SHALLOW REFLECTION DETECTION USING THE RADIAL TRACE TRANSFORM

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ABSTRACT *In most of seismic data acquisition, shallow reflection data will be masked with refraction and first arrival events and observation of this event is not usually easy. Radial trace transform is a simple transform for mapping x-t gathered data into apparent velocity and travel time domain. The apparent frequency of refraction and first arrival events will be changed completely in RT domain. With knowledge of this changes and the application of frequency filters in RT domain, these events can be attenuated. In this paper the result obtained from filtered gathered data acquired from oil filed in x-t domain and RT domain has been compared. The results showed that the RT filters is much better affecting those events with respect to x-t filters.*

INTRODUCTION

The radial trace transform was introduced by the Stanford Exploration Project many years ago (Ottolini, 1979), (Claerbout, 1983), primarily for use in migration and imaging applications. It is a simple mapping from the usual X-T domain of seismic trace gathers to a domain described by coordinates of apparent velocity and travel time, the R-T domain. Linear event with constant apparent velocity in the x-t domain, include refraction and first arrivals, can be attenuated with respect to the other event by applying simple operations in the RTdomain, such as frequency filtering. An RT domain filter can be designed to attenuate parallel linear event with a common apparent velocity.

THEORY and METHOD

The radial trace transform

The elementary radial trace transform R is a simple mapping of the amplitudes of seismic traces S whose coordinates are source-receiver offset *x* (or some other lateral distance from a single reference point) and two-way travel time *t* to the new coordinates apparent velocity *v* and two-way travel time *t'*. The transform is defined by:

$\mathbf{R\{S(x,t)\} = S'(v,t')}$, (1) with the inverse given by:

$\mathbf{R^{-1}\{S'(v,t')\} = S(x,t)}$, (2) where $\mathbf{t' = t;\ v = x/t}$, (3)

Figure 1-left is schematic illustrations of the process of mapping a seismic shot gather from the conventional X-T domain to the radial trace (R-T) domain. As can be seen from the figure, each radial trace consists of samples gathered along a linear trajectory of constant apparent velocity. However, an event not parallel to timing lines has a different *duration* in the R-T domain than in the X-T domain, being either stretched or compressed, depending upon the angle the event wavefront makes with R-T trace trajectories. For an event whose wavefront is nearly parallel to an R-T trajectory, its duration is greatly increased in the R-T domain.

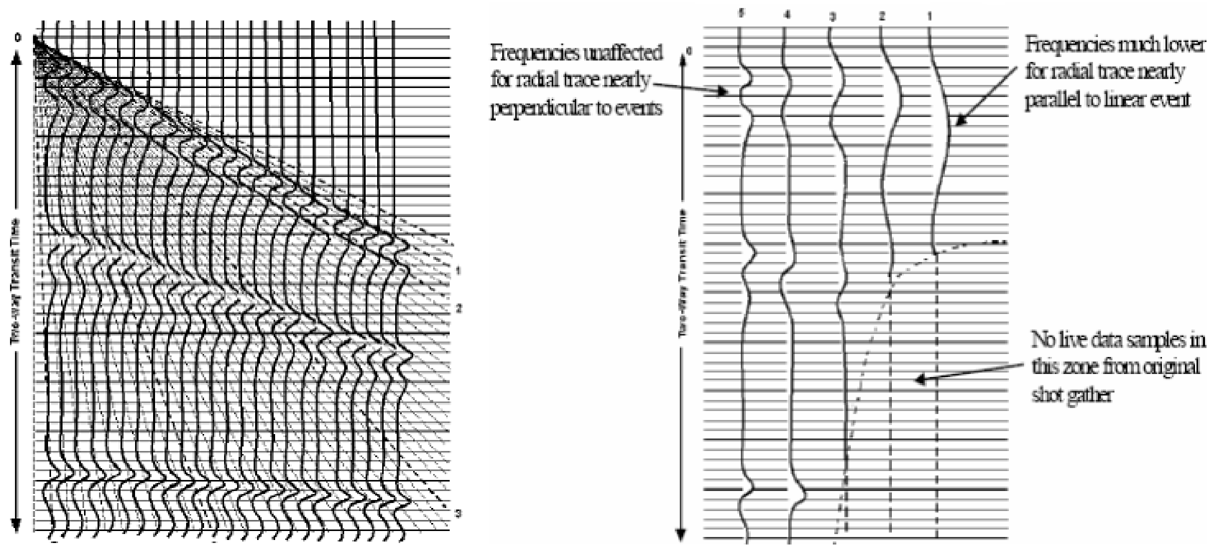

Figure-1. Schematic showing the mapping of seismic traces from the X-T domain to the radial trace (R-T) domain (left). Schematic showing selected radial traces from the X-T panel in the left figure. Trace numbers correspond to like-numbered trajectories in the left figure (right).

Conversely, an event whose wavefront is nearly *perpendicular* to an R-T trajectory will have its duration *decreased* relative to the X-T traces, and hence its apparent frequency increased in the R-T domain. Figure 1-right follows from figure 1-left and shows representative radial traces corresponding to the numbered trajectories across the X-T panel in figure 1-left. We display only a few of the R-T traces that would be generated using the set of R-T trajectories in figure 1-left so that we may more easily see details. In figure 1-right we illustrate the event stretching, or change of apparent frequency, due to the R-T transform, on a linear event whose origin and slope make it nearly parallel to some of the R-T trajectories that span it. This is illustrated by radial traces 1 and 2 in figure right, which cross the linear event at very small angles. Traces 3, 4 and 5 encounter the linear event at much larger angles and show correspondingly less stretching for the linear event.

It is the fact that linear events, include refraction and first arrivals, in the original X-T domain whose apparent velocity and origin nearly match those of one or more radial traces into which they map have their apparent frequencies dramatically lowered. Therefore, by applying low-cut and band-pass frequency filter in RTdomain this event can be attenuated, greatly.

Examples

To illustrate and illuminate the use of R-T domain filtering techniques, we use one of the 2-D data sets acquired from oil filed. There are 500 stations on the line, spaced 5 meters apart. Figure 2-top-left shows one typical shot gather from this line .on this records we can see two main types of linear event; direct arrivals and shallow refractions near the top of the records, and ground-roll dominating the central portion of the records. The direct arrivals and refractions obscure shallow reflections at larger offsets while the ground roll dominate the deeper reflections at smaller offsets.

Figure 2-top-right shows the row shot of figure 2-top-left in RT-domain. It can easily be seen that the direct arrivals and refractions have been rotated to near vertical orientations, such that their apparent frequency is very low. The ground-roll has not undergone such great changes, but their frequencies have been lowered nevertheless, increasing their susceptibility to low-cut filtering. Reflections on these records have been changed little in appearance from those on the X-T gathers of figure 2-top-left. The result of application of a low-cut filter to these R-T traces after reverse RT transform can be seen in figure 2-bottom-left.

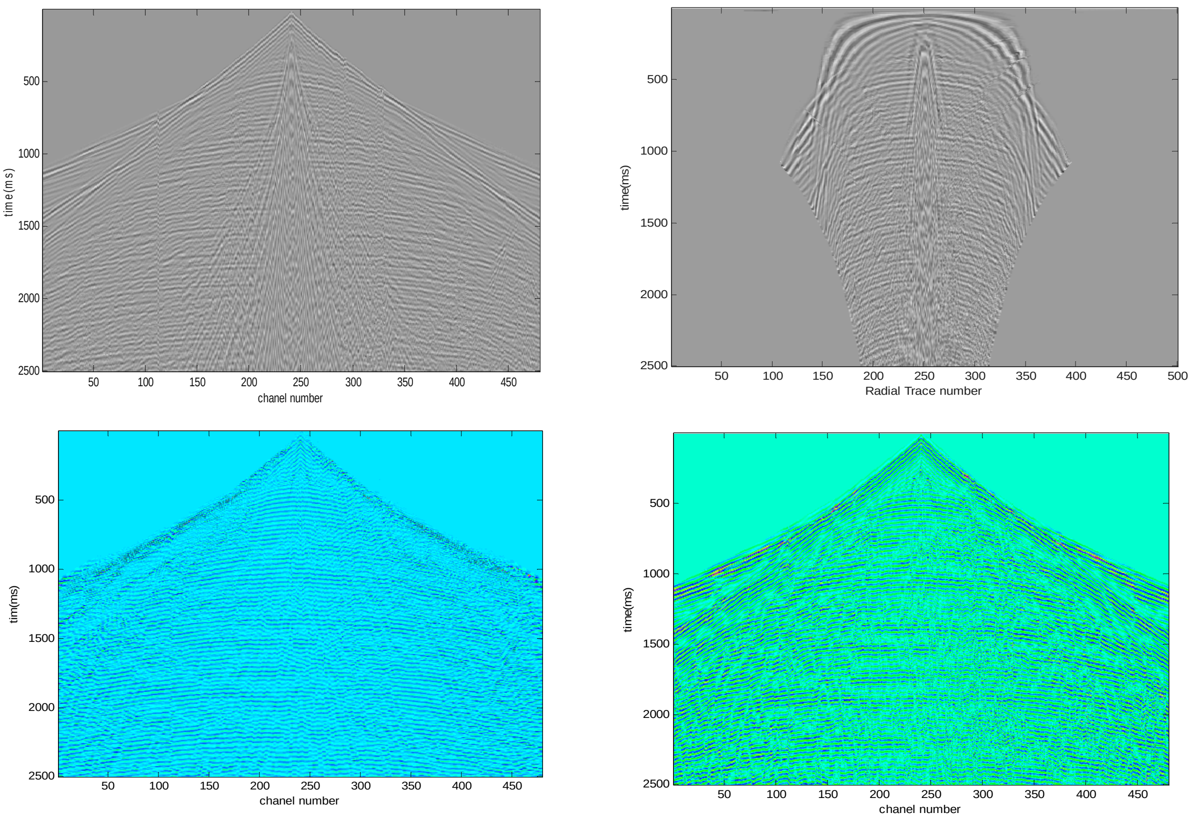

Figure-2. Raw shot gather (top-left), raw shot gather in RT domain (top-right), shot gather after filtering in RT domain(bottom-left),after filtering in x-t domain(bottom-right)

In comparison with figure 2-top-left, improved lateral continuity for all reflections is evident, particularly those previously obscured by the shallow refractions near the top of record. As our control image for comparison, figure 2-bottom-right shows the record after applying Orsmby filter at 10-20-55-65 Hz in x-t domain. Figure 3-left shows a CDP stack of shot gathers whose X-T traces have been Orsmby filtered at 10-20-55-65 Hz and

NMO corrected. It can be seen that the Orsmby filter and the stacking process have removed much of the coherent noise, as anticipated. Figure 3-right contains a comparable stack of shot gathers which have received one application of R-T domain filtering, with the same Orsmby filter. Differences between the two sections are relatively small, but the shallow portion of the section has been significantly improved by the R-T domain filter, which has removed the direct arrival, thus improving the shallow part of the stack and shallow reflection in this section is observable, greatly.

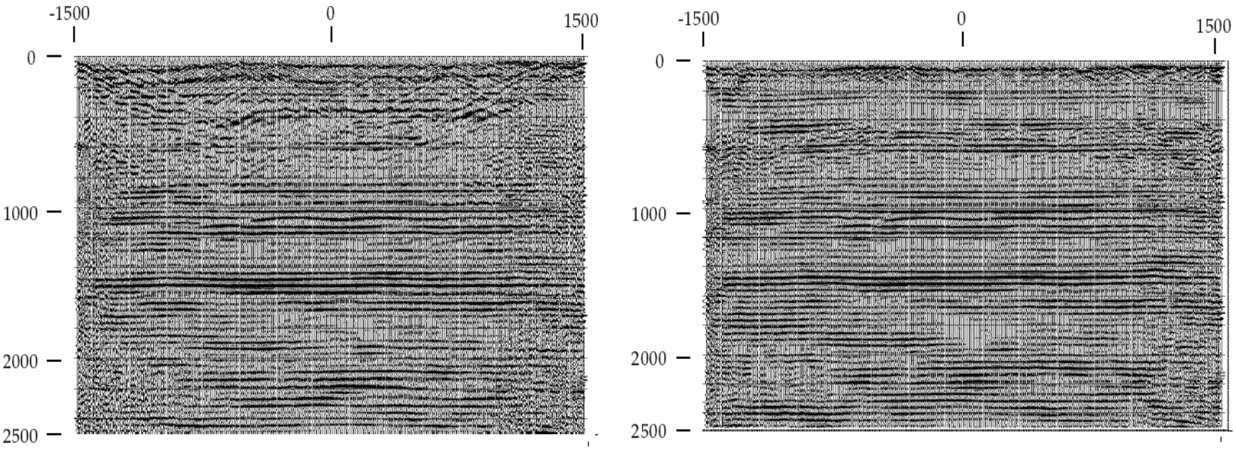

Figure-3. Stack of shot gather which have been filtered in x-t domain (left), Stack of shot gather which have been filtered in RT domain (right)

CONCLUSIONS

A technique for linear events attenuation based upon RT transform has been described and exploited to real data. This technique is effective in attenuating linear events while it is aimed to detect shallow reflections. Since the RT transform is a simple mapping, it is straightforward to complete and invert. It is the fact that linear events include refraction and first arrivals, in the original X-T domain whose apparent velocity and origin nearly match those of one or more radial traces into which they map have their apparent frequencies dramatically lowered. Therefore, by applying low-cut and band-pass frequency filter in RTdomain this event can be attenuated, greatly, while these events in X-T domain can not been removed from records by applying frequency filtering or another approach. For example if we use the muting for removing the events, the reflections hidden behind these events will also been removed from data and shallow reflection detection will be impossible.

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