



Theoretical aspects and the experience of studying spectra of low-frequency microseisms

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The appearance of low-frequency spectral anomalies in natural microseismic noise over oil and gas deposits is observed since 1989 in different oil and gas regions (S. Arutunov, S. Dangel, G. Goloshubin). Several methods of prospecting and exploration of oil and gas deposits based on this effect (NTK ANCHAR, Spectraseis AG). There are several points of view (S. Arutunov, E. Birialtsev, Y. Podladchikov) about the physical model of effect which are based on fundamentally different geophysical mechanisms. One of them is based on the hypothesis of generation of the microseismic noise in to an oil and gas reservoir. Another point of view is based on the mechanism of the filtering microseismic noise in the geological medium where oil and gas reservoir is the contrast layer. For the first hypothesis an adequate quantity physical-mathematical model is absent. Second hypothesis has a discrepancy of distribution energy on theoretical calculated frequencies of waveguides «ground surface – oil deposit» eigenmodes. The fundamental frequency (less than 1 Hz for most cases) should have a highest amplitude as opposed to the regular observation range is 1-10 Hz.

During 2005-2008 years by specialists of «Gradient» JSC were processed microseismic signals from more 50 geological objects. The parameters of low-frequency anomalies were compared with medium properties (porosity, saturation and viscosity) defined according to drilling, allowed to carry out a statistical analysis and to establish some correlation.

This paper presents results of theoretical calculation of spectra of microseisms in the zone of oil and gas deposits by mathematical modeling of propagation of seismic waves and comparing spectra of model microseisms with actually observed. Mathematical modeling of microseismic vibrations spectra showed good correlation of theoretical spectra and observed in practice. This is proof the applicability of microseismic methods of exploration for oil and gas.

Correlation between spectral parameters of microseisms and reservoir parameters were investigated on results of subsequent drilling. Dependences of the low-frequency seismic signal from collecting properties of the reservoir which have been identified indicate that the change in the spectrum of microseisms occurs when changing filtration and capacitive properties of the reservoir-collector. Changes of physical properties of oil also affect to spectral anomalies of the microseismic field. Obtained dependencies of the influence of a deposit and fluid parameters on spectral characteristics of microseisms are consistent with theoretical ideas about the nature of this influence.

In general, performed the research allows confirming previously expressed hypothesis according the physical model of effect of low-frequency spectral anomalies in natural microseismic noise over oil and gas deposits and significantly refining the approach in the method of interpretation.

Since the 2005 year the method of interpretation of microseismic spectrum anomalies which based on the hypothesis of filtering microseisms by geological medium widely are using by «Gradient» JSC on the territory of the Volga-Ural oil province. About 70 wells were drills according to results of our researches. According by results of independent experts the effectiveness of the forecasting is more 80%.