Ground roll rejection via f-v filtering

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ABSTRACT

Ground roll is often apparent on seismic records and as it can obscure events of greater interest, it generally needs to be suppressed. This paper discusses the use of f-v filters operators in the 1-D Fourier transform of the (τ,p) domain to reject ground roll. Several implementations of f-v filters are used: a surgical filter to suppress low velocity events; a phase difference filter (supposing the ground roll has 90° phase difference in both vertical and radial component data); and a cross-correlation filter (assuming ground roll has a similar amplitude signature on both vertical and radial channels). These filters are developed and applied to synthetic data and field data from the Crystal area of central Alberta Canada. We find that f-v filters outperform f-k filters on the cases discussed here.

INTRODUCTION

In seismic exploration, ground roll is generally considered as noise and so is suppressed. It is a particular problem in multicomponent data, as we are interested in shear waves which have a similar velocity and where we often only use single geophones (no ground roll attenuation arrays). What are the characteristics of ground roll and how can we use them to suppress the ground roll? We propose a surgical filter, phase difference filter and cross-correlation filter in (f,v) domain, which use frequency, apparent velocity and phase or dispersion to reject ground roll.

Methods

We transform horizontal and vertical component data from (x,t) to (τ,p) and then to (f,p) by the 1-D Fourier transform over τ. Displaying the (f,v) data in a contour map can often separate the ground roll and other noise from the signal. After finding this area, we surgically mute it and transform the data back to (τ,p) and (x,t) to get the results. The surgical mute filter can be used on a single component, but like the (f,k) filter, is decided by hand. The following 90° phase and cross-correlation filters need to use two component data together, but can be used automatically.

Simple ground roll has a 90° phase difference between vertical and horizontal components. We calculate the phase difference of both data components in the (f,p) domain and design a filter to reject events with phase differences around 90°.

We generally see little P-wave on the radial channel and little S-wave energy on the vertical channel. However, we expect to record significant ground roll on both channels. Therefore we can calculate the cross-correlation of both data components in

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the (f,p) domain and design a filter using cross-correlation to attenuate the ground roll. These procedures are outlined in Fig. 1.

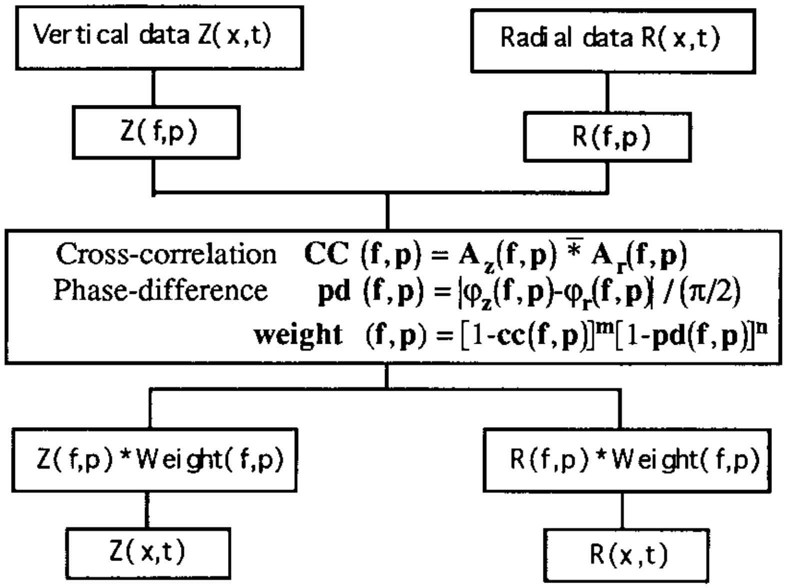

Figure 1. Block chart of the processing flow.

Synthetic Data

The processes outlined above are applied to synthetic data generated by a finite difference algorithm over the model shown in Fig. 2. The raw data and their f-v transforms are shown in Fig. 3. The results of filtering are given in Figs. 4 and 5.

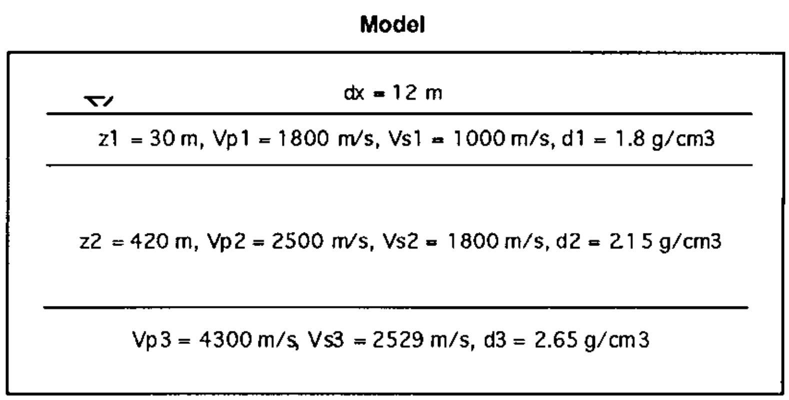

Figure 2. Model used to calculate synthetics.

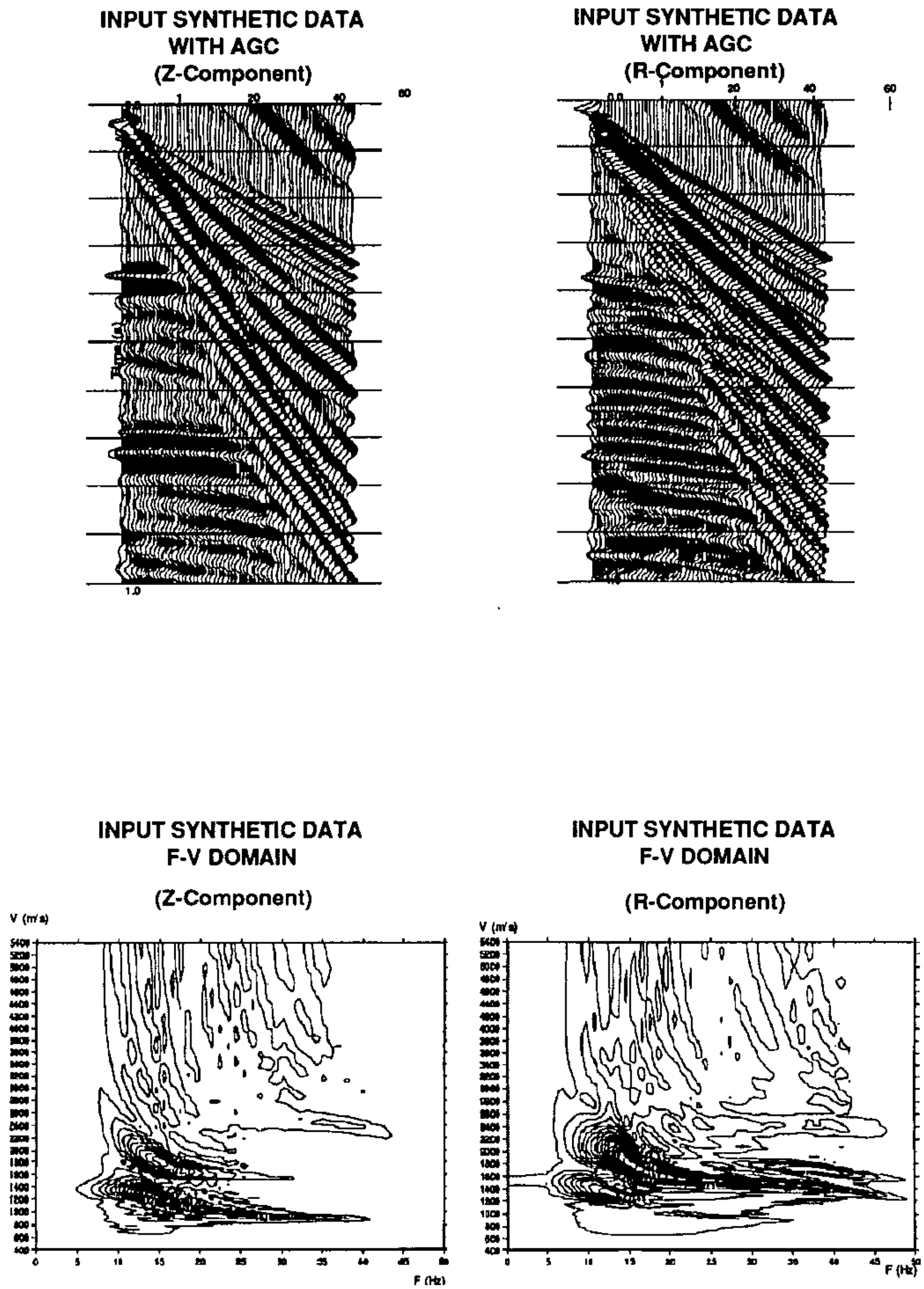

Figure 3. The synthetic was calculated with a finite difference program by Dr. Nan Xun Dai.

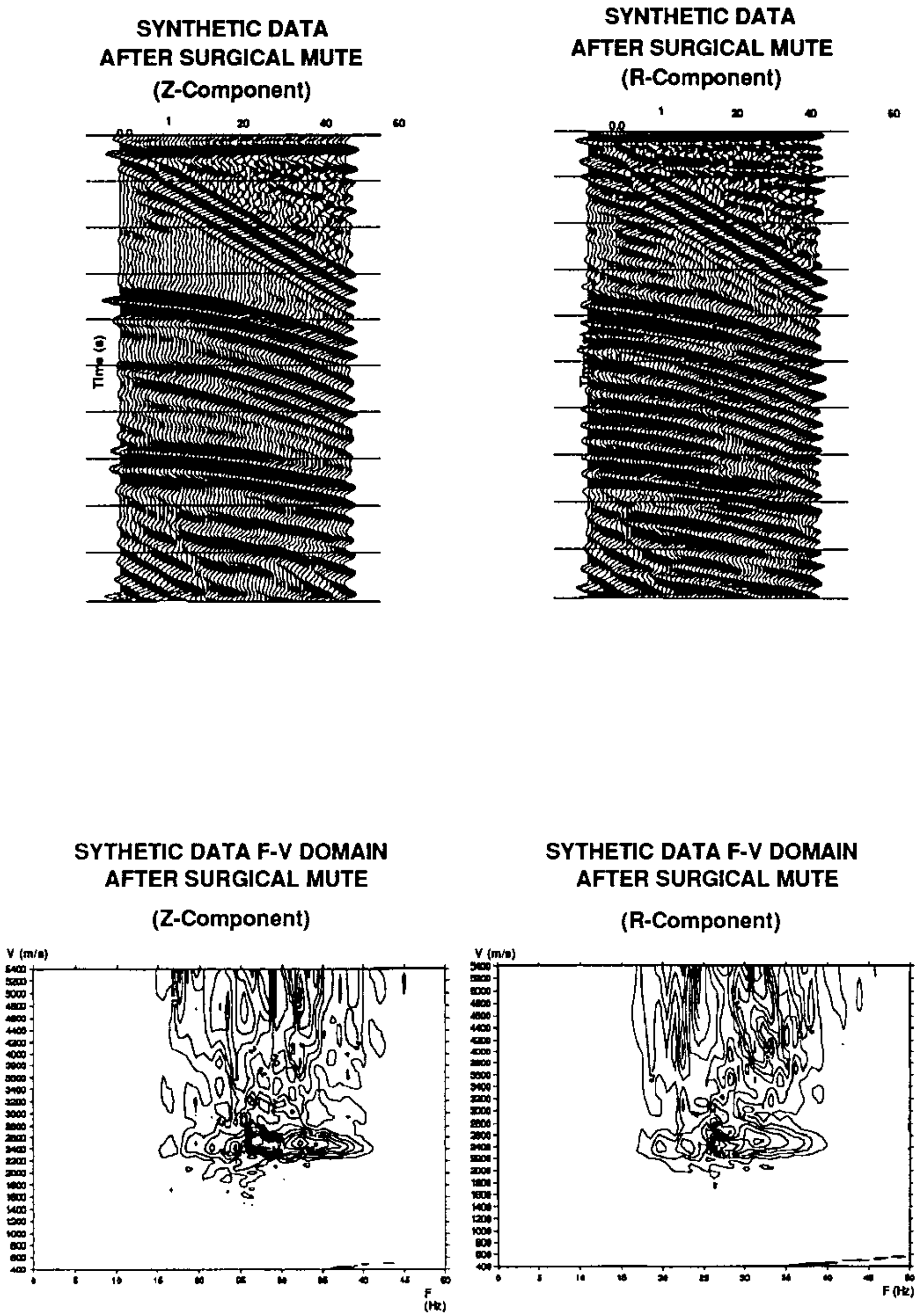

Figure 4. Vertical and radial component synthetic data after surgical mute with associated f-v spectrum.

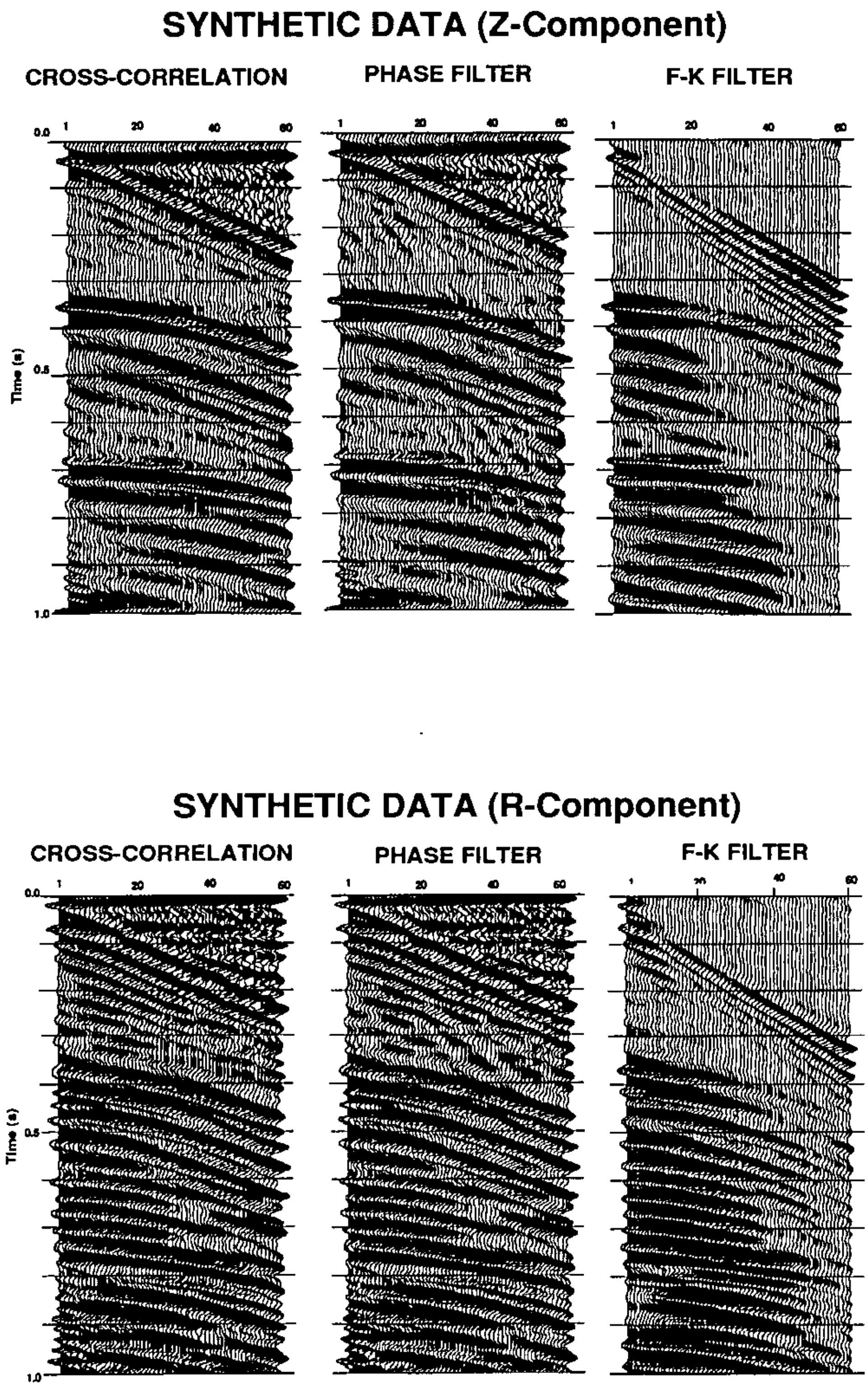

Figure 5. Comparison of filtering methods for vertical and radial component synthetic data.

Field Data

The field data under consideration were collected in the Crystal East field, central Alberta, Canada by the Alberta Energy Company Ltd. Figure 6 presents the input field data vertical and radial components individually as well as filtering results. Record #28 from line #6223 is displayed. The survey used a dynamite source and geophone group interval of 25m, vertical geophone the nearest offset of 37.5m, radial geophone the nearest offset of 62.5m, number of traces of 120, sample rate of 0.002s, time from 0.0s to 3.0s, Geophone type, vertical: LRS 280(14Hz), radial: LRS 280(8.5Hz), Geophone array, vertical: 9 over 25m, radial: 9 over 75m.

Results

We used a surgical mute filter in the (f,v) domain. For vertical and radial components, the frequency pass band is from 15Hz to 65Hz and the phase velocities passed are above 3000m/s. The results are shown in both components and the ground rolls have largely been rejected.

We tried a phase difference filter on the two component data. For the vertical and radial components, the range of phase difference filtering is from 1000m/s to 3000m/s. Above this velocity range, band-pass filters are used and under this range the data are set equal to zero. The results are shown that ground roll has been largely rejected.

Also we used a cross-correlation filter for the two component data. For vertical and radial components, the velocity range for calculating the cross-correlation is from 1000m/s to 3000m/s. Above this velocity range band-pass filters are used and under this velocity range the data are set equal to zero. The results are shown that ground roll again has been largely rejected.

Finally ground roll on the Crystal vertical and radial data was suppressed using a conventional f-k filter for comparison (passed range: f=14 Hz. k=0; f=67 Hz. k=0; f=67 Hz. k=0.00625; f=20 Hz. k=0.003125; f=14 Hz. k=0.0025).

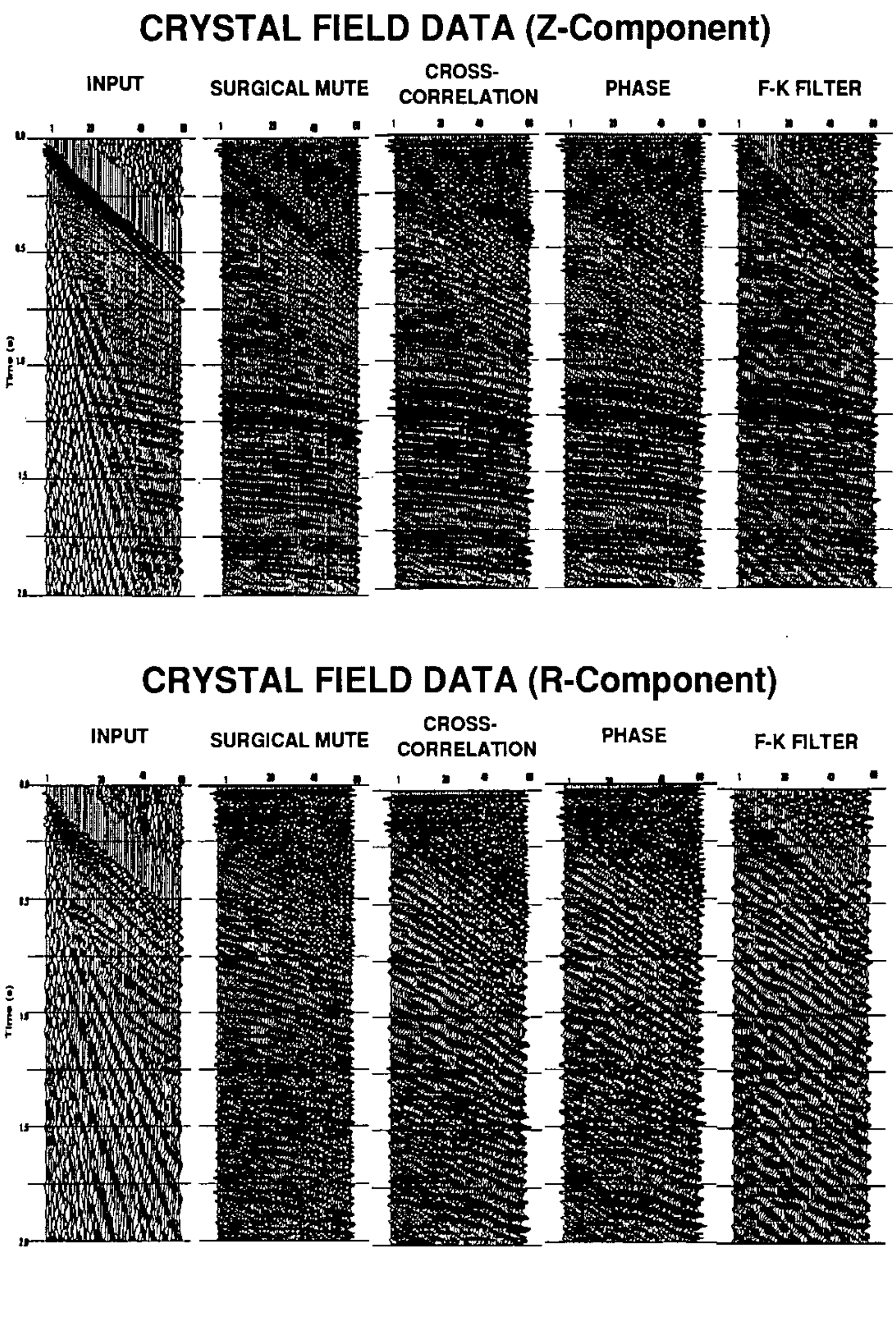

Figure 6. Field data and comparison of filtering methods for vertical and radial components.

CONCLUSIONS

In our examples, the f-v filter has led to less smeared output section than the f-k filter. It also appears to be less sensitive to aliasing. If there is a 90° phase difference noise between vertical and radial components, we can use a phase difference filter for suppression. If there is high cross-correlation noise between vertical and radial components, we can use a cross-correlation filter for suppression.

ACKNOWLEDGMENTS

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