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GEOLOGICAL CONDITIONS AND FACTORS OF KARST FORMATION (ON THE EXAMPLE OF GEORGIA)

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Abstract*. This paper discusses the role of geological conditions and factors (stratigraphy, lithology, chemistry of karstified rocks, structural-textural characteristics, the nature of the cementing substances of the mineral particles making up the rock, issues of general and fracture tectonics, stratification of karst waters and the nature of their bedding) in karst development in the karst belt of Georgia.*

Key words*: karst, syncline, anticline, orogen*

Introduction

Georgia is one of the outstanding countries in the world for the diversity of karst processes. Limestone rocks occupy more than 10% of the territory of Georgia, where various surface and underground karst landscapes are represented. Karst is especially well developed in Western Georgia, where it stretches as a continuous belt for 325 km in length and from 2-3 km to 30-35 km in width, from the Psou River to the area of Lake Ertso. It includes the northern hilly part of the Colchis lowland and the adjacent southern slopes of the Western Caucasus. The vertical spread of karst begins at sea level (Gagra) and reaches up to 2757.6 m absolute height (Speleologists' Peak, Arabika massif) (Fig. 1).

Study area, material and methods

The belt of carbonate sediments on the southern slope of the Caucasus, where karst phenomena are developed, is characterized by rather complex stratigraphic, lithological and tectonic conditions. Based on materials and knowledge accumulated over years by previous researchers of Georgian karst and ourselves, as well as the analysis of geological maps of different scales, the work presents the significant role of the geological factor in karst formation. The paper uses field, experimental and laboratory research methods. The chemical composition of the carbonate sediments was studied in the laboratory. The data of boreholes and geological sections, electrometric prospecting methods, and tracing experiments of underground waters were used.

Results

According to Petre Gamkrelidze's tectonic scheme, the limestone belt of Georgia is situated between the fold system of the southern slope of the Caucasus and the Georgian belt, as a result, both orogenic and platform karsts are presented here, which are characterized by different karst formation conditions and features [1].

In tectonic terms, the common Caucasian strike linear anticline and syncline folds predominate in the Georgian karst belt, while disjunctive dislocations play a subordinate role [2]. This fact is linked to the comparatively weak openness of vertical fractures in the mountainous limestone regions of Georgia. Nevertheless, a number of karst massifs (Bzipi Ridge, Arabika, Migaria, Askhi, Kudaro-Buba, Racha Ridge, Migaria) are distinguished by significant break-fault tectonic dislocations, which accounts for the extensive development of karst shafts and abysses. A completely different picture is found on the Zemo Imereti Plateau, which is the only platform-structural karst in the Caucasus. Here, karst voids are represented mainly by sub-horizontal caves and are related to widely spread stratification fractures and other break-fault dislocations in thin (on average 230-240 m) bedded Upper Cretaceous limestones lying quietly on the Dzirula crystalline basement, which were revealed by structural interpretation of aerial photographs of the Zemo Imereti structural plateau and by field studies (Fig. 2) [3, 4, 5, 6].

Fig.1. Map of the karst of Georgia

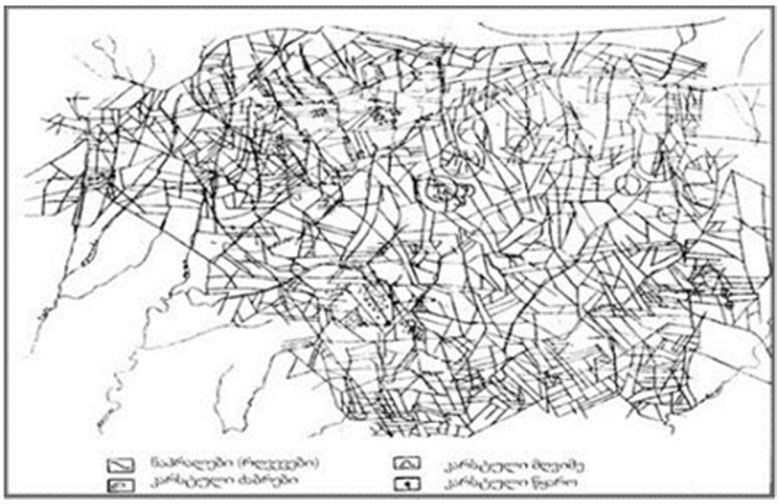

Fig. 2. Scheme of break-fault dislocations of the Zemo Imereti structural plateau.

Karst formations of rocks of various ages create a certain lithological-facies, structural and textural variability, which affects the intensity of karstification of different horizons, and the morphogenesis of underground and surface forms.

Here, karstification affects Upper Jurassic (Lias), Lower and Upper Cretaceous and Paleogene age carbonate sediments. The Cretaceous system is especially widely represented, all stages of which reach major thicknesses (1200-2600). Such significant thicknesses of carbonate rocks, along with other contributing factors, determine the geomorphological, hydrogeological and speleological complexity and diversity of several massifs (Arabika, Bzipi Ridge, Okhchakhue, Askhi, Migaria, and others), whereas regions composed of karstifiable rocks of relatively small thickness (Zemo Imereti, Kudaro-Buba, Central Samegrelo, Sataplia-Tskaltubo, etc.) are characterized by karst phenomena of relatively smaller scale. In the first case, complex systems of vertical and horizontal voids are formed, and meteoric waters appear after migration from absorption areas through quite complicated routes after prolonged flow; in the second case, mainly horizontal cave systems are formed, and due to the minor thickness of karstifiable rocks, precipitation quickly passes into horizontal channels via fractures.

One of the hydrogeological features of high-mountain massifs composed of thick karstifiable rocks is that they not only allow significant dynamic reserves of underground waters to accumulate, but also to be stored and discharged gradually, which cannot be said about massifs composed of thin karstifiable rocks [7].

The bedded or massive nature of limestones and the bedding characteristics, together with other contributing conditions, determine several essential points in the morphology of both surface and deep karst forms. For example, karst voids initiated in bedded, inclined limestones are characterized by distinctly stepped floors (bottoms) and frequent change in the direction of the cave's main channel (e.g., Kelasuri, Tkibula-Dzevrula, Mtiskalta and other caves), which is caused by alternation of easily and poorly soluble bedded fractured limestones. By contrast, voids developed in massive limestones are distinguished by high vertical and sometimes

cascade-like steps, unlike regions composed of thin-bedded limestones. For example, the Asazkhitsri karst shaft located in the Bzipi Ridge is represented by a single 85 m deep vertical step, while "Snowy Abyss" is with a 165 m deep shaft. A similar situation is observed in the Kudaro-Buba, Rikhva and other massifs, which are related not only to the textural characteristics of rocks but also to the nature of fracturing. Sometimes horizontal and inclined karst voids with balanced longitudinal profiles develop even in massive limestones, linked mainly to the corresponding fracturing.

Areas built of massive and bedded limestones are characterized by different morphological peculiarities of surface karst forms. Karst surfaces in massive limestones are distinguished by deep, severely dissected grooves and sharp crests forming intricate meandering labyrinths. In contrast, karst developed in thin-bedded limestones are characterized by frequent but shallow (0.3-0.7 m) dissection and comparatively smoothed crests. Karstic dolines in massive or poorly bedded limestones predominantly have rounded outlines and straight conical shapes, while in inclined bedded limestones, they are mainly asymmetric in form.

The rate of solubility and, therefore, the intensity of karst processes largely depends on the chemistry of rocks, structural-textural features, and the nature of the cementing substance of the mineral particles forming the rock.

The study of the chemical composition of Georgia's carbonate rocks confirms the known fact that, in the presence of other favorable conditions, karst formation is more intensive in rocks with a negligible percentage of insoluble residues. Mainly, this explains the concurrence of rather intensely karstified surfaces of Georgian karst regions (certain areas of the Arabika massif, Rikhva, Bzipi Ridge, Gumista-Pskritskha, certain areas of the Askhi Ridge, etc.) with the distribution areas of relatively pure lower and upper Cretaceous carbonate rocks [8].

Coarse-grained rocks are destroyed more quickly than fine-grained rocks, although their solubility is conversely lower. Also, calcitic cement is more easily soluble than clayey or siliceous cement.

Conclusion

Karst formations of rocks of various ages create certain lithological-facies, structural and textural variability, which affects the intensity of karstification of different horizons, and the morphogenesis of underground and surface forms. The bedded or massive nature of limestones and the bedding characteristics, together with other contributing conditions, determine several essential points in the morphology of both surface and deep karst forms. The rate of solubility and, therefore, the intensity of karst processes largely depends on the chemistry of rocks, structural-textural features, and the nature of the cementing substance of the mineral particles forming the rock. The available factual material and our research confirm the immense role of break-fault tectonics in the migration of waters and, accordingly, in the formation of karst voids in the karst massifs of Georgia.

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