HYPOGENIC SPELEOGENESIS IN THE CRIMEAN FORE-MOUNTAINS (THE BLACK SEA REGION, SOUTH UKRAINE) AND ITS ROLE IN THE REGIONAL GEOMORPHOLOGY

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The leading role in the geomorphic development of the Crimean fore-mountain region is played by the processes of dismemberment of "shielding" limestone layers of the monoclinal stratified structure through valley entrenchment, and by further retreat of vertical rocky outcrops via block-toppling mechanism. These processes are guided by the presense of hypogene karst structures, whose formation preceded the modern relief. Karstified fracture-karst zones, 100 to 400 m wide, in the Cretaceous-Paleogene strata controlled the entrenchment of valleys in the limestone layers. The basic elements of hypogenic karst structures, which form their spatial framework, are sub-vertical fracture-karst conduits (karst "rifts"). Denudational opening of vertical fracture-karst rift conduits in limestone layers set the cliff-like shape of valleys slopes, and presence of such rift conduits in the rear of cliffs of already incised valleys determines the block-toppling mechanisms of slope retreat. This maintains the verticality of cliff segments in the cuesta ridge and controls their position.

Hypogenic sculptural morphology is extensively displayed in the exposed walls of cliffs (former conduit walls), which determines the originality and nomenclature of morphology of limestone cliffs of the Inner Ridge. In those areas of slopes where position of cliffs has stabilized for considerable time due to absence of new lines of block detachment in the rear, weathering becomes a significant process in the morphogenesis of surfaces. The abundance, outstanding expression, preservation and accessibility of relict hypogene karst features in the extensive cuesta cliffs of the Inner Ridge makes the region the foremost one for studying regularities of hypogene solution porosity development, the process currently ongoing in the adjacent artesian basin of the Plain Crimea.

The Crimean Mountains in the south of the Crimean Peninsula (the Black Sea region, south Ukraine), with its Main Ridge composed by Jurassic limestones, are a part of the Alpine fold-thrust belt. Adjacent to north, lays the Prichernomorsky artesian basin resting on the basement of the Scythian Plate within the Crimea Peninsula (Figure 1).

The Crimean fore-mountain region stretches as an arch along the tectonic suture junction zone between the above two structures. It is composed by two cuesta-like ridges (the Outer Ridge and Inner Ridge) whose structural slopes are formed by limestone beds of Paleocene and Eocene (the Inner Ridge), and of Neogene (the Outer Ridge).

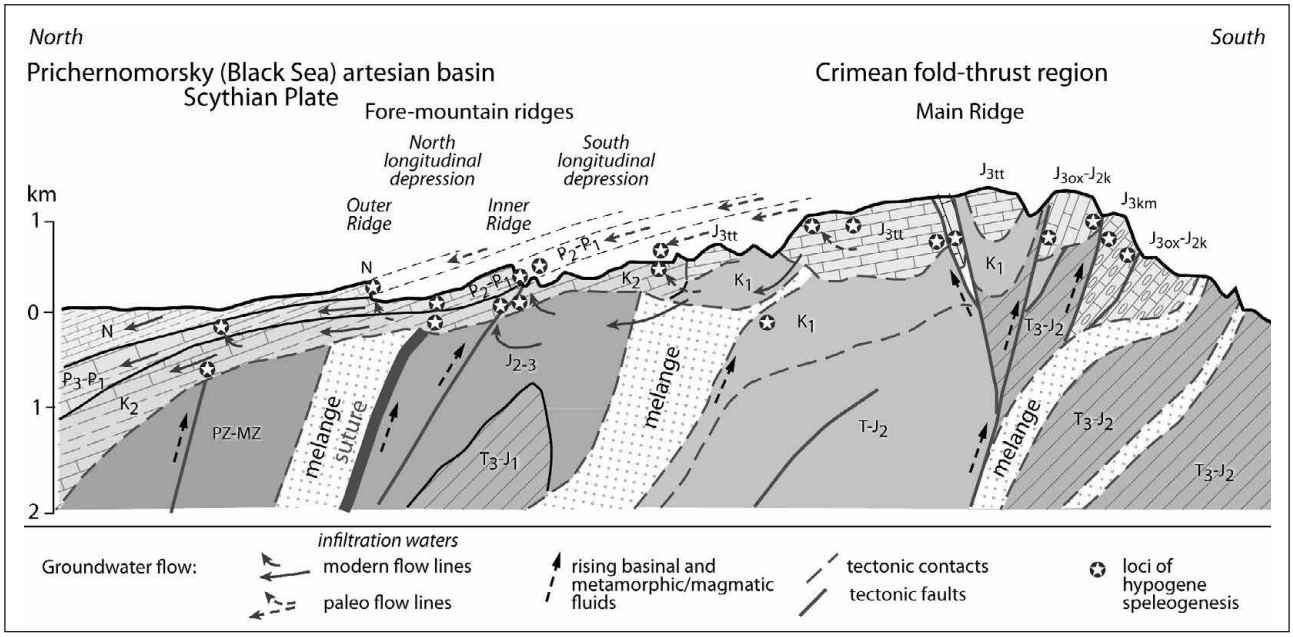

Figure 1. Schematic geological cross-section across the Crimean fold-thrust region and its junction with the Scythian Plate (simplification based on Yudin 2011), showing modern and paleo flow systems and localization of hypogene speleogenesis.

In the south-east-faced cuesta cliffs of the Inner Ridge, as well as in the canyon-like transverse valleys that cut the ridge, extensive vertical outcrops of the Upper Cretaceous marls and Paleocene and Eocene limestones display a rich array of features indicative of wide-spread hypogenic karst development in the region, which occurred before the monoclinal layered structure had been dissected by erosion. Upwelling of deep fluids across the layered aquifer system of the monoclinal slope was likely linked with the geodynamic activity along the suture zone (Figure 1).

Erosional valleys that transected the area and formed cuesta main escarps followed a linear pattern of hypogenic karst structures developed along fault zones and fracture corridors. The basic elements of these structures, which formed their spatial framework, are sub-vertical rift-like conduits (Figure 2). Elements of such karstified corridors are still present along the edges of massifs, in the rear parts of cliffs, causing the dominant block-toppling mechanism of the slope retreat processes (Figure 3). This maintains the verticality of limestone escarps and exposes "fresh" hypogenic karst morphology of former rift-like conduits. The suit of hypogenic karst features displayed in exposed walls includes variously sculptured surfaces, honeycomb, boxwork and spongework surfaces, metasomatic alteration halo, and a rich array of forms composing a cavernous "fringe" of the principal rift-like conduits. The features of the "fringe" are now displayed in the exposed walls as grottoes, niches, large vugs, and zones of smaller vuggy porosity. Caves in the region are fracture-controlled, linear, or crude mazes (the longest one is 500 m long), demonstrating the complete suite of speleogens indicative of the hypogenic origin. Caves are, in fact, those "branches" of former karst systems that are oriented normal or oblique to the present escarps, and hence retain their integrity, in contrast to those former caves that had been utilized by valleys. U/Th dating of phreatic calcite (rising spring "facies"; 260–350 ka) and stalagmite bases (ca. 130 ka) permitted to establish age constrains for the period of termination of the hypogenic development of karst systems in the south-west sector of the range, geomorphologic expression of the modern Paleocene segment of the cuesta in the relief, and respective transition to vadose conditions.

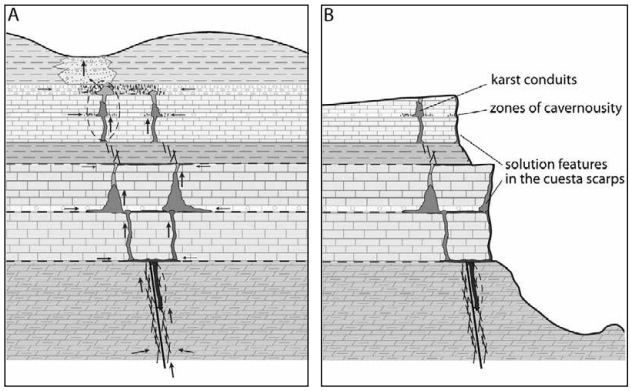

Figure 2. Conditions of the formation (A) and the current geomorphic situation (B) of caves and other karst features in the Inner Ridge of the Crimean fore-mountains.

The main speleogenetic process, clearly discerned from hydrostratigraphic/structural relations and morphology of caves and features at cliffs, is the renewal of aggressiveness due to mixing of deep rising flow (along cross-formational fracture conduits) and shallow stratiform flow in the layered aquifer system (Figure 1). Dissolution by rising thermal waters and by sulfuric acid (due to oxidation of H_2S) is also likely to play a role, at least locally.

We conclude that hypogenic karst was one of the primary factors of regional geomorphic development, as it determined locations and specific morphology of valleys and cuesta cliffs, as well as further landform development in the adjacent areas of the structural surfaces (blind valleys). The abundance, outstanding expression, preservation and accessibility of relict hypogene karst features in the extensive cuesta exposures of the Inner Ridge makes it the foremost region for studying regularities of hypogene solution porosity development, the process currently ongoing in the adjacent artesian basin of the Plain Crimea.

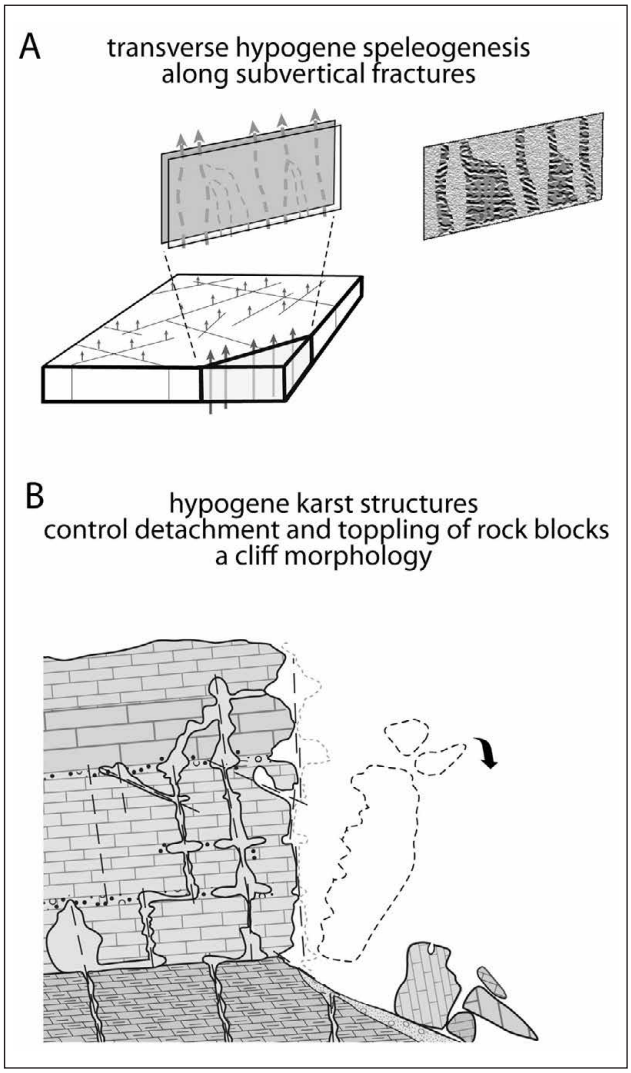

Figure 3. Cartoons illustrating transverse hypogene speleogenesis (A) and its control over slope processes in the Inner Ridge of the Crimean fore-mountains.

References

Yudin VV, 2011. Geodynamics of Crimea. Diaypi, Simferopol.