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Efficiency of Vertical Electrical Sounding in Water Prospecting Problems in Adjara Region (Khelvachauri Municipality)

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ABSTRACT

Different prospecting methods are used in geophysics. The electrical method of prospecting is one of the major fields of applied geophysics. Electrical methods can be divided into two types depending on what source is used, natural or artificial. The first is called natural electric field (NF) methods, and the second is called resistance methods. The vertical electrical sounding method is one of the main resistance methods used in the study of rock watering. The materials presented in our paper are obtained in Khelvachauri district (Georgia), by vertical electro-sounding method to study of rock humidity and research on the possible existence of groundwater at different depths.

Key words: *Vertical electrical sounding (VES), resistivity, groundwater*

Introduction

If the 19th century was dominated by the acquisition and defence of land (territory) and the 20th century was dominated by the acquisition and control of oil and energy resources, then the 21st century will be dominated by the politics of water. Geophysical methods, mainly electroprospecting methods, are used to search and study groundwater. In electroprospecting (resistance method) is used artificial power source. The electricity reaches the ground through the power electrodes and the difference between the arised potentials is measured by the receiving electrodes on the earth surface. If the environment is homogeneous, the resistance method gives us true conductivity, which will not depend on the configuration of electrodes and the position of electrodes on the surface of the earth, since the true conductivity is a constant. In electric resistivity imaging (ERI) electric currents are injected into the ground and the resulting potential differences are measured at the surface, yielding information about the distribution of electrical resistivity below the surface. Finally, this gives an indication of the lithological and structural variation of the subsoil (since resistivity depends on sediment porosity and pore water). In the shallow subsurface, the presence of water controls much of the conductivity variation. Measurement of resistivity is, in general, a measure of water saturation and connectivity of pore space. This is because water has a low resistivity and electric current will follow the path of least resistance. Increasing saturation, increasing salinity of the underground water, increasing porosity of rock (water-filled voids) and increasing number of fractures (water-filled) all tend to *decrease* measured resistivity. Increasing compaction of soils or rock units will expel water and effectively increase resistivity.

In environment ΔV, and therefore impedance ρ should be dependent on the configuration and location of electrodes, as secondary fields influence on the primary field [2]. Therefore, the measured ρ value in nonhomogenous environments is called an apparent resistivity and is signed as ρ_a. The coefficient of reaccount for uneven environment depends on the configuration of electrodes. Different configurations of the electrodes are used according to the type of problem. In our tasks we used the Schumerberger method. Receiver MN electrodes are fixed in the center of the device, while the distance between the current AB electrodes increases gradually [3].

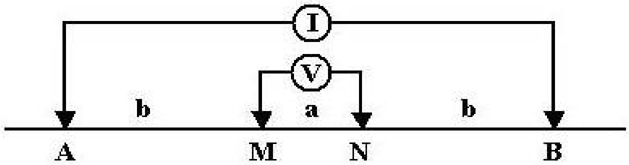


Fig.1. Schlumberger method of vertical electrical sounding

The vertical electrical sounding (VES) method relies on the fact that the greater is the distance between of current electrodes (AB), deeper penetrating the current, than from more deep layers we receivs information by measured potential on the electrode.

Electrical resistance table for some of the rocks

The name of the rock	Electrical resistivity (ohm. m)		
	min	typical	max
clay	5	10	15
loam	10	30	50
sand clay	30	50	80
Water-saturated sands	50	80	200
Sands slightly moist	100	150	500
Dry sands	200	500	10000
Carbonate rocks weakly cracked	500	1000	5000
Intrusive rocks weakly fractured	1000	2000	10000
Bulk	30	50	500
Permafrost rocks of various ice content	500		80000
Ores minerals conductors(in mostly sulphides)	0,001		1-5

As we see from this table [2], the electrical resistance is different for different rocks that allow us to be more confident about the definition of rocks, the water content in them, and to overcome various geophysical tasks.

Study region

Groundwater exploration was carried out in Khelvachauri district by means of electric search (vertical electrical sensing). Khelvachauri municipality is located in the extreme southern part of western Georgia. The territory of the municipality is a hilly foothill zone. The Adjara basin is bordered by Meskheti from the north, Shavsheti from the south, Arsiani ridges from the east, and Guria foothills from the west.

According to E. Gamkrelidze tectonic zones, the territory of Khelvachauri municipality includes the Abastuman-Boshur subzone of the central zone of the Adjara-Trialeti fold system. The tectonic structure of Adjara is not difficult. Only two large folds are established here, which extend over the entire territory of Adjara.

Middle geocene volcanic tuff breccias, breccias, tuffs and volcanic formations of various origins are involved in the geological structure of the municipality. In most cases it is covered with deluvial sediments of the fourth age, clay-clays and inclusions of various coarse-grained materials, and in the river valleys with alluvial sediments. Volcanogenic formations are in most cases chemically depleted and are characterized by sharply reduced physical-mechanical properties. This circumstance creates a favorable environment for the development of natural geological processes.

According to the hydrogeological zones of Georgia, the study area is located in the area of the Adjara-Imereti fissured water pressure system. The following aquifers and complexes are distinguished within it:

1. Aquifer horizon of modern alluvial sediments, which is distributed in the river valleys in the form of strips of different widths (1-1.5 km). Pebbles predominate in the riverbeds, which in lowland conditions turn into rock-sandy and loamy; Total capacity ranges from 2 to 15 m; Nutritional sources are atmospheric precipitation,

filtrates, alluvial, alluvial-deluvial sediments, and downstream water pressure horizons. The use of this precipitate as drinking water is impossible due to its low quality;

2. The aquifer hopping of the undivided alluvial and Old Quaternary marine sediments is particularly widespread along the river. On the right bank of Chorokhi - in Kakhaberi lowland. It is represented by pebbles, clays and sandy compositions. The total precipitation capacity is about 150 m. The lower horizon waters of this complex are suitable for drinking.

3. The aquifer of the Middle Eocene sedimentary aquifer is lithologically represented by alternating andesitic and porphyritic lavas, tuff breccias, tuff sandstones, tuffs, argillites and marls; It is fed at the expense of atmospheric precipitation and river waters and is suitable for drinking.

Results of geophysical survey

It was necessary to investigate the watering of the rocks at different depths in order to subsequently drill wells to obtain drinking water. Electrical prospecting works were carried out in several villages of Khelvachauri district (Fig. 2), based on the appeal of the Khelvachauri Municipality City Hall Ltd. "Khelvachauri Water Channel" administration.

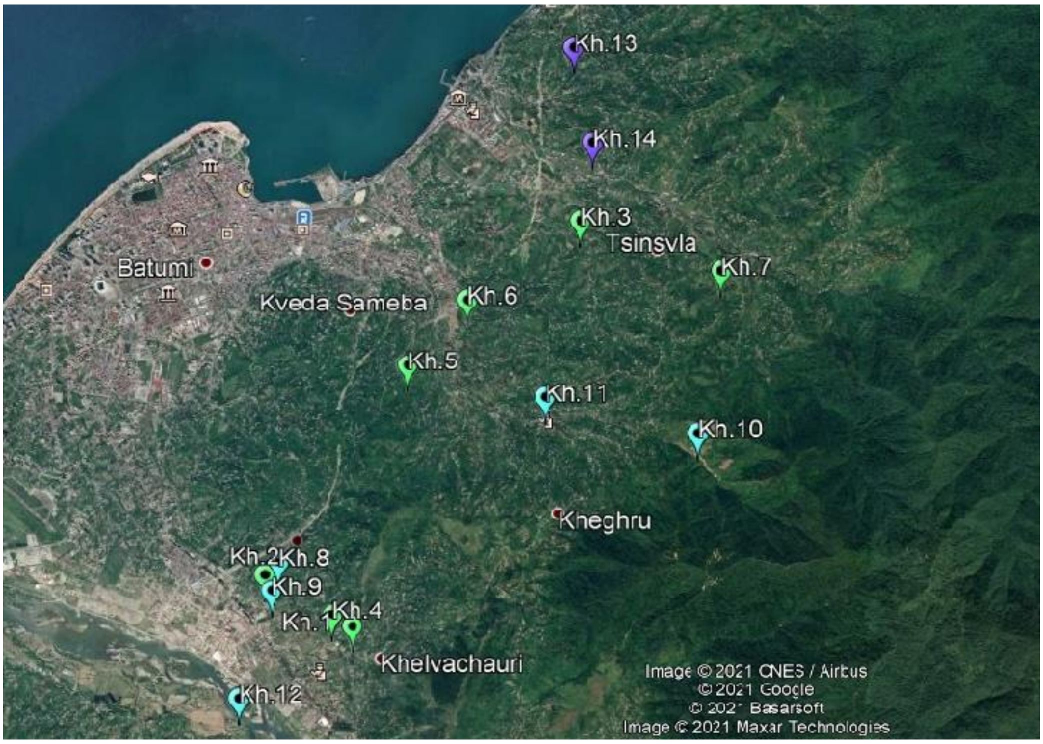


Fig.2. Locations in Khelvachauri district where electrical exploration works were carried out

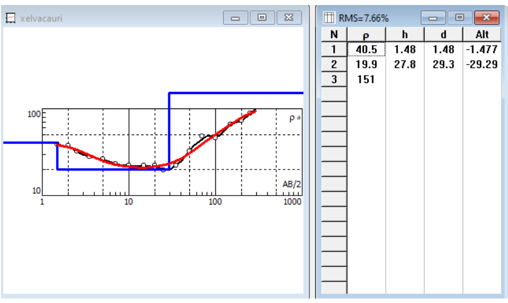
To solve the given task, geophysical surveys were conducted by the method of vertical electric sensing (VEZ) of the constant current. The method is based on the use of artificially created electromagnetic fields on the diurnal surface, which allows the lithological differentiation of rocks according to the change in the depth of the specific electrical resistance (ρ) of the layers. Due to the specifics of the work, the studies were carried out with a Schlumberger four-electrode symmetrical unit with a maximum expansion of the feeding electrodes AB = 500 m, which allowed electrical sensing to be carried out to a depth of 140-150 m. The works were carried out using an Italian-made electrometric device Earth Resistivity Meter PASI 16GL-N (Fig. 2). Data processing was done through a certified IPI2WIN program.

a. **b.**

Fig.3. a) Earth Resistivity Meter PASI 16GL-N, b) measurement process.

The research was conducted in Khelvachauri district, at 14 different points, which was distributed in almost the entire territory of the district. Based on the obtained results, we can form a certain idea about the depth of groundwater in the area, the thickness of the watered layers, the lithology of the subsurface.

1. The first sounding (Ves-1, Fig. 4.1) was conducted in the village of Zanakidze (Fig. 2, Kh.1). Distribution of current supply electrodes AB = 500 m. A classic type curve is obtained. The first layer with a thickness of h_1 ≈ 1 - 1.5 m and a resistance ρ_1 ≈ 40 - 50 ohm.m-s corresponds to the soil cover. The second layer with a thickness of h_2 ≈ 30 m and a resistnance ρ_2≈ 20 - 22 ohm.m-s should be represented by clay and gravel. The third powerful layer of with electrical resistance ρ_3 ≈ 100 - 150 ohm.m-s, correspond to volcanic formations (breccias, tuff-breccias, tuffs). The aquifer horizon probably starts at the border of the second and third layers, at a depth of about 30-31 m from the surface.
2. Ves-2 (Fig. 4.2) was made in the village of Sharabidze (Fig. 2, Kh.2), behind Medina. Distribution of power electrodes AB = 500 m. The first layer with a thickness of h_1 ≈ 15 - 20 m and with el.resistance ρ_1 ≈ 65 - 70 ohm.m, corresponds to slightly watered quaternary deluvial sediments (clayey, coarse-grained inclusions). This layer is transferred to the Middle Eocene volcanic formations (alternation of andesitic and porphyritic lavas, argillites, marls). This layer's own electrical resistance ρ ≈ 300 ohm.m. From a depth of about 120 - 130 m from the surface will be observed a sharp drop in el.resistance, which in some ways indicates the existence of an aquifer.



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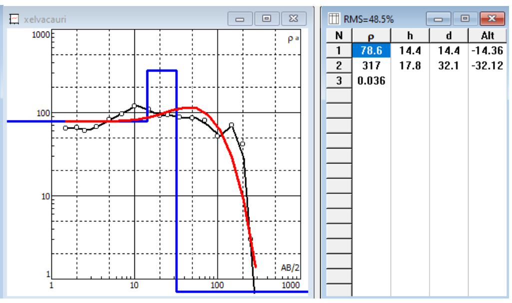

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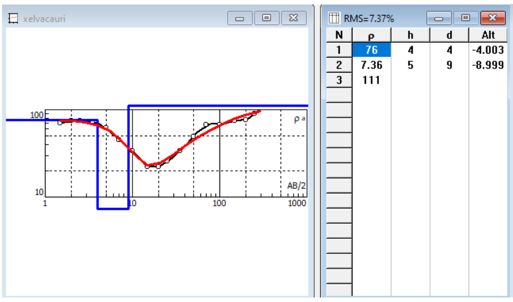

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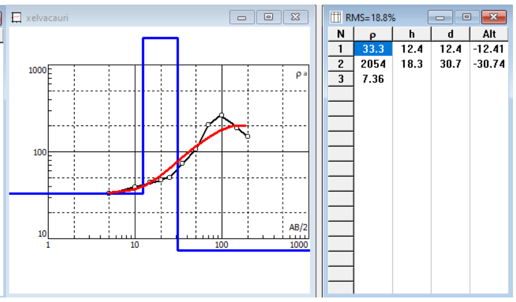

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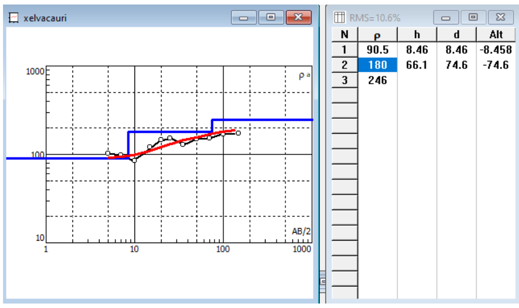

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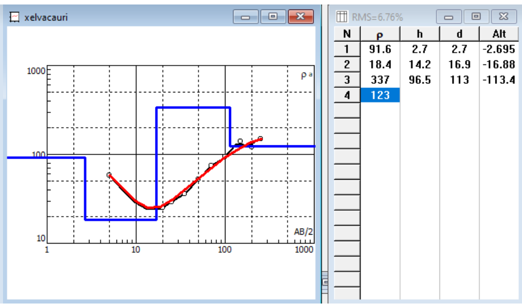

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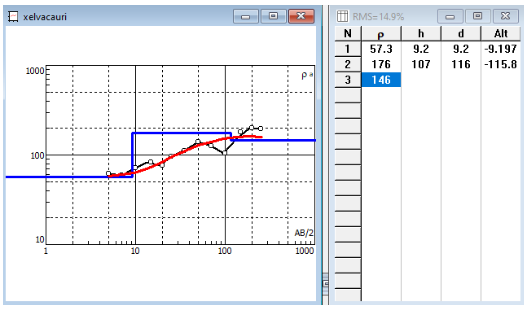

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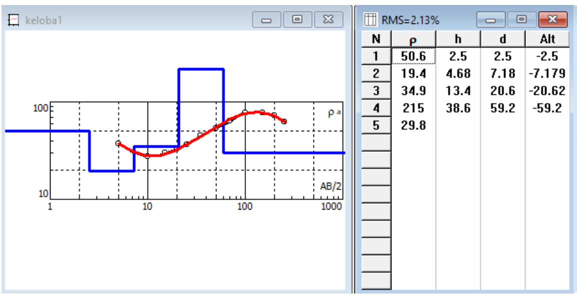
Fig.4. Vertical electrical sounding curves performed in 7 different points in Khelvachauri district: 1. Zanakidzeebi village, **Kh.1**, 2. Sharabidzeebi village, behind Medina, **Kh.2**, 3. Tsinsvla village, Vaneli district, **Kh.3**, 4. Sharabidzeebi village, **Kh.4**, 5. Ganaxleba village, **Kh.5**, 6. Lower Sameba, **Kh.6**, 7. Village Tsinsvla, **Kh.7**.

3. Ves-3 (Fig. 4.3) was made in the village of Tsinsvla (Fig. 2, Kh.3), in the district of Vaneli. Spreading of the power electrodes = 500 m. The first layer with a thickness of $h_1 \approx 2.5$ - 3 m and a specific el.resistance $\rho_1 \approx$ 70 ohm corresponds to deluvial precipitation. The second layer with a thickness of $h_2 \approx 5$ - 6 m and the electrical resistance of about 7 - 10 ohms should be represented by clay. The following sequence is volcanic formations with el.resistance ρ ≈ 100 - 110 ohm. The aquifer appears to be separated at a depth of 110 - 120 m, but watering may appear in the higher layers.4.
4. Ves-4 (Fig. 4.4) was made in the village of Sharabidze (Fig. 2, Kh.4). Spreading of current supply electrodes AB = 400 m. The Ves-4 point is located next to the operating well. The first slightly watered layer is at a depth of about 15 m. The drinking water horizon is probably located at a depth of about 130-140 m from the surface and is represented by volcanic formations.
5. Ves-5 (Fig. 4.5) was made in the village Ganaxleba (Fig. 2, Kh.5). Due to the difficult terrain, the maximum spreading of the electrodes is AB = 300 m. The first 15 - 20 m corresponds to the slightly watered sediments of the quaternary (gravel, clayey, coarse-grained inclusions), which then move into volcanic formations. Due to the geometry of the electrode expansion, the probing depth does not exceed 100-110 m. No signs of watering will be observed at this depth.

6. Ves-6 (Fig. 4.6) was made in the village Qveda Sameba (Fig. 2, Kh.6). Maximum spreading of power electrodes AB = 500 m. The first watered horizon corresponding to groundwater ($h_1 \approx 12$ - 15 m, $\rho_1 \approx 20$ - 25 ohm) is represented by alluvial sediments (gravel, sand). The potable aquifer may be located at a depth of approximately 110 - 120 m in the Middle Eocene volcanic rocks (tuff breccias, breccias, sandstones), with resistance ≈ 140 -150 ohm.
7. Ves-7 (Fig. 4.7) was made in the village of Tsinsvla (Fig. 2, Kh.7). Maximum spreading of power electrodes AB = 500 m. The first aquifer is separated at a depth of 22 - 25 m in alluvial-deluvial sediments of the quaternary. The drinking water layer is probably located at a depth of about 110-115 m in the Middle Eocene volcanic rocks.
8. Further research (Ves-8, Fig. 5.1) was conducted in the village of Sharabidzeebi, in the Vaneli district of Medina (Fig. 2, Kh.8). An HK type curve is obtained. The first layer with a thickness of $h_1 \approx 1$ - 1.5 m and a specific impedance $\rho_1 \approx 35$ - 50 ohm.m-s corresponds to the soil cover. The second layer with a thickness of $h_2 \approx$ 10-12 m and a specific resistance $\rho_2 \approx$ 25 - 30 ohm.m-s should be represented by clay. Then comes a powerful layer that matches the pebble with tuff-breccia inserts, with el.resistance $\rho_3 \approx 65$ - 80 ohm.m. Signs of watering should be observed from 15-20 meters, but to get a sufficient amount of water should be drilled to a depth of 130-140 meters.
9. Ves-9 (Fig. 5.2) was also made in the village of Sharabidzeebi, near Medina (Fig. 2, Kh.9). An Q-type curve of specific electrical resistance is obtained. The first watered layer should be located at a depth of 12-15 m from the surface, in the old Quaternary marine sediments. The second aquifer is probably located at a depth of 100-120 meters.



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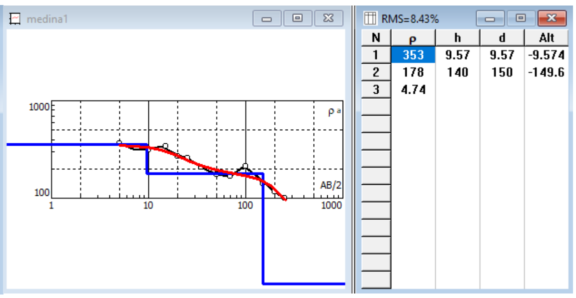

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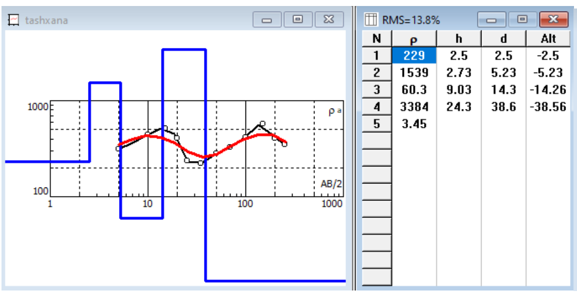

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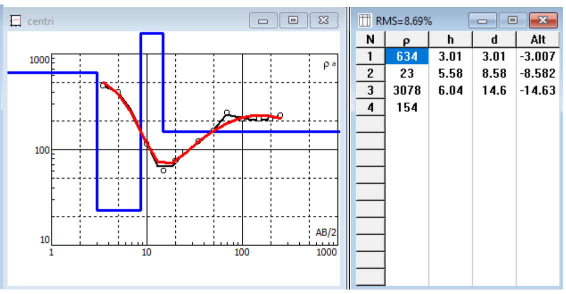

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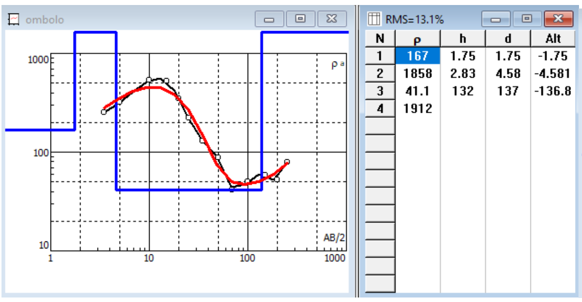

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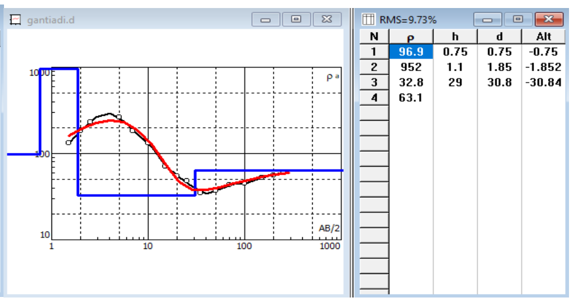

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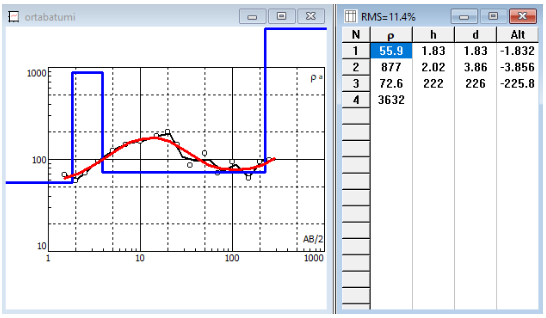

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Fig.5. Vertical electrical sounding curves performed in 7 different points in Khelvachauri district: 1. Sharabidzeebi village, Medina1, **Kh.8**, 2. Sharabidzeebi village, Medina2, **Kh.9**, 3. Akhalsheni village, **Kh.10**, 4. Akhalsheni village, center, **Kh.11**, 5. Village Ombolo, **Kh.12**, 6. Village Gantiadi, **Kh.13**, 7. Village Ortabatumi, **Kh.14**.

10. Ves-10 (Fig. 5.3) was made in the village of Akhalsheni, (Fig. 2, Kh.10). The KHK type curve of specific electrical resistance is obtained. The environment is mainly composed of Middle Eocene volcanic formations (tuff breccias, andesites, porphyrites). Increased humidity should be observed from 30-35 meters. The main horizon is probably located at a depth of 130-140 meters, but the presence of water at a depth of 80-90 meters is not ruled out.
11. Ves-11 (Fig. 5.4) was also made in the village of Akhalsheni, in the center (Fig. 2, Kh.11). An HK type curve of specific electrical resistance is obtained. Signs of water should appear from a depth of 18-20 meters in the Quaternary sediments (loamy, gravel). The aquifer is likely to be located at a depth of 100–110 m in volcanic rocks.
12. Ves-12 (Fig. 5.5) was made in the village of Ombolo, (Fig. 2, Kh.12). An KH type curve of specific electrical resistance is obtained. The first aquifer should be opened from 20-25 m into the quaternary sediment. The second aquifer is probably located at a depth of 110-120 meters.
13. Further research (Vez-6, Fig. 3a) was conducted in the village of Gantiadi (Fig. 2, Kh.13). A KH type curve is obtained. The first aquifer should be opened from 8-10 m into the quaternary sediment. The second aquifer is probably located at a depth of 75-80 meters.
14. Vez-7 (Fig. 3b) was made in the village of Ortabatumi (Fig. 2, Kh.14). An KH type curve of specific electrical resistance is obtained. The first watered layer should be located at a depth of 27-30 m from the surface, in the old Quaternary marine sediments. The second aquifer is probably located at a depth of 110-120 meters.

Conclusion

1. The method of geophysical survey (vertical electrical sensing) was found to be effective for these areas to solve the given tasks and well reflects the existence of a geological environment with different subsurface electrical characteristics at the observation points. The reliability of the results is confirmed in some cases by the drilled wells.
2. Based on the surveys conducted at all points of observation, the geophysical characteristics of the studied environments are more or less different from each other. This indicates on the one hand the similarity of the geological environments here and on the other hand the objectivity of the studies conducted.
3. Based on the analysis of the obtained results, the presence of humidity increased layers at the observation points is well expressed. Most of the vertical electrical sounding curves show watered areas. It can be said that Khelvachauri district is quite rich in groundwater. There are places (for example, the area around Kakhaberi Valley) where particularly strong watered layers can be assumed. However, it should also be noted that there are areas where the likelihood of the existence of watered layers is quite low.

4. The results are quite informative, but it is necessary to continue the work to get a more complete picture of the deep distribution of groundwater in the region and their possible capacities. Groundwater micro-zoning through vertical electrical sensing will facilitate the separation of desirable areas for geophysical work.
5. Finally, it should be noted that although the vertical electrical sensing method is a powerful and experienced method for groundwater exploration, it should also be emphasized that at this stage no method can ensure the exact amount of water inflow and the degree of its mineralization. Their real determination can only be done after drilling a well.

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ვერტიკალური ელექტრული ზონდირების ეფექტურობა აჭარის რეგიონში (ხელვაჩაურის მუნიციპალიტეტში) წყლის ძიების ამოცანებში

ნ. ვარამაშვილი, ა. თარხან-მოურავი, ნ. ღლონტი

რეზიუმე

გეოფიზიკაში გამოიყენება ძიების სხვადასხვა მეთოდები. ძიების ელექტრული მეთოდი (ელექტრომიება) გამოყენებითი გეოფიზიკის ერთ-ერთი ძირითადი დარგია. ელექტრული მეთოდები შეიძლება ორ ტიპად დავყოთ იმის მიხედვით, თუ რა წყარო გამოიყენება, ბუნებრივი

თუ ხელოვნური. პირველ მათგანს ბუნებრივი ელექტრული ველის (ბევ) მეთოდებს უწოდებენ, ხოლო მეორეს -წინააღმდეგობის მეთოდებს. ვერტიკალური ელექტრული ზონდირების მეთოდი ძირითადია წინააღმდეგობის მეთოდებს შორის, რომლებიც გამოიყენება ქანების გაწყლიანების კვლევისას. ჩვენს ნაშრომში წარმოდგენილი მასალები მიღებულია, ხელვაჩაურის რაიონში, ვერტიკალური ელექტრული ზონდირების მეთოდით ქანების გაწყლიანებას და მიწისქვეშა წყლების სხვადასხვა სიღრმეებზე შესაძლო არსებობის კვლევისას.

Эффективность вертикального электрического зондирования в задачах поиска воды в Аджарском регионе (муниципалитет Хелвачаури)

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Резюме

В геофизике используются разные поисковые методы. Электроразведка - одно из важнейших направлений прикладной геофизики. Электрические методы можно разделить на два типа в зависимости от того, какой источник используется, естественный или искусственный. Первый называется методом естественного электрического поля (НЭ), а второй - методом сопротивления. Метод вертикального электрического зондирования - один из основных методов сопротивления, используемых при изучении обводненности горных пород. Материалы, представленные в нашей статье, получены в Хелвачаурском районе (Грузия) методом вертикального электрического зондирования с целью изучения влажности горных пород и исследования возможности существования подземных вод на разных глубинах.