# Preface

Ideas that karst can develop at depth without direct genetic relationship to the surface have a long history, but remained on the periphery of karstological thinking, not influencing the traditional paradigm of karst until the last 25 years. More attention to hypogene karst since 1990, and particularly the dramatic burst of studies in this field during the last decade, has changed our notion of hypogene karst from a curiosity to one of the fundamental categories of karst, at least of compatible importance with more familiar epigene karst.

Hypogene karst develops where the ascending flow of reactive fluids migrates across lithologies that are soluble in those particular fluids. Ascending fluid flow is ubiquitous in most of the upper crust in which deep-seated flow takes place. It is also a significant component of the circulation pattern in the uppermost zones of meteoric groundwater flow. A wide range of pressure–temperature conditions and the variety of compositions of fluids within the upper crust offer the potential for diverse dissolutional mechanisms to operate in a variety of lithologies. The depth limit for the development of dissolutional macro-porosity is difficult to establish, but available data suggest that it can form within depths of at least several kilometers. The time during which hypogene karstification may take place in deep-seated rocks is much greater than the common lifetimes for epigene karst systems in exposed formations. Hence, the potential for the development of hypogene karst is immense, not only in the continental domain but also in the oceanic domain.

The association of hypogene speleogenesis with ascending flow (leakage and discharge in confined fluid systems) was the major development that caused the recent burst in hypogene karst studies. It allowed (1) identifying the common genetic background and explaining the similarity of a large array of caves previously considered unrelated, which formed in different rock types by a variety of dissolutional mechanisms; and (2) interpreting hypogene karst in the context of regional hydrogeology and geodynamics. This triggered a dramatic expansion of regional and cave-specific studies and reinterpretation of many cases in light of the new conceptual framework.

Progress in regional studies has been reviewed in a series of conferences and their subsequent publications, such as "*Advances in Hypogene Karst Studies*" (edited by K. Stafford, L. Land, and G. Veni, 2009), "*Hypogene Speleogenesis and Karst Hydrogeology of Artesian Basins*" (edited by A. Klimchouk and D. Ford, 2009), "*Hypogene Cave Morphologies*" (edited by A. Klimchouk, I. Sasowsky, J. Mylroie, S.A. Engel, and A.S. Engel, 2014), and "*Origins, resources, and management of hypogene karst*" (edited by T. Chaves and P. Reehling, 2016).

This book was proposed as a next step in consolidating the growing wealth of regional data about hypogene karst. It is neither an inventory, nor a comprehensive coverage of all hypogene karst regions and caves of the world, but is rather a selection of regional and cave-specific case studies that represent a remarkable variability of relevant patterns and settings (geological, hydrogeological, tectonic, and geodynamic). In this way, it provides a solid reference for further generalizing and modeling studies of the topic, which may be the focus of a future collaborative volume on hypogene karst.

The book contains 61 chapters authored by 131 scholars from 25 nations and all continents. It starts with a chapter that reviews basic concepts about hypogene karst, speleogenesis, fluid dynamics, and hydrodynamic zoning of the upper crust, and outlines a pattern for classifying hypogene karst and its settings. Specific case studies are organized into four large geographic regions or continents. Although coverage is truly global, it is not uniform. Whereas 25 chapters are concerned with regions in Europe and 24 chapters deal with the North American regions, only 11 concern other parts of the world. This reflects the uneven distribution of research rather than scarcity of hypogene karst in underrepresented regions. On the basis of geological characteristics and fragmented reports of features scattered throughout petroleum and mining publications, it is evident that hypogene karst is widespread in many regions of Africa, Asia, Australia, and South America, although there are few focused studies. Moreover, even in Europe and North America, many areas have been recognized only recently to host hypogene karst, and its study is still ongoing. This means that next editions of volumes under this title will be needed.

Most contributions in this book deal with karst systems accessible to direct examination, which presently occur in the shallow subsurface. Most are relict systems, decoupled from their original genetic environments and brought into the shallow subsurface from considerable, sometimes large, depth. The advantages of direct observations and sampling, and of using methods developed in karst and cave science, make it possible to obtain unique information about patterns, processes, conditions, and controls of the origin of void-conduit systems at depth and about their hydraulic function. Many parameters of cave-forming environments can be reconstructed from mineralogical and geochemical footprints or inferred from other considerations, such as paleo-hydrogeological analysis. Studies of features that are analogues of deep-seated void-conduit systems are indispensable for interpreting data from drilling and geophysical surveys and for the development of conceptual models. Unfortunately, a wealth of information about the topic in mining areas and petroleum fields is difficult to obtain by karst scholars. Bridging the gap between karst science and industrial geology is a promising opportunity for further developments in hypogene karst studies.

Recognition of hypogene karst and the scale of its phenomena dramatically expand both the boundaries of karst and the significance of karst science far beyond the traditional, dominantly epigenic, karst paradigm. This has numerous scientific and practical implications. Hypogene karst studies hold a promise to help solve many problems in prospecting and exploration of deep petroleum, ore, and geothermal resources in soluble rocks. Proper reservoir characterization and modeling requires a skillful genetic interpretation of void-conduit systems and understanding of their hydraulic function. The role of hypogene karstification lies not only in enhancing reservoir properties but also in facilitating vertical fluid migration across heterogeneous strata. Therefore, it plays a dual role: It not only creates pathways for migration of hydrocarbons and metalliferous fluids to sites of deposition, but also contributes to the loss of the deposits by compromising the integrity of their seals. The latter aspect of hypogene karst also has important implications for the exploration of unconventional oil and gas resources and the sequestering of $CO_2$ and other troublesome fluids. The recognition of specific characteristics and functioning of hypogene karst is crucial for assessment and mitigation of environmental/engineering hazards, including sinkhole formation and groundwater flooding of mines.

The preparation of this book was initiated and coordinated by the Commission on Karst Hydrogeology and Speleogenesis of the International Union of Speleology, as a part of its ongoing HypoKarst project ("*Hypogene Karst & Speleogenesis: Nature, Processes, Mechanisms, Manifestations and Applications*"). The conference "DeepKarst 2016" held in Carlsbad, NM, organized and hosted by the National Cave and Karst Research Institute (NCKRI) has played an important role in the preparation of this book. Our special thanks to Margaret V. Palmer for her help in editing the chapters on North America.

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We hope that this book will stimulate further research into hypogene karst and caves around the globe, as well as interaction between karst scientists and industrial geologists.

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