APPLICATION OF THE GEO-EMR METHOD IN HYDROGEOPHYSICS

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During the recent decade, several new geophysical techniques have been introduced for mapping subsurface features, estimating properties, and monitoring processes important for hydrological studies, (Jean R., 2009). This paper discusses application and results of a new geophysical method based on electromagnetic nuclear resonance (GEO-EMR).

INTRODUCTION

The accelerating level of interest in electromagnetic resonance method for hydrological problems is obvious because it performs well in a free scale element discrimination-hydrogen, a major component of the water molecule. In addition, our GEO-EMR method has a very good depth penetration (up to 4 km) and excellent definition of the lithology and aquifer geometry. Exploration area is located near town Velika Plana, along the Morava River Valley, which is situated in the central part of Republic Serbia. Composite facies model in the Valley is complex and detailed mapping of the subsurface features was the key objectives of this hydrogeophysical study.

Climate of the area varies between continental and moderately continental. During the winter time the temperatures are mostly between -5^0C to 20^0 C, while during summer season temperatures reach more than 40^0C.

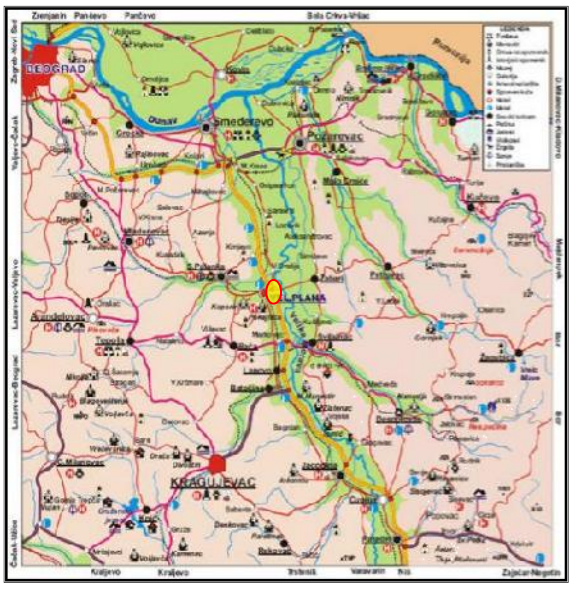

Figure 1. Geographical location of the exploration area

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Using the GEO-EMR sounding method the investigation of lithological profiles were made to determine suitable aquifers without pollution at the depth up to 200 m, for the local water supply.

GEOLOGICAL CHARACTERISTICS OF EXPLORATION AREA

Exploration area consists of alluvium deposits of the Velika Morava River (gravel-sand-clay sediments). Average thickness of these sediments is more than 20 m (Vujisic, T. et al.).

On the larger exploration area a key tectonic element influencing the architecture of the Valley is the South Morava fault, which was active during the Neogene sedimentation. The Neogene sediments consist of following formations: $^{2}M_{3}^{2}$ (sand, clayey sand and sandstone), $^{1}M_{3}^{2}$ (sandy clay, clayey sand and clay), $^{2}M_{3}^{1}$ (sand and limestone layers). Their average thickness is about 500 m, (Vujisic, T. et al.).

EXPLORATION METHODS AND TECHNICAL DATA

This hydrogeophysical survey was designed on the base of the previous regional hydrogeological study of this area. Electromagnetic resonance technique is a highly appropriate method because of economics. In our implementation, the GEO-EMR instruments pack is less than 20 kg so the entire system can be backpacked-transported.

GEO-EMR method represents one kind of electromagnetic method for geological and hydrogeological prospection of ground produced by “Eko Solar” Ltd., Belgrade, Figure 2.

Figure 2. “GEO-EMR” equipment

Functionally, GEO-EMR fits comfortably between several established techniques; nuclear absorption used in well-logging, gradient method in medicine and a spin-echo technique. Our hybrid spin-echo technique using the radio frequency continuous beam has the potential to widen range of application because of high penetration and an innovative electronic solution capable to detect a weak echo-signal. This equipment consists of transmitter and receiver unit. Transmitter is portable device with ability of transmitting different specific frequencies (in range

from 2 until 20 kHz) relevant to every chemical element or compound. Receivers are sensitive detector arrow, which deflection indicates strength of the radio frequency echo-signal.

To define depth to aquifer, oil, ore bodies and minerals, the transmitter antenna points vertically to the ground. Depending on transmitted frequency, signal will be reflected in response to atomic composition of the searched material. The nuclear spin resonance is a key process allowing us to map the underground lithological composition. Briefly, it sounds like a well logging from the surface. Both the survey methods, the electromagnetic sounding and profiling could be performed separately or in combination. Only serious obstacle could be some severe geomorphology of area. In this project the survey has been done on three selected location with the maximum sounding depth up to 215 m.

EXPLORATION RESULTS AND INTERPRETATION

In principle, the key objectives of the project were to map the deeper water resources, estimate properties and asses ecological aspects i.e. the contamination of a potential aquifers. Figure 3 is example and the GEO-EMR results and the hydrogeological interpretation of the data at location MT-1:

0.0 – 2.5 m	Humus
2.5 – 8.5 m	Clayey sand
8.5 – 17.2 m	Water saturated sand and gravel
17.2 - 38 m	Sandy clay
38.8 - 54.1 m	Clay
54.1 - 98.5 m	Sandy clay
98.5 - 151.3 m	Clay with sand lenses
151.3 - 156.2 m	Water saturated sand and/or gravel
156 .0- 178.0 m	Clay with small sand layers
178.2 - 187.6 m	Water saturated sand and/or gravel
187.6 - 215.0 m	Solid clay

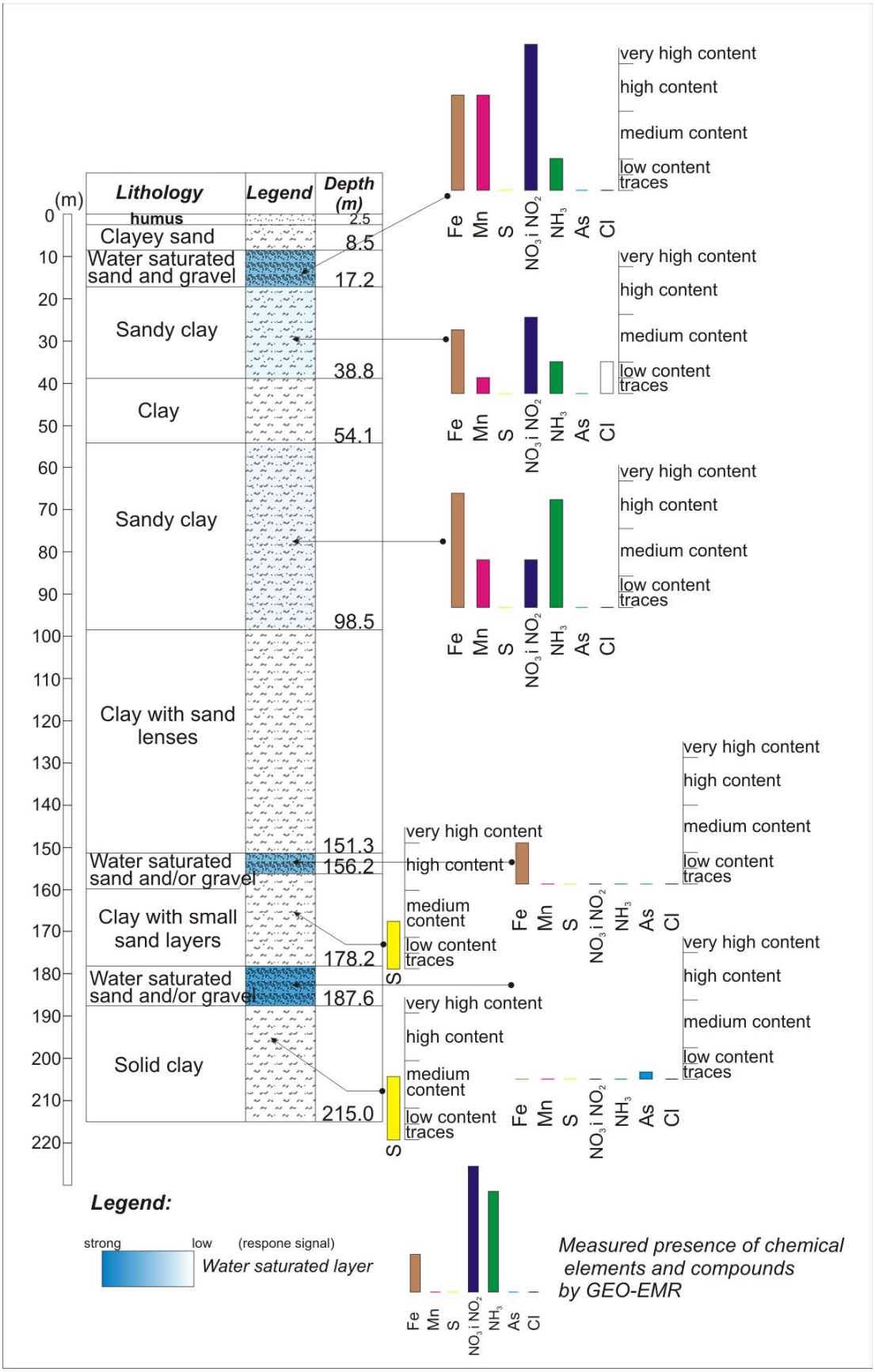

Figure 3. GEO-EMR pseudo lithological column, location Staro Selo

From the hydrogeological point of view, the most attractive aquifers as potential additional water supply are the following zones: from 151 m to 156 m, and from 178 m to 187 m. In the shallow section, the following aquifers are expected to be contaminated with a higher volume of: iron, manganese, ammonia, total NO_3 and NO_2. In deeper aquifer (from 151.0 to 156.0 m), the presence of iron in moderate concentrate was indicated. In the deepest aquifer (from 178.0 m to 187.0 m), no presence of either iron or sulphur was registered, or any other measured contaminants. The only suspicious element which could cause subtle pollution of waters was As, but in very low concentration.

CONCLUSION

As we can see on the illustrated gross lithology column, the first insight in the explorations using GEO-EMR method in the Velika Plana area approved interesting and important geological and hydrogeological outcomes:

1. According to the results on the measuring point MT-1, the most perspective layers for providing additional quantities for the water supply were defined as follows: from 151 m to 156 m and from 178 m to 187 m. The only reason, which could cause difficulty, is the potential ecological issues because of indicated presence of sulphide in moderate concentration in the underlying and overlaying formations. Further investigation would be desirable. In the aquifer from 151 m to 156 m presence of iron in a moderate concentration was also indicated.

2. To quantify more precisely amount of all contaminated elements in the aquifers we envisage that the laboratory calibration would be necessary in order to achieve more accurate concentrations (mg/l) of the critical chemical elements.

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