Research Paper

Pulsating Electromagnetic Sounding Method (PEMS) for search and investigation of oil and gas deposits

Ihor Skopychenko [1]*, Sergiy Kuznetsov [2]

[1] *State Institution "Scientific Center for Mining Geology, Geoecology and Infrastructure Development of the National Academy of Sciences of Ukraine", Ukraine, Kyiv*
[2] *LLC Ukrnaftogazposhuk, Ukraine, Kyiv*
*Corresponding Author

ABSTRACT: Introducing a new unique high-technology for searching for oil and gas deposits - the Technology of Pulsating Electromagnetic Sounding (PEMS). Theory of method and means of interpretation are based on algorithms that have been created and tested for a long time in the production of experimental methods and search operations. PEMS method, we can more effectively plan the exploration, development and production of hydrocarbons and, ultimately, help the customer to avoid the expense on drilling the empty boreholes. Work is based on the volumetric model (3 D) of oil and gas fields, maps and profiles, as drill hole as recommendations issued by the points on the laying of drill holes, indicating the depth of the productive layers. The PEMS studies are used to decide the ecological problems, i.e. detecting and locating the petroleum product leakages from their storage facilities. PEMS Technology has been employed for Oil&Gas and Solid minerals exploration and Exploitation in different geological settings.
KEY WORDS: Oil, Gas, Technology of Pulsating Electromagnetic Sounding.

I. INTRODUCTION

Introducing a new unique high-technology for searching for oil and gas deposits - the TECHNOLOGY OF PULSATING ELECTROMAGNETIC SOUNDING (PEMS). Our technology enables high accuracy in a short time to identify and assess the field. The accuracy of the field location in the space is up to 0,5 m in area and depth. Of the 17 boreholes drilled in Tatarstan on our recommendations, all 17 ones entered the reservoirs at the specified depth.

PEMS is an improved version of the method of point electromagnetic sounding with new hardware and software [1- 3]. PEMS Technology is the most efficient in the construction of a detailed geological model and the design of optimal schemes of development of hydrocarbon deposits. In recent years, volumes of research on this technology over other methods of field geophysics are continuously growing.

Theory of method and means of interpretation are based on algorithms that have been created and tested for a long time in the production of experimental methods and search operations. The method was introduced to the production of geological survey work in 2000-2020. The method is protected by 3 patents.

Our technology enables high accuracy in a short time to identify and assess the field. The reliability of our predictions is close to 80%, i.e. three times higher than that of the seismic survey. The accuracy of the field location in the space is up to 0,5 m on the area and in the depth.

Fundamentals of PEMS and the distinctive features of all the other are as follows:

All algorithms for primary data processing software have developed on the basis of 30-year experience with the methods of non-electric character.

Provision of hardware provides the most objective information on the electromagnetic image for the prospecting area.

In the electromagnetic interaction equation it is shown that the basis for the existence of EMF of the Earth is the equality of the kinetic energies of its constituent elements, namely:

◆ $\quad m_e c2 = (2m_p + m_n) \, V2_{Earth} \; (1)$
◆ $\quad \mu_{nuc} c2 = 3\mu bohr \, V2_{Earth} \; (2),$

where m_e is the rest mass of the electron, m_p is the rest mass of the proton, m_n is the rest mass of the neutron, c is the speed of propagation of the electromagnetic field in vacuum.

c = 299 792 458 m/s, **V$_{Earth}$** - speed of propagation of electric field in the medium **VEarth= 4039,297 | km/s**, **μ$_{nuc}$** - nuclear magneton, **μ$_{bohr}$** - Bohr magneton.

Used equipment:
"Phoenix 10-01 10-01" is own production ("home-made").
The resulting information is many times greater than the information obtained by standard methods (seismic, electric, gravity, magnetic).
The work produced multicomponent measurements that establish a 3D, 4D system information.
PEMS method involves the gradual solution of search problems:
1) electromagnetic survey carried out in air or road, or variant from ship and interpretation of raw materials, are provided by local (Area) depth anomaly of nature, which may be related to oil and gas;
2) ground (pedestrian version) Industry surveys in previously allocated to the electromagnetic anomalies, providing a target and deep linking selected objects, specify the options for their possible nature, is spatially referenced objects allocated in the plan and in depth, refined versions of their possible nature;
3) the decoding, processing of information in the computer center, the clarification of the results of the 1 st and the 2 nd phases of adjustment on the ground and determine the most reliable points laying drill holes.
The effective use of the PEMS to perform reconnaissance on the profiles, which connect the prospecting area for the known holes.
Thus, using the PEMS method, we can more effectively plan the exploration, development and production of hydrocarbons and, ultimately, help the customer to avoid the expense on drilling the empty boreholes.
Our work is based on the volumetric model (3 D) of oil and gas fields, maps and profiles, as drill hole as recommendations issued by the points on the laying of drill holes, indicating the depth of the productive layers.
A pilot-training work was conducted on many areas of the Dnieper-Donets Depression, led confidently identify hydrocarbons at depths of up to 10 km [4].
We study the temporal features of the induced electromagnetic field of the Earth, which appears in the following short-term impact of a rectangular pulse of a direct current transmission installation with a registration response from the receiving installation (multispiral installation, the perimeter of one cycle of up to 20 cm). Use specially designed manufactured and tested «Phoenix 10-01» and "Phoenix 10-01 10-01" equipment with the appropriate software. Depending on the geological, engineering and other tasks the various components of the induced field were measured and analyzed with the construction of special maps and sections of electromagnetic parameters of the surroundings.
When interpreting the PEMS results the Author's program «Pipe» and the best interpretation programs are used. The very small size of the equipment using excitation and reception facilities enables the sounding and measuring the subsurface on almost any areas and landscapes (lengthways roads, on arable lands, on water, etc.).

II. MAIN SPECIFICATIONS AND CHARACTERISTICS

2.1. Dynamic range of the measured electrical signal - at least 100 dB.

2.2. Maximum measured voltage signal transients - not less than 4 V.

2.3. The range of measurement time of transition - from 100 ns to 30 μs.

2.4. Root-mean-square value of their own noise in the inlet short-circuited channel determined when the number of stocks is N = 64 and the initial measurement time is 1 μs, did not exceed 0.5 μV.

2.5. The power consumed by the PHOENIX 10-01 equipment is no more than 2.5 W at voltage 12 V.

2.6. Output voltage measuring from 4 to 10 V.

2.7 Duration of the measured current pulse is 100 to 1000 μs.

2.8. PHOENIX 10-01 equipment provides the synchronization with the time scale to a precision of satellite navigation system (GPS).

2.9. PHOENIX 10-01 equipment provides data to the computer via the USB port.

2.10. Weight of PHOENIX 10-01 equipment - 6 kg (without batteries).

2.11. Installed nonstop work of the PHOENIX 10-01 equipment - at least 8 hours.

The PEMS is based on the original method of calculating the depth of research. The experimental studies shown that the propagation velocity of electromagnetic fields in a geological environment is a constant value.

III. RESULTS AND EXPLORATION

Data Processing
•Typical processing procedure sequence include noise removal which is automatically done by the equipment through gated frequency filters.
•Parametric analysis using the PROFIL software developed based on solutions to direct problems of unsteady field dipoles in layered medium to obtain electromagnetic images.

Data Presentation
•2-D sections from Profiles or Lines.
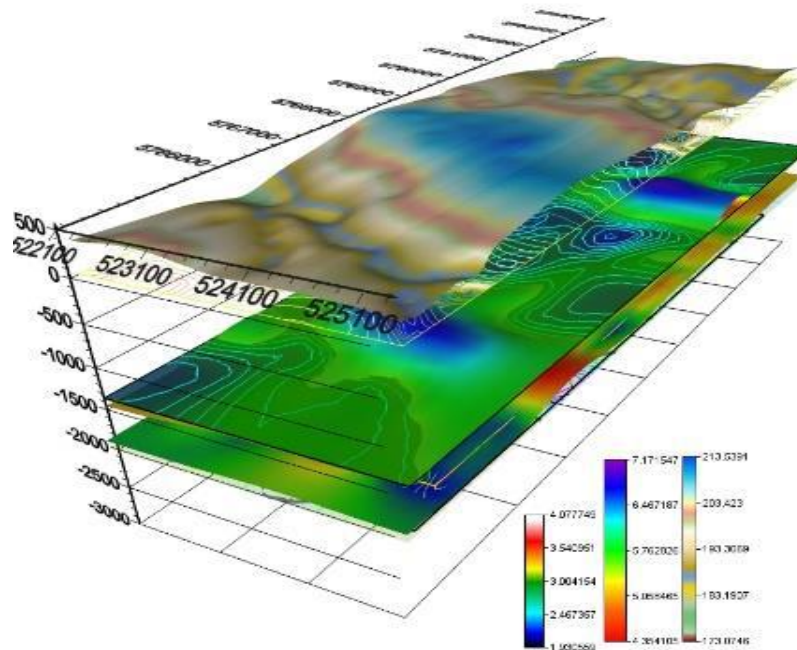•3-D volumes (Fig. 1).
•4-D (Time-Lapse).

Figure 1: The results of electrical exploration of PEMS 3D volumes

Merits of the PEMS method
Purely inductive in nature;
Ease of deployment;
The measurements is in the time domain;
The source and receiver are placed both on the surface and the media (car, plane or ship). Independent of T_x-R_x spacing;
The mathematical apparatus allows you to give information about the formation depth without inversion;
Effective depth of investigation up to 10km;
Cost effective with respect to other methods.

The vertical section (fig. 2) represents the intensive anomalies of electromagnetic parameters determined for surroundings in the depth range of oil field position. The results of study indicate the direct correlation between oil content in seam-traps and the intensity of electrometric anomalies that may be used to estimate the current conditions of oil -gas fields.

The electrometric study performed before the borehole drilling at the depth of 1970 - 2050 m has revealed the seam anomaly with the low values of electromagnetic parameters (red, yellow color), which characterizes the unconsolidated seam-traps. Prior to drilling the geological information for this part of section (prospect holes have deepen to 50 m into crystal basement rocks) was absent.
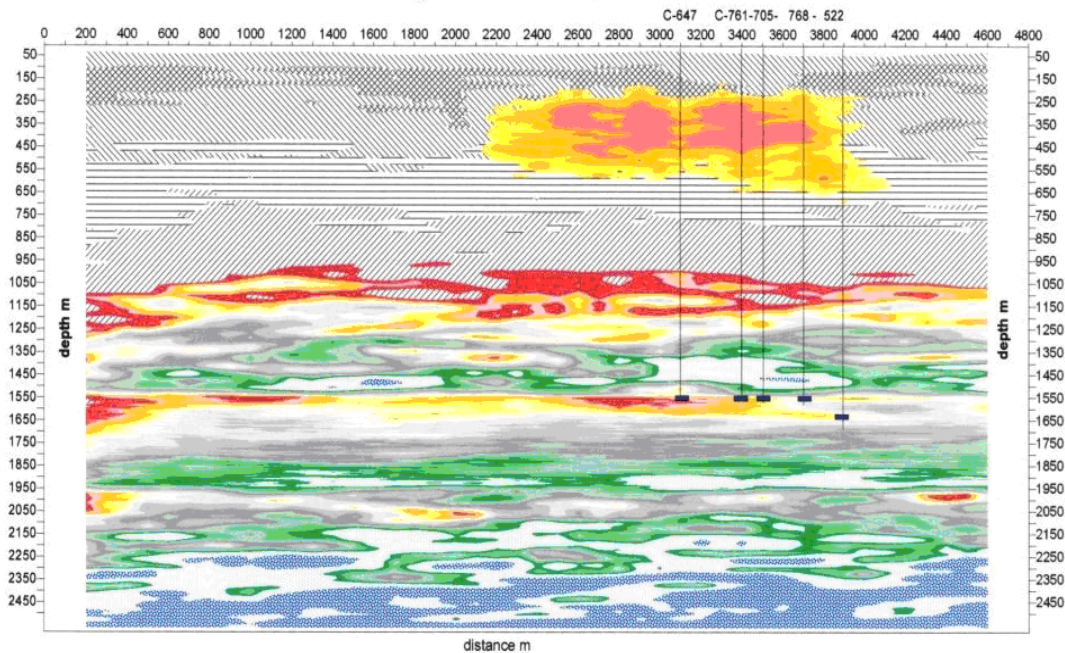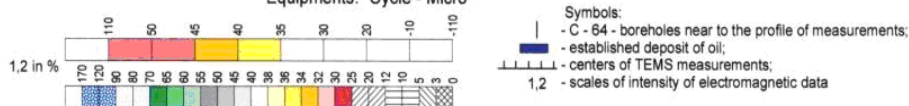
Fig. 2. The results of investigation by method of transient electromagnetic sounding (TEMS). Deposit of oil. Vertical sections of electromagnetic parameters of environment on PR1. Equipments: "Cycle - Micro"

PROBLEM DEFINITION
•Hydrocarbon bearing levels within known field.
•Seismic interpretation reveals positive structure in adjacent areas.
•Occurrence and limit of oil pool with structure unknown so as to warrant exploration work.
The PEMS studies are used to decide the ecological problems, i.e. detecting and locating the petroleum product leakages from their storage facilities.

IV. CONCLUSION
PEMS Technology has been employed for Oil&Gas and Solid minerals exploration and Exploitation in different geological settings.
It has been applied globally with cost efficiency, high degree of accuracy and successful results e.g. Ukraine, North America, India, Russia, Angola and Nigeria.
Its ease of deployment and application make it a veritable tool for quick and accurate decisions.
PEMS Technology can always compliment the use of Seismic data in Oil and Gas business, at reconnaissance and detailed field study levels.

REFERENCES
[1]. Skopychenko I.M. (2017) Determination of the peculiarities of hydrocarbon collectors by of point electromagnetic sensing method *Tectonics and stratigraphy*.№44. p. 152–157.
[2]. Finchuk V.V., Skopichenko I.M. (2003). Method of point electromagnetic sensing and its capabilities. In the collection "Ecology and Nature Management". iss. 6, p. 169-172.
[3]. Finchuk V.V., Skopichenko I.M., Novikov A.V. (2003). Method of point electromagnetic sensing. Theory and methods of processing. In the collection "Ecology and Nature Management". iss. 6, p. 173-178.
[4]. Finchuk V.V., Skopichenko I.M. (2011). The results of forecasting hydrocarbon accumulations on the Naryzhnyanska Square of the Dnieper-Donetsk depression according to the data of electrical exploration works by the method of point electromagnetic soundings Geological Journal, № 3 (336). p. 131 - 138.