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Geophysical research results of buried relief and distribution groundwater runoff of the Aragats massif

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ABSTRACT

Based on the synthesis and reinterpretation of long-term data of geophysical studies together with the hydrology - hydrological materials it has been received new data about the buried topography and spatial distribution of groundwater runoff of the Aragats massif. First of all, it requires to determine the structure of its buried relief, which is basically a regional relief aquitard. The underground water sources are considered to be precipitation on the massif (approximately 83% of the total), infiltration of the surface (11%), the condensation of water vapor in the aeration zone (5%) and underground inflow from adjacent areas (1.3%). It is established to find connection (for topographical scale 1: 50,000) based on the heights of the distribution function analysis of modern and buried reliefs (composed by using paleorelief maps of scale 1: 50,000). The distribution of heights set size space between adjacent contour lines reliefs. It is created correlation relation between the buried and surface reliefs in different slopes and has been specified the ways of focused groundwater runoff and the possible locations of buried watersheds.

Overall, the new data concerning the structure of the buried relief of Aragats massif and the distribution of its underground runoff allow to develop effective measures for the selection of underground waters and their rational usage for the purpose of water supply and irrigation.

1. Introduction

The Aragats volcanic massif is one of the largest volcanic chain of the Armenian highlands. The massif composed of lavas and tuffs (basaltic to dacitic lavas) with prevalence among andesite - basalts and basalts.

The problem of rational usage of water resources of Aragats massif has always been in the center of professionals' attention in different fields. It's explained by the presence of considerable resources of fresh groundwater for the development of different sectors of the economy and, primarily, for the purpose of water supply and irrigation. Currently, many areas and settlements located on the slopes the Aragats massif, facing severe shortage of water.

In recent decades, as a result of human impact such as irrigation and drainage facilities, significant seepage losses from irrigated areas and mutations, both in the natural and climatic conditions, there was a redistribution of water resources of the massif, creating a "new" hydrologic - geologic environment in the region. In the study the situation and the development of effective measures for the rational use of water resources are considered to be important tasks to establish the distribution of groundwater runoff in the region and identification of groundwater abstraction. First of all, it requires to determine the structure of its buried relief, which is basically a regional relief aquitard. The underground water sources are considered to be precipitation on the massif (approximately 83% of the total), infiltration of the surface (11%), the condensation of water vapor in the aeration zone (5%) and underground inflow from adjacent areas (1.3%) [1–4]. Overall, the volcanic complex is characterized mostly by the magnitude of the aquifer groundwater runoff module, varying from 0.9 to 12 l/s per sq. km. It is known that the formation of the ancient hydrographical network depends on the structural - geological, volcanogenic - tectonic and climatic factors. Commonly paleo-geomorphological methods are used for the reconstruction of the buried (paleo) relief of volcanic areas. However, in the case of volcanic regions (cyclical outpourings of

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lava and volcanic rocks) the task of mapping is much more complicated for the buried relief as it is covered by powerful ancient formations that practically. In such complex geomorphological and hydrological conditions effective method is geophysical method. Moreover, it is widely used for establishing a connection between ground and buried reliefs, for allocating and tracking concentrated groundwater runoff both sites of paleovalleys [5].

2. Research results

Nowadays, it has been done electrical sensing in the Aragats massif at more than 1200 points (Armgeology, ArmNIIVPiG). Complications and reinterpretation of this material, together with the results of drilling work have provided new information about the buried topography and distribution of groundwater runoff in the studied area. The maps (scale is 1: 50,000–1: 25,000), and geological - geophysical sections (scale is 1: 10,000–1: 5000), make it possible to determine the structure paleorelief, to establish a correlation between ground and buried watershed having different river basins.

The following are the some of the research results [5,18].

2.1. The relationship between the land and buried reliefs

It is established to find connection (for topographical scale 1: 50,000) based on the heights of the distribution function analysis of modern and buried reliefs (composed by using paleorelief maps of scale 1: 50,000). The distribution of heights set size space between adjacent contour lines reliefs. Histograms of the height distribution of ground and buried reliefs are shown in Fig. 1.

The correlation relation between the studied reliefs estimated coupling coefficient K: when K = + 1 there is full compliance (heredity) of both the reliefs; when the K is about zero, there is no connection between the reliefs and,finally, when K = - 1, there is an inversion in the form of ground and buried reliefs [6,7].

The points of electrical soundings, based on the complexity of the terrestrial relief massif, selected mainly on the areas with an altitude of less than 2500–2600 m. For information on buried relief for area massif with hypsometric depths of over 2600 m we have established the connection between the reliefs sought in the form of dependence [18,8,9]:

These regression equations are obtained for the individual slopes of the Aragats massif (n is the number of observations, H_{Π} and H_c are the absolute height of the buried mark and modern (ground) reliefs).

For the southern slopes of the massif (n = 197)

$$H_{\Pi} = -1022,4 + 1.8H_c$$

for the western slopes of the massif (n = 343)

$$H_{\Pi} = 625,68 + 0,02H_c$$

to the eastern slopes of the massif (n = 413)

$$H_{\Pi} = -617,05 + 1,42H_c$$

for the northern slopes of the massif (n = 219)

$$H_{\Pi} = 637,05 + 0,23H_c$$

Plots of $H_{\Pi} = \int(H_C)$ for individual slopes of Aragats massif shown in Fig. 2 taken into account the principle of extrapolation to calculate evaluation of paleorelief for the territory of more than 2600 m [5].

These new data on the structure of the buried (impervious) relief give an opportunity to do an evidence - based conclusion about the distribution of the groundwater runoff of separated river basins. Schematically, this information is shown in Fig. 3 [10,11,18].

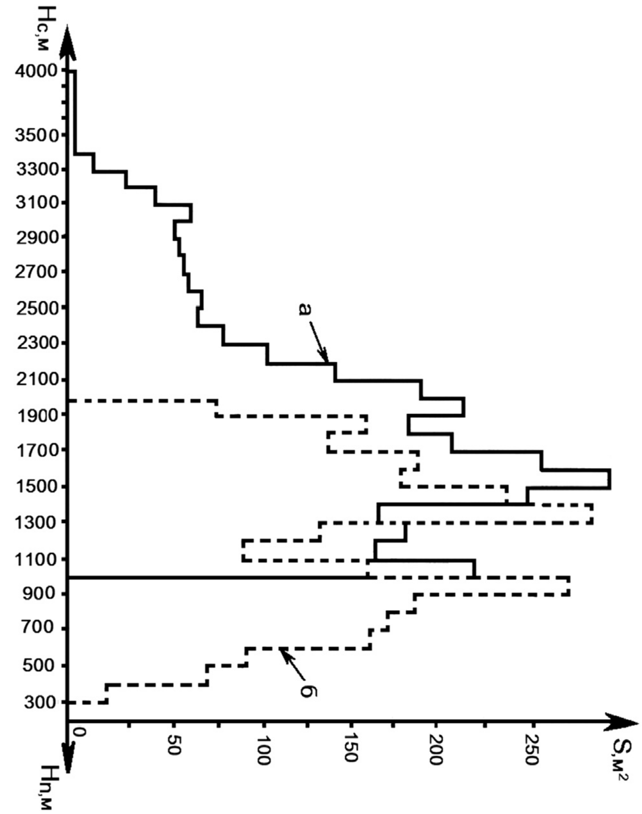

Fig. 1. Histograms of the distribution of the heights of the modern (a) and buried relief (b) Aragats volcanic massif.

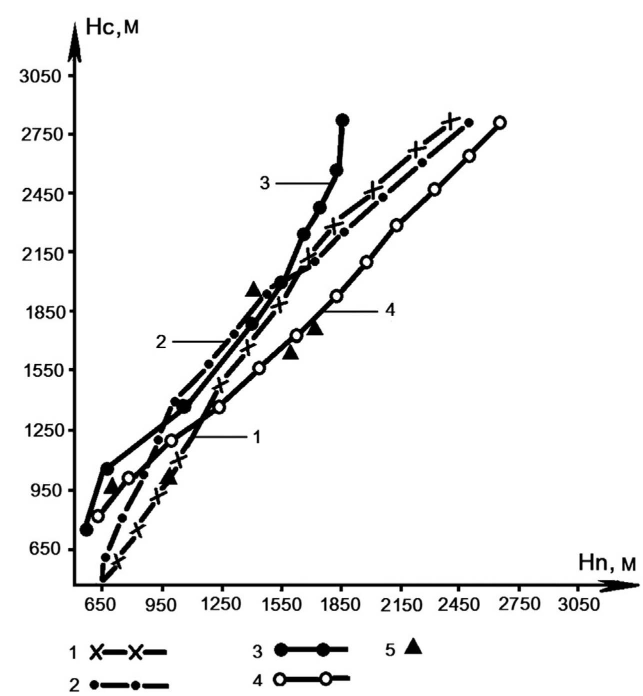

Fig. 2. The dependence diagrams of the Paleo (Hn) - and modern (Hc) reliefs massif of Mount Aragats: 1,2,3,4 for northern, western, southern, eastern slopes; 5. boreholes data.

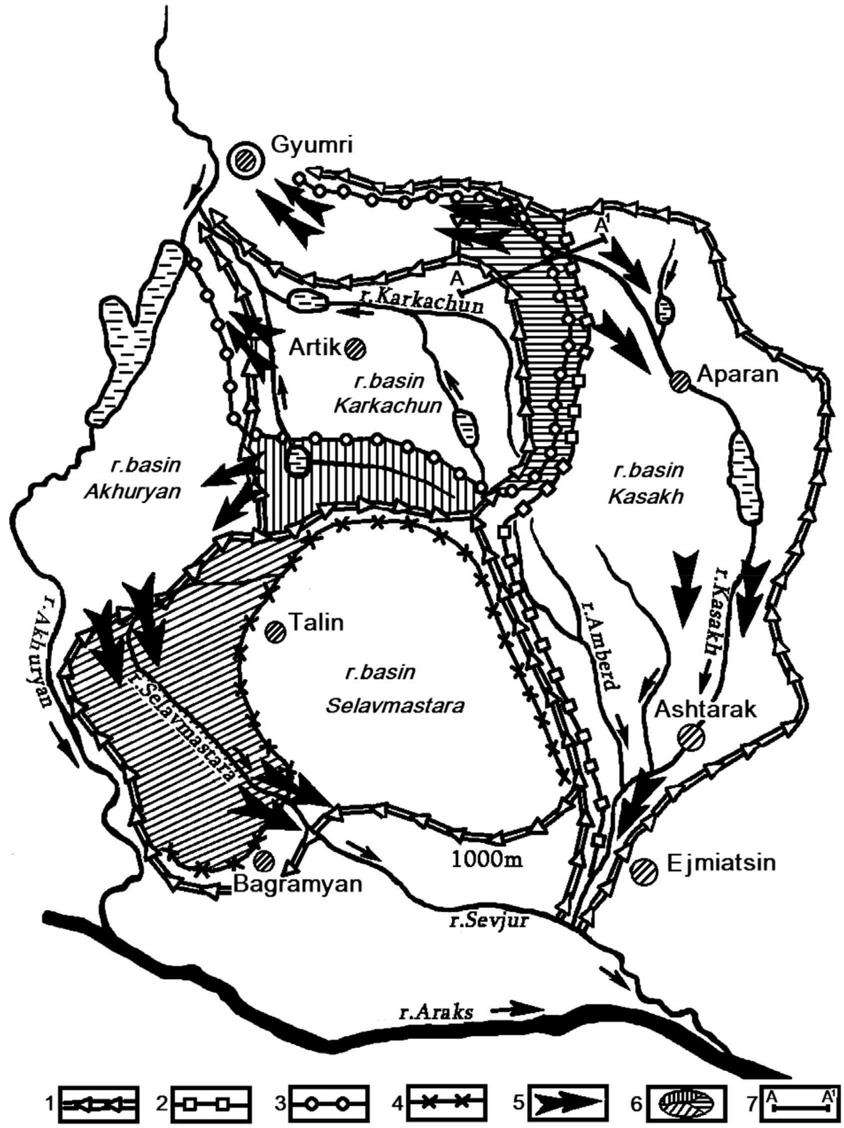

Fig. 3. Schematic map of the areas of modern and buried inversion watersheds of major rivers of Aragats massif.
1. modern watershed; 2, 3, 4. paleo river basin watersheds of Kasakh, Karkachun and Selavmastara; 5. The main directions of groundwater runoof; 6. The area where the relief is inverted; 7. Geophysical cutting line.

2.2. Kasakh river basin as a buried catchment

At the estuary at Kasakh almost 25–95% probability precipitation altered groundwater runoff, taking into account the effect of irrigation and water supply (634–241,000,000. m^3/year (or 20,2–7,7m3/s)) (Pakhchanyan GG, Mkrtchyan SM). The distribution of this water according to the analysis of the buried topography maps (regional aquitard) has focused runoff, especially in paleovalleys of Kasakh river (groundwater runoff).

On Tsilkar plot the river channel of Gegharot passes to the left comparing with the modern channel. Other pathways of focused runoff of groundwater is considered to be the direction along the Pamba Armenian - Berkarat and Tsilkar – Berkarat villages. Here, groundwater runoff is directed towards the basin of Karkachun river and controlled buried watershed established along the Tsilkar - Gegharot - Vardablur - Tsaghkahovit – Geghadzor villages. This area is about 140 km^2, and the runoff towards the groundwater runoff Karatchoun basin is estimated about 50 million m^3/year (Mnatsakanyan B.P.). From the south – southeast till to Aparan plot, on the left bank of Kasakh highlighted groundwater rivers (Pamba Nameless, Halavar and Bozehosh rivers). The paleochannels' water specified together with the waters of river. Paleokasakh comes to the plot of Hovit - Aparan -. Kasakh where it is installed a buried basin. Apparently, this hydrogeological basin should be associated with the famous basin of groundwater of Aparan basin [3]. Using geophysical data and newly drilled wells it has been possible to clarify the contours of the basin. From Aparan plot to Aray groundwater passes through a relatively wide meridional basin bounded contour buried relief at around 1700–1750 m. To the south groundwater moves mainly to individual paleovalleys. The largest of them is Kasakh paleovalley [3]. Groundwater flows from buried valleys to directly Bazmaghbyur – Karbi plot. Here, for the first time (according to the results of geophysical surveys), it is indicated the existence of the buried catchment area at a depth of 80–100 m. The groundwater outflows through the waterways between and under lavas to the south, in the direction of the Ararat depression [12,13,18].

2.3. Buried catchment basin of the Karkachun river

According to the studies the maximum layer of groundwater runoff is formed from 2700 to 3500 m altitudes, and the volume of the flow is from 1700 to 2300 m altitudes. For 25–95% probability of precipitation change in that depth of flow is 469.1–249.7 million m^3/year (or 15.08–8.0 m^3/s). For\ some parts of basin the analysis of the forms of ground and buried reliefs has shown discrepancy between them (which is inversion). One of these areas is located in the north (S1 area) and the other in the south (S2 area) which is often considered the catchment area (Fig. 3) and the area are, respectively, 160 and 115 km^2. Among these, the depth of discharge is directed to the north-west (towards the river basin of Svlavmastsra). The number of depth runoff is estimated 55 and 42 million m^3 annually.

The following is the established groundwater runoff. The watercourse of Paleomantash is formed about at the same elevations of the Montash reservoir; it passes to the east from the modern Mantash river and moving almost parallel till it enters the Shirak valley. The depth of drainage in the area of its formation reaches 400–450 m; in the western and northwestern it gradually decreases till 200–250 m. In Shirak valley from the side of Aragats massif to. Pemzashen - Megrashen villages (former Artik region) comes another focused watercourse: part of its water as springs is discharged from northeastern part of Pemzashen village. At the northern and western slopes of Aragats massif exist paleovalleys which are assumed to be the areas of Lernaker, western Haykasar – Hayrenyats villages; they are directed towards Gusanagyuh village. The buried basin are mainly important for screening purposes of water-supply among Dzhrarat -Gehanist - Ovtashen - Arevik settlements which total area is 160 km^2. It is considered that there is formed depth runoff about 66 million m^3 (about 2.0 m^3/day) [14,15,18].

2.4. Buried catchment basin of the Selavmastara river

The studied basin is included land-drainage basin of the southern slopes of Aragats. Depth runoff is about 447.1–141.5 million m^3/year (14.3–4.5 m^3/s) at a 25–95% precipitation probability the most significant changes are seen at the 2000 to 1000 m elevations, which is explained mainly by the presence of water facilities and irrigated areas.

The catchment area of the Selavmastara river is 1458 km^2. The inversion which is in its south - western part between the ground and buried reliefs resulted in a reduction of the modern catchment area (470 km^2). This area is formed by 44.5 million m^3/year of groundwater discharge, which is directed towards the Ararat basin groundwater (Fig. 3). The analysis of the buried topography maps (regional aquitard) allows to conclude about the distribution of groundwater catchment area. The territory of the the Selavmastara river basin, in contrast to the above mentioned river basins, in significant period of the year is devoid of surface flows (river), which will definitely affect the areal distribution of groundwater runoff. As for other catchments, the main morphological elements for distributing the underground runoff is the existence of contrails form of relief and local paleovalleys buried basins. Thus, for instance, the riverbed of Akhuryan parallel to the modern watershed of the Selavmastara river paleorelief is declined to the west and southwest, while in the southern part is declined to the south and southeast. Focused groundwater runoffs are set in the following areas: Bagraavan - Akko and Suser - Gyalto; both watercourses are combined into a single watercourse in the south, heading towards Artenik - Karakert station. Garnahovit Mastara - Areg - Barozh - Dalarik - Baghramyan settlements have been allocated quite a large buried watershed, which separates the underground runoff of the above streams on the western slopes of Aragats massif to the east of the watershed installed buried in paleovalleys of Aghakchi - Akunk - Dashtadem and Shgharshik - Katnaghbyur – Ashnak villages [16–18].

3. Conclusions

Overall, the new data concerning the structure of the buried relief of Aragats massif and the distribution of its underground runoff allow to develop effective measures for the selection of underground waters and their rational usage for the purpose of water supply and irrigation.

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