Comparative approach of attenuation methods for multiple events in seismic reflection data

Ygor Bastos Mesquita Minora de Almeida, Carlos César Nascimento da Silva, Rosângela Correia Maciel (UFRN/Department of Geophysics)

Abstract

The multiple attenuation is a fundamental process in the analysis of seismic data, because multiple events may affect the identification of reflectors and reservoirs of interest to the petroleum industry. This work is preliminary, therefore presents only the use of FK filter for attenuate several multiple reflections that occur in the real data, acquired in the region of the Mississippi Canyon, in the Gulf of Mexico. To serve as attenuation control, it was elaborated a seismic model that considers the three main interfaces of real data. From this method it was obtained a good correlation between modeled and real data, as well as, the FK transform was very effective in attenuation of this multiple events.

Introduction

This work is part of the Program of Human Resources of ANP for Oil and Gas Sector (PRH22), which aims the formation of researcher in geology, geophysics and computing at the oil and gas sector in UFRN.

In the context of oil exploration, the seismic data, obtained with the seismic reflection geophysics method is major interpretative information. However, without appropriate processing this data don't present many features that may to make it useful to define the geological interfaces. Thus, the seismic processing is inserted in the "acquisition-processing-interpretation" as one of principal steps to make the raw data reliable in terms of interpretation. But, the interfaces observed in seismic data processed aren't always reflected the geological signal. Often the observed reflections in seismic involve events related to a wave field propagated from the surface that has two or more reflections (multiple reflections), which are included as noise in seismic data (Fig. 1).

Using the Seismic Unix (CWP, Colorado School of Mines), free software, it was sought construct a seismic model and with the SeisSpace (Landmark, version 5000.0.3.0), commercial software, the attenuation of multiple events through the analysis in the temporal vs. spatial frequencies (FK).

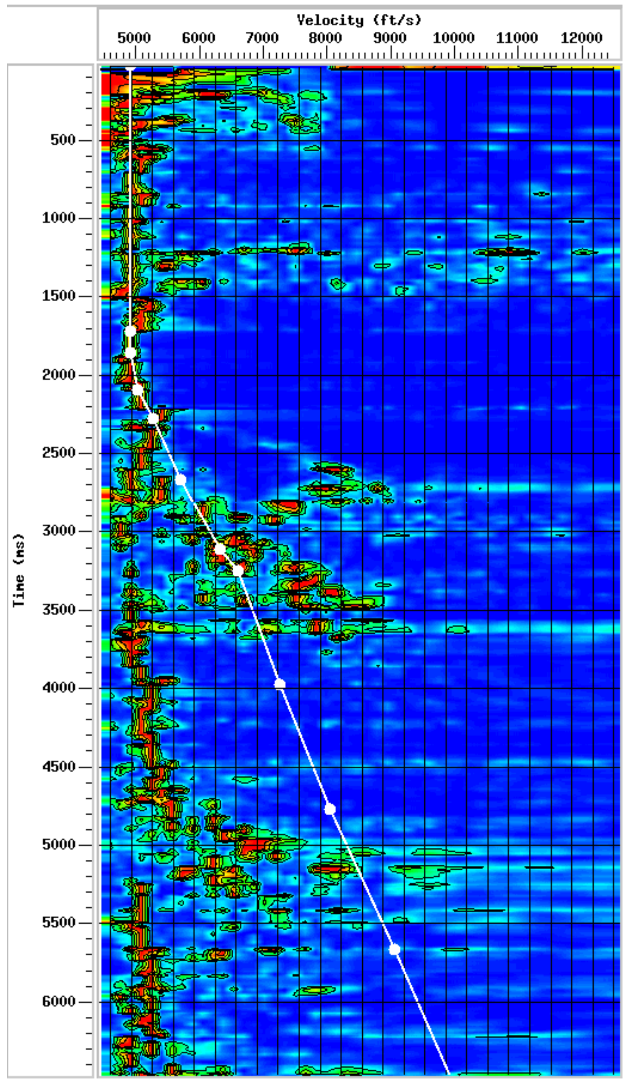

Fig. 1. *Velocity analysis at CDP 1083. If not recognized the multiple field multiple, it can be add incorrect points to the velocity field. Here this field occurs mainly between 3500 and 6000ms. Observe Fig. 9 to identify the location of the CPD 1083 with respect to the salt body.*

Method

The approach used consisted of analysis of multiples attenuation in seismic data, initially in the real data and after in synthetic data based in the real data.

The acquisition represents a 2D seismic reflection survey, conducted in the Gulf of Mexico, Mississippi Canyon region. This data shows three well characterized interfaces that generate very strong multiple events (Fig. 9). These interfaces correspond to the sea bottom, top of the salt body and base of this body. These events obscuring several reflectors, which will complicate a future interpretation of data (Fig. 2).

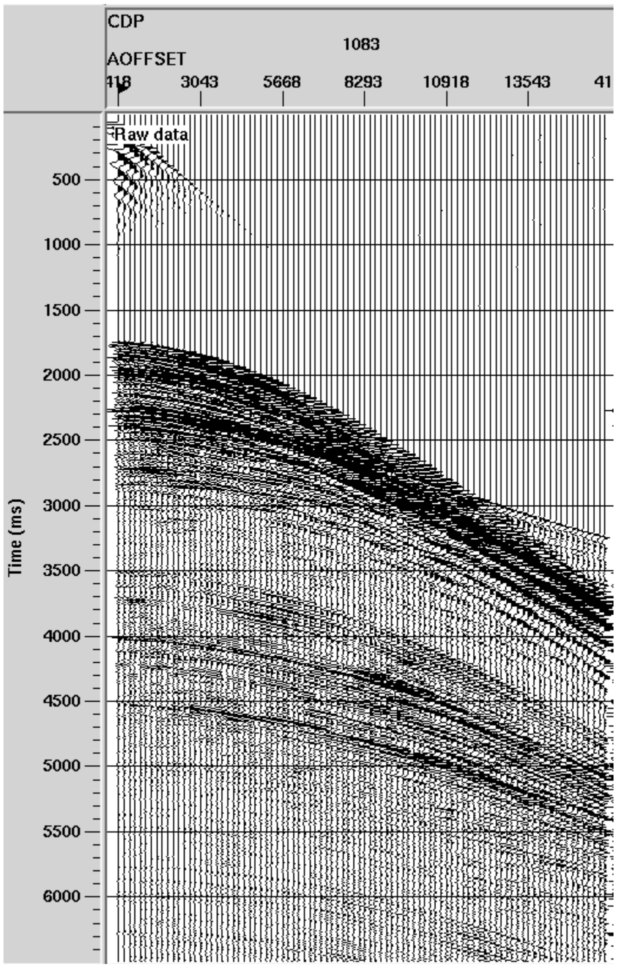

Fig. 2. *CDP 1083, before any processing, showing raw data. One can see intense contamination of data with multiple events, from 3500ms. Observe Fig. 9 to identify the location of the CPD 1083 with respect to the salt body.*

Seismic Modeling

Associated with this data, especially considering the cited interfaces, a seismic model was developed (Fig. 3) with Seismic Unix (SU) Software, which enabled a good control of the geophysical information in order to clearly distinguish each event, with regard to its origin.

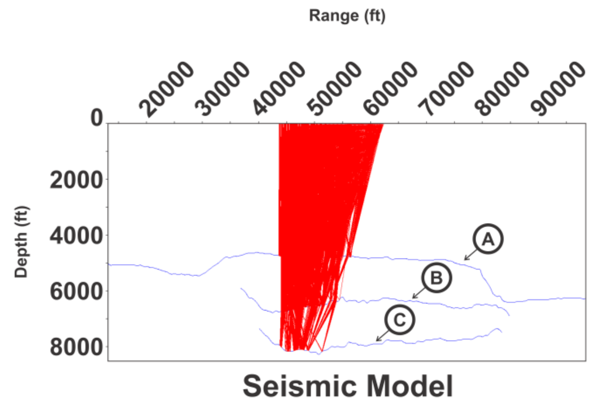

Fig. 3. *Synthetic model developed with SU, where A is the sea floor, B is the top of salt and C is the base of the salt. The red lines represent the ray tracing. To simplify the view in this picture, it was used 1 shot and 180 receivers, according real data. Here is also contemplated the first multiple of the seabed.*

In the development of synthetic data was used the demo 8, contained in SU package (version 42), but modifications were made to suit the interest of research. This demo is based mainly on the FORTRAN routines cshot 1, cshot 2 and SU routine xcshot.

The cshot 1 is responsible for generate information that will be used in the seismic model, incorporating in it the ray tracing, the geometry of each interface, the velocity of each layer, the amount of shots and receivers, the offset, the source and shooting range, and type of event that one wants to view (i.e. direct wave, primary and multiple reflections).

The cshot 2 generates data that will be used in the seismogram, based on information from the seismic model associated with the frequency spectrum of wavelet, wavelet length, sample rate and number of shots and receivers.

The outputs of a cshot 1 and cshot 2 were, then, used by xcshot whose function is produce the image of seismic model and synthetic seismogram.

To generate the seismic model and synthetic seismogram, 3 interfaces were used: the sea floor, the top of the salt layer, and the base of the salt layer, showing each layer its speed. On the other hand, the parameterization used in the data acquisition model, consisted, basically, in the use of 180 receivers, with a minimum offset of 300ft, spacing between them of 100ft and a range of source and shooting of 100ft.

Seismic data processing

In view that this work aimed is the multiple attenuation associated with the sea floor, the processing was done, basically, in three steps, as the flow below:

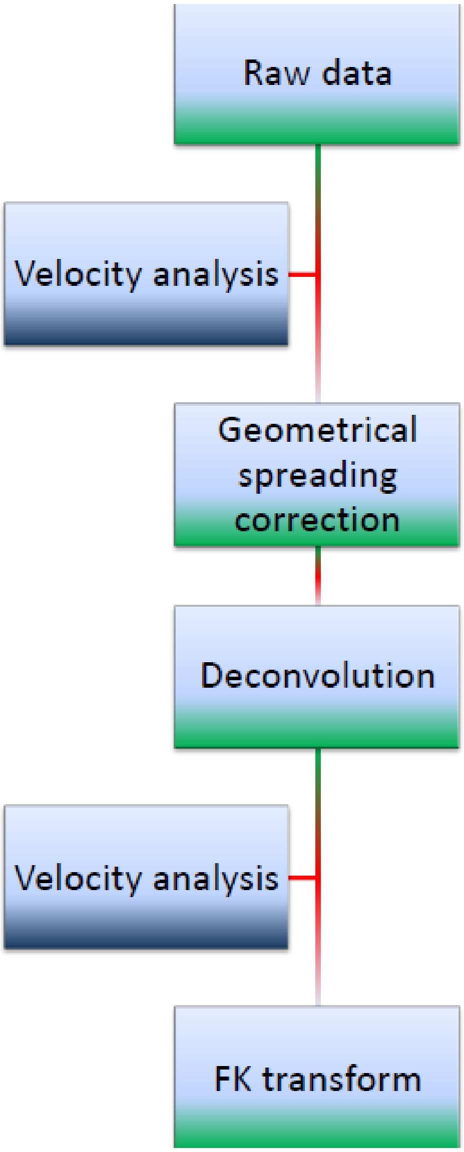

Fig. 4. *Processing flow adopted for multiple attenuation. It is interesting that the data is still at a preliminary stage (not migrated, for example), which reflects the initial phase of the research.*

Results

Regarding the seismic model, there was good correlation between the interfaces obtained with real data and the seismic model, as well as, between the arrival times obtained with real data and model. This could be observed both for the primary reflections and the multiples.

Through of processing flow adopted, one obtains Fig. 5, which shows the data corrected for the geometrical spreading effect. On the other hand, with applying deconvolution one obtains the Fig. 6 and Fig. 9.

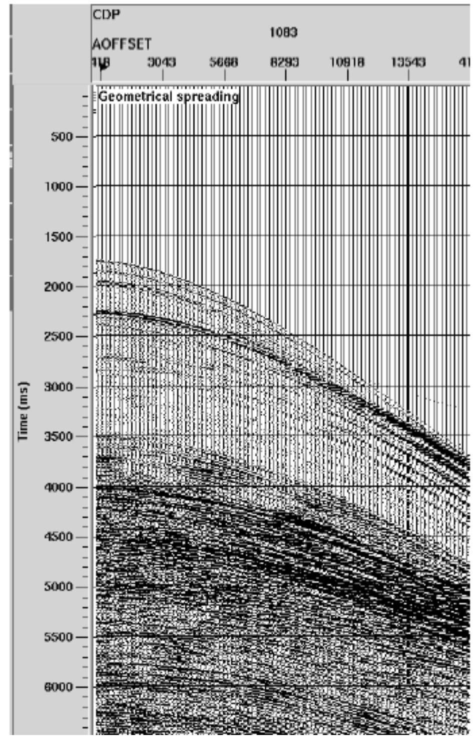

Fig. 5. *CDP 1083 after geometrical spreading correction. Perceives the increased amplitude of the seismic signal, especially for the largest transit times. Compare with Fig. 2.*

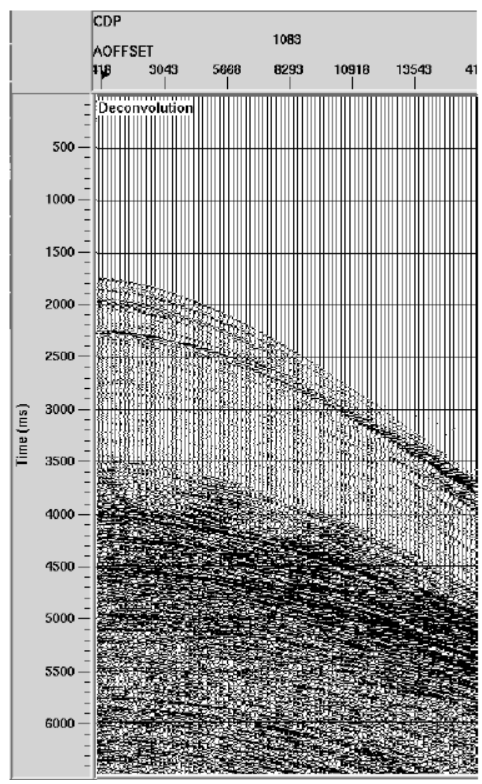

Fig. 6. *CDP 1083 after deconvolution. It can be seen an improvement at temporal resolution (increased frequency). Compare with Fig. 5.*

Finally, it was applied the FK filter, it is a dip discriminator (Fig. 7). With that, one could eliminate unwanted energies present in the seismic data (Yilmaz O, 2001).

The energies of primary and multiples reflections can be separated into different positions in the FK domain. This is possible through the NMO correction using velocity functions. To determine it were done several tests and velocity field that proved most promise was that of multiple. Thus, the multiples in the CDP panel will be NMO corrected and, when analyzed in the FK domain will occupy the null and positive part of wavenumber (K) axis. Because of this, primary reflections aren't corrected properly, staying contained in the negative portion of wavenumber axis. So, Multiples can be attenuated by zeroing the quadrant corresponding to multiple energy in the FK domain (Ryu, 1980; Sengbush, 1983) (Fig. 8).

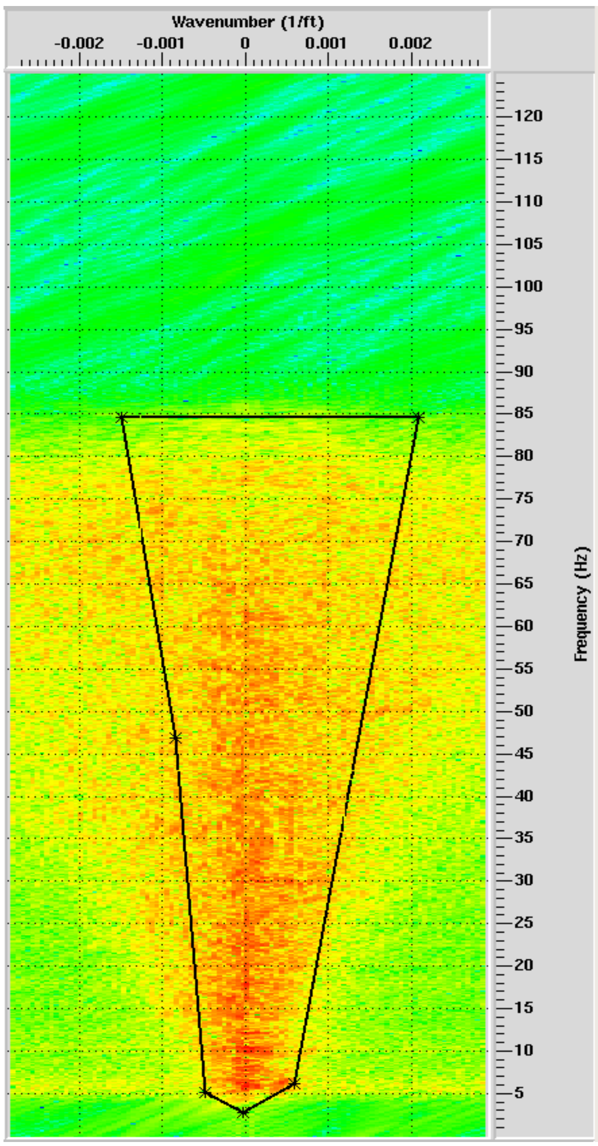

Fig. 7. *The region contained within the black contour is associated with multiple energy. The remaining points in the negative portion of wavenumber axes are related to primary energy.*

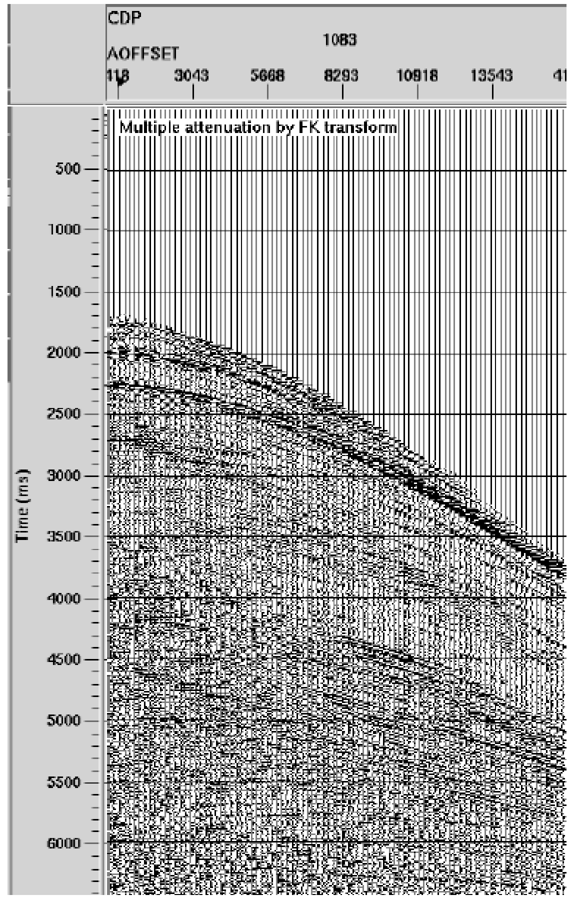

Fig. 8. *CDP 1083 (without NMO correction), after application of FK transform for removal of multiples events. Compare with Fig. 6. Observe Fig. 11 to identify the location of the CDP 1083 with respect to the salt body.*

Conclusions

Through the seismic modeling and analysis of real and synthetic seismograms were identified mainly multiple events. That was crucial, for example, during the velocity analysis, avoiding add to the velocity model points related to multiple events.

The analysis in the temporal vs. spatial frequencies (FK) attenuated rather multiple events between 3500 and 5000ms, allowing the visualization of some reflectors that were previously being masked by the signal of multiple (i.e. increases the signal/noise ratio). See and compare figures 9, 10, 11 and 12.

Tests performed with the Radon method hasn't proved as effective as to the FK transform, but a significant response was obtained with these tests. Then, it is intended to use this method in conjunction with the FK transform to maximize the signal/noise ratio in the next step of this research.

Acknowledgments

We would like to thank the brazilian federal organ: Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP), for research funding. We also thank Landmark for having provided the academic license of SeisSpace. And a special thank for Francisco de Assis Silva Neto from UFPA for his technical support.

References

Ryu, J. V., 1980, Decomposition of seismic gathers into velocity components by a space-time filter: Presented at the 50th Ann. Internat. Mtg. Soc. Expl. Geophys.

Sengbush, R.L., 1983, Seismic exploration methods: Internat. Human Res. Dev. Corp., Boston.

Yilmaz, O., 2001. Seismic data analysis: processing, inversing and interpretation of seismic data, Society of Exploration Geophysicists, Tulsa.

Abreu, A. S., 2005. Processamento de dados sísmicos do Golfo do México usando Seismic Unix.

Cohen, J. K. and Jr., J. W. S. (2008) The New SU User's Manual, Colorado School of Mines.

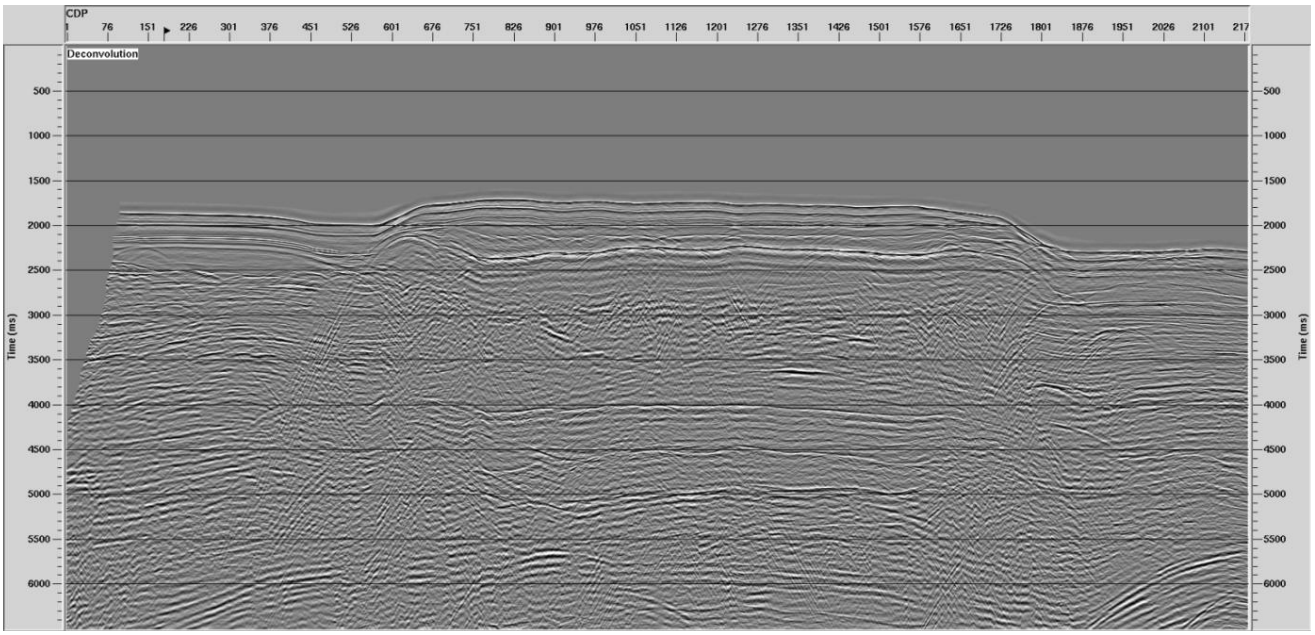

Fig. 9. *Seismic section of the Mississippi Canyon, after application of deconvolution. The sea bottom (1700ms), the top of salt layer (2200ms) and the base of salt layer (2700ms) correspond to some of the interfaces responsible for generate multiple events between 3500 and 5000ms.*

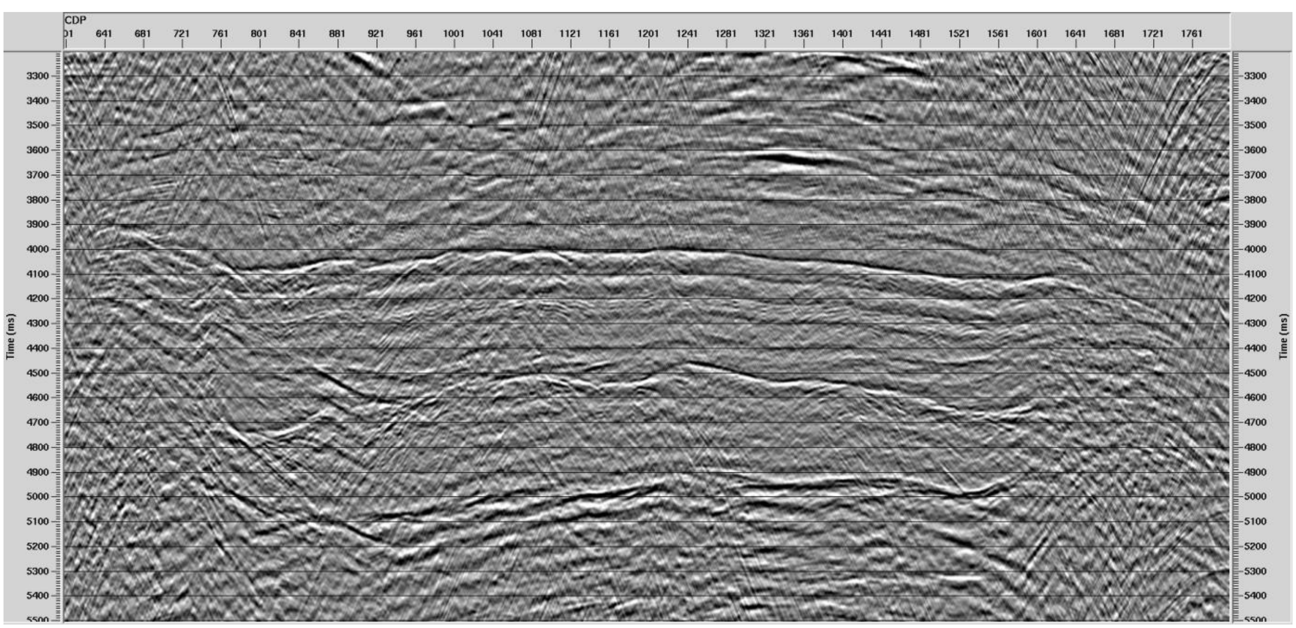

Fig. 10. *Zoom of Fig. 9 in the region contain many multiples. Observe the range between 3500 and 5000 ms, there are many multiples in this interval.*

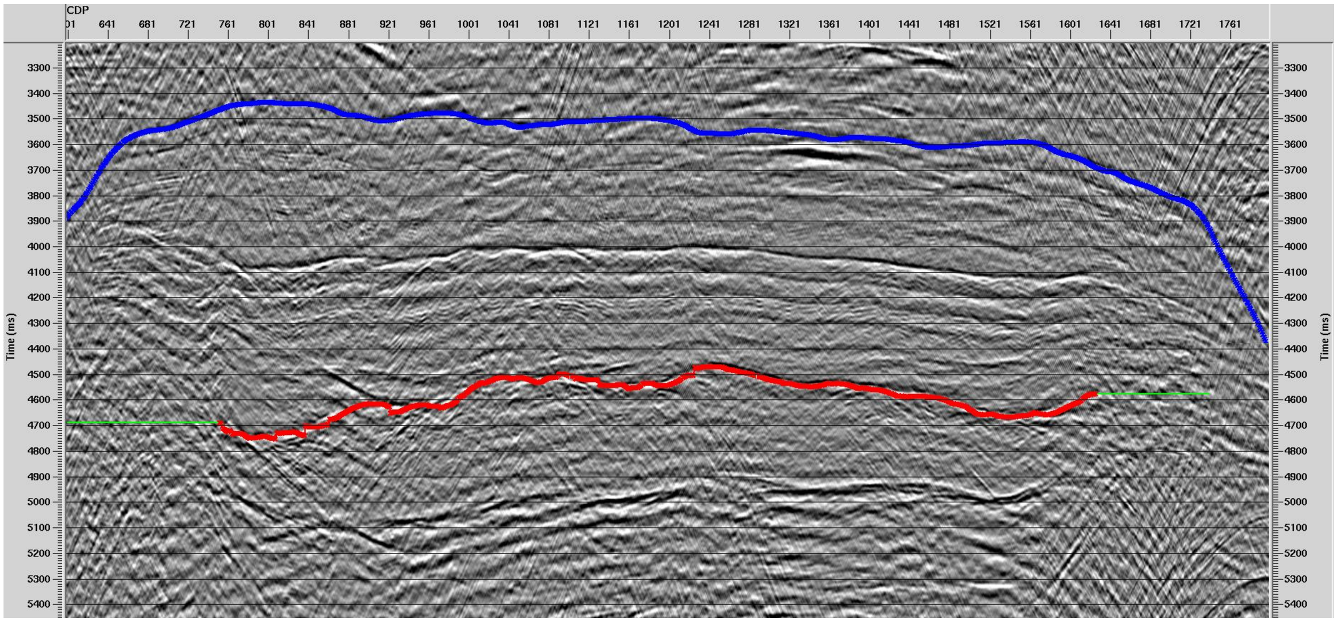

Fig. 11. *The same image of Fig. 10, but here, it emphasizes the multiple of sea bottom (blue) and the multiple of the top of salt layer (red). Note that in 4000 and 5000ms there are multiple reflections occur, however these are internal multiples.*

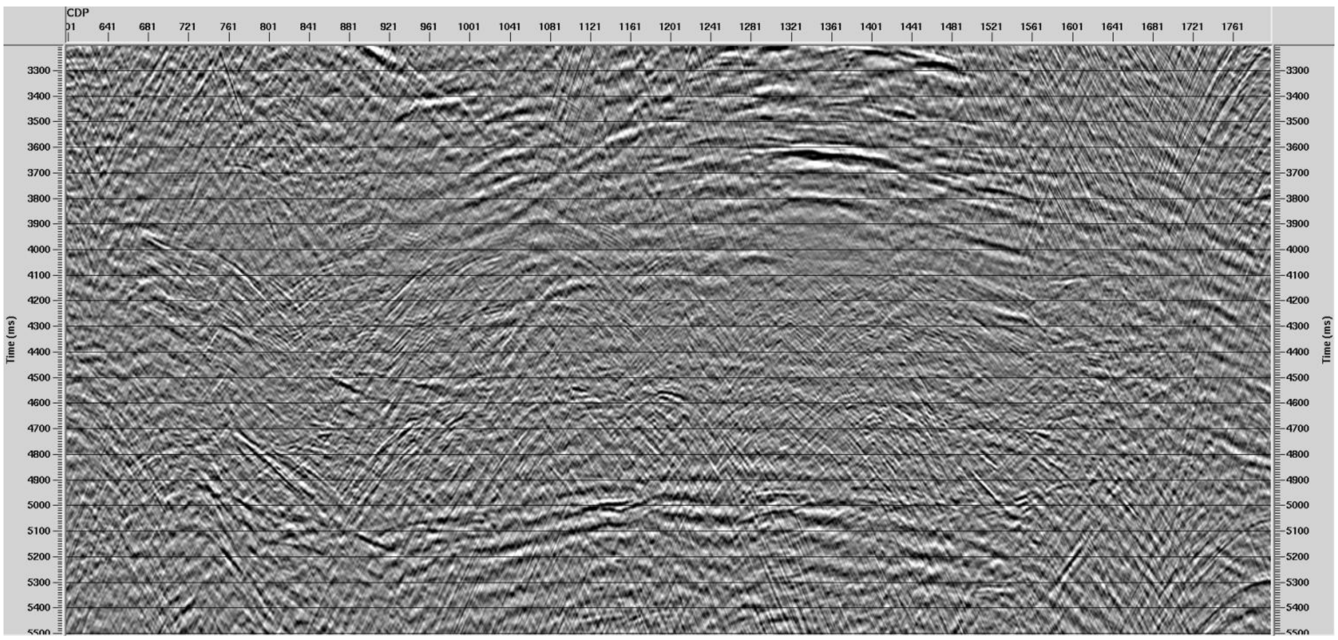

Fig. 12. *Shows the same region of figures 10 and 11, but here it was applied the FK filter, that attenuates rather the multiple reflections. Compare Fig. 12 with figures 10 and 11.*