ABOUT KARST (CHEMICAL) DENUDATION IN ZEMO IMERETI PLATEAU (COUNTRY OF GEORGIA)

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ABOUT KARST (CHEMICAL) DENUDATION IN ZEMO IMERETI PLATEAU (COUNTRY OF GEORGIA)

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ABSTRACT

One of the discussion issues of karstological studies is the identification of karst denudation intensity; it means the quantitative evaluation of the intensity of this process, which, in turn, allows to predict the karst development. The problem of karst denudation is developed insufficiently today, which can be explained by the complexity of the issue and at the same time, the methods used to assess the intensity of denudation are not yet refined. The intensity of denudation and its general regularities in the Zemo Imereti Plateau can be judged based on the materials available at our disposal today, which were obtained based on field, experimental and laboratory multi-year studies. Based on the materials obtained by comprehensive research conducted by us, we have studied and calculated the intensity of karst denudation in the Zemo Imereti Plateau. Studies have identified that the karst denunadation intensity (surface - 64.2-190.6 m^3/km^2; underground - 1.5-117 m^3/km^2 a year) in the Zemo Imereti Plateau significantly exceeds the similar indices of Apkhazeti (values of surface and underground karst denudation in high karst strip is equal to 75-108 and 30-45 m^3/km^2 a year respectively, and in the foothills - 38-58 and 5-12 m^3/km^2 a year respectively) and Askhi karst massifs (59 m^3/km^2 a year), which is a result of impact of technogenic factor.

Keywords: Karst, Plateau, Massif, Technogenic factor, Denudation intensity

INTRODUCTION

Definition of kart denudation intensity that allows predicting karst development is one of the discussing problems of karstological studies.

Karst denudation problem is weakly developed in general, which can be explained by the problem complexity. Modern methods to assess denudation intensity are not finally developed so far. For this purpose, it is necessary to identify the rivers' topographic and underground basins areas true boundaries, as well as indices of rainfall amount, runoff and evaporation, to take into account the mineralogical and chemical features of karstified rocks, etc. In addition, it is difficult to get a full picture of the real indicators of the denudation with single or episodic observations. Such conclusions on the karst rivers and karst sources should be based on seasonal observations if not on annual ones.

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The intensity of denudation in the Zemo Imereti Plateau and their general regularities can be judged based on the materials available at our disposal today, which have been obtained on the basis of multi-annual field, experimental and laboratory studies. The amount of ion runoff determines the rock destruction and distribution of rock destruction product:

$$Ru=31.54\ QC \quad (1),$$

where: Ru – is the ion runoff, t/year; Q – stream discharge, m^3/sec; and C – is the concentration of ions, mg/l.

Different modifications of this (1) formula are used in assessing chemical denunciation in karstology. Mostly they are based on the amount of runoff and the calcium content in it. The intensity of karst denudation in the study area has been calculated by us according to the formulas of A. Kruber [1], Zh. Korbel [2] and M. Pulina [3]. A. Kruber (2) was one of the first who calculated karst denudation. The mentioned author and Zh. Korbel [2] identify the amount of chemical denunciation by the amount of dissolved calcium carbonate. Their formulas have the following look:

$$Q=31.54\cdot 10^3\cdot n\cdot a \quad (2),$$

where Q – is a leaked $CaCO_3$ mass in kg/year; n – discharge, l/s; and a – $CaCO_3$ content, gr/l.

$$X=\frac{4ET}{100} \quad (3),$$

where x- – is karst denudation value, m3/km^2 per year or mm/millennium; E– the height of runoff layer, dm; T – content of calcium carbonate in water, mg/l;

$\frac{4}{100}$ – is the coefficient of transfer of the weight units into the volume units.

Somewhat different formula is offered by M. Pulina (4). It has the following look:

$$D=0.0126\cdot V\cdot \Delta T \quad (4)$$

where: D – is the speed of karst denudation in m^3/km^2 per year or mm/millennium, ΔT- the mineralization of karst waters ($\Delta T = T_1 - Ta$, where T_1– is the karst waters mineralization, Ta – atmospheric precipitations mineralization), and V – runoff module from l / sec.km^2.

From the results obtained from the abovementioned three methods, we believe that to this actual situation is most fitted the results obtained by the karst- hydrometeorological method offered by M. Pulina, as it considers the mineralization of atmospheric precipitations, ignoring of which gives 8-12% of error. It is also calculated not only the number of ions in water but also the overall mineralization (mg/l). Therefore, during the analysis, we mainly depend on the results obtained by the formula of M. Pulina [3]. A number of papers were dedicated to karst denudation in Georgia [4]-[7]. In this respect, there is no such investigation has been conducted in the karst region of Zemo Imereti.

STUDY AREA

Zemo Imereti Plateau includes the easternmost part of western Georgia's limestone strip, characterized by its peculiar natural conditions (relief, tectonics, climate, surface and underground waters) and is the only region of the platform karst in Georgia [8]-[13].

The main morphological peculiarity of the study area is determined by geological structure. The boundary of the Zemo Imereti Plateau's karst region coincides with the surface of the surface contact of the Cretaceous limestones with the older formations (Bajocian porphyritic suite in the north and east and the Middle Paleozoic granitoids in the south and west), which is the geological substrate of the karst. The existence of a solid Hercynian platform stipulated the character of layout of the Meso-Cenozoic suites (subhhorizontal or slightly inclined), which is represented mainly by the Valanginian-Hauterivian, Barremian and Turonian-Danian limestones, Tertiary clays and sandstones. Platform construction of the plateau has played an important role in the genesis and development of surface and underground karst forms and underground karst streams developed here (Fig. 1).

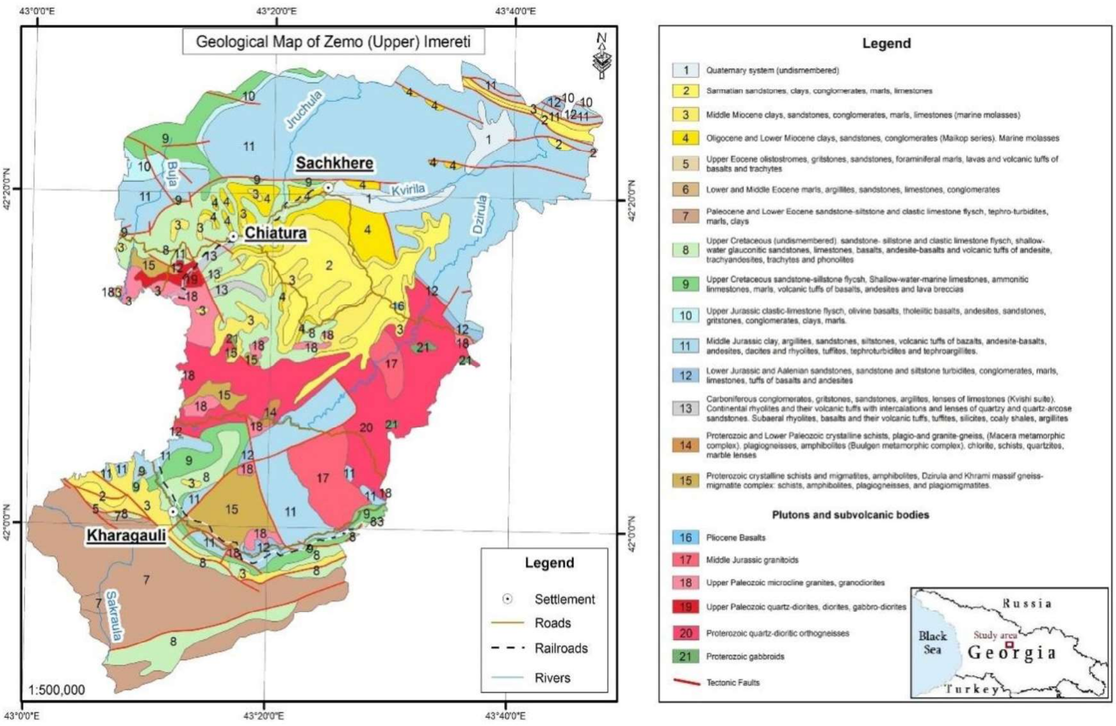

Fig. 1. Geological map of the Zemo Imereti Plateau [14]

As it is known, the intensity of the karst processes greatly depends on the physical-geographic and geological conditions of the region. The amount of atmospheric precipitations and a runoff module along increase according with the increase in altitude

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of the karst massifs of Georgia that stipulate activation of karst processes. Korbel [2] and later M. Pulina's [3] observations confirmed this opinion by the case study of the karst regions of the moderate and subtropical regions of the Eurasian continent. Indeed, with the increase in precipitation and runoff by altitude, the speed of karst denudation increases gradually. Namely, intensity of karst denudation increases up to 4 m^3/km^2 in foothills and up to 8 m^3/km^2 - in high karst per year when the amount of annual precipitations increases by100 mm [3].

What is the situation on the Zemo Imereti (Chiatura) Plateau? Based on the comparison of amount of atmospheric precipitations and the evaporability data, it may be noted that the balance of the annual runoff is everywhere positive within the karst strip of the study area [15], which leads to the activity of karst processes throughout the year, especially in the cold period of the year. Apparently, in the abovementioned trend, there may be made corrections by technogenic factors and play stimulating role in the activation of karst processes that are confirmed by our studies.

RESEARCH METHODS

Field, experimental and laboratory research methods were used in the study. Cartographic methods were used for determination of surface water catchment basins, and the method of painted water tracing with special paints (indicators) to determine the boundaries of underground basins.

The available climatic and hydrological data and the results of our long-term observations have been used to determine the amount of atmospheric precipitation, runoff and evaporation indicators.

The chemical composition and hydro-chemical regime of karst waters (namely, surface streams, karst sources and cave streams) were determined by stationary observations and laboratory investigations.

RESULTS

Based on the materials obtained by our researches, first time was studied (calculated) the intensity of karst denudation on the Zemo Imereti Plateau, the results of which are given in the Table 1. The obtained data is partially based on episodic observations, though the chemical analysis of vaucluse sources and surface streams have been carried out once again several times in the different seasons of the year. In addition, detailed hydrochemical studies of karst waters were carried out, as well as regime observations on karst sources. Laboratory and experimental methods have identified the true boundaries of the areas of topographic and underground riverbasins. At the same time, for solution of a number of issues (substances migration, formation of composition of underground karst waters is formed, and etc.) the chemical (namely, macro and micro elements of surface streams, karst springs and cave streams) composition and hydrodynamic regime have been identified by stationary observations and laboratory studies [8] [10].

As it is known, the feature of the atmospheric precipitation, the fissureness of karstified rocks, the lithology and others have a considerable impact on the intensity of karst denudation. Based on the results obtained by us, we can discuss some of the trends that is characteristic of the karst massif of Zemo Imereti Plateau. In particular, there is a close relation between runoff and karst denudation, which means that karst denudation increases with the increase of runoff (Table 1).

Table 1. Karst denudation intensity in the Zemo Imereti Plateau.

The source or river name	Water catchment basin area, km^2	Water discharge, l/sec	Run off module, l/sec. Km^2	Common Mineralization, mg /l	Composition of $CaCO_3$, m/l	Dissolved $CaCO_3$ amount, kg/day	Dissolved substance general amount (ion runoff), kg/day	Dissolved substance general amount (ion runoff), kg/year	Karst denudation, m^3/km^2 per year		
									By Kruber	By Korbel	By Pulina
Ekvtimeskld e (cave)	0.7	1.0	1.4	409	139.5	12.0	18	6570	1.5	2.2	5.6
Namdzlevisk lde (cave)	0.5	1.0	0.5	318	116.2	10.0	10.5	3650	1.2	0.5	1.5
Kldekari (cave)	3.8	45.0	11.8	531	210.0	34.0	1287	468755	102.0	30.5	60.8
Nekrisa (cave)	12.9	260.0	20.2	959	268.8	251.7	16850	6150250	762.0	67.7	190.6
Ormoebi (cave)	0.5	0.5	1.0	1932	213.1	0.3	75	27375	1.1	25.5	19.1
Shvilobisa (cave)	1.1	7.5	6.8	368	115.0	3.1	109	39785	9.0	9.6	24.0
Jruchula (cave)	2.5	5.0	2.0	469	245.0	4.4	116	42340	13.1	5.9	9.0
Karianiklde (cave)	4.8	250.0	52.0	240	125.0	112.5	3024	1103760	327.3	82.0	117
Shekiladzee bisklde (cave)	0.6	16.0	26.6	349	183.0	10.5	206	75190	31.4	60.8	84.0
Rganisghele (river)	13.0	320.0	24.6	276	126.0	145.1	2101	766865	452.7	39.0	64.2

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Distribution of karst denudation by heights is also interesting. In particular, in the study area, the increase of karst denunal intensity is observed with the increase of absolute height. For example, in the underground stream (570 m above sea level) basin of the Namdzleviklde Cave, thy karst denudation value is 1.5 m^3/km^2 per year, in the underground stream of the Shvilobisa Cave (612 m above sea level) – 24 m^3/km^2 per year, in the underground stream of the Shekiladzeebi cave (860 m above sea level) – 84 m^3/km^2 per year, and in the underground stream basin of the Karianiklde Cave (1300 m above sea level – 117 m^3/km^2 per year.

The intensity of karst denudation is different for the different limestone stratigraphic horizons. Relatively low rate of denudation (1.5-5.6 m^3/km^2) was observed in the areas built by Middle Miocene limestones and marls, the average values (9.0-60.8 m^3/km^2) – in the areas built by Upper Cretaceous limestones, and the highest rates (84-117 m^3/km^2) in the areas built with by Barremian limestones.

It means that the intensity of karst denudation increases more, the more pure the limestones are. Surface streams are also distinguished by high intensity of denudation (Nekrisa River - 190.6 m^3/km^2 per year, Rganisghele River – 64.2 m^3/km^2 per year).

As hydrochemical studies of karst waters have been identified, the mineralization of underground karst waters of the research area is 1.5-3 times higher than the analog indicators of neighboring karst regions. The reason for this is not only the complex lithological-stratigraphic structure of the region but also the wide distribution of open pits of manganese ore (Fig. 2). In open pit areas (especially during rainfalls) intensive washing of substances from loose rocks take place.

Fig. 2. Karst relief of the Zemo Imereti Plateau transformed under the anthropogenic impact

Due to the above reason, mineralization of karst waters in the areas of distribution of open quarries on the Zemo Imereti Plateau varies between 500-712 mg.l^{-1} and occasionally reaches the anomalous high values (Σ¡ 1052-2290 mg.l^{-1}).

The sharp increase in the overall mineralization of sources also leads to increased intensity of karst denudation. That is why a number of deviations are observed in the above mentioned trend. For example, the underground water discharge of the Ormoebi Cave is the lowest among the streams we have studied, but with the karst denudation rate (19.1 m^3/km^2 per year) it exceeds the sources with excess discharge that can be explained with a high rate of total mineralization of the underground stream of the Ormoebi Cave (Σ¡ = 1932 mg/l) (Table 1). By the same reason is explained the high karst denudation rate (190.6 m^3/km^2 per year) of the Nekrisa River, which is fed with high mineralization karst springs and cave streams (Σ¡ 1052-2290 mg.l^{-1} accordingly). Such high rates of mineralization are mainly because of the widespread of manganese open pits in the underground karst waters feeding basins. The influence of high mineralization is noticeable in the distribution of karst denudation according to the height above sea level.

CONCLUSION

Based on the research material available at our disposal, it is possible to note that the Zemo Imereti Plateau exceeds the Apkhazeti (in the high karst strip the surface and underground karst denudation values are correspondingly 75 - 108 and 30 - 45, and in the foothills – 38-58 and 5-12 m^3/km^2 per year) and Askhi (59 m^3/km^2 per year) karst massifs with the indices of karst denudation (surface – 64.2-190.6; underground - 1.5-117.0 m^3/km^2). In our opinion, the higher indicators of chemical denunciation intensity in the Zemo Imereti karst region are related to the technogenic factors (especially the open mining of manganese): the overall increase of water aggression, the high mineralization (mineralization of karst waters of the manganese areas is 1.5-3 times higher than the same indices of the karst regions of Georgia) and intensive washting of substances.

In order to avoid adverse consequences during agricultural use of karst massifs of the study area, we consider it necessary to consider and predict karst denudation.

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REFERENCES

[1] Kruber A.A. Karst region of the mountain Crimea. 1915.

[2] Korbel J. Annales de geographie. № 336. 1959. LXIII, Mars-Avril.

[3] Pulina M. Geogr. Polon. №14. 1968.

[4] Jishkariani V. M. On karst denudation in the basin of the r. Tsachkhuri (Askhi massif, western Georgia). Bulletin of the Academy of Sciences of Georgia, 60, №2. 1970. Tb.

[5] Gabechava D. Sh. Ion current and denudative action of the karst waters of western Georgia. In the book "Problems of hydrogeology and engineer-geology of mountainous-folded area", № 8. 1978. Tb.

[6] Kochetov N. I. K. On comparative assessment of the intensity of karst denudation of some limestone massifs of the Western Caucasus. Geomorphology, №2. 1983.

[7] Tintilozov Z. K. Karst caves of Georgia (morphological analysis). 1976. Tb.

[8] Lezhava Z., Tsikarishvili K., Asanidze L., Chikhradze N., Chartolani G., Sherozia A. Karst relief development history of Zemo Imereti Plateau, Georgia, Caucasus. Open Journal of Geology. v. 9. P. 201-212. 2019a.

[9] Lezhava Z., Asanidze L., Tsikarishvili K., Gaprindashvili G., Chikhradze N. About genesis of karst caldera of denudation-tectonic landform. Georgia, Caucasus. SGEM - GeoConference: Sofia, Bulgaria. Vol. 19, Iss. 1.1. p. 3-10. 2019b.

[10] Lezhava Z., Asanidze L., Tsikarishvili K., Chikhradze N., Gadrani L., Chartolani G. Hydrodynamic zones of fissure-karst waters of Zemo Imereti Plateau in the Republic of Georgia. Journal of Environmental Biology. V. 40. p. 337-343. 2020.

[11] Asanidze L., Chikhradze N., Lezhava Z., Tsikarishvili K., Polk J., Chartolani G. Sedimentological Study of Caves in the Zemo Imereti Plateau, Georgia, Caucasus Region. Open Journal of Geology. Scientific Research. 7.. p. 465-477. 2017.

[12] Asanidze L., Lezhava Z., Tsikarishvili K., Gaprindashvili G., Chikhradze N., Polk J. Karst map of Georgia (Caucasus region) scale: 1:1,500,000. Carbonates and Evaporites. v. 34. p. 1205-1212. 2019.

[13] Maruashvili, L. Geomorphology of Georgia. Tbilisi. 1971.

[14] Gudjabidze GE. Geological map of Georgia, Scale 1:500 000. (Editor: Gamkrelidze et al.). Georgian State Department of Geology and National Oil Company Saqnavtobi. Tbilisi, Georgia. (in Georgian). 2003.

[15] Kordzakhia M. Climate of Georgia. Tbilisi. 1961.