km^2 of limestone, in which so far eight caves have been recognized (Ulloa et al., 2011). In this area, the layers of limestone are not very extensive and the main karst manifestations are sinkholes, springs and caves. The limestone has been defined as Middle Eocene in age, according to Malavassi (1961). Two tourist caves are the ones of our concern: Damas and Olla Quemada.

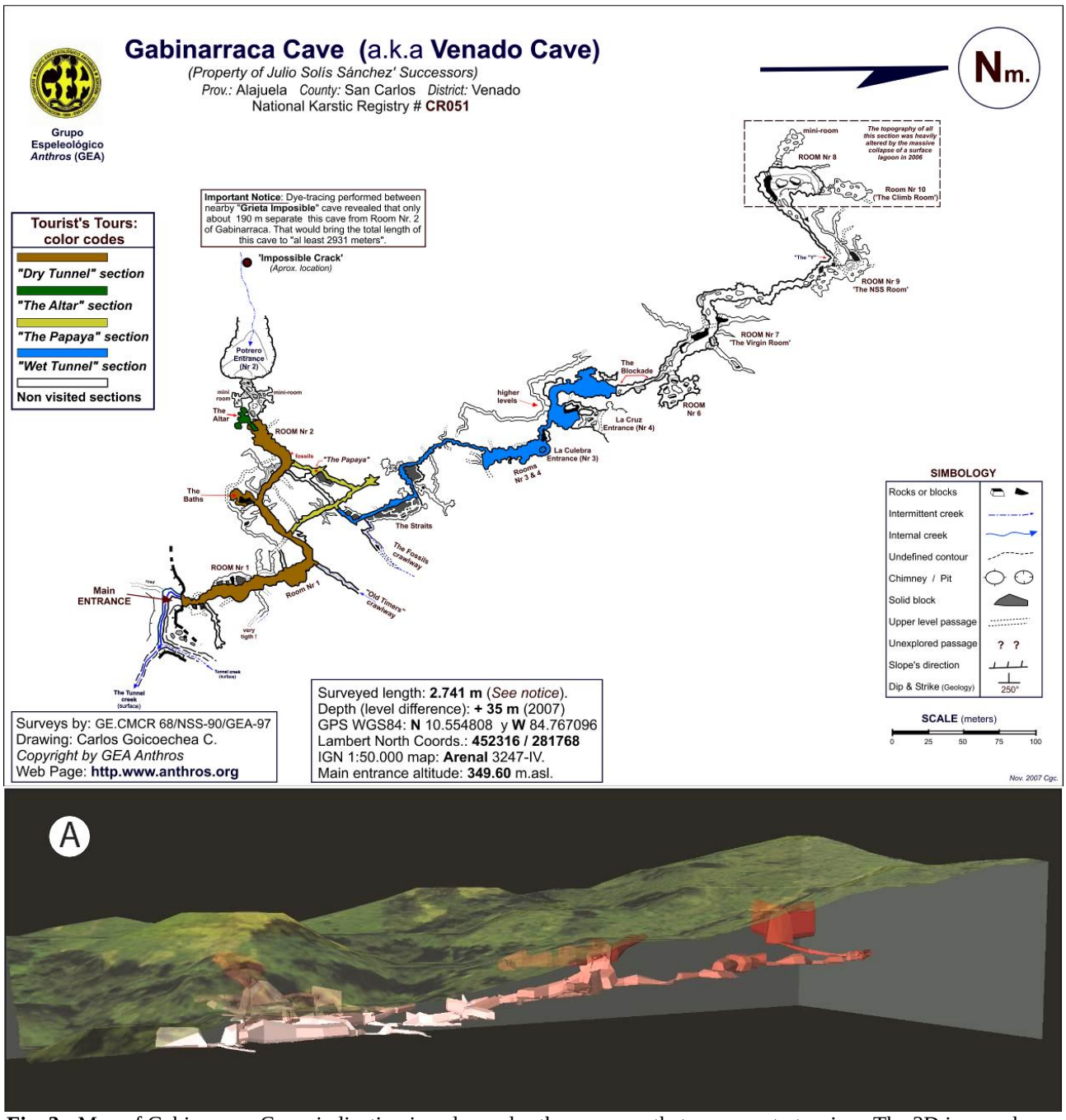

Fig. 3 - Map of Gabinarraca Cave, indicating in color codes the passages that are open to tourism. The 3D image shows the shape of the cave, related to the surface features. Modified from (GEA, 2007).

Damas cave is located 16 km northwest of the Quepos (touristic town) and 9 km to the north of the *costanera* road (CR-34). It became known in recent times, circa 1925. In 1960, the first cave map was drawn, using only a compass and tape (Contours not shown). During October 2006, GEA cavers and a member of the NSS surveyed the cave in detail. This cave presents 286.4 m in length and 21.6 m of depth. The cave has 3 entrances. Damas Cave (Figure 4) is named after the Damas River, which runs just outside the cavity, on its NW flank. No water circulates inside, but there are some sections with mud and puddles. This cave is horizontal and relatively easy, but has some crawlways that are quite narrow. It is the home of thousands of bats; a species caught was identified as *Saccopterix* sp. There are many spiders, crickets, cockroaches and other troglobite insects that live permanently in it. Until the end of 2006, the cave was shown in tours to organized groups of visitors, offered by the owners of a small private reserve (356 hectares). The full day tour included horseback riding and other activities, such as trekking and bird-watching. Some nearby outdoor river pools allow for a refreshing swim (ESCAPE VILLAS, 2013). Presently, the farm seems to have new owners that allow visiting.

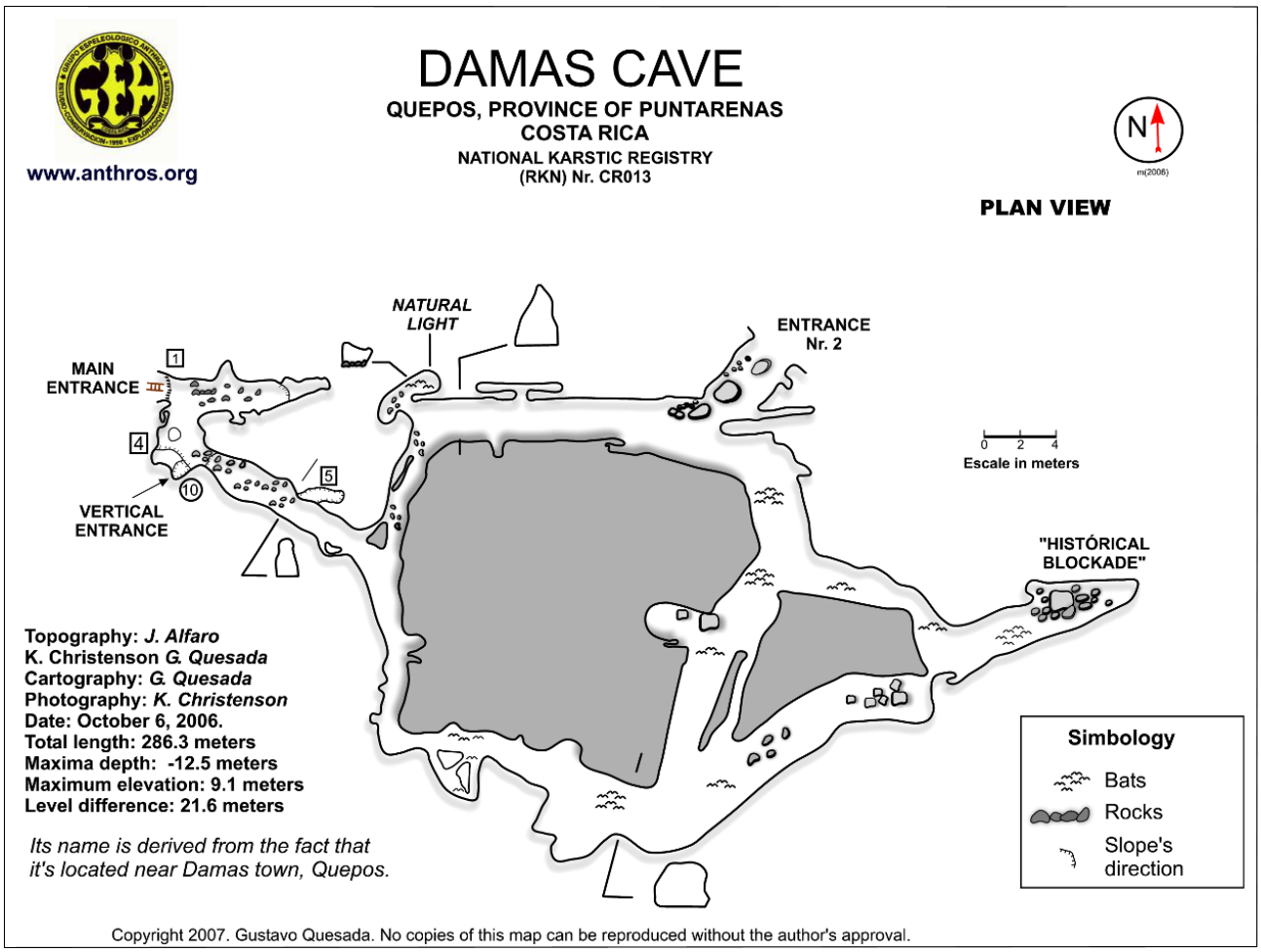

Fig. 4 - Map of Damas Cave (GEA, 2006).

Olla Quemada cave is situated in the limestone hills that rise south of the small town of *Piedras Blancas* de Brujo, on the south bank of the Savegre River, about 37 linear km WNW of the port of Quepos, an important tourist destination. *Piedras Blancas* can be accessed only by hiking or a horse ride; there are three possible routes: *Cerro Nara*, *el Brujo* and *La Chaqueta*; all require hiking through the tropical forest. A local guide is needed to reach the cave and the final route up to the cave is a rustic trail, in which even horses have difficulty going up. This cave has been known to scouts and locals since around 1985, but was re-discovered by some members of the Costa Rican Speleological Association (AEC) in September 12, 1987. Carlos Goicoechea drew the first 'sketch' of this cave. In August 2009 the cave was visited by Keith Christenson, of the NSS, who located it with a GPS and provided some modifications to the initial sketch map. During 2010, GEA performed another survey and completed the exploration of the entire cave (Figure 5). A total depth of 57 m was reached, besides completing the map of the 346 m of its length.

Olla Quemada cave does not exhibit a profusion of formations, except in the Hall of Columns and there are some passages with an important amount of sediments. The main entrance is inclined and opens 1.40 m above the ground, at the base of a muddy wall. It has 4 meter wide and 1.40 m high, surrounded by jungle. Entrance Nr 2 is a sinkhole about 2 m in diameter that drops 12 meters to the cave's floor. After this entrance opens Room Nr 1 on the left side (Esperanza Room, aka the Column's Room), which ends in 2 chimneys that lead vertically to the outside. Following a fairly straight line, the visitor continues along the main passage, up to 10 m high, passing on the left side by Room Nr 2 (Don Lulo's Room) and then on forward to Room Nr 3. Here starts a narrow dirt-floor gallery, with a low ceiling (2 m high), which leads to Room Nr 4 (The Dome Room), up to 10 m high. At point 'C' (on the map), on the right side, starts a tight fracture, at the end of which opens 'Andy's Crawlway', only 0.40 m high. This catwalk becomes vertical, shaping into 3 short consecutive tight pits - (5, 4 and 8 m)- that sort of "corkscrew" down to a point where one can not go on any further. Tourist tours correspond to the main passage. There is also much guano throughout the cave and bats, spiders, crickets and similar insects. The cave is located in an area where the primary forest has been rather

intervened by agriculture and livestock practices developed by residents of neighboring communities. That could account for the eroded material. This cave is in a private property, owned by Neftalí Granados Elizondo, a resident of Piedras Blancas of Savegre.

This whole area is beginning to organize for the proper reception of tourism. COOPESAVEGRE (a Cooperative) has outlined a comprehensive plan entitled "Agro-ecotourism as a source for the improvement of the revenue to the inhabitants of the Savegre River Watershed". There are many lodging options, varying from tent camps to hostels, with optional food service. Tours for foreigners are advertised in the Web (The Costa Rica online, 2013).

2.4. Southern Region: Grand Gallery and Corredores caves

This region is the one that presents more karst surface (185 km^2) and caves (156); located in the Sothern Region of Costa Rica, it presents many limestone outcrops along the *Fila Costeña* Range (Ulloa et al., 2011). These limestone beds correspond in age mainly to Middle to Upper Eocene, according to Malavassi (1961) and a few to the Oligocene limestone (Yuan, 1984). The main karst features in the area correspond to sinkholes, dry rivers, blind valleys, karren, karst springs and travertine waterfalls.

There are two tourist caves: Grand Gallery and Corredores. Both are located on the SW flank of the *Fila de Cal* (in *Fila Costeña* Range), in the environs of Ciudad Neily. The Grand Gallery cave is the only one that offers organized tours. Corredores cave is visited by the annual speleological course of Grupo Espeleológico Anthros, and some occasional visits by locals and occasional foreign tourists.

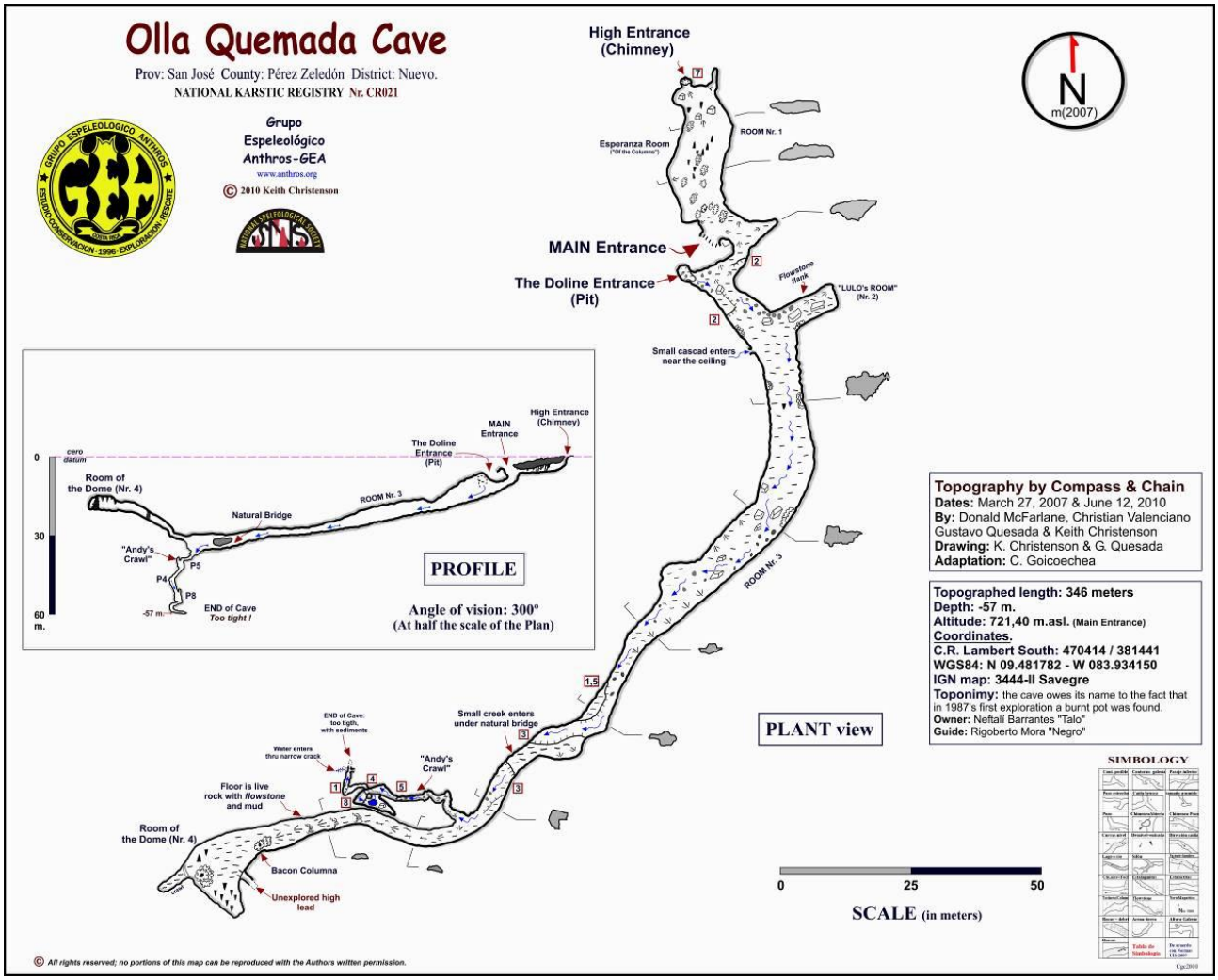

Fig. 5 - Map of "Olla Quemada" cave, drafted by GEA and the NSS between March 2007 and June 2010 (GEA, 2010).

Grand Gallery cave is located in the base of a cliff, inside a large sinkhole and present 3 access points. The cave was locally known, but was re-discovered by Gordon McCracken and Carlos Goicoechea in 1989. The farm where it is located belonged to a Panamanian nicknamed *"Chiricano"* (Jorge Vidal), but he sold it some years ago to Alvis Mora Salas. This man built a large house near the cavity and is starting to offer it as a "show-cave". For now, there is already a good path open to the entrance. This cave has 148 m length and 26,4 m depth, according to the NSS map (Figure 6). There is no running water inside the cave presently, but it is speculated that in the past the water of the Quebrada Seca (Dry Creek) flowed into this cave (Peacock; Hempel, 1993).

The tours offered in Grand Gallery cave include visiting the nearby Quebrada Seca sink and optionally, the entrance to a cave that is located at the sink-site, named Macameca. During the visit, a good description of both the flora and fauna that characterizes the region is provided by a professional in tourism. It can also be reached by means of a 26 m rappel from the top of the cliff atop the cave, an activity provided with an extra expenditure.

The business that manages the cave operates a web-site where there are information on topics such as wildlife and other appeals included in the tours, as well as accommodation and food facilities in the neighboring Ciudad Neily (Cavernas Guayabí, 2013). These tours have duration of 5 to 6 hours, the cost ranges from $ 20 (minimum 2 people) to $ 50 (single person). It is required to fill-in and sign a liability release form by the tour operator.

2.5. *Abismo Oscuro* cave (Dark Abyss)

This facility is situated at Quebrada Honda of Patarrá, about 10 km South of San José (30 minutes drive). It is within the *Fossil Land Complex*, on the farm of Otto von Schroeter. This region only has 6 km^2 of limestone outcrop and there are reports of only six caves (Ulloa et al., 2011). This is a bioclastic limestone, with abundant fossils (principally *Pecten* sp.) and of Miocene age. In general, there are some incipient karst features, like small caves (Ulloa et al., 2011). Fossils abound throughout the park, but especially on a large wall that is showcased to the tourist, where they can dig their own "souvenirs". This segment presents only one tourist cave, named *Abismo Oscuro* (Dark Abyss), also known as "Captain Tula's Cave" and / or Patarrá Pit.

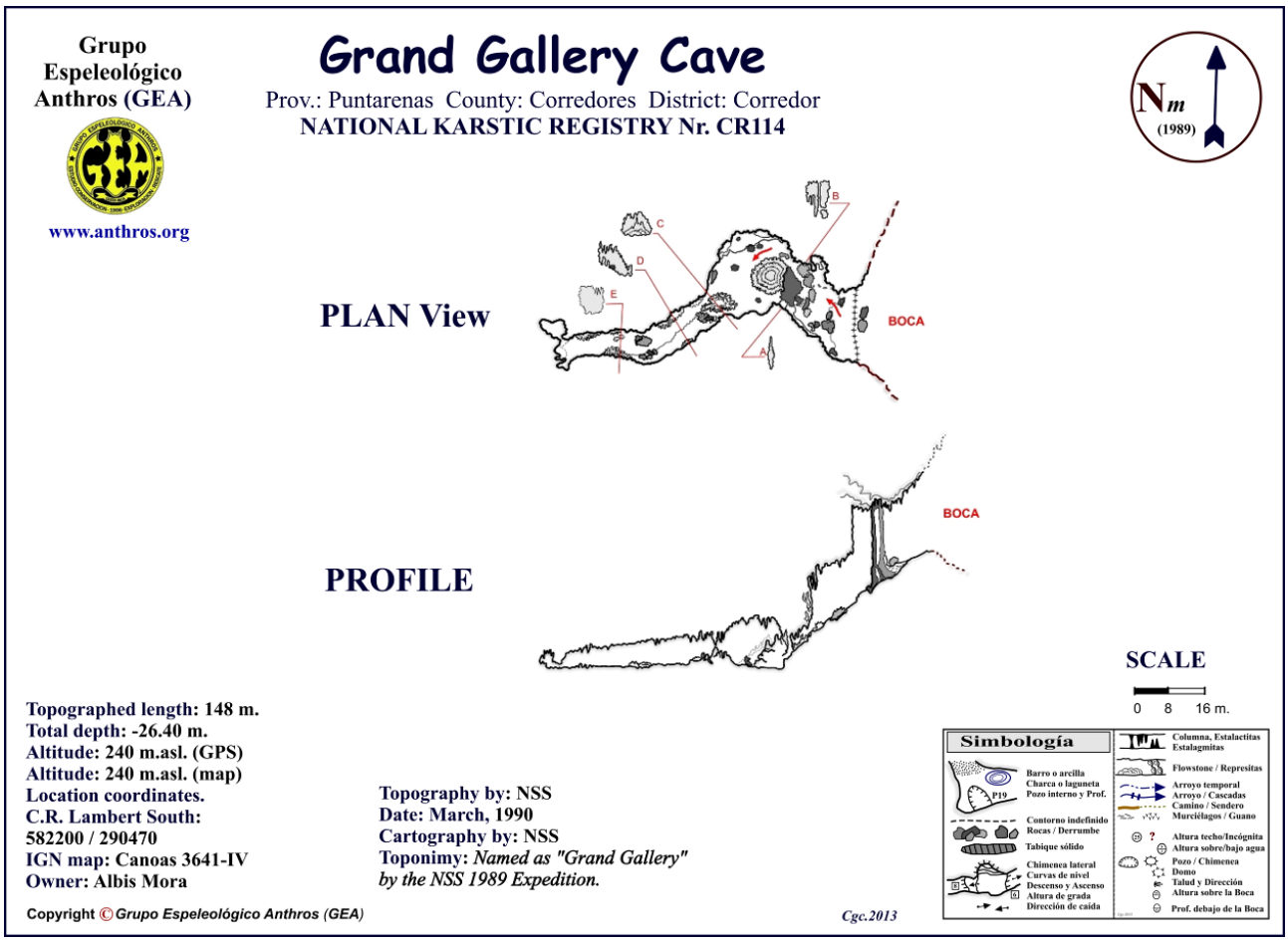

Fig. 6 - Profile and plant map of Grand Gallery Cave. Modified from Peacock; Hempel (1993).

Dark Abyss cave is small (69.5 m length and 24.1 m depth). This pit was probably discovered by a laborer of the von Schroeter farm, on an unspecified date. As early as 1968, there were speculations about 'chasms' and caves in this area. It appears that journalists from TV Channel 6 (REPRETEL, "The Explorer"), back in 2000, wanted to film and photograph the cave. This led to a power plant being introduced inside the cavity. The obvious results were air contamination and all of them had to be evacuated in an emergency. The *Asociación Espeleológica Costarricense* (AEC) apparently visited the site in 2002, but without issuing a report or sketch. GEA explored and surveyed it on July 2010 (Figure 7), and since then it is used as a practice site added to the caving courses that are taught. Proprietor is Mr. Otto von Schroeter (and family).

"Fossil Land" keeps the place clean and has suspended the extraction of limestone in the area where the cave is located. There is entirely no water inside the cave, except that which enters during rainfalls. Air circulation inside the cave isn't ideal, gases seem to pile-up and stagnate, but not to the point of being critical. The venture's owners have installed three metal ladders, so no rope work is necessary, unless one wants to avoid the use of them and have fun on-rope. The site is a tourist operation since October 2001 and has a web page site (Fossilland, 2013). Among the attractions, it offers abseiling (rappel), caving, canopy for children, mountain bike, ATV, paintball, geological tours, climbing, camping and hiking. The Park is open Monday through Saturday, with previous reservation. On Sundays it operates from 9 a.m. to 4 p.m. The fares range from $ 11 to $ 67, depending on the amount of people and the number of attractions booked. Fast foods services have also been implemented.

2.6. Other tourism potential karst areas

There are some caves that are close to presently operating tourist places that have occasional visitation, which could well be used entrepreneurially for such purposes, according to its localization. La Capilla cave opens in Portete, close to the Port of Limón area; presently there's an on-going development of it as a modern port, with heightened tourism opportunities. Although historically it is mentioned since 'the 70's', it was not until 1994 that the *Centre d'Etude du Karst* inspected it (Guilli et al., 1994), but according to their description it was collapsed after the *Limón* earthquake, and has low tourism potential.

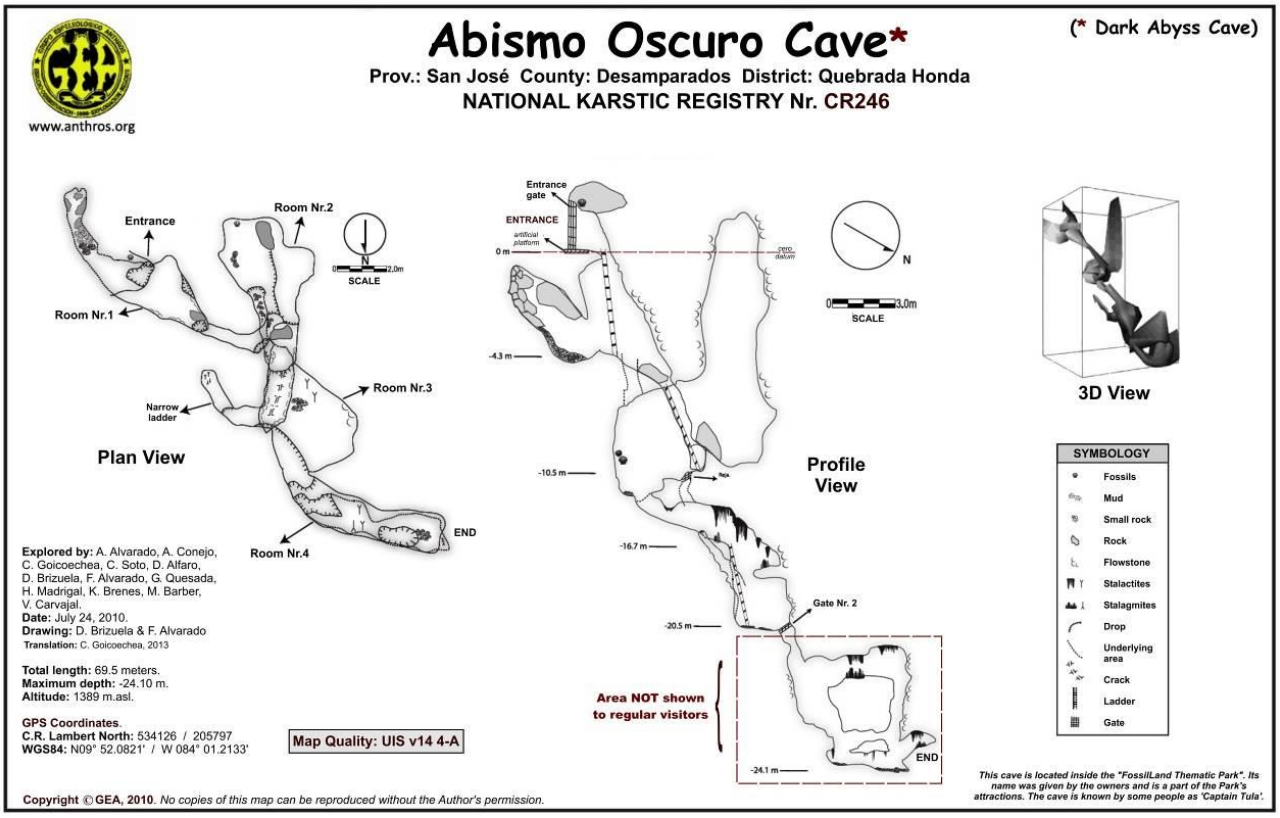

Fig. 7 - Plant and profile of the 'Dark Abyss', located in the "Fossil Land Tourist Complex", in Quebrada Honda of Desamparados, San José (GEA, 2010).

Malpaís is a rocky and sandy beach, located on lower western flank of the Nicoya Peninsula and frequented mainly by surfers. This is a small area with karstic signs (5 km^2) and according to Calvo (1987) the limestone is of Middle-Upper Eocene age. Anthros Speleological Group (GEA) has located, explored and surveyed some small sized caves: *Peñón cave* (a 16.6 meter long 'V'-shaped cave, with a sand & pebbles floor), *Pochote-115* cave (34.2 m long and 5 m depth), *La Grande* cave (The largest, 112 m long and 18 m deep, located inland); a beach rock-shelter is also present. This group of caves or grottos, located within a 200 by 250 meters area which lies between the Pacific Ocean and some small limestone hills that rise next to it, are a local attraction and are sometimes shown to tourists. There is no understructure at all, but they are located on a Protected Land Area (*Refugio de Vida Silvestre Cueva de Los Murciélagos*), which is part of the Cabo Blanco Absolute Natural Reserve. The largest ("La Grande",) is perhaps the only one worth while a visit of this type, since it consists of a larger 20 by 15 meter central room, out of which originate 3 galleries, the largest about 22 m long. It is fairly decorated, but has suffered a bit of vandalism.

3. OTHER NON-KARSTIC UNDERGROUND SITES WITH TOURISTIC POTENTIAL

3.1. Mine tunnels in Costa Rica

As discussed earlier, mining extraction of metals led to many mine tunnels being dug in different mine districts along Costa Rica. Among those tunnels, some are abandoned and others are still exploited, principally for artisanal mining (small-scale miners and "*coligalleros"*). As a result of this activity, in the highest production areas were left a large amount of tunnels and/or perforations, which reached important dimensions in both the horizontal and the vertical aspects. A few have been conditioned as tourism resources, in which the attractive of the perforations and other charms of the sector are combined, such as rivers, forests, swimming holes & pools, horse riding, ATV rentals, museums, etc. Incipient examples of this are happening in several places.

Where the Union Mine operated, in Desmonte of San Mateo (Alajuela), a small fee is charged for visiting 150 meters of partially illuminated and rustic mining tunnels, combined with the sale of meals and the opportunity to take a dip in the mountain stream that runs just alongside the tunnel. Parking and souvenir stores are available.

In the city of Abangares (Guanacaste) is the "Eco-Museum of the Abangares Mines", which displays large amounts of the machinery used in the extraction and transport of gold material. Right there was the largest operation center of the Abangares Gold Fields Company.

3.2. *Topolandia* Tunnels, San Pedro of Pérez Zeledón

The information available so far is limited. It's located on a 25 minutes drive from downtown San Isidro of Pérez Zeledón (Province of San José), on the Inter American Highway (CA-2). Upon reaching this town, it's 1 km to the northeast from the intersection of the secondary road that leads into San Pedro, adjacent to the Bailey bridge over the San Pedro River. "Topolandia" consists of artificial tunnels in weathered alluvial fans, some with chambers up to 15 m deep. In several artificially made and interconnected tunnels (Figure 8), the owner of the property has established a museum, exhibition hall, conference room and other facilities. Open all year round, 8 a.m. to 5 p.m. Fees: $ 4 adults and $ 2 children. It advertises 'controlled temperature' (between 18 ° and 24 ° C), mineralized drinking water from 2 wells (15 m deep pond), sculptures, stone beds, bathrooms and outside recreational areas. The tour lasts for 1 to 2 hours (Jara, 2013)

Figure 8. Aspect of part of the facilities at "Topolandia", seen from across the access road (Jara, 2013).

4. DISCUSSION

In Costa Rica, the use of caves for tourism purposes is a fairly recent activity. It began in 1974, with the declaration of the Barra Honda hills (Nicoya, Guanacaste) as a National Park, in order to protect the 50 caves discovered to that date. Even before this, some caves in different parts of the country were visited locally during holidays and

special occasions. Around 1976 starts the offering of tours at the Venado Cave, in San Carlos of Alajuela, and around 2002, *'Fossil Land Recreational Park'* opens, in Quebrada Honda of Desamparados (San José). Late in 2010, Grand Gallery Cave, in the southern zone of the country, joins the tourism offer. More recently, informal tours to Olla Quemada Cave (Savegre River, San José) began to be carried out, but without any special organization. Other caves, like Damas Cave, in Parrita and Corredores Cave, in the county of the same name (Both in Puntarenas province), are occasionally visited by tourists, both foreign and national, but there is no operational structure. Therefore it can be said that, although tourism is nowadays the largest source of national income, the share corresponding to 'cave related tourism' is quite low, representing an almost negligible part of the total.

A comparison of Costa Rica's tourist caves is presented in table 2.

Even though, in the aspect of 'using caves as a means of promoting tourism', the undertaking should come from the private sector, *Grupo Espeleológico Anthros* (GEA) -a non profit organization- is visualizing the option of proposing to the proper government officials that several specific karst areas be declared as "protected land". This project, nevertheless, is in the preliminary stages. There is a special interest in protecting the caves around Ciudad Neily, because there are some important karst systems, such as Quebrada Seca, Carma and La Bruja/Corredores, which have important springs.

Presently, Carma cave is a source of drinking water and is under partial administration by the local municipality and the AYA (National Water Administration Institute). This area covers an extensive basin, where several large caves open and has a hydrological connection with the next 'proposed' area, which drains into the Corredores River: the fault-line segment where the Quebrada Seca area caves are located, such as Grand Gallery and Macameca. This project should also comprise the "Bruja / Rectángulo / Tururún / Corredores System" (Corredores county, southern part of the province of Puntarenas).

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Table 2. Comparison of characteristics of the studied caves.

Data	Gabinarraca	Gran Galería	Abismo Oscuro	Olla Quemada	Terciopelo	La Cuevita (Grotto)
Visitors per guide	1 guide for up to 15 visitors.	1 guide for up to 10 visitors.	1-3 guides per group.	1 guide for up to 10 visitors.	1 guide for up to 10 visitors.	1 guide for up to 10 visitors.
Artificial light	No	No	No	No	Yes	Yes
Safety gear	Helmet, helmet-fixed light and rubber boots.	Helmet and light.	Helmet and a handheld flashlight.	No gear at all is provided. Flashlight used to be loaned.	Helmet, harness, belay rope & first aid kit (Carried by the Guide).	Helmet & first aid kit (Carried by the Guide).
Approx. number of visitors	Presently: 500 by month. In 1996-97: 500 per week (Aprox.).	N.A.	4600 persons p/ year (2012 data).	100 persons per year.	3600 visitors per year.	Around 120 visitors per year.
Tour duration	1 to 2 hours	45 minutes to 1 hour	25 minutes	2 hours	1 hour and 30 minutes	45 minutes
Source	Owners and experienced local guide.	Local guide with experience.	Fossil Land Adventure Park.	Local guide with experience.	National Park Administrator.	National Park Administrator.

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CONSUMER-BASED CAVE TRAVEL AND TOURISM MARKET CHARACTERISTICS IN WEST JAVA, INDONESIA

CARACTERÍSTICAS DO MERCADO CONSUMIDOR DE ESPELEOTURISMO EM WEST JAVA, INDONÉSIA

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Abstract

Caves as destinations for geotourism, were some of the first documented geologic features that had become the object of tourism. While cave tourism development in Indonesia is still in its infancy, in line with the increasing popularity of geotourism and ecotourism, it has great prospects. The main objective of this study was to identify the current consumer-based market conditions for cave travel and tourism in West Java of Indonesia focussing on the motives and the characteristics of the visitors that include geographic, socio-demographic, behavioural, and psychographic characteristics. The sample population comprised visitors who have visited caves within the Districts of Tasikmalaya and Ciamis where most of caves in West Java were located. Visitors' characteristics were clustered based on three main motivations, specifically recreation, adventure seeking and religious purposes. Results of the study indicated that cave visitors of West Java were basically called visitors since none spent overnight at the site. They mostly originated from districts and cities that were in proximity to the caves, unmarried youth to young adult males with monthly income of less than USD 100, whom enjoyed travelling with friends, and showed great interests for intellectual benefits of caves. The caves were mostly visited during holidays, and only the adventure-seeking and cultural cave visitors stayed for more than 3 hours. The visitors had limited knowledge of the caves, although their intellectual needs proved to be the main contribution to visit caves.

Key-Words: Cave travel; Cave tourism; Cave visitors; Market segments.

Resumo

Cavernas estão entre as primeiras feições geológicas documentadas como atrativos para o geoturismo. O espeleoturismo na Indonésia ainda está em seu estágio inicial, alinhado com a crescente popularidade do geoturismo e ecoturismo, trazendo grandes perspectivas. O principal objetivo deste estudo foi identificar as condições atuais de mercado baseadas em consumo, para viagens de espeleoturismo em West Java da Indonésia, centrado sobre os motivos e as características dos visitantes (sócio-demográficas, comportamentais e psicográficas-geográficas). A amostra foi composta de visitantes que visitaram cavernas dentro dos Distritos de Tasikmalaya e Ciamis, onde a maioria das cavernas em West Java estão localizadas. Características dos visitantes foram agrupadas com base em três motivações principais, especificamente recreação, busca de aventura e fins religiosos. Os resultados do estudo indicaram que os espeleoturistas de Java Ocidental são, basicamente, excursionistas, uma vez que não pernoitam no local. A maioria deles é proveniente de distritos e cidades que estão na proximidade das cavernas, sendo jovens solteiros e jovens-adultos do sexo masculino, com renda mensal de menos de US$ 100, que gostam de viajar com os amigos, e mostraram grande interesse em obter conhecimentos sobre o ambiente das cavernas. As cavernas foram mais visitadas durante as férias, e só os visitantes de aventura e com interesses na cultura permaneceram por mais de 3 horas. Os visitantes possuíam conhecimento limitado das cavernas, e suas necessidades de busca de conhecimentos foram compreendidas como a principal motivação para o espeleoturismo.

Palavras-Chave: *Viagens em cavernas; Espeleoturismo; Espeleoturistas; Segmentos de mercado.*

1. INTRODUCTION

Geotourism is defined by Newsome; Dowling (2010:4) in Dowling; Newsome (2010) as "*a form of natural area tourism that specifically focuses on geology and landscape. It promotes tourism to geosites and the conservation of geodiversity and understanding of earth sciences through appreciation and learning*". Cave is a significant component of

geodiversity (Gray, 2004) and is one of the first documented geologic feature that has become the object of tourism (Forti, 2011). In fact, some authors consider that visiting show caves is the oldest form of geotourism (Bourne et al., 2008).

Various articles on cave tourism have already been written with much emphasis on the environmental impacts of tourism in caves such as by Cigna (1993), Huppert et al. (1993), Cigna; Burri (2000) and Aley (2004). To date, there have been few studies that focus on cave visitors. Yet, consumer plays important roles in tourism planning and marketing activities. One known study of cave tourists was conducted by Kim et al. (2008) in Hwansun Cave of South Korea where they found that cave tourism has gained popularity in recent years.

Cave is a special feature within a landscape referred to as "karst". Karst sites have a particular use in tourism and human recreation, thus form the basic components of tourist attraction (Kušen, 2002 in Bočič et al., 2006). Of all the different karst types, tropical karst forms are the most distinctive and these are widespread in Southeast Asian countries including Indonesia. Considering that karst is well developed in tropical region, Indonesia apparently has huge potential to develop cave tourism.

Development of cave tourism in Indonesia is still in its infancy although Indonesian caves have long association with spiritual human activities such as through the findings of many cave paintings and current uses of caves as holy places for the pilgrims. With the rising of current tourism trend from mass tourism concept to quality tourism concept, caves offer attractions to be developed for recreation tourism as well as special interest tourism. Unfortunately, it is evident that many people do not respond well and give negative feedback such as that caves is a place of darkness, wet, often muddy, smelly and full of creepy animals. These images often pull the people away from visiting caves. Pull factors in recreation area, are attributes of an area that reflect an individual to stay away from the recreational area (Mohamed; Othman, 2012).

Um; Crompton (1990) concluded that image and attitude dimensions of a place are very critical in making up a destination choice. In similar line, Lancaster (1966) suggests that consumers are rather influenced by their perceptions in choosing goods. Place attachment is an important indication of tourists' affective identification and dependence toward a destination (Cheng et al., 2012). Place is therefore one of the most important key element in tourism marketing. A place of interest can be developed into a tourist destination that attracts people with specific characteristics. Hence, understanding the needs and wants of visitors is the starting point for tourism marketing. However, there is heterogeneity in the purchasing patterns of the consumer living in urban, semi-urban, and rural areas that place importance on market segments (Kasali, 2005). It is therefore central to identify markets characteristics based on visitors motivations. Such market characteristics will provide references for the promotion and marketing of cave tourism, as it is one of the main problems in the development of geotourism in Indonesia (Kemenbudpar, 2010).

2. METHODOLOGY

2.1 Area of Study and Study Population

Karst areas in Java Indonesia are densely populated and threatened by limestone conversion and many other human activities. Geotourism is seen as an alternative means of reducing negative impacts on these karst landscapes. The Indonesian karst classification based on the Ministerial Decree of Energy and Mining Resources No. 1456 of 2000 on Karst Management Guidelines, has classified karst into three classes, namely Class I, II and III:

1. ***Class I*** karst area is intended for conservation where mining is absolutely prohibited. Class I karst areas can only be used for (1) the development of ecotourism based on nature, ecosystems, and or culture, (2) research and development of science and (3) development of water resources that are not for commercial use.
2. ***Class II*** karst areas can be mined under strict conditions. Class II karst areas can be used as an area for (1) the development of ecotourism based on nature, ecosystems, and or culture, (2) research and development of science, (3) development of water resources, (4) development of agriculture and animal husbandry on a limited basis; and (5) excavation and mining under a very strict conditions.
3. ***Class III*** karst area can be used for the activities referred to the other two classes above and may also be used for other activities. Only the Class III karst areas can be mined.

This study is focused on karst regions in West Java of Indonesia. West Java karst areas are distributed in 11 districts where Tasikmalaya and Ciamis are the districts with the largest karst coverage as shown in Figure 1. Figure 1 also indicates that the two districts were mostly comprised of Class I karst regions, which placed significant importance on the development of cave tourism especially for conservation purposes.

Therefore, the two districts formed the locations of the study. Both developed and undeveloped caves in both districts were visited.

2.2 Data Collection

The research is descriptive and explorative. The descriptive character of the research is a consequence of trying to gain insight into cave visitors market demand based on similar characteristics. The research also has an explorative character because it tries to understand visitors' needs and motivations to conduct cave tourism. These characteristics were shown as variables comprising data collected for this research (Table 1). Data were collected from September – December 2012.

2.3 Survey sample

One method that can be used to classify and acquire tourist demand segmentation is *a priori segmentation method*. In a priori segmentation, the type and number of segments is determined prior to data collection (Wind, 1978 in Kazbare et al., 2010). Setiadi (2003) states that a priori segmentation is important to be conducted when we want to throw a product into the market while there is no similar product in the market that can be used as a reference in designing marketing program.

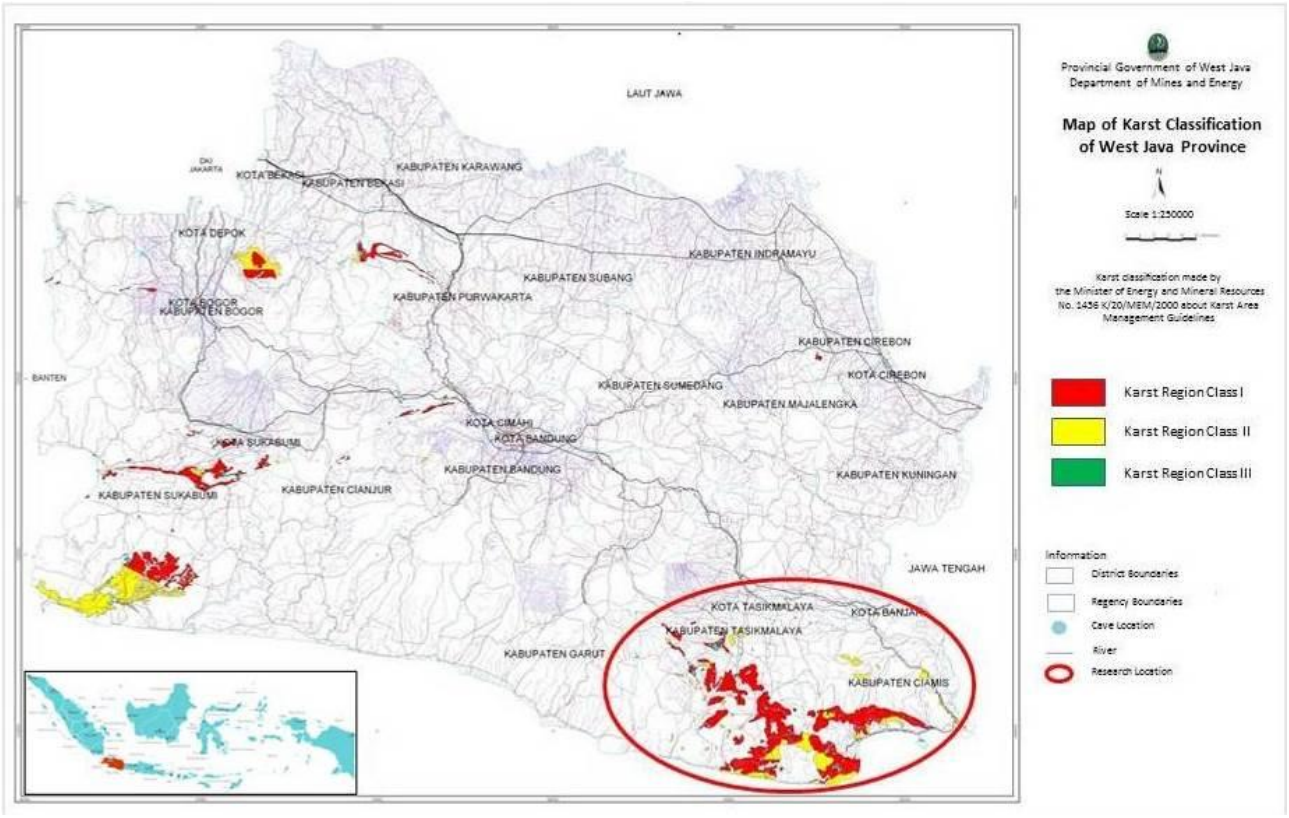

Fig. 1 - Distribution of Karst Areas in the Province of West Java and Location of Study

Table 1 - Data Collected and Methods

No.	Parameters	Variables	Data collection method/technique
1	Visitors' socio-demographic characteristics	Origin, age, gender, education, occupation, income and marital status	Questionnaire
2	Preferences and pattern of visits	Purpose of visit, benefits sought, activities, travel companions, expenditures, time, duration and type of visits.	Questionnaire
3	Visitors' perception, satisfaction, and expectation	Perceptions about caves, cave tourism, satisfaction, willingness to revisit, and expectations	Questionnaire
4	Use of caves	Caves for pilgrims, caves with religious historical values, show caves	Literature study, interview

A priori segmentation approach in this study was used to identify cave visitors segments. Market segmentation is the process by which people with similar needs, demands and characteristics are grouped together to provide greater precision in serving and communication with its chosen consumer. Based on a research by Prastiwi (2012), it was found that visitors' motives to visit caves in West Java were based on recreation, adventure and religious purposes. Unlike other research on cave tourism which very often resulted in the cluster or typology of visitors/tourists such as that of Kim et al. (2008), this research started by taking the already existed typology (clustering) by Prastiwi (2012) and look into the visitors characteristics within each cluster. Therefore, the visitors were divided into three segments, namely for the purpose of recreation, religion and adventure. These would be termed recreation, cultural and adventure seeker cave visitors.

The survey design involved a cluster sampling method. The respondents for this research comprised of cave visitors within the Districts of Tasikmalaya and Ciamis that visited the developed and undeveloped caves. Developed/show caves were selected through literature reviews on caves that have met the requirements of a developed site, *i.e.*, have managers, ticketing and built facilities. The developed caves were then divided into caves with mass tourism and caves with religious historical values. The undeveloped caves, on the other hand, were selected based on direct interviews with the Caving Communities within the two districts. Caves used as pilgrimage sites were not considered as part of this research, since the presence of researcher would be regarded as disturbance to the pilgrims. Within each cluster, 30 respondents were selected randomly.

To evaluate personal characteristics of the visitors and to find out their motives of visiting caves, questionnaires were used. The questionnaire had three separate parts, of which the first is designed to evaluate the socio-demographic characteristics of the cave visitors. The second part was designed to collect information on visitors' preferences and travel pattern to evaluate visitors' behaviour and the third part was design to evaluate the perceptions and attitudes toward cave and cave tourism (Table 1).

2.4 Data Processing and Analysis

The next step was to process and analyze data through the following steps:

1. Editing examines the collected raw data for their accuracy. The completed questionnaire is checked for overall accuracy, completeness and general usability;
2. Coding were given in field notes, observations, and data from documentation and answers given by the respondents, to categorized data under broad headings;
3. Tabulating, this is the stage of entering data on certain tables and arrange the figures to be easily analyzed. It is simply counting the number of responses in various data categories.

The analysis used in this research is descriptive qualitative analysis to describe the characteristics of the visitors in question and using a priori segmentation approach for segmenting visitors based on purpose of visits. Qualitative analysis in this study is used to analyze the data obtained from the results of the questionnaire. This analysis is expected to provide an overview of the characteristics of the actual demand for cave tourism as well as the management of cave tourism objects.

3. RESULTS AND DISCUSSION

3.1. Cave Tourism Market Segments

A considerable amount of literature has been published on tourist motivation in recent decades and it is ubiquitous in tourism studies (Singh, 2008). However, it is apparent that previous tourism studies pay scant attention to the issue of why people travel to certain geosites. Yet, literature reviews revealed that motivation theories and studies play a vital role in developing different types of tourism demand. Without motivation in tourism, demand will not exist (Sharpley, 2006).

Following Maslow's Hierarchy of Needs (1943), motivation is the driving force behind all behaviour and in tourism it is reflected in both travel choice and behaviour. It influences people's expectations which in turn determine the perception of experiences. Motivation is therefore a factor in satisfaction formation (Gnoth, 1997). In the case of cave tourism, motivations were affected by the needs that one placed to a cave. According to Bočić et al. (2006), people visit caves out of aesthetic-emotional, recreational, educative and sometimes medical reasons, whereas Prastiwi (2012) concluded that cave visitors comprised of recreational, cultural and adventure-seeker cave visitors. Based on motivation factors, Kim et al. (2008) clustered cave tourists in Hwansun Cave of South Korea as those seeking escape, knowledge, novelty or socialization.

Visitors can be split into groups based on the place of origin, which arguably represents the most common market approach in tourism and socio-demographic variables where a destination may attract people with specific socio-demographic characteristics (Dolnicar; Kemp, 2009). Overall, the socio-demographic characteristics of cave visitors in West Java are presented in Table 2.

Table 2 - Socio-demographic Characteristics of Cave Visitors in West Java

No.	Variables	R	C	A	Total	R%	C%	A%	Total%
		N = 30	N = 30	N = 30	N = 90				
1	**Age Group**								
	12-18	0	1	10	**13**	0	3	33	12
	19-21	10	1	10	**39**	33	3	33	23
	22-35	20	11	10	**11**	67	37	33	46
	36-59	0	17	0	**7**	0	57	0	19
2	**Gender**								
	Women	16	13	3	**32**	53	43	10	**36**
	Men	14	17	27	**58**	47	57	90	**64**
3	**Origin**								
	City of Tasikmalaya	0	1	23	**24**	0	3	77	**27**
	Ciamis	2	11	0	**13**	7	37	0	**14**
	City of Banjar	2	16	0	**18**	7	53	0	**20**
	Garut	1	0	0	**1**	3	0	0	**1**
	Bandung	19	0	5	**24**	63	0	17	**27**
	Cimahi	1	0	0	**1**	3	0	0	**1**
	Sumedang	1	0	1	**2**	3	0	3	**2**
	Kuningan	1	0	0	**1**	3	0	0	**1**
	Jakarta	2	2	0	**4**	7	7	0	**4**
	Tangerang	0	0	1	**1**	0	0	3	**1**
	Jogjakarta	1	0	0	**1**	3	0	0	**1**
4	**Education**								
	Elementary	1	2	0	**3**	3	7	0	**3**
	Junior high school	1	7	1	**9**	3	23	3	**10**
	High school	20	11	17	**48**	67	37	57	**53**
	University	8	10	12	**30**	27	33	40	**33**
5	**Occupation**								
	Students	26	1	21	**48**	87	3	70	**53**
	Private	0	3	4	**7**	0	10	13	**8**
	Self-employed	3	4	5	**12**	10	13	17	**13**
	Civil servants	1	11	0	**12**	3	37	0	**13**
	Housewives	0	7	0	**7**	0	23	0	**8**
	Farmers	0	2	0	**2**	0	7	0	**2**
	Others	0	2	0	**2**	0	7	0	**2**
6	**Monthly income**								
	< USD 100	27	10	22	**59**	90	33	73	**66**
	USD 100 - USD 200	2	8	4	**14**	7	27	13	**16**
	USD 201 - USD 500	1	12	4	**17**	3	40	13	**19**
7	**Marital Status**								
	Unmarried	27	6	29	**62**	90	20	97	**69**
	Married with no children	2	2	0	**4**	7	7	0	**4**
	Married with children	1	21	1	**23**	3	70	3	**26**
	Single mother	0	1	0	**1**	0	3	0	**1**

Note: R = recreation; C = cultural; A = adventure

3.1.1. Geographic variable

3.1.1.1. Place of origin

Visitors to the caves were originated from various cities and provinces (Table 2); to be specific from 11 cities and districts in 4 different provinces, namely Tangerang, Jakarta, West Java (Kuningan, Sumedang, Cimahi, Bandung, Garut, city of Banjar, Ciamis, city of Tasikmalaya) and Jogjakarta.

Table 2 indicated that most of the visitors seeking adventure seeker originated from the City of Tasikmalaya. These adventure cave visitors were generally associated with caving community who deliberately came to look for challenges. This was due to the existence of Caver Community based in the City of Tasikmalaya who spent their leisure time by conducting challenging activities in the caves and providing the city's youth communities with cave outreach and caving training programmes.

Another category of cave visitors were those with religious purposes who were dominated by those originated from Eastern Priangan Region (Ciamis, Tasikmalaya City and Banjar) apart from Jakarta. The Eastern Priangan communities were very well known as religious communities. Within the District and City of Tasikmalaya itself, as many as 853 religious boarding schools were established within the region with hundreds of thousands of students (Tamam, 2009). The proximity of this region to the locations of the caves also resulted in less travel time hence did not require much effort and expenses to be incurred. This is in line with the statement by Widyaningrum (2010) that prospective visitor domicile and accessibility to a destination site would determine the hustle and frequency of visits to such sites.

Unlike the previous two types of special interest visitors, the number of visits for cave visitors with recreational purposes was dominated by cave visitors originated from Bandung. Bandung is the biggest metropolitan city in West Java with a density of 14,255 people per km^2. The high population density has been the push factors to conduct recreational activities away from the hustle of a crowded city. Push factors according to Mohamed; Othman (2012) are associated with visitors and their environments that predispose the individual to visit a recreational area. The caves that were mostly visited by such mass visitors are mostly located on natural surroundings, quiet, unpolluted and scenic surrounding, hence able to provide refreshing atmosphere for those who wanted relief from everyday stress.

3.1.2. Socio-demographic variables

Demographic segmentation consists of dividing the market into groups based on demographic variables such as age, gender, marital status, education level, employment status and income. Whereas geographic segmentation looks at where people from, demographics looks at a number of aspects of who people were. Demographic variables are important to market segmentation for hospitality marketing (Aksöz, 2013).

3.1.2.1. Age Group

The cave visitors' age ranged between 12-59 years old which could be classified into youths (12-18), young adults (19-21), mature adults (22-35) and middle aged adults (36-59) (Table 2). Youth to young adults dominated cave visitors with recreational purposes and middle-aged adults dominated cave visitors with cultural purposes, while no specific age group seemed to dominate visitors with adventure seeking purpose, although Table 2 suggested that none of the middle-aged visitors visited caves for adventure seeking purposes.

Nurchasanah (2005) mentions that age indirectly effected the decision for recreation. Furthermore, Sumarwan (2004) states that various age structures will result in various forms of products or services they consumed. If the middle-aged visitors chose cave tourism for cultural purposes to satisfy their spiritual needs, the young to mature adults were more likely to visit caves for recreational purposes and adventure seeking to relieve boredom and escape from daily work-days loads.

3.1.2.2. Gender

Cave visitors were predominantly males (58%). The cultural and adventure seeking cave visitors were dominated by male with 57% and 90% respectively. On the contrary, cave visitors with recreational purposes was slightly dominated by female visitors (53%) (Table 2).

Cave tourism for cultural and adventure purposes on the other hand is categorized as special interest tourism. It is a form of travel where visitors visited a place because he/she had an interest or a specific purpose toward an object or activity that could be conducted within the location or the destination (Kemenbudpar, 2004). In cave tourism for cultural purposes, visitors came solely for the historical value that is attached to the caves and for

worship. Caves for cultural purposes were often caves with certain historical and or religious values, such as the Safarwadi Cave, which around the 17th century AD, was the residence of Sheikh Abdul Muhyi, a Muslim scholar and missionary who came from East Java.

Cave visitors seeking adventures, generally came to experience challenging and adrenaline boosting activities in nature. Unlike the cultural cave tourism, adventure seeking cave tourism took place in caves with difficult level of terrain that required special skills and equipments to conduct exploration. Such exploration required the visitors to be able to move actively like climb, bend, crawl, creep, lying face down, lying face up, swim and even dive (Belantara Indonesia 2012). Hence, such type of cave tourism is more attractive to men who instinctively like to explore their masculinity such as adventure, competition, self-actualization and challenging (Cohen, 1972).

Cave tourism for recreational purpose is considered as a mass tourism, where visitors carried out activities during their leisure time. In a recreational activity, there was no specific goal to be achieved and mostly conducted just for fun (Kemenbudpar, 2004). This type of cave tourism did not require special skills or prime physical condition since generally the terrain is easy to be passed by various groups with a variety of age groups. Such activities very much related to female-based activities as stated by Mehmetoglu (2007) who identifies that women preferred activities associated with pleasure seeking (entertainment and fun), non-physical, and cultural. Therefore, composition of female visitors in cave tourism for recreational purposes was slightly higher than that of male visitors.

3.1.2.3. Marital status

Status is one of the factors affecting tourism demand because someone's status is closely linked to family responsibilities that determine the size of the income set aside for tourism activities. The greater the disposable income, the more likely a person will travel (Yoeti, 2008). The majority of recreational cave visitors (90%) and adventure cave visitors (97%) had unmarried status. On the contrary the majority of cultural cave visitors are married with children (Table 2). The cultural cave tourist often use family gatherings to visit caves having historical value, thus very often they travelled in with families.

Recreational and adventure seeking cave tourism activities implied fun, self-actualization and leisure pursuits, which were synonymous with unmarried status. In contrast, cave tourism for cultural purposes went beyond pleasure seeking that was more toward finding peace of mind and getting closer to the Creator.

Results in Table 2 indicated that the absence of a husband for a single mother formed the pull factor. This is in line with the research result by McCreedy et al. (1992) that showed the fact the absence of a husband delays travel for single mother and that they are not as well-off as their married counterparts.

3.1.2.4. Education

The level of education of the cave visitors was relatively diverse as shown in Table 2 from elementary school to university. Majority of the cave visitors had high school (48) and university backgrounds (30%), followed by junior high (9%) and elementary school (3%). Visitors with junior high degree were housewives and farmers, while visitors with higher education degree were generally employees, both civilian and private.

The adventure seeker cave visitors were dominated by visitors with higher education background, such as high school and university. This was related to the fact that they belong to the caving community and that at these psychological development stages of age, high school (15-18) and university (19-21), they still like to be free.

3.1.2.5. Employment status

The majority of cave visitors were students which formed as much as 48%. They dominated the recreational and adventure seeker visitors. Widyaningrum (2010) states that school and university students have longer leisure time, unemployed, nor have dependents, hence they would likely to choose natural areas which provide low-cost tourism activities but something to bring out their self pride. Show caves in Indonesia basically offer relatively affordable ticket, for example in Pananjung Pangandaran the entrance fee was only USD 7. Furthermore, most of the adventure caves were still unmanaged hence no admission fees were required. Consequently, many students chose recreational and adventure seeking cave tourism.

Self-employed and civil servants cave visitors formed the next segments based on percentage. The self-employed had relatively free and flexible day jobs and working hours. Qomariah (2009) states that self-employed visitors dominance is due to cost and leisure factors that encourage the desire to fill their

spare time by conducting activities in nature. Whereas the civil servants proved to be mostly engaged with cultural cave tourism activities.

Cultural cave visitors were dominated by civil servants and housewives (Table 2). They usually visited the caves with family, work colleagues and religious community gathering so that their activities were relaxing and provided peace of mind. As mentioned previously, the majority of cultural cave visitors were mature to middle-age adults groups. At these age classes, a person's showed greater attention to religion and sometimes their interests and attentions towards the religion were based on personal and social needs. According to Deaton (2009), it is almost universal that the elderly and women are more religious, and they are more likely to be married, to have supportive families and friends.

3.1.2.6. Monthly income

Monthly income was closely related to occupation. The monthly income for the visitors ranged from <USD 100 - USD 500 (Table 2). Parthana (1995) states that income level and leisure time are important factors in the analysis of recreation demand, especially in deciding to travel to suit the ability and desire of a person. Income is related to the ability of a person to purchase something. The monthly income for the recreational and adventure seeking cave visitors were dominated by the amount of <USD 100, since such cave tourism were dominated by students, in line with the results of occupation. The cultural cave visitors had generally higher monthly income as seen from Table 2, because the majority were employees.

3.1.3. Behavioural variables

Understanding tourism demand required evaluation of the consumer behaviour. Behavioural segmentation divides customers into groups based on the way they respond to, use or know a product.

3.1.3.1. Expenditures

Costs incurred by the visitors were varied. The majority of cave visitors spent <USD 100 (Table 3). The low expenses were influenced by many factors, such as monthly income, duration of visit, and mileage. As stated previously, the cave visitors were dominated by students with monthly income <USD 100. The low monthly income affected the visitors' decisions on how to spend money on the destination site. Visitors with relatively low incomes would be more efficient in spending their money because their travel budget is definitely lower when compared with higher-income visitors.

The low expenses incurred by the majority of visitors were also caused by the duration of visit. Most visitors generally spent in 1-3 hours in the area. Short duration of visit resulted in low spending. Visitors usually spent money to pay for parking, entrance fees, guides, flashlight/lamp rental, use the bathroom and buy food/soft drinks.

The recreational visitors mainly spent 2 hours while the cultural and adventure seeking visitors spent more than 3 hours but none of the cave visitors spent overnight (Table 3). The majority of cave visitors (62%) were originated from the Districts of Ciamis and Tasikmalaya which is in proximity to where the caves were located. With a relatively close distance, visitors did not require a long time to reach the location of the cave. Trip commute could be reached in less than a day so they did not need to pay any amounts on lodging.

3.1.3.2. Travelling companions

Visitors came to the caves very often accompanied by others. Table 3 showed that 75% of cave visitors came with friends. Out of this, 90% of the recreational cave visitors came with friends. Furthermore, travelling with friends reached 100% for those visitors who were seeking adventure in caves. The adventure seeking cave visitors were mainly teens and early adulthood. Hamm (2000) states that adolescents choose friends who were similar psychologically and shared similar passions such as having common hobbies, interests, attitudes, values, and personality. The cultural cave visitors visited caves with families.

3.1.3.3. Benefit sought

The responses provided by the respondents addressed similar reasons that influenced their satisfaction feelings towards caves. The benefits derived from cave tourism were quite varied, which could be classified into five categories, namely spiritual, physical, intellectual, personal, and prestige benefits. Spiritual benefits include gaining inner peace and feeling closer to the Creator. Physical benefits eliminate stress and physical fatigue. Intellectual benefits add insight and knowledge. Personal benefits enhance personal relationships with family, friends, and/or colleagues, and prestige enhance the dignity of having been to a place that has been considered by the community as having prestige.

Table 3 - Behavioral Characteristics of Cave Visitors in West Java

No	Variables	R	C	A	Total	R%	C%	A%	Total%
		N = 30	N = 30	N = 30	N = 90				
1	**Motivation**								
	Recreation	30			**30**	33			**33**
	Culture		30		**30**		33		**33**
	Adventure			30	**30**			33	**33**
2	**Benefits**								
	Spiritual	0	3	0	**3**	0	10	0	**3**
	Physical	7	2	2	**11**	23	7	7	**12**
	Intellectual	22	24	26	**72**	73	80	87	**80**
	Personal	1	0	2	**3**	3	0	7	**3**
	Prestige	0	1	0	**1**	0	3	0	**1**
3	**Activities**								
	Marvel God's creation	0	2	2	**4**	0	7	7	**4**
	Pray	0	11	0	**11**	0	37	0	**12**
	Enjoying cave attractions	18	14	21	**53**	60	47	70	**59**
	Wildlife watching	3	2	3	**8**	10	7	10	**9**
	Photography	9	0	4	**13**	30	0	13	**14**
	Others	0	1	0	**1**	0	3	0	**1**
4	**Travel companions**								
	Friends	27	18	30	**75**	90	60	100	**83**
	Families	3	12	0	**15**	10	40	0	**17**
5	**Expenditures**								
	< USD 100	22	13	19	**54**	73	43	63	**60**
	USD 100- USD 200	6	9	5	**20**	20	30	17	**22**
	USD 201- USD 500	2	7	2	**11**	7	23	7	**12**
	USD 501-Rp 1.000	0	0	0	**0**	0	0	0	**0**
	> USD 1.000	0	1	0	**1**	0	3	0	**1**
	Abstain	0	0	4	**4**	0	0	13	**4**
6	**Time of visit**								
	Long holidays	18	6	10	**34**	60	20	33	**38**
	Weekend	1	13	12	**26**	3	43	40	**29**
	Weekday	11	6	3	**20**	37	20	10	**22**
	Others	0	5	5	**10**	0	17	17	**11**
7	**Duration of visit**								
	< 1 hour	6	9	0	**15**	20	30	0	**17**
	1 hour	5	3	3	**11**	17	10	10	**12**
	2 hours	19	5	4	**28**	63	17	13	**31**
	3 hours	0	2	10	**12**	0	7	33	**13**
	> 3 hours	0	11	13	**24**	0	37	43	**27**
	Overnight	0	0	0	0	0	0	0	0
8	**Type of Visit**								
	First timer	21	19	7	**47**	70	63	23	**52**
	Repeater	9	11	23	**43**	30	37	77	**48**

Note: R = recreation; C = cultural; A = adventure

The majority of respondents felt that caves offered a high value and benefits experiences for them especially as places to observe and be close to nature (72%), relieve from stress (11%), social space (3%), peaceful & quiet (3%), and prestige (1%) (Table 3). The visitors felt that their visits to the cave could improve their knowledge and provided insight into the history, condition, and culture of the places they visit. Spiritual benefits were felt only by cultural cave visitors conducting religious activities while physical benefits were obtained the most by recreational cave visitors.

3.1.3.4. Activities

Cave seeing was the most common activity undertaken by the visitors (Table 3). Other activities undertaken by the cave visitors, among others, include photography, cave fauna observation, worship, or simply marvel God's creation. The beauty and uniqueness of form, texture, and colour of the cave ornaments attracted the visitors. This has resulted in the most activities conducted by visitors with recreational purpose. The beauty and uniqueness of cave ornaments were the main attractions for this type of cave visitors.

Some caves had historical religious values, such as Safarwadi Cave that was instrumental in the spread of Islam in East Priangan. People believed that by visiting the caves, they will acquire blessings and intercession of the clergy who was instrumental in spreading Islam in East Priangan. Hence their activities in the cave focused more on worship, such as pray. Such activity was only conducted by the cultural cave visitors. On the contrary, none of the cultural cave visitors were into photography.

3.1.3.5. Time of visit

Peak season in cave tourism in West Java occurred during holidays, especially long holidays such as school holidays. The volume of visits during the holidays reached up to 34%, while on weekend reached 26%, weekdays 20%, and other times 10%. Table 3 indicated that show caves were mostly visited during holidays and adventure cave and religious cave were more crowded during weekends (Saturday-Sunday).

Recreational cave visitors were mainly students who generally had more free time in the holidays, resulted in many more visits during holidays. This is in line with the opinion of Qomariah (2009) who states that school holidays were frequently used by the students to get together and do activities with their friends, while weekends were more widely used for family gatherings and recreation. So the short term weekend can be used to travel with friends or family.

3.1.3.6. Duration of trip

Durations of cave trips were quite varied. The majority of recreational visitors spent 2 hours to enjoy caves, while the majority of adventure and cultural cave visitors spent over 3 hours in the caves (Table 3). The length of time it takes the visitor to be in the cave is closely related to the activities carried out in the cave. Recreational cave visitors came to the area solely for fun. Visitors came to see the beauty and uniqueness of the scenery in the caves. Having satisfied with what they saw, they would immediately leave the area, forming relatively short visits. The cultural cave visitors were indeed deliberately came for worship. So the time of their visits were relatively much longer than visitors who are just merely come for fun. The adventure visitors come to seek adventure and thrilling experiences in caves which were rarely explored by other visitors, thus spending more time than the recreational visitors.

3.1.3.7. Types of visit

Based on their type of visits, the cave visitors could be classified as first timer and repeater. The proportion of first-timers and repeaters were not so much different with 52% being first timers. Korah (1995) states that the frequency or pattern of visits to natural attractions is influenced by the quality of experience, taking the appeal and component facilities offered by a natural attraction. If visitors are satisfied, then the quality of the journey can be said to be good so they tend to want to come back to the attraction.

Most of the adventure cave visitors were repeaters (Table 3). They came from caving clubs/associations that had an interest to spend free time by conducting challenging activities with friends. Such community is actively conducting outreach and training programs to the youth around the town of Tasikmalaya. Such activities led to many repeaters for adventure cave visitors. First timer among adventure cave visitors were usually a new member of the caver community who were still in junior high school

Recreation and religious pilgrim cave visitors were mainly first timers. They often came after hearing about the place from a friend or media. The cultural cave tourists often came back if they get satisfaction after first visits, such as obtaining calmness and inner peace.

3.1.4. Psychographic variables

Psychographic segmentation divides the market into groups based in personality characteristics. It is based on the assumption that the types of products and brands an individual purchases will reflect that persons characteristics and patterns of living. Psychographic segmentation of the cave tourists in West Java (Table 4) focused on attitudes, values and beliefs of consumers.

Table 4 - Psychological Characteristics of Cave Visitors in West Java

No.	Variables	R	C	A	Total	R%	C%	A%	Total %
		N = 30	N = 30	N = 30	N = 90				
1	**Perception on caves**								
	Don't know	17	9	11	**37**	57	30	37	**41**
	Dark	3	0	4	**7**	10	0	13	**8**
	Scary and mysterious	0	10	0	**10**	0	33	0	**11**
	Historical and scientific	3	5	4	**12**	10	17	13	**13**
	Must be protected	0	0	2	**2**	0	0	7	**2**
	Challenging	0	1	1	**2**	0	3	3	**2**
	Attractive and unique	0	1	2	**3**	0	3	7	**3**
	Place to socialize	0	0	1	**1**	0	0	3	**1**
	Scenic and natural	7	4	5	**16**	23	13	17	**18**
2	**Likes about cave**								
	Don't know	5	8	1	**14**	17	27	3	**16**
	Cave ornaments	18	8	13	**39**	60	27	43	**43**
	History & myth	3	2	0	**5**	10	7	0	**6**
	Species	2	0	1	**3**	7	0	3	**3**
	Cave atmosphere	2	5	2	**9**	7	17	7	**10**
	Strengthen friendship	0	0	2	**2**	0	0	7	**2**
	Able to see light again	0	0	2	**2**	0	0	7	**2**
	Challenging	0	0	7	**7**	0	0	23	**8**
	Darkness	0	0	2	**2**	0	0	7	**2**
	Water droplets	0	7	0	**7**	0	23	0	**8**
3	**Dislikes about caves**								
	None	10	3	10	**23**	33	10	33	**26**
	Difficult access	0	1	1	**2**	0	3	3	**2**
	Dark, humid and stuffy	3	7	2	**12**	10	23	7	**13**
	Vandalism	0	0	3	**3**	0	0	10	**3**
	Smelled	0	1	8	**9**	0	3	27	**10**
	Slippery	0	9	1	**10**	0	30	3	**11**
	Dirty and full of rubbish	4	4	2	**10**	13	13	7	**11**
	Lack of facilities	3	0	0	**3**	10	0	0	**3**
	Misuse of cave	2	3	0	**5**	7	10	0	**6**
	Difficult passages	6	1	1	**8**	20	3	3	**9**
	Others	2	1	2	**5**	7	3	7	**6**

Note: R = recreation; C = cultural; A = adventure

3.1.4.1. Motivational factors

Visitors had extremely diverse opinions about caves from positive to negative perceptions. Positive perceptions include aesthetic, natural, historical, and sources of knowledge while negative perceptions include creepy, mystical, and dark. The recreational cave tourists thought of caves as beautiful and natural (23%), has historical value and are source of knowledge (10%). However, the majority of visitors (57%) could not reveal their perceptions, since they were mostly dominated by first-timers.

The cultural cave visitors had negative perceptions about caves, such as creepy and mysterious (33%). Such negative perception could arise from the guide's explanations that only convey the mystical side of the cave without giving scientific explanation of the process of formation of the caves. Nevertheless, some other visitors had

positive perception, which were related to historical and source of knowledge (17%) as well as aesthetic and naturalness (13%).

Meanwhile, the majority of adventure seeking cave visitors (60%) had positive perceptions of the cave. Since they belong to caving community, they generally had acquired knowledge about the cave so that they no longer see the caves as a creepy and mysterious, but as a source of knowledge which required the caves to be preserved.

3.1.4.2. Attitudes toward cave: likes and dislikes

Visits to tourism sites would leave impressions for visitors, both positive and negative impressions. Positive impression arose because of the things that were considered interesting or liked by visitors (push factors). Whereas negative impressions often arose due to visitors' experience of things he/she did not like or felt discomfort from the area (pull factors). Although as many as 14% visitors could not relate their feelings towards caves, results in Table 4 indicated that respondents had a great satisfaction towards the beauty of cave ornaments (39%) as well as influenced by the atmosphere in the cave (9%), water droplets (7%), and the challenges that exist (7%). It is clear that cave ornaments formed the main attraction of a cave. The micro condition of cave that is associated with water such as wet and water droplets had given some cooling and refreshing feeling, where in previous research, they are two psychological benefits of water that influence people to visit a recreational area (Chiesura, 2004 in Mohamed; Othman, 2012).

Table 4 revealed that only the cultural cave tourists that liked the droplets of water, since water in the cave believed to give blessings to those who drink it. Furthermore, the sound of the droplets and movement of water have given soothing feeling for peace and quiet, related to the spiritual benefits that they sought. Likewise, only the adventure seeking cave visitors are the ones who liked the existing challenges and the darkness of the caves. These were related to their background which were cavers and that the majority were males who had more interests and passions in the things that are adventurous and challenging.

Things that have been the pull factors related to cave tourism were mostly related with the natural condition of caves such as darkness, humid and stuffy conditions in the caves (12%), slippery conditions in the cave (10%), area hygiene such as loads of garbage (10%), the smell of bat droppings (9%), etc. (Table 4). What was interesting was the fact that out of all the dislikes that the respondents shown towards caves, a great majority said there was nothing to dislikes.

Out of the expectation, Table 4 showed that the cultural cave visitors were the ones that mostly complaint about the conditions of the caves, that they were wet dark, hot, and stuffy (23%) and slippery (30%). Considering that caves are used for holy places and religious activities, it was expected that the cultural cave visitors were the one who should be able to accept the natural condition of the caves. However, at Safarwadi Cave, which is a cave with religious value, no visitor management efforts were implemented. Therefore, sometimes crowding occurred especially during holidays. Very often, these visitors travelled with families and within a group size that could not be called small, hence conditions inside the cave were always crowded resulted in stuffy feeling.

On the contrary, the recreational cave tourists were the ones that least dissatisfied with the natural condition of the caves although mobility in the caves became their main interest as they were the ones that mostly disappointed with the difficult cave passages. Visitors felt disappointed that they must struggle down the narrow and rocky passages. Whereas their motivation to visit the caves were basically to seek pleasures and eliminated physical fatigue due to daily routines.

The adventure seeking cave visitors mostly did not like the smell of bat droppings and only they who showed great interest in preserving the cave, where out of all the cave visitors, only this type that were worried about vandalism found in the caves. This makes sense since this type of visitors was generally individuals who appreciate nature. Caving activities they performed were always based on caving ethics. Thus, they were not very fond of and against the destruction of cave ornaments (vandalism).

4. CONCLUSIONS

This study provided insights into the consumer based variables that influenced people's choice for cave tourism in West Java of Indonesia. This research presents a framework for simultaneously evaluating multiple travel choices and empirically identifies factors that appear to influence visitors' decision to participate in cave tourism. Empirical results showed that upper-income visitors did not select cave as a tourism destination, while proximity to the location of caves positively influenced the decision to participate in cave tourism. It can be concluded that the factors that influenced or pushed the visitors to visit caves were

associated with the cave elements related to attractiveness, microclimate and challenges. The values and benefits that the visitors sought such as peaceful and quietness, relieve from stress and get close to nature were also associated with their feeling of satisfaction. As for pull factors that influenced the visitors' satisfaction towards caves were clearly the unsafe and not well maintained surroundings which were giving negative impacts to the visitors' satisfaction. The visitors had limited knowledge of the caves as most were first-timer suggesting they were mostly not interested to come back to the site although their intellectual needs proved to be the main contribution to visit caves.

The caves were mostly visited during holidays, and only the adventure-seeking and cultural cave visitors stayed for more than 3 hours. Results of the study indicated that cave visitors of West Java basically can only be called visitors since none spent overnight at the site. The cave visitors were mostly originated from districts and cities that were in proximity to the caves, where they are mostly comprised of unmarried youth to young adult males with monthly income of less than USD 100, whom enjoyed travelling with friends, and showed great interests for intellectual benefits of caves.

Such consumer-based characteristic revealed that cave tourism in Indonesia is not well developed and still uninterested for many, since the majority of the visitors came from proximity areas. The regional government need to consider these study results to take cave tourism into a higher level that would attract other visitors and tourists from further areas. Care should also be taken with regard to the sensitivity nature of caves for recreational tourism.

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