## Introduction

Multiples attenuation sometimes necessary of a land seismic 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. Primary events may create outstanding multiples to perplex and perturb seismic interpreters. The removal of multiples becomes necessary to obtain true image of the subsurface. The diversity of multiple attenuation methods available and continuous rapid advance of multiple attenuation process in general can make it difficult to decide which technique is best suited to our particular data set. There is however no method or group of methods that works in all area.

Methods that attenuate multiples can be classified (M. Das, 2006) as belonging to three categories:
1. Methods based on prediction and then subtraction of multiples from seismic data.
2. Methods that separate primary from multiples in some domain or other based on their properties
3. Methods based on modeling of the multiples and their adaptive subtraction.

The first group assumes that the key difference between multiple and primary is that the multiples are periodic while primaries are not. Predictive deconvolution in T-X or Tau-P domain is based on this periodicity of multiples. These methods are effective on the periodicity of the multiples.

The second group assumes that by applying some transform to the data, the separation between primaries and multiples can be distinctly achieved and by muting a portion of the data in transform domain, multiples can be attenuated. The transform is based on a feature that differentiates the difference in moveout between primary and multiple events. Many methods based on separability exist to attenuate multiples like Stacking, FK Filter, Radon filter etc. (Foster and Mosher 1992, M M Nurul et al. 1999). These methods are effective when their assumptions and prerequisites are satisfied.

The third group is based on modeling of the multiples generation and then their subtraction from the recorded data. The modeling may be carried out by creating subsurface model. But now techniques (Surface Related Multiple Elimination, SRME) are available which requires no prior knowledge of the subsurface geology (Verschuur, DJ, 1992).

## Theory

Radon Filter is commonly used for suppression of multiples. The normal technique is to model multiples and subtract them from the input seismic trace data. Radon filters are then applied to pass the primary energy. However, in practice this tends to produce an artificial and wormy appearing result.

The Radon transform distinguishes between primaries and multiples based on the residual moveout from near to far offset. A parabolic form of the Radon transform is used since multiples have an approximately parabolic form after NMO. An approximately hyperbolic form can also be used. This hyperbolic approximation is more accurate at times around offset=depth, but is not as accurate for shallower events as the parabolic method.

The transform is applied for linear moveout as well.

## Sparse Transform Option

Conventional Radon Filtering has limitations on the discrimination possible between multiples and primaries. This limitations stem from the fact that events in T-X space do not transform to points in Tau-P space, but exhibit a “butterfly” shape. The sparse transform option will reduce the size of the butterfly in the Moveout (P) direction, but can cause dispersion of energy in the time (Tau) direction. The sparse transform does this by concentrating energy on the Moveout samples which have the most energy. This discrimination against weak events tends to reduce the effect of aliased events as well as enhance those which are desired.

There are two options for the computation of the sparse radon transform. The frequency domain sparse radon transform attempts to generate a sparse transform in the P-direction using a stability parameter to help stabilize the solution. The time-domain sparse radon attempts to generate a transform in both the P and time directions.
In order for the sparse option to be most effective, the primaries should be flattened by applying NMO before Radon Filter or Analysis. This will align all of the primary energy near P=0, giving greatest weight to the primary reflections in the sparse transform. Multiple energy should be expected to fall on a variety of P-values, so the sparse solution does not reconstruct it as well as the aligned primaries. Incoherent noise and aliased energy should be diminished for this same reason.
Testing should be done to determine the optimum amount of sparseness to use for each dataset. There is a tradeoff between the fidelity of data reconstruction and the separation of events which can be obtained.

Type of transform to perform:
Parabolic is a parabolic radon transform
Hyperbolic is exactly hyperbolic for events at depths equal to the reference offset. This has greater error than Parabolic for shallower events.
Linear is used to attack linear noise, also known as slant stack.
Parabolic and Hyperbolic are normally used for multiple rejection.

## Real Data Example

The Radon filter is effectively applied for attenuating the multiple on the real dataset.

The Radon filter facilitates the velocity analysis and avoids picking of the velocity of multiples. The semblance obtained before and after radon filter application is shown in figure 1 and 2. A comparison of PSTM image obtained with and without radon filter has also been shown in figure 3 and 4. The clear image obtained with the application of radon filter will be helpful in carrying out meaningful interpretation.

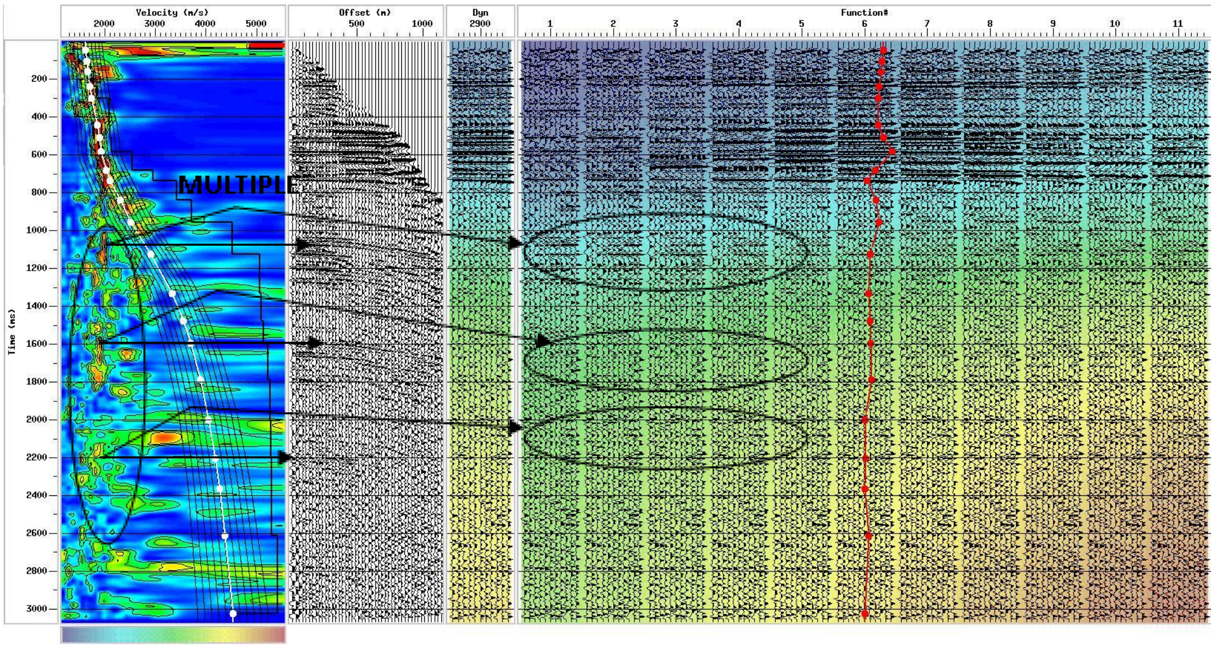


***Figure 1*** *Line-09 Typical Velocity Analysis (white) and Multiple field - ( cdp_sloc 240)*

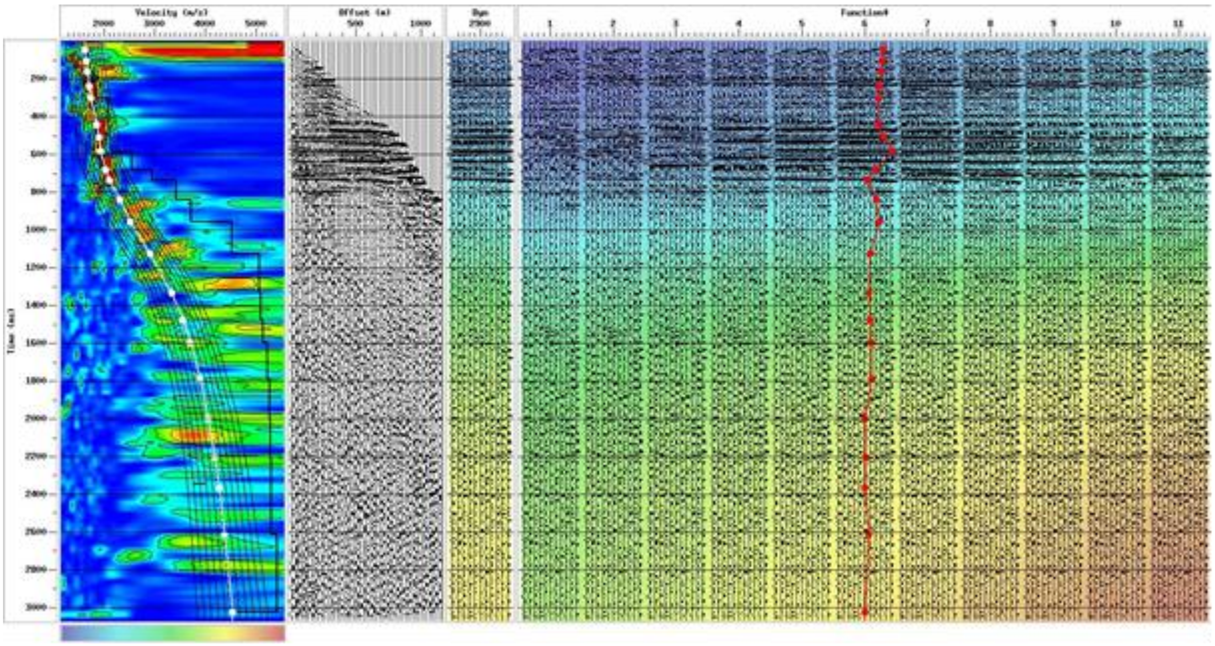

***Figure 2*** *Line-09 Typical Velocity Analysis after Radon Filter applied - ( cdp_sloc 240)*

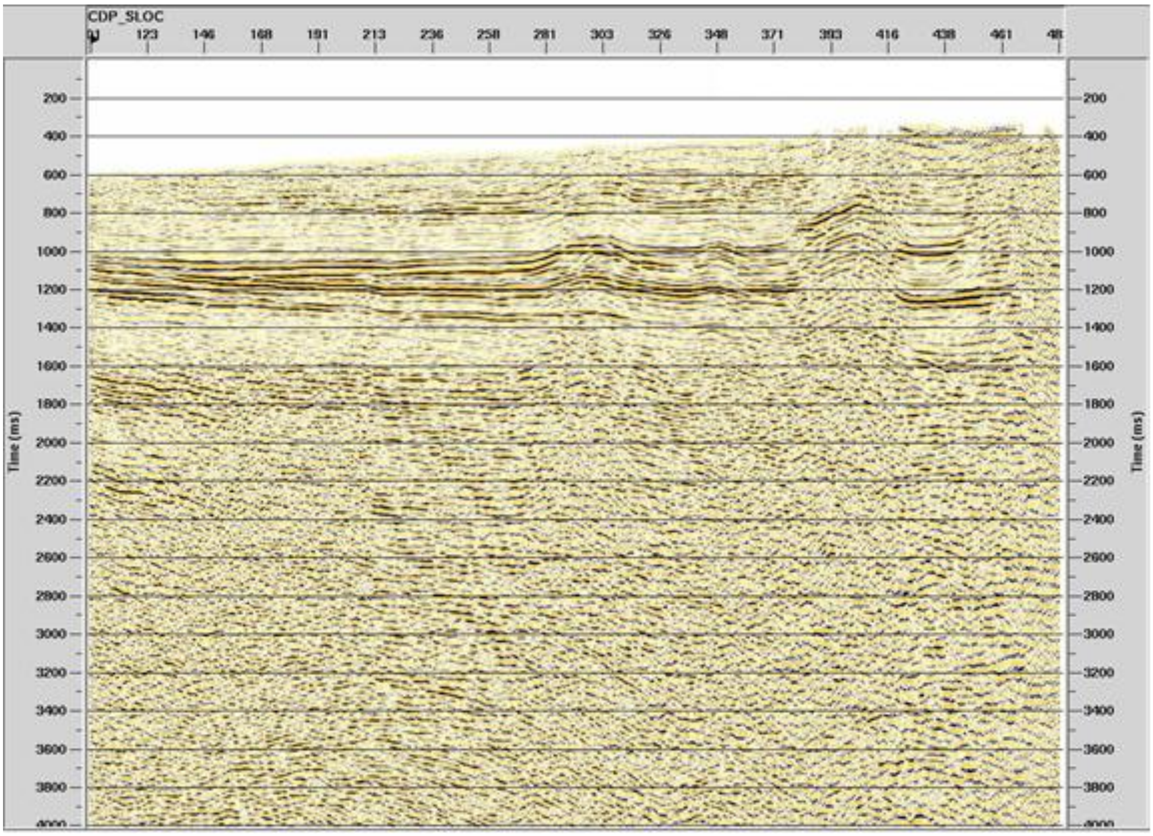


***Figure 3*** *Line-09 Filtered Stack without RADON filter applied*

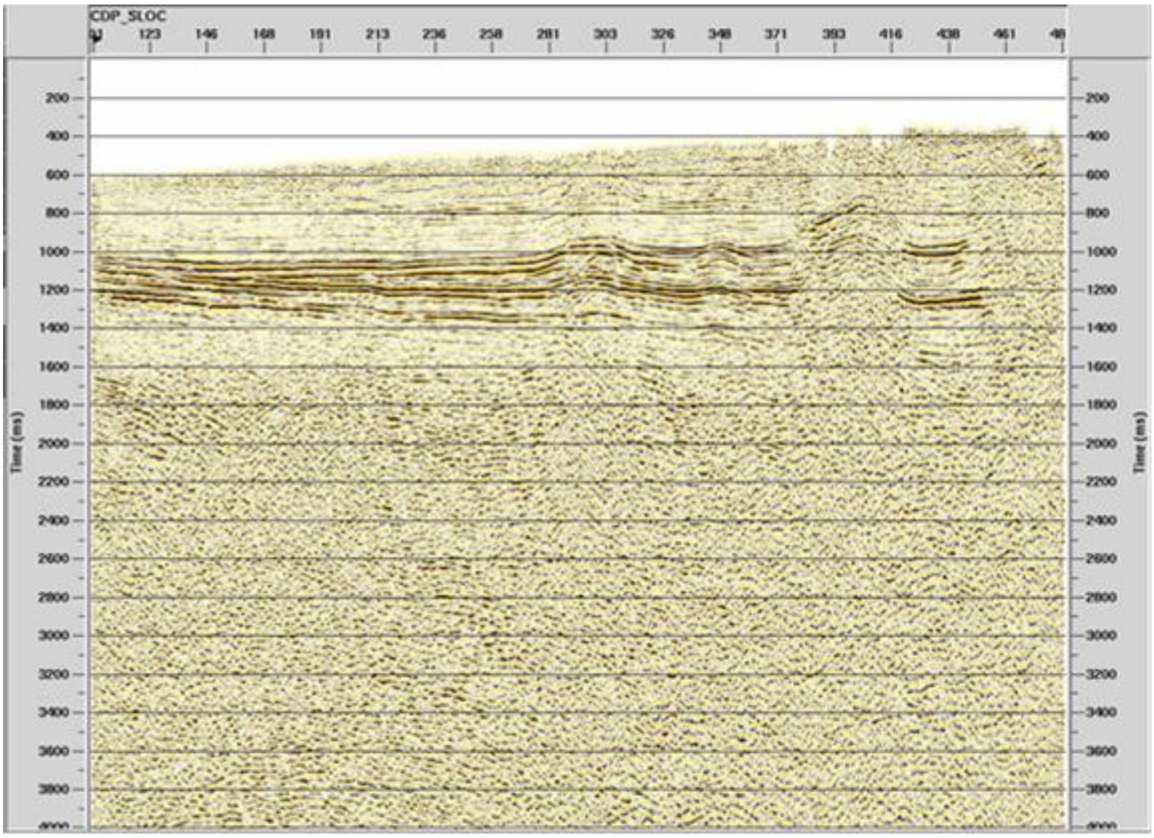


***Figure 4*** *Line-09 Filtered Stack with RADON filter applied*

## Conclusion

Radon filter techniques of multiples attenuation are based on residual moveout to discriminate multiples from primaries. Velocities must be picked with sufficient accuracy to distinguish primary energy from slightly slower multiples energy. Radon filter is still effective when primaries and multiples are co-incident at near offsets in TX domain. It provides a high degree of attenuation, especially on long period multiples.

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## References

1. M. Das et al. 2006, Multiple Attenuation- Case study: 6th SPG conference, Kolkata, 2006.
2. Foster,D.J., and Mosher,C.C., 1992, Suppression of multiple reflections using the Radon Transform: Geophysics, 57, 386-395
3. Verschuur, DJ Berkhout, AJ, Wapennar, CPA, 1992, Adaptive Surface related multiple eleimination: Geophysics, 57.
4.Cary,P.,1998.The simplest discrete Radon transform. SEG Expanded Abstracts, Vol. II, p. 1999-2002.