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OUTLINING COMPLICATED SUBSURFACE GEOLOGICAL CONDITIONS BY ELABORATING 1-D ELECTRICAL SOUNDINGS FOR HYDROGEOLOGICAL PURPOSES.

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INTRODUCTION

Subsurface investigations for hydrogeological purposes using geophysical (mainly geoelectrical) methods are widely used today. For geoelectrical methods, the array type and the way the electrodes are expanded, are highly depended on the nature of the hydrogeological target, the depth of investigation and the strike of the geological setting. For deep investigations (AB/2=1000 m), the Schlumberger array is more suitable and is mostly used, although the dipole-dipole array gives similar results. In addition, the inherent difficulty of interpreting 1D Schlumberger soundings, arising from non horizontal layering and lateral variations, has recently been faced by proposing several methods, for recognizing lateral resistivity inhomogeneities (Rønning and Tønnensen 1990) and detecting them by combining the Schlumberger sounding array with two dipole-dipole soundings (Morris et.al. 1997). During the last two decades emphasis has also been given among the geophysicists, to develop 2D interpretation algorithms for a reliable earth structure simulation (Dew and Morrison 1979, Barker 1981, Dahlin 1993, Loke and Barker 1994). Furthermore, it has been pointed out that in some cases the 1D approximation of Schlumberger curve interpretation is adequate (Beard and Morgan 1991, Morris et. al. 1997). In contrast, less attention has been paid among the geophysicists on the role of the *in situ* electrical measurements, mainly because of the diversity of the measured values, and dealing with detailed surface geology observations. Both investigations can contribute to the construction of a reliable 2D structure.

In this paper, deep soundings conducted by using the Schlumberger array, were interpreted by 1D approximation (Zohdy 1989), for outlining the hydrogeological conditions of a deep and structurally complex alpine basement (Lekkas 1978). Field measurements took place more or less along the strike of geological formations (as they revealed at outcrops) to avoid lateral variations arising from the dipping of the geological formations. Emphasis was given in conducting *in situ* electrical measurements at sites where outcrops of representative geological formations were existed and close to boreholes, in order to constrain the resistivity values and assign the range of resistivity values to known geological formations. The knowledge of local range of earth resistivity values, played a crucial role in determining the subsurface structure based on the 1D Schlumberger data and interpretation.

Field investigations were carried out at Tripolis plateau in central Peloponnesus Greece, an area covered by post-alpine sediments and presenting highly complex alpine basement with overturned folds, intense karstic phenomena, thrusts, etc. The target of this investigation aimed at outlining the hydrogeological conditions, from a structurally point of view, at depth and laterally but not in great detail.

In Situ ELECTRICAL MEASUREMENTS

Near boreholes. In situ electrical measurements were conducted nearby boreholes of known stratigraphic column, to assign the range of resistivity values of pleistocene sediments (clays, silts, sands, gravels, etc.) and those of calcareous formations of Pindos Unit belonging to the alpine basement (limestones and marly-limestones). Characteristic geoelectrical curves along with interpretation results and borehole data are shown in figure 1 (1a and 1b).

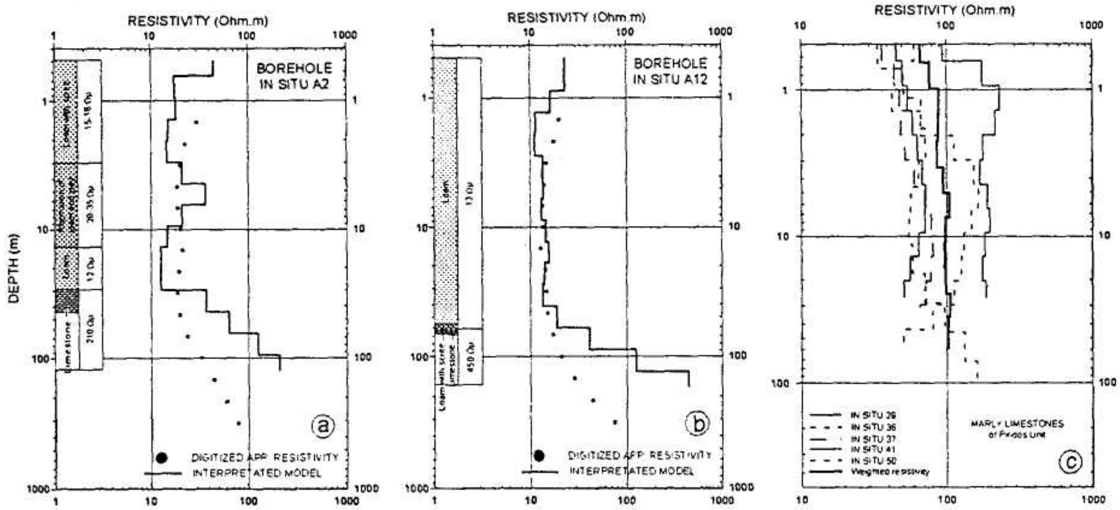

Figure 1

Over outcropping formations. In situ electrical measurements were conducted at sites of known geological formations that are exposed at the surface. According to the results obtained, an overall step-like diagram of earth resistivity distribution with depth, for outcrops of the same geological formation, was constructed. Furthermore, a weighted step-like resistivity function with depth, for each formation, was determined (see thick solid line in figure 1c) and finally a mean resistivity value was assigned, taking into account all the resistivity values of the step-like function with depth. For each formation, the standard deviation around the mean value was also calculated and resistivity values within 1σ were considered as the most representative ones. In Table I, the mean resistivity value and the corresponding one standard deviation value, for each geological formation, is presented. Deviations from the mean value were attributed to either near surface inhomogeneities due to weathering, or to lithological differentiation within the same formation.

Table I

	Unit	**Type**	**Average Resistivity**
Post–Alpine Formations		Sediments (Pleistocene)	21 ± 2
Alpine Formations	Pindos	Flysch	35 ± 1
		Marly Limestones	95 ± 10
		Limestone	460 ± 45
	Tripolis	Limestone	1850 ± 85

For example, the transitional layer of marly limestones of Pindos Unit (see fig. 1c), shows large deviations from the mean value due to the neighboring of low or high resistivity formations i.e.

flysch or limestone, respectively. In this case, the resistivity value less affected by the presence of flysch or limestone formation was considered as the most representative one.

GEOLOGICAL – GEOPHYSICAL PROFILES

Based on *in situ* electrical measurements, existing borehole data, surface geology and the results obtained from 1D deep geoelectrical soundings, combined geological-geophysical profiles were constructed for the area of Tripolis plateau (see figure 2). As it is shown along these profiles, a good 2D presentation of the subsurface structure was obtained not only laterally but also at depth. The lack of bedrock detection (limestone of Pindos Unit) at the central part of figure 1a, between VES 323 and 411, indicates possibly the presence of a polje. In figure 2b, the geological setting, as it is revealed by the geoelectrical investigation, it is clearly explained by the presence of a thrust fault (thick solid line) bringing the Pindos Unit (low to medium resistivity values) over the Tripolis Unit (very high resistivity values). In figure 1c, an overturned fold was detected at the western part of the profile.

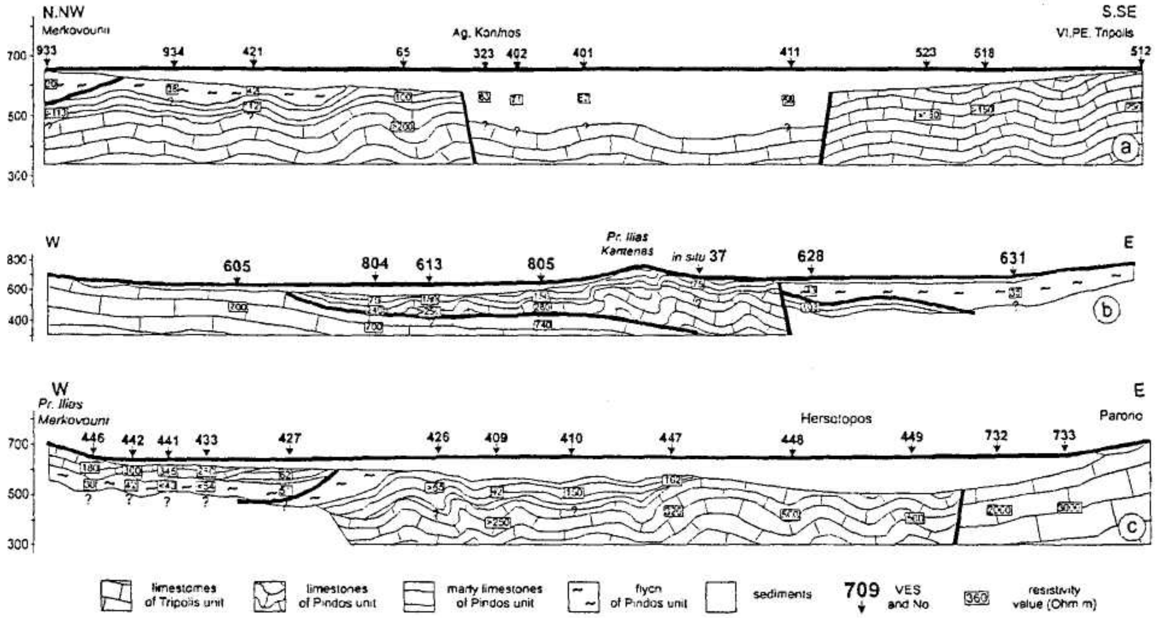

Figure 2

As it is pointed out above, the alpine basement of Tripolis plateau at central Peloponnesus, presents a rather complex geological setting and consequently the hydrogeological conditions are highly depended on the tectonic and morphological structure of the basement. Besides, the limestones of Tripolis Unit are older and highly karstified formations not allowing the development of a potential aquifer. In contrast, marly limestones and limestones of Pindos Unit are favorable in developing high productive aquifers, in the areas they overlie impermeable formations.

CONCLUSIONS

For hydrogeological purposes, the 1D approach of geoelectrical soundings, combined with *in situ* electrical measurements, borehole data, surface geology and hydrogeological observations, can produce reliable 2D presentation models of subsurface structures. Furthermore, the continuation of the geological mapping of the basement can be accomplished in areas covered by a thick overburden formation. In cases where significant resistivity contrast exists between the geological formations, as in this case at Tripolis plateau, reliable 2D models can be constructed for a first approximation. If shallow and more detailed investigations are needed (i.e. in karstic areas for polje structure, mechanism of fountain development, etc.), more sensitive and intelligent 2D procedures could be applied (dipole-dipole array).

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