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Main Results of Complex Research into the Tskaltubo Cave System

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ABSTRACT. The paper presents the results of complex research carried out for years into the Tskaltubo cave system. Main features of aeroionization, morphological, climatic, hydrological, and radiological characteristics of the cave system have been analyzed. Complex research results served as a basis for equipping the cave for speleotourism purposes. *© 2010 Bull. Georg. Natl. Acad. Sci.*

Key words: *karst, cave, complex research, main results.*

Complex study of Tskaltubo limestone massif, namely, the Tskaltubo (Kumistavi) Cave system and its adjacent objects is dictated in the interests of rational management of a number of branches (speleo-tourism, speleo-therapy, etc.) of unique underground economic monuments, investigated by the speleo-team of the Institute of Geography in the region in the 1980s.

The complex studies aimed at determining the general regularity of karst development in the region in connection with the improvement of the mentioned speleo-objects.

To achieve this aim the following work had to be done: complex study of karst forms of the relief and fissure-karst waters; supplementation of the available topographical materials on the karst caves making them more precise, land-surveying and working out of distribution scheme; carrying out of permanent and episodic meteorological observations in the cave system according to the seasons of the year; identification of the composition of certain elements of atmospheric electricity in the cave air (ionization of the air, radio-activity, gas and bacteriological composition of the air); elaboration of hydrometeorological monitoring of the catchment basin of Tskaltubo Cave System; statement of coefficient of thermal disturbance, discharge (by seasons) of the air arriving in the cave and the simultaneously admissible number of visitors related with it [1].

Considerable amount of factual material was studied and generalized in the period of conduction of field researches (2006-2009), such as: more than 40 karst wells and caves; permanent or temporary karst streams, complex underground siphon sections, etc. [2].

Geological, geomorphological and karst-speleological surveying of karst relief was conducted. The genesis of the surface and underground karst forms of the relief of Tskaltubo limestone massif is mainly related to the sediments of Valanginian, Hauterivian and Barremian Ages, which are divided into several lithostratigraphical units as follows:

a) sandy dolomites of medium and thick layers, rare middle layers (thickness 40-50 m) of sandstones, marls (lower horizon) and limestones (upper horizon) of Valanginian Age;

b) organogenic limestones of medium and thick layers, inner layers of marls and sandy limestones of Hauterivian Age;

c) hard organogenic and crystal Urgonic limestones of massive and thick layers with flint marl concretions (thickness 120-130 m) of Upper Hauterivian Age;

d) pelitomorphic and sandy limestones of medium and thick layers (thickness 6-9 m) of Upper Barremian-Lower Aptian Ages.

Maximum development of the caves involved in the system falls to three units, such as: "a", "b" (Didghele, Melouri, Bgheri) and "c" (Tskaltubo, Orpiri, Satsurblia, etc.) [3].

Three rings of the cave system are distinctly distinguished within the cave system, such as: western – of Tskaltubo, Orpiri, Opicho, Ghliana, Kumi and "fractured siphon" that are mainly the areas of underground water discharges. The easternmost ring is represented by Melouri, Didghele and Bgheristskali caves.

Streams that pass through them provide the Kumi vaucluses with underground waters. The studied objects of the inner ring are Solkota, Satsurblia and "Downfall well".

The indicator experiments and geophysical observations proved the unity of the cave system and presence of hitherto unknown water corridors, which form a complex labyrinth under the ground.

Analysis of the synchronous hydrometeorological materials allow us to express our views on the occurrence of strong underground flooding in the cave; it is important to identify the total amount of precipitation in the period preceding the flooding, as well as the duration of rainfall and mainly the amount of critical precipitation during the days of maximum development of flooding.

Four kinds of landscapes are distinguished on the basis of a large-scale survey in the area of Tskaltubo limestone massif:

1) hilly foothills with Colchic forests developed on the weakly podsolic turf-carbonate soils of medium thickness with evergreen sub-forest;

2) low hills with karst forms, here and there washed out turf-carbonate soils of medium thickness as well as forest-shrubs and fragments of cultural forests developed instead of former Colchic forest;

3) hills and flatlands with karst forms with meadow-shrubs developed on the alkali-free clay-hilly-carbonate and forest brown podsolic soils of medium thickness and with domination of cultural landscape;

4) narrow canyon-type gorges with huge vertical walls, weathered products and Colchic forest groves.

The indicator tracing method was used as a basis for the identification of catchment basins of karst streams of the Kumi and Ghliana, centres of discharge and possible directions of water flow.

Regime observations were conducted on the streams of Semi, Didghele and Bgheristskali rivers and hydrochemical observations of underground karst waters (Opicho, Bgheristskali, Didghele, Kumi, Ghliana, Melouri). There have been revealed: the centres of vaucluse of the Kumi and the discharge of the Ghliana river, situated on a similar hypsometric level.

Up to 20 siphons of complex morphology of the cave system have been investigated, dry and watery sections beyond the unknown siphon corridors are surveyed; semi-instrumental method was applied for surveying the second siphon of the cave system (length – 32 m); from the fissured siphon to the outflow of the Kumi a section of 180 m long has been traversed; a siphon corridor of 35 m long and 7 m deep was surveyed between two outflows of the Kumi; 130 m long and 5 m deep water section was traversed from the outflow of the Kumi in the direction of the fissured siphon (Fig. 1).

It was ascertained by long-term meteorological observations (1985-2009) that the cave climate is relatively stable, the underground air has not changed essentially. Air temperature is 13.5-14.5 ^{0} in winter and summer (Fig. 2), and the amplitude of its fluctuation during the year at one and the same point does not exceed $0.2 - 0.5^0$.

Relative humidity of the air of the cave is high (95-98%) everywhere, which is due to the location of the cave itself in a very humid subtropical zone and abundant atmospheric precipitation (1818 mm).

The coefficient of humidification totals 3-4 mm here, which means that a considerable part of the territory is humidified sufficiently or moderately.

Relative humidity is nearly stable (in the seasons) along the main corridor of the cave, barring the section before the entrance, where the difference between the winter relative humidity and summer relative humidity is insignificant.

The concentration of radon in the cave halls varies within 307 and 6905 bk/m^3. γ-radiation background is within 45 and 133 nanoziverd/hour. It is worth noting that the concentration of radon was observed nearly in equal amount and in certain cases, even higher in the caves of Turkmenistan ("Geophysical" - 14500-69110 bk/m^3), Perm district ("Kunguri Icy" - 234- 12280 bk/m^3), Krasnodar Krai ("Vorontsov" - 20-5900 bk/m^3), Northern Caucasus ("Azikhi" - 77-1080 bk/ m^3), Georgia (Abkhazia, Arabica Limestone massif - 1628 bk/m^3), Ukraine (Crimea, "Marble" -155-39300 bk/m^3), etc. [4]. Evidently, the cave air radiation indices of northern and southern karst regions do not differ substantially from each other.

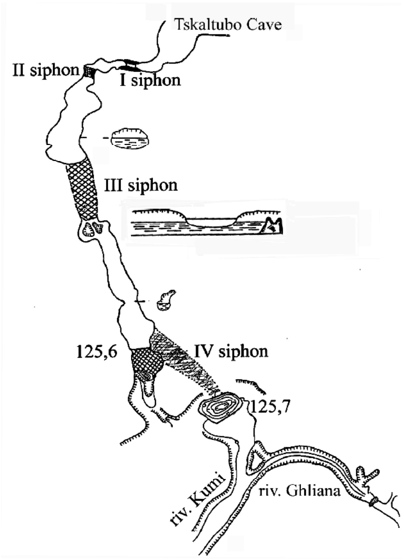

Fig. 1. Schematic plan of siphon exits

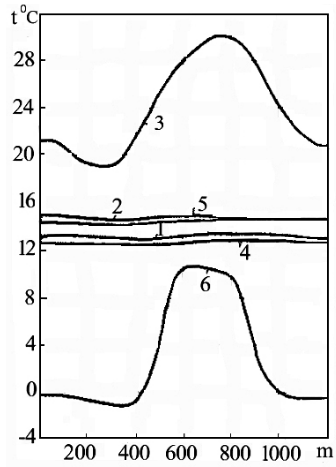

Fig. 2. Curves of the diurnal course of air temperature in summer: in the cave (1, 2)and on the surface (3); in winter: in the cave (4, 5) and on the surface (6)

The concentration of light ions in the cave air is directly related to the radon amount (Fig. 3). The number of negative ions (16000 - 43000 cm^3) exceeds that of positive ions (12000-42000 cm^3) nearly in each hall, which also has a positive influence on the human organism.

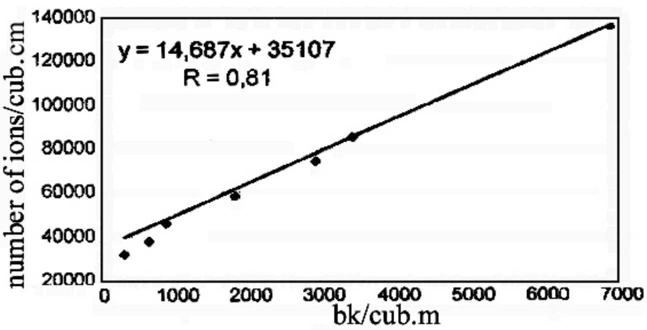

Fig. 3. Correlation of light ions with radon content

The concentration of carbon dioxide (CO_2) is minimum in the initial sections of the caves in winter. From the entrance to the depth this value increases gradually and from the entrance at H" 600 m in winter and summer it is characterized by almost stable indices (0.3- 0.4 %) (Fig.4).

High indices of carbon dioxide (CO_2) are observed in the first part of August and September. In these periods the CO_2 concentration exceeds the acceptable limits of the norm (0.5 %) in the ascending air of the cave.

At a glance, this result is hard to explain, as due to air draught in summer months there are ideal conditions for natural ventilation in the cave. Gas release in caves is an ordinary event and the Tskaltubo Cave belongs to those which are characterized by relatively stable indices from the viewpoint of climate.

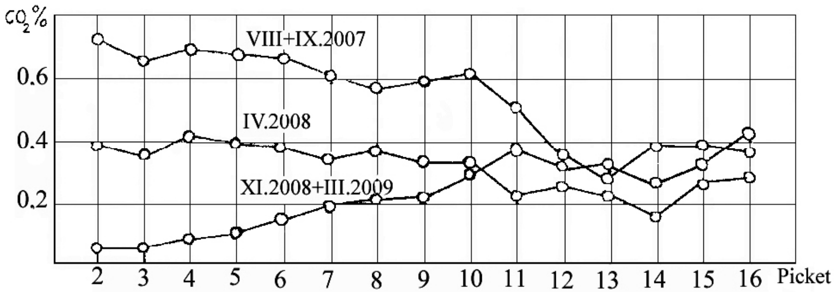

Fig. 4. Distribution of carbon dioxide gas in the cave air along the main line

Methane (CH_4), hydrogen sulphide (H_2S) and sulphur dioxide (SO_2) were not detected in the cave; the content of oxygen (O_2) underground is slightly higher (20.4%) than the acceptable norm (20.0%). The cave air does not contain hazardous admixtures, poisonous and other asphyxiating gases.

It should be borne in mind that systematic control should be carried out on the permanent monitoring of climate, air ionization and radioactivity during the exploitation of the cave, as well as on gas and bacteriological content of the air; it is necessary to continue observation of the stability of composing rocks, possible increase of fissuring, diurnal and seasonal variability of levels of underground waters and risk of their pollution.

Works on the organization of amenities for the reception of tourists is underway in Tskaltubo Cave. Viewing the beautiful underground halls will afford great pleasure to cave tourism fans, and will bring economic profit to the region.

ფიზიკური გეოგრაფია

წყალტუბოს მღვიმური სისტემის კომპლექსური კვლევის ძირითადი შედეგები

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