KARST HYDROGEOLOGY AND GEOMORPHOLOGY: KEY ACHIEVEMENTS TO-DATE AND NEW FRONTIERS FOR RESEARCH AND CONSERVATION

Paul W. Williams

University of Auckland, New Zealand

ABSTRACT: The last half century has seen karst science transformed. Fifty years ago prevailing ideas were still dominated by concepts developed in the early 20th century. Explanation of karst landforms was mainly in terms of climato-genetic concepts. We had little information on carbonate dissolution, the rate at which karst developed, and the absolute age of karst features. Explanation of groundwater movement was mainly in terms of porous media flow concepts and factual data on subterranean flow paths and flow-through times were scarce. Ideas on cave development were dominated by competing phreatic, water table and vadose concepts, and there was no awareness of the importance of cave archives for reconstructing past climates.

We now have abundant quantitative data and process-based models on the rate and effectiveness of carbonate rock dissolution. Radiometric dating using U/Th and U/Pb has transformed our understanding of the age of caves and karst landforms. We now appreciate that some karsts are tens of millions of years old. Modern techniques enable dating of speleothems with precision, and micromilling permits sampling in 25µm steps; this yielding sufficient calcite for determination of stable isotope values. Thus a new world of karst palaeoclimatology has developed, with cave records becoming the mid-latitude terrestrial equivalent of deep-sea cores and ice-cores, although speleothem chronology is more reliable.

In karst hydrogeology we now recognize the 3-phase nature of karst groundwater movement and storage that involves matrix, fissure and conduit porosity. While most storage occurs in intergranular and fissure porosity, groundwater transmission is dominated by secondary conduits. Darcian groundwater models have been shown to have limited applicability in karst, and may even be seriously misleading, when it comes to management of groundwater resources. The epikarst, unrecognized 50 years ago, is now known to be fundamental to the storage and spatial distribution of recharge.

Coupled hydrogeological and hydrochemical models have been used successfully to model the rate of speleogenesis and the propagation of subterranean conduit networks. Fluids of hypogean origin are now also known to sometimes have an important role in the development of karst cavities. Along carbonate coasts, the mixing of fresh and salt waters enhances dissolution and is now known to increase permeability.

From the compilation of maps of carbonate outcrops, we now know the global distribution of carbonate rocks. These outcrop across about 11% of the ice-free continental area, but considering also the sub-crop participation of carbonates in groundwater circulation, it is likely that ~14% of the continental area is in the carbonate karst realm. These terrains provide water for about 25% of the world's population; so karst recharge areas need effective protection. The karst outcrop contains some inspiring landscapes both above and below ground. Some are recognized by UNESCO as of World Heritage quality, but other equally inspiring karsts still require formal international protection. Much work therefore remains to be done in karst, especially in hydrogeology, paleoclimatolgy, dating, and conservation.