Time and Moveout Filtering

- Frequency filtering
- Wavelet shaping (deconvolution)
- Dip and Moveout (2-D) filtering
  - *f-k* (frequency-wavenumber)
  - τ-*p* (slant stack)

- Reading:
  - Sheriff and Geldart, Sections 9.5, 9.9, 9.11

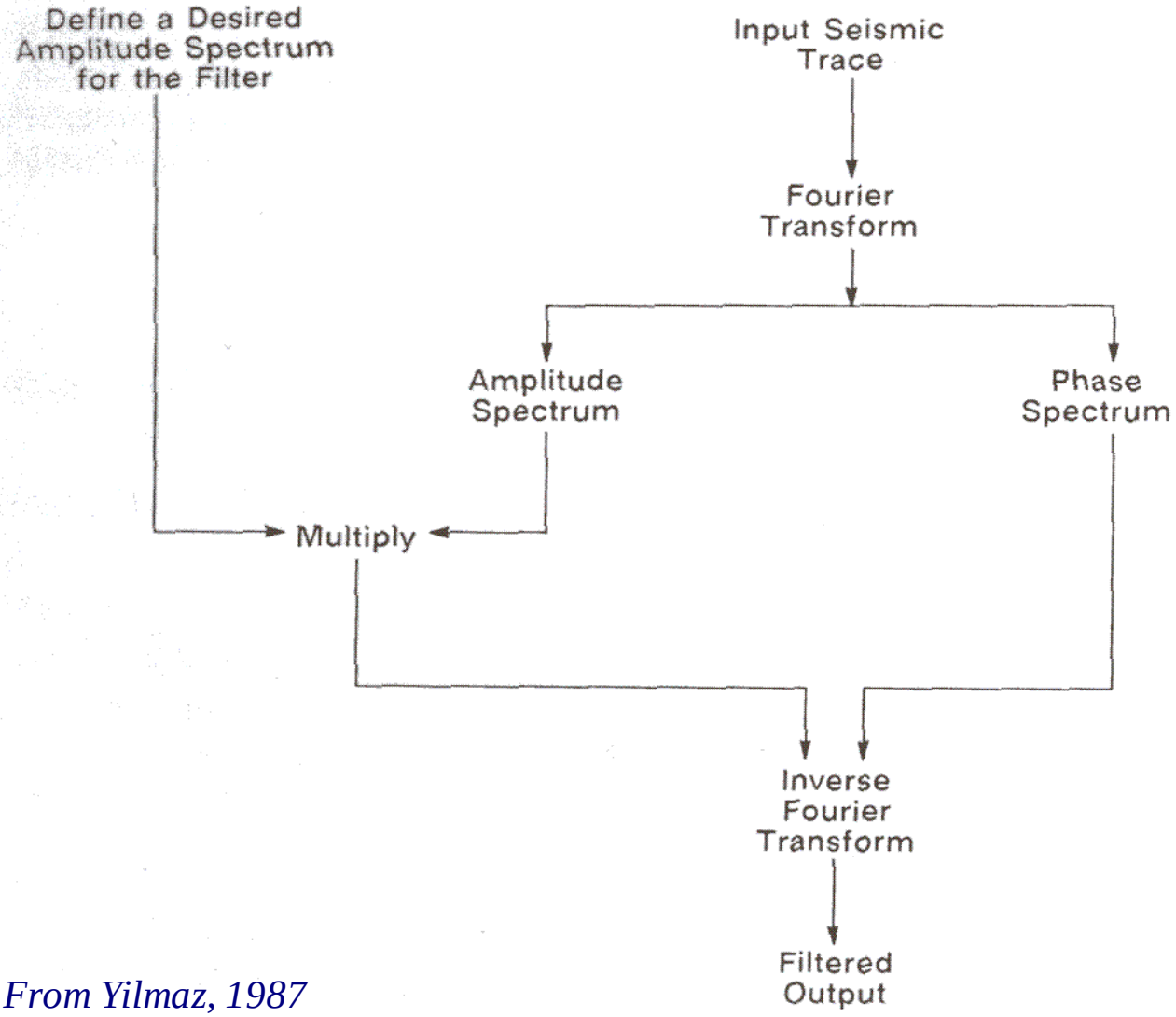
Single-channel Filtering
Objectives

- Performed in order to increase the Signal/Noise ratio or to improve signal shape:
  - Modify the frequency band
  - Flatten (“whiten”) the spectrum
  - Convert the wavelet into minimum- or zero-phase (*wavelet shaping*)
    - Minimum-phase wavelet is causal;
    - Zero-phase is better for display and interpretation
  - Normalize the effects of different sensors by bringing them to a common response (*matching filters*)
  - Remove reverberations (*deconvolution*)
- The Filter is always a time series *convolved* with the signal
  - This can always be done in *time* or *frequency* domain

Frequency filtering

Frequency-domain

- Most common
- Zero phase filter in order to preserve phase character

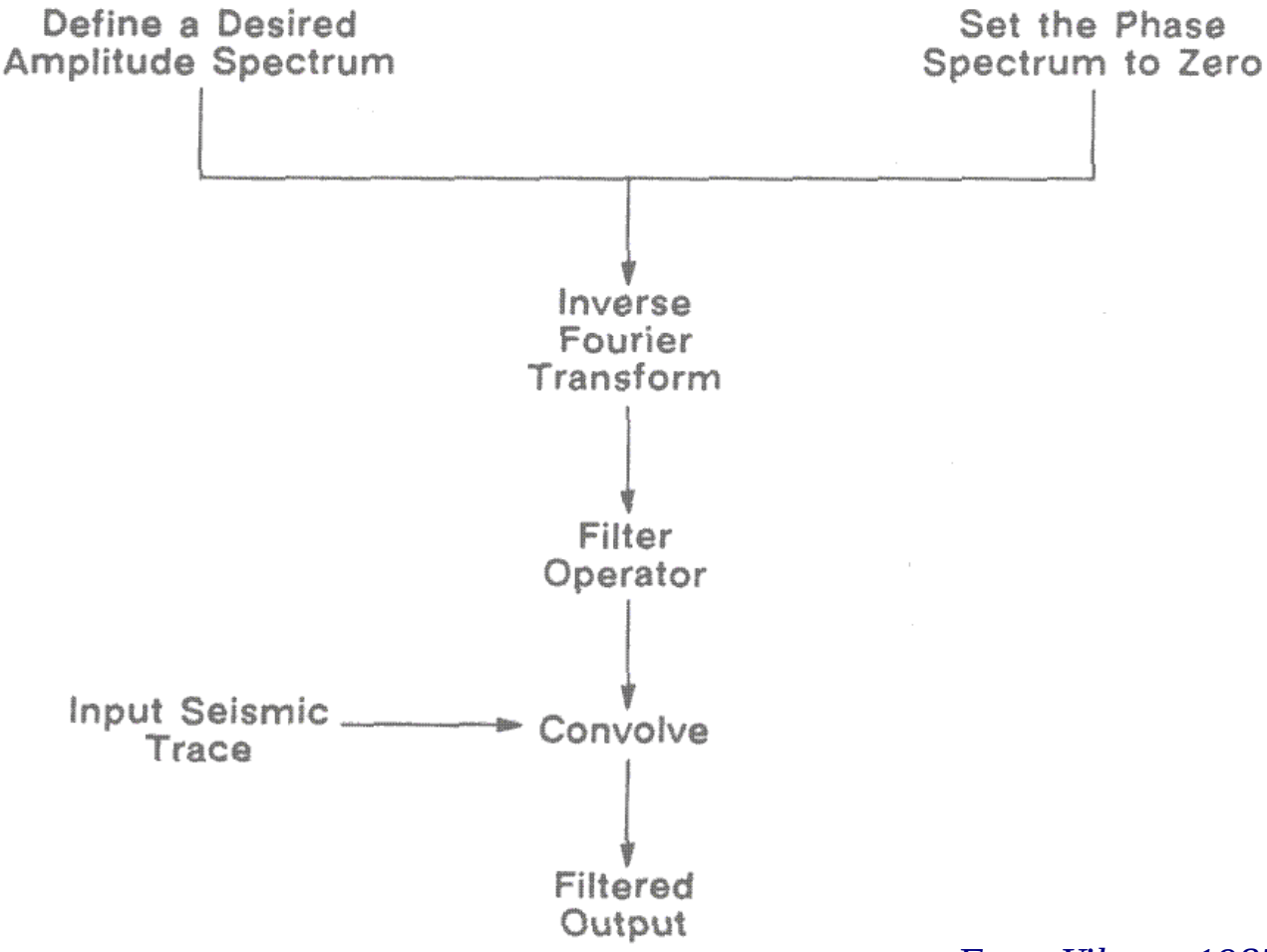


From Yilmaz, 1987

Frequency filtering

Time-domain

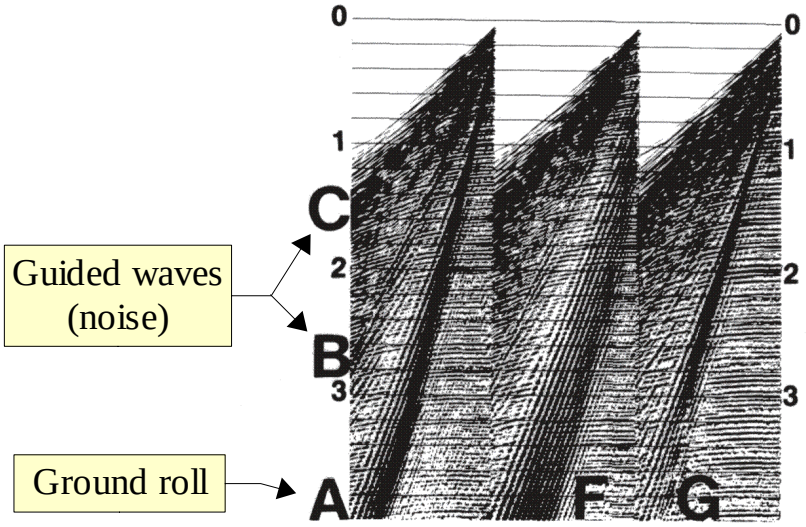
- This is used only for broad-band (short in time) filters when time-domain convolution is more efficient then forward and inverse FFT



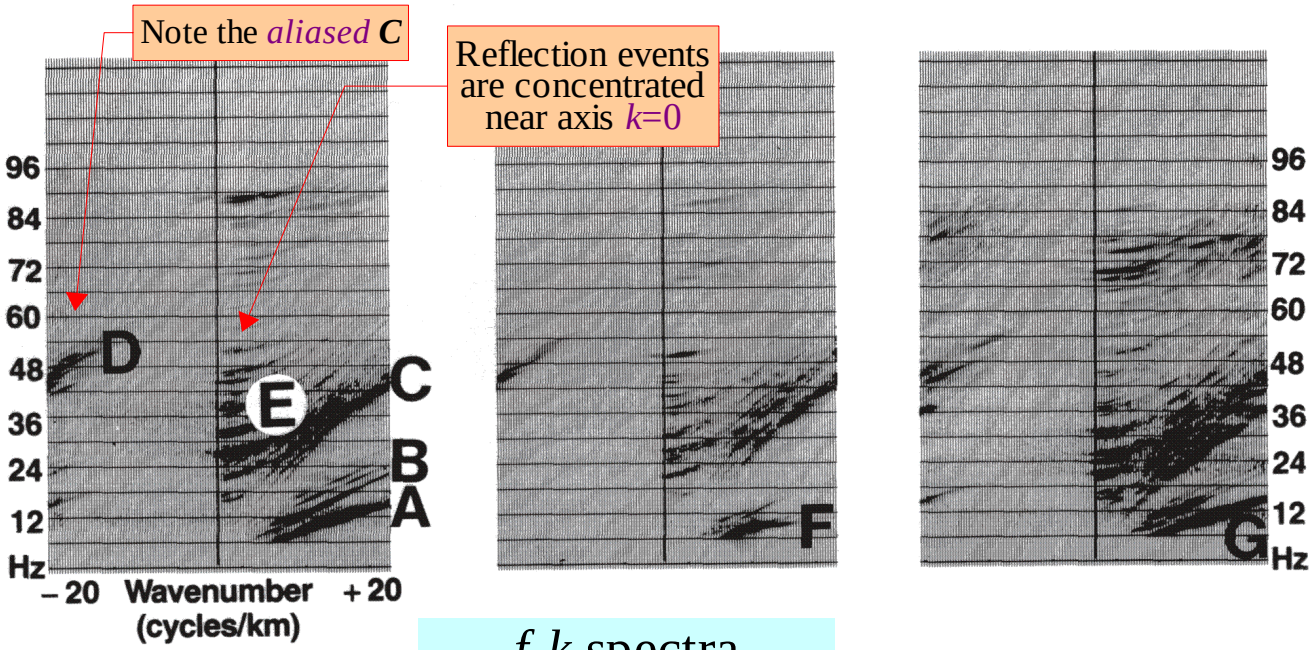
From Yilmaz, 1987

F-K spectra (shot gathers)

- By performing Fourier Transform in both time and space, the *f-k spectra* are obtained
- The physical significance is in decomposition of the wavefield into *harmonic plane waves*



Shot gathers

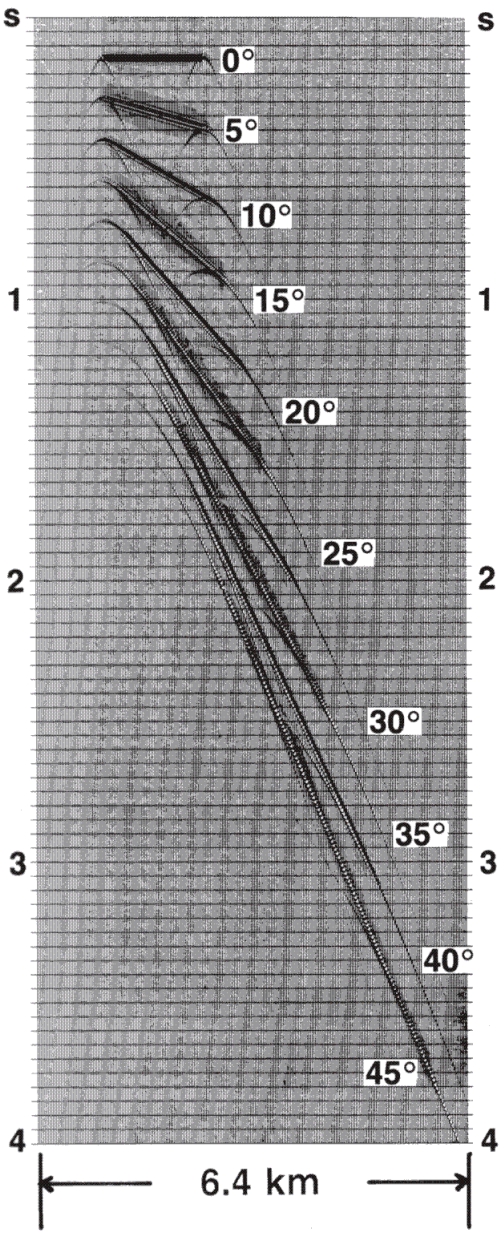


f-k spectra of the same gathers

From Yilmaz, 1987

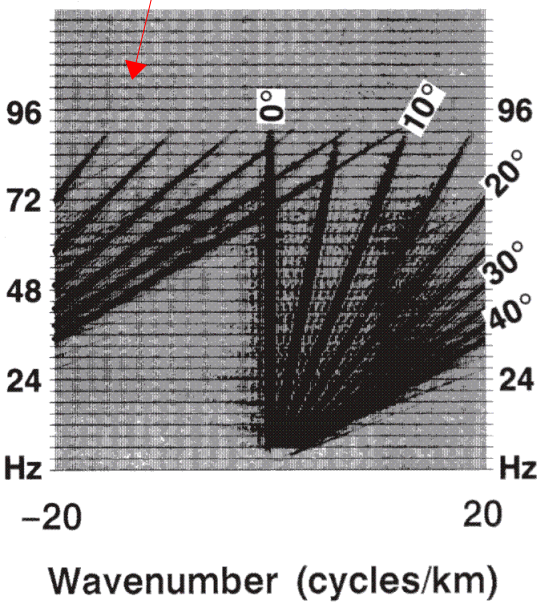
F-K spectra (dipping events in a zero-offset section)

- Events with different (apparent) dips occupy different parts of the *f-k* spectrum, regardless of their positions in time or space



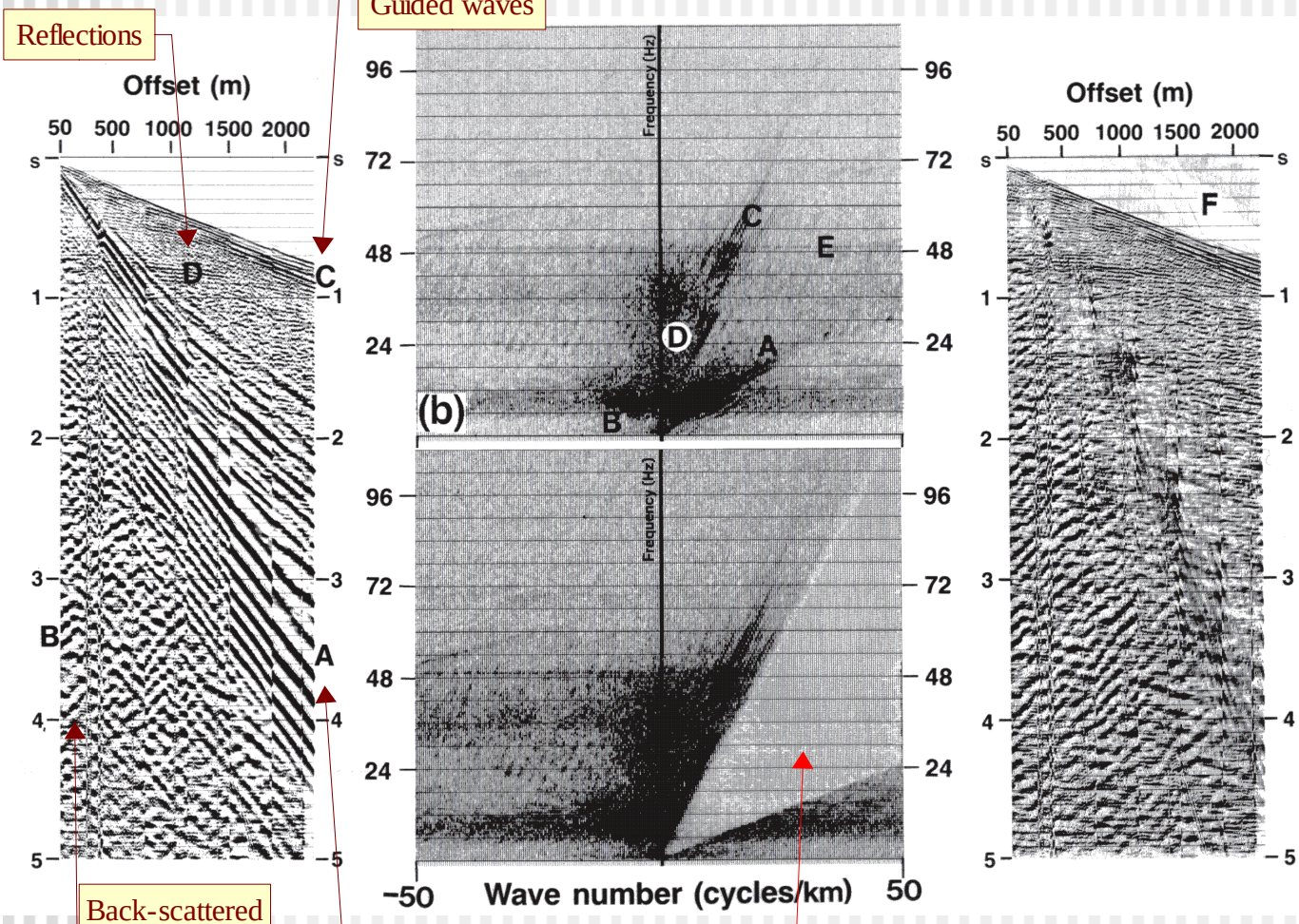
From Yilmaz, 1987

With increasing dips, the events become *aliased* at progressively *lower frequencies*



F-K filtering

- Here, only forward-propagating ground roll is rejected by the filter.



From Yilmaz, 1987

Plane-wave decomposition
t-p transform

- Instead of *f-k* transform, plane waves can be extracted from the section by *slant-stacking:*

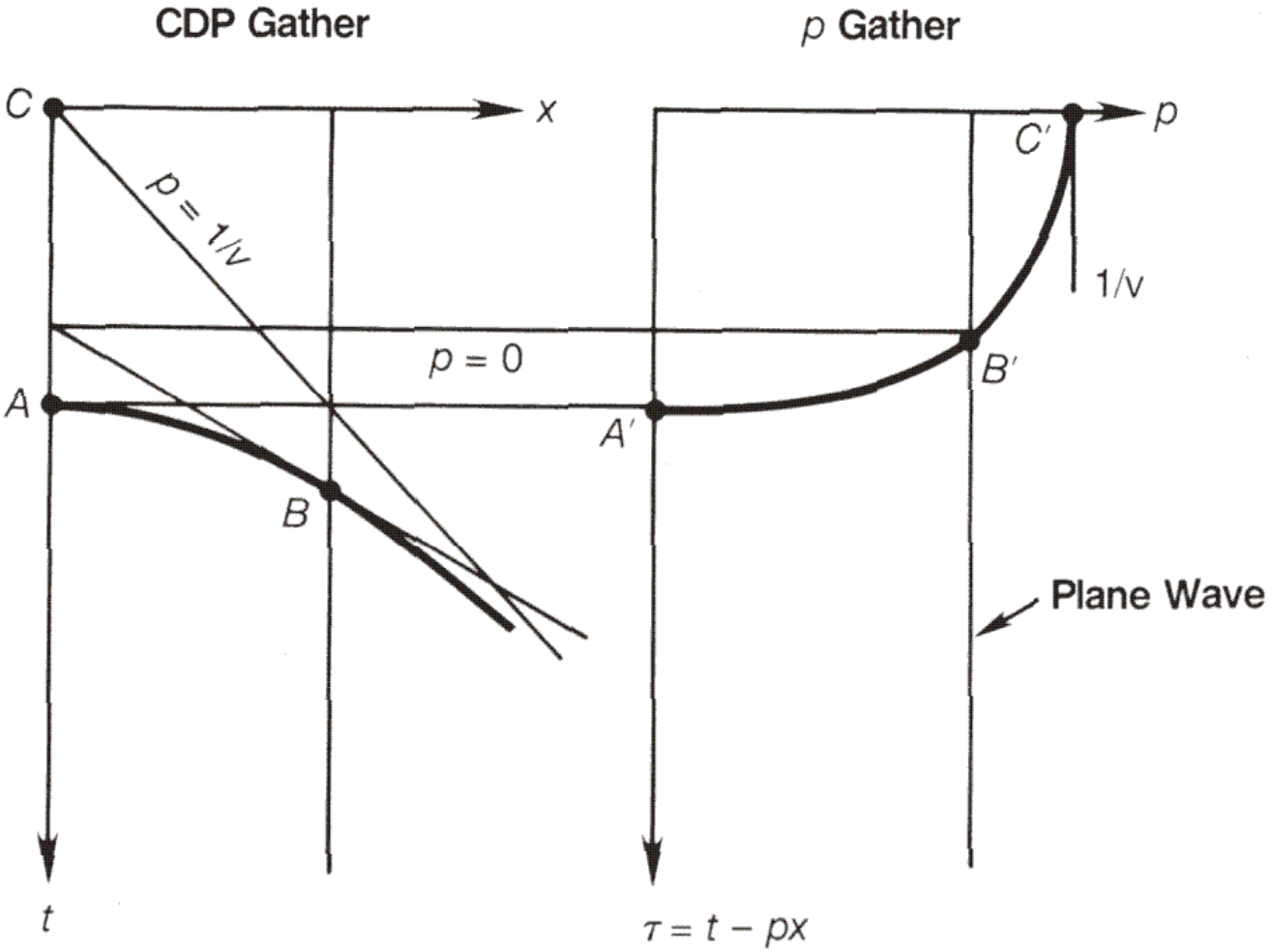
$$S(p,\tau)=\sum_x u(x,\tau+px)$$

$t = \tau + px$ describes the wavefront of a plane wave

- This is done for every τ (intercept time) and p (slowness), resulting in a (τ,p) section
- The difference from *f-k* is in using plane waves *localized in time* (pulses instead of harmonic functions),
  - ...and therefore filtering can be based on *moveouts* AND *times* of the events.

Refractions and reflections in τ-p domain

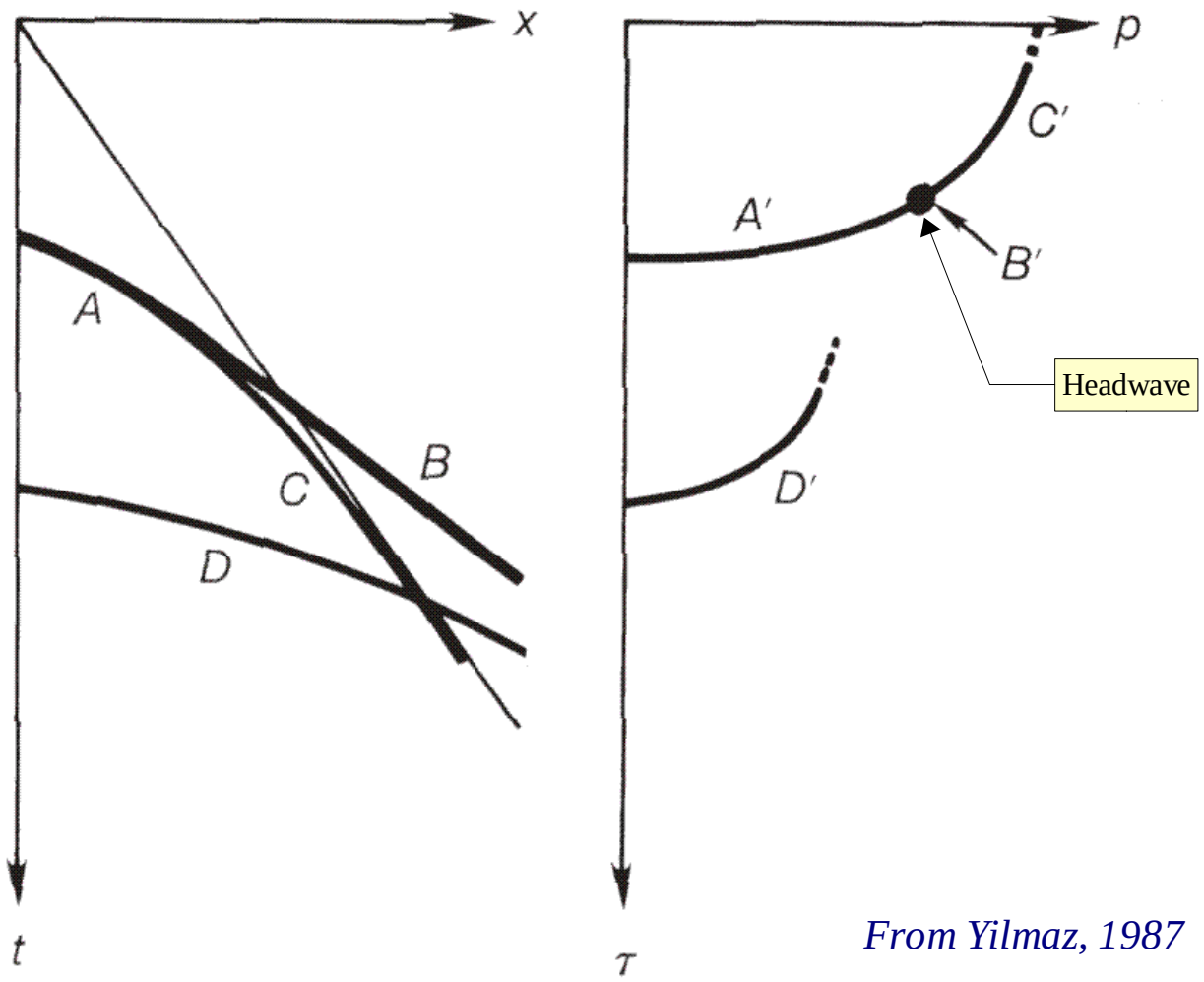
- Reflections (straight lines in (x,t) become points,
- ...and reflections (hyperbolas in (x,t)) - ellipses



From Yilmaz, 1987

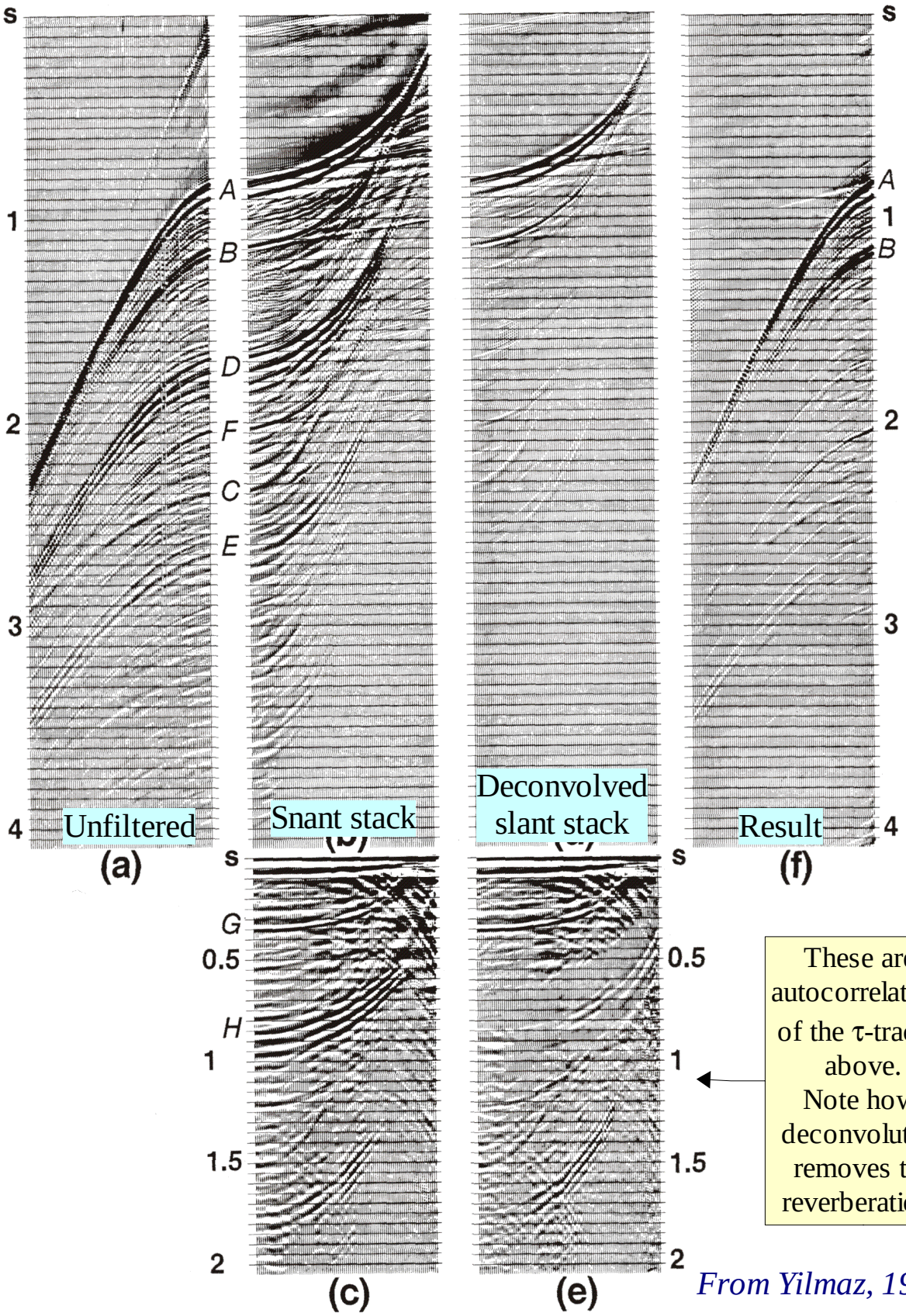
Several reflections in τ-p domain

- Reflections can be separated by their intercept times
- Phases retain their waveforms – this simplifies interpretation and facilitates waveform shaping (e.g., deconvolution)



From Yilmaz, 1987

Multiple suppression using τ-p



These are autocorrelations of the τ-traces above. Note how deconvolution removes the reverberations

From Yilmaz, 1987