VERIFICATION OF BRIGHT SPOTS IN THE PRESENCE OF THIN BEDS BY AVO AND SPECTRAL ANALYSIS IN MIOCENE OF CARPATHIAN FOREDEEP

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Introduction

Gas pay zones in the Miocene siliciclastic fill of the Carpathian Foredeep occur chiefly in unconsolidated sandy and thin-bedded heterolithic deposits of the Machów Formation, which are deformed by compaction-driven antiforms developed above structural highs of the basement (Myśliwiec, 2004). However, such thin-bedded and strongly heterogeneous reservoir rocks tend to generate a misleading signal in terms of direct hydrocarbon indicators on the seismic record, which have resulted in a number of exploration failures. An example of this is provided by compaction traps in the Cierpisz and Mrowla area that drapes two, adjacent and similar basement highs, of which the former yielded producible gas, and the other turned out dry.

In this paper, we present the joint reservoir interpretation by the utilization of AVO analysis and spectral decomposition for verification of seismic anomalies in the Miocene deposits of the Carpathian Foredeep.

Method

The standard procedure used to visualize seismic anomalies caused by gas saturation is the application of seismic attributes. They are additional information obtained from seismic data, allowing to reinforce or quantify the interesting features of the record visually. For reservoir interpretation, we used the post- and pre-stack seismic attributes. From the post-stack seismic attributes, we choose sweetness, which joins instantaneous amplitude and frequency. Areas characterized by high values of the instantaneous amplitude and low values of instantaneous frequency will give high values of sweetness. Therefore, this attribute highlights gas saturation zones but can also be an indicator of contact between clay and sand (high impedance contrast) (Yoshun et al., 2011).

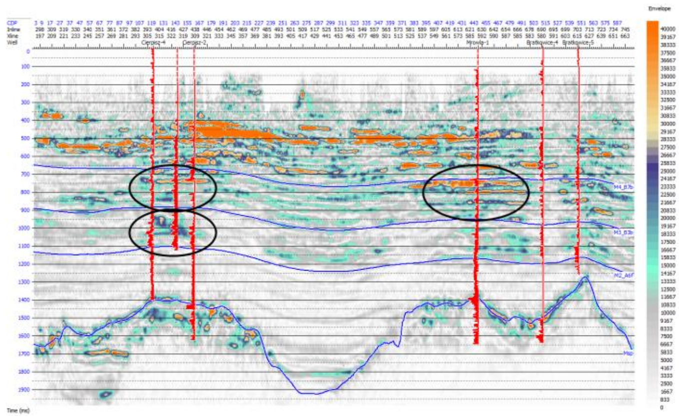

Figure 1. *Seismic arbitrary line in sweetness attribute.*

From the group of AVO pre-stack attributes, we have chosen the Fluid Factor attribute (Fatti et al., 1994). The Fluid Factor incorporates P-wave reflectivity (R_P) and S-wave reflectivity (R_S) at the zero-angle incidence estimated by the Geostack method form CMP gathers. The basic idea of the Fluid Factor is that brine-saturated clastic silicate rocks define a "mudrock line" trend when plotted on the V_P-V_S cross plot (Castagna et al., 1985). Points that lie away from the mudrock line can be suspected of being hydrocarbon saturated. The Fluid Factor is defined as a difference between reflectivity calculated from mudrock line and the actual P reflectivity.

Spectral decomposition enables study in detail amplitude and phase changes in a time-frequency domain. By applying the method, it is possible to analyze in detail how amplitude and phase values are distributed in a seismic section for a given frequency. This ability is of the overriding importance since the hydrocarbon-bearing zone behaves as a high frequency filter of a seismic signal (Castagna and Sun, 2002).

Results

The analysis of the sweetness (Fig. 1) showed high values in the reservoir zone in the area of C-2 and M-1 well. However, it also shows anomalous values outside of them. This effect may appear due to the lithological variability and changes in sedimentation of the Miocene strata (i.e. anomalies above the M4 horizon).

Fluid Factor (Fig. 2) significantly reduced anomalous zones. Anomalies between horizons M4 and M2 correlate with gas saturation in the well data. Only small individual anomalies remain above M4 horizon. Gradient analysis of these anomalies shows AVO IV class. Hydrocarbon saturation in one of these anomalies is confirmed in B-4 wellbore.

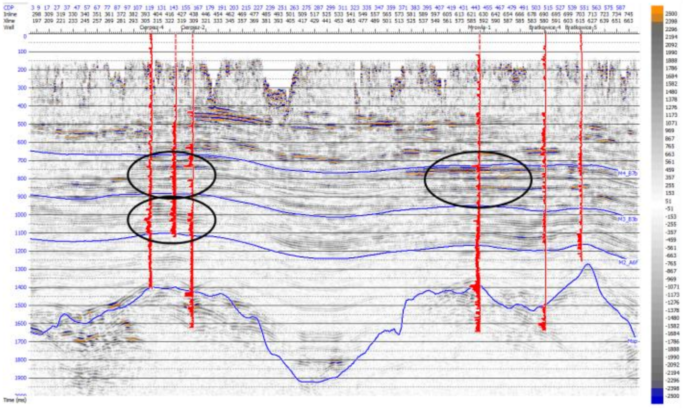

Figure 2. *Seismic arbitrary line in Fluid Factor attribute.*

We applied amplitude and phase analysis for the two targets zones and noticed that there exist a similarity in the phase behaviour of a seismic signal. On the other hand, analysis of amplitude frequency (Fig. 3) show that there is a difference between anomalies above Cierpisz and Mrowla basement highs. The frequency analysis gives additional information and can differentiate between anomalies that were a subject of the research. We performed the frequency analysis using different algorithms and tested the decomposition parameters. All the methods gave similar solutions but were slightly different in details.

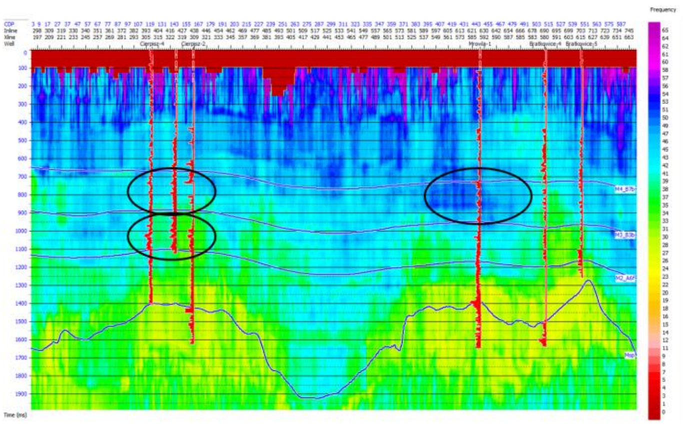

Figure 3. *Seismic arbitrary line in average frequency attribute.*

Conclusions

Seismic data interpretation using only post-stack attributes in thin beds sediments of the Carpathian Foredeep does not allow for unambiguous verification of anomalies. The application of pre-stack attributes significantly reduced the ambiguity of reservoir interpretation. Except for several bright spots that are confirmed by well data, on a seismic section can also be seen single shallow anomalies that show AVO IV class behaviour. Reservoir interpretation in the area of the Carpathian Foredeep requires integration of all available seismic data, both post-stack and pre-stack. Frequency analysis enabled to verify the results of AVO analysis and was integrated to perform a comprehensive reservoir reasoning for the study area.

References

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