Karst Science and The Geological Society of America

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GSA'S NEW KARST DIVISION

Thanks to the efforts of a large number of people and two years of very dedicated and determined efforts, we are very pleased to announce that GSA Council approved the creation of the GSA Karst Division!

Division officers for our inaugural year are as follows:

- Chair and JTPC representative: **Cory BlackEagle,** Dept. of Earth and Environmental Science, University of Kentucky;
- 1st Vice-Chair: **Bonnie Blackwell,** Chemistry Dept., Williams College;
- 2nd Vice-Chair: **Jason Polk,** Dept. of Geography and Geology, Western Kentucky University;
- Secretary: **Penny Boston,** Dept. of Earth and Environmental Science, New Mexico Tech;
- Treasurer: **Ben Tobin,** National Park Service; and
- Webmaster and Social Media Coordinator: **Pat Kambesis,** Dept. of Geography and Geology, Western Kentucky University.

WHAT IS KARST?

Karst is a terrane[1] comprised of distinctive landforms (Fig. 1) and hydrology in which the host rock is highly soluble in the presence of naturally occurring acids. Karst terrane is an open system that contains geological, hydrological, biological, geochemical, geomorphological, and meteorological components that interact with and upon one another both at Earth's surface and in the subsurface (Fig. 2). Connections between all components can be dynamic and operate on very short to very long time scales. Such terranes can be active and contemporary, inactive, and/or completely decoupled from current conditions. Features commonly associated with karst terrane include caves, sinkholes, springs, disappearing streams, and surface areas lacking any surface drainage or naturally occurring water bodies.

Figure 1. Broadway, or Main Cave, inside Mammoth Cave along the historic tour route. Photo taken from the top of the Corkscrew looking toward the Rotunda. Image courtesy National Park Service.

WHERE IS KARST?

In the U.S., rocks with the potential to be karstic occur in every one of the 50 states, and ~18% of their area is underlain by soluble rocks either having karst or the potential for its development (Weary and Doctor, 2014). Portions of major U.S. cities are underlain by karst (e.g., St. Louis, Missouri; Nashville, Tennessee; Birmingham, Alabama; Austin, Texas; and Louisville, Kentucky). According to Veni et al. (2001), karst terrane underlies ~25% of the global land surface. Ford and Williams (1989) estimated "that 25% of the global population is supplied largely or entirely by karst waters" (p. 6) (Fig. 3), and ~1.5 billion people live in karstic terrane.

UNDERSTANDING KARST DEVELOPMENT AND FUNCTION IS CRITICAL

Karst terrane serves as a fragile foundation for both urban and rural populations. However, for most people, karst systems are unknown or ignored, falling into the mindset of "out of sight, out of mind." Nonetheless, among karst scientists, the catch-phrase of "what goes down must come up" has long been used to summarize how water flows through karst aquifers. Perhaps even more importantly, though, this simple phrase serves as a strong warning about how easily contaminants may appear in and pollute karst wells and springs.

The world's largest springs and most productive groundwater supplies are karstic, yet water resources in karst areas are the most easily polluted. Karst hydrology and hydrogeology are complex and still confound the best efforts at modeling. Water quantity and quality can change rapidly and dramatically. Storage in karst aquifers can vary from nonexistent to time frames of thousands of years, and its character and mechanisms are still largely unknown. Contaminants can be transmitted miles from their source and re-emerge without dilution in locations completely unanticipated. Flooding in karst terrane can be extensive and dramatic.

Karst terranes are areas of exploitable and critical natural resources, such as water, limestone for building stone and aggregate, minerals, oil, and natural gas. Important oil and gas production throughout the world occurs in fields that formed in porous

[1]The term "terrane" as used here is typically defined as an area or region with a distinctive stratigraphy, structure, and geological history. A specific terrane can be distinguished from neighboring terranes by its different history, either in its formation or in its subsequent deformation and/or metamorphism. The term "terrain" refers to the elevation, slope, and orientation of land features. It can be argued, therefore, that the karstic terrain (landscape) is a subset and consequence of the features and processes (stratigraphy, structure, and geologic history) that define the karst terrane in which it occurs. To describe an area of karst as "terrain" excludes the subsurface suite of geologic factors that led to its creation and critically interact with it.

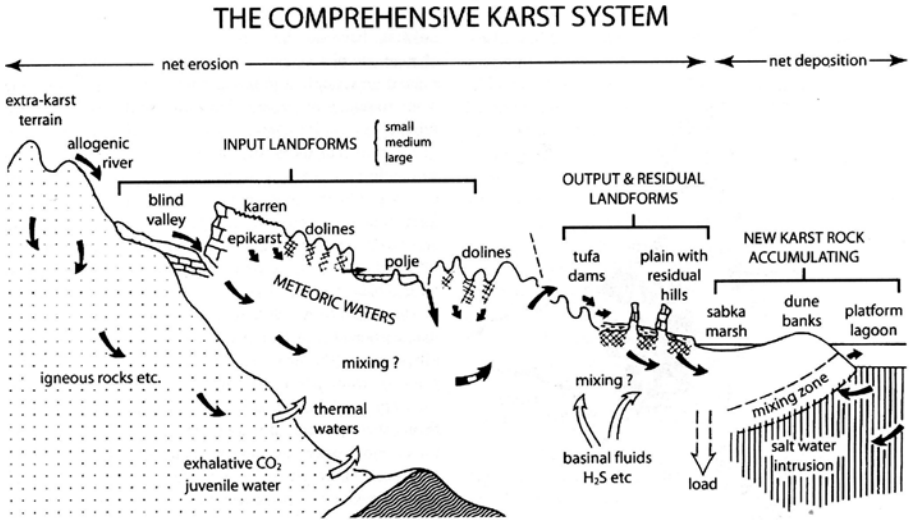

Figure 2. Diagrammatic representation of the components of the comprehensive karst system (Ford, 2006).

and permeable paleokarst reservoirs. According to Li et al. (2008), the Jingbian gas field, China, has a proven initial in-place gas reserve of ~11 trillion m^3 and is the largest paleokarst carbonate gas field in China. However, paleokarst can also create numerous difficulties in exploiting such reservoirs. According to Dou and colleagues (2011), "Paleokarst systems are one of the major factors resulting in carbonate reservoir and heterogeneity" (p. 1).

Karst terrane can present hazards to life and infrastructure. Sinkholes can form without warning, causing costly damage to buildings and infrastructure, and even resulting in human death. The surface-subsurface linkage is intimate, complicated, and extremely variable spatially and temporally. Many rare and endangered flora and fauna exist solely in karst environs. Destabilization of this linkage can lead to ecosystem collapse.

Recreation opportunities in karst terrane can be a substantial source of income to area residents. For example, Mammoth Cave National Park (Kentucky, USA) generates US$62 million annually to the south-central area of Kentucky in the form of money spent by visitors in the park and surrounding communities as well as jobs directly supported by park tourism (Carson, 2012). Mammoth Cave National Park acts as an anchor attraction in the area that draws tourists to not only the park itself but other area attractions. As a result, cave area tourism generated US$514 million to the region's economy and supported 8916 jobs (Stynes, 2011). A similar story can be found at some of the other cave-centered national park units (Table 1; figures for Mammoth Cave National Park are included for comparison).

KARST SCIENCE IS COMPLEX AND MULTIDISCIPLINARY

The study of karst terranes necessarily involves a wide variety of subjects and specialties, spanning almost every division in GSA and scientific disciplines outside of GSA's purview. These include geology, biology, microbiology, soils, environmental geology, engineering, geology, geochemistry, geophysics, structural geomorphology, archaeology, urban planning, climatology, paleoclimatology, meteorology, hydrology, speleology, and even planetary studies. Comprehensive karst studies also can require the assistance of cave explorers and mappers, cave divers, mathematicians, modelers, and computer programmers. In all cases, practitioners in each discipline bring with them their own experiences, perspectives, insights, tools, and scales of reference.

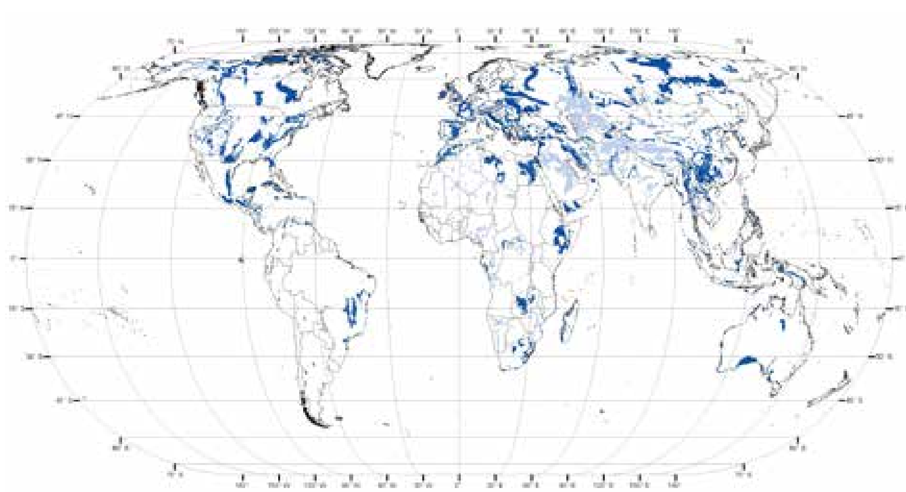

Figure 3. Approximately 25% of the global land surface is underlain by karst terrane (blue; Williams and Fong, 2010).

Table 1. Economic impact of tourism in cave-centered national park units in 2010 (Stynes, 2011)

Park	Visitors		Impacts of non-local visitor spending		
	Total	Spending	Jobs generated	Labor income	Value added
Carlsbad Caverns National Park (NM)	428,524	$23,328,000	346	$7,225,000	$11,843,000
Jewell Cave National Monument (SD)	103,462	$5,146,000	82	$1,955,000	$3,224,000
Mammoth Cave National Park (KY)	497,225	$32,841,000	530	$12,290,000	$19,826,000
Oregon Caves National Monument (OR)	86,335	$4,113,000	62	$1,559,000	$2,529,000
Russell Cave National Monument (AL)	23,374	$1,163,000	18	$363,000	$589,000
Timpanogos Cave National Monument (UT)	120,241	$7,775,000	124	$3,647,000	$5,996,000
Wind Cave National Park (SD)	557,141	$51,500,000	925	$22,350,000	$37,231,000
Totals	1,816,302	$125,866,00	2,087	$49,389,000	$81,238,000

The presence and characteristics of karst impacts a number of key scientific and infrastructure topics. Most karst studies require a multi- and inter-disciplinary approach.

- Because sediments and speleothems (mineral deposits) in caves are, in many respects, isolated from surficial processes on both short and long time scales, they provide valuable resources to study Earth's conditions recorded in them. Careful study provides information on fluctuations in regional temperature, atmospheric gases, rainfall, glaciation, sea-level change, flora, and fauna (cf. Granger et al., 2001).
- Karst terrane, like many other areas, is valuable for the economic resources it provides. The beer brewing and bourbon whiskey industries rely heavily on water from karst areas. The rock that hosts karst (e.g., limestone, dolomite, marble, gypsum, travertine, and rock salt) are quarried throughout the world. Paleokarst areas (areas containing karst that has been decoupled from the surface) contain many of the world's largest economic reserves of lead, zinc, aluminum, oil, and natural gas (cf. Barton et al., 2012, for a linkage between limestone and bourbon).
- Cave fauna, adapted to low energy and low- to no-light conditions, exist in highly specialized, unique, and extremely fragile ecosystems. Many cave species can exist in perhaps a single cave or a single region, and many are listed as rare or endangered both in the United States and worldwide. Biologists often study cave species to gain insight into ecosystem development and evolution. Further, many cave microbes are extremophiles, and studying them assists in understanding crucial geomicrobiological processes and the interplanetary search for life (cf. Engel et al., 2004). Bats, one of the most well-known species to depend on caves, eat prodigious amounts of insects on a daily basis. Boyles et al. (2011) estimate the value of bats to the agricultural industry in the continental U.S. alone to be roughly $22.9 billion/year.
- Cave environments preserve and protect archaeological material that otherwise would have been destroyed by surface processes. As a result, many of the most important archaeological sites in the world are found in caves. For example, enjoy a virtual tour of Chauvet Cave at http://www.culture.gouv.fr/culture/arcnat/chauvet/en/ or Husted and Edgar (2002) for an excellent example of a multidisciplinary study with archaeology at its heart.
- Due to the cavernous nature of many karst areas, infrastructure can be severely impacted by ground subsidence and catastrophic collapse. Fortunately, deaths are rare when sinkholes form, but they can be extremely costly in terms of property damage. According to Pearson (2013), "insurance claims submitted in Florida alone between 2006 and 2010 totaled $1.4 billion." Flooding is also a serious problem in karst terrane, and can also be extremely damaging and costly. Consequently, the ability to document the presence of karst terrane and properly design structures accordingly is crucial.
- Water is the most commonly utilized resource in karst areas, which contain some of the largest volume wells and springs in the world. Very large volumes of water are stored as groundwater in karst terrane; however, utilizing water from karst terrane is not without severe risk. Movement of water from Earth's surface into a karst aquifer is rapid and without any filtration. Whatever is on the ground will flow unmitigated into karst aquifers, making them highly susceptible to pollution (cf. Goldscheider, 2005; Jagucki et al., 2011).

WHY CREATE THE GSA KARST DIVISION?

Karst terranes have been important to distinguished GSA members since the 1890s. The *GSA Bulletin* includes landmark karst research, such as "Origin of Limestone Caverns," by William Morse Davis (1930), and "Origin and Morphology of Limestone Caves," by Arthur N. Palmer (1991). Other important research articles can be found throughout GSA's publications. For illustration, a simple search of GSA publications for any article with the word "cave" in its title or abstract resulted in 186 citations, while a similar search for the term "karst" resulted in 125 citations. These citations are spread across multiple disciplines and GSA publications, indicating a broad interest in karst within the GSA membership.

Despite this, no single division within GSA encompassed the interdisciplinary and multifaceted subject of karst. This widespread, fragile, and troublesome landscape absolutely requires a multidisciplinary forum where all aspects of karst studies can converge and share research and results. Further, there is no single organization dedicated to the scientific study of karst in the United States. The National Speleological Society does publish a journal, *Journal of Cave and Karst Studies* (formerly *The NSS Bulletin*), quarterly. However, its public persona is primarily one of cave exploration, mapping, and conservation. The American Geophysical Union has seen increased activity in karst science in recent years, with many karst scientists voicing a desire "simply to have a professional home."

GSA, with its multidisciplinary geosciences scope and large, international membership, is uniquely positioned to fill this gap, bring a prominence to karst science, and provide a scientific focal point for karst researchers across the disciplines. This step by GSA Council ensures that GSA will continue to fulfill its vision statement: “To be the premier geological society supporting the global community in scientific discovery, communication, and application of geoscience knowledge.” By approving the creation of the new Karst Division, GSA may soon be able to state that it is also the premier geological society supporting the U.S. karst community.

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