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EDITORIAL

Introductory editorial to the topical collection: hydrogeological and geomorphological advances in karst and caves research

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Karst is the term used to define a singular landscape developed on soluble rocks, mainly carbonates and evaporites. It covers around 20% of the emerging land (Ford and Williams 2007) and is characterized by unique landforms, both on the surface and underground, created by bedrock dissolution. This process allows the formation of conduit networks, which convert this type of media into triple porosity aquifers (Worthington 2007). Consequently, karst formations are commonly good groundwater reservoirs, particularly those of carbonate type, which often have an excellent chemical quality. For those reasons, humankind has relied on karst groundwater resources for drinking and irrigation in many civilizations since ancient times. Nowadays, the use of karst groundwater accounts for roughly 13–20% of the global groundwater abstractions (Ford and Williams 2007; Stevanović 2019), although the percentage increases in some areas of the world, such as southwest China, the United States, or many European countries (Green et al. 2006; Chen et al. 2017). The relationship between people and karst is also closely linked to caves, which have been used as shelters since the dawn of humanity. Although societies no longer inhabit karst cavities, the inner beauty of most of them and the speleothems that adorn them continue to attract people. Proof of this is the existence of hundreds of tourist caves worldwide that jointly attract 150 million visitors annually (Chiarini et al. 2022).

The importance of karst lies not only in its resources for humans but also in its environmental value. Karst caves host unique but fragile ecosystems (Simon 2019); many karst landscapes are also protected natural spaces and some are even UNESCO World Heritage Sites; additionally, drainage from karst aquifers supports many water-dependent habitats, such as springs, wetlands, and riparian forests (Kløve et al. 2011). Unfortunately, the exploitation of karst resources, mainly groundwater, some mining activities that are not very respectful of high-value karst elements (caves, for example), and pollution from human activities sometimes threaten the integrity and conservation of these ecosystems, as well as the unique karst landscape (Siegel et al. 2023). Therefore, it is necessary to develop appropriate management and conservation policies and practices that guarantee the preservation of such natural heritage. However, that task is challenging, as karst geomorphological and hydrogeological dynamics are very complex. Consequently, it is necessary to keep generating scientific knowledge about the functioning of this type of environment and to continue developing specific techniques that help to study karst processes in greater detail.

Karst research has made great progress during the last decades of the twentieth century and the first decades of the present century. Projects and programmes developed by associations and institutions, such as the Karst Commission of the International Association of Hydrogeologists or the UNESCO International Hydrological Programme, have supported this scientific progress. Similarly, creating specific congresses on karst geomorphology, speleology, and hydrogeology has contributed enormously to advancing knowledge on the matter. In that sense, it is worth mentioning the Conference on Limestone Hydrology and Fissured Media, co-organized by the universities of Neuchâtel (Switzerland) and Franche-Comté (Besançon, France), and the International Symposium on Karst Aquifers, hosted by the University of Málaga (Spain), the Nerja Cave Foundation and the Spanish Geological Survey (IGME-CSIC). They were held every 4–5 years since 1976 and 1992, respectively, until they were unified as a single biennial European karst conference under the name Eurokarst. After the two first editions celebrated in Besançon (2016) and Neuchâtel (2018), and

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to a forced postponement due to the COVID pandemic, the Eurokarst conference was held in Málaga in 2022.

This topical collection includes expanded versions of selected contributions to Eurokarst 2022, after they have been peer-reviewed by international experts under the supervision of the Editorial Board of the Environmental Earth Sciences Journal. Two contributions are review articles; one presents the most relevant aspects of the south-eastern Dinaric karst, the problems derived from using its water resources, and their management (Stevanović and Milanović 2023), while the other synthesizes the state of the art in modelling karst environments and discusses its challenges and prospects (Jourde and Wang 2023). Precisely, different perspectives of karst modelling occupy an essential part of the volume: modelling of spring discharge based on stochastic models (Petrović et al. 2023) and data-driven approaches (Rudolph et al. 2023); evaluation of predictions and uncertainties of karst models (Leins et al. 2023); and analysis of karst conduit sized distribution from speleogenesis modelling (Maqueda et al. 2023). Besides, two articles are related to aquifer recharge in Italy; one concerns snow infiltration assessment in the Gran Sasso aquifer, Italy (Lorenzi et al. 2023), while in the other, the use of GPS data enables the evaluation of the deformation of the Matese massif due to recharge-discharge cycles (Leone et al. 2023). A new hydrodynamic method for the unsupervised clustering of hydrodynamic variations in boreholes is presented in one contribution (Erguy et al. 2023). Regarding karst hazards, a case study assesses the flooding risk in the Mucille karst depression, in Italy (Zini et al. 2023). A paper on groundwater chemical quality is also included, especially focused on the combination of major ions and selected trace elements with turbidity to estimate allogenic recharge contribution in two Spanish karst springs intended for human consumption (Fernández-Ortega et al. 2023). Another manuscript deals with the mesoscale dual porosity of the karst, which is investigated by combining geological, petrophysical, and hydraulic techniques to interpret injection tests (Danquigny et al. 2023). Last but not least, cave research is also present in the Topical Collection, with a contribution regarding the gaseous dynamics of the Rull Cave in Spain (Pla et al. 2023).

This publication compiles recent investigations dealing with the matter from a broad range of perspectives, including hydrogeology, water management, karst hazard, speleology, petrophysics, hydrogeochemistry, and mathematical modelling. Thus, the compilation provides a reference of interest for ongoing and future research on karst media.

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Declarations

Conflict of interest The authors declare that there are no competing interests.

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