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NEW METHOD OF INVERSION VERTICAL ELECTRICAL LOGGING (IVEL) FOR IDENTIFICATION OF COAL SEAM PROSPECT OF MUARA ENIM REGENCY, SOUTH SUMATERA

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ABSTRACT

The Measurement Inversion Vertical Electrical Logging (IVEL) in the Regency of Muara Enim Indonesia aims at measuring and mapping the resistivity associated with the spread of lithologi coal seam as Coal Bed Methane reservoirs (CBM). Resistivity measurements of new method performed with the sounding system as much as 5 points, with spaces between the point of 100-200 m, range of penetration achieved with these measurements to a depth of 500 m from the ground surface. The results of the processing and interpretation of data from the IVEL indicate that on site research was generally dominated by layers of rock and clay shale with a resistivity less than 2 Ohm.m as well as sandstones 2-5 Ohm.m. while the coal layer was found at the depth of 60 to 80 meters,100 to 180 meters, and 340 to 350 meters above the resistivity value of 5 Ohm.m.

Keywords: CBM, IVEL method, Reservoir, Coal seam, Resistivity values, Sounding system, Processing and interpretation.

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Contribution/ Originality

New method in data acquisition to extract structural and lithological information. A IVEL survey for coal seam exploration should be designed by using Schlumberger electrode configuration.

1. INTRODUCTION

In South Sumatra Basin tectonics lies active tectonic areas, where its coal layers have experienced at least one period of folds, fault and final experience of extrusion and intrusion of magma activity. This magma activity led to local progress, demonstrated by an increase in rank of

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coal from lignite to anthracite in some areas. Thus be obtained rank as well as the characteristics of the coal that varies both vertically or horizontally [1].

IVEL or Inversion Vertical Electrical Logging is a method of resistivity done to get the data type of each prisoners a certain depth (generally the hose 5-10 meters), by performing a measurement on the surface using Schlumberger methods. Resistivity logs at some point obtained by describing the price on each type of prisoners after a depth measurement data inversion become a subsurface information using the concept of Anisotropy.

The basic working of this method is that each type of soil, every kinds of rocks, and water saturation different would result in a difference value of resistivity. In general it can be said that each of the rock or mineral has a value of a certain type of custody (specific resistivity). On the rocks in nature, besides rock resistivity is determined by the composition of major minerals, grains, it is influenced by the content of water, salts and more. The value of the resistivity will decrease the value of the actual type of custody, if such rocks contain high salt containing water.

2. MEASUREMENT METHOD AND THEORY

This method is done in the field by delivering an electric current that flows into the ground through two metal electrodes with two shaft pots serving to measure the potential difference caused in certain places. This method is implemented by using a direct current or alternating current, low-frequency (I), which flowed into the Earth, through two electrodes (electrode-flow). The resulting potential difference (V) is measured by two electrodes, namely measuring electrode potential.

Configuration of electrodes used in the drilling program at IVEL in this area uses the rules of sounding Schlumberger. The equation can be formulated its inmates as follows:

$$\rho_{(s)}a = K_s \frac{V}{I}$$

Where is *:*

$\rho_s a$	=	Pseudo resistivity(ohm-m)
K	=	Schlumberger geometry factor
V	=	Potential difference (mV)
I	=	Injection current (mA)

Geometric factor (Ks) is the arrangement of electrode factor to Schlumberger. By doing a number of measurements range AB/2 and MN are used to calculate the ρa, then ρ is plotted against each AB/2 or a curve is obtained, it will be the field. Observation data obtained are corrected and plotted on a semilog scale paper 62.5 mm/cycle. The price of the pseudo ρm, ρt and ρl are done by utilizing the concept of Anisotropy of Maillet [2] whereas micro resistivity anisotropy Imaging performed for pseudo ρm, ρt and ρl. To get the data up to a depth of 800 metres at Schlumberger rules requires 4000 meters along the cable (Figure 1):

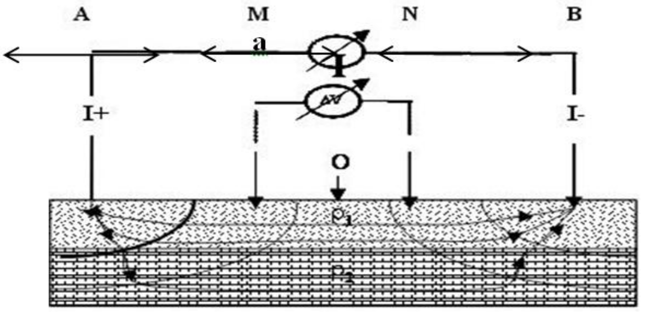

Figure-1. Schlumberger Configuration
(**Source:** Modified by the Researchers)

2.1. Inversion of Resistivity Log In

The core of Dar Zarrouk parameter is the notion of a Penal Unit Electric Transversal (T, Transverse Resistance Units) and the Longitudinal Conductivity (S, Longitudinal units of Conductance). The price of the measured resistivity of a medium is remotely from total media properties including : Prisoners of the electric field perpendicular to the direction of the lining and the custody of electricity to the direction perpendicular to the plane of the layers and the prisoner's electricity with the direction parallel to the direction of convicts the layers.
The prisoner happens to convict on transversal serie relationship :

$$T = \rho_1 h_1 + \rho_2 h_2 + \rho_3 h_3 .... \rho_n h_n = \sum_{1}^{n} \rho_i h_i \quad (1)$$

While the electrical conductivity (S) for longitudinal prisoners is:

$$S = h_1 / \rho_1 + h_2 / \rho_2 + h_3 / \rho_3 .... h_n / \rho_n = \sum_{ind}^{n} \frac{hi}{\rho i} \quad (2)$$

Then the transversal type prisoners can be derived :

$$\rho_t = \frac{T}{H} = \frac{\sum_{i-1}^{i=n} \rho_i h_i}{\sum h_i} \quad (3)$$

As for the components of an electric current flowing parallel to the plane of the layers (horizontally), the resistivity is calculated as substitute on the electrical parallel summation as prisoner conductance (S) or the sum of the electric conductivity.
Then the total electrical conductivity as a parallel summation is formulated:

$$S = \sum s_i = \sum_{i=l}^{i=n} \frac{h_i}{\rho l_i} \quad (4)$$

The value of the conductivity substitute (substitution) to the whole unit from 1 to n, or the longitudinal conductivity is:

$$\rho_\ell = \frac{S}{H} \quad (5)$$

Thus the longitudinal resistivity can be derived as follows:

$$\frac{1}{\rho\ell} = \frac{H}{S} = \frac{\sum_{i=1}^{i=n} h_i}{\sum \frac{h_i}{\rho i}} \qquad \rho l = \frac{\sum hi}{\sum \frac{hi}{\rho l_i}} \tag{6}$$

While ρm is a function of these two parameters to it.

By calculating each depth so log resistivity material (ρm) is obtained.

2.2. Regional Geology Research

2.2.1. South Sumatra Basin

In general the South Sumatra Basin is one of the back arc basins of tertiary age, lying in the southern part of the Mainland from the island of Sumatra in the direction of Northwest - Southeast Basin on the Asian Continent namely plate on the Southeast edge of Sundaland, limited by the Barisan mountains in the Southwest. Barisan mountains are a volcanic/ magmatic arc which is also a horizontal fault regional zone.

To the North- Northwest of the South Sumatra Basin shaped this symmetry is bounded by Mountains and the mountains of the twelve Thirty, in the South and East is bounded by the mountains of Garba, the altitude specifications Lampung and an altitude specifications that are parallel to the East coast of Sumatra. On the West is bounded by fault-fault and outcrops of rock outcrops-pre-tertiary uplifted along the slopes of the mountains in the Northeast while the Sequence is limited by the sedimentary formations of the land of Sunda.

Structural basis of South Sumatra basin can be divided into Sub-basin, basin of Jambi and Palembang. Both basins are separated by fault-major fault related to the bedrock. The main fault ruptured along the Lematang among others direction, Northwest-Southeast and fault Kikim with a North-South direction (Figure 2.).

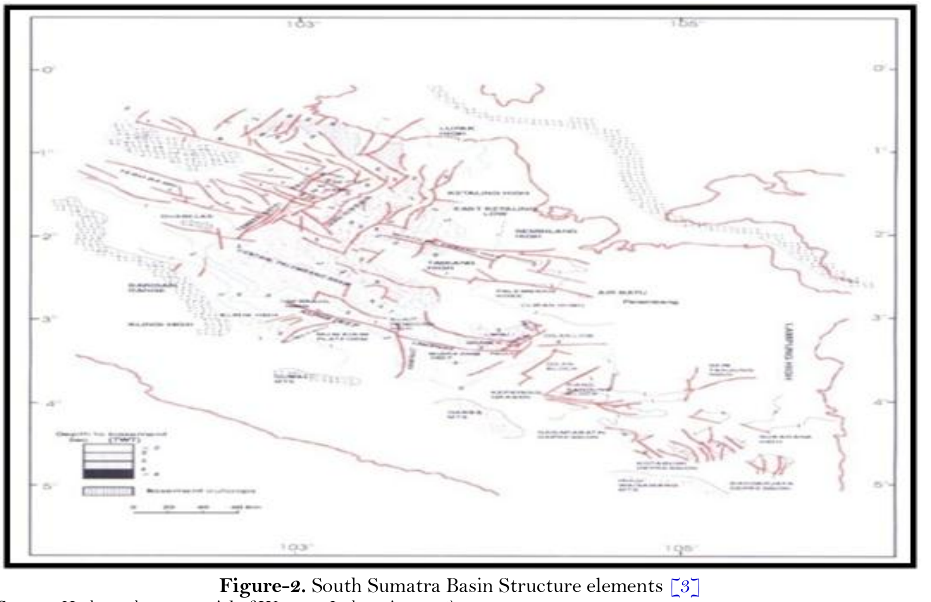

Figure-2. South Sumatra Basin Structure elements [3]
(**Source:** Hydrocarbon potential of Western Indonesia, 1985)

In South Sumatra and Jambi basins there are several forms of the structure of Tertiary tectonic activity resulting from Sumatra island which consists of a period of tectonic [4].

2.2.2. The Geological Structure of the Direction of Northeast-Southwest

According to Ryacudu [5] structural geology towards northeast-southwest (TL-BD) very clearly observed in the Sub-basin structure Formation of Jambi, northeast-southwest direction in this area is associated with the formation of the directional system of graben East of TL-BD region Jambi. Besides, the general direction of the geological structure of the above also thrives in the sub-tropical regions of South Sumatra basin, such as the Sloping Cape Graben. Graben system towards northeast-southwest is also observed in the basin area of the bow front of Bengkulu, namely Manna Graben. The structure of the folds developing on this pattern is caused by reactivation of normal fault (graben) tectonic compression during the Plio-Plistosen in association with the horizontal fault (wrench fault). However, the intensity of the crease formed in this direction is not so strong.

2.2.3. Structure of the Geology of the Northwest-Southeast Direction

The directional pattern of fault systems in Lematan is about U 3000 T. General direction of this structure is known as a part of the system, a very dominant Lematang Fault is found in the area of Sub-basin Palembang. Analysis of SAR in the area of the South Sumatra Basin exposes some geological fault systems that align with Sesar Lematang i.e. Sesar Musi, Javanese poetry, Saka and the South coast of Lampung [6]. The manifestations of the current pattern of Lematang structure in the form of folds are associated with the rising caesarean formed by Plio-Pleistocene compression style.

2.2.4. Geological Structure of the North-South Direction

As well as Central and Northern Sumatra Basin, in the South Sumatra Basin is found the presence of seemingly growing North-South geological fault system (U-S). The major fault systems in the U-S direction in this area are: Benakat Gulley-Kikim Fault , Palembang, and the East Coast. As with the pattern of Jambi, Sunda Pattern that was originally

3. RESEARCH METHODS

3.1. Location of Research

This research was conducted at the Tanjung Enim Mine Area of South Sumatera PTBA.

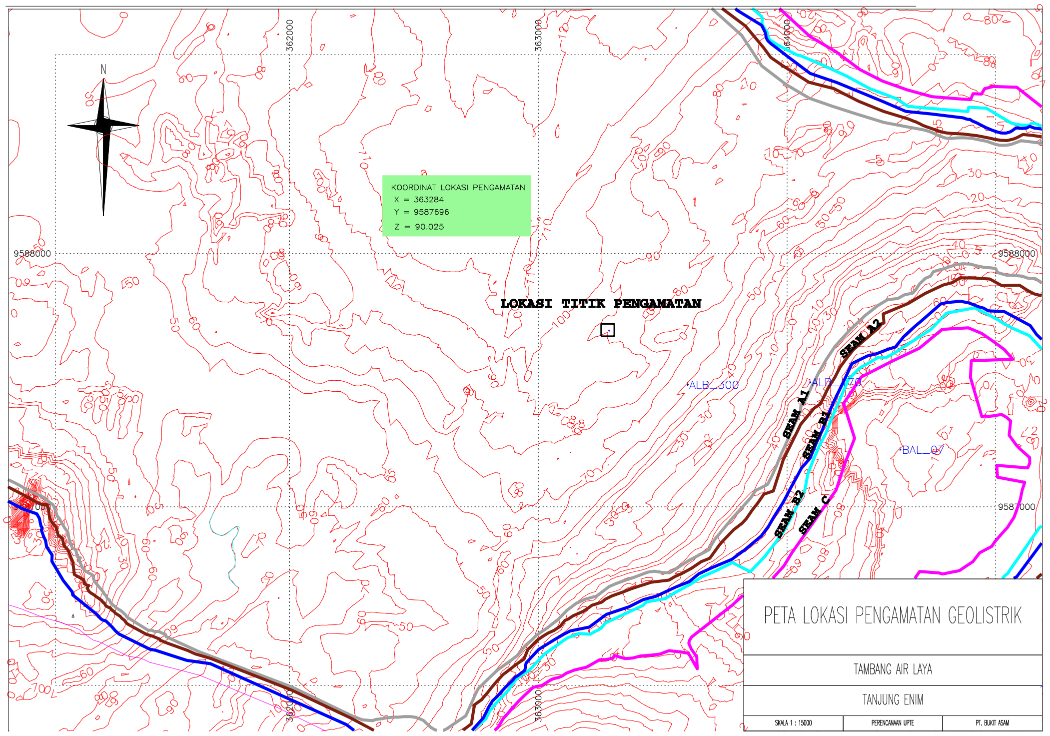

Figure-3. Location of Research (cube)

(**Source:** Modified by the Researchers)

3.2. Tools and Materials

The equipment used in this research is:

- Resistivity Meters.
- Accu 12 volts.
- Fruit of the electrode currents and 4 pieces of the electrode potential.
- Roll the power cable current 2400 meters and 4 potential cable roll 800 meters.
- A Multitester.
- The Handy Talky.

3.3. Research Methodology

This research comprises several stages, as for the activities, the detailed stages are as follows:

- Determination of the location of the observations using GPS.
- Observation site (sketch of geology, the position of the point of the observer, etc.).
- Survey & geolistrik; calculation of track length 2000 m at a distance of 10 m with the target electrode depth cross-section of resistivity 0 – 800 meters
- Data retrieval Inversion Vertical Electrical Logging on a site plan
- Geoelectric data processing by using inverse technique

4. RESULTS AND DISCUSSION

The results of the acquisition of Schlumberger Configuration using resistivity inversion are then right towards the depth by using the method of "Anisotropy Inversion". Anisotropy Inversion method is done based on the concept of the Anisotropy of Raymond Maillet, 1947, the results will get depth inversion "Pseudo Transversal Resistivity (ρ t)", "Pseudo Media Resistivity (ρ)", and "Pseudo Longitudinal Resistivity (ρ l)".

The interpretation against the cross-section Imaging (imaging) is done based on the cross section of iso-ρt, iso-ρm and iso-ρl to get lithology interpretation (1), (2) coal indication and the indication of the structure (4).

Interpretation of the geology and lithology on the whole is done with the binding of resistivity imaging data with existing wells, so it is a combination of interpretations, which sometimes can provide additional information or new information.

4.1. Track 1

Interpretation of the results of lithology based resistivity properties of rocks in the study area, From the depths of 0-120 m showes a low value to a high resistivity, which is 2-100 ohm m, Generally dominated rock layers alternating between clay and shale and coal seam thickness varies.

Coal seam is found at a depth of 10 -20 meters, 30-35 meters, 80 -90 meters and 190 to 200 meters.

4.2. Track 2

Interpretation of the results of lithology based on resistivity properties of rocks in the study area. From the depths of 0-10 m shows a high resistivity values, which is 2-100 ohm m, generally dominated rock layers alternating between clay and shale and coal seam thickness varies.

Coal seam is found at a depth of 60 -70 meters, 100-115 meters, 140 -145 meters.

4.3. Track 3

Interpretation of the results of lithology based on resistivity properties of rocks in the study area, from the depths of 0-10 m shows a high resistivity value, which is 2-100 ohm m, generally dominated rock layers alternating between clay and shale and coal seam thickness varies.

Coal seam is found at a depth of 20 -35 meters, 40-60 meters, 180 -185 meters. 240 -255 meters and 330 – 325 meters.

4.4. Track 4

Interpretation of the results of lithology based on resistivity properties of rocks in the study area, from the depths of 0-20 m shows a high resistivity value, which is 5-100 ohm m, generally dominated rock layers alternating between clay and shale and coal seam thickness varies.

Coal seam is found at a depth of 20 -30 meters, 100-110 meters, 330 -340 meters.

4.5. Track 5

Interpretation of the results of lithology based on resistivity properties of rocks in the study area, from the depths of 0-10 m shows a high resistivity value, which is 2-100 ohm m, generally dominated rock layers alternating between clay and shale and coal seam thickness varies.

Coal seam is found at a depth of 20 -30 meters, 60-70 meters, 160 -165 meters.and 240 -260 meters

5. CONCLUSION

The imaging results in the study area show a common characteristic resistivity as follows:

- Shale / clay has a resistivity of less than 2 Ohm.m
- Sandstone has a resistivity of 2-5 Ohm.m
- Coal has a resistivity above 5 Ohm.m

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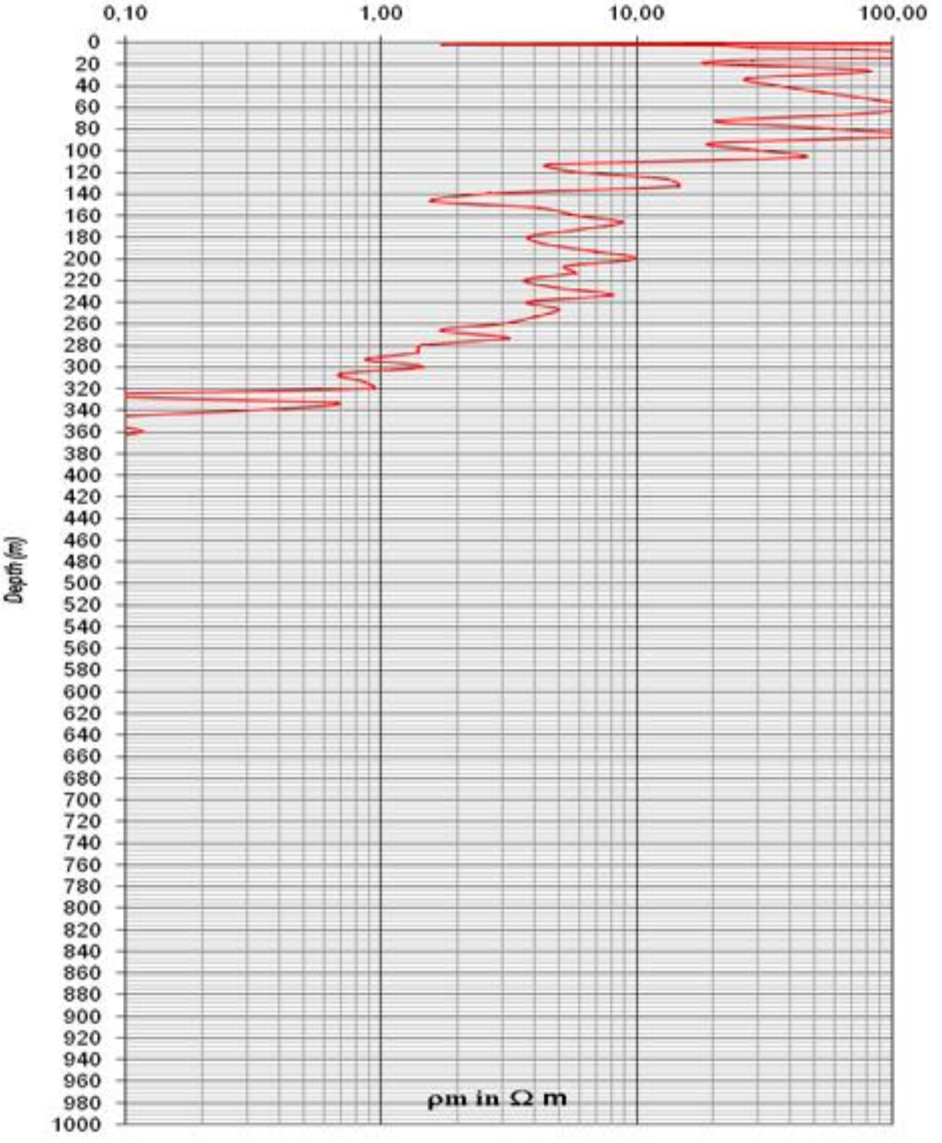
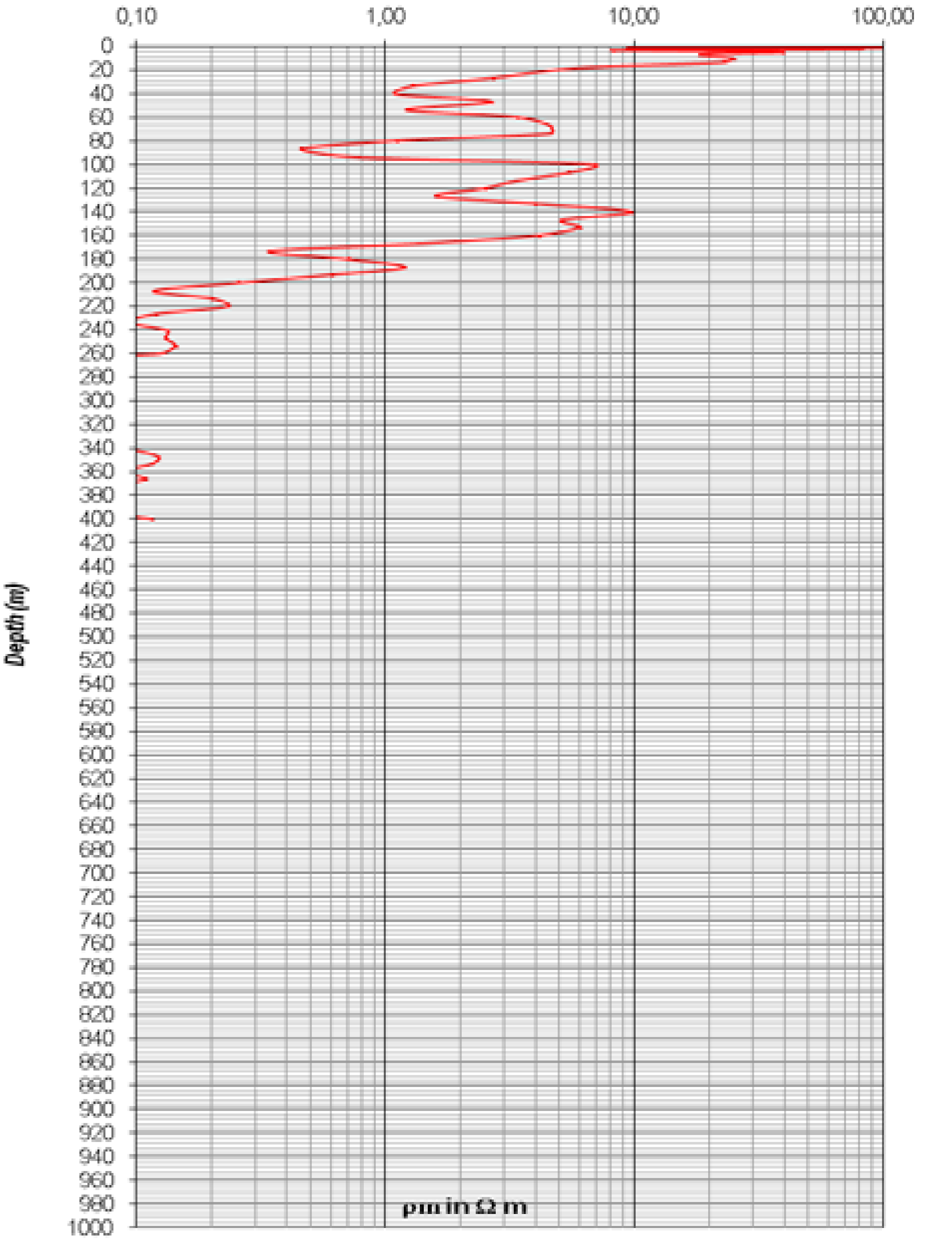


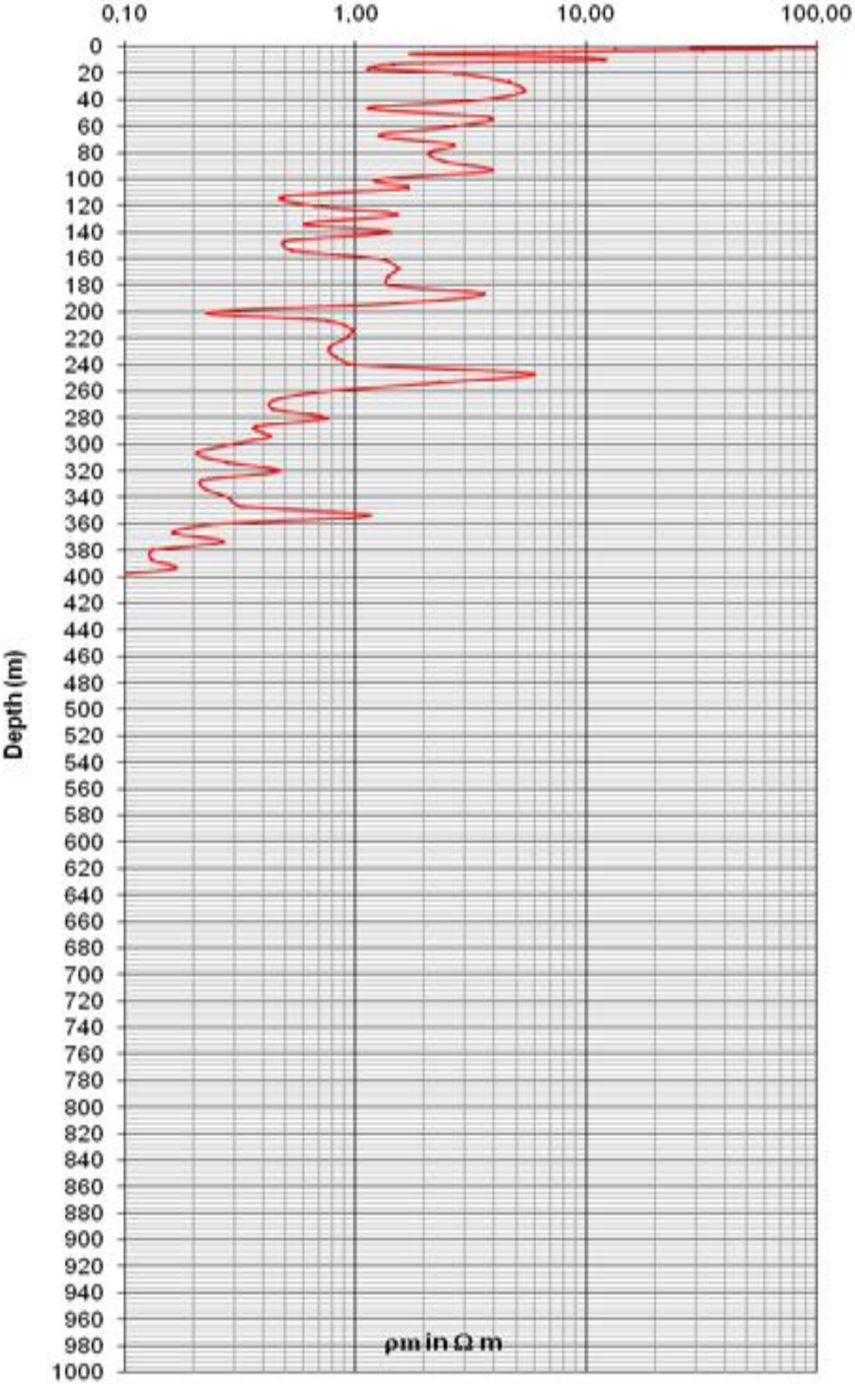
Track-1. LOG IVEL (Inversion Vertical Electrical Logging)

(**Source:** Data Processing by the Researchers)



Track-2. LOG IVEL (Inversion Vertical Electrical Logging)

(Source: Data Processing by the Researchers)



Track-3. LOG IVEL (Inversion Vertical Electrical Logging)

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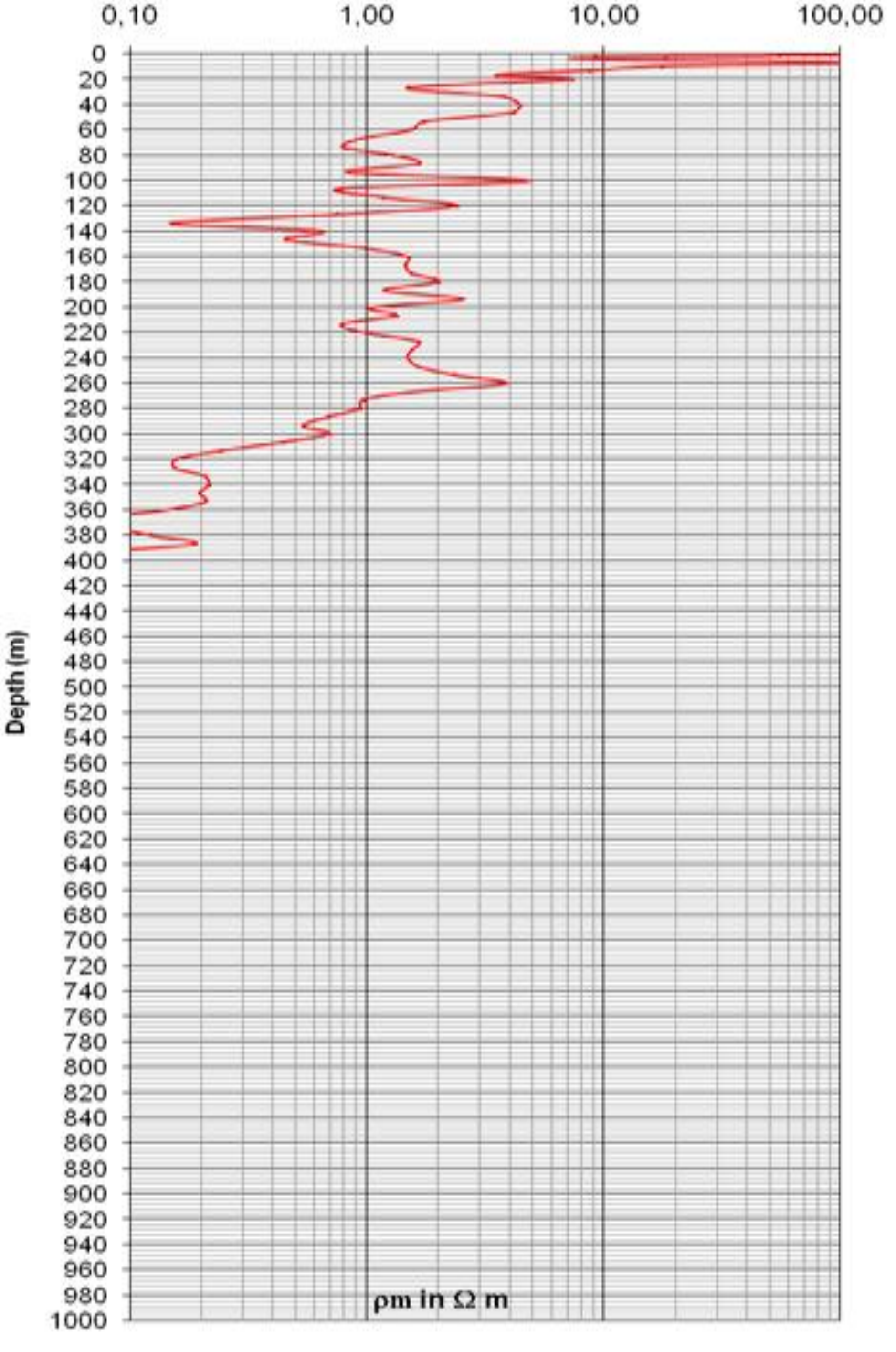
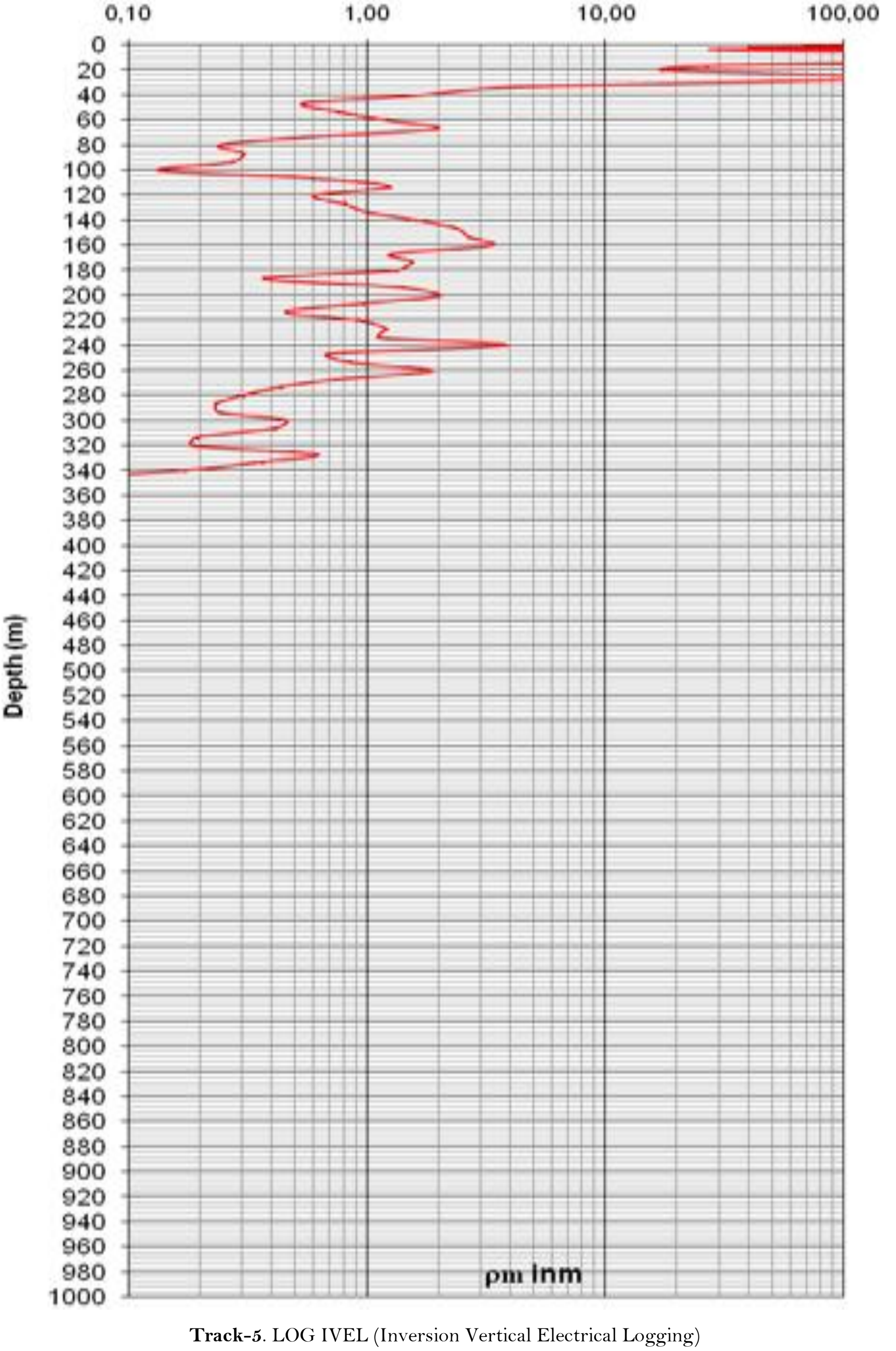


Track-4. LOG IVEL (Inversion Vertical Electrical Logging)

(**Source:** Data Processing by the Researchers)



Track-5. LOG IVEL (Inversion Vertical Electrical Logging)

(**Source:** Data Processing by the Researchers)