B024

Fracture and Cavernous Reservoirs Prospecting by the CSP Prestack Migration Method

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SUMMARY

Results of fracture and cavernous reservoirs forecasting using scattered waves extracted from multichannel seismic data are presented. The forecast is based on an original prestack migration method – the Common Scattering Point (CSP) method, which enables constructing two independent seismic cubes: a conventional cube with reflectors and a new cube with diffractors – the image of space distribution of acoustic impedance inhomogeneities. The last are joined with fracture or cavernous zones – strong sources of scattered waves. The method was tested on synthetic data and in areas with oil deposits in carbonate and shale rocks.

Introduction

A considerable part (25-50%) of the world oil hydrocarbon resources is accumulated in fracture/cavernous reservoirs. These reservoirs usually do not reflect but scatter seismic energy. For layered sediments amplitude of the scattered waves is by 1-2 orders of magnitude less intensive than that of the reflected ones. That's why fracture/cavernous reservoirs are usually missed, when conventional seismic data processing is used, and special efforts are needed to reconstruct the scattering objects.

CSP method

The CSP method is an original time prestack migration method which enables extracting scattered waves from entire 2D/3D multichannel seismic field. It makes possible to construct two independent seismic cubes: a conventional cube with reflectors and a new cube with diffractors – the image of space distribution of acoustic impedance inhomogeneities.

The CSP method is based on a strict mathematical solution of the problem of extracting scattered waves from entire wave field. It marks the CSP method out of other approaches – see, for example, Kozlov et al. 2004. The CSP method was implemented on a specialized computer cluster with 12 Teraflops performance using Message Passing Interface (MPI) parallelization technique.

In Figure 1, the result of the test of the CSP method on 2D synthetic data is displayed. The model consists of three layers (top of the image). The intermediate layer 50 m thick contains five circular inclusions with the diameter of 40 m with different velocities. Amplitudes of the waves scattered by these inclusions are from 50 (left inclusion) to 250 (right inclusion) times less than those of the reflected waves. The time section obtained with the use of conventional time prestack migration method (middle of the image) shows only the reflecting interface while the scattering elements can not be seen. Whereas the diffractors are distinctly visible (except the fifth one, acoustically less contrast) in the section obtained with the use of the CSP technology – see bottom of Figure 1.

Examples

The CSP method was tested on several oil deposits in Western Siberia. Two of them are presented downward.

In the first example oil deposits are located in carbonaceous rocks of the Devonian basal complex and are confined to its upper part. The reservoir is of cavernous fractured type. Deposits are massive and not controlled structurally. The filtration properties of the reservoir are distinctively lateral and vertical related. Maximum oil inflows are from organic limestones. The predicted thickness of the reservoir varies from 0 to 100 meters. The left part of Figure 2 shows the combination of CSP-diffractors and CSP-reflectors cubes. Here and further on the diffractors are presented in red. The right part contains the forecast map of reservoir distribution zones.

In the second example oil accumulations are located in two productive horizons: in the upper Jurassic and in the basal complex rocks. The basal complex contains effusive rocks both core basal and persilicic, shale rocks and porphyries. At the top of the basal complex (the first meters thick) there is mantle of waste with no reservoirs. In the unweathered rocks the reservoir is cavernous fractured. The reservoir thickness varies between 0 and 50 meters. The deposits are lithologically screened. The upper Jurassic horizon is composed of argillaceous rocks with carbonaceous and siliceous intercalations. The total thickness of these intercalations varies between 3 and 10 meters. The reservoir is formed mainly within these intercalations and is cavernous fractured. The deposits are facial controlled and tectonic screened. The CSP-reflectors and CSP-diffractors cube combination is shown in Figure 3.

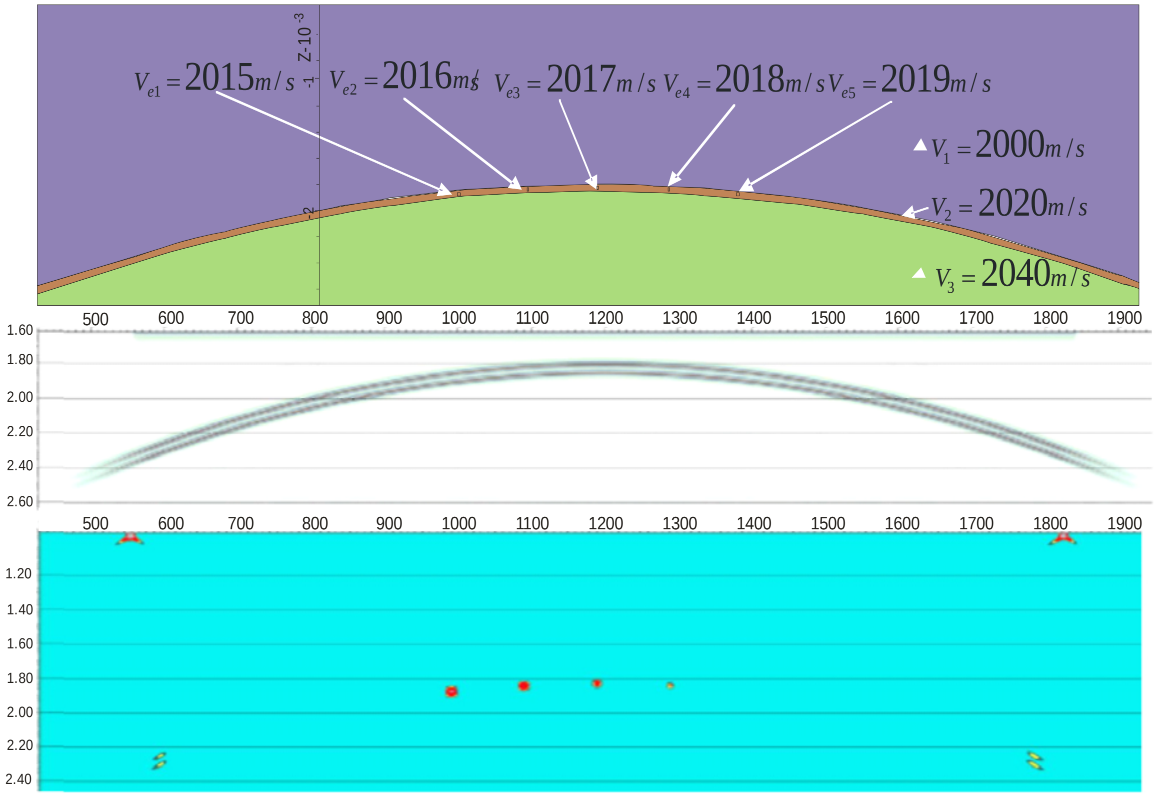

Figure 1: *Synthetic data CSP-method test.*

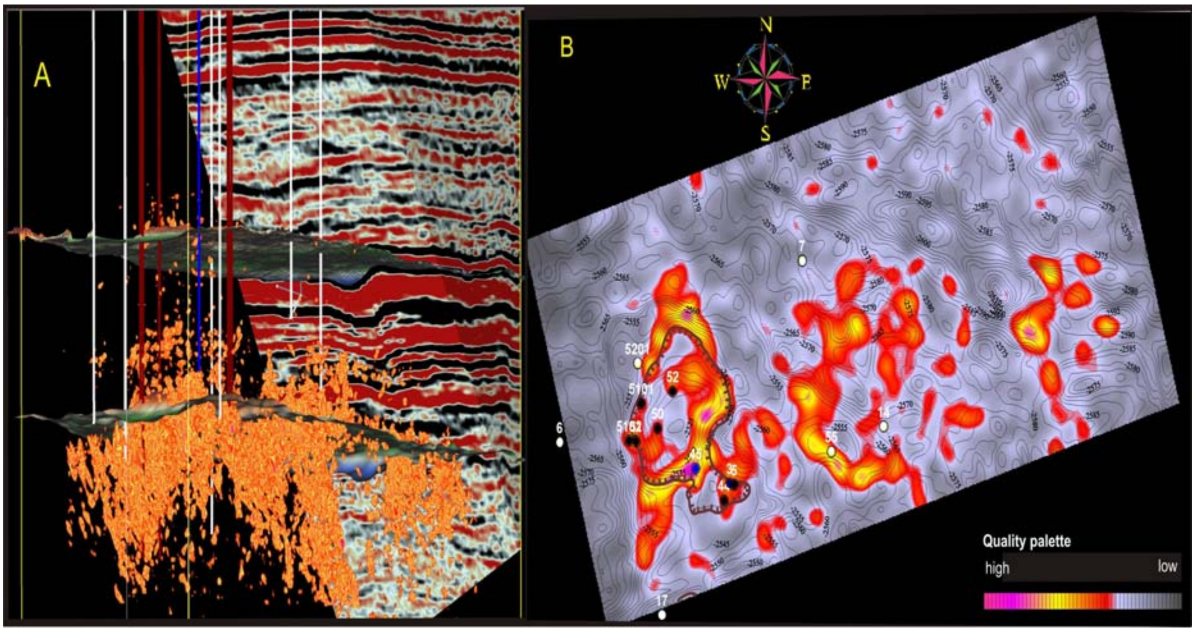

Figure 2: *A – CSP-diffractors and CSP-reflectors cube combination. B – Forecast map of reservoir distribution zones (wells with inflows of oil – black, water – blue, without inflow – white)*

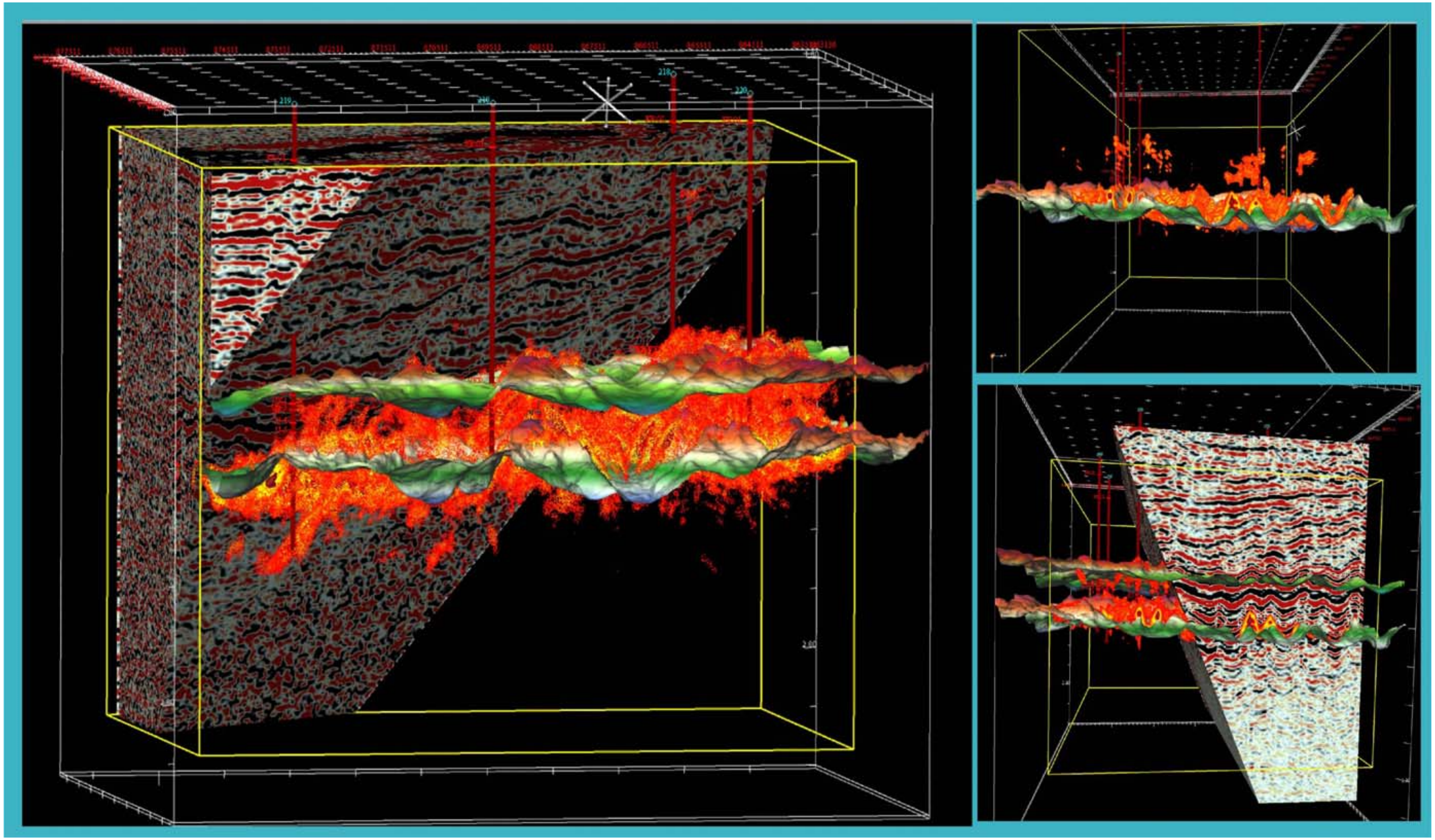

Figure 3: *CSP-reflectors and CSP-diffractors cube combination. The reservoir is formed by the basal complex rocks (effusive rocks, shale rocks and porphyries) and by the upper Jurassic argillaceous rock. The reservoir type is cavernous fractured. The four wells drilled due to the forecast have had oil inflow.*

The forecast map of diffractors amplitude map for A (pre-Jurassic rocks) and B (top of the Jurassic deposits) horizons with oil-productive wells is shown in Figure 4.

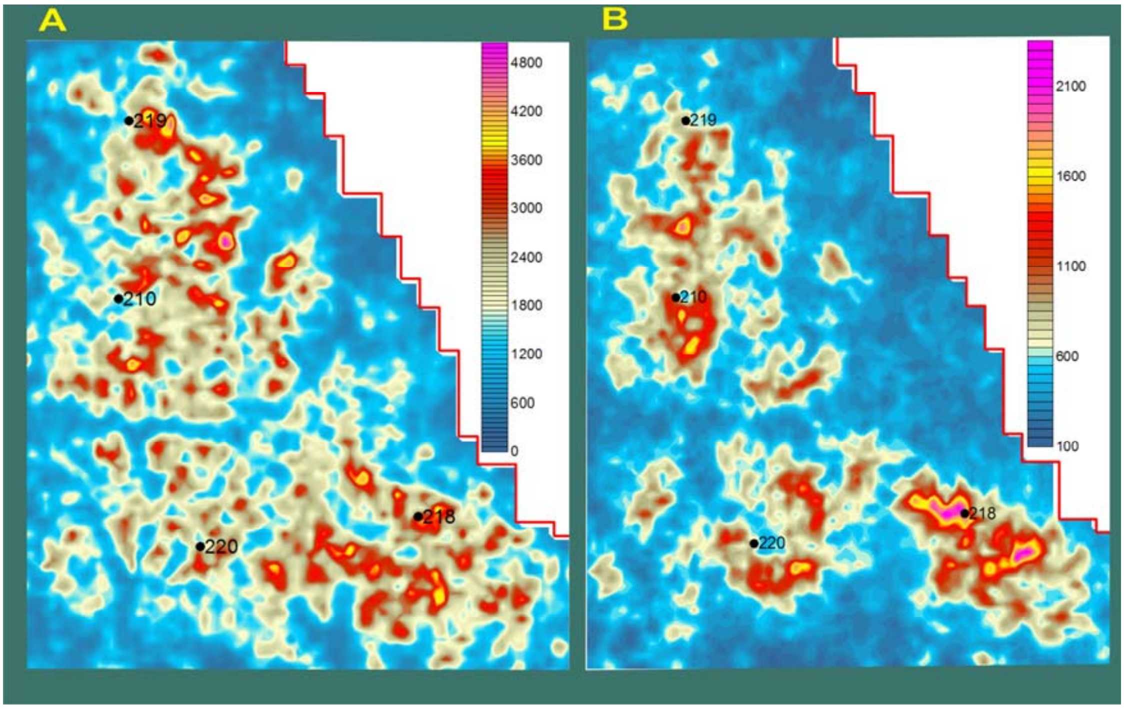

Figure 4: *A – CSP-diffractors amplitude map of the basal complex rocks, B – CSP-diffractors amplitude map of the Jurassic reservoir.*

Conclusions

The CSP method gives the possibility to reveal and to map fracture and cavernous zones with enlarged fluid filter and capacity attributes using conventional multichannel 3D seismic data.

Acknowledgements

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References

Kozlov, E., N. Baransky, E. Korolev, A. Antonenko, and E. Koshchuk, 2004, Imaging scattering objects masked by specular reflections: 74 Annual International Meeting, SEG, Expanded Abstracts, 1131-1134.