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ВОЗМОЖНОСТЬ ИНТЕГРАЦИИ МИКРОСЕЙСМИЧЕСКОГО АНАЛИЗА С ДРУГИМИ ГЕОФИЗИЧЕСКИМИ МЕТОДАМИ НА ПРИМЕРЕ ГАЗОКОНДЕНСАТНОГО МЕСТОРОЖДЕНИЯ

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Данное исследование посвящено анализу микросейсм, зарегистрированных на территории газоконденсатного месторождения. Показано присутствие эффекта сейсмической эмиссии на части профилей площади. Оконтурена аномалия микросейсм в северо-восточной части площади, подтверждаемая тремя профилями и интерпретируемая как залежь УВ. Результаты специальной обработки сопоставлены с результатами ряда других геофизических методов. Показана корреляция найденной аномалии микросейсм с аномалией, полученной методом аэрогамма-спектрометрии. Результаты исследования микросейсмической эмиссии могут использоваться в комплексной интерпретации геофизических данных при поиске залежей УВ, в том числе неструктурных.

Ключевые слова: поиск углеводородов, микросейсмичность, сейсмограммы ОГТ, спектральный анализ

INTEGRATION POTENTIAL OF MICROSEISMIC ANALYSIS AND GEOPHYSICAL METHODS. GAS CONDENSATE FIELD CASE STUDY

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This study is devoted to an analysis of microseisms registered on gas-condensate field area. Presence of seismic emission effect on a part of the area is demonstrated. A microseismic anomaly is outlined in NW part of the area and proves correct by 3 seismic CDP profiles and interpreted as a reservoir. The results of the special processing was compared to the results of a set of other geophysical methods. Correlation between the found anomaly and an anomaly found with aerogammaspecrtometry is shown. The results can be used in an integrated interpretation of geophysical data for oil and gas reservoirs of both structural as nonstructural types.

Keywords: oil and gas prospecting, microseismisity, CDP gathers, spectral analysis

Introduction

An analysis of microseismic spectra over an oilfield provides advanced nonstructural information on geological media. Often such analysis requires additional resources and observations with special devices. SanMcs technology [1], applied in this study, is based on raw seismograms observed in common depth point survey and represents a calculation of mean microseismic spectra at receiver points along a profile. Case studies showing this technology aimed to oil and gas prospecting are published [2–4].

The Chaykinskaya area is located on the East of the Nepa-Botuoba anteclise, on the SE Nepa anticline plunge, at the area of its jointing with the Predpatomsky deflection. This region is included in a number of objects, studied by SRIGGMIM specialists [5]. Under their supervision, complex geophysical survey was conducted, which included 2D common depth point seismic survey, near-field time-domain electromagnetic sounding, geochemical and aero geophysical survey. The results were compiled by A.S. Efimov, M.Yu. Smirnov et al to the prognostic map of the area [6].

There are two parametric wells drilled on the area 24 km apart. Well №279 revealed a layer comprised of gas-saturated breccia dolomite. Well №367 showed noncommercial oil flow.

Results

The obtained seismic data was provided for special processing. Fig. 1 demonstrates the results of microseismic spectral analyses along line №5 in two different time windows 0.512 s length and corresponding time section. Fig. 1, a represents the result for a chosen time window including intervals before the obtained first brakes, Fig. 1, b – at the end of the recorded traces – after 3,5 s. Comparison of both results shows midfrequencies microseismic noise enhancement at the end of the line. Fig. 1, a demonstrates some weak midfrequency anomalies at the end of the profile, while Fig. 1, b shows common amplification of low frequency microseisms. The value of the integrated spectra (Fig. 1, c) in frequency range 0–30 Hz at T0=3.5 s exceeds the same value at T0=0 on 39–51 km of the profile by 3–4 times. Such increase of the spectral anomaly at low frequencies corresponds to the emission respond of saturated media, induced with the source pulse, which proves the presence of hydrocarbons.

Except line №5, intense microseismic emission is shown on parallel profiles №7, №8 and №9 across the line №5. Fig. 2 demonstrates microseismic spectra along the profiles, the intersection points are shown as black marks. Some parts of line №7 demonstrating high microseismic energy, and strong intervals 9–13 km of line №8, 8–12 km of line №9 outlines the main microseismic anomaly at the same frequency about 10 Hz.

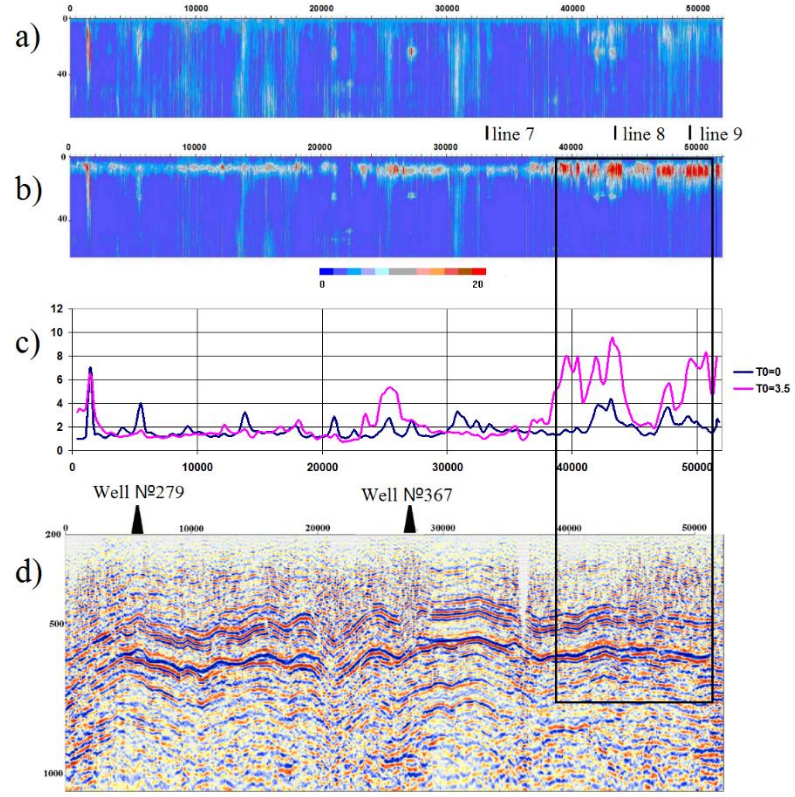

Fig. 1. Line №5 at Chaykinskaya area. Mean spectra at 2km+ offsets:
a – early times, T0 = 0; b – T0 = 3,5 s; c – mean spestra at 0–30 Hz at same time windows; г – time-domain seismic section

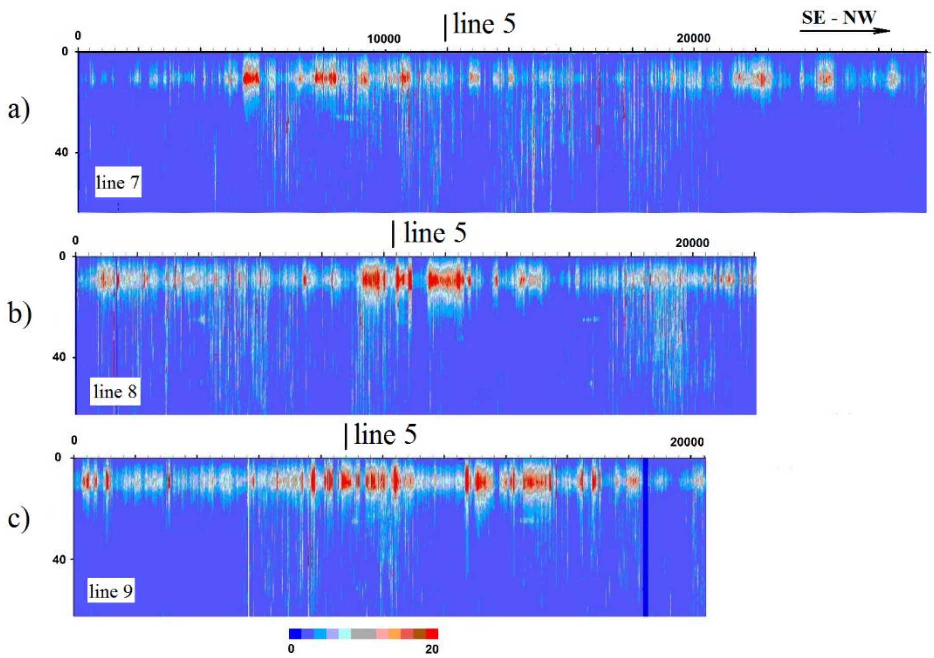

Fig. 2. Lines №7, №8, №9 at Chaykinskaya area. Mean spectra at 2km+ offsets at T0 = 3,5 s; a) line №7; b) line №8; c) line №9. Y – frequency, Hz, X – coordinate. Black ticks show line №5 crossing point

Thus, we can conclude that in the northeast of the area, there is a stable anomaly of mid frequency microseisms, presumably associated with hydrocarbon deposits. The available profile material was interpolated over the entire area using the kriging procedure. The resulting map was used to contour the anomaly along the 0.65 isoline of the normalized microseismic spectrum. The anomaly is demonstrated on fig.3 along with the results of A.S. Efimov at al. study.

The integrated geophysical analysis reveals nine reservoir traps. Prospectivity of the reservoir is shown with colour, dark brown corresponds to high prospectivity, blue corresponds to least prospective reservoirs. Found large anomaly of microseisms in the NW of the area correlates to the trap outlined with aerogamma survey (№5, yellow line). It is important to note, that this survey is based on different indicator of hydrocarbon deposit exposed in radioactive field, i.e. does not relate directly to ambient microseismic noise.

Lyaschenko at al. in their study [7] found that at the South of the Siberian platform all abnormal correlation halos of radioactive elements (mainly of the uranium group) were revealed over all dome structures consisting hydrocarbons, within its water-gas-oil contacts.

To sum up, the prediction based on the study of seismic emission is confirmed by the prediction method based on another feature of the reservoir, presented in different physical field.

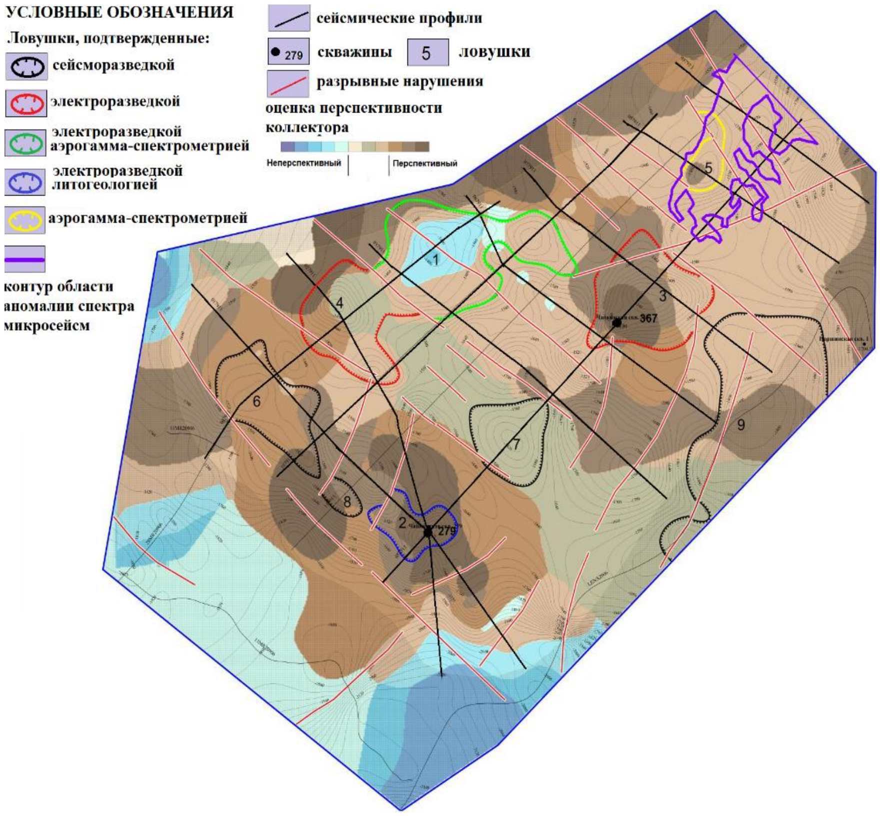

Fig.3 Chaykinskaya field. Detail of the prognostic map of perspective objects built with geophysical complex survey. Based on A.S. Efimov, M.Yu. Smirnov et al. [6]. Blue line on NE of the area shows the main anomaly of microseismic spectra

Conclusion

As a result of our research it was established, that mid-frequency range of ambient microseismic noise, registered in the wavefield at later times than source waves, correlates to mid-frequency ambient noise from the beginning of the seismic record. The difference lies in the more prominent mid-frequency noise at later recording times: its amplitude increases 3–4 times (Fig. 1, d).

Length of the anomaly of microseisms along the line significantly exceeds weak anomalies found in microseismic field at earlier times before the first brakes, which shows an effect of seismic emission induced by source waves. Preferable parameters of the analysis window for microseisms are following – offsets larger than 2 km, times T_0 more than 3.5 s.

In the result of testing our method on seismic material of the Chaykinskaya area, we observe the anomaly of the spectrum of medium frequency microseisms located in the northeastern part of the area. Presence of the anomaly on two parallel adjacent lines №8 and №9 lay 7 km apart and on the transversal line №5 (Fig.2) demonstrates its reliability. Characteristic size of the anomaly shown on lines №8 and №9 is about 2.5 km and *is* more than 10 km on line №5. Stability of the anomaly and its high contrast prove aerogamma prognosis of hydrocarbon deposit presence on this certain part of Chaykinskaya field.

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