3D Internal Multiple Attenuation Campos Basin

Jarred Hostetler, WesternGeco

XIMP is a date driven multiple prediction and elimination technique which overcomes the limitations of existing techniques. The XIMP technique was applied as part of a large pre-pocessing project in the Campos basin with impressive results.

Introduction

An interbed multiple is a seismic event in which the rays do not travel directly to and from the reflecting interface but rather contain at least one downward reflection which is not the surface. Interbed multiples contaminate all seismic datasets and can be very difficult to remove because they possess very similar properties to the primary events. Traditional techniques, to address inter-bed multiples, which rely on velocity discrimination, dip discrimination and periodicity are not generally successful.

Extended Interbed Multiple Prediction (XIMP) overcomes some of these challenges by using a data driven type approach to predict the multiple and does not rely on discrimination of the multiple from the primary or multiple periodicity. XIMP predicts interbed multiples at true azimuth which makes it a suitable technique for any type of acquisition including rich azimuth techniques such as coil and WAZ land geometries.

Theory

XIMP is an extension of the common surface multiple prediction technique in which the surface multiple wavefield is decomposed into two primary wavefieilds. XIMP decomposes the interbed multiple wavefield into three components; S-R1, S1->R and S1->R1 (Figure 1). The kinematics of the interbed multiple can be predicted by convolving two primaries S-R1 and S1->R1 and correlating with a third primary event S1->R1. i.e. an addition followed by a subtraction. This obviously relies on these primary events being recorded in the acquisition experiment.

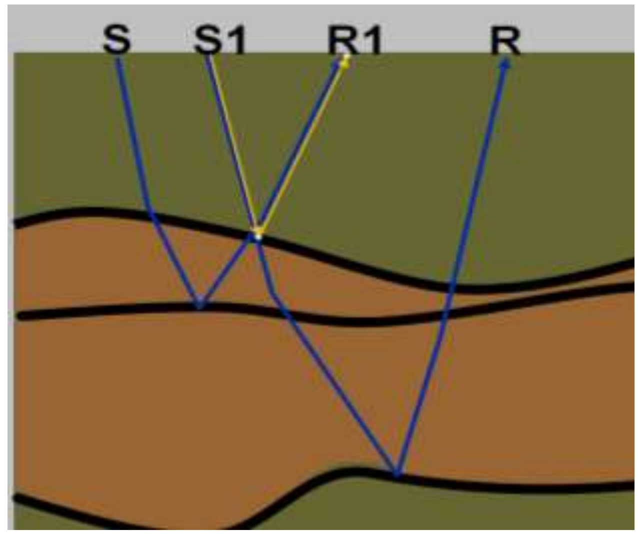

Figure 1

The challenge here is that we do not know which source and receiver trace pairs need to be convolved to accurately describe the interbed multiple we are trying to predict for a given trace. To resolve this we convolve and correlate all possible source and receiver pairs, within a defined aperture(*Figure 2*). This contribution of all the traces creates a multiple contribution gather(MCG) which is later stacked to create the predicted multiple trace. While the concept is relatively simple the implementation is very complex because of the millions of traces which need to be processed to build the multiple prediction model.

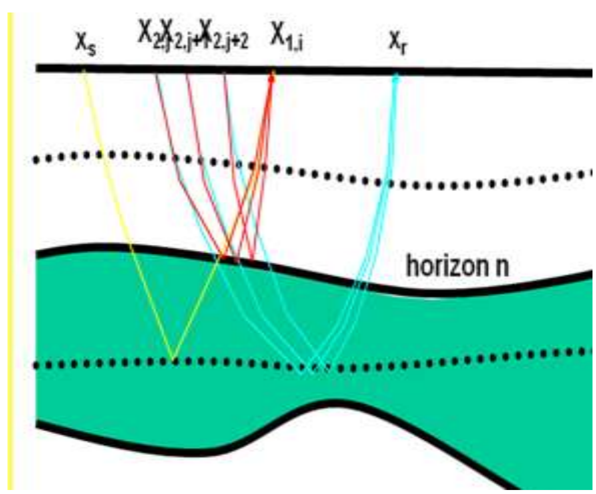

Figure 2 Creating a Multiple Contribution Gather.

As mentioned previously as with SRME, XIMP only predicts the kinematics of the multiple events. The amplitudes are addressed by supplying an accurate estimate of the wavelet in conjunction with a least squares simultaneous subtraction routine. Unlike SRME XIMP requires the multiple generating horizons to be identified. Rather than using an iterative top down methodology, starting with the first generating horizon and then moving to the next horizon below, XIMP has the ability to predict all interbeds from multiple generating horizons in a single run. It does this by saving the computations of the previous generating horizon prediction and using those to predict the multiples from the next horizon below. The adaptive subtraction workflow has been adapted for this simultaneous prediction.

Data Example

The XIMP technique was used within a large re-processing project in the Campos Basin offshore Brazil. Campos Basin is located at the southeast portion of Brazil, along the northern part of the state of Rio de Janeiro. The basin covers approximately 100,000 Km2 with water depths down to 3000m. The geological limits of the basin are the Vitória High in the North, which separates it from the Espírito Santos Basin, and the Cabo Frio High to the South, which separates it from the Santos Basin

An open marine environment developed about 112 million years ago (Early Albian) and still persists today. It started with shallow water carbonate deposition followed by predominantly deep-water siliciclastic.

Campos Basin contains a hard water bottom followed by a carbonate layer overlaid on top of salt bodies. The main plays of interests for exploration today are below the salt in the pre-salt layers. While the targets are in the pre-salt the layers below the pre-salt are of interest to investigate fractures that give a path for oil migration from the deeper source rock. The strong acoustic impedance contrasts at the waterbottom, top of salt and top of carbonate generate a complex suite of interbed multiples which can contaminate the pre-salt targets inhibiting interpretation.

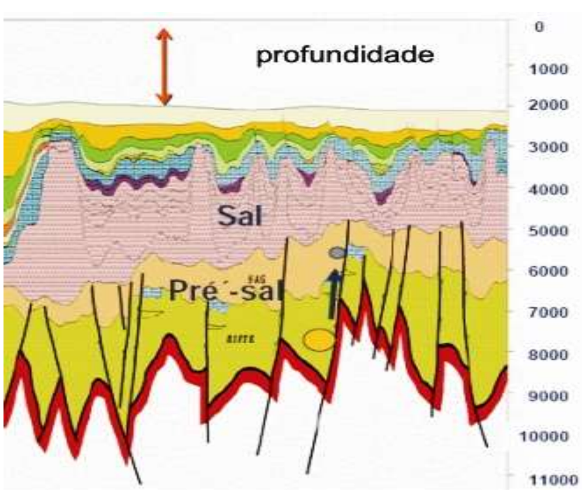

Figure 3 Campos Basin Geology.

The data being presented in this paper comes from WesternGeco's Multi-Client Library.

Four vessels in total were used to acquire the original volume, however only two of these, the M/V Geco Eagle and M/V Geco Triton contributed to Campos 3D Phase I. It was acquired by Triton towing 8 streamers, on the 18th October 1999 and Eagle, towing up to 10 streamers (but usually 8), started acquisition on November 5th.The Triton finished on the 20th December 1999 and Eagle completed shooting on April 4th, 2000. This was a conventional narrow azimuth type of acquisition.

The data followed a reasonably standard pre-processing sequence including noise attenuation(random and linear), surface multiple attenuation and water-velocity correction

.

. Two different approaches were taken to remove the interbed mutliples. The first approach used the top of salt as the generating horizon for the interbed multiples while the second approach used the water bottom as the generating horizon. After creation of the interbed multiple model, the data was then put through a least squares adaptive subtraction process. This removes any small errors in timing, amplitude, and/or phase from the multiple model before it is subtracted from the original data.

Results

The data prior to XIMP application (*see Figure 4*) has distinct repetitive events just below the base of salt that have phase and amplitude characteristics of a interbed multiple.

After the application of XIMP using the top of salt as the generating horizon (*see Figure 5*) you can see the events have been attenuated, leaving a clear picture of the events that were previously hidden by the multiple. This produced a seismic section that provides any easier interpretation any faults below the pre-salt.

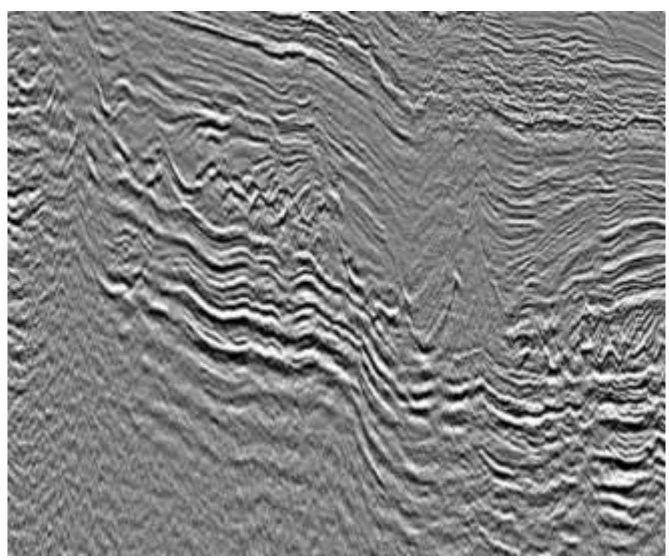

Figure 4 Migrated stack without XIMP.

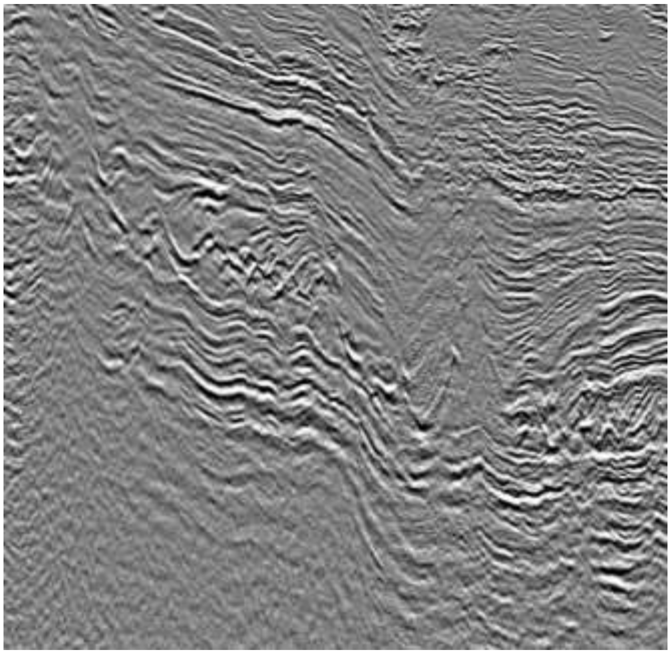

Figure 5 Migrated stack with XIMP using top of salt as generating horizon.

.

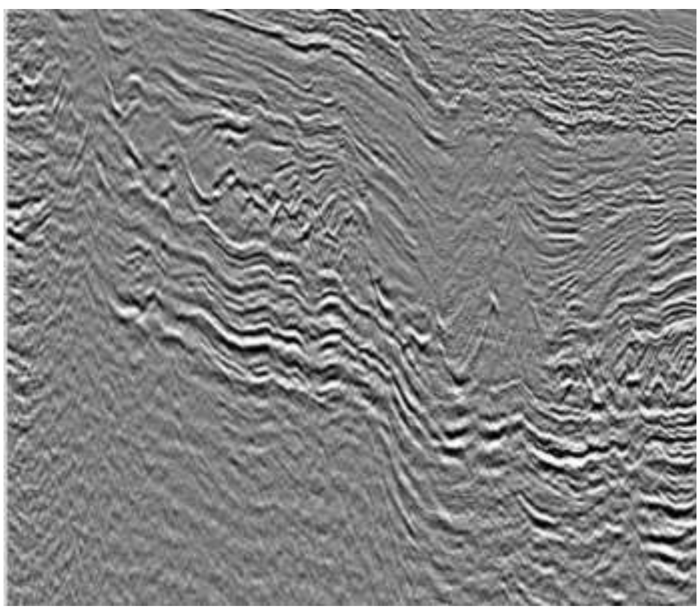

Figure 6 Migrated stack with XIMP using the water bottom as the generating horizon.

Conclusions

The application of XIMP provided significant uplift to the pre-salt area of the seismic section. XIMP was able to predict the internal multiples and provide a model for adaptive subtraction. Further work on using more horizons and experimenting with the adaptive subtraction of multiple horizon internal multiple predictions would provide further uplift.

References

El-Emam, A., Moore, I. and Shabrawi, A. [2005] Interbed multiple prediction and attenuation:
Case history from Kuwait. 75th SEG Annual International Meeting, Expanded Abstracts,
448–451.

Jakubowicz, H. [1998] Wave equation prediction and removal of interbred multiples. 68th SEG Annual International Meeting, Expanded Abstracts, 1527–1530.

El-Emam, A., Al-Deen, K.S., Zarkhidze, A. and Walz, A. [2011] Advances in interbed multiples prediction and attenuation: Case study from onshore Kuwait. 82nd SEG Annual International Meeting, Expanded Abstracts, 3546-3550.

Wu, Z.J., Sonika, Dragoset, B. [2011] Robust internal multiple prediction algorithm. 82nd SEG Annual International Meeting, Expanded Abstracts, 3541-3545.

Moore, I. and Dragoset, B., [2008] General surface multiple prediction: a flexible 3D SRME algorithm. First break volume 26.