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Vertical Electrical Sounding and Georadiolocation to Assess Groundwater Level During Orchard Cultivation

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ABSTRACT

Too high a level of groundwater, especially stagnant, is detrimental to all species of fruit trees and many berries. An excess of soil moisture worsens air exchange processes in the soil, the oxygen content decreases in it, which inevitably leads to death in the zone of the root system. As a result, the nutritional regime of fruit trees deteriorates, over time, their growth processes stop. Geophysical prospecting methods are very effective in determining the levels and thicknesses of groundwater layers. The article presents the work of the search for groundwater carried out in the Kakheti region (Sagarejo district). The methods of vertical electrical sounding and ground penetrating radar were used. Together, these two methods yielded reliable results at different search depths, which was additionally confirmed during the drilling process.

Key words: *Vertical electrical sounding (VES), georadar, 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. Globally, secure access to potable water has been identified as the key political, humanitarian and military flash point (8). Groundwater it is a subsurface water in the permanent aquifer closest to the earth's surface. They are formed due to the percolation through the soil of atmospheric precipitation and waters of nearby water bodies. Ground-water systems are continuous saturated systems made up of different earth materials. As a simplified classification, these saturated earth materials can be classified as either aquifers or confining beds. As previously defined, an aquifer contains sufficient saturated permeable material to yield significant quantities of water to wells and springs. A confining bed is a rock unit of very low hydraulic conductivity that restricts the movement of ground water either into or out of adjacent aquifers. A ground-water system can be made up of many aquifers and confining beds. The top boundary of the saturated ground-water system is the water table (6,7). Too high groundwater level is detrimental to all types of fruit trees, shrubs and other cultivated plants. Too high a level of groundwater, especially stagnant, is detrimental to all species of fruit trees and many berries. An excess of soil moisture worsens air exchange processes in the soil, the oxygen content decreases in it, which inevitably leads to death in the zone of the root system. As a result, the nutritional regime of fruit trees deteriorates, over time, their growth processes stop.

There are plants, trees that thrive in high groundwater levels conditions. Such plants helps to dry the moist soil.

For fifteen years now there has been a tendency to expand scientific research into the possibilities of geophysics in the agricultural sector. Unsurprisingly, this science can provide predictable agriculture, good groundwater control, accurate soil salinity estimates, and help map the surveyed soil. The use of geophysical methods is increasingly expanding the range - with their help, additional agricultural tasks are already being solved, such as the cultivation of high-quality grain crops, livestock waste management, forestry, the description of the hydrological characteristics of the soil, and in addition - the localization and assessment of underground infrastructure.

Vertical electrical sounding and georadiolocation methods are widely used to determine subsurface humidity and groundwater levels.

The marked part of the agricultural-reclamation area adjacent to the village of Tokhliauri in Sagarejo region, Georgia was studied by georadiolocation profiling and vertical electrical sounding methods.

Georadiolocation prospecting

What is GPR? This is a modern device that solves a wide range of tasks using radar. It is mobile, compact, and its main feature is the ability to conduct non-destructive monitoring of the environment with high detail, which makes it unique among all geophysical equipment. GPR allows the operator to "see" through water, soil and stone. In any environment, the GPR is able to show voids and foreign bodies, changes in density and structure, hidden internal structures - any anomalies.

Agrarians use GPR, in particular, to assess ways to restore contaminated soils, to optimize fertilization in fields, in gardens and vineyards, to control the uniformity of irrigation.

The GPR emits ultra-wideband pulses in the meter and decimeter range of electromagnetic waves and receives signals reflected from irregularities, objects or other inclusions in the soil that have a dielectric conductivity different from the medium. The reflected signals are converted into digital form and displayed on the georadar display. The results can be viewed and processed on a computer. In order to obtain data from different depths, antenna units are used that operate at different frequencies. It is necessary to take into account the general rule: the lower the operating frequency of the antenna, the higher the signal penetration depth, but the lower the antenna resolution.

In our case, we use the GPR Zond 12- e with our standard receiving and transmitting antenna using a frequency of 75 MHz (Fig.1). To receive and process georadar data, we use the PRIZM 2.5 software.

a. b.

Fig.1. a) ground penetrating radar ZOND 12, b) measurement process

Three points were marked at the study area where was performed cross-sectional georadiolocation profiling. First point, a (0536279, 4613113). Second point, b (0536452, 4613083). Third point, c (0536708, 4613047).

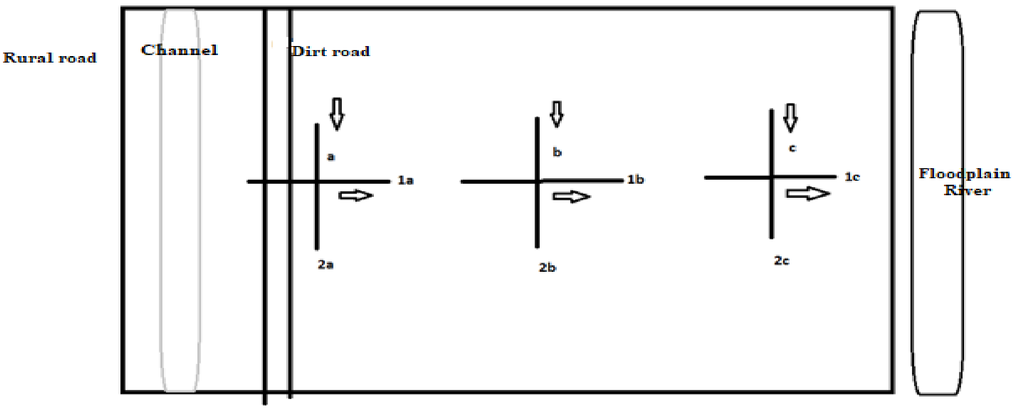

Fig.2. Study place and workplace location diagram.

Conditional drawing of the study area (Fig.2), with intersection points of cross-profiles and schematic placement of profiles.

The georadiolocation profile / (georadar section) shows the radio faces of the separated geological layers, measured in meters vertically and horizontally at a distance, which are presented in accordance with the sinphase texture of the electromagnetic field (4).

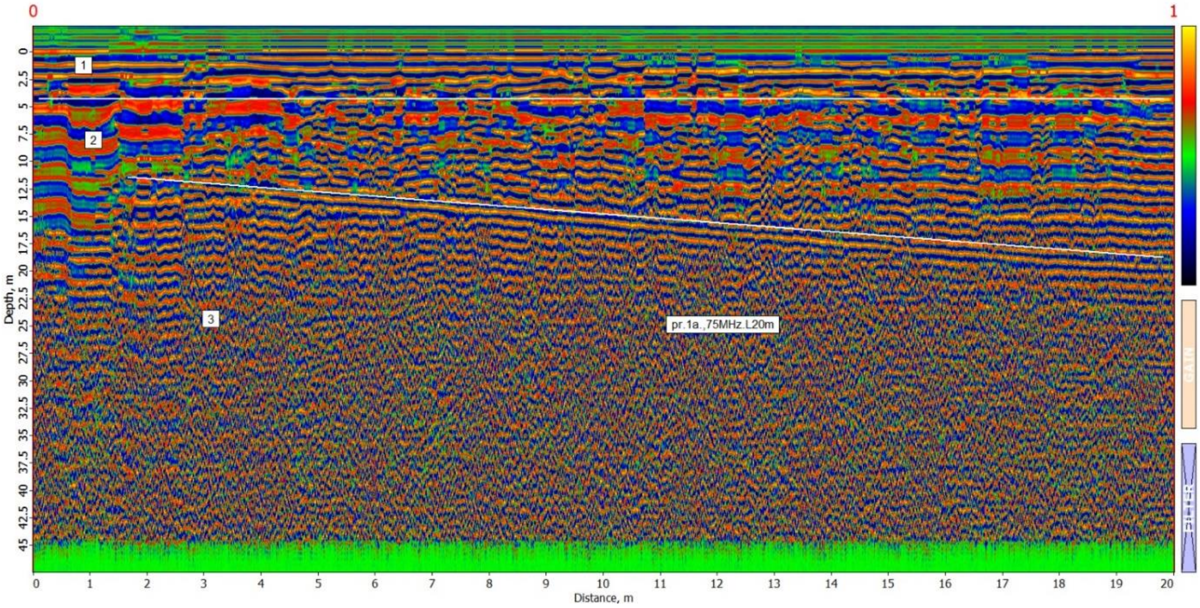

Fig.3. Georadiolocation profile was performed with Georadar 75 MHz dipole antenna, distance - 20 m. Profile 1a, directed normal to the river / floodplain.

Three georadiolocation layers were identified on Profile 1.a (Fig.3). The first layer is 5 m thick, the second layer begins from 5 m deep and extends to a depth of 10-17 m, the third layer starts at 10-17 m and extends below 45 m. Between the first and second layers there is a moistened, in places highly hydrated transitional boundary layer. The second layer bears the marks of hydration with little watering. Moisturization is observed in the presented part of the third layer.

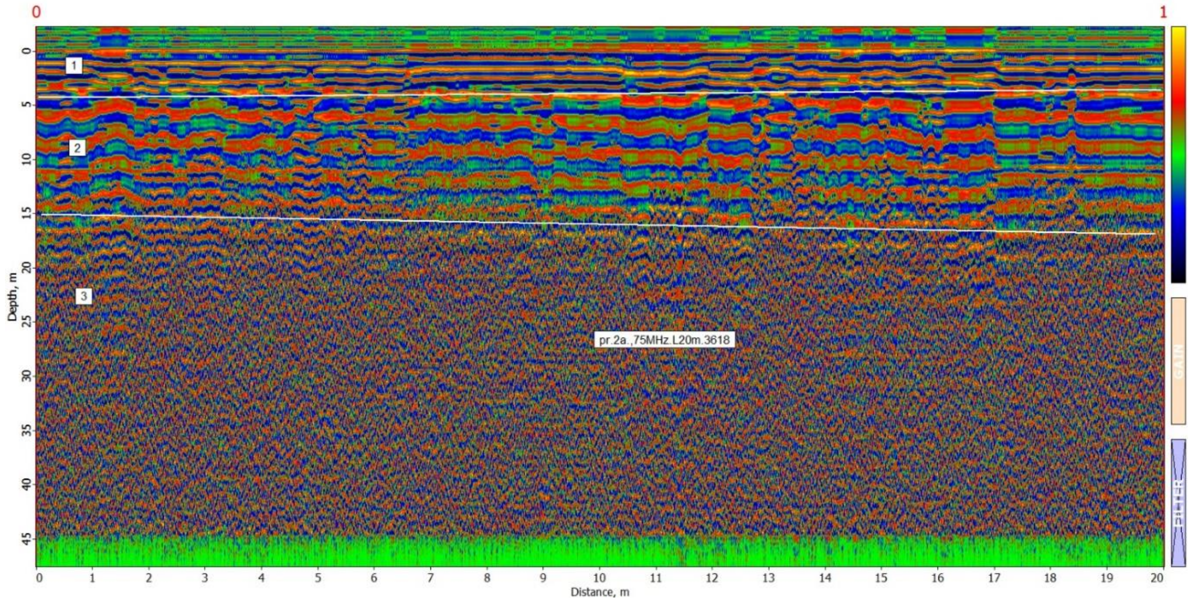

Fig.4. Georadiolocation profile was performed with Georadar 75 MHz dipole antenna, distance - 20 m. Profile 2a, directed tangential to the river / floodplain.

Three georadiolocation layers were identified on Profile 2.a (Fig.4). The first layer is 5 m thick, the second layer begins from 5 m deep and extends to a depth of 15 m, the third layer starts at 15 m and extends below 45 m. Between the first and second layers there is a moistened, in places highly hydrated transitional boundary layer. The second layer bears the marks of hydration with little watering. Moisturization is observed in the presented part of the third layer.

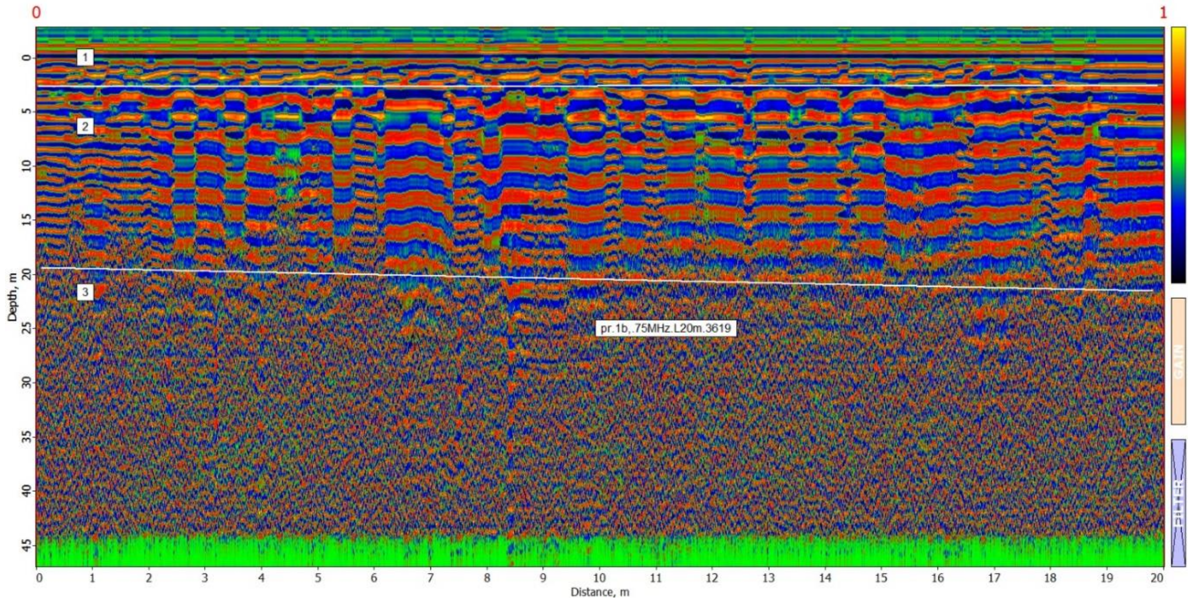

Fig.5. Georadiolocation profile was performed with Georadar 75 MHz dipole antenna, distance - 20 m. Profile 1b, directed normal to the river / floodplain.

Three georadiolocation layers were identified on Profile 1.b (Fig.5). The first layer is 3 m thick, the second layer begins from 3 m deep and extends to a depth of 20 m, the third layer starts at 20m and extends below 45 m. Between the first and second layers there is a moistened, in places highly hydrated transitional boundary layer. The second layer bears the marks of hydration with little watering. Moisturization is observed in the presented part of the third layer.

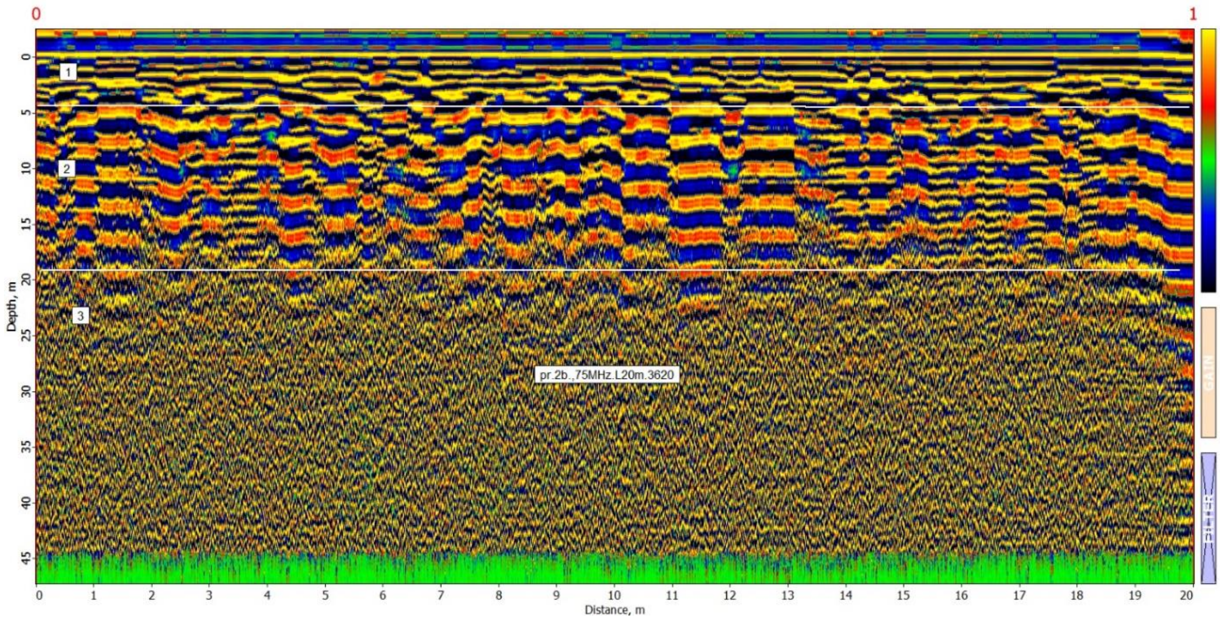

Fig.6. Georadiolocation profile was performed with Georadar 75 MHz dipole antenna, distance - 20 m. Profile 2b, directed tangential to the river / floodplain

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Three georadiolocation layers were identified on Profile 2.b (Fig.6). The first layer is 4-5 m thick, the second layer begins from 4-5 m deep and extends to a depth of 20 m, the third layer starts at 20 m and extends below 45 m. Between the first and second layers there is a moistened, in places highly hydrated transitional boundary layer. The second layer bears the marks of hydration with little watering. Moisturization is observed in the presented part of the third layer.

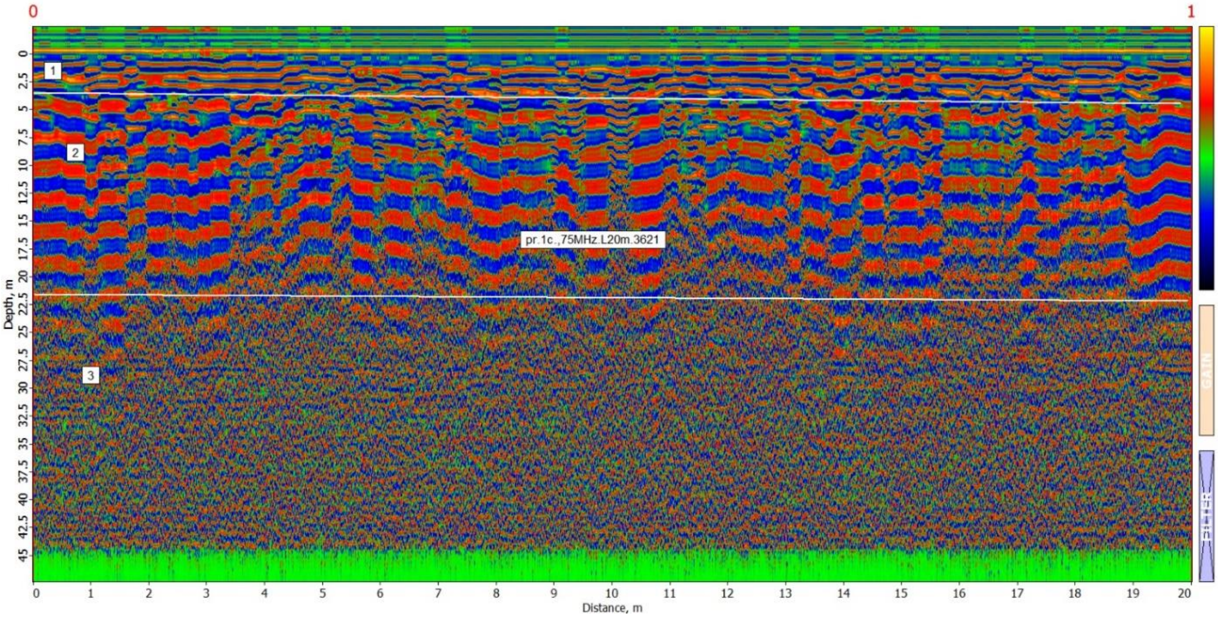


Fig.7. Georadiolocation profile was performed with Georadar 75 MHz dipole antenna, distance - 20 m. Profile 1c, directed normal to the river / floodplain.

Three georadiolocation layers were identified on Profile 1.c (Fig.7). The first layer is 3 m thick, the second layer begins from 3 m deep and extends to a depth of 22 m, the third layer starts at 22 m and extends below 45 m. Between the first and second layers there is a moistened, in places highly hydrated transitional boundary layer. The second layer bears the marks of hydration with little watering. Moisturization is observed in the presented part of the third layer.

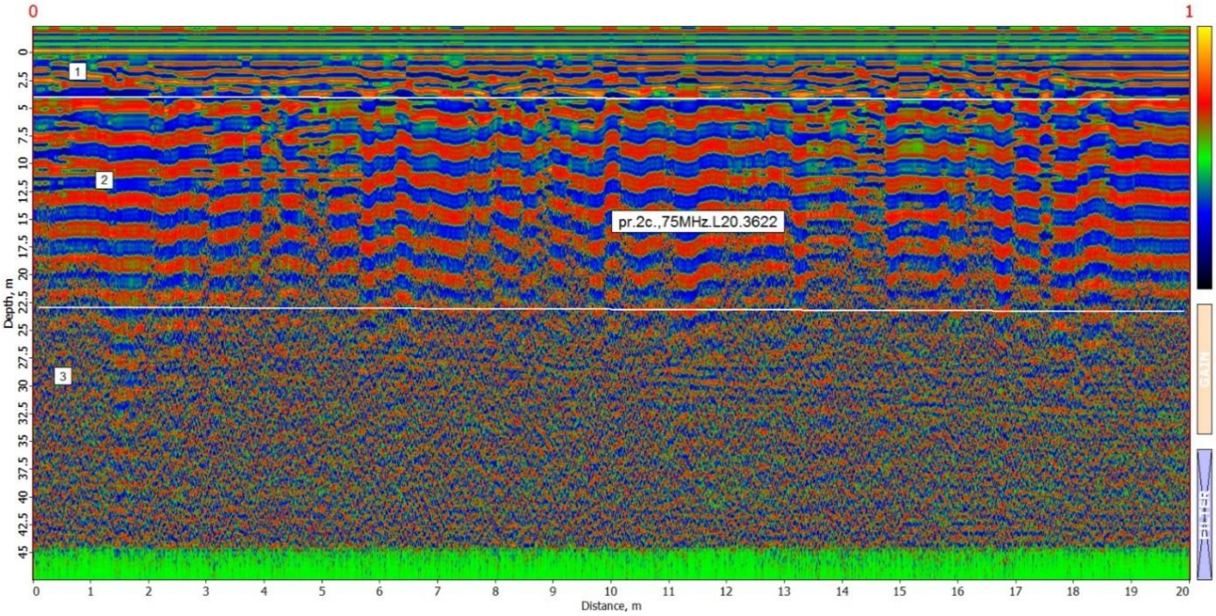


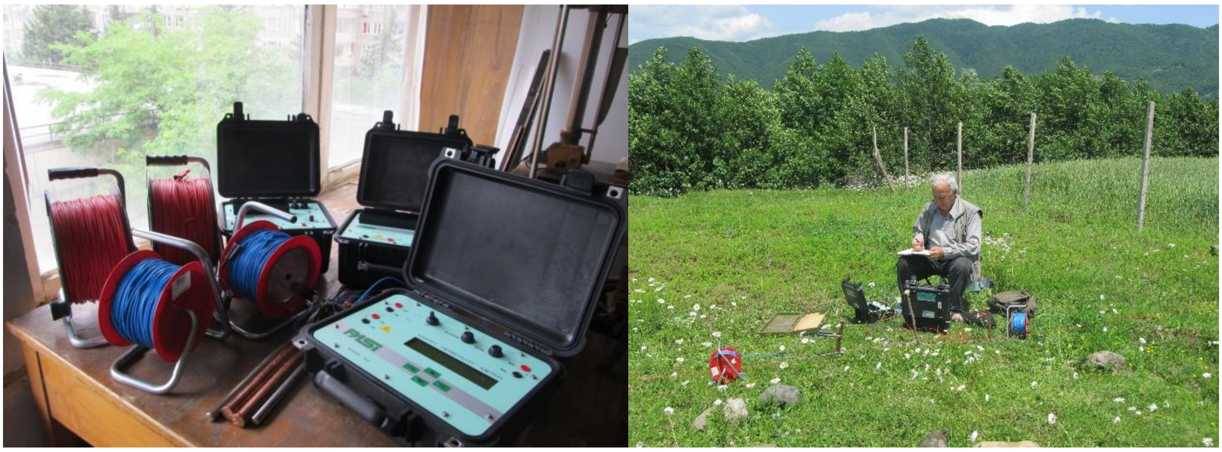
Fig.8. Georadiolocation profile was performed with Georadar 75 MHz dipole antenna, distance - 20 m. Profile 2c, directed tangential to the river / floodplain.

Three georadiolocation layers were identified on Profile 2.c (Fig.8). The first layer is 4-5 m thick, the second layer begins from 4-5 m deep and extends to a depth of 22 m, the third layer starts at 22 m and extends below 45 m. Between the first and second layers there is a moistened, in places highly hydrated transitional boundary layer. The second layer bears the marks of hydration with little watering. Moisturization is observed in the presented part of the third layer.

Electroprospecting (Vertical Electrical Sounding)

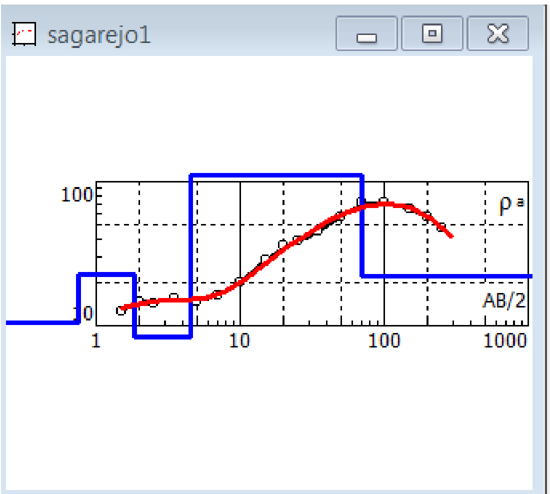
In electroprospecting (resistance method) is used artificial power source. The electricity reaches the ground through the power electrodes and the difference between the arised potentials is measured by the receiving electrodes on the earth surface. If the environment is homogeneous, the resistance method 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 (1,2,3,5).

Vertical electrical sounding was performed at points "a" and "b" (Fig. 2, Fig.9). The works were carried out by the Italian electrometer equipment (Earth Resistivity Meter PASI 16GL-N). Data processing was done through a certified IPI2WIN program.



a. b.

Fig.9. a) Earth Resistivity Meter PASI 16GL-N, b) measurement process



RMS=3.28%

N	ρ	h	d	Alt
1	10.6	0.75	0.75	-0.75
2	22.6	1.1	1.85	-1.852
3	8.46	2.72	4.57	-4.573
4	111	64.7	69.2	-69.25
5	22			

Fig.10. The curve of vertical electrical sensing and the distribution table in the depth of specific resistance are presented for the point "a" of study area.

According to the interpretation of VES (Fig.10), y up to a depth of 4.5-5 meter we have depleted clays , from 4.5-5 meters there is a high humidity, presumably moistured sand, which extends to about 70 meters.

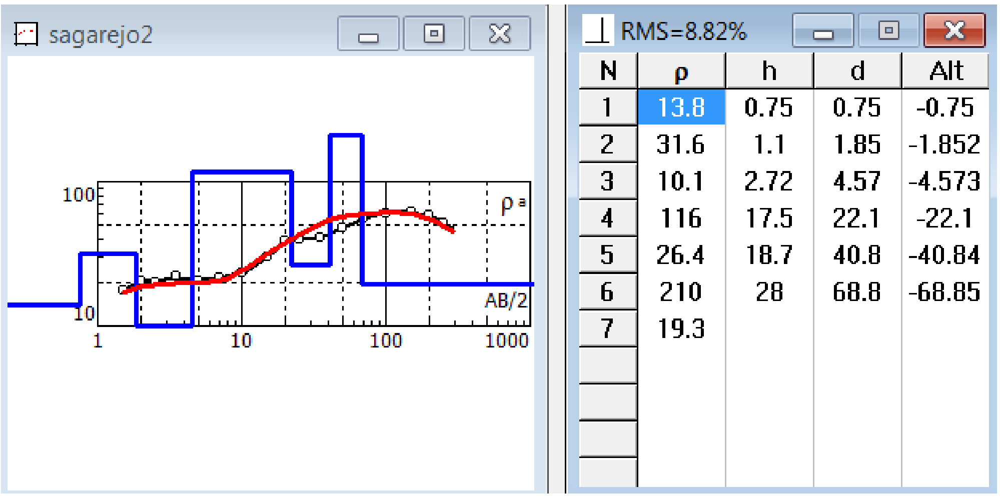


Fig.11. The curve of vertical electrical sensing and the distribution table in the depth of specific resistance are presented for the point "b" of study area.

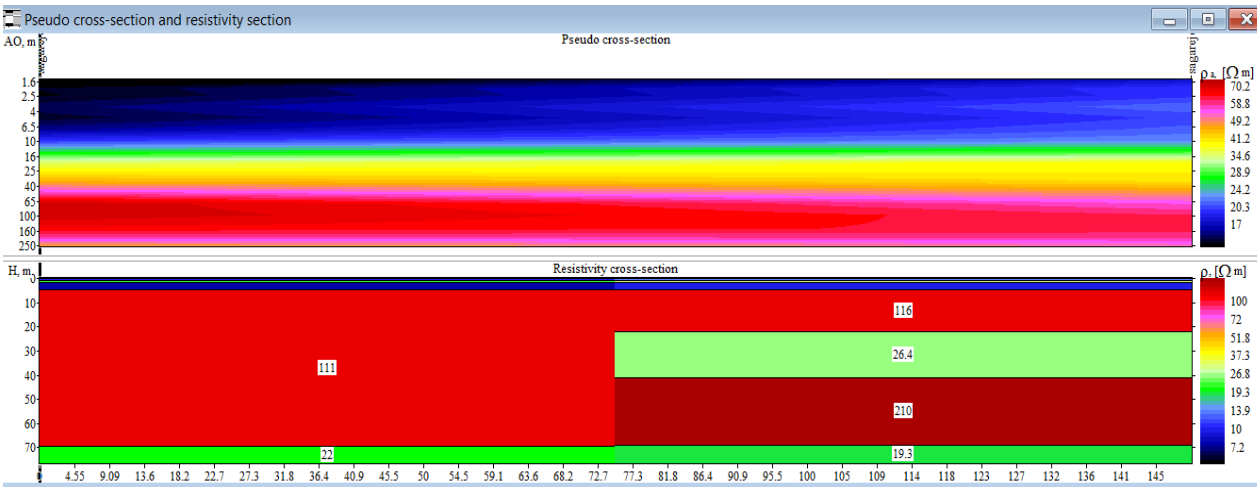


Fig.12. Profile of resistivity based on vertical electrical sensing curves.

According to the interpretation of VES (Fig.11), up to a depth of 4.5 meters, we have depleted clay from 4.5-5 meters there is a high humidity, presumably water-containing sand. The alternation of clayey and relatively dry sand starts from about 22 meters and extends to about 70 meters. A layer of clay-sand appears below 70 meters.

Conclusion

1.Georadiolocation and electrometric search methods are effective in determining groundwater levels and estimating moisture of the subsurface rock. Also, to evaluate the thickness of moistened areas.
2.Each of these methods has its limitations. In the complex they complement each other and can be used without geological restrictions.
3.Georadiolocation and electrometric surveys for the marked area revealed the following - (naturally) moistened, presumably water-saturated layer, which was marked from 4.5-5 m to 70 m. This was additionally confirmed during the drilling process.
4.Based on the above results, fruit varieties and garden cultivation methods will be selected.

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ვერტიკალური ელექტრული ზონდირება და გეორადიოლოკაცია გრუნტის წყლების დონის შესაფასებლად ხეხილის ბაღის გაშენების პროცესში

დ. ოდილავაძე, ნ. ვარამაშვილი

რეზიუმე

მიწისქვეშა წყლების ზედმეტად მაღალი დონე, განსაკუთრებით მდგარი წყლების, საზიანოა ყველა სახის ხეხილის და მრავალი კენკროვანისათვის. ნიადაგის ტენიანობის სიჭარბე აუარესებს ნიადაგში ჰაერის გაცვლის პროცესებს, მასში ჟანგბადის შემცველობა იკლებს, რაც აუცილებლად იწვევს ფესვთა სისტემის ზონაში სიკვდილს. შედეგად, ხეხილის კვების რეჟიმი უარესდება, დროთა განმავლობაში მათი ზრდის პროცესები წყდება. მიწისქვეშა წყლების დონეების და ფენების სიმძლავრეების დასადგენად ძალზედ ეფექტურია ძიების გეოფიზიკური მეთოდები. ნაშრომში წარმოდგენილია მიწისქვეშა წყლების ძიების პროცესი, რომელიც ჩატარდა კახეთის რეგიონში (საგარეჯოს რაიონი). გამოყენებული იქნა ვერტიკალური ელექტრული ზონდირების და გეორადიოლოკაციის მეთოდები. კომპლექსურად ამ ორი მეთოდის გამოყენებით მიღებული იქნა საიმედო შედეგები სხვადასხვა სიღრმეებზე, რაც შემდგომში დადასტურდა ჭაბურღილის გაყვანის პროცესში.

Вертикальное электрическое зондирование и георадиолокация для оценки уровня грунтовых вод при посадке фруктового сада

Д.Т. Одилавадзе, Н. Д. Варамашвили

Резюме

Слишком высокий уровень состояния грунтовых вод, особенно застойных, губителен для всех пород плодовых деревьев и многих ягодников. Избыток почвенной влаги ухудшает воздухообменные процессы в почве, в ней уменьшается содержание кислорода, что неизбежно приводит к отмиранию в зоне корневой системы. Вследствие этого ухудшается режим питания плодовых деревьев, со временем у них прекращаются ростовые процессы. Методы геофизического поиска очень эффективны при определении уровней и мощностей слоев грунтовых вод. В статье представлена работа поиска подземных вод, проведенный в регионе Кахетий (район Сагареджо). Использовались методы вертикального электрического зондирования и георадиолокации. В комплексе с этими двумя методами были получены надежные результаты на разных глубинах поиска, что было дополнительно подтверждено в процессе бурения.