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Research

NEW POINT OF VIEW TO COMPLEX INTERPRETATION OF SEISMIC AND ELECTROMAGNETIC DATA AT HYDROCARBONS ENVIRONMENTAL DEPOSITS SEARCH

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ABSTRACT

This work describes main principles of seismic and electromagnetic data combination which were record on the same research objects. Theoretical and methodical bases of interpretation of geophysical data at hydrocarbons deposits searching are presented. Features of complex field works carrying out the proved increasing of reliability of the forecast of deposits existence are described. The description of new approach to an integration of the seismic and electromagnetic data at interpretation of seismic prospecting by reflection method and electric prospecting by method of resistance and the caused polarization results is submitted.

INTRODUCTION

Main principles of complex interpretation are based on dependence existence on the one hand between elements of a geological structure and anomalies of geophysical fields, and with another-between physical properties of rocks and ores, and a high-quality communication between the corresponding anomalies, this dependence is various for different methods and the it more, the better for interpretation. It provides, from the point of view of an information theory, increase in information in a combination of two and more methods in comparison with each of them separately. In the presence of close and identical connection the increasing does not occur.

At complex interpretation of seismic and electromagnetic data the more difference in nature of dependences between anomalies and a geological structure, the more information contains in their complex.

The substance of the complex analysis consists that if on each of methods it is possible to receive anomalies of the studied sign X and Y, and ≥ 0each of ≥ these 0 signs has the reference distribution p(x) and p(y) with limits of abnormal and mistakes of first (p1) and second (p2) sorts, then by combination of the abnormal values it is possible to receive more reliable decision (Fig. 1), than on each of them separately.

If between two methods there is a non-linear connection, then at complex interpretation the dividing function $\phi(x,y)$ can significantly reduce p1 and p2 and to respectively increase reliability of detection and/or selection of searching objects.

Development of theoretical and methodical bases of interpretation

Existence of natural and/or correlative connection between velocity (and/or density) and electrical resistance (and/or structural characteristics of rocks and ores gives us the chance to construct correlation methods of interpretation on the basis of comparison of data (velocity, the structural horizons-surfaces, conduction, polarizability, etc. parameters) and/ or results of preliminary interpretation of two or more geophysical methods with use of one results in of interpretation of other method and/ or on the contrary-methods of synchronous and/ or asynchronous relative statistical interpretation, including iterative (Fig. 1).

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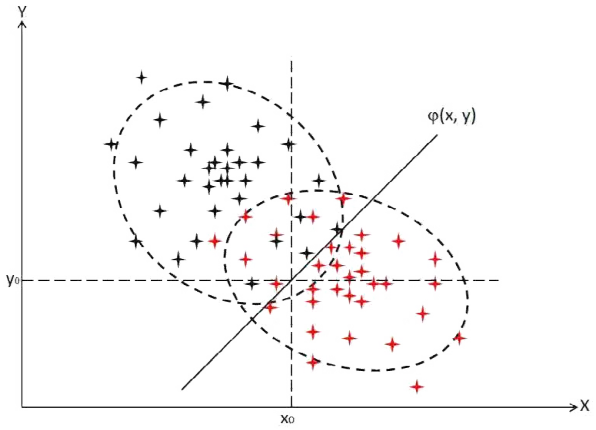

Fig. 1 Principles of complex interpretation of these two methods.

In the area of complex interpretation two main ways are widely used: one of them is bound on using the theory and algorithms of a pattern recognition which is used in the presence of reference objects (hydrocarbons deposit) to which the "examined" objects are compared, the second-uses various correlation methods in various modifications. One of such correlation methods based on model operation according to the experimental data of one method, and correlation of results of model operation with results of supervision on the second method is offered by authors of work.

Features of complex field works carrying out

Due to the carrying out field geophysical works with the purpose of searches of deposits of oil and gas there is a question of the choice of a rational complex of geophysical, geochemical and other methods by means of which the problem of search solving most efficiently and with the smallest expenses.

The choice of a rational complex is carried out by efficiency of methods in this area, features of a geological structure, physical parameters of oil and gas deposits, by geologic-geophysical analysis and economic reasons. For the choice of a rational complex the special express researches are carried out on the known oil and gas fields, and also empty structures of the area. All types of geophysical, geochemical and other surveys are carried out on the same profiles (Beriozkin, *et al.*, 1978).

As an example we will consider electric prospecting in two modifications and seismic exploration.

Electric prospecting

The solution of a problem of searching of oil and gas fields is carry out on the basis of studying of resistance and polarization of rocks. Studying of resistance is made with use of both simulated and natural sources of an electromagnetic field, and for polarizability studying-modification of the caused polarization on the basis of sources constant and alternating-current (Beriozkin, *et al.*, 1978).

The abnormal effects, connected with deposits of hydrocarbons, are shown in electromagnetic fields differently. Resolving power of various modifications is not identical. It predetermined need of studying of features of perspective anomalies in the oil-and-gas relation on the basis of the solution of direct and inverse tasks of electric prospecting for various modifications, development of ways of efficient selection of required anomalies, statement of the parametrical experimental researches on the known deposits. Electric anomalies are caused as directly connected with deposits, and the natural changes of a geoelectric section of fields occurring under the influence of deposits (Beriozkin, *et al.*, 1978).

Results of electric prospecting works on many fields of various types show that the major factor influencing on formation of anomalies, especially in case of small fields are the common changes of a geoelectric section of zonal type caused by secondary changes of rocks under the influence of deposits. The problem of complex interpretation consists in detection of high-quality and quantitative connections between observed electric anomalies and types of gas-oil fields (Beriozkin, *et al.*, 1978).

The nature and intensity of anomalies of a method of the caused polarization on oil and gas fields it is defined on oil and gas fields on observations in wells and on a day surface. The nature of these anomalies on gas-oil fields is connected with existence in area of deposits of congestions the electron-conductivity of minerals like sulfides. Formation of the increased concentration of a dispersion of sulfides is explained by restitution of the sulfates dissolved in reservoir waters, hydrocarbons in deposit, and also its aura or on the ways of migration to a trap. Restitution of sulfates by hydrocarbons (process of a sulfate reduction) leads to hydrogen sulfide accumulation. Thus, there is a pyritization of the oil and gas containing thicknesses and overlying deposits. At the same time in the upper part of a section accessible to receipt in enough oxygen, a hydrogen sulfide is oxidized to sulfur that is why formations of sulfur often accompany oil and gas fields (Beriozkin, *et al.*, 1978).

Similarity of results of works on a method of the caused polarization in different areas allows explaining now anomalies of induced polarization on gas-oil fields with existence in an upper of a

section of fields of congestions of sulfides (generally pyrite) an epigenetic origin, connected with presence of hydrocarbons on a depth. By induced-polarization method the zones of a sulfide mineralization accompanying under certain conditions deposits of oil and gas could be detected.

Background values of polarizability of sedimentary rocks usually make 1% to 5%, seldom reaching 2% to 3%. Excess of polarizability over this background is the main sign of anomaly of induced polarization (Beriozkin, *et al.,* 1978).

Seismic prospecting

Physic-geological basis of application of seismic exploration as for the solution of a wide range of prospecting tasks, and problems of searches of oil and gas deposits is differentiation of a geological section by set of the physical properties (density, velocity, an absorption coefficient) influencing on features of distribution of elastic waves and/or receiving structures to which the fields of hydrocarbons used for calculation of effect of a deposit in resistance and polarizability can be bound to. Such system (operating sequence) can serve as a new way of interpretation.

Seismic recordings, along with information on the relative spatial arrangement of thicknesses and layers in a subsoil, contain information on such characteristics of the studied section as sheet density, sheet velocities of elastic waves, sheet absorption coefficients, information on stability (extent) of the reflecting borders, stability of their properties. Between that single sign of possible detection of a deposit according to seismic exploration is existence of anticlinal self-contained structure and only at its integration with electric prospecting its role raises (Fig. 1) (Beriozkin, *et al.*, 1978; Request for invention).

At identification of deposits of not anticlinal type possibilities of seismic exploration, for an assessment of seismogeological inhomogeneity of a section, mapping of tectonic violations and zones of weak violations are used.

In the field deposit the section pyritization, a mineralization of waters and tires liming raise. Respectively the seismogeological properties of rocks undergo some changes in the space surrounding a deposit.

Regarding the geological space containing a deposit and in the thicknesses, adjacent to a deposit, this underwent geochemical influence of hydrocarbons the redistribution of seismogeological characteristics is occurred. For example, acoustic rigidities changes and respectively coefficients of reflectivity and refractions and their dependence on an angle of incidence for the borders coinciding with a roof and a sole of deposits directly in the thickness of layer collector the padding reflecting elements are formed (Zemtsova and Zemtsov, 1966; Gerasimov and Udovotsky, 1971), and in zones of change of a reflectivity in a roof and a sole conditions for a diffraction are created. As a result of these changes of sheet speed and a sheet absorption coefficient in a deposit and the rocks surrounding it effective valuations of interval and average velocities, and also weakening of seismic waves (Pavlenkin, *et al.*, 2010).

Way of an integration of seismic exploration and electric prospecting data

This method development is carried out within implementation of the federal target program "Researches and Developments in the Priority Directions of Development of a Scientific-Technological Complex of Russia for 2014-2020", unique identification number of the project RFMEFI62414X0008.

The way of an integration of seismic exploration by method of reflection waves and Δ1=50 m, -distance between the profiles) and by network for example, ΔΔ electric prospecting by method of resistance and the induced polarization at searching of fields of Δ1, Δ1 and Δ2 hydrocarbons on the shelf containing seismic sensors (bottom stations) on a network Δ1=Δ2=500 m, (where electric stations arranged along the profile and/or square in united system of registration and source of simulating: seismic (pneumatic airgun) and electric (dipole) working by defined cycle of time, working consistently for a given cycle time, different by fact that to detect the hydrocarbons deposits by results of observations the structural buildings are carried out.

Using average data for research region and/or on a basic well, and/or the expected (theoretical) changes of electric properties (porosity, resistance, polarizability) build options of geological model of a section,

On change of the structural horizons depending on the given fluctuations of physical properties estimate probable errors of seismic structural buildings.

Electromagnetic data interpretation carries out without using of seismic data-as a zero approximation. For example, $h=h_0$.

On seismic structures find (define) the places where probable location of a deposit and/or connection with deposit to the particular structural horizons, and on geological and/or theoretical (given) variability of a deposit build the variants of sections which form

a basis for calculation of theoretical fields (anomalies of resistance and polarizability, etc.) from which choose those anomalies which have the maximal looking alike the experimental anomalies received on electric prospecting, and consider the section corresponding to this similarity as the most reliable on which build a probable contour of a deposit and a contour of ambiguity of location of a deposit on change of options of seismic sections.

CONCLUSIONS

The offered new approach allows to reduce costs of prospecting works due to application of a technique of selection of probability anomalies for the physical properties of rocks set a priori and with the known structure of a geological section received according to seismic exploration by reflection method.

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