PS Using Seismic Inversion and Seismic Stratigraphy as a Combined Tool for Understanding a Small Scale Turbidite System: Gola Field, Pannonian Basin, Croatia*

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Abstract

Goal of the study was to identify and define small scale turbidite system of upper Miocene retrogradational depositional system in the Drava basin, using seismic inversion and seismic stratigraphy tools, in combination with attribute analysis. The studied seismic volume covers a part of the Drava depression and includes the Gola gas field. The quality of data is crucial for interpreting geology through seismic; therefore, methods of increasing the seismic resolution while preserving the amplitude spectrum and dominant dip were applied. Seismic-stratigraphy-based analysis greatly assists in the geological constraint or "geovalidation" of interpreted seismic stratigraphic relationships and provides potentially critical insight into stratigraphic and structural problems of nonunique interpretations (Pigott, 2010). The fact that the variability of reflectors' characteristics indicated lithology changes within a horizon was taken into consideration. For such small-scale turbidites, every seismic reflector contains more than one facies not only horizontally, but also vertically oriented. Therefore, every seismic reflection and its variations in amplitude spectrum in the Gola gas field were interpreted as a horizon. Channels were interpreted in such a way that their relative geological age was respected. The sequence of deposition was studied by Wheeler scenes; depositional system was interpreted; and the lithology was estimated and correlated with well data. Seismic facies were singled out and interpreted. Additional attributes were analysed to confirm obtained results, such as spectral decomposition attribute, that was used to indicate changes of facies, and coherence attribute which was used to define the main channel flow direction and depositional infill. Results gained from these analyses, such as continuity and spatial distribution of turbidite channels were verified by a seismic inversion (method of deriving seismic parameters, such as acoustic impedance, from reflection seismic data constrained by borehole data (e.g., Sheriff and Geldart, 1995)). Acoustic impedance inversion is applied for reservoir-quality characterization; generally lower acoustic implies better reservoir properties, i.e., porosity. When unified, interpretations obtained from this workflow lead to an understanding of chronostratigraphic significance of seismic-reflection correlations, and allow a more detailed study of stratigraphic traps and small-scale turbidites.

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Using seismic inversion and seismic stratigraphy as a combined tool for understanding a small scale turbidite systems: Gola field, Pannonian basin, Croatia

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INTRODUCTION

Goal of the study was to identify and define small scale turbidite system of Upper Miocene retrogradational depositional system in Drava basin, using two mayor tools; seismic inversion and seismic stratigraphy, including attribute analysis. Gola field is situated in Northern part of Croatia in Drava depression. Geological evolution and hydrocarbon potential of Drava depression is related to complex geology of southern Pannonian basin, i.e. North Croatian basin (Pavelić, 2001) during the Neogene and Quaternary.

Complex geological situation is a consequence of transpressional events in the Oligocene, as well as continental rifting processes during syn-rift phase and alteration of lacustrine to marine sediments, and finally compressional phase affected in the Pliocene. It resulted with more than 6000 m (Saftic et al., 2003) of sediments produced in Drava depression.

Conglomerates and sandstones of the Lower and Middle Miocene and Pannonian sandstones represent hydrocarbon reservoirs in the western part of Drava depression (Saftic et al., 2003).

In the Croatian part of the Drava depression, 30 gas and oil fields were discovered, of which 23 are presently producing oil, gas condensate or gas.

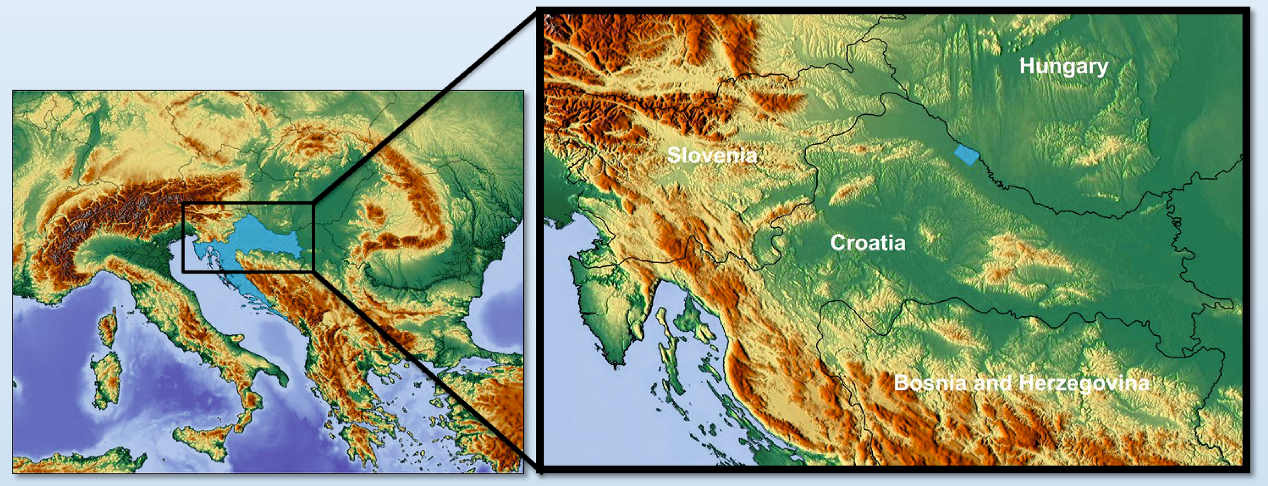


Figure 1. Location of studied area

METHODOLOGY

The studied seismic volume was recorded in the area of the northwestern part of Drava depression, and includes gas field Gola. Seismic stratigraphy based analysis greatly assists in the geological constraint or "geovalidation" of interpreted seismic stratigraphic relationships and provides potentially critical insight into stratigraphic and structural problems of nonunique interpretations.

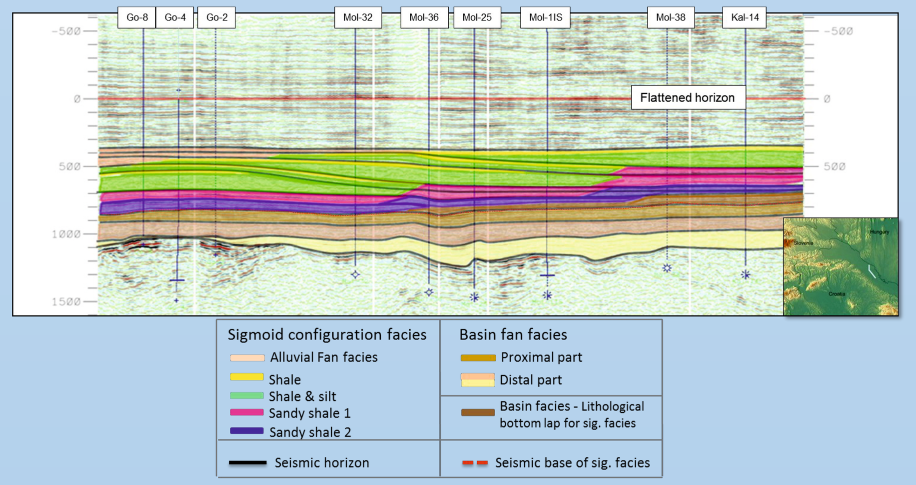


Figure 2. Shematic profile of strathgraphic system

The fact that the variability of reflex characteristics indicated lithology changes within a horizon was taken into consideration. For such small scale turbidites, every seismic reflex contains more than one facies not only horizontally, but also vertically. Therefore, every seismic reflex and its variations in amplitude spectrum in Gola gas field area were interpreted as a horizon. Channels were interpreted in such a way that their relative geological age was respected, and thalweg tracker was used for 3D channel visualisation.

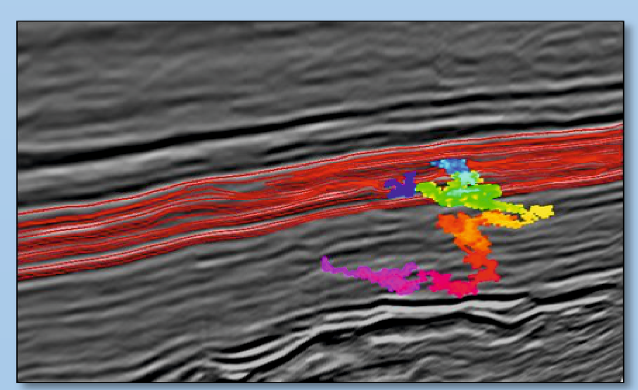


Figure 3. 3D view of turbidite flow

Seismic facies were singled out and interpreted. Additional attributes were analysed to confirm obtained results, such as spectral decomposition attribute, that was used to indicate changes of facies, and coherence attribute which was used to define the main channel flow direction and depositional infill. Attribute analyses include similarity, spectral decomposition and RMS amplitude. Similarity confirmed the direction of deposition and channel systems, a spectral decomposition gave detailed facies within a certain time window.

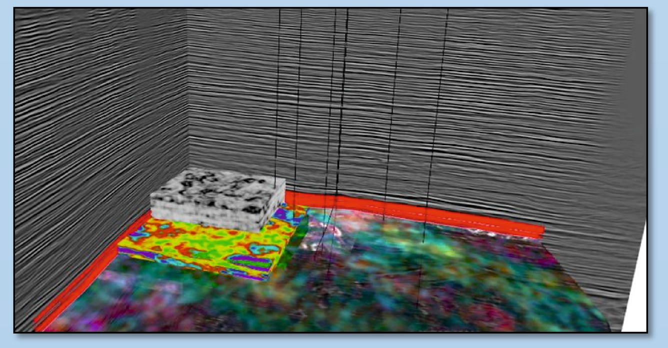


Figure 4. 3D view of attribute cubes

Results gained from these analyses, such as continuity and spatial distribution of turbidite channels were verified by a seismic. Acoustic impedance inversion is applied for reservoir quality characterization, generally lower acoustic implies better reservoir properties i.e. porosity. We use seismic inversion as reservoir characterization tool for confirmation sequence analysis of turbidites reservoirs.

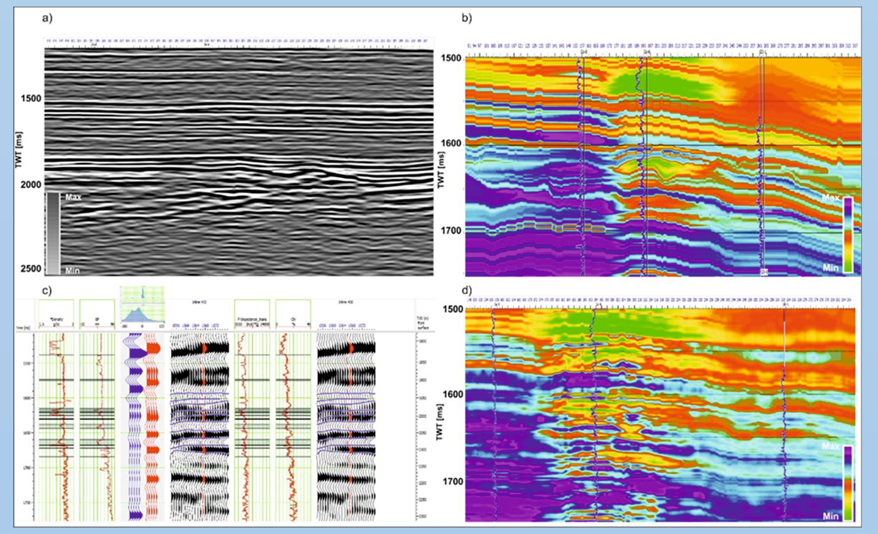


Figure 5. Seismic inversion of acoustic impedance workflow. (a) Post-Stack seismic section, (b) Acoustic impedance model incorporate well log data (P-wave and density), horizons which makes distribution of values in the area, (c) seismic well tie, (d) absolute acoustic impedance.

RESULTS

Horizons are of a non-regional character, mainly following the channel fills whose relative geological age was respected. In order to better distinguish horizon properties and add geological meanings to it, each lateral and vertical change in seismic reflex amplitude was analysed. Such procedure was beneficial for seismic facies determination, with the lithological meaning added to the correlation with the borehole data. The succession of the investigated deposits can be separated into the agradation-retrogradation older sedimentation system and the progradation younger sedimentation system. The agro-retrogradation system includes the turbidite complex deposited in the basin and slope basin areas, while the progradation system belongs to the deposits of the upper part of the slope and the slope.

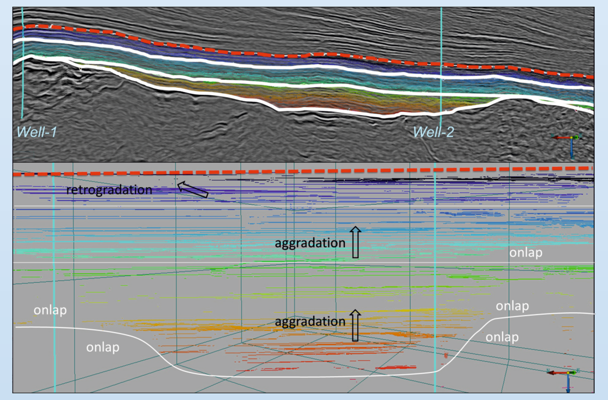


Figure 6. SSF sequence with Weeler diagram

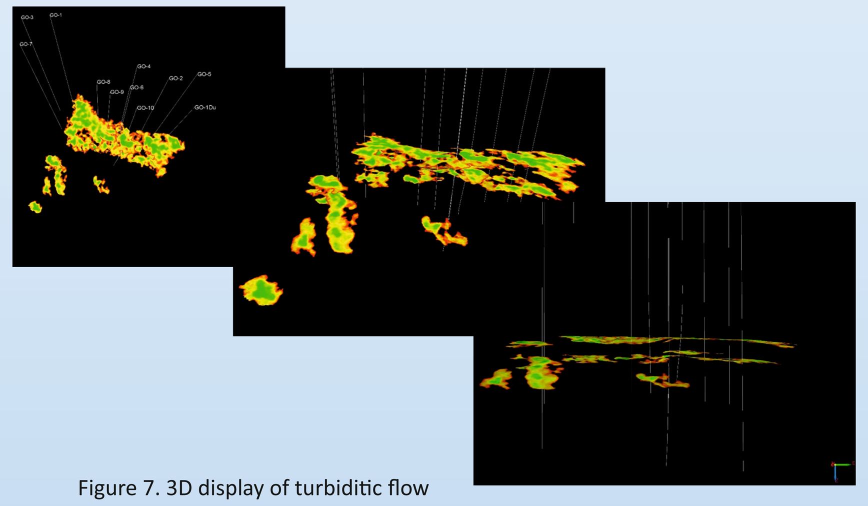


Figure 7. 3D display of turbidite flow

For the purposes of estimating the hydrocarbon saturation within certain turbidite flows, seismic inversion was used. Spatial distribution was confirmed by analysis of acoustic impedances. Seismic inversion was a final analysis which confirmed the results of seismostratigraphy analyses. Correlation with the petrophysical parameters confirmed the best reservoir properties within the seismic facies representing the turbidite sediments.

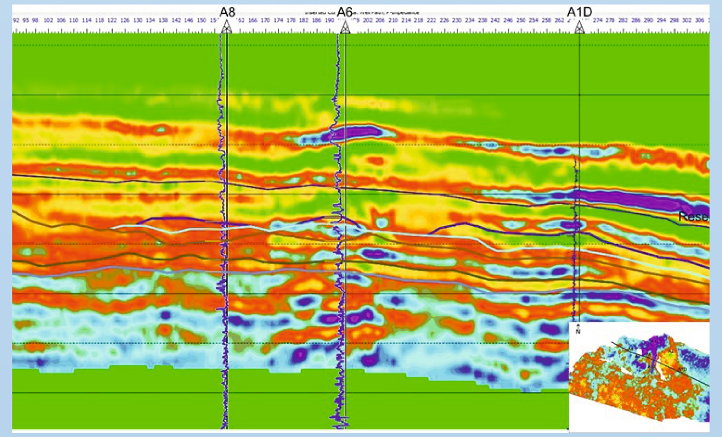


Figure 8. Absolute acoustic impedance section with interpreted horizons

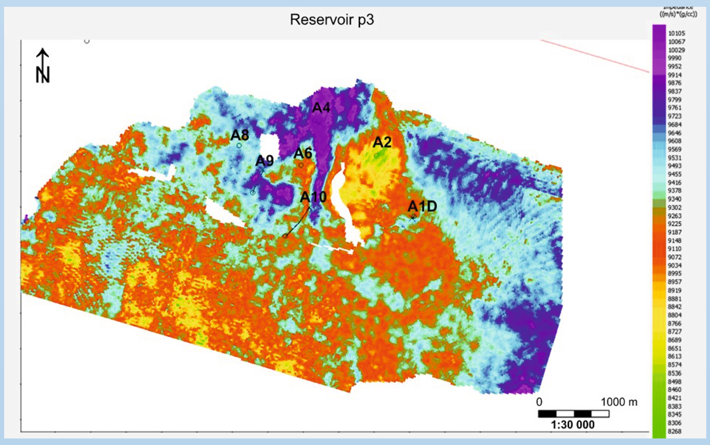
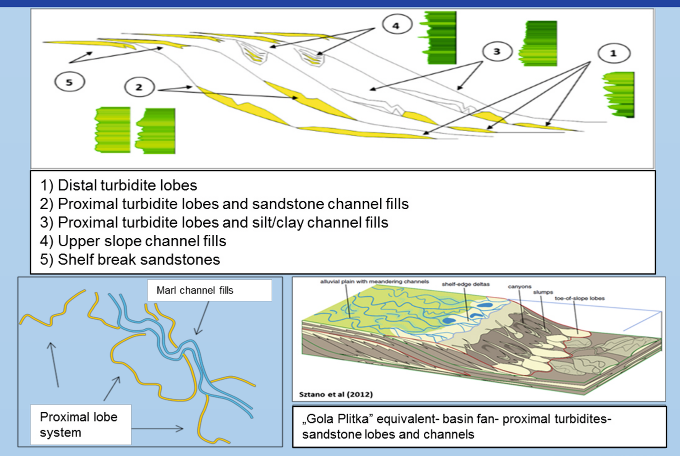


Figure 9. Absolute acoustic impedance reservoir map

CONCLUSION

When unified, interpretations obtained from this workflow lead to an understanding of chronostratigraphic significance of seismic-reflection correlations, and allow a more detailed study of stratigraphic traps and small scale turbidites. Furthermore, by combining these two separated methods and attribute analyses used for better seismostratigraphic analysis, isolation of not only deposits as seismic anomalies was accomplished, but their sedimentological properties was attributed to them through geophysical characteristics.



Sztano et al (2003)

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