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Reservoir localizations with using of registration of seismic emission

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Summary

The classic theory of seismic methods assumes that the geological medium is passive and doesn't generate its own microseism. But in practice we often confronted with seismic activity of geological environment. The authors assert the real geological medium is an active system: it can generate microseism itself. This effect of seismo-acoustic emission becomes pronounced in hydrocarbon reservoir. The main goal of this paper is an investigation of seismic emission character, its frequency content and distribution for all three components along the test lines. The final objective was a development of a special technology for spatial localization of a reservoir based on the methods of seismic tomography. Presented results of experimental study of the seismic emission demonstrate the promises of using these effects to improve the efficiency of seismic survey. Combination of the registration of passive seismic emission by modern system of wideband three-component receivers with special data processing allow to localize reservoirs more confidently. One of the perspective features is a possibility to use ordinary vibrogrammes registered during traditional field works instead of special field data

Introduction

Classic elasticity theory doesn't take into account seismic nonlinearity of real geological medium. It is supposed to be continuous, linear-elastic and passive. Oscillations in such media don't interact with each other and diffuse irrespective of the amplitude. On the way of the evolution conventional theory confronted with many effects inexplicable with help of classic theory. These effects usually caused by intergranular cracks, dislocations, porosity and permeability of the rock, viscosity and compressibility of the fluid.

On practice the real geological medium represents a system of blocks being in different strained states. It's an active system, in other words it generates microseism itself. Oscillations in such medium interact with each other and its propagation depends on signal's amplitude.

Development of the classic theory leaded to complication of linear-elastic model of the Earth. Various mechanisms of absorption of seismic energy had been studied. Generation of this seismic energy due to the internal medium's energy disregards in classic theory except the seismology and study of microseism – forerunners and consequences of the earthquakes. The methods of seismic tomography for localization of noisy objects in lower half-space had been developed just there. Later on these methods had been extended to engineer geophysics for localization of geothermal sources centers and investigation of pressure-water horizons. This fact leaded us to use methods and ideas of emission tomography for spatial localization of oil and gas reservoirs.

The first attempt to use these methods was the well-known ANCHAR technology – one of the methods of passive seismic.

Invention of the full-wave digital three-component VectorSeis accelerometers (I/O) gave the powerful push in development of using a phenomenon of natural seismic-acoustic emission (SAE) to identifying and locating hydrocarbon zones.

Field experiments

During 2005-2006 years "GDS Ltd" together with "TNG-group" realized a row of development works along the test lines for registration of natural seismic-acoustic emission from hydrocarbon reservoirs. The goal of these experiments is an investigation of a character of SAE, its frequency content and distribution for all three components along the test lines. The final objective was a development of a special technology for spatial localization of a reservoir and definition of its parameters.

All the results presented in this paper had been obtained in the field experiments carried out at three different Russian oil-fields. VectorSeis accelerometers were chosen to investigate natural emission. The lines length was about six kilometers.

The noisy background was registered during several days. Time duration of registration time was 20 seconds. There was no special influence on geological medium. Besides the noise, which had been registered on these lines during ordinary vibroseis field works, was analyzed.

Results

The results of data processing and analysis are the following:

1. The SAE activity of Z and X components along the test lines is in correlation dependence with hydrocarbon reservoir location.

Amplitude value of Z component ranks over amplitude value of X component (fig. 1). This regularity can be used in prognosis of hydrocarbon reservoir location. Such kind of technologies had been widely used in exploration (for example, it's the Russian ANCHAR technology mentioned above).

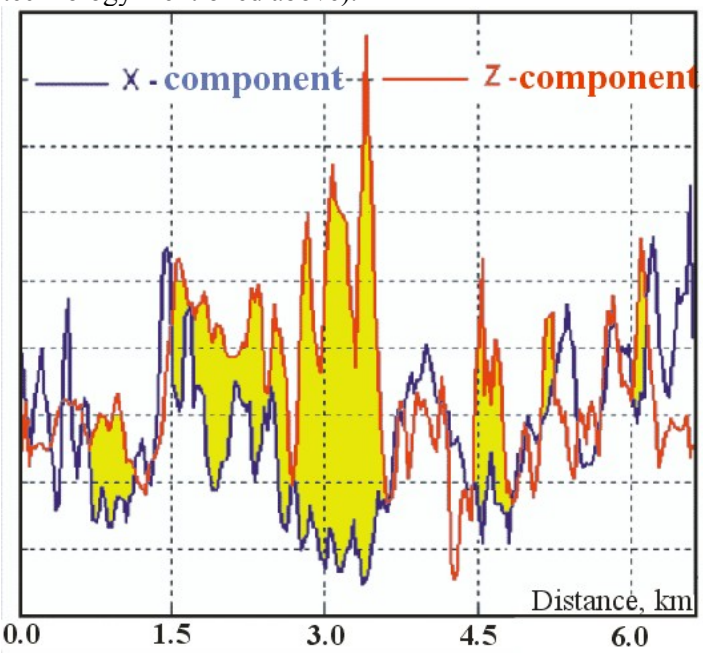

Fig. 1. The amplitudes values of the noise for X (blue ghaph) and Z (red graph) components along the test line.

2. There are some different frequency ranges in SAE amplitude spectrum which related to different noise sources (fig. 2). The difference may be in the origin or in the location.

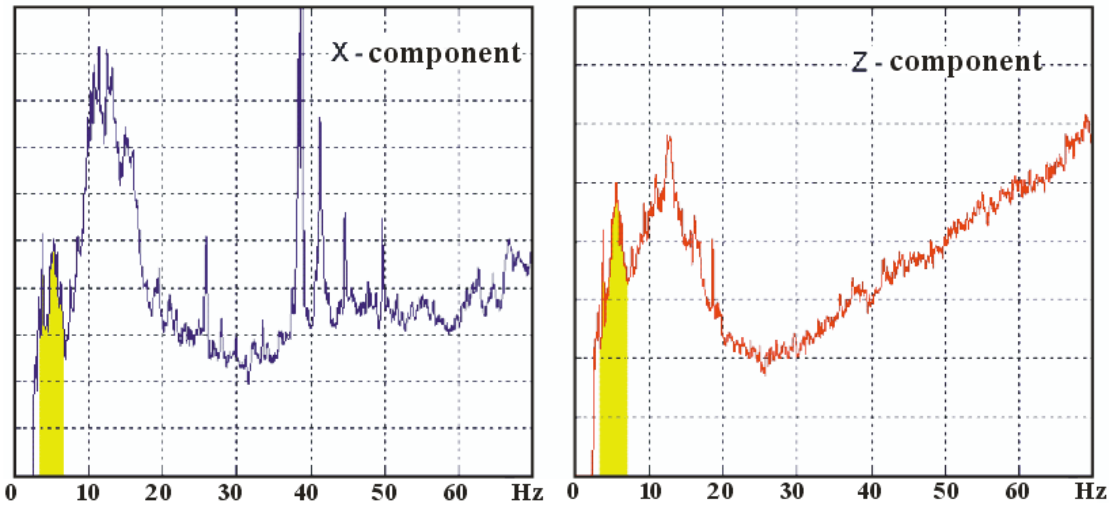

Fig. 2. The amplitude spectrum of SAE for X (blue ghaph) and Z (red graph) components.

3. Data analysis shows that there's a possibility to use the special processing based on principles of seismic tomography for more accurate localization. The methods of emission tomography allow us to localize the areas of possible reservoir location and the interstitial zones in basement - probable oil travel paths.
It's possible to use different algorithms which transform noise into tomographic image of lower half-space. The first group of algorithms allows locating the areas of noise-source accumulation in different frequency ranges (fig. 3).

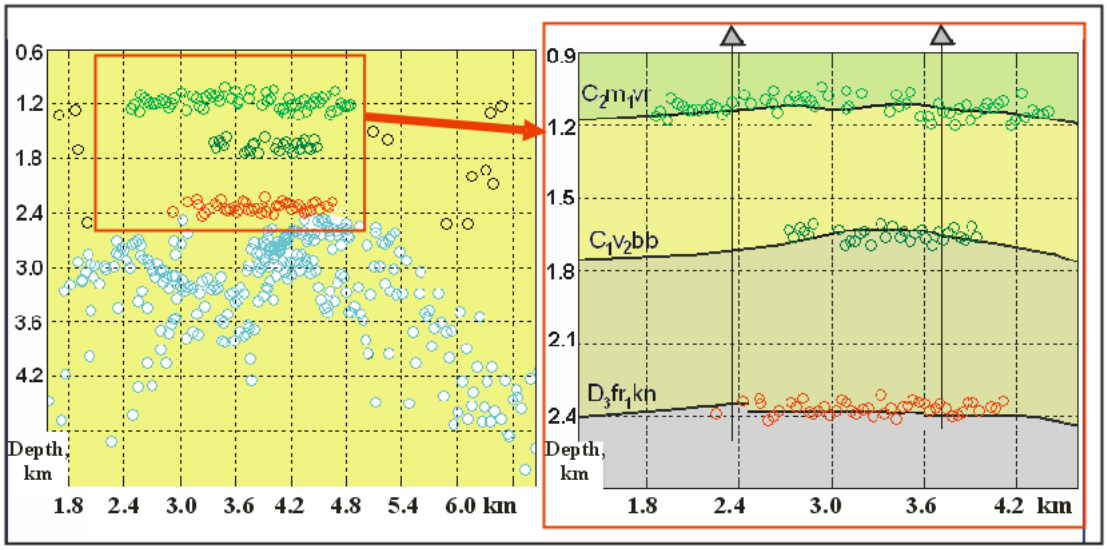

Fig. 3. The distribution of seismic emission sources after averaging their coordinates withing specially defined zones.

The second group of algorithms allows defining and visualizing the SAE activity in every position of lower half-space in wide frequency band (1-100 Hz) (fig. 4).

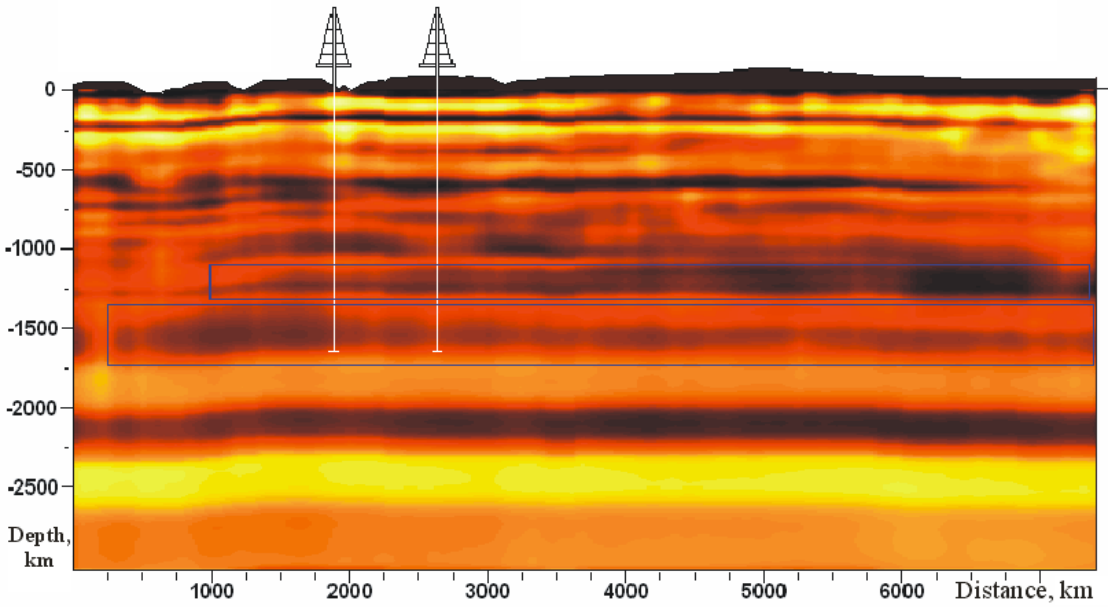

Fig. 4. Seismic emission depth section. The initial data were registered without special influence on the medium.

4. It's possible to use an ordinary vibroseis data for tomographic analysis of the seismic emission instead of special field works and technologies. The only requirement is a registration of vibrogrammes during field-works (fig.5). Special processing allows getting the images as you can see above.

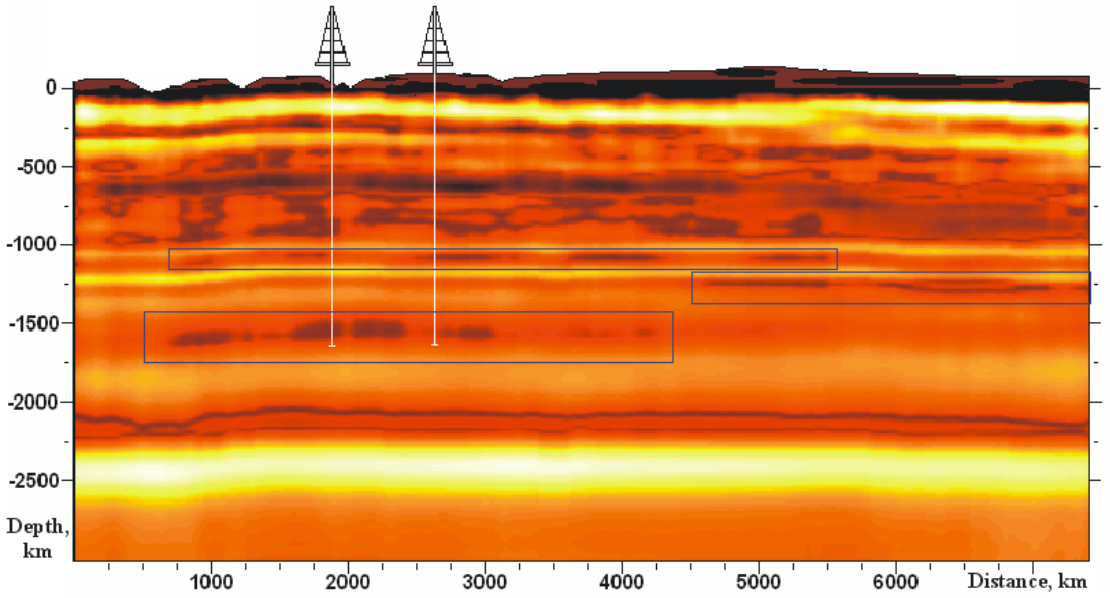

Fig. 5. Seismic emission depth section. The initial data were registered during an ordinary field-work.

Conclusions

Presented results of experimental study of the phenomenon of seismic emission demonstrate the promises of using these effects to improve the efficiency of seismic survey.

- Combination of the registration of passive seismic emission by modern system of wideband three-component receivers with special data processing using principles of emission tomography allow to localize reservoirs more confidently.

- Using the system of intersecting lines (field work volume less then traditional 3D-survey) for emission registration allows getting volume model of the reservoir.
- The evolution of our method is closely related to using not only low-frequency but the whole spectrum of spontaneous emission and to realization of extra physical and systematical investigations in the wells.
- One of the perspective possibilities is the using of not only a special field data but also the ordinary vibrogrammes registered during traditional field works.
- The using of this technology lead to self-descriptiveness increase of seismic method with small increase of costs.

Acknowledgments

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