PROSPECTING AND EXPLORATION OF HYDROCARBON FIELDS BY EARTH REMOTE SENSING METHODS

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Background and Aim

The contemporary approach to geological oil and gas exploration works is such that the seismic survey nearly eliminated all other methods of subsoil study. It is caused by great results that tri-dimensional (3D) seismic survey provides when studying the deposit structure and achievements of attributive analysis when estimating porosity and permeability of the reservoir.

3D-seismic survey is carried out at the stage of preparation of promising sites to prospecting drilling, i.e. on already discovered by 2D-seismic survey hydrocarbon traps. The week point of the latter method is that it identifies the location of structural traps but cannot estimate their productivity since every seismic profile is processed separately with its parameters of processing graph. Therefore, the attributive analysis would produce incorrect results. For the same reason it is problematic to use 2D-seismic survey for identification of non-structural traps. As a result only 30% of prospecting wells provide hydrocarbon inflow.

It is possible to enhance the efficiency of prospecting drilling by using earth remote sensing method – remote geological exploration [1].

Remote oil and gas geological exploration is a complex of air space surveys aimed at hydrocarbon field discovery or assessment of oil and gas bearing capacity of sites.

Contemporary technologies of remote sensing allow to identify indicators of hydrocarbons in subsoil through their shows on the surface. They include local anomalies of density and magnetic volumes; anomalies of spectral characteristics of remote images obtained in narrow zones of electromagnetic spectrum; specific movements of contemporary relief detected by satellite radar interferometry, etc.

Method: Indicators of hydrocarbon fields detected by remote surveys

The fundamental factor that has an impact on the development of indicators of oil and gas fields on the day surface is hydrocarbon microseepage from traps to above lying formations.

The hydrocarbon microseepage theory dates back to the beginning of the 1980s, it was formulated in works by T. Donovan, R. Forgey, A. Roberts, H. Machel, S. Pirson (USA), V.M. Berezkin, V.M. Novoselitskii, N.I. Tuyezova (USSR) and other scientists. The main idea of microseepage is secondary formation of minerals under the influence of fluids that migrate from the deposit via the cap in fracture and fault zones. There is continuous production of both hydrocarbon (CmHn) and non-hydrocarbon (H2S, CO2, H2, CO, He and etc.) chemically active components from the cap, they migrate and can reach day surface, change geochemical features of field landscapes and provide field indicators on remote survey materials.

It is evident that methods aimed at identification of microseepage on the earth surface belong to direct prospecting methods since they directly indicate the presence of hydrocarbons in the subsoil.

The hydrocarbon microseepage theory can explain experimentally detected changes of magnetic field on hydrocarbon fields. Depending on the proportion of secondary magnetite, pyrrhotite, pyrite and other minerals to destroyed hematite, there can appear rocks with enhanced or reduced magnetic susceptibility. In the magnetic field they are deciphered as local maximums and minimums.

Apart from density properties of the reservoir, the deposit density is determined by the difference in density properties of oil or gas and formation water, which causes the deficit of mass in the deposit. In anticline traps the reservoir density can be influenced by the structural factor related to the deconsolidation in structure crests, for example due to cleavage fractures.

Cumulative deconsolidation factors in the soda part of the anticline and deposit density reduction caused by hydrocarbons can lead to relatively reduced and sometimes negative anomalies of the gravity field that can reach 1-1,5 mGal.

However, in a number of cases fields have negative gravity anomalies that amount to several dozens of mGal (Yamburg, Urengoy, Tazovskoe, Zapolyarnoe, among others), which cannot be accounted for only by deposit deconsolidation factors. Such “hurricane” values can be caused by insignificant temperature increase in the whole thickness of rocks above the deposit (due to hydrocarbon microseepage), which leads to thermal expansion of rocks. It causes the difference in densities of contour and edge water rocks, which effect accounts for dozens of mGal.

Apart from magnetic minerals, hydrocarbon microseepage in near surface soils leads to increased concentration of such metals as titanium, vanadium, nickel and copper, which causes vegetation stress.

Both laboratory and field tests showed that plants subject to stress caused by the increased concentration of mentioned metals in the soil change their spectral response characteristics. The persistent change of spectrum was detected only under wavelength from 680 to 750 nanometers. This range comprises the red colour boundary, which in case of vegetation suppression moves to short waves (to blue) in average for not more than 20 nanometers. This phenomenon was called “blue shift” [2].

The special processing of space images with spectral channel from 680 to 750 nanometers allows to identify areas of suppressed vegetation, which is an indirect indicator of hydrocarbons.

The space radar interferometry data allows to identify contemporary relief movements related to the growth of anticline folds-hydrocarbon traps and active fractures that create deconsolidation in the crust and are accompanied with active fluid dynamics.

In case of spatial coincidence of local positive gravity anomaly and increasing relief elevation identified by radar interferometry data, we can speak about developing but already sufficiently high amplitude anticline structure in the sedimentary cover. The anticline amplitude should be quite high since its foundation block should be significantly elevated compared to its surrounding to be seen in the gravity field.

Conclusion

To increase the reliability of oil and gas fields exploration, it is reasonable to combine traditional 2D-3D seismic data with results of remote geological exploration.

The economic assessment of the application of remote geological exploration methods gives 50% decrease in prospecting costs and 10% decrease in hydrocarbon field exploration costs. The saving is provided by the decrease in “dry” wells.

Bibliography

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