DETECTION OF FRACTURED RESERVOIRS ON THE BASIS OF COMBINATION OF THE SCATTERED WAVE SEISMIC EXPLORATION AND SURFACE PASSIVE MICROSEISMIC MONITORING AT THE OIMASHA FIELD (KAZAKHSTAN)

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Introduction

At the moment a large number of major and unique high-output fields, the productivity of which is connected with the porous-type reservoir reached a late and closing stage of development. In order to maintain and increase crude oil output the new targets for OIP increase are needed. These targets may be the fractured-cavernous-type reservoirs. Search, exploration and development of deep-seated compound hydrocarbon deposits with fractured-type reservoirs require a combination of different technologies and fracturing forecasting methods.

The work presents a sequential interpretation of the results of passive seismic monitoring [1,2] and the results of fracture zone forecasting according to the CSP (Common Scattering Point) method [3].

Technique of fracture zone forecasting

Fracture zone forecasting is performed on the basis of scattered waves obtained according to the CSP method. Using the material processing according to the CSP method, we obtain two time volumes: standard time volume, which is the reflector volume, and time volume characterizing an acoustic heterogeneity of geologic environment, which is the diffractor volume.

Reflector volume serve as a basis for development of the fault block model for the field under study. The identification and tracing of the targeted reflective horizon, development of the fault block model are performed based on reflector volume time sections. The created fault block model and all geological and field data are imported to the diffractor volume that is a basis for forecasting of formations with a fractured-cavernous reservoir.

Microseismic emissions occur in the zones of currently living faults and in the zones of open natural fracturing. These zones are recorded during the passive microseismic monitoring. The principle of method of the microseismics inverse problem solution according to the SMTIP (Seismic Moment Tensor Inverse Problem) technology is a digital processing of data of the passive microseismic monitoring of deep-seated events (including the HFR) based on the mathematical algorithms of inverse problem solution for determination of the right side of differential equation system [4-6]

Specialized processing of seismic exploration data according to the CSP technology allows to detect natural open fracture zones and zones of faults that are not healed. Thus the passive microseismic monitoring in combination with the specialized processing of seismic exploration data according to the CSP technology can solve the problem of mapping of the open fracture zones, with which the fractured-cavernous reservoirs are connected.

The hydrocarbon deposits at the Oimasha fields are confined to Middle Trias carbonate deposits and granitic intrusion rocks. Basic type of reservoir contained in these deposits is the fractured-cavernous-type.

The 3D seismic survey has been performed at the field, the data of which were processed according to the CSP technology, and the passive microseismic monitoring has been performed in the area of wells No. 9 and No. 16. The data obtained allow to perform the combined interpretation of the results processing according to the CSP technology and passive microseismic monitoring.

Results of combined interpretation for well No. 9

Well No. 9 is drilled in an area of large-scale faults of sub-latitudinal strike. This fault in the Middle Trias carbonate igneous rocks (production horizon T_2) has created the fracture zone that is mapped in scattered wave field. Production horizon T_2 on the time sections is controlled by the reflective horizon V_2^{II} in roof and by the reflective horizon V_2^{IV} in bottom. During testing of the production horizon T_2, the oil influx of 150 m^3/s was obtained with 15 mm flow choke. This fact indicates the presence of high-quality fractured reservoirs.

Let's consider the results of the combined interpretation of scattered wave field and passive microseismic monitoring data. The figure 1 depicts the stratigraphic control of microseismic emission events.

It is evident that the event cloud falls within a gross interval of the production horizon T_2. It is evident from the scattered wave sections that the microseismic event cloud falls within an anomaly of scattered wave field with high amplitude values that is created by a fractured-cavernous-type reservoir with high permeability and porosity (Fig. 1). The same picture is as well observed in the three-dimensional space (Fig. 2). The microseismic event cloud corresponds with an anomaly of scattered wave field characterized by high amplitude values.

Results of combined interpretation for well No. 16

Well No. 9 is drilled in an area of influence of large-scale northwest-striking fault within the most elevated portion along the granitic intrusion roof. The anomalous zones of scattered wave field characterized by high amplitude values are mapped in the most elevated portion of granitic intrusion based on the results of the specialized processing of seismic exploration data according to the CSP technology. These zones are created by formations with a fractured-cavernous-type reservoir having high permeability and porosity. During the well testing, the oil influx with flow rate of 102 m^3/s was obtained with 13 mm flow choke from the granitic intrusion. There are no reservoirs in the Middle Trias and Lower Jurassic deposits.

The figure 3 depicts a location of the microseismic event cloud in the structural geometry of the granitic intrusion roof and related to location of the well No. 16. It is evident from this figure that the microseismic event cloud is oriented according to the fault strike, i.e. from south-east to north-west. The microseismic event cloud is concentrated within the interval of the high amplitude values of scattered wave field. Tests have shown that the oil deposit is concentrated right in this interval.

The figure 4 shows a location of the microseismic event cloud related to anomalies with the high amplitude values of scattered wave field in three-dimensional space. The positional connection of the results of studies undertaken is the most clearly demonstrated in the three-dimensional view.

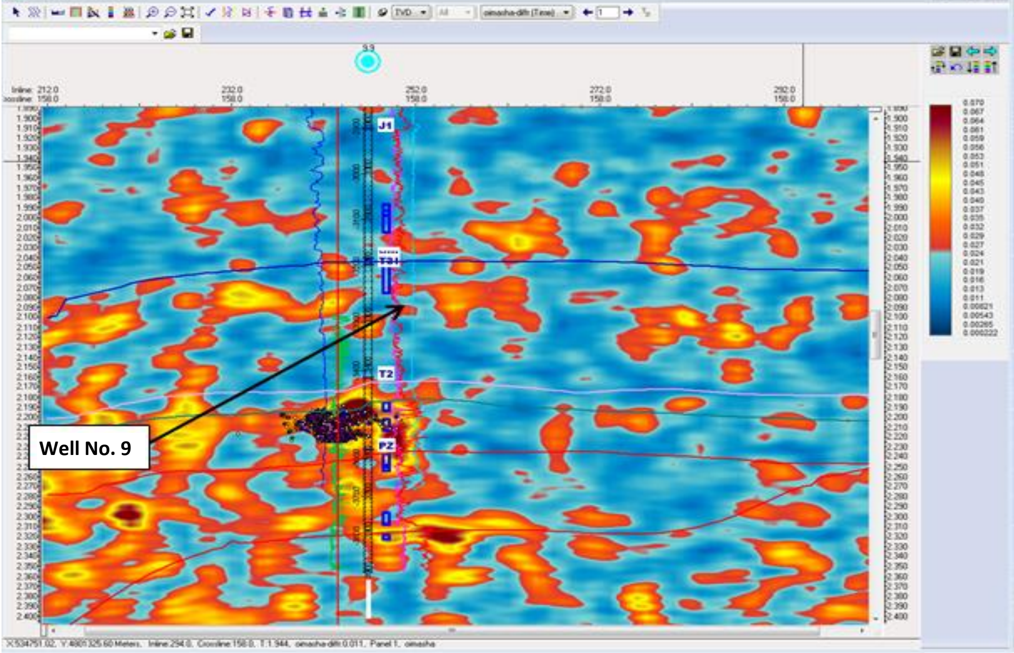

Fig. 1. Segment of scattered wave volume time section with a projection of the microseismic event cloud of the well No. 9.

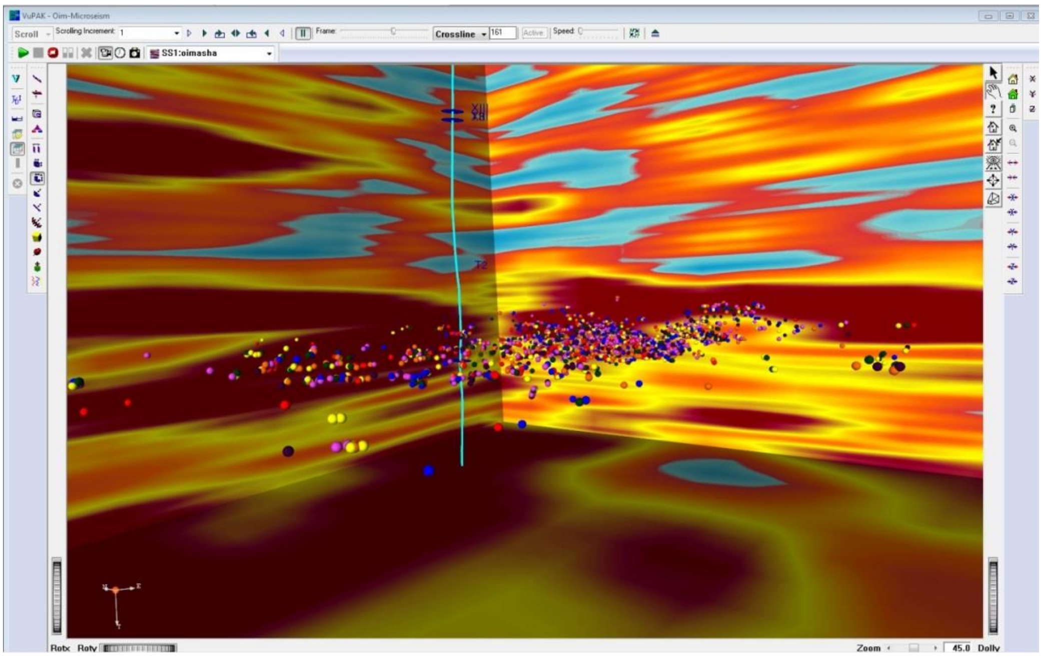

Fig. 2. Location of microseismic event cloud of the well No. 9 in the scattered wave volume. Projection on the time sections.

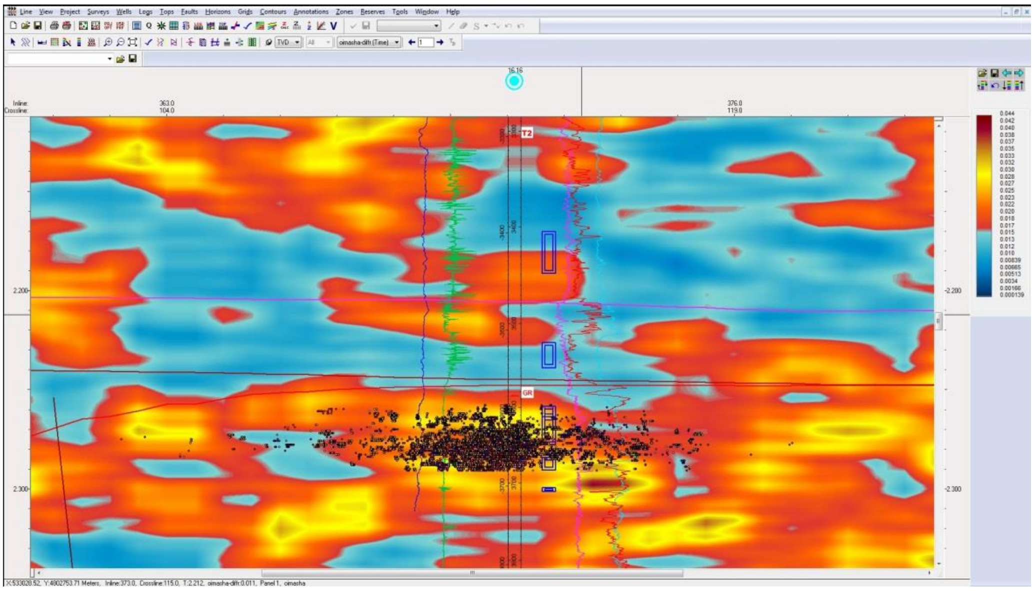

Fig. 3. Segment of scattered wave volume time section with a projection of the microseismic event cloud of the well No. 16

Conclusion

The combined interpretation of the results of passive microseismic monitoring at the Oimasha field demonstrated the following:

- The microseismic events and anomalies of the high values of scattered wave field occur in the open fracture and drainage zones;
- It is possible to definitely forecast the position in space of the open fracture and drainage zones based on the results of combined interpretation of data of the passive microseismic monitoring and specialized processing of seismic exploration data according to the CSP technology;

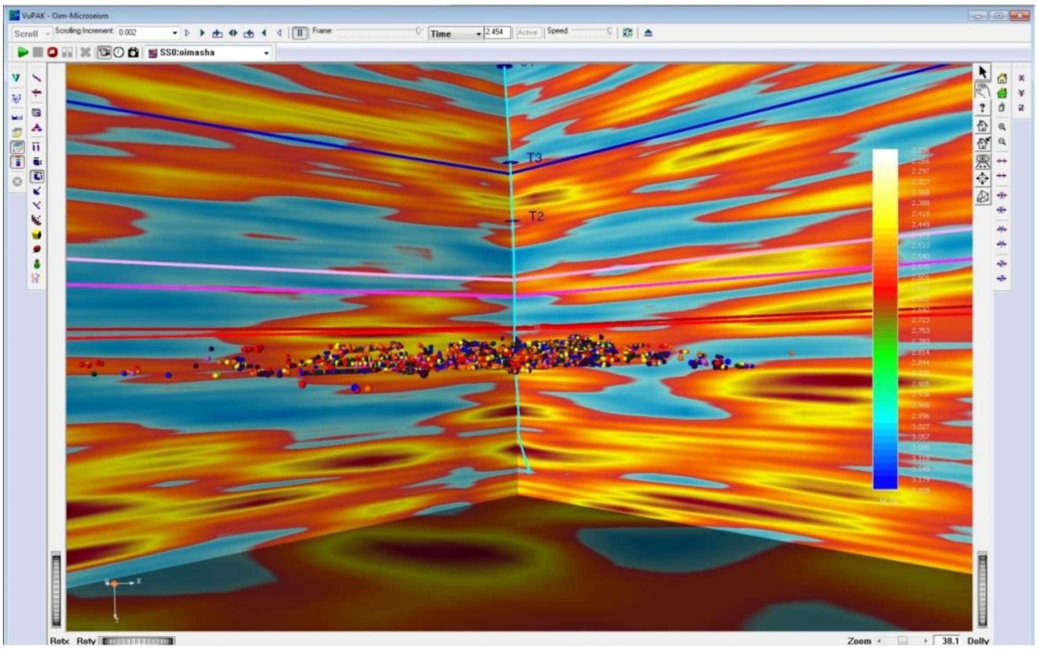

Fig. 4. Location of microseismic event cloud of the well No. 16 in the scattered wave volume. Projection on the time sections.

- It is necessary to provide the passive microseismic monitoring in the recommended well locations during the seismic exploration works in the regions where the formations are present in the column when the fractured-cavernous reservoirs are possible to be located;
- Use of results of the combined interpretation of data of the passive microseismic monitoring and specialized processing of seismic exploration data according to the CSP technology can significantly improve an effectiveness of exploration drilling.

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