GEOELECTRICAL MEASUREMENTS APPLIED TO THE ASSESSMENT OF GROUNDWATER QUALITY

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Abstract. The aim of this paper is to convince both the specialists in the drilling fields and those in the environmental protection field to use the geophysical methods of investigation, especially in the field of water supply. It is almost essential to use geophysical methods especially in the geoelectrical domain when you have drilled for water if you take into consideration the possibility this method gives of an optimum setting for estimating the quality of these waters. Below we are laying before you some examples of water quality estimation through geophysical methods. We are also mentioning that applying this geoelectrical method important savings can be realized, concerning the performing of same drillings for potable water

Key words: geoelectric, resistivity, groundwater, VES, well log, drill, borehole

INTRODUCTION

Geoelectrical measurements are very often used to identify the underground aquifers, their geometrical characteristics, groundwater quality, aquifer porosity layers and even the direction and flow velocity of the groundwater.

Generally, the geophysical and especially the geoelectrical techniques (Buselli *et al.* 1990) were successfully used in realizing the image of a very wide feature variation, including: the heterogeneity of the aquifers lithology, the under pressure aquifer layers width, position of the hydrostatic level, the depth to the aquifers bed , presence of the clay lenses, fracture zone identification, the geometry of underground cavities concerning the cavernous limestone, as well as the characteristics of the contamination lenses with both organic and inorganic compounds (Castany 1972, Gheorghiu 1969).

In order to satisfy the requirements of drinking water, a series of boreholes have generally been made at medium depths (50 -100 m) lately. For an optimum placement it is compulsory to make a geophysical measurement mainly the standard electrical logging, which is a cheap, rapid and precise geophysical method. Resistivity measurements in boreholes can present useful information, not only regarding the existence of an aquifer horizon or geological information with compact characteristic (sandstones, limestones), but also regarding groundwater quality.

In the following chapters, we will present some typical situations regarding the groundwater quality estimations using both geoelectrical surface and borehole measurements.

1. GEOELECTRICAL MEASUREMENTS

Rocks and geological formations can vary in their capacity of conducting the electrical current, a capacity which is usually called electrical resistivity. Electrical current implies electricity moving electrical loads, in the case of geological formations these louds being either electrons or ions, ions moving through the fluids of spongy space of rocks. Experimental results have shown that water consistency has the most important contribution to the electrical current conduction through rocks and sedimentary geological formations.

According to the electrical resistivity variations of underground formations, some hydrogeological characteristics may be identified.

The surface alternative of geoelectrical research (Modin *et al*., 1997) can supply regional or local information about the distribution of aquiferous formation at depth, over their development and the degree of mineralization in groundwater pollution estimations.

In the electrical logging, the information is local, the degree of accuracy in determining the aquifer horizon is to the nearest centrimetre and the contact, almost direct between measurement device and aquifer horizon, may lead in many times to almost exact estimates of the groundwater quality especially when, in the case of drilling for water, the existing geological situation may be easily surveyed during drilling.

As we know, water conductivity is influenced by the content of free electrical charge that may be electrons, in case of the existence of chemical elements with some iron content, or free ions, in case of azoth and a azothates. Delimitation of the type of water mineralization cannot be done using geoelectrical data. This method indicates, in a qualitative mode, the existence of a certain degree of water mineralization.

2. RESEARCH METHODOLOGY

Geo-electrical measurements in boreholes have been taken using a GEOLOGGER 3000 logging installation. General results consisted in 3 curves, two of them representing resistivity correlations and one is a potential curve (PS). While the first two curves make evident the resistivity of the formations, penetrated by the boreholes, the PS curve shows the electro-chemical processes inside those geological formations. As a result, the total potential has the form of a ponderate average between diffusion and absorption potential, oxido-reduction potential and electro filtration potential (Gheorghiu, 1969). In the case of geological sedimentary formations the diffusion and absorption potential is mainly present. The prevailing rocks of this type are: clayish sands, fine or coarse sands and broken stones; all these do have water in their content. The PS curve is very useful in analyzing geophysical data, especially in locating the aquifer horizons but only if it being correlated to the resistivity curve.

Surface geo-electrical measurements have been taken with Intel91 V3 resistivity meter that uses Schlumberger disposal (Mundry 1980). Data interpretation and management is done using the self modelling program for VES (Simulation 2).

3. DATA ANALYSIS

As previously presented, geological formation resistivity depends on mineralogical composition, water content and the degree of mineralization in the water. The geo-electrical perspective shows that, (in the case of sedimentary formations), apparent resistivity measured using electrical logging is as follows:

- clay and marl 5-10 ohmm
- dry sands > 150 ohmm
- sandstone > 150 ohmm
- limestones > 500 ohmm
- sandy clays 10 – 15 ohmm
- clayish sands 10 – 25 ohmm
- aquiferous sands 50 – 100 ohmm
- mineralizated water 0 – 0.1 ohmm

The values presented above have only an informal character, occasional major modifications being possible due to either layer thickness penetrated by the electrode, the composition of the mud drilled or the mineralogical groundwater composition or the specific conditions for that particular borehole.

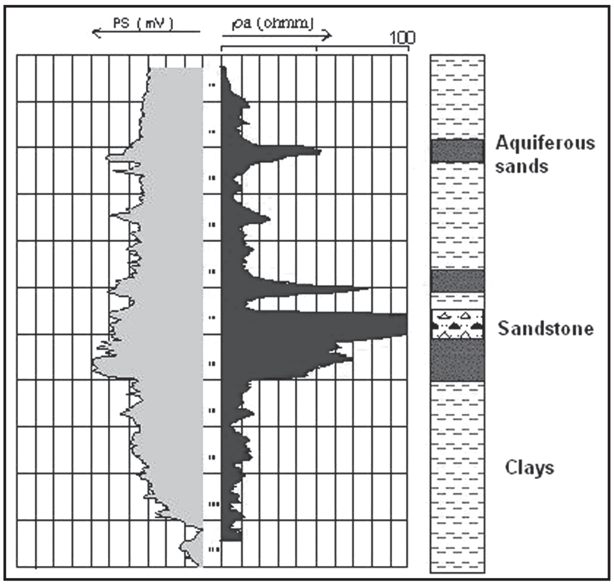

Fig. 1 Well log H = 110 m - Vela

The geophysical well log presented in Fig. 1 was recorded in the Dolj area. From a lithological point of view, this area is mainly argillaceous, horizons with aquifer sands being located (using the electrical logging results) in-between 19-23, 48-52 and 61-70 m. Due to the fact that the average value for resistivity is 70 ohmm, we have considered that the groundwater deposited in sandy horizons is not mineralized and is accordingly drinkable. We must also mention that in-between 55-61 m, high levels of apparent rezistivity (200 ohmm) indicate the presence of some compact sands; the same result being obtained during the drill process.

Close to Ramnicu Valcea city quite an opposite situation was noted from the groundwater quality point of view. The well log presented in figure 2 indicates the presence of a sandy horizon within 0-18 m interval. After this interval, the resistivity curve remains constant around 2 – 5 ohmm although the PS indicates the presence of some sandy horizons. In this condition, we can definitely identify the mineralized groundwater.

Because the salt concentration (NaCl) within this borehole was so dense, it was quite impossible to separate the salty water horizons from possible drinkable water horizons. In order to solve the problem some surface measurements were taken (VES). The results obtained from these measurements are presented in the figure 3.

After the interpretation of SEV, the existence of two very conductive horizons between 17-37 m and 47-70 m and of a resistive horizon between 37 and 47 m was noted. The first two horizons were composed of salty sands and the resistive one was composed of a volcanic tuff. This last horizon was also identified during the drilling process.

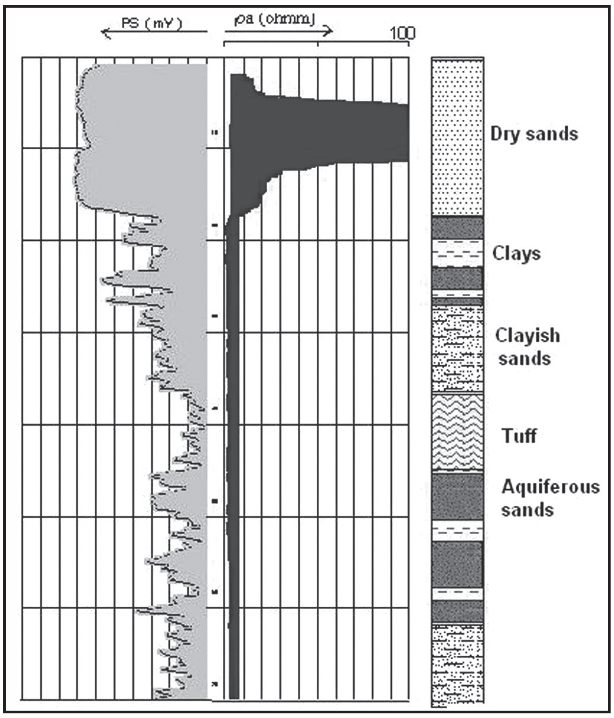

Fig. 2 Well log H = 70 m – Rm. Vâlcea

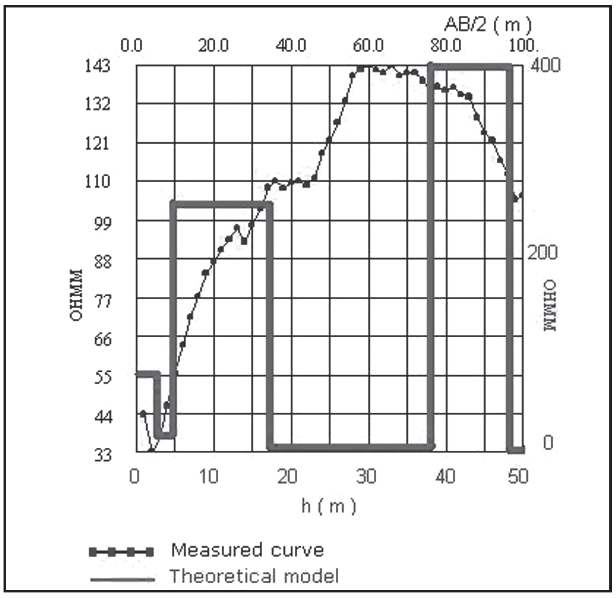

Fig. 3 Vertical electrical sounding (VES) – Rm. Vâlcea

The boreholes taken in the Movilita region at depths of about 50 m (Fig. 4 and Fig. 5) present very low resistivity, which proves that the groundwater retained especially in the clayish sands (prevalent in this area) is very well mineralized.

Fig. 6 presents the state of the Liscoteanca region. There, the groundwater source is situated in the clayish sands at 5-40 m depth, but also in two small sandy horizons (of about 20-30 cm) within a 60 m interval. The lowest resistivity values indicate the presence of a very strongly mineralized water.

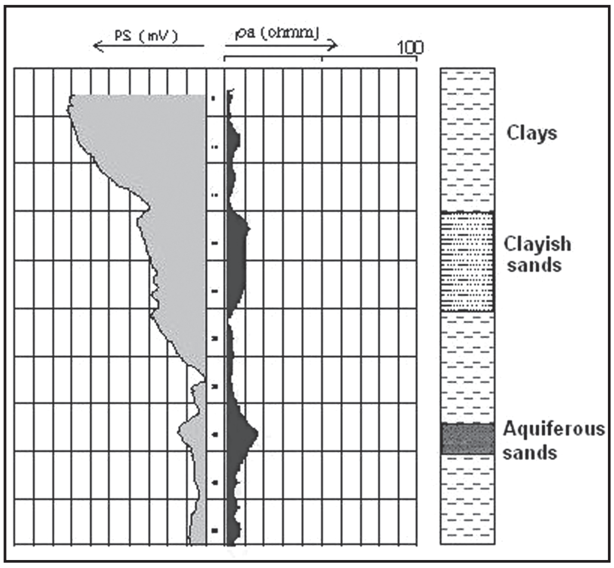

Fig. 4 Well log H = 50 m - Movilita

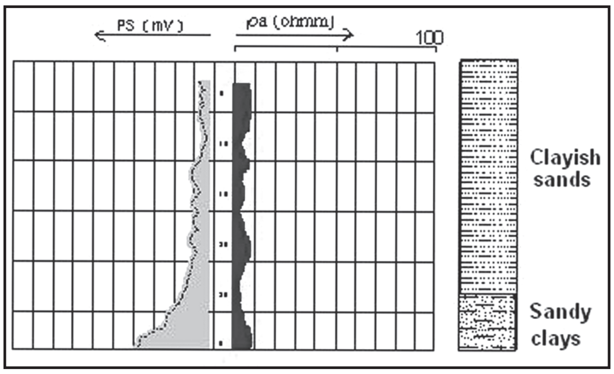

Fig. 5 Well log H = 30 m - Movilita

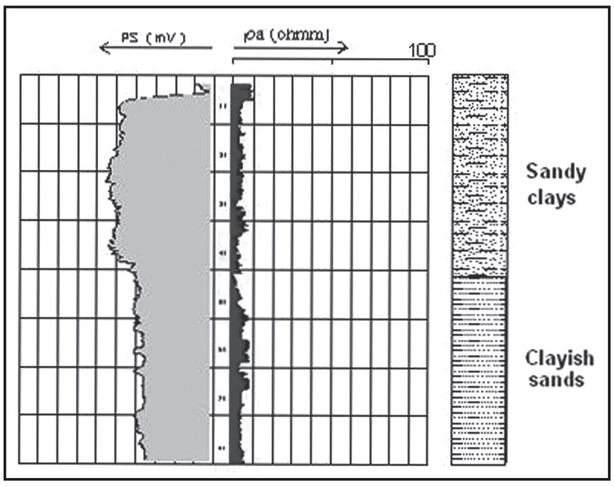

Fig. 6 Well log H = 80 m - Liscoteanca

CONCLUSION

The aim of this article is to demonstrate that the groundwater quality may be measured using geoelectrical measurements, before using cased boreholes. In this way it is possible to reduce the costs of drilling if drinking water is desired. When a decision regarding groundwater quality is needed, it is recommended to gain all the information about that area (some geological information, hydrological or geophysical information). It is also recommended to use surface geoelectrical measurements, in order to locate the optimum water drilling, especially in areas where there is a lack of hydrogeological information or in areas where there are doubts about the groundwater quality.

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