Application of High Definition Frequency Decomposition techniques on Western Siberia reservoirs

Pavel Morozov*, Gaynor Paton, ffA, A. M. Milyushkin, V. V. Kiselev, SeverEnergy LLC, D. N. Myasoedov, LARGEO LLC.

ffA, Premier House, 10 Greycoat Place, London, SW1P 1SB, United Kingdom *Contact: pmorozov@ffa-geosciences.com

Introduction

Frequency Decomposition is an effective tool at identifying both structural and stratigraphic changes in the geology that are represented by frequency variations in the reflected signal. In the reservoir as imaged layers approach the limit of seismic resolution, frequency variation can expose geometries, lithology or porefill variations that are invisible on the reflectivity. Conventional transform based decomposition techniques require applying large windows to the seismic trace in order to accurately identify the frequency response at each point in the data. This leads to poor localisation in time/depth of the frequency measurements, visual 'smearing' of the results and the extension of vertically limited geological features into over and under lying strata.

We present a new interactive technique for frequency decomposition which provides high resolution frequency information with improved localisation in the time domain, identifying geological features up to the limit of seismic resolution. This removes the effect of vertical smearing and enables complex geological features like channels and fan systems to be resolved, with maximum confidence that stratigraphic boundaries are being placed in their correct positions.

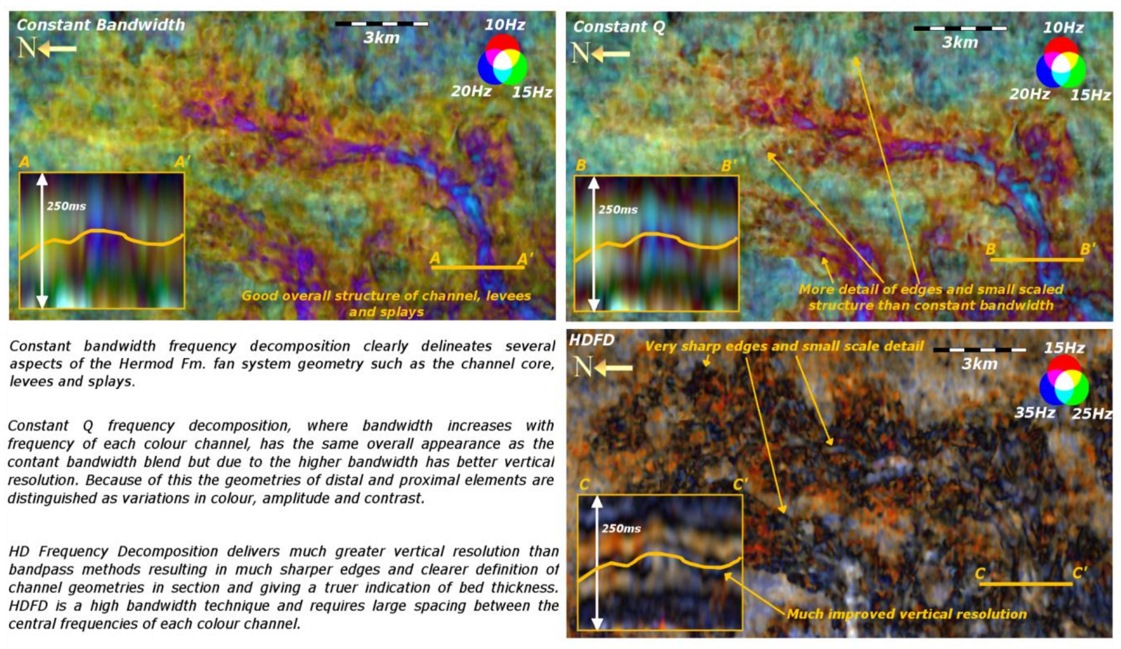
This technique has been applied to data from Western Siberian provinces and was compared with filter based techniques when used to delineate channels, fans and various thin events. This study details the differences in the results achieved with the new technique when compared with those achieved with other methods of decomposition. It was found that applying high definition frequency decomposition provided significantly more insight and confidence when interpreting the results.

Comparison of Frequency Decomposition Techniques

Three methods of frequency decomposition are investigated here whereby the data are decomposed into three distinct frequency magnitude responses which are then colour blended. Constant bandwidth and constant Q are both band-pass methods of decomposition using a Gabor filter. For the constant bandwidth method the width of each frequency response remains constant around a central frequency. This technique is the lowest bandwidth method and because of this, the technique is most successful when individual responses have central frequencies that are close together, allowing for overlap in bandwidth and variation of colour in the blend. Constant Q is a variable bandwidth method, with bandwidth increasing with frequency so that the proportion of power to bandwidth remains constant between different responses.

HD Frequency Decomposition (HDFD) is a technique based on a matching pursuit algorithm whereby each seismic trace is decomposed into a number of individual wavelets, which when summed equate to the original trace. After decomposition into wavelets, a trace can be reconstructed at a given central frequency and different frequency responses blended together. The HDFD technique is the highest bandwidth method used here and the resulting HDFD blends are most successful when the central frequencies of the corresponding red, green and blue colour channels are distributed at intervals across the entire seismic spectrum. A comparison of the three different methods of frequency decomposition applied to a North Sea Eocene dataset is shown in Figure 1.

Fig. 1

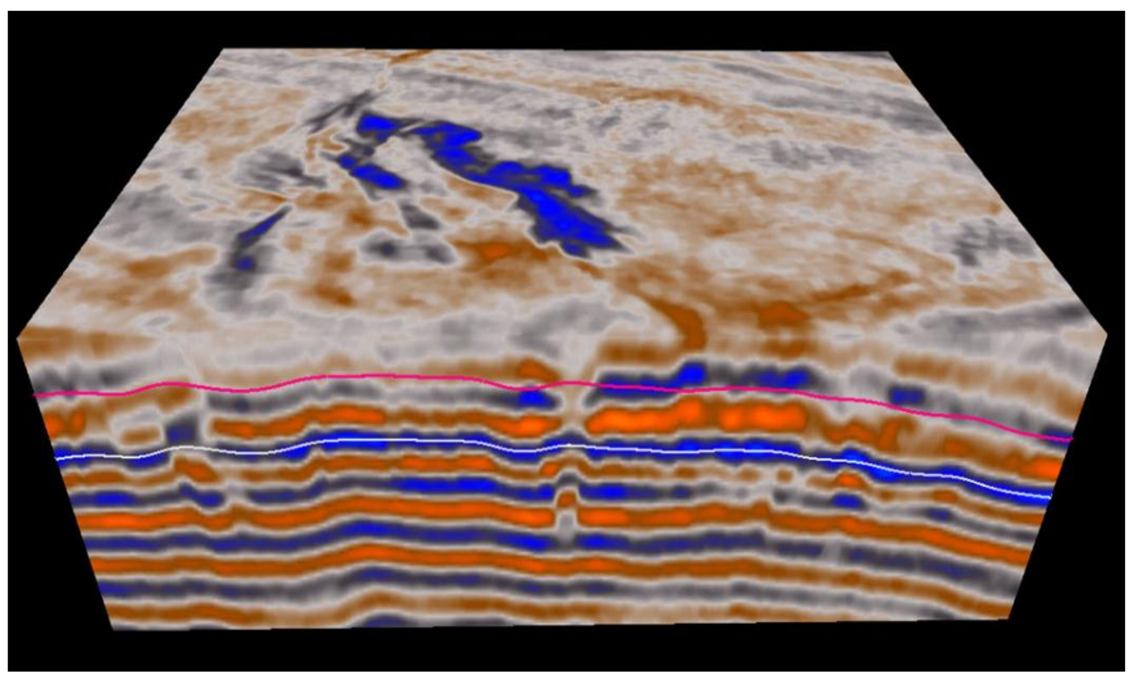


Comparison of RGB blends of Hermod formation submarine fan system generated using different frequency decomposition techniques and mapped onto a horizon (from McArdle and Ackers,2012)

West Siberia Case Study

The data used for this study was a Pre stack time migrated data set from the West Siberia basin, focussing on a braided channel system. The channels are visible in the reflectivity data as high amplitude zones within continuous lower amplitude reflection events. In some places they also exhibit small scale anti-formal structure, rather than incised channel cuts (Figure 2).

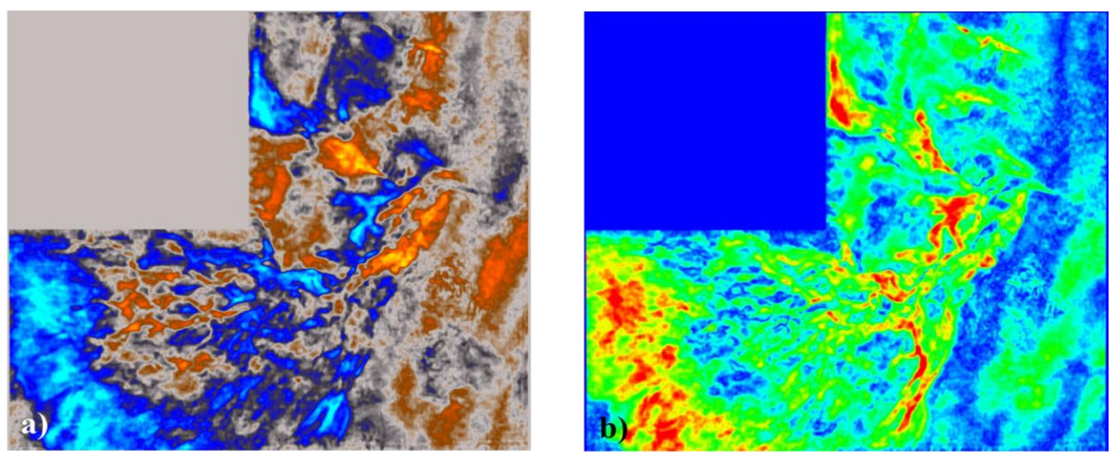
Fig. 2



A N-S line through the reflectivity data showing the seismic expression of the channel system on a vertical section and a time slice. The white horizon is the base package horizon, the pink horizon is the base package shifted up by 32ms and is the horizon slice used for later images.

Instantaneous amplitude extraction along a horizon within the zone of interest is effective at highlighting the major channels of the system but does not provide information on the more subtle channels associated with the main system (Figure 3). Frequency Decomposition and RGB blending provides a more sensitive method of analysing both the amplitude and the frequency content of the data and therefore reveals more information about the channel system.

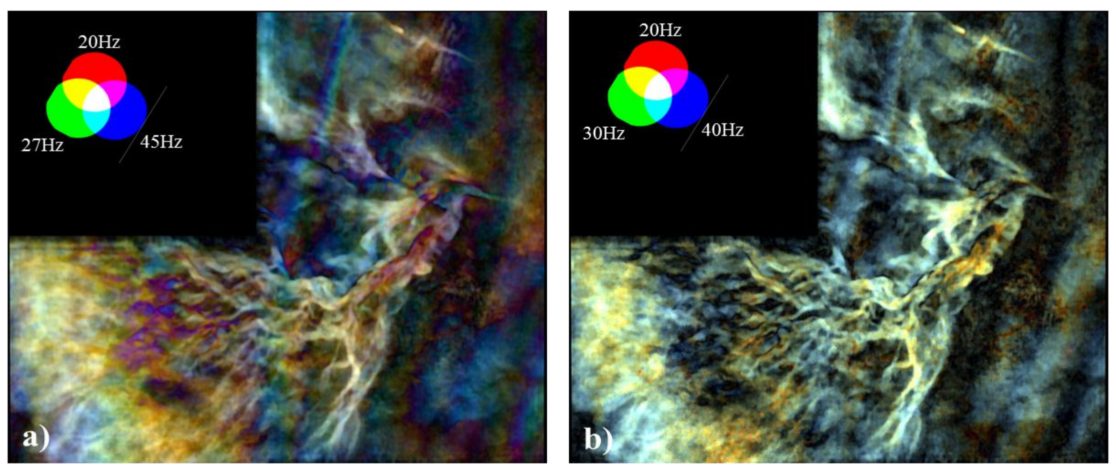
Fig. 3



A horizon slice through the zone of interest showing a) the reflectivity data and b) the full frequency instantaneous amplitude data.

In Figure 4 we show a comparison between the standard definition and high definition frequency decomposition techniques and the instantaneous amplitude extraction. Both the RGB blends reveal more detail on the extent and morphology of the channels when compared with the envelope data, and the high definition technique provides a sharper image with more focussed edges due to the lack of vertical averaging. It also provides greater contrast between the channel system and the surrounding matrix. There is less colour variation in the HD blend due to the higher bandwidths used with this techniques, but it is still possible to determine areas of differing frequency response which are likely to correspond to differing thickness in the channel package.

Fig. 4



A horizon slice through the zone of interest showing a) an RGB blend of three magnitude volumes using a standard frequency decomposition technique b) an RGB blend of three magnitude volumes using a high definition decomposition technique.

Conclusions

This study has demonstrated how frequency decomposition combined with RGB blending can reveal more information about the morphology and extent of a channel system in the West Siberia basin. In particular, the new technique of high definition frequency decomposition has given greater confidence in the positional accuracy of the channels imaged, and has created a sharper image with more defined edges to the channel system.

References

- McArdle,N.J. and Ackers, M.A., 2012, Understanding seismic thin-bed responses using frequency decomposition and RGB blending. First Break, 30,57-6.