Introductory editorial to the Topical Collection on “Engineering Problems in Karst”

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Outcrops of karst rocks cover approximately 20% of the Earth’s continental surface and provide about 25% of the world’s drinking water. Karst systems can be extremely complex and, due to their unparalleled geological and hydrological intrinsic features, are among the most vulnerable settings in the world. These are commonly difficult environments from the engineering perspective that suffer from severe impacts and are the arena of a variety of natural and anthropogenic hazards (Parise and Gunn 2007; Gutierrez 2010). Such peculiar and sensitive environments require the application of specific approaches to foresee and reduce the negative effects of engineering projects, including human-induced hazards and impacts, allowing for sustainable development. Karst hydrology is particularly vulnerable to pollution events, groundwater withdrawal, construction of reservoirs, underground excavations, and land-use changes (Gutierrez et al. 2014;

Stevanovic 2015). In addition, subsurface dissolution creates voids in carbonate and evaporite rocks that may propagate upwards leading to ground subsidence. These instability phenomena, including the occurrence of catastrophic collapse sinkholes, may severely damage any human structure and create serious difficulties to the design and development of engineering works. Management of karst environments is definitively a very delicate matter, which requires the participation of multidisciplinary teams with a proper understanding of their specific functioning and associated problems.

Starting from these considerations, and from multiple years of experience on practical case studies in different regions of the world, a session was proposed on “Engineering Problems in Karst” on the occasion of the 12th Congress of the International Association of Engineering Geology (IAEG), held in Turin, Italy, September 15–19, 2014. The session was very successful (actually, among the most popular ones at the congress in terms of abstracts received: 26 papers submitted from 15 different countries). Following the invitation by Springer to prepare a Topical Collection from that session, the conveners worked with the Environmental Earth Sciences (EES) editorial staff to produce the outcome summarized here. This thematic issue includes expanded versions of twelve selected contributions from the session at the IAEG Congress, which have been rigorously peer-reviewed by international experts under the careful supervision of the Editorial Board of EES.

One of the contributions presents a summary of the main types of engineering problems that can be encountered in karst, an environment characterized by distinctive landforms and by an extremely unique hydrological behavior, dominated by subsurface drainage. The focus in this contribution is specifically drawn on karst hydrology, and on

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the importance of karst aquifers, that provide 20–25% of the world's drinking water; but, on the other hand, they are highly vulnerable to pollution. This paper also addresses the most typical hazard in karst sinkholes.

Several papers deal with sinkhole hazards and the variety of strategies and solutions that may be applied to mitigate the associated problems. A case history from Guanxi province, China, documents the development of a large number of subsidence features in dolomite triggered by water level rise after a heavy rainstorm. Another paper proposes the likely evolution of a sector within a geosite (i.e., site with educational value for an improved understanding of the Earth's history) that might be impacted by sinkhole enlargement; and another contribution presents an experimental monitoring technique for sinkhole recognition, developed by means of the Brillouin optical time-domain reflectometry.

A couple of contributions deal with road networks and engineering works along communication routes in karst settings. One of them describes the exploration and analysis of caves found in the last decades during tunnel construction and road engineering works. The other one documents the use of hydro-geothermal energy and renewable energy, in general, for the maintenance of road networks during the winter season, aimed at reducing environmental impacts.

Another contribution deals with groundwater inflows observed during construction of a tunnel and their influence on the surrounding environment, with particular reference to lakes in the karst area above the tunnel. This leads us to those contributions dealing with karst hydrogeology and water resources management. Even though references to this very important issue in karst are present in almost the whole Topical Collection, two articles are specifically dedicated to it: The first describes a hydropower project to manage water resources, highlighting the need to monitor the related potential impacts. The second paper deals with the main types of subsurface dams to store floodwaters or water from temporary streams in arid and semi-arid areas, where the scarcity of water represents the most serious problem to be faced.

Relationships between tectonics and karst cave development below and in the vicinity of a densely inhabited city are analyzed in another contribution. A paper deals with the engineering geological characterization of tufa deposits, which may be problematic materials for foundations due to their highly variable mechanical behavior. Another article discusses the use of available rock mass classifications and geomechanical models for carbonate

massifs affected by karst, which too often are implemented without taking into account the relevance of karst processes and features.

It is worth noting that numerous contributions integrate different techniques and investigation methods, combining geological, geomorphological, geophysical, and hydrogeological data, as well as speleological explorations, which play an instrumental role in karst studies, whenever the conditions and logistics allow them to be safely carried out.

This compilation of recent investigations provides a reference for karst researchers and practitioners involved in the design and management of engineering projects in karst environments. Furthermore, it represents core knowledge for all future works that will be based on the long-term European Union Earth observation and monitoring program "Copernicus". The very first data became available to users only three weeks after the IAEG congress, on October 6, 2014, marking the beginning of Sentinel-1A operational life. During the last two years, this very ambitious project has provided open access to thousands of scenarios ("big data") from a constellation of optical, infrared, and radar satellites. Such unprecedented inputs will enable new studies of karst systems in Europe and around the world—from the Earth surface point of view—at high resolution, both spectral and temporal.

Publication of this issue was accomplished thanks to the hard work of the authors and reviewers. To all of them, as Guest Editors, we address our sincere thanks for their efforts. Further, we would like also to thank the organizers of the IAEG Congress (and, in particular, the IAEG Congress Chair, Giorgio Lollino) for supporting our proposal of a session dedicated to Engineering Problems in Karst.

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