**Buletini i Shkencave Gjeologjike, Nr. 1, 2005, pp…19-30**

# RESISTIVITY SURVEYS - EFFECTIVE METHOD FOR INTEGRATED GEOELECTRICAL EXPLORATION IN ALBANIA

Tribute to the brothers Conrad and Marcel Schlumberger

Alfred FRASHERI
Faculty of Geology and Mining
Polytechnic University of Tirana, Albania

## Përmbledhje

Ky artikull është referuar në Konferencën Ndërkombëtare të 65-të Bashkimit Europian të Gjeoshkencëtarëve dhe Inxhinjerëve (EAGE) në Paris, qershor 2004.

Pesëdhjetë e një vjet më parë, për mua, teknikun elektrik 18 vjeçar, që filloi punën si operator i karotazhit në indsustrinë e naftës dhe të gazit në Patos, mbiemëri i vëllezërve Shlimberzhe ishte i barazvlefshëm me gjeofizikën. Sot, pas gjysëm shekulli përvoje për kërkimet gjeoelektrike dhe përgatitjen e inxhinjerëve gjeofizikë, kam arrtitur në përfundim se metoda e rezistencës, e propozuar nga vëllezërit Konrad dhe Marsel Shlimberzhe në fillimin e shekullit të 20-të, ka demostruar efektivitet të lartë në fusha të ndryshme të kërkimit, dhe përsëri sot ndodhet në frontin e kërkimeve gjeoelektrike moderne. Analiza e kërkimeve gjeoelektrike në Shqipëri paraqiten në këtë artikull. Eshtë në nderin e gjeofizikëve shqiptarë që e kanë zbatuar dhe zhvilluar me sukses këtë metodë në kushtet e ndërtimit gjeologjik të Albanideve.

Në referat janë analizuar dhe paraqitur 32 raste nga rezultatet e përdorimit të metodës së rezistencës në Shqipëri gjatë 50 vjetëve të fundit; për arsye vendi në këtë artikull po analizohen vetëm gjashtë raste.

## Abstract

This paper is presented at 65$^{th}$ Conference and Exhibition of European Association of Geoscientists and Engineers (EAGE), Paris 2004.

Fifty-one years ago, for me, the 18 years old electric technician, starting the work as a well-logging operator at the Well-Logging Service of Albanian Oil and Gas Industry, the name of Schlumberger brothers use to be equivalent to that of geophysics. Today, after half a century experience in geoelectrical prospecting and in the education of the geophysical engineers, I believe that the resistivity method, proposed by brothers Conrad and Marcel Schlumberger, many tens of years ago, has demonstrated high effectiveness in various prospecting/exploration situations, and still stands in the front of the modern geoelectrical surveys. A summary presentation of the main geoelectrical survey results in Albania is shown in the paper. It has been an honour for the Albanian geophysicists to successfully apply and develop the resistivity method in the geological setting of Albanides.

In the Conference were presented and analyzed 32 case histories from these results of the last 50 years; in the published paper are presented only six cases due to limited publishing space.

## 1. History of resistivity method applications in Albania

First applications of the resistivity method in Albania have been reported in 1934, for shallow electrical soundings performed with Schlumberger array, by current electrode spacing 820m, in oil and bitumen exploration in Kuçova and Selenica areas, and resistivity well logging in shallow oil wells (1935), carried out by the Italian geophysicists of A.I.P.A. Company, project leader A. Belluigi, A. Baglio, and Eng. C. Sq., (A.I.P.A. 1934, Biçoku T. 1964, 2004).

The application of deep electrical resistivity soundings in oil and gas exploration have been started in 1950, by Baranov I.A., a Russian and Albanian geophysicists Teki Biçoku and Hasan Topçiu (Baranov I.A.). At the same period have been started the integrated electrical well logging of the oil weep wells (1951), by Russian operator David A. Bronshtein and Albanian operators Hamdi Bejtja, and Alfred Frashëri (1953) (Frasheri, 1964).

Geoelectrical surveys in search for solid minerals have started in 1953 with electrical resistivity profiling in cooper ore exploration in Derveni area (Maroçkina Z.P. 1953). From 1958 the resistivity surveys included many copper bearing zones in the Mirdita areas by the Russian V.M. Pogrebinskiy and the Albanian geophysicists Ligor Lubonja and Alfred Frashëri (Pogrebinskiy, 1959). During the sixties, the Albanian geophysicists Ligor Lubonja, Alfred Frashëri, Esat Daja, Radium Avxhiu, Mihallaq Malaveci, and later in seventies up to present, Përparim Alikaj, Spartak Kasapi, Llesh Prenga, Pirro Leka, Fatmir Duli, Idriz Jata, Sami Nenaj, etc. have successfully applied the electrical profilings and soundings in search for copper/gold sulphide deposits, placers for heavy, rare and precious minerals. The year 1961 represents the beginning of the first integrated geophysical exploration in placers of the rare and precious minerals (Ligor Lubona and Alfred Frashëri). From 1959 we have carried out shallow borehole resistivity logging in solid minerals exploration and development by the Russians (Murat Tokmulin) and the Albanian geophysicists (Neim Çavani from 1963, Sillo Muçko 1964, Violeta Murati from 1973).

The years sixties and seventies presented a period of successful and broad range applications of the resistivity methods. In 1975 re-started the geoelectrical survey with deep electrical soundings in oil and gas exploration (Frashëri A., Jani Lefter, Ciruna Kozma, 1982). In this period Ligor Lubonja, Alfred Frasheri, Mihallaq Malaveci and Thimi Nathanaili have investigated other solid minerals like bauxites with the IP/Resistivity Schlumberger soundings and gradient array. In early eighties the resistivity method was experimented and applied in chrome exploration as well by Fatmir Duli, Llesh Prenga, etc.

In 1961 was carried out the first electrical soundings by the Chinese and the Albanian (Zoto Rjepaj and Sillo Muçko) geophysicists in engineering geology studies with the Schlumberger array, for soil investigation in the industrial building construction area in Fier city and in the riverbed investigation at the dam of Vau Dejës hydropower station. First electrical profiling and soundings in the archaeological exploration have been carried out in the Margëlliçi Ancient Castle (Alfred Frashëri and Radium Avxhiu). At the present, Vladimir Kavaja is successfully continuing the geoelectrical exploration in many important archaeological sites in Albania, as in Apolonia, Butrint, etc.

The year 1975 has opened a new era in Albanian geoelectrical resistivity surveys, recording the performance of the first experimental marine electrical profiling in the Albanian Adriatic shelf for oil and gas exploration by Alfred Frashëri, Radium Avxhiu, Përparim Alikaj, Spartak Kasapi (Frasheri et al. 1977). Based on this experimental study the marine geoelectrical survey expedition was set up in Albania in the late seventies (Alfred Frashëri, Vasillaq Leci). In

1982 was carried out the first deep marine electrical sounding with a Schlumberger array up to AB/2= 8 km, at a sea depth of 50 m. The marine geoelectrical station has been designed, constructed and set up for a power of 250 kW by Alfred Frashëri, Reis Çani, Ymer Luga, Franc Malo and Burhan Çanga (Frasheri et al.1980).

The performance of a broad spectrum of resistivity surveys has been increasingly based on computer data processing and interpretation. In 1974 started the first computer programming and processing of the electrical survey data, which continued to grow in years by Alfred Frashëri, Gudar Beqiraj, Neki Frashëri, Ylli Vejsiu, Dhimitër Tole, Radium Avxhiu, Nehat Likaj, Ivoni Çani (Frasheri et al. 1974, 1976, 1979, 1984). In 1978, Përparim Alikaj proposed a new survey method called IP/Resistivity "Real Section" based on scale modeling and field experimental surveys using the multiple gradient and Schlumberger arrays and the concept of depth of investigation. Several deep mineralized structures were discovered in Albania with this method (Langore L., Alikaj P. and Gjovreku D.1989). The last 14 years P. Alikaj has further developed and successfully applied the method in base metals and gold exploration, mostly in Canada but in other parts of the world as well (Alikaj P. and Morrison D.F. 1997). The years eighties was been period fo the intensively studies and experiments for increasing of the depth of investigation, up to 800-1000m, using underground geoelectrical surveys in the boreholes (Lubonja et al. 1984, Frasheri et al. 1995).

The electrical soundings and resistivity borehole loggings have been used extensively in groundwater investigations in Albania by Pëllumb Haxhiaj, Nexhip Maskaj and Genc Kallfa. (Frasheri 1983).

Karst zones investigations using profilings and soundings with the Schlumberger arrays have been used since 1984 in irrigation reservoir areas by Alfred Frashëri, Ludvig Kapllani, Burhan Çanga (Frasheri 1982).

The last decade has been a period of intensive developments in engineering and environmental integrated geophysics, where the resistivity represents the main method. In 1997 was completed with our home made program the 2D Resistivity Tomography for a raw material dam and a landslide investigation by Alfred Frashëri, Ludvig Kapllani (Frasheri et al. 1997, 1999). At present, the resistivity method in Albania is vastly being used to solve various geological engineering and environmental tasks (Alfred Frashëri, Përparim Alikaj, Radium Avxhiu, Pirro Leka, Llesh Prenga, Burhan Çanga, Sami Nenaj, Vladimir Kavaja, Idriz Jata, Fatbardha Vinçani, etc.).

## 2. Direction of the resistivity method applications in Albania

Apparent resistivity method, for half a century, is an important element of the integrated geophysical surveys in Albania, with high accuracy and discrimination capabilities:

- **Borehole logging**: for oil and gas deep wells and shallow boreholes for coil exploration.

There are used gradient arrays B0.1A0.5M; B0.1A0.45M, B0.1A0.95M, B0.2A1.9M, B0.4A3.3M and B0.7A7.65M and potential arrays M0.25A2B, M4A40B, M8A40B, which from 1952 are represented the base arrays and important elements for electrical borehole logging in oil and gas industry. B0.2B1.9M and M0.25A2B represent standard normal arrays. Particularly, by all these arrays were realised lateral electrical soundings. Arrays B0.1A1.95M and M1.95A0.1B are used for coal boreholes logging.

- **Geoelectrical surveys**: In Albania, the electrical soundings and profiling by Schlumberger array AMNB, were successfully used for solving of following geological problems, as important method of the integrated geophysical surveys:

**1) Onshore Electrical Soundings**, for:

- Method in the integrated oil and gas exploration, for lithological identification of seismic reflectors from carbonate anticline tops, and for the sandstone packs of the Neogene's molasses structures mapping.
- Engineering investigations of construction areas, raw materials dams, slope stability and landslides, traces of the highways, railways, tunnels and main irrigation channels.
- Hydrogeological Exploration.
- Karst zones and cavities investigations.
- Environmental investigations: Underground waters aquifer and soil pollutions, soil and bedrocks degradation.
- Solid mineral exploration: copper minerals deposits, high, rare and precious placers, coal basin tectonics, bauxites etc.

**2) Marine electrical soundings** in the Albanian Adriatic Shelf were a part of integrated marine geological-geophysical for oil and gas exploration. Marine Electrical Soundings have a depth of investigation about 2500 m and depth of influence 3500 m, the current electrode spacing up to 16 km, the maximal distance from the coastline 10 km, averagely sea depth 10-20 m and maximal sea depth about 50 m.

Marine electrical soundings have the geological tasks:

-. Mapping of the Neogene molasses structures in the Albanian Adriatic Shelf.-. Exploration of shallow oil and gas bearing Neogene molasses in the Albanian Adriatic Shelf, having geoelectrical markers as top of Pliocene clay and Tortonian and Serravalian sandstone pack.

-. Mapping of eroded fold flanks covered by loose Quaternary marine deposits or seawaters.

-. Exploration of littoral heavy minerals placers.

-. Mapping of loose Quaternary deposits.

**3) Onshore electrical profiling** with Schlumberger multiple arrays $A_1A_2MNB_2B_1$ for geoelectrical mapping of the contacts between volcanic and sedimentary rocks in Lower-Middle Triassic volcanic sedimentary pack, last ones with Upper Triassic limestone, tectonic faults etc. Pole-dipole array for combined profiling AMNB, $C\to\infty$ was used for massive structure of copper minerals bodies exploration.

Resistivity tomography is used for the solving of engineering investigations, hydrogeological exploration, karst zones and cavities investigations, environmental investigations and archaeological research.

**4. Marine profiling,** for:

- Quaternary loose sediments and outcrops of the Neogene's molasses sea bottom mapping.
- Mapping of eroded fold flanks covered by loose Quaternary marine deposits or sea waters.
- Exploration of littoral heavy minerals placers.
- Mapping of loose Quaternary deposits.

Profiling was carried out by differential array MAN, $B\to\infty$, axial dipole array ABMN, and pole-dipole array AMN, $B\to\infty$, with a spacing 100-400 m.

## 3. Results and discussions

### 3.1. Solid minerals exploration

Resistivity profiling have been important method of the integrated geophysical surveys for exploration of the sulphide cooper mineral deposits, heavy, rare and precious placers, bauxites, etc. Surveys are performed by Schlumberger arrays: Symmetric multiple arrays $A_1A_2MNB_2B_1$ and pole-dipole combined arrays profiling AMN, $C\to\infty$ , MNB, $C\to\infty$.

### 3.1.1. Massive sulphide cooper deposits exploration:

The most typical and distinctive physical properties are induced polarization chargeability and resistivity, which are conditioned by mineral content, structure and degree of rock alteration. Massive sulphide ores have a minimal resistivity 0.1 Ohmm up to 30 Ohmm. Surrounding magmatic rocks has a average resistivity 200-1200 Ohmm. Schistose detritus overburden with clays and silica has a average resistivity about 20 Ohmm. This property serves as base for application of resistivity methods using by pole-dipole combined arrays profiling AMN, $C\to\infty$ , MNB, $C\to\infty$.

Between many tens of the case histories of geoelectrical exploration of the cooper deposits in Albania, following three objects in different time periods, depending from the depth of investigation.

In the fig 1 is presented a geological-geophysical section in the Gjegjani massive sulphide deposit at northeaster region of Albania. Based on geoelectrical and geological surveys, Pogrebinsky S.A etc. have designed the borehole that has discovered the cooper deposit (In 1959), which has been one of most important in Albania. Ore body is located in diabase individualization of Lower-Middle Triassic volcanic-sedimentary pack. Over the ore body is observed complex geophysical anomalies. Resistivity anomaly is important element of this anomalous complex. Resistivity anomaly represents a crossing of the resistivity graphics surveyed by both arrays AMN, $C\to\infty$, MNB, $C\to\infty$.

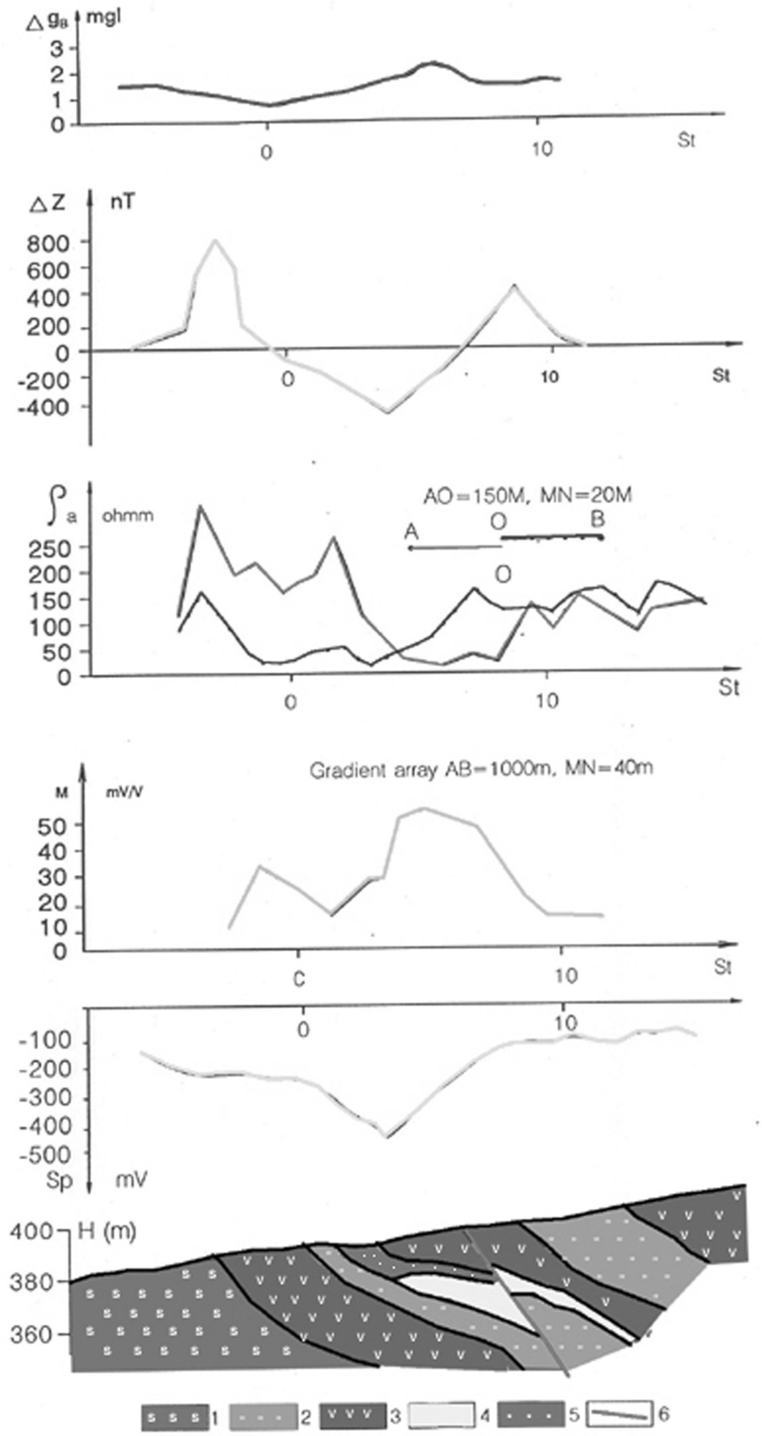


Fig. 1. Geological-geophysical section in the Gjegjani massive sulphide deposit (Compiled by Frasheri A after Pogrebinkiy S.A., Mihayllovskiy J.A. and Boronayev V.A. data).

1- Ultrabasic rock; 2- Argillaceous schists; 3- Diabase; 4- Massive ore body; 5- Disseminated mineral zone; 6- Tectonic faults.

After rapid development in the early 1970s, the IP method in the complex with resistivity and self-potential method became the major surveying method for cooper sulphide exploration, in particular for massive ore bodies (Fig. 2).

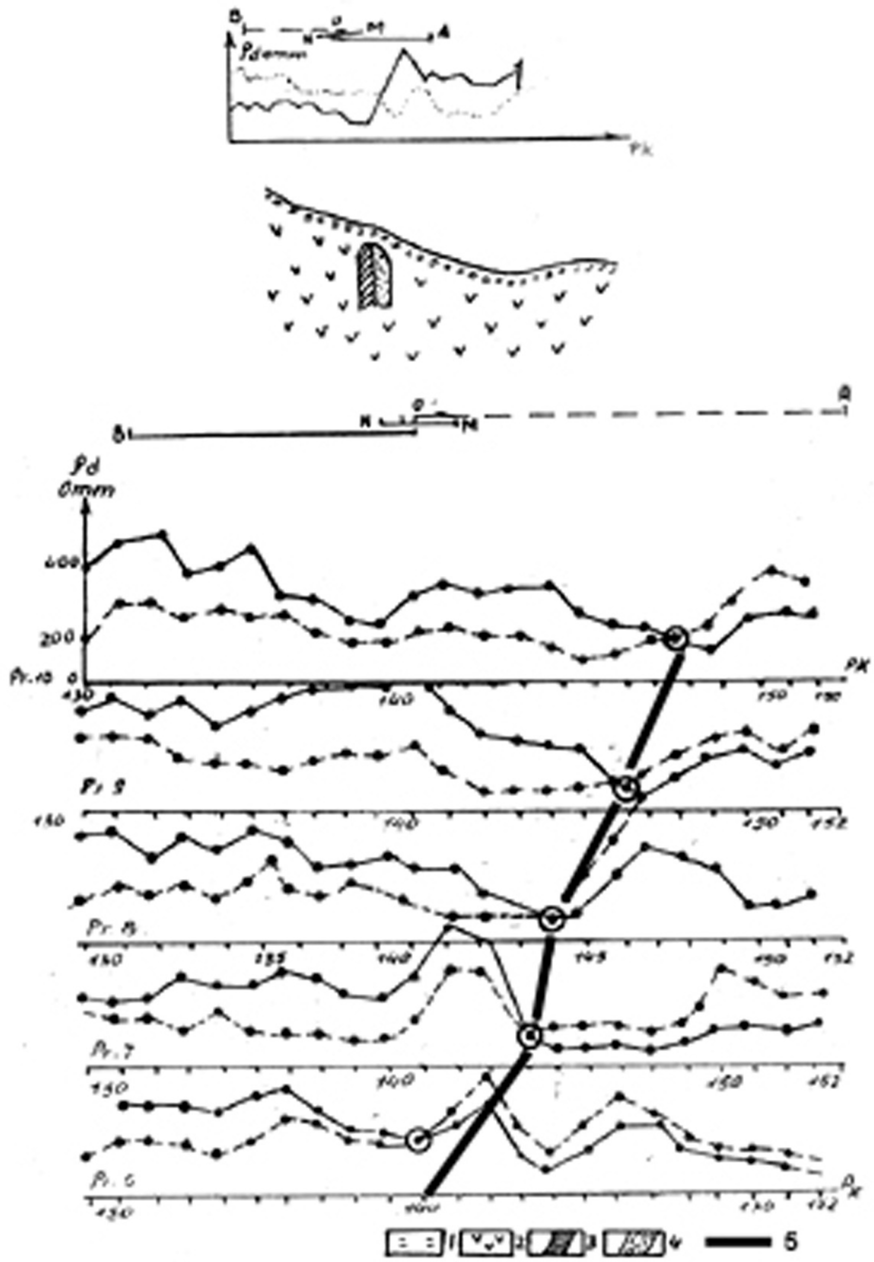

Fig. 2. Apparent Resistivity map and geoelectrical section in the Kaçinari massive sulphide deposit (After Daja E. and Avxhiu R.).

1- Overburden; 2- Diabase; 3- Massive ore body; 4- Disseminated ore sulphides; 5- Electrical conductivity axe.

In this period the depth of investigation increased to 200 m. Based on interpretation results of integrated geophysical-geochemical and geological data, Avxhiu R. etc. have discovered massive sulphide cooper deposit at Qafa Barit area (Fig. 3) (Avxhiu 1979).

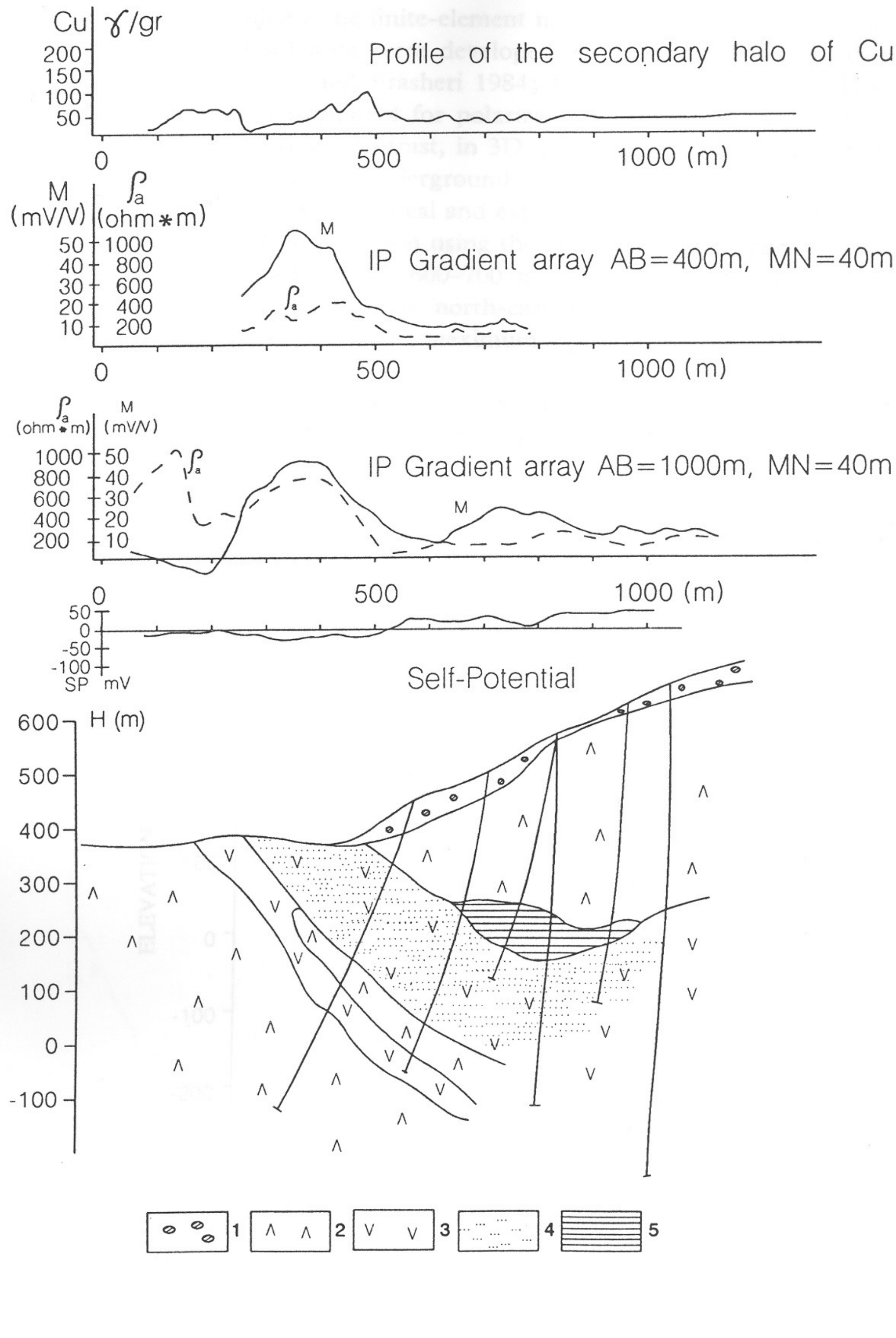


Fig. 3. Geological-geophysical section in the Qafa Barit massive sulphide deposit (Compiled after Avxhiu R. and Frasheri A data).

1- Overburden; 2- Keratophyre rock; 3- Spilites; 4- Disseminated sulphides;
5- Massive sulphide ore body.

Prospecting by the vertical geoelectrical sections, using “Real Section” as experimental method from 1978 year has been developed a new exploration strategy by Alikaj P (Alikaj P. and Morrison D. 1997, Alikaj P. 1998, Langiora Ll. and Alikaj P. 1989). Geoelectrical mapping by standard technology present a research in one of depth investigation over all surveys area. “Real section” method has creates the possibilities to realize a vertical exploration, from Earth surface up to the depth in surveys line, according to the used current electrode spacing.

**3.1.2. Heavy, rare marine placers and river gold placers exploration.**

Shallow Schlumberger vertical soundings and profiling have been used for solving of the different geological task: For littoral marine placers, search, mapping and shape determination of the sand dunes has been exploration objects. Mapping of the gravel riverbeds and morphology of riverbed base has been objects during the river gold placers prospecting. Geoelectrical markers in the littoral areas are top and base of sand dunes, among the Quaternary clay.

## 3.2. Marine resistivity surveys

Marine electrical soundings and profiling have been a part of integrated marine geological-geophysical for oil and gas exploration, along Albanian Adriatic Shelf, from Vlora Bay at the south to Shengjini Bay at the north (Frasheri A. 1987, Leci V. 19>>>>>.). Surveys lines have been extended within a distance of 10 km from the coastline, where the sea depth reaches about 50 m. Averagely sea depth was 10-20 m. in this marine space. Maximal current electrode spacing for the sounding arrays has been up to 16km, and for the profiling 100-400m.

The Durresi structure exploration represents a successfully example of integrtaed marine geological-seismic, resistivity soundings and profiling application. Based on this exploration have been drilled a deep well Du-16 which has been discovered a gas deposit; under the Adriatic Sea water structure (Fig. 4,5).

Durrës – Kepi Pallës area is characterized by a presence of Neogene’s molasses formation: Tortonian clay-sandstone, Messinian clay, sandstone interbeds and lens, and gypsum debris and blocks stage and Pliocene clay deposits. Up to present, by deep wells, is known that 2975-3125 m is thickness of Neogene molasses. Marine Quaternary loose deposits have covered bedrocks of the neogene molasses. These deposits are extended in the shallow offshore in Durresi-Kepi Palles area, and are presented by loose sand in the coastal line and clay mud far from coastline. Marine deposit thickness in the offshore are is 10 m near of the coastline in the Kepi Palles sector, which increased up to 20-50 m at the west.

Durrës-Kepi Pallës anticline is asymmetric and structure top is extended about 1600 m at the west of the coastal line, under the Adriatic Sea waters (Fig. 4,5). After Pliocene field extension, about 40 km is length of the structure, and 2 km width. The anticline amplitude is varies of 2000 up to 2500 m. Eastern flank is tectonically abrupt. Part of eastern limb of the structure has a dipping 45-55$^{o}$ in the western location from tectonic line. At the depth, the dipping gradually is increased to 75-80$^{o}$ up to overturned. At the surface, the tectonic line is outcropped at Kepi Pallës on shore. The tectonic line is located under Adriatic Sea waters toward the Porto Romano sector.

Tortonian sandstone packs of the eastern anticline flank, covered by marine Quaternary loose deposits, are mapped by electrical profiling (Fig. 5).

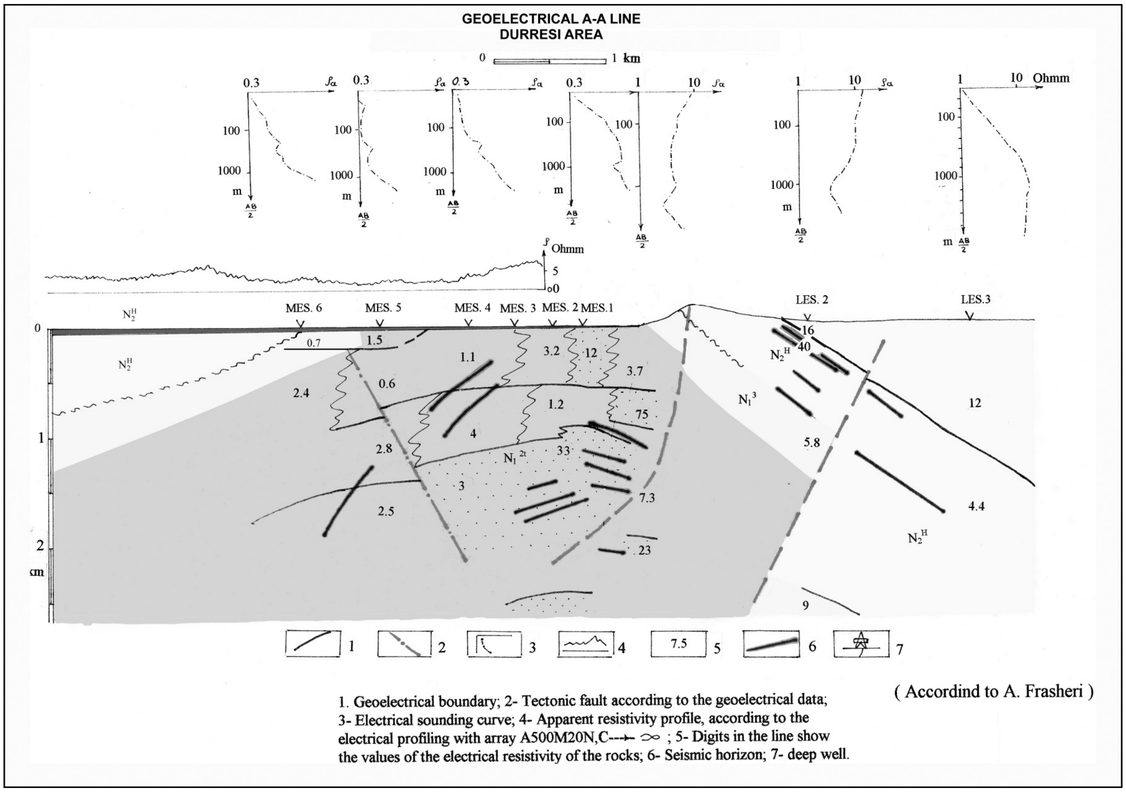


Fig. 4. Geological-geophysical profile, Durresi gas bearing structure.

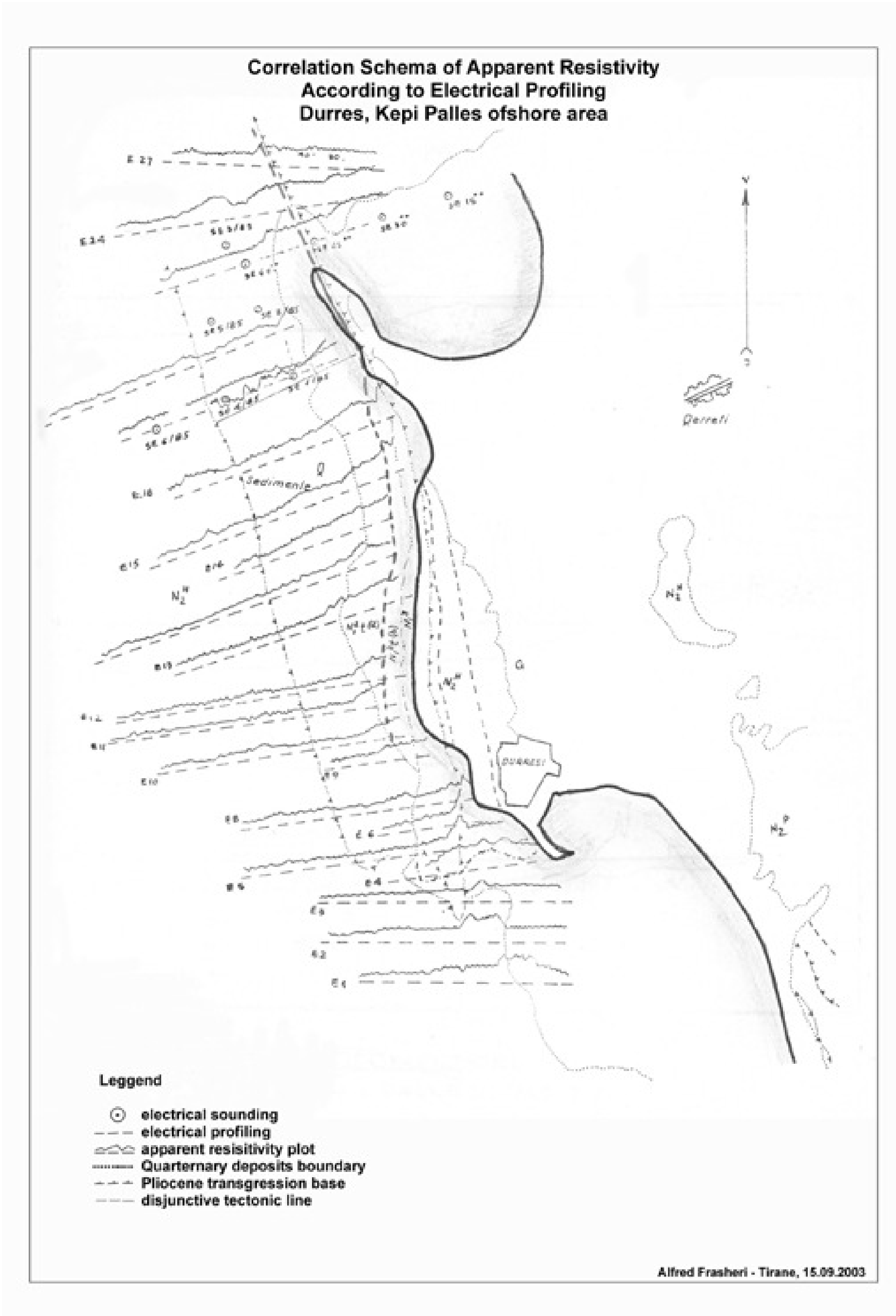


Fig. 5. Geoelectrical marine mapping of offshore eastern flank of Durresi anticline.

### 3.3. On shore oil and as exploration

On shore Schlumberger electrical soundings have been used for lithological identification of seismic reflectors from carbonate anticline top covered by terrigenoeus formations (flysch and molasses), for the sandstone packs estimation of the Neogene's molasses structures mapping, and salt diapir contact mapping in some reagions (Frasheri et al. 1982). Maximal current electrode spacing has been 16 km, consequently electrical soundings have a depth of investigation about 2000m and depth of the influence more than 4500m.

### 3.4. Geoelectrical mapping

Geoelectrical mapping of the contacts between different kind of the rocks, and of the tectonic faults, has been realized using multiple Schlumberger $A_1A_2A_3MNB_3B_2B_1$, with maximal electrode spacing $A_1B_1$=300m. Most effective has been mapping of the tectonic contact between Upper Triassic limestone and Lower-Middle Triassic Volcanic-Sedimentary pack, which is covered by diluvium.

### 3.5. Engineering investigations

**3.5.1. Construction areas** of industrial buildings and works, public and private buildings Traces of the highways, railways, tunnels and main irrigation channels (Frasheri et al. 1995).

**3.5.2. Raw materials dams**Geoelectric tomography was used to investigate the clay core of the dam's raw materials. The resistivity part of geoelectric tomography use multiple gradient arrays with the maximal current electrode spacing 300m, which provided a survey depth of 50-70m (Frasheri et al. 1995, 1992). The geoelectric tomography results in this paper are from Vau Dejes hydroelectric plant. Its Qyrsaqi dam has a concrete section and a gravel fill with central clay core section. The dam has a crest length of 480m and maximum height of 79m. Geoelectric tomography was performed only in the raw-material section.

The soil dam in Qyrsaqi is studied at the top of clay core and at its slope. Fig.6 shows a electrical resistivity tomography along the dam axe. It is noticed at the centre, that the clay material has a lower resistivity than the two dam's edges. The water filtering into the core explains this phenomenon.

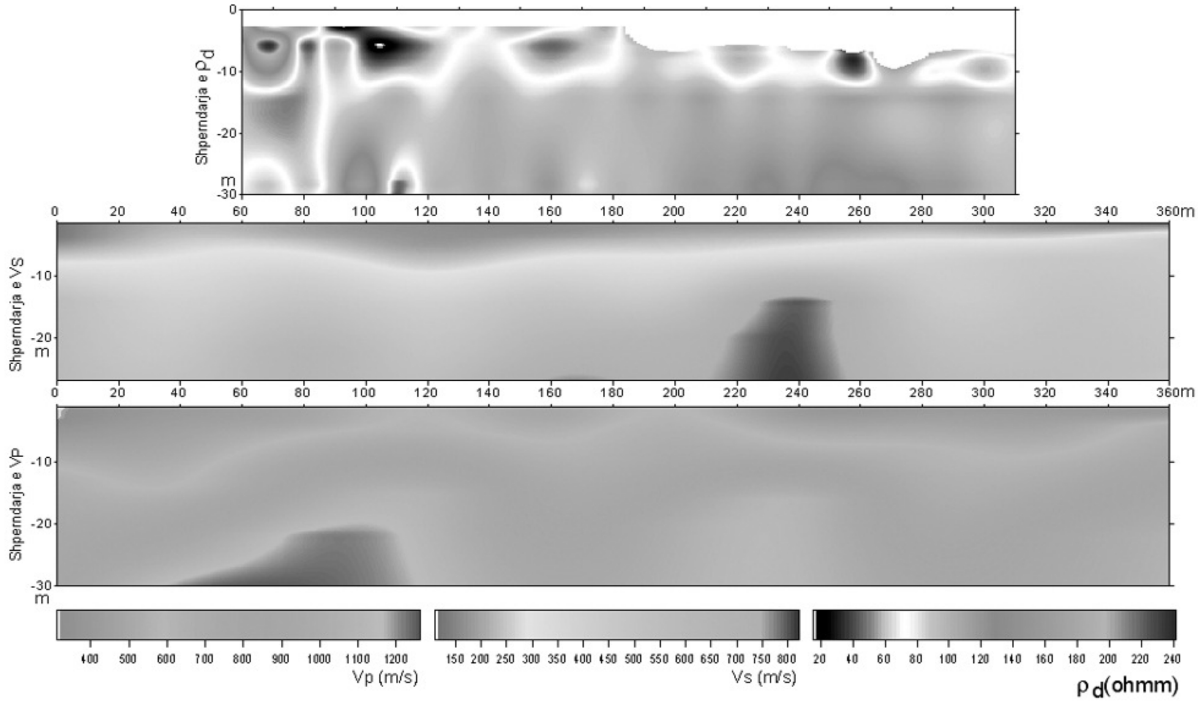


Fig. 6. Electrical Resistivity and seismic 2D Tomography, Qyrsaqi Hydropower Plant, Raw Material Dam

### 3.5.3. Slope stability and Landslide Investigation

Albania represents a mountainous country with complicated geology. There are unstable mountain and hill's slopes. Developing of new landslides or re-activation of the old ones is mainly due to construction works.

Landslides are located in the deluvial deposits, and in the altered-bedrock. The slipping bodies of some landslides have very big volume, more 50 million cubic meters.

Slope stabilization and landslides investigations have been realized successfully by integrated geophysical methods, which electrical soundings present an important method (Frasheri et al. 1985, 1997).**Porava landslide** is located in the lakeshore of the Fierza hydropower plant lake. Two geoelectrical markers are determined configuration of the sliding structure in the rocks of the volcanic sedimentary section.

Slope stabilization and landslides investigations have been realized successfully by integrated geophysical methods, which electrical soundings present an important method (Fig. 7).

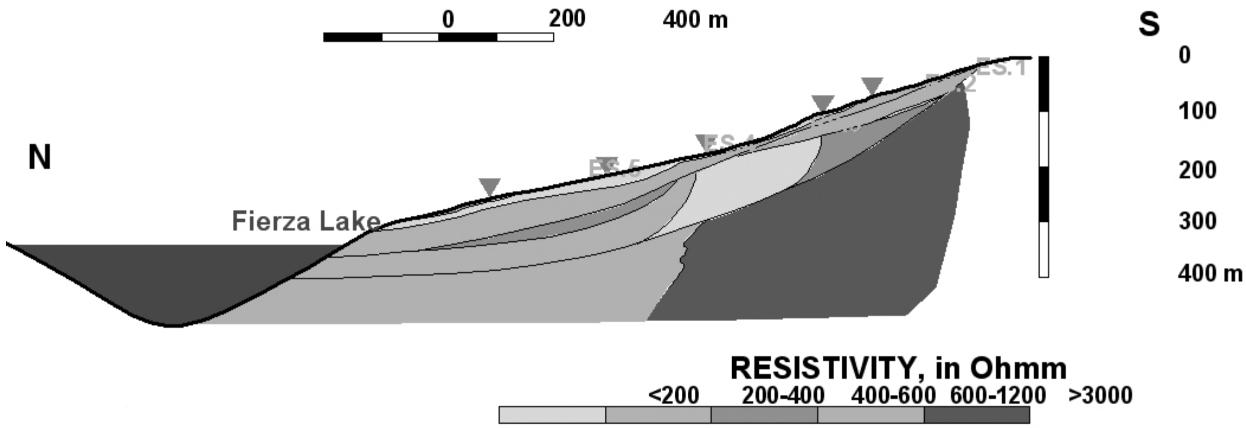


Fig. 7. Geoelectrical section  and views of Porava landslide.

Section shows presence of two categories of geoelectrical markers in the profile, which are determined full configuration of the sliding structure in the rocks of the volcanic sedimentary section. The primary category belongs to the lower contact, at 140-160 m depth and the upper at 20 m depth, which separated rocks with different electrical properties. The lower boundary is the major boundary, which separated the slipping body from the main sedimentary-volcanic rocks. It is the geoelectrical marker that clearly envisages the bottom of the slipping body. As a result of the slipping phenomenon, these rocks have low up to medium electrical resistivity value (200-100 Ohmm). While the rock located under the whole massive slipping body have higher electrical resistivity values (in the farthest sector of the profile in the lake side 3000-3800 Ohmm and 1200-1400 Ohmm in the sector located near the artificial lake of Fierza hydropower plant). The upper boundary separated the slipping body into two big layers. The most upper part of this slipping body represented by the diluvium- eluvium deposits, is very active today and has very low resistivity values (120-500 Ohmm). This part is in continuous intensive movement, causing big damages for the houses of Porava village. The second category of boundaries is linked to the changes at heterogeneity in falling of slipping body, which is separated into blocks.

Considering the so far results of integrated geophysical-geotechnical investigations for Porava landslide, we realize that the Porava slipping body will not happen the immediate fall and at the same speed as the whole mass, because it is separated into blocks and cab fall in parts. The answer to this question is certain only after the slipping dynamic is studied and monitoring, when the question for slipping body's progress during strong earthquakes.

### 3.5.4. Investigation of the ground degradation Kruja Castle Area

The Castle of Kruja is the symbol of Albanian culture and history. In 1995 the Castle was "shaken up" under the Museum Gjergj Kastrioti Skenderbeg which was considered a safe. This downfall occurred after a period of heavy rainfall, characterized by heavy showers and a rapid decrease of temperature. The overnight failing down of the large detached masses of about hundreds of cubic meters was unexpected. The ground has started to deteriorate and at the sides in some places is developing a process of collapse .

By means of the geotechnical-geophysical investigation, it will be possible to provide a complete structural knowledge of the massifs either rock or half rock or soils. At the same time the characteristics and properties of the formation together with their dynamics can be provided through integrated in-situ tests: engineering geotechnical, geological and geophysical surveys: Refraction seismic of high frequency surveys, electrical soundings, recording of natural seismic micronoises, in situ parametric geophysical measurements on natural denudations and laboratory investigations of the rock samples. These data are necessary for determining technical solution for the emergency and future situation. The electrical soundings were carried out according to the Schlumberger array, with spacing $AB/2_{max}$ = 100 m.

### 3.6. Karstic zones and cave investigation

The karstified zones can be distinguished from the compact limestone by using the resistivity soundings carried out with Schlumberger array and by electrical profiling with multiple Schlumberger array $A_1A_2A_3MNB_3B_2B_1$ (Frasheri et al. 1982). In the karstified zones, the geoelectrical section is KH type. Depending on the thickness of layers, A type geoelectrical section is also possible. Karstified surface forms, which are filled with residues of the altered material has a resistivity of first layer is smaller than that of the second layer, represented by karstified limestones with empty lattices. The third geoelectrical layer shows the resistivity is lower that of the second layer. This is because the less dense karst lattice is filled with water or clay. The fourth geoelectrical layer is represented by compact limestone, and consequently its resistivity is higher than that of all overlying layers. Geophysical surveys have been realized by using detailed mapping scales 1:500 and even 1:200 with survey grid (1-2)x(2-5) meters.

## Conclusions

Fifty years of a period of intensive resistivity method application in Albania, for solving of wide spectre of geological tasks, have demonstrated: 1) Resistivity method successfully has stood the time test, for more of a half a century. Resistivity method represents an important method in the applied geophysical exploration.

2) Applied with a numerous arrays, resistivity method successfully has solved many geological tasks for oil and gas exploration, mining hydrogeological prospecting, and engineering and environmental geophysics.

## Acknowledgments

The gratitude goes to the plead of the scientist that have paved the long and right way for the resistivity method: brothers Schlumberger (France), H. Lundberg (Sweden), O. Gish (USA), S. Stefanescu (Rumania), Wenner (Germany), A.I. Zabarovsky, V.N. Dahnov and A.P. Krayev (Russia) etc. and so many geophysicist engineers, which have developed the resistivity method.

I appreciate so much the contribution of my Albanian colleagues, geophysicists Docent Ligor Lubonja, Prof. Dr. Radium Avxhiu, Prof. Dr. Përparim Alikaj, mathematics Prof. Dr Neki Frasheri and Prof. Dr. Gudar Beqiraj, and Russian engineers V.M. Pigrov and S.A. Pogrebinskiy, for developing the resistivity surveys in Albania.

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