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Selection of an optimised multiple attenuation scheme for a west coast of India data set

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Summary

In recent years a number of new algorithms have been added to the seismic data processor's arsenal for dealing with multiple reflections. Nevertheless, in many regions of the world multiple reflections remain the biggest impediment to obtain high-quality, easily interpretable seismic surveys. Standard pre-stack multiple elimination techniques fail in the presence of complex structures. This task becomes more challenging in the transition zone from shelf to deep water environments. Out of plane scattered multiples hamper imaging of the deeper section, whilst steeply dipping water bottom from shallow to deep, and considerable variation in pattern of shot gathers makes it difficult to find out a generalised de- multiple technique well suited for the area as a whole. In this present paper an attempt has been made to deal with these complexities and find out a suitable strategy for multiple attenuation.

Keywords: Multiple Attenuation, SRME, West Coast of India

Introduction

Multiple attenuation remains an integral part of a marine processing flow as seismic imaging techniques assume that the input data are free of multiples. The presence of multiples leaves us with spurious images and amplitudes. The removal of multiples becomes necessary to obtain the true image of subsurface. The recent developments in multiple attenuation technology have focused on attenuating multiple energy while preserving primary energy. The choice of multiple attenuation method is crucial task and totally dependent on the complexity and structural component of the data. There is no method or group of methods that works in all areas. The choice of the right multiple-attenuation technique is still a matter of trial and error. Multiples are not fully attenuated in one pass or by one method; therefore, cascading two methods is also becoming an industry standard approach. A brief description of multiple attenuation methods used in present study is given below.

Parabolic Radon Transform is one of the effective tools for multiple attenuation and is extensively used in the industry. Radon transform models the original data along a range of lines, parabolas, or hyperbolas. The modelled multiples are subtracted from the input seismic data to get filtered out put. The radon transform distinguishes between primaries and multiples based on the residual move out from the near to far offsets of CDP gathers. Therefore, it requires NMO corrected gathers and hence stacking velocity analysis is to be carried out before the application. A parabolic form of the radon transform is used since multiples have an approximately parabolic form in radon domain after NMO correction. A hyperbolic approximation is more accurate at time around deeper depth but is not accurate for shallower events as the parabolic method. Linear form of the radon transform is used for modelling linear events and therefore used for suppression of ground rolls and other linear coherent noises.

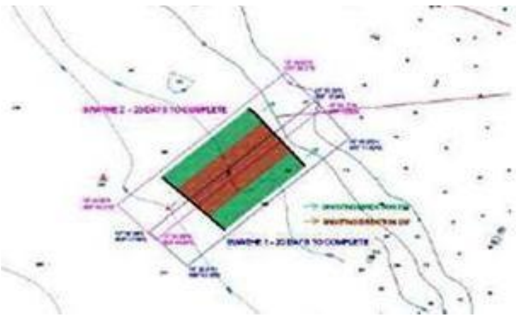

Figure 1: Location map of the area.

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SRME - Surface Related Multiple Elimination is a method for removing all free surfaces multiple energy. It is a data driven approach which operates in the prestack domain and attempts to predict and subtract the multiples. Surface related multiples include all multiples except those generated by totally internal reflection. They are typically the strongest multiple events present in the seismic data and therefore need to be removed from prestack shot gathers prior to any further imaging process. The SRME technology is designed to attenuate these multiples in a two steps fashion. During the first step, surface related multiples are predicted kinematic ally. The predicted multiples have about the same travel times as the multiple recorded in the seismic data but the different amplitudes and the wavelet shapes. In the second stage the surface related multiples present in the seismic data are attenuated using predicted multiples.

WEMA - Wave Equation Multiple Attenuation is a wave equation based multiple attenuation module that performs multiple modelling and adaptive subtraction in the shot domain. Multiples are modeled by downward continuation of the receivers to the multiple generating water bottom and upward continuation of the receiver field by same amount. This is followed by adoptive subtraction and receiver continuation back to the original receiver depths. This method makes no assumption about the character and complexity of the water bottom as long as its depth is known .Such information is almost always available for modern day survey. This works in common shot or common receiver mode for both 2D as well as 3D data. For input shot gather WEMA generates a multiple attenuated gather.

ASMA – Apex Shift Multiple Attenuation incorporates apex shifted parabolic Radon transform, designed primarily to model and subtract multiple energy. Unlike parabolic radon which transforms t-x domain data into tau-p domain, ASMA transforms the data into the tau-p-y domain, tau and p are coefficients defining the intercept time and the curvature of parabolic curves of NMO corrected events in the input ensembles, and y specifies how far the apex of a parabolic event is from the zero offset. This performs a forward parabolic Radon transform on gathers of data that have been corrected for normal move out. The transform separates reflection events on the basis of move out differences and apex differences. After normal move out correction with proper RMS velocity derived from primaries, the primary reflection events are expected to be flattened and the multiple reflection events may have residual move outs. The primary and multiples events can be distinguished and separated from their move out differences in the tau- p y domain. Apex shifted Radon transform may have the advantage of better focusing those parabolas whose apexes are apart from the zero offset.

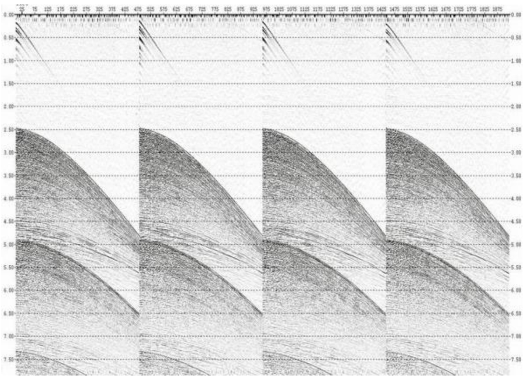

Figure 2: Sample shot gather showing water bottom multiples.

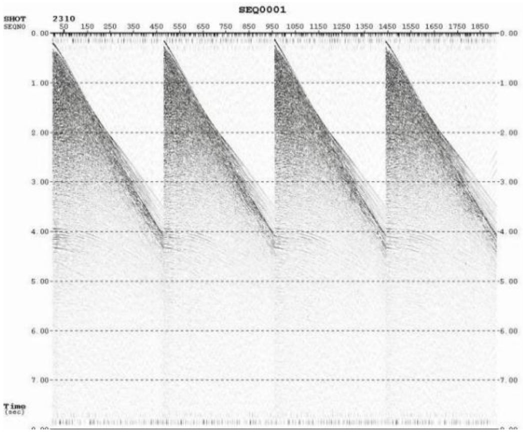

Figure 3: Variation in patterns of shot gathers taken from shallower part of the data.

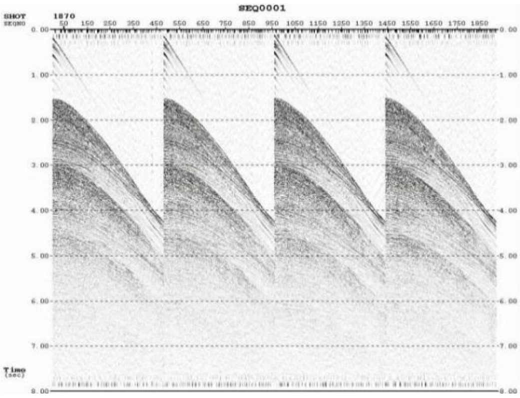

Figure 4: Variation in patterns of shot gathers taken from deeper part of the data.

Methodology

Finding the best multiple attenuation method is an everyday challenge in seismic processing. There is no such method or a group of methods which holds good for all data. Multiple attenuation methods are totally data dependent and can be find out by trial and error method. After visualisation of data it has been found that shot gather patterns are changing considerably along a line in which patterns having apex shift from zero offset position are also present. Water bottom is steeply dipping from shallow to deep as area under consideration falls in the transition zone from shelf to deep water environments. Firstly, SRME and WEMA were tried in shot domain. Keeping in view the variable shot gather patterns involving apex shifted pattern, ASMA cascaded with normal parabolic radon was used in CDP domain. These methods operate upon NMO corrected gathers hence good velocity is required. In order to meet this requirement velocity analysis was done in two pass. Initial stacking velocity analysis was done on CDP sorted data, which subsequently was used for offset regularisation and running parabolic Radon transform. Second pass velocity was done on this partially demultipled and regularised data which provided better velocity for testing. A comparative study of results obtained through all these methods has advised that ASMA cascaded with parabolic radon has given desirable results.

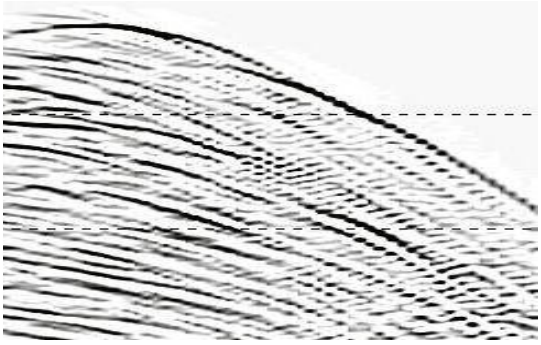

Figure 5: A typical shot gather pattern showing apex shift from zero offset position.

Real Data Example

The area under consideration falls in the transition zone from shelf to deep water environments pertaining to West Coast of India. Location map is shown in the figure 1. The zone of interest lies between times 1.0-3.5 sec. With geological objective to delineate bright amplitude seismic anomalies and to map the strati-structural play within Neogine. The 60 fold 3D data was acquired using four steamers with group interval 12.5 m and shot interval 25 m. The minimum offset is 100 m and the maximum far offset is 6100 m. The PSTM is to be carried out to meet the geological objectives. This has necessitated the conditioning of data so that it does not have any multiple energy. Water bottom is steeply changing from shallow to deep water. Seismic data is highly contaminated by water bottom multiples of 1st, 2nd, and 3rd order as shown in figure 2.. Figure 3 and 4 illustrate the variation of shot gather patterns across an in line. There are many shot gathers present in the data in which apex is shifted from their zero offset positions as shown in Figure 5.

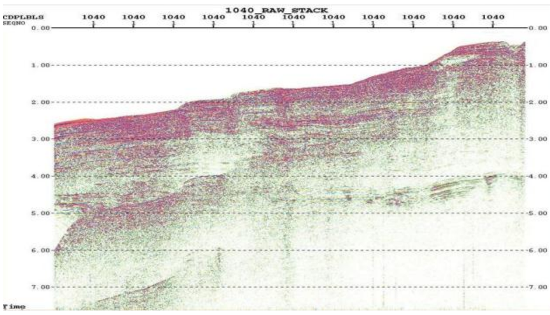

Figure 6: Raw stack.

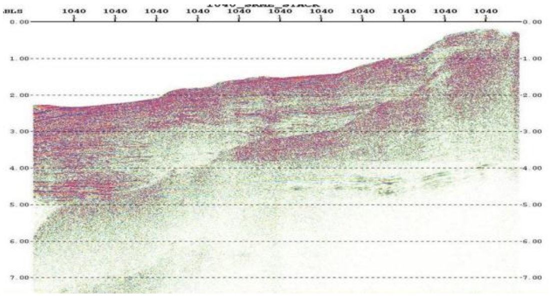

Figure 7: Raw stack after SRME.

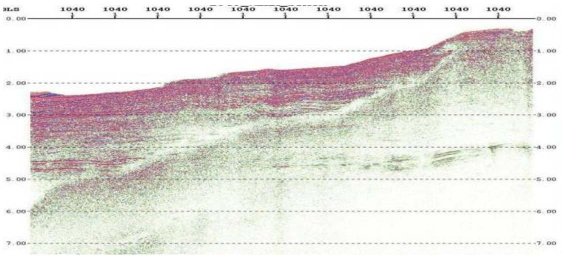

Figure 8: Raw stack after WEMA.

Keeping all these complexities in mind a suitable scheme for multiple attenuation is to be work out. The results of SRME and WEMA are demonstrated in figure 7 and figure 8 respectively which have not reached up to the desirable level. Further apex shifted multiple attenuation followed by parabolic radon is attempted which results are shown in figure 9 to figure 12. Figure 9 shows the semblance patterns on velocity panel which indicate that velocity picking has become easier and more accurate. Figure 10 demonstrates the comparison between NMO corrected CDP gather before and after multiple attenuation. This shows that multiples are removed. Figure 11 and figure 12 represent raw stack and post stack processed section after application of cascaded apex shift multiple attenuation and parabolic Radon transform scheme. After evaluation all these results it is crystal clear that this scheme of multiple attenuation is well suited in the present scenario of seismic data.

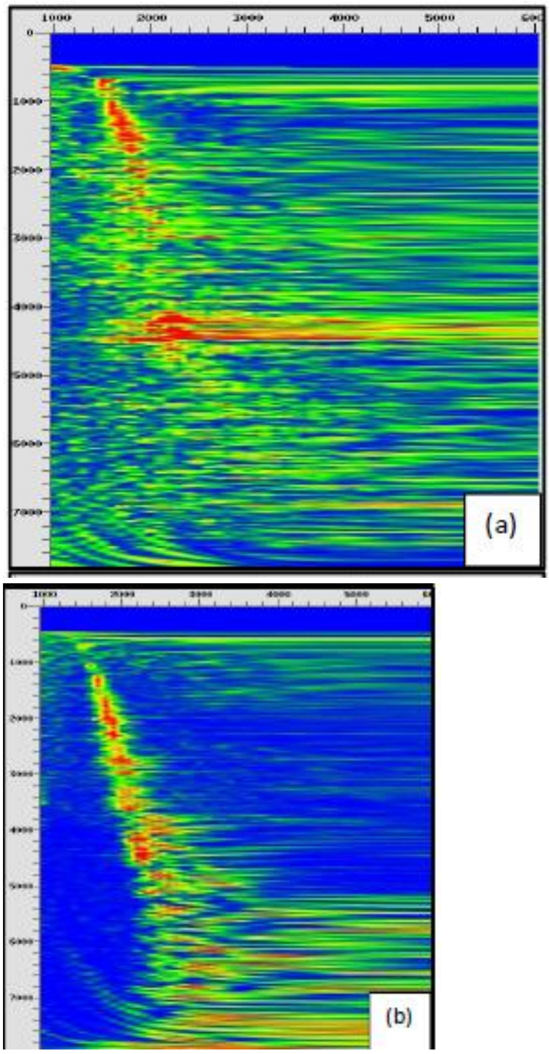

Figure 9: Semblance pattern before (a) and after (b) multiple attenuation.

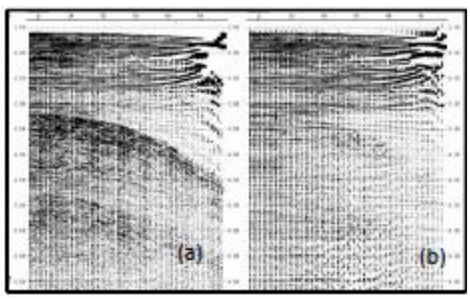

Figure 10: Comparison between NMO corrected gathers before (a) and after (b) multiple attenuation.

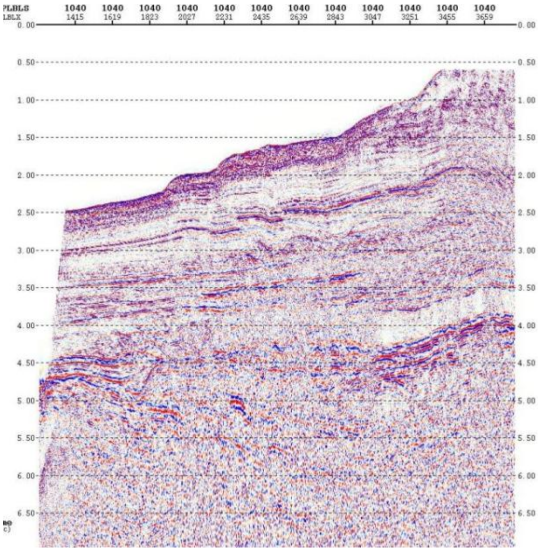

Figure 11: Raw Stack after multiple attenuation using apex shift multiple attenuation technique followed by parabolic Radon transform.

Conclusions

For imaging in complex environments, it is necessary to employ a wide range of tools for suppression of the various classes of noise and multiple. Multiple attenuation methods are totally data dependent and can be find out by trial and error method. As complexity arises multiples are not fully attenuated in one pass or by one method developed for this purpose. Cascading two methods of multiple attenuation is also setting trend in industry of seismic data processing. In the present study various methods have been tested and critically examined, Apex shifted multiple attenuation method followed by parabolic Radon transform has given desirable results.

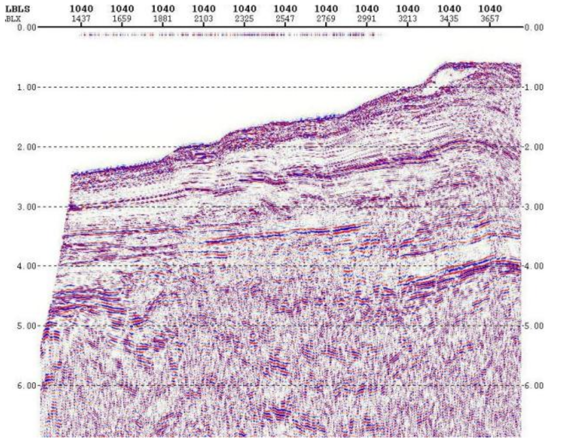

Figure 12: Post stack process applied section on raw stack after multiple attenuation using apex shift multiple attenuation technique followed by parabolic Radon transform.

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