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Graphic Representation of the Parameters of Hydrogeochedmical Composition of Mineral Water in Central Armenia

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Abstract

The possibilities of graphic representation of the geochemical parameters of the composition of mineral water is shown. In order to represent visually the results of the chemical composition of water, formulas were designed; hydrogeochemical profiles of the ionic and cationic composition of water were constructed in a certain direction and in time. Vertical sections of changes in concentration are made for a separate chemical component of the composition of water along the locations of mineral springs.

Keywords: Hydrogeochemistry, Seismology, Profiles, Sections, Deformation, Earthquake.

Introduction

The possibilities of graphic representation of the geochemical-parameters of the composition of mineral water is shown. In order to represent visually the results of the chemical composition of water, formulas were designed; hydrogeochemical profiles of the ionic and cationic composition of water were constructed in a certain direction and in time. Vertical sections of changes in concentration are made for a separate chemical component of the composition of water along the locations of mineral springs. The analysis and the results of hydrochemical observations are accurate if the obtained data is systematized and processed. The graphic method of systematization of hydrogeochemical materials is applied. These are hydrogeochemical maps.

The maps of separate components such as magnesium, chlorine, sulfate-ion etc., profiles and sections are of the greatest interest. M.G. Kurlov's formula is applied for the results of single analyses of the chemical composition of underground water and graphic representation. This formula allows to show graphically the composition of water as a pseudo fraction in which numerator indicates the content of anions, and denominator - the content of cations in a % equivalent form in decreasing order. In order to determine changes of the chemical composition of underground water in a certain direction (along borehole), the hydrochemical profile was constructed according to A.A. Brodsky. The seismological section (1-2) along the hydrogeochemical profile reflects the distribution of seismic centers of the earthquakes that occurred at the depth of the earth's crust in the territory of Central Armenia. The generated hydrochemical profile allows you to monitor changes in the ionic and cationic composition of mineral water for each mineral source, as well as provide a quantitative assessment of the ionic and cationic composition. Vertical sections are compiled according to individual chemical elements of the water composition. The analysis of changes of concentration (increase or decrease) of chemical element is assessed by increase of the activation of seismicity and stress-strain state of earth crust of Central Armenia.

Materials and Method

To analyze and systematize data from monitoring observations of changes in the chemical composition of mineral waters in Central Armenia, a method of graphically depicting the parameters of the hydrogeochemical composition of waters was used. The use of data visualization will enhance the ability to obtain answers to the questions posed. The duration of monitoring observations makes it possible to create a data bank on the parameters of the geochemical composition of the studied mineral waters. Seismicity data (catalog of earthquakes) was provided by the "Regional Seismic Protection Service" State Non-Profit Organization, (Ministry of Internal Affairs of the Republic of Armenia) (SNCO TSSZ MIA RA). The mineral water deposits of Cen-

tral Armenia include: Bjni, Arzni, Vedi, Surenavan (Fig.1). The geological structure of the territory involves sedimentary, volcanic-sedimentary, igneous and metamorphic formations. Among the geological formations of Quaternary rocks, lava covers and flows occupy a special place. Regional tectonic disturbances are represented by: Garni, Ararat and Yerevan deep faults [1]. The groundwater of the study area belongs to the intermountain Ararat basin. The Ararat Basin is an area of accumulation of underground runoff and the formation of ground and pressure aquifers and includes large reserves of mineral waters confined to Paleozoic terrigenous-carbonate rocks [2, 3]. The confinement of mineral waters to deep tectonic faults, which are characterized by increased geodynamics, is reflected in the hydrogeochemical composition of mineral waters, with anomalous changes in some chemical parameters. To visually depict the chemical composition of water for each water deposit, the formula of M.G. Kurlov was compiled [4].

The Vedinskoe mineral water deposit is confined to a zone of tectonic disturbance, crossing the Upper Cretaceous deposits of the near-meridial direction. In the dynamics of mineral waters of the deposit, mixing of groundwater plays an important role, which leads to a change in the total mineralization in the vertical section. Hydrocarbonate calcium-magnesium water.

$$CO_2 1.0\ M3.7\ \frac{HCO_3 79 SO_4 15 CL6}{Ca43 Na33 Mg22}\ pH\ 6.7\ T$$

The Surenovan deposit is located in the middle of the structural block, almost on a fault (Yerevan deep), and is also characterized by different hydrogeological conditions. The section is dominated by lake-river sediments of Quaternary age, interlayered with young andesite-basaltic lavas. . The well is self-flowing with a flow rate of 5 l/s. Lake-river sediments discovered by a well at a depth of 180-200m are aquiferous. Reservoir waters of hydrocarbonate-sulfate magnesium-sodium composition:

$$CO_2 0.35 M4.0\ \frac{HCO_3 46 SO_4 30 CL23}{Mg50(Na+K)39 Ca10}\ pH7.0T22$$

The Bzhninskoe deposit is confined to the valley of the river. Razdan. The deposit site is located in the core of the Arzakan fold, composed of metamorphic schists interrupted by granites. Within the field, the core of the fold is broken by a large tectonic disturbance of post-Eocene age - the Hrazdan fault, which has a northwest strike and a steep dip angle. The width of the fault zone is 35-50 m. The zone of the second tectonic disturbance - Bzhninsky, with a north-western strike, can be traced here, the width of the fault zone is 20-25 m. The mineral water deposit is confined to the intersection of the Hrazdan and Bzhninsky tectonic disturbances. The main inflows of mineral waters were discovered at depths of 110-150 and 180-200 m. Bzhninsky mineral waters form a water-pressure system of fissure-vein waters within the Hrazdan fault zone. Mineral water from the production well comes to the surface by self-flowing. The mineral waters of the Bzhninsky deposit are warm -20-250C, the main components are hydrocarbonate and sodium. Hydrocarbonate-chloride-sodium water:

$$CO_2 1.2\ M4.5\ \frac{HCO_3 71 CL23 SO_4 6}{Na71 Ca15 Mg10}\ pH6.7T21$$

The Arzni mineral water deposit is structurally confined to the middle part of the Hrazdan depression of tectonic origin. In hydrogeological terms, the Hrazdan depression is an artesian basin, the groundwater of which is found in all stratigraphic rock complexes with the exception of the gypsum-salt-bearing strata of the Middle Miocene and the marly-clay deposits of the Upper Miocene (Sarmatian). The mineral waters of the deposit are confined to the horizons of effusive-alluvial deposits of the river valley. Razdan. The mineralization of hydrocarbonate-chloride mineral waters of the deposit varies widely: from 3.1 to 14.5 g/l with a temperature from 17.3 to 19.70C. Mineral water. are formed as a result of mixing fresh waters of the upper horizons with rising mineral waters. In addition to the main components - HCO3, CL and Na, mineral waters are characterized by a high content of silicic acid - 93 mg/l. Microcomponents in the waters include bromine, iodine, copper, molybdenum and manganese. Mineral water from the production well comes to the surface by self-flowing. Chloride-bicarbonate-sodium water.

$$CO_2 1.3\ M5.9\ \frac{Cl67 HCO_3 26 SO_4 7}{Na73 Mg14 Ca10}\ pH\ 6.8T19$$

Gas saturation - CO2 g/l of waters of mineral springs: Bjni and Arzni - high (1-0.5), Vedi - medium (0.5-1.0), Surenavan - low (0.1-0.5). Mineral waters are classified as brackish and moderately brackish waters based on their salinity value (3.7 mg/l-8.3 mg/l); based on their pH value (6.7-7.0) they are classified as neutral waters [5].

Seismicity map of central Armenia, built based on earthquake catalog data for 2022-2023, with the drawing of earthquake epicenters and hydrogeochemical profile (1-2).

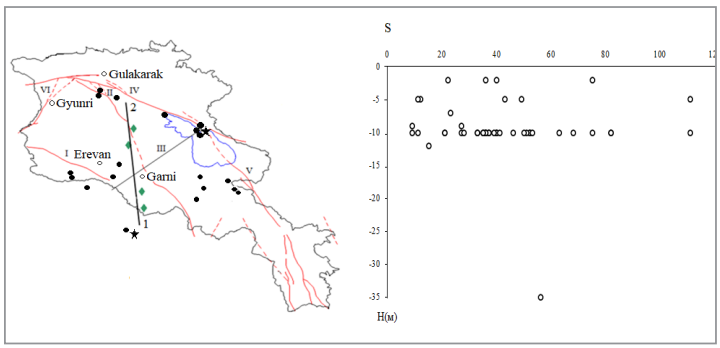

Figure 1: a, b. Seismicity Map of the Territory of Armenia, Seismological Section of the Hydrogeochemical Profile (1-2). -Deep Fault: 1-2 hydrogeochemical profile. I-Yerevan fault, II- Garni fault, III- Ararat-Sevan fault, IV- Pambak-Sevan, V- Pambak-Sevan-Syunik, VI- Akhuryan fault, ♦ – mineral springs, o – cities, ● - M=2 ÷4.0, - M= ≥ 4.0.

The seismicity map of the central part of the region reflects the location of the epicenters of the earthquakes that occurred on the deep faults: Yerevan and Bazum-Sevan. Hydrogeochemical monitoring is carried out on the waters of mineral deposits, shown on the map, conditionally, along hydrochemical profile 1-2 (Fig. 1b). In order to identify the deep distribution of earthquake sources that occurred in Central Armenia, a seismological section was constructed along profile (1-2). As can be seen from the section, most of the hypocenters of earthquake foci vary within the range of 0-10 km, a concentration of foci is observed in a dense row along the lateral at a depth of -10 km, a small concentration of earthquake foci is observed at the beginning of the seismological section.

Activation of seismicity at the beginning of the section may be associated with the intersection of the hydrogeochemical profile with deep faults: Garni (II) and Yerevan (I).

Results

As a result of the use of graphical methods for depicting hydrogeochemical information, hydrochemical profiles were built according to A.A. Brodsky, (Fig. 2) [6].

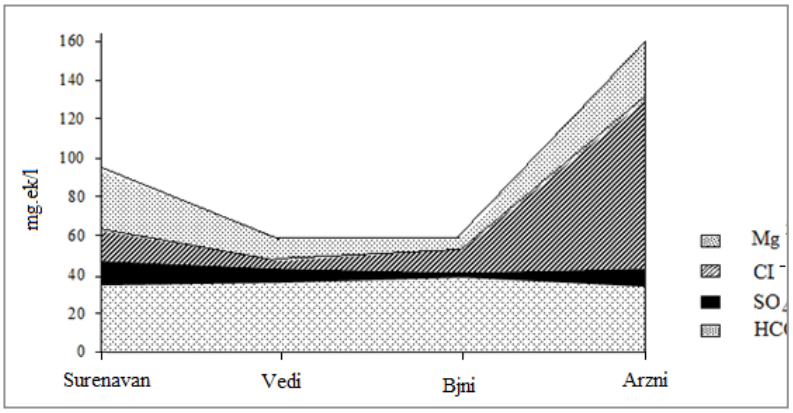

Figure 2: Hydrogeochemical Profile Compiled Along the Outlets of Mineral Water Deposits in Central Armenia.

To construct a hydrogeochemical profile, the x-axis (Fig. 2) shows the distance between the water sampling points: mineral springs Arzni and Bzhni; Vedi and Surenavan. Along the coordinate axis, the content of ions and cations in mg-eq/l. Thus, the constructed hydrochemical profile allows us to trace the nature of the variation in the chemical composition of groundwater in a certain direction (S-N), as well as give a quantitative assessment of changes in the ionic and cationic composition of water.

Based on the use of a graphical method for systematizing hydrogeochemical materials, maps of the content of chemical components, in particular the Mg2+ cation, were constructed. For this purpose, the ArcGIS program was used using spatially static analysis methods, which are based on spatial averaging, which makes it possible to obtain the spatial background of this parameter [7]. The maps reflect the distribution of the dynamics of the concentration of elements of the chemical composition for each month along a vertical section along the locations of mineral springs in time, during which one can visually observe the change in the concentration of a chemical element by month (Fig. 3) [8]. As can be seen from the figure, the dynamics of the concentration of the Mg2+ cation in the waters of mineral springs: Vedi and Surenavan is more pronounced, which in time (VI-IX) months 2022) coincides with increased seismic activity and modern deformations of the earth's crust in Central Armenia (Fig. 4), [9] .

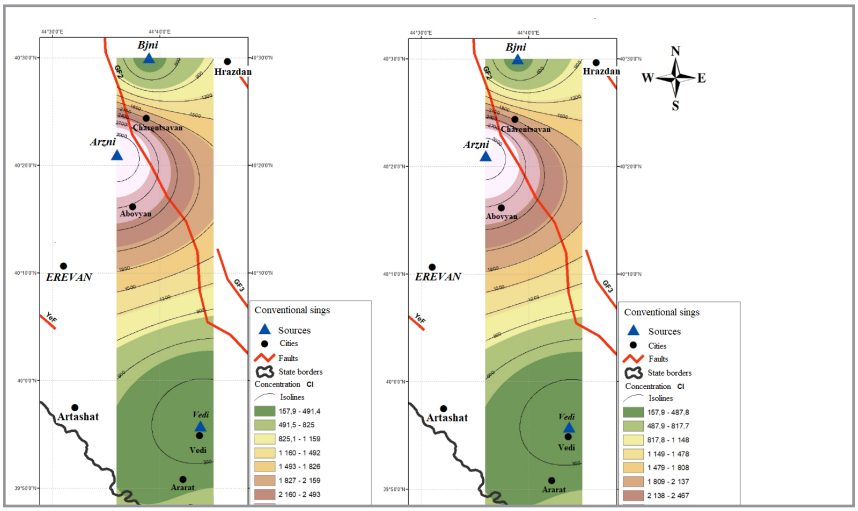

Figure 3: Vertical Section of Changes in the Dynamics of the Concentration of the Chemical Component – Mg in Mineral Water Deposits.

The field map of the stress-strain state of the earth's crust in central Armenia was built according to the values of the calculated values of deformations formed in the areas of observation points depending on the epicenter of the earthquake that occurred [10].

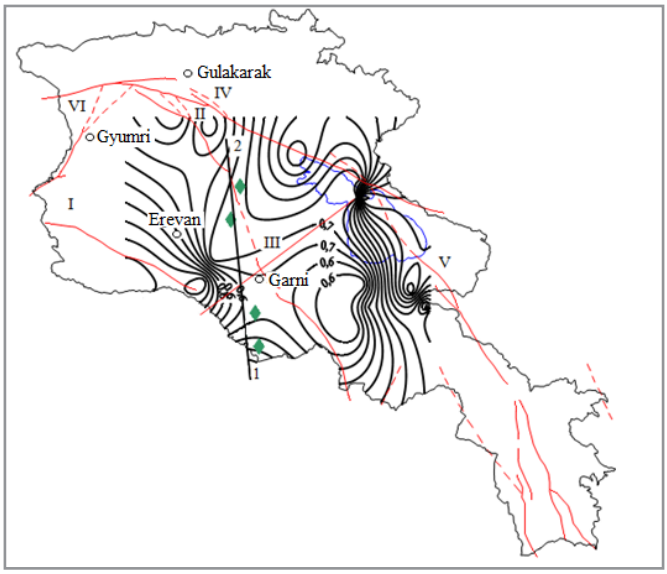

Figure 4: Map of the Stress-strain State of the Earth's Crust in Central Armenia. -Deep Fault: - deformation isoline, 1-2 hydrogeochemical profile, I-Yerevan fault, II- Garni fault, III- Ararat-Sevan fault, IV- Pambak-Sevan, V- Pambak-Sevan-Syunik, VI- Akhuryan fault, ♦ – mineral sources, o – cities.

The map of the stress-strain state of the earth's crust in the central part of the Armenian region reflects the modern deformations of the earth's crust along the Pambak-Sevan and Garni faults, and the stress points that occurred at the intersection of the deep faults: Bazum-Sevan and Ararat-Sevan; Yerevan and Ararat-Sevan.

Discussion

Analysis and systematization of the results of long-term monitoring observations of the chemical composition of mineral waters create the opportunity to expand the basis for decision-making on the assigned tasks.

Familiarization with the main methods of graphic images of hydrogeochemical information and their widespread use in the future will expand the possibilities of interpreting geophysical information.

Conclusion

The compiled seismicity map of Central Armenia reflects the spatial distribution of the epicenters of earthquakes that occurred during the period under study, most of which are confined to deep faults: Pambak-Sevan, Garni and Yerevan.

The seismological section compiled along profile 1-2 reflects the distribution of the sources of earthquakes that occurred within the depths of the earth's crust in the territory of Central Armenia. A graphical representation of the hydrochemical profile compiled according to A.A.Brodsky allows you to monitor changes in the ionic and cationic composition of mineral water for each mineral source, as well as provide a quantitative assessment of changes in the ionic and cationic composition.

Vertical sections were constructed for a separate chemical element of the water composition. Analysis of changes in the dynamics of concentration (increase or decrease) of a chemical element is assessed by an increase in the activation of seismicity and the stress-strain state of the earth's crust in Central Armenia Based on the results of monitoring hydrogeochemical observations and comparison with the seismicity of the region, the stress-strain state of the earth's crust in Central Armenia was assessed. An increase in tension in the region can be seen in the southwestern and eastern coast of Lake Sevan on the territory of Armenia.

The mechanism for the formation of anomalies in changes in the parameters of the chemical composition of mineral waters preceding geodynamic processes in the region's crust is explained by changes in the stress-strain state of the environment.

The use of graphical methods for visualizing hydrogeochemical information made it possible to note that important ways of presenting the composition of water are maps, hydrogeochemical profiles and sections.

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