Imaging non-specular reflections through a conventional processing workflow

Frederico A. F. de Oliveira, Adelson S. de Oliveira, Margarida M. Okahara PETROBRAS S/A, Brazil

Abstract

Here we present a procedure to separete non-specular from specular signal in regular seismic data using conventional processing tools. It is equivalent to other procedures found in literature like those based on plane-wave destruction filters. Its principal objective is imaging features associated to non-specular reflectors, like surrounding fracturing zones due to more proeminent faults and shortly continuous reflectors whose extension are comparable to the first Fresnel zone. Besides the resulting image, which offers more detail to structural interpretation, its result can be used as an input to a faulting and fracturing attributes extraction.

Introduction

It is assumed that seismic signal is composite of both specular and non-specular energy. Conventional seismic processing sequence privileges the former one since continuity is a parameter for selection of events. The distinction between specular and non-specular reflections lies on the extent of their respective Fresnel's zones, so that even a piecewise continuous reflector can present a non-specular behavoir. Other events like multiple reflections, converted or refracted waves could also present such a behavoir, but their consideration is out of the scope of this work.

Geological features as faults, fractures and rough surfaces are prone to originate non-specular reflections. In a transition from totally uncorrelated to correlated signals, we restrict our interest to events associated with scattering at piecewise continuous horizons. That is, horizons with local discontinuities between soft regions that extents less than Fresnel's zones. This means events that are discontiuous if observed at large areas but can be traced in a smaller scale.

Methodology

It basically consists of obtaining a specular model of the data and its adaptive subtraction from original one.

F-xy deconvolution

It is usually applied in seismic processing for randon noise attenuation. It makes use of the predictability of linearly dipping events in the frequency domain. Events with a short lateral extent are less predictable and tends to be attenuated. Their origins are thought of as being due to non-specular reflections. Therefore the F-xy deconvolution results in specular model of seismic data.

Domain of filter application

A trasformation to $\tau - p$ domain is convenient due to the fact that Radon linear transform privileges continuous events as well as gives a randon behavoir to descontinuous ones, so that they are strongly attenuated by F-xy deconvolution, more than in commom-mid-point (CMP) or commom-source (CS) domains.

Linear Radon transform spreads one sample in $t - x$ to all samples in $\tau - p$ domain in spite of an occasional irregular spatial distribuition, providing a regular representation of the input data. It permits to compensate irregularities in offset distributions, commonlly seen in real data. Although some irregularity in CMP positiong can occurr, the commom-p (or commom moveout)are more homogenuous than CMP or CS gathers.

Retrieving the non-specular portion of the data

The separation between non-specular and specular signals is achieved by an adaptive subtraction of the specular model obtained as above from the input conventional data.

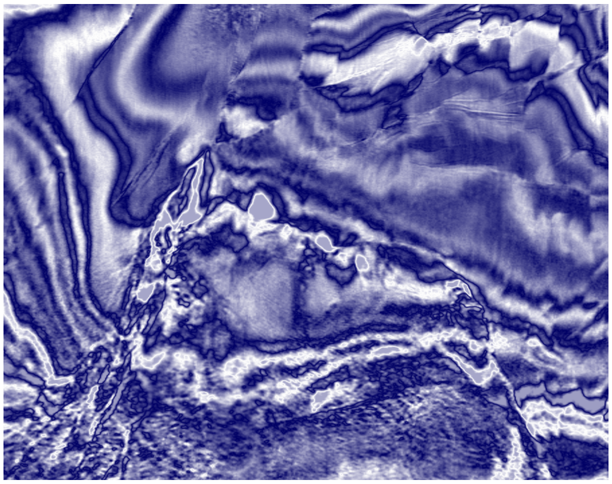
Workflow

1. Radon linear transform of CMP gathers of original pre-processed data;
2. $F - xy$ deconvolution of linear moveout-CMP gathers, resulting the specular model;
3. inverse linear Radon transform, from CMP-linear moveout to CMP-offset;
4. adaptive subtraction of specular model from input data, resulting in non-specular data;
5. migration.

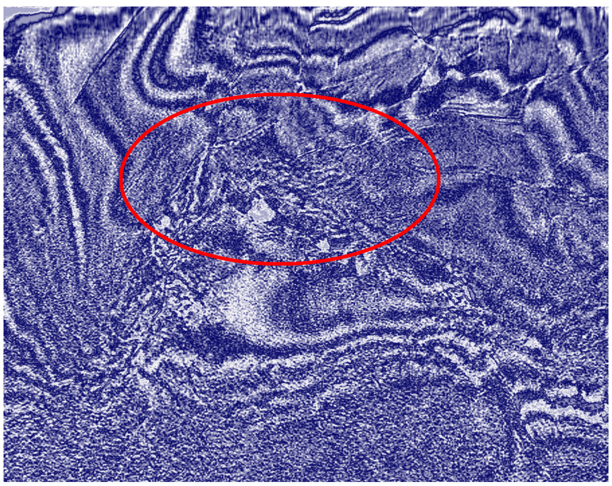
Results

The figure 1 illustrates the same time slice from a time converted PSDM of input data and non-specular data. There is a considerable amount of common features in both figures, but the non-specular data reveal an apparently higher degree of fracturing in the neighborhood of more pronounced faults. On the other hand one observes how attenuated the strong specular reflections were from figure 1(a) to 1(b).

The figures 2(a) and 2(b) show how the enhanced details in non-specular slice agree with the suggested faults on in-line and crossline directions, so that it permits an alternative structural interpretation.

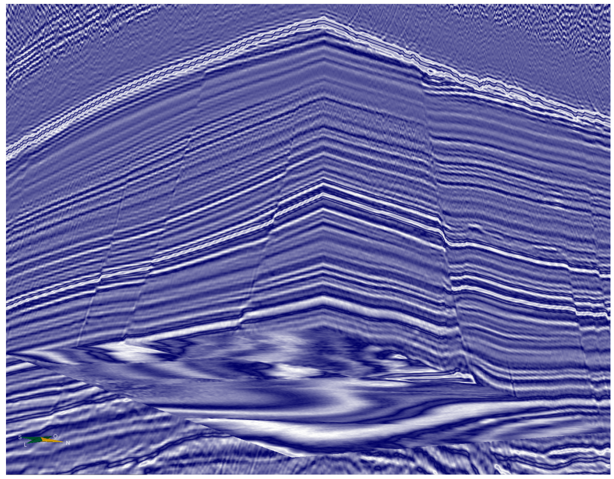


(a) Original data.

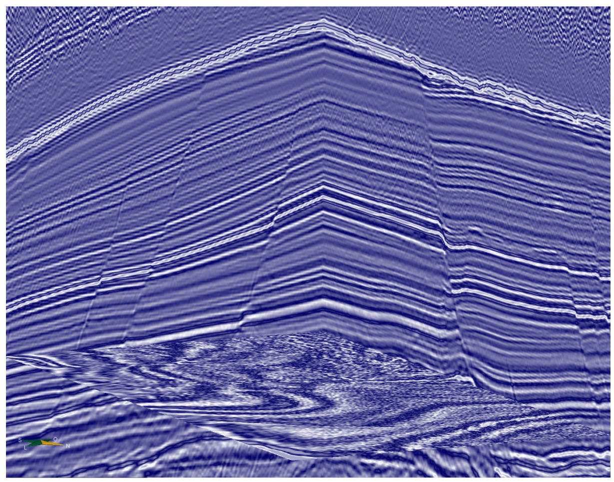


(b) Non-specular data.

Figure 1: Time-slice of time converted PSDM volumes.



(a) Original data.



(b) Non-specular data.

Figure 2: The same time slice as in the previous figures with corresponding inline and crossline sections in perspective. Non-specular slice (b) corroborates and adds concordant details to full-stack (a).

Summary and Conclusions

A workflow to non-specular reflectors enhancement was presented. It is based on the attenuation of non-specular signals via $F-xy$ deconvolution on $\tau-p$ domain in conventional seismic data, followed by an adaptive subtraction of the obtained specular model. The imaging step is achieved by a conventional migration, with the original velocity model.

This technique provides a volume whose lateral resolution is closer to first Fresnel zone so that it is possible to resolve subtle discontinuites, usually obscured by specular reflection signals.

In imaging process, depth migration is recommended, since the wavepath is the same for both specular and non-specular reflections.

References

Aggio, A., de Oliveira, A. S., de Oliveira, F.A.F, Gélio, A. B., Okahara, M. M., Filho, A. M., 2008, Identificar fraturas por filtro de destruição de mergulhos: XI Simpósio de Geofísica da Petrobras, Natal. Resumos expandidos (in CD).

Chase, M. K., 1992, Randon noise reduction by 3-D Spacial prediction filtering: SEG International Meeting, New Orleans, LA. Expanded abstracts.

Fomel, S., 2002, Aplications of plane-wave destruction filters. Geophysics, Vol 67, No. 6 , p1946-1960.

Acknowledgments

To PETROBRAS for permission to publish this work. To geophysicists Sérgio Guimarães, José Luís Carbonesi, Fernanda Thedy and Gilberto Lima for their greateful contribuition both in obtaintion and discussion of the results.