NEW GEOPHYSICAL METHOD FOR DETERMINING THE CHARACTER OF RESERVOIR SATURATION WITH OIL, GAS AND WATER

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High rates of oil production cannot be attained without application of numerous means and methods of intensifying inflows and raising oil production of layers.

Pumping water into a productive (oil) layer in one of the technological methods.

In this connection during the process of exploitation of the layer (deposit) there arises the necessity of control over technical condition of boreholes and a change in the nature of collectors' oil saturation in time.

The difference of oils as per their viscosity and saturation with gas suggests various approaches to evaluating the character of reservoir saturations.

High-viscosity oils are characterized by a spectrum of geoacoustic noises with maximum frequencies of 300-400 Hz (Gremikhinskoye field, Udmurtia; Karazhanbas field, Kazakhstan). Estimates of the effective coefficient of absorption for high-viscosity oil and water saturated zones indicates that this parameter may be used to determine the character of the reservoir saturation.

Low-viscosity with a gas factor of up to 20-30 cu.m./ton

and higher have, as a rule, a discrete spectrum of geoaoustic signals with high frequencies of 1.0 to 1.8 KHz (Kiengopskoye field, Western Siberia; Kalamkas field, Kazakhstan; Barsukovskoye field, Western Siberia). Gas saturated reservoirs are characterized by a continuous spectrum of geoaoustic noises in a frequency range of 20-4500 Hz. Water saturated reservoirs are characterized by the spectra of their geoaoustic noises being limited by maximum frequencies of 500-600 Hz.

Thus, the character of reservoir saturations with oil, gas and water are described by spectral parameters of geoaoustic noises.

Fig.1. The detection of an interval of water encroachment
1, 2 - SAN diagrams, 3, 4 - the spectra of water - saturated and oil-saturated seams.

The following informative parameters of SAN are offered for

use:

- distribution of integral amplitude level both within the frequency band of 100 - 500 Hz and 500-2500 Hz for each of the three inducers (X,Y,Z);
- relation of signals' amplitudinal level from the vertical induser to signals' amplitudes from the horizontal induser within the frequency band of 100-500 Hz (parameter Z/X or Z/Y);
- relation of signals from the horizontal inducers within the frequency range of 500-2500 Hz (parameter X/Y);
- relation of signals' level within the frequency range of 500-2500 Hz to the signals' amplitudes within the frequency band of 100-500 Hz for each of the three inducers (parameters Nx,Ny,Nz);
- relation of signals' amplitudes within the frequency band of 500-2500 Hz registered by the vertical and horizontal inducers (parameter Z/X or Z/Y);
- amplitude-frequency spectra of signals.

For practical purposes there used those informative **SAN** parameters that are required for solution of a concrete geological task.

The use of SAN three-component measurements allows to solve the following tasks:

- 1.To reveal non - hermetic character of a casing column and behind-tube circulations in production boreholes;
- 2.To determine the intervals of fluids movement along the layer;
- 3.To study the profile of inflow in a perforated interval of a casing column;
- 4.To find behind-tube circulations before perforation and after repairs;

5. To determine the nature of gas, water and oil saturation of layers not opened by perforation.

An example of practical realisation of SAN measurements for evaluation of the nature of collectors' saturation in borehole 382 (Udmurtia) is given on Fig. 1. The section of productive stratum opened by a borehole in 1975 is shown in column I. The SAN investigation have been carried out after the borehole exploitation during 11 years. Correlation of signals in the frequency bands of 100-500 Hz (curve 1) and 500-2500 Hz (curve 2) gives reason to consider two low oil layers, opened by perforation in 1975, filled with water (column II). It is true, the spectrum of water-saturated layer (3) does not show high-frequency signals (>1 kHz), specific for the oils spectrum with a gas factor $17-27 \text{ m}^3/\text{T}$. Water-filling of oil layers and a rise of water-oil contact up to the of mark of 1535 m have been checked and proved by testing in the process of work by oil and gas production department "Izhevskloil".

At present, oil-borehole equipment and the methodology of studying geoacoustical noises, developed at the Institute of Geophysics of the Urals Branch of the Russian Academy of Sciences, are used to control the exploitation of oil reservoirs.