THE USE OF DIP GUIDED FILTERING AND BEAM PARTITIONED ANALYSIS FOR ADVANCED SEISMIC STRUCTURE ENHANCING PROCESSING

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Introduction

To acquire refined seismic targets, the use of more accurate and more precise methods of seismic signal processing is crucial. Novel seismic processing approach is even more important in case of complex geology of mountainous regions (e.g. Carpathians, Carpathian Foredeep) where sub-vertical layering of varying rock complex can be found, but also in case of old seismic data reprocessing (especially when the signal to noise ratio and general quality is low). Regardless of many research papers and significant progress in seismic processing techniques, a properly processed and interpreted seismic image is still hardly affordable for this region (Zaręba 2018). Obtaining a new value of straitened to process seismic data is a core function of the presented research. The use of dip-guided filtering combined with beam partitioned analysis for reprocessing of 3D seismic data (in *Omega Schlumberger Geophysical Data Processing Platform*) from the Carpathian inner-mountain basin region has been studied.

Samples and methods

It has been observed that using advanced signal processing methods based on guided filtering and beam partitioning analysis can significantly improve the signal to noise ratio and estimation of local signal magnitude (He et al. 2013, Randen et al. 2000). It has been proved that similar procedures based on image processing improved the final seismic section for structural interpretation by preventing edges, true dips, and enhancing the signal in Carpathian Foredeep (Zaręba 2018). However, due to increased demand for high-quality seismic data processing in challenging regions, the use of new procedures is extremely necessary for subtle targets imaging. This issue has been addressed in many scientific articles relating to the Carpathians region (Zareba 2018, Myśliwiec et al. 2004). It is caused by a specific mosaic type of flysh rocks tectonic in Carpathian Foredeep and high values of dips in the mountainous part of the region (Mysliwiec et al. 2006, Moryc 2005). This research is focused on two techniques of signal processing which have been used in digital image processing and are adapted for novel seismic needs. The first one is named DGF (dip-guided filtering) and it is based on Gaussian low-pass smoothing filter (Randen 2000) combined with impulse response in a 3D cube:

$$F(d) = \frac{1}{\sqrt{2\pi\sigma}} \exp(-0.5\ \frac{d^2}{\sigma^2}) \qquad (1)$$

where the parameter d is the distance from the particular seismic trace, σ is the standard deviation of the distribution (in practice it is equal to the filter width defined by geophysicist) and F(d) is the filter response. Typically smoothing filters reduce different types of noise but it also reduces vertical and lateral resolution. It is unwanted phenomena in case of seismic investigation for detailed geological targets. Smoothing can reduce or remove information about dips and faults which are important in case of planning for oil and gas or water explorations, and other purposes like a geological investigation for the construction of power stations. To prevent such behaviour the beam partitioned analysis of input data is performed for dips field estimation. First, the input data are transformed into a specific set of elements (beams) that should represent only locally planar geological elements. Secondly, the reconstruction process is performed in which the cleaner image, residual image, and beamlets are obtained. It is a process of interactive iterations in which the quality control of the residual image is performed. The final seismic image is obtained when residual representation contains only noise. Thirdly, the dips estimation using image form second step is performed to obtain energy representation of dips in a 3D cube, dips azimuths and quality control coherency file. The last step of the presented procedure is to use data reconstructed from beam partitioned analysis as an input for DGF and guide it by an estimated dip filed to prevent detailed information about discontinuities.

Results

It this study, data from the Carpathian region was used. The sub-vertical layering in one part of the mentioned area and almost flat deposits in the second part (on time over 2 s TWT (two-way traveltime) can be found. Their presence and related phenomena of signal destruction in the deeper parts of cube significantly impeded correct imaging of deepest structures (Fig 1a) including information about fault system (Fig 2a). We used presented techniques based on a novel approach for seismic signal processing adopted from digital image processing and deterministic stock market series analysis. The obtained results undoubtful increase the quality of the seismic image. The deep reflection (time 4.4 and 4.5 s TWT) can be easily interpreted and correlated with logs and borehole seismic after applying the presented procedure (Fig. 1b). What more the fault system in a contact zone can be properly examined after it (Fig. 2b).

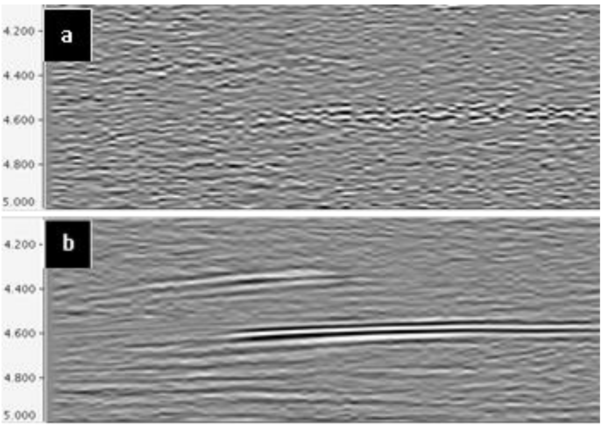

Figure 1. *Seismic image of deep reflection a) before presented procedure; b) after presented procedure.*

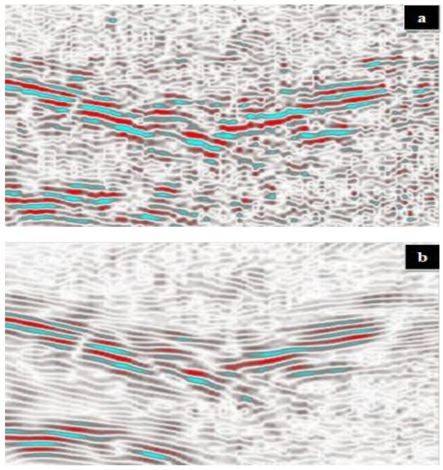

Figure 2. *Seismic image with faults system a) before presented procedure; b) after procedure.*

Conclusions

Nowadays, proper seismic imaging of the geological structures in the mountainous region, where complex geology with the complicated tectonic system can be found, is even more important then it was in the past. The application of presented techniques and algorithms for more detailed and precise seismic processing show the strong legitimacy to use them in the final processing step – before migration (where the role of diffracted waves energy is important) or after (where proper fault system is under consideration).

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