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New equation of Geophysical Prospecting of Oil and Gas Field

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Abstract:
Background*: The Moesica Platform and the Moldovan Platform in Romania are geological structures that still have oil and gas deposits that have not been explored and exploited.*
In recent times, geophysical and geological research has multiplied in order to discover the reserves of condensable gas needed to ensure Europe's energy independence.
But geological faults and fractures of deposits make geophysical research complex and absolutely necessary to determine the quality of productive layers and especially the possibility of exploitation.
That is why in this paper we analyze several drillings made in various local geological structures in the northeast of the Moesic Platform.
Materials and Methods: *The geophysical profiles of geological research boreholes have been studied in accordance with the properties of productive rocks.*
The cores extracted from the productive rocks were analyzed and their porosity, thermal conductivity, permeability and density were determined.
Also, 5 geological research wells and 7 productive layers were analyzed.
The data collected were processed in order to make correlations between the electrical profiles and the properties of the cores harvested from the well.
Results: *The analyzed data allowed us to analyze the oil and gas deposits and can be done by interpreting the data of electrical resistivity and permeability.*
By performing mathematical regression equations can be determined depending on the thickness of the productive layer, both electrical resistivity and permeability.
We notice that the relations are of order 2,3,4 and the electrical resistivity and the permeability are correlated very well.
Conclusion: *The article examines simulation models for electrical resistivity and permeability in order to interpret the potential regime of oil and gas production layers.*
Analyzing the analysis data of the cores taken from the wells depending on the permeability determined by electric coring, we find a perfect correlation (over 95%) between the two permeabilities.
We also managed to write simulation equations between:
- Productive wall thickness and permeability,
- Productive wall thickness and electrical resistivity,
- Electrical resistivity and permeability.

Key Word*: Geophysical analysis; Oil and gas fields;Permeability; Porosity .*

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I. Introduction

The Moesica platform is an important oil area, being bordered to the north by the conventional Drobeta Turnu Severin-Bibești-Drăgășani-Brazi-Tinosu line, which materializes a large crusty fault, and to the south it extends to Bulgaria (to the Balkan mountains).

To the east it extends under the waters of the Black Sea, and to the west it is bordered by the structural units of the Alps-Dinaric Mountains.

The crystalline foundation consists of crystalline rocks with metamorphic character, crystalline shales to the west and green shales to the east, over which they are deposited, with frequent and important stratigraphic gaps.

Sedimentary deposits began in the Cambrian and ended with the Quaternary.

Lithofacial cycles with a predominantly lagoon character were highlighted in these deposits.

Bordered by mountain ranges, the platform had to cope with tectonic movements, being both elastic (sedimentary layers) and plastic (crystalline foundation).

So there were parting crustal fractures that compartmentalize and delimit the crystalline foundation.

Also found were the presence of intrusive bodies of magma of granite-gabrou, with different shapes and volumes and different depths.

Such intrusions were detected in the Corabia-Turnu Măgurele area, they being corresponding to the Paleogene-Middle Miocene [1]

From the point of view of the formation of oil deposits, I mention as possible generators (mother rocks):

- Silurian and Presilurian clay-shale series,
- Devonian dolomite-evaporitic formation,
- Carbonated series of the Middle Triassic,
- Cretaceous marl-limestone complex,
- Pelitic horizons from Tortonian, Sarmatian, Meotian.

Collector rocks (accumulators) are very diverse in physical properties from sands, clays and sandstones to cracked limestones and often vacuolar - and in age from Devonian to Carboniferous to Pliocene.

We must also mention the character of the tectonic block, closed by slicing planes of the most frequent geological traps.

The oil fields in the area of the Moesic Platform are characterized by:

a. The presence of non-native micro-vegetal elements that demonstrate its transport through different geological rocks. For example, crude oil from the productive structures Brâncoveanu-Titu-Serdaru-Petrești-Corbii Mari is confined to geological structures from the Lower Cretaceous. But the analysis of the deposit waters indicates the presence of numerous palynological specimens identified in the Middle Jurassic (bedrock), located at the same level as the analyzed deposit. The result is a horizontal transfer of crude oil (through porous rocks and high field energy).

b. The existence of crude oil deposits at different distances from intrusive magmatic bodies, which also influenced the quality of crude oil. It should be mentioned that in Sâmnic (where an intrusive magma-batholith body was identified, from Craiova-Balş), crude oil is of the paraffin type (reduced naphthenic carbon) and with a gas solution ratio r_0 = 165 Nm^3 / m^3, p_{sat} (saturation pressure) = 236 atm and reservoir temperature of 98ºC.

Also the crude oil from the Videle area, where the magmatic body was stuck at great depths, the crude oil is of the naphthen-aromatic type with a gas solution ratio r_0 = 19-23 Nm^3 / m^3, the saturation pressure of p_{sat} = 76-80 atm and the reservoir temperature of 54-66ºC.

According to the research of Vassoievici and Teichmuler [2.3.4], the main stage of formation of liquid hydrocarbons is 60-135ºC.

As the temperature increases, respectively the proximity to the body of intrusive hot magma, the formed crude oil evolves into a lighter crude oil, containing white fractions in larger quantities, until finally turning into natural gas (as in the Transylvanian Basin).

In conclusion, it can be said that the deep magmatic intrusions signaled by the indicated magnetic maxima, acted by the intense magnetic flux they generated both on the organic matter in the generating rock (mother), completing the process of hydrocarbon formation and continuing the migration. to the collector rocks.

So the location of the hydrocarbon deposit depends on the nature and efficiency of the geological trap.

Analyzing the geothermal curves, it can be said that the overlap of the intrusive magnets with the existence of oil deposits also indicates the presence of high temperature gradients.

The Moldovan platform represents the extension on the Romanian territory of the vast Finno-Sarmatian platform that occupies the entire Eastern Europe.

The platform is limited to the west by the Eastern Carpathians and to the south and south-west by a conventional Bacău-Bârlad line that separates it from the Precarpathian Depression (Moldova) and the Predobrogean Depression (Scythian).

From a litho-statistical point of view, the platform's deposits start with the Mayor, continue with the Secondary and the Tertiary, ending with the Quaternary.

Structurally tectonic, this geological unit is an inclined platform that descends in steps to the southwest, disappearing under the two depressions that take its place, the Precarpathian Depression (Moldova) and the Predobrogean Depression (Scythian).

As a geological evolution, the Moldavian Platform functioned as a land for very long periods, the stratigraphic segments deposited on the general background of descent to the southwest.

The Predobrogean Depression functioned as a deep basin, based on crystalline rocks, strongly metamorphosed, covered with quasi-horizontal segments deposited starting with the Triassic, continuing with the Tertiary and ending with the Quaternary.

The body of magma that attracts attention is the one in the center of the Bârlad Depression, with an elongated shape of north-northwest to south-southeast orientation, where the most exploited oil fields are located (Independența-Suraia area).

II. Material And Methods

The analyzed oil and gas areas are part of the geological structures:

- The Moesic Platform,
- North Dobrogea Promoter.

The Moesic Platform (Figure 1) is between the Precarpathian Depression in the north, the Pre-Balkan Depression in the south, and the North-Dobrogean Orogen in the northeast [6,7,8].

The Moesica platform consists of two sectors, one located in the east and consisting of statistical gaps (higher) and one in the west made up of successions of sediments (the delimitation is made by the Târgu Fierbinți-Belciugatele fault).

Conditions for the formation of hydrocarbon deposits:

- The bedrock is located in the Ordovician, Silurian and Lower Devonian, consisting of black or gray argillites, in the Upper Devonian, bituminous dolomites with pyrites, in the Middle Triassic (muschel-kalk), anise dolomite intercalations, and dolomites and Ladinian clays).
- The rocks of Posidonia in Jurassic and the intercalations of clays, clayey limestones and dolomitic limestones of Cretaceous and the intercalations of pellets in Tortonian, Sarmatian, Meotian, Pontian and Dacian can also be considered mother rocks.
- Protective rocks are the intercalations of impermeable pelitic rocks, represented by argillites, clays and marls.
- Anhydrite intercalations (Upper Devonian, Permian, Middle Triassic) are also considered protective rocks.
- The deposits are of the vaulted stratiform type (Pontian), tectonic shielded stratiform (Sarmatian), lithologically shielded stratiform (Sarmatian, Pontian), lithologically delimited (Pontian, Meotian), massive (Devonian).
- A peculiarity of these deposits is the presence of overlaps in the case of the same exploitation (Devonian and Triassic-Bibești structure and the Triassic dogger from Oporelu).
- The North-Dobrogean promontory is an extension of North Dobrogea between the lower courses of the Siret and the Prut.
- Its sinking area is located between Țepu and Adjud.
- It is found the presence of the lens at 700 m above which is located the pilocene and local and Sarmatian.

Reservoir rocks are Cambrian, Silurian, Devonian and Carboniferous sandstones, as well as Mesozoic sandstones and limestone.

The protective rocks are the impermeable intercalations in the litho-stratigraphic column of the platform.

The deposits are tectonically shielded and lithologically delimited stratiform.

The analyzed boreholes have the following properties in Table 1.

Table 1. Data on analyzed boreholes and properties of harvested cores (oil-free cores)

Well driling	Geological layers	Rocks type	Thermal conductivity	Density, g/cmc	Porosity, %	Permeability, mD
Suraia	Sarmațian	Compact tiles	1,5299	2,73	1,1	0,01
Smirna strat productiv 1	Carbonifer	Floor tiles	2,0923	2,77	1,6	0,018
Smirna strat productiv 2	Devonian superior	Compact clay	1,7226	2,69	1,3	0,017
Ianca Berlescu strat productiv 1	Sarmațian	Compact limestone	1,9686	2,3	0,1	0,397
Ianca Berlescu strat productiv 2	Devonian	Cracked limestone / dolomite	1,6704	2,8	1	0,03
Cireșu	Sarmațian	Cracked marl	0,289	2,78	21,4	0,01
Zăvoia	Malm	Limestone tiles	1,5127	2,7	6	0,8

All the drillings benefited from deep geophysical research, being determined the electrical resistivity and the permeability of the productive layers.

In order to observe the differences between electrical resistivity, permeability and rock quality, we determined by mathematical regression relations that show the dependence of electrical resistivity and permeability depending on the width of the productive layer.

All equations have a degree of error 0 %, namely $R^2=1$.

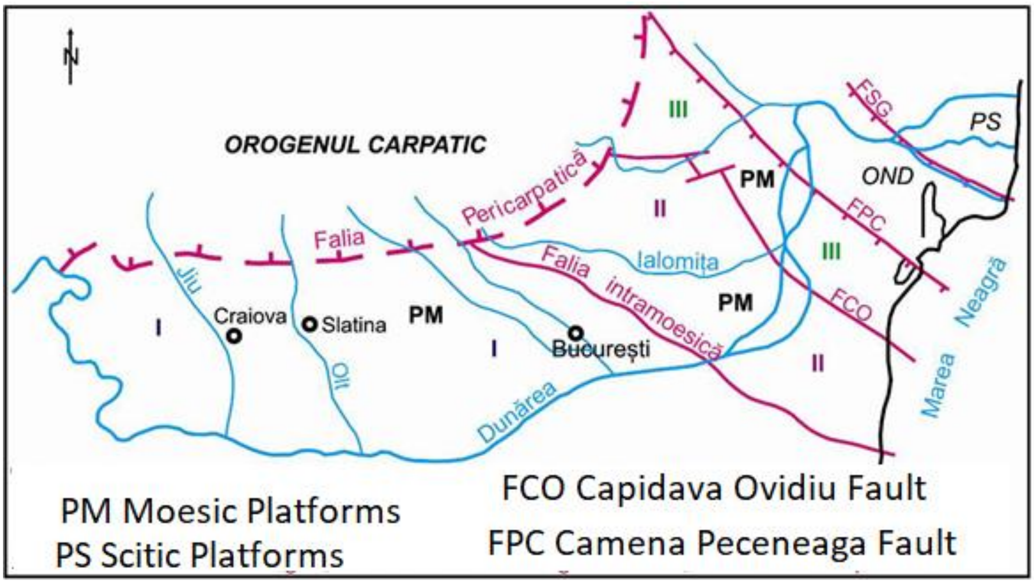

Fig.1. Moesian Platforms [4]

III. Result

The mathematical regression equations of electrical resistivity and permeability, depending on the thickness of the productive layer are given in Table 2.

Table 2. Mathematical regression equations of electrical resistivity and permeability, depending on the thickness of the productive layer

Well driling	Geological layer thickness	Rocks type	Equation Electrical resistivity Ω m (y) as a function of productive layer width (x)	Equation Permeability mD (y) as a function of productive layer width (x)
Suraia	400	Compact tiles	$y = 2E-08x^4 - 0,0004x^3 + 2,3861x^2 - 6468,7x + 7E+06$	$y = 1E-09x^4 - 2E-05x^3 + 0,1414x^2 - 381,4x + 385723$
Smirna	200	Floor tiles	$y = -0,0057x^2 + 32,851x - 46661$	$y = 5E-06x^2 - 0,0305x + 43,492$
Smirna	330	Compact clay	$y = 3E-05x^3 - 0,3373x^2 + 1300,9x - 2E+06$	$y = -3E-07x^3 + 0,0035x^2 - 13,472x + 17330$
Ianca Berlescu	300	Compact limestone	$y = 2E-06x^3 - 0,0146x^2 + 33,374x - 25420$	$y = 2E-08x^3 - 0,0001x^2 + 0,3462x - 266,63$
Ianca Berlescu	200	Cracked limestone / dolomite	$y = 1E-06x^3 - 0,0106x^2 + 30,526x - 29246$	$y = -1E-09x^3 + 1E-05x^2 - 0,0344x + 31,87$
Cireșu A	200	Cracked marl	$y = 8E-06x^2 - 0,0294x + 26,915$	$y = -8E-05x^2 + 0,5415x - 659,83$
Zavoia	300	Limestone tiles	$y = 1E-05x^3 - 0,1032x^2 + 289,84x - 271276$	$y = -2E-09x^3 + 1E-05x^2 - 0,0397x + 37,659$

The equations are of order 2 (sandstone, cracked marl), order 3 (calcareous sandstone, cracked limestone / dolomite, compacted limestone, clay) and order 4 (compact sandstone).
The correlation between the two types of equations is observed, their ordinal being identical.
So it is found that there is a correlation between Electrical resistivity Ω m and permeability (mD).

That is why we were able to determine the correlation relations between Electrical resistivity Ω m and permeability (mD), being given in table 3.

Table 3. Correlation relations between Electrical resistivity Ω m and permeability (mD)

Well driling	Geological layer thickness	Rocks type	Mathematical relationship between Electrical resistivity Ω (x) m and permeability mD (y)
Suraia	400	Compact tiles	$y = -2E-09x^3 + 1E-05x^2 - 0,0397x + 37,659$
Smirna	200	Floor tiles	$y = -1E-05x^2 + 0,004x - 0,3363$

Smirna	330	Compact clay	$y = 2E-05x^3 - 0,0132x^2 + 2,5945x - 165,46$
Ianca Berlescu	300	Compact limestone	$y = -0,0042x^3 + 0,1699x^2 - 2,2328x + 9,615$
Ianca Berlescu	200	Cracked limestone / dolomite	$y = -0,0012x^3 + 0,071x^2 - 1,3243x + 7,6334$
Cireşu A	200	Cracked marl	$y = 9559,9x^2 - 2752,5x + 227,03$
Zavoia	300	Limestone tiles	$y = -8E-08x^4 + 2E-05x^3 - 0,0017x^2 + 0,0476x - 0,4126$

The graphical representation of the permeability variation (mD) (y) as a function of Electrical resistivity Ωm (x) indicated the following:

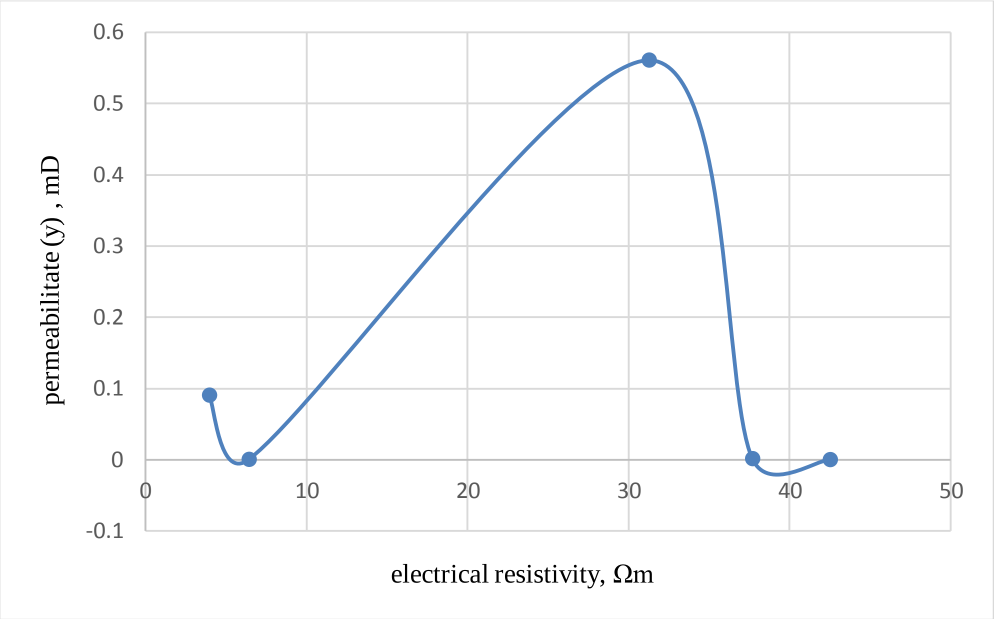

Fig. 2. Permeability variation (mD) (y) depending on Electrical resistivity Ωm (x) -Suraia drilling

The productive layer from the Suraia borehole is located in compact sandstone, which shows the existence of a gas layer in the 33 Ωm area and a field water deposit in the 5 and 45 Ωm areas.

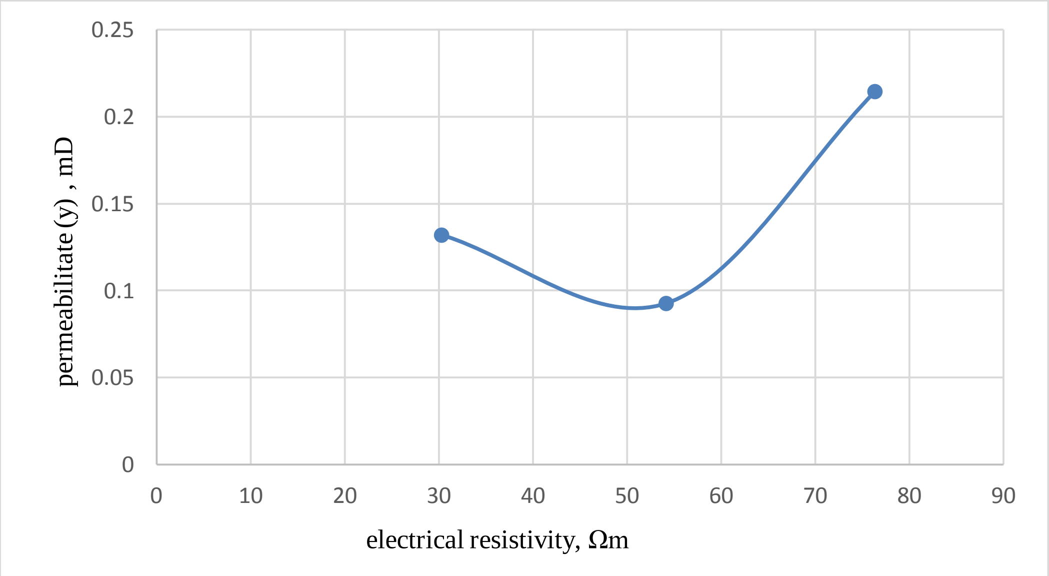

Fig. 3. Permeability variation (mD) (y) depending on Electrical resistivity Ωm (x) - drilling Ciresu

The productive layer of the Cireşu borehole is located in the cracked marl, which shows the existence of a rich layer of crude oil and reservoir water (more reservoir water) in the 50 Ωm area and a gas deposit in the 80 Ωm area.

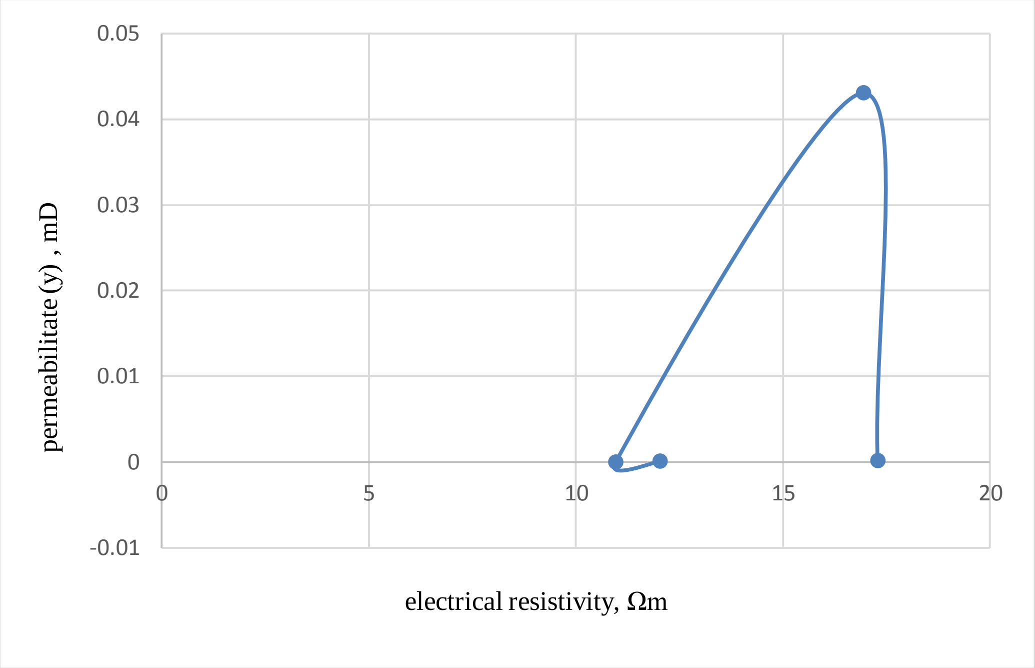

Fig. 4. Permeability variation (mD) (y) depending on Electrical resistivity Ωm (x) - drilling Ianca 1

The productive layer number 1 in the Ianca borehole is located in compact limestone, which shows the existence of a rich layer of gas in the 17 Ωm area with water.

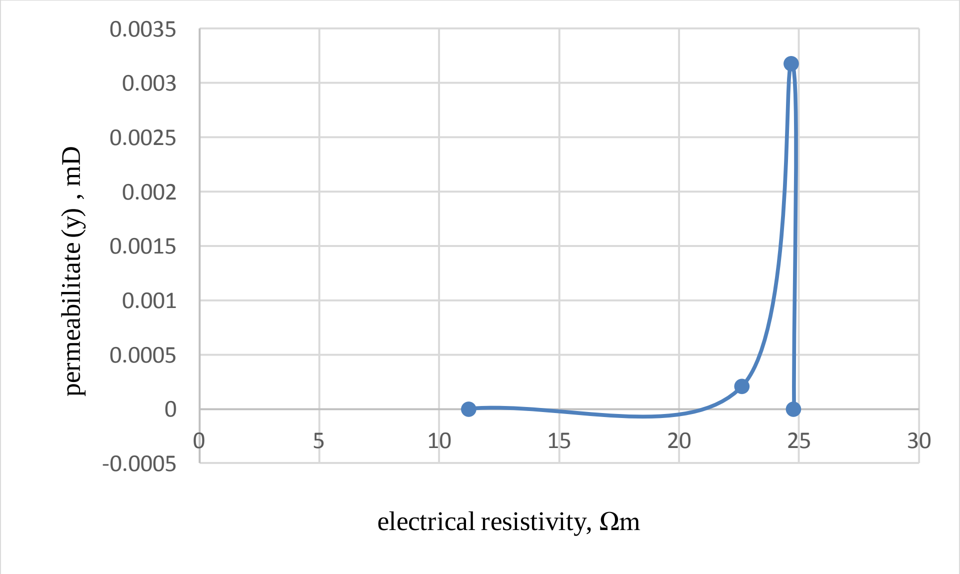

Fig. 5. Permeability variation (mD) (y) depending on Electrical resistivity Ωm (x) - drilling Ianca 2

The productive layer number 2 from the Ianca borehole is located in cracked limestone / dolomite, which shows the existence of a rich layer of gas in the 25 Ωm area.

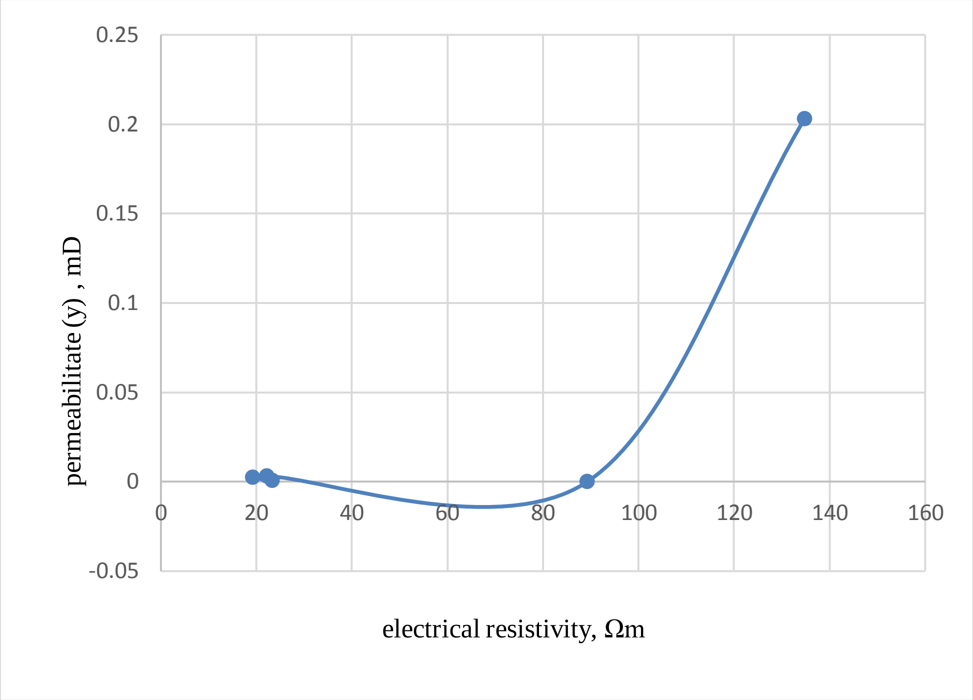

Fig. 6. Permeability variation (mD) (y) depending on Electrical resistivity Ωm (x) - drilling Zăvoia

The productive layer of Zăvoia drilling is located in calcareous sandstone, which shows the existence of a rich layer of crude oil and gas in the 65 Ωm area.

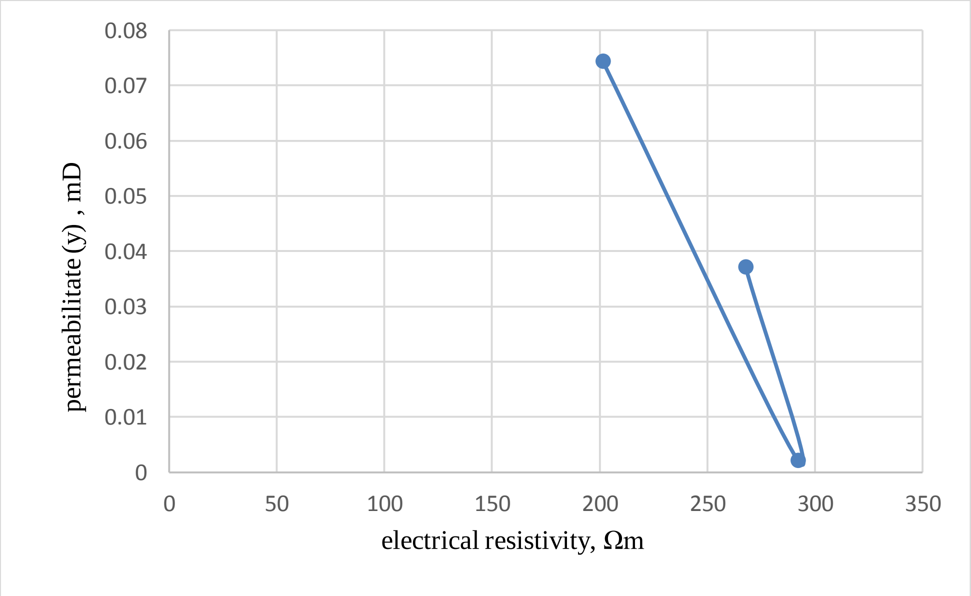

Fig. 7. Permeability variation (mD) (y) depending on Electrical resistivity Ωm (x) - drilling Smirna 1

The productive layer number 1 of the Smyrna borehole is located in sandstone, which shows the existence of a rich layer of crude oil and reservoir water in the area of 300 Ωm (90% reservoir water).

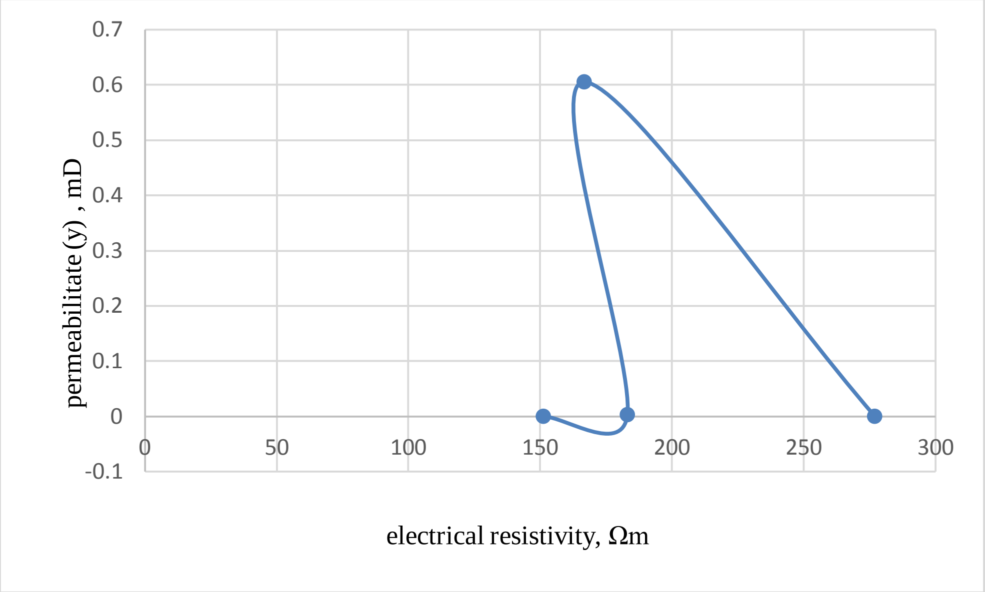

Fig. 8. Permeability variation (mD) (y) depending on Electrical resistivity Ωm (x) - drilling Smirna 2

The productive layer number 1 in the Smyrna borehole is located in compact clay, which shows the existence of a rich layer of gas in the 180 Ωm area.

IV. Discussion

The analysis of oil and gas deposits can be done by interpreting the data of electrical resistivity and permeability.

By performing mathematical regression equations can be determined depending on the thickness of the productive layer, both electrical resistivity and permeability.

We notice that the relations are of order 2,3,4 and the electrical resistivity and the permeability are correlated very well.

V. Conclusion

The article examines simulation models for electrical resistivity and permeability in order to interpret the potential oil and gas regime of productive layers.

Analyzing the analysis data of the cores taken from the wells depending on the permeability determined by electric coring, we find a perfect correlation (over 95%) between the two permeabilities.

We also managed to write simulation equations between:
- Productive wall thickness and permeability,
- Productive wall thickness and electrical resistivity,
- Electrical resistivity and permeability.

The determined equations have degree of error 0 and therefore $R^2 = 1$.

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