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ABOUT GENESIS OF KARST CALDERA OF DENUDATION-TECTONIC LANDFORM. GEORGIA, CAUCASUS

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ABSTRACT

The paper considers previously unknown denudation-tectonic circular landforms with the diameter of 1.5-2 km, defined by us as karst calderas. These forms are presented in western Georgia, namely in Zemo Imereti Plateau, on the carbonate-terrigenous cover of the Georgian block. Endogenous-exogenous mechanism and conditions of their origin have been proposed in the paper. The integrity of the substrate cover in its local volume is violated by the stamp impact of the hearth structure on the covering of Pre-Cretaceous substrate, thus creating favorable conditions for selective denudation, activation of destructive processes and occurrence of inversive depressions of the circular shape. Field geomorphological and karst-speleological large-scale survey of the area was carried out during research process. In order to properly study the tectonic-structural situation in the research area, we also made a structural decoding of satellite images that allowed us to make a detailed scheme of fault dislocations and specify the regularities of distribution of karst forms. The structural decoding of satellite images revealed the previously unknown terrain circular forms of chain distribution in the Zemo Imereti Plateau. The genesis and evolution of above-mentioned landforms is closely related to the geomorphological and geological structure of the research area.

Keywords: Denudation, Karst, Tectonics, Caldera, Georgia.

INTRODUCTION

Georgia is a classical karst country that is located in the Caucasus region between Russia, Turkey, Armenia and Azerbaijan. Diverse karst landscapes are represented in Georgia considering different factors (geology, geomorphology, tectonics, climate, etc.); the impressive surface and underground karst forms are developed in these landscapes itself [1] including the Veriovkina Cave (the region of Apkhazeti), which is the deepest nowadays in the world [2]. The karst landscape is mainly developed in western Georgia, which extends over 325 km from the Psou River to the east up to the

Ertso Lake [3], [4], [5]. There are several dozen limestone massifs represented within the abovementioned strip, which differ from each other both by hypsometrical distribution and area [6].

Among the above-mentioned limestone massifs the Zemo Imereti Plateau is notable, which is interesting area in Georgia in view of the development of karst terrain, and which is the only platform karst region in the Caucasus [7]. This area is a constituent part of the limestone strip of intermountain plain of Georgia and includes the easternmost part of western Georgia [8], which is distinguished by its peculiar natural conditions (relief, tectonics, climate, surface and underground streams). Zemo Imereti Plateau is built of Pre-Cambrian and Paleozoic crystalline slates, granitoids, gneisses, tuffs, and phyllites (which are dissected by intrusive in some areas). The part of the washed surface area is inconsistently covered by the layers of the Lower Jurassic (Lias), Middle Jurassic (Bajocian), Cretaceous (mainly carbonate suites), Oligocene (the manganese containing deposits) and the Miocene deposits (Fig. 1).

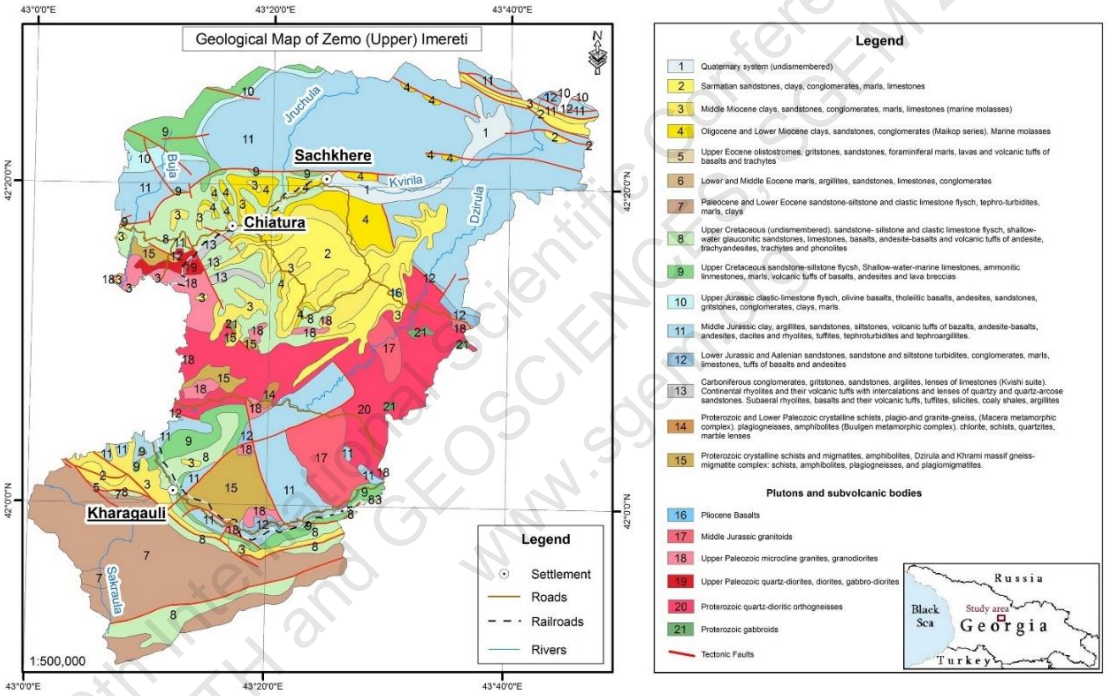

Fig. 1. Geological map of the Zemo Imereti Plateau [9].

Zemo Imereti Plateau, as part of the Georgian block, is represented by two structural levels - the Pre-Cretaceous substrate and Cretaceous-Neogene platform cover. The latter is also divided into the Cretaceous-carbonate and Neogene-terrigenesub-horizontal sub-levels.

Sedimentation of the above-saidsediments (of upper structural level) took place in the platform conditions, and therefore, their total capacity does not exceed 500-550 meters.The abovementioned territory has passed a long and hard way of geological development. Unlike the folded orogenic strip of Georgia, this region was formed in the platform conditions. On the tectonics of the latter, an important role played the washed and consolidated part of the Georgian block (the ancient Paleosoic terrain), which greatly resisted to the mountain forming processes that took place in the geological Tertiary period (Fig. 2).

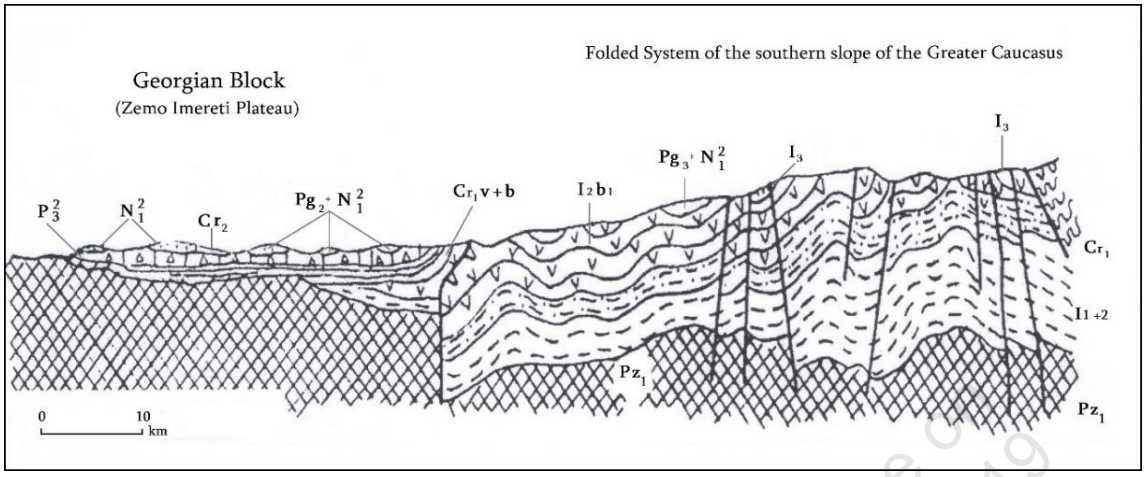

Fig. 2. Geological sections of the folded system of the southern slope of the Greater Caucasus and the Georgian block [10].

Exactly, the solid platform resulted in a relatively simple tectonic structure of the Zemo Imereti Plateau, namely, a quite horizontal or slightly sloped situation of Cretaceous and Tertiary suites located on the Hercynian platform that contributed to the development of gently hilled plateau shaped relief and related karst phenomena.

Nevertheless, the Mesozoic-Cenozoic suites that build substrate seem to have experienced plicate and especially disjunctive dislocations. Intense tangential movements in the neighboring geosynclinal zones in the Zemo Imereti platform caused the geodynamic tension, which was revealed on the Mesozoic-Cenozoic sedimentary cover on the solid fundament in the forms of faults, overthrusts, fissures, wavy folds, laccolith-extrusives and others. All above-mentioned was reflected in the results of the decoding of satellite images as well.

RESEARCH METHODS

Field and experimental studies are often insufficient to get a detailed scheme of tectonic structures of the area and, in particular, the fault dislocations. In the Zemo Imereti Plateau, the Tertiary (Paleocene-Eocene) covering sediments complicate the detection of fissures and shearings. In such conditions, we have used a structural decoding method of satellite images, which is successfully used to reveal hidden tectonic structures.

Field geomorphological and karst-speleological large-scale surveying of the area was carried out in the research process. In order to properly study the tectonic-structural situation in the Zemo Imereti Plateau, we made a structural decoding of satellite images that allowed us to make a detailed scheme of fault dislocations and specify the regularities of distribution of karst forms.

RESULTS AND DISCUSSION

The structural decoding of satellite images revealed the previously unknown terrain circular shapes of chain distribution in the Zemo Imereti Plateau, which is the classic area of platform karst distribution across the Caucasus (Fig. 3). As it was revealed, the genesis and evolution of different forms of the above-mentioned relief is closely related to the geomorphological and geological structure of the research area [6]. As it turns out, in the Zemo Imereti Plateau, the fault dislocations control the absorption of underground water flows and their movement routes.

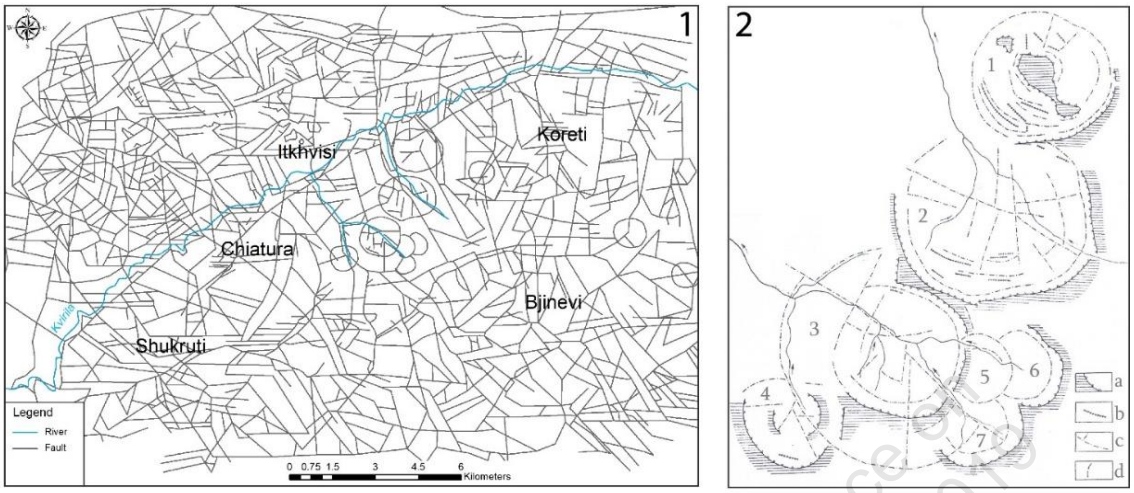

Fig. 3. 1) The scheme of fault dislocations of the Zemo Imereti structural plateau (derived by decoding of satellite images); 2) Radially concentrated structures of karst calderas and their distribution scheme (1-Koreti caldera; 2-Kveda Itkhvisi caldera; 3-Zeda Itkhvisi caldera; 4-Shukruti caldera; 5-6-7 - nameless small calderas-satellites). **Conventional signs:** a-danudative-tectonic cliffs on the upper cover of carbonate rocks; b-denudative-tectonic remnants on the bottom of the karst caldera; c-radial and concentrated fissures (shearings, lineaments) revealed by structural decoding; d-identified external contours of karst calderas.

The diameter of these landforms revealed during the decoding varies from 1.5 to 2 km and morphologically they are depressions. These forms are developed in the Neogene tectonic sediments, which, in their turn, cover the Upper Cretaceous limestones. Depressions are linearly circular, with 40-60 m tall slopes not almost exposed to erosion, and they have a strong front and back side [6]. These slopes encompass the flat subhorizontal bottom of saucer-shaped depressions.

The described peculiarities distinguish the above-mentioned depressions from common watercatchment depressions of the exogenous origin. In our opinion, the endogenous processes play an active role in the origination of these depressions, which should be conditioned by the circumstances and facts described below. It is known that hydrodynamics of river currents in the process of their development does not generate strict geometric shapes-neither linear non circular, in case they are not controlled by tectonic disorders [11].

The endogenous nature of the origin of these depressions, which prepared the tectonic conditions for realization of further denudation processes, is also indicated by: radially concentrated denudative remnants built of Tertiary rocks that quite complicate the flat-bottomed relief of these depressions;also, radially and concentratedly oriented lineaments (fissure zones), which have been observed within depressions as a result of decoding. It is noteworthy that the lineaments are related to fissures and fault lines.

These circular forms of the relief are also well represented on the schemes we have compiled using geo-information systems (GIS). Structures of circular forms on the Pre-Cretaceous substrate are vividly depicted on those schemes that are in compliance with the structures derived by us as a result of decoding (Fig. 4).

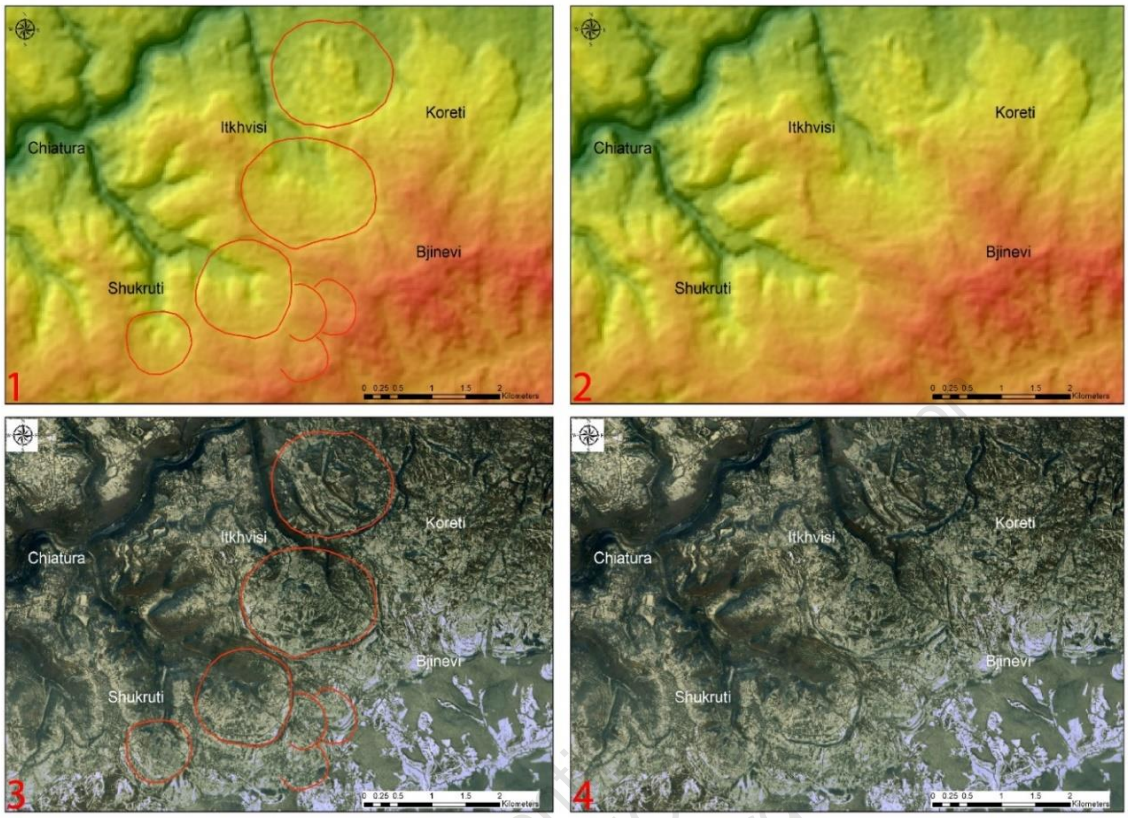

Fig. 4. 1) The red circular lines show the distribution areas of karst calderas in the Zemo Imereti Plateau (the 30-meter resolution digital 3D model); 2) Thedistribution areas of karst calderas are seen without the red circular lines in the 30-meter resolution digital 3D model; 3) The red circular lines show the distribution areas of karst calderas in the Google Earth's image; 4) The distribution areas of karst calderas are seen without the red circular lines in the Google Earth's image.

It is noteworthy that the origination of such circular depressions is characteristic of certain stages of development of volcanic apparatus [12]. It is important that in the research region the volcanites are represented in cross-section of Pre-Cretaceous fundament and the revelations of volcanism took place in Quaternary, it resulted in the formation of the Goradziri (Fig. 5) and other laccolith-extrusives that are represented in the relief in the form of hills [13], [14].

Fig. 5. The Goradziri hill of volcanic origin.

Hence, depressions discussed in the article by authors can be considered the depressions of magmatic genesis formed along the fault on their top. Taking into consideration these circumstances, we for the first time introduced the term "caldera", denoting earlier unknown morphostructural formation. However, considering that in the research territory, in the limestone rocks the intensive karst development takes place,we finally named it the "karst caldera", the genesis of which is endogenous-exogenous. Thus, the karst caldera-forming mechanism is similar to the volcanic, or, in the broader sense, the inversive depressions of magmatic origin.

The chainwise layout of the mentioned karst calderas are similar to the chainwise layout of the circular volcanic-tectonic morpho-structures in Kamchatka and other volcanic areas [15] . This makes us think of the origin of the karst calderas along the fault on their top. Their strict circular shape indicates the hearthmechanical tension, which may be central type of structures (volcanic apparatus, intrusives of isometric form) on the Pre-Cretaceous substrate. These structures control the faults and act as a tectonic stamp. The latter, in its turn, causes the disintegration of the common cover of the platform and creates favorable conditions for activation of selective denudation. It is natural that firstly the relatively weakly consolidated Neogene-terrigene layers are subjected to denudation, resulting in unearthing the Cretaceous rocks.

CONCLUSIONS

Thus, a new, the previously unknown denudative-tectonic land form (karst caldera) observed within the Zemo Imereti Plateau and studied by authors through the structural decoding of aerial images, are represented by saucer-shaped depressions.

The mentioned depressions are characterized by a strictly circular structure, and the structural decoding revealed the radially oriented lineaments (fissured zones) within the depressions that gives us an idea of primary endogenous nature of the origin of

depressions, which prepared the tectonic conditions for realization of further denudation processes.

In our opinion, the mechanism of origin of karst calderas is similar to the inverse depressions of magmatic origin. Their strict circular form indicates the hearth mechanical tension on the Pre-Cretaceous substrate cover, which may be the central type of structures; specifically, the volcanic apparatus, and the intrusives of isomeric form. The mentioned structures control the faults and act as a tectonic stamp. All this leads to the collapse of the common cover (in local volume) and create favorable conditions for selective denudation.

In addition, first of all, it is natural that the weakly consolidated Neogene layers denudate and the digging of Cretaceous rocks are underway respectively. Tkibuli cave should also be of similar genesis,where the denudative and karst processes are quite advanced and are in the mature stage of development.

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