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EDITORIAL

Evaporite karst processes, landforms, and environmental problems

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Evaporite karst is widespread, but relatively unknown when compared with carbonate karst; this special issue addresses that lack of familiarity. Evaporite rocks have much higher solubilities and faster dissolution rates than carbonate rocks, and they also commonly have lower mechanical strengths and more ductile rheologies. Many of these factors are dependent on the local hydrogeology, and when combined they can result in areas where karst features evolve on a human time scale, rather than a geological time scale. Karst collapse and subsidence are common in such areas, making them problematical for the local population. The evaporite karst environment is very sensitive to changes in the local hydrology and hydrogeology, so that human factors such as groundwater extraction, drainage, and irrigation can act as triggering factors to collapse events. Some evaporite karst features such as caves and saline springs have been beneficially exploited, but most of them, including sinkholes, subsidence, and water degradation, pose a threat to the local environment and a hazard to development.

The papers in this special issue of Environmental Geology arose from a successful session on Evaporite Karst convened by us at the Sixth International Conference on Geomorphology. This was held in Zaragoza, Spain, in September 2005, and was organised by the Spanish Society of Geomorphology and the International Association of Geomorphologists (IAG; http://www.geomorph.org/). Authors of the twenty-eight presented abstracts were invited to submit full papers to this special issue. Nineteen papers were proposed and sixteen papers have been accepted and are published here.

These papers cover a wide geographical canvas, including studies on aspects of evaporite karst in Albania, Great Britain, Italy, Iran, Spain and the USA. The papers are grouped into three board categories. The first group of papers provide national or regional overviews of evaporite karst. Johnson, in his first paper, outlines the main evidence of evaporite dissolution in the contiguous United States, where about 40% of the land is underlain by these soluble rocks. This contribution presents spectacular examples of catastrophic subsidence induced by human activities that cause fresh water to flow through salt formations; these human activities include petroleum tests, solution-mining, and underground mines. The second paper by Johnson characterizes the problems that gypsum karst may pose on lakes and reservoirs, and describes four examples in which the presence of karstified gypsum at a dam site and/or the impoundment area has led to abandonment of the project, collapse of the dam, or substantial leakage. Gutiérrez et al. review the geological and environmental implications of evaporite karst in Spain. Here, the interstratal karstification of evaporites has generated

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large-scale subsidence structures and dissolution-collapse breccias, which constitute major regional aquifers. Quaternary alluviums deposited in fluvial valleys that overlie evaporites locally thicken dramatically to fill dissolution-induced basins more than 100 m deep. The main environmental issues related to evaporite karst in Spain include sinkhole hazards, mass movements from karstified gypsum scarps, severe hydrochemical degradation of surface waters, and pollution and destruction of caves. Parise et al. describe karst features developed in the main evaporite outcrops of Albania and document the principal environmental problems, including water pollution and destruction of caves by quarrying. Liguori et al. provide an overview of evaportie karst in Sicily and also document the hydrochemical degradation of the River Platani, caused by brines derived from an abandoned salt mine. Water circulation and dissolution in this mine is renewed by the ingress of fresh water through sinkholes that result from the collapse of mine galleries. Cooper presents the GIS-based karst inventory of Great Britain that is being constructed by the British Geological Survey. The database has been used to generate a national karst hazard susceptibility map. Both the database and the susceptibility zonation will be a reference for other countries and will be of great use for planners, developers, and the insurance industry.

The second group of papers deal with sinkhole hazards, providing general insights or site-specific studies. Gutiérrez et al. present a methodological review of the assessment and mitigation of sinkhole hazards in evaporite karst areas, highlighting the importance of quantitatively evaluating the temporal-spatial probability of sinkhole occurrence in different areas through the generation and validation of hazard models. In the next paper, Gutiérrez et al. propose a new genetic classification of sinkholes applicable to both evaporite and carbonate karst areas, based on the study of paleokarst features exposed in several Spanish Tertiary basins. This classification scheme describes sinkhole types by the use of two terms that refer to the material affected by downward gravitational movement (cover, bedrock, or caprock) and the main process involved (collapse, suffusion, or sagging). The studied exposures indicate that the sagging mechanism, not included in previous classifications, plays an important role in the generation of sinkholes in evaporite karst areas. The paper by Lucha et al. is primarily focused on the impacts of mining activity on the salt karst of the Cardona Diapir in Spain. Here, the alteration of surface and underground hydrology by mining operations has led to the generation of several human-induced caves up to 4,300 m long. In March 1998, the interception of a phreatic conduit by a mine gallery caused the inrush of fresh water from the Cardener River, resulting in flooding of the mine, massive dissolution, and the generation of a large number of sinkholes. Buchignani et al. investigate the causes and factors involved in the sudden occurrence of a catastrophic collapse sinkhole 30 m across in Camaiore village (Tuscany, Italy). This sinkhole, formed 5 days after an earthquake was felt in the area, resulted from the upward propagation of a dissolutional cavity through more than 100 m of alluvium. In some of the valleys that perpendicularly traverse the halite-bearing evaporite core of the Barbastro Anticline (NE Spain), Lucha et al. document evidence of halokinesis as well as past and currently active dissolution-induced subsidence. Here, Quaternary terrace deposits locally show anomalous thickening (>100 m) generated by dissolution-induced subsidence and deformation produced by the upward flow of salt. The detrimental effects and mitigation of subsidence on canals and buildings in Ivars de Noguera is the other main topic of this contribution. Simon et al. contrast past and present-day subsidence activity in an area of the Ebro River valley (Spain), comparing the density of paleosinkholes exposed in Quaternary alluvial deposits (mostly mantled pediments) and the density of sinkholes mapped in terrace surfaces. They also analyse the spatial and temporal evolution of sinkholes using aerial photographs from different dates and subsidence measurements in active sinkholes. Mochales et al. explore the applicability of magnetic, low frequency Ground Penetrating Radar and microgravimetry techniques by studying a buried collapse sinkhole filled with urban debris in the Ebro River valley (Spain).

The final group of articles study erosion rates in salt exposures and speleothems in gypsum caves. Bruthans et al. used plastic pegs to measure denudation rates on salt diapir surfaces located in different climatic settings in the Zagros Mountains. Motthershead et al. obtain accurate measurements of surface erosion in salt slopes in the Cardona Diapir of Spain by means of a scanning total station and analyse the control of several topographical factors on the erosion rates. Finally, Calaforra et al. analyse the influence of climate on the mineralogical composition of speleothems deposited in gypsum caves, and illustrate how these chemical deposits may be used for paleoclimatic investigations.

The guest editors of this special issue would like to thank all the contributors to the Zaragoza conference, the authors of papers, and the many referees for their efficient and generous work towards producing this collection of papers. This special issue is a companion of other special publications on evaporite karst, including; Oklahoma Geological Survey Circular 109; *Environmental Geology* 48(3); *Carbonates and Evaporites 16*(1) and 17(2), and *International Journal of Speleology* 25(3–4). We welcome contact from others interested in evaporite karst so that we can include them in plans for future meetings about this exciting subject.