Geophysical Research Abstracts, Vol. 9, 03225, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-03225

Numerical simulation of karst evolution in multi-storey artesian systems

S. Birk (1), C. Rehrl (1), A. Klimchouk (2)

(1) Institut für Erdwissenschaften, Karl-Franzens-Universität Graz, Austria , (2) Ukrainian Institute of Speleology and Karstology, Ministry of Education and Science, National Academy of Science, Simferopol, Ukraine; (steffen.birk@uni-graz.at)

The interrelation between hydrogeological environment and void evolution in soluble rocks is examined by process-based numerical modelling. Whereas earlier research focused on generic conceptual settings, this work aims to establish site-related numerical models that are largely based on field data compiled from the karst terrain of the Western Ukraine. Field observations from this area were earlier used to develop a detailed conceptual model describing speleogenesis in cratonic multi-storey artesian basins. In this work, the existing conceptual model is tested by numerical modelling and iteratively improved by comparing model outcome and field observations. Thereby, the model simulations aim to agree in principle with the field observations rather than to reproduce details of specific cave systems. Field observations from the Western Ukraine and elsewhere suggest that conduit development in multi-storey artesian systems is driven by the upward hydraulic gradient across a soluble layer, maximized below river valleys, so that the cave-forming flow is directed transversely relative to bedding, laterally extensive stratiform fissure networks, and the long dimensions of intrastratal fissures (transverse speleogenesis). Thus, the temporal and spatial characteristics of the regional hydrogeologic setting, in particular the hydraulic boundary conditions, are believed to be a controlling factor of the geometry of the evolving cave patterns. In order to allow an adequate representation of the regional hydrogeological setting, a coupled continuum-pipe flow model is employed for simulating conduit development within the soluble units of multi-layer aquifer systems. Important discrete pathways, such as prominent fractures and solution conduits, are represented by a pipe-network model, while a continuum model represents the regional flow system, including non-soluble aquifers and confining beds as well as the porous matrix and

dense networks of narrow fissures within soluble units. The two flow models are hydraulically coupled by a linear exchange term, i.e. water exchange between porous fissured rock and embedded discrete pathways is assumed to be proportional to the hydraulic head difference between them. The pipe flow model is coupled to a module calculating dissolution rates and corresponding widening of conduits depending on the flow conditions. Earlier, generic models of conduit development suggest there is a positive feedback between increasing flow and dissolution rates and thus a speleogenetic competition of discrete pathways. Although operative at the early stage of karstification, this speleogenetic competition is later found to be suppressed within the artesian type of setting studied in this work, because inflow to and outflow from the conduit system are limited by the permeability and boundary conditions of the regional flow system. Thus, conduit development is less selective, and maze patterns may develop provided appropriate structural prerequisites exist.