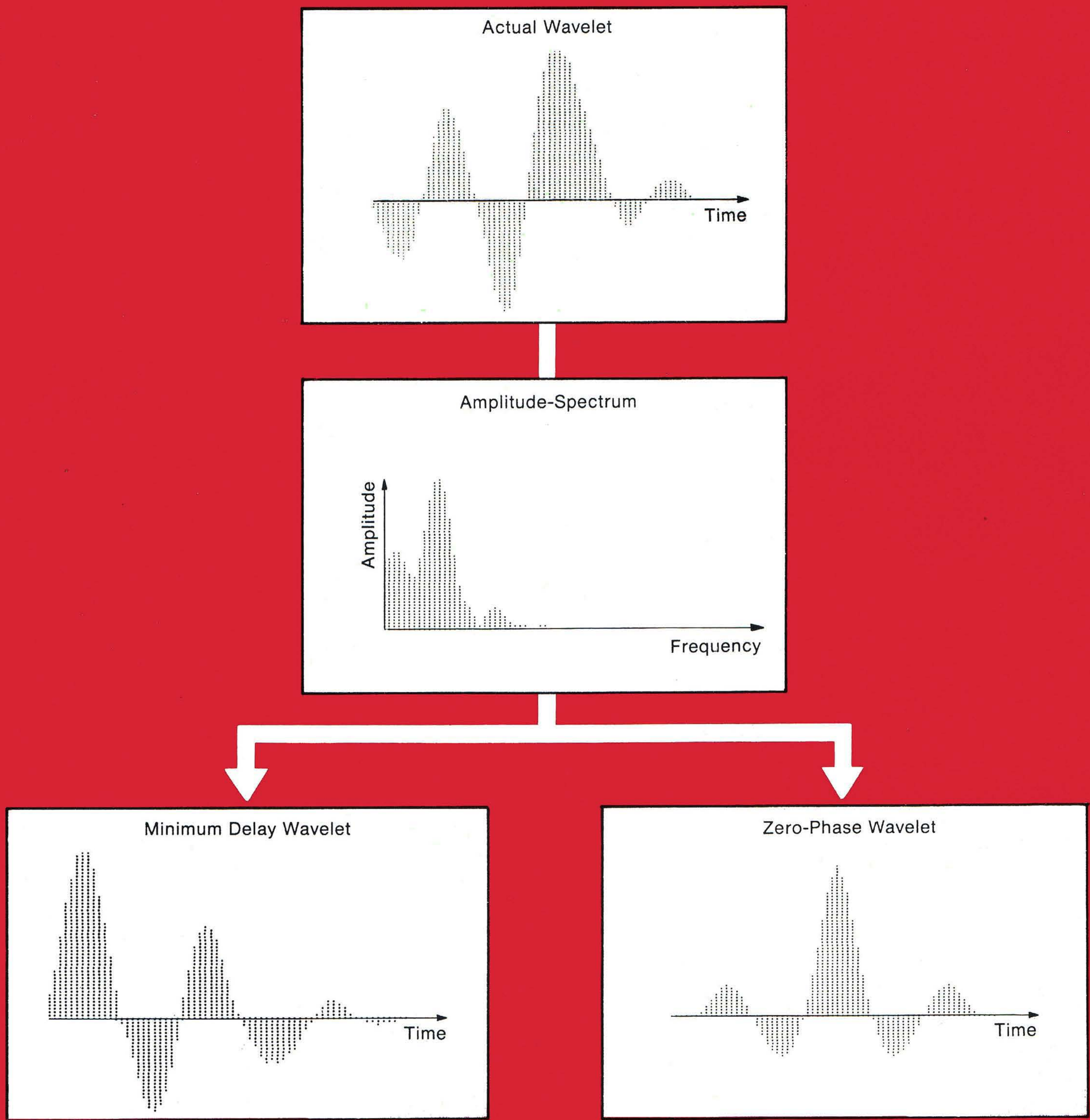
PRAKLA-SEISMOS INFORMATION No. 8

Wavelet Processing



Wavelet Processing

A seismic trace is the convolution of a reflectivity function and a time-variant wavelet. If this wavelet is known, a variety of seismic processes may be improved.

Up to now a common assumption is the existence of a minimum delay wavelet in the seismic trace. Based on this assumption the deconvolution-parameters are designed. If this assumption is not true, the result of deconvolution, applied in order to attenuate short period reverberations, may be unreliable. Therefore, the existing wavelet should be replaced by its "minimum delay correspondent", i. e. a minimum delay wavelet with the same amplitude spectrum. This procedure, applied prior to deconvolution, would improve the effect of the deconvolution process.

A typical processing scheme for marine data, to which of course a lot of variations may be added, is shown on the last page.

The first step of wavelet processing is the **derivation of the actual wavelet contained in the trace and its replacement by its minimum delay correspondent.**

For the determination of the existing wavelet additional information is necessary. The most favourable additional information is a well survey with the corresponding log-information. Often one is interested in an improvement in reflection quality of possible reservoir-layers, i. e. only in a certain part of the section. In this case the wavelet determination is limited to the chosen time gate. For this purpose a least mean squares procedure is used.

The correctness of wavelet determination can be checked by comparing the impulse seismogram, convolved with the derived wavelet, with the stacked trace at the well position (Fig. 1).

If no well data are present, additional information may be derived by direct source pulse measurement, by the use of sea bottom multiples, by cepstrum filtering or by phase splitting. But in general, the use of well data is superior, because by this method the influence of the overburden (absorption and dispersion) is in the best way included in the computed wavelet.

The newly developed phase splitting method consists of a successive determination of a sequence of mixed phase wavelets having identical amplitude spectra, followed by minimum delay shaping and subsequent deconvolution. The comparison of the deconvolved results leads to the most probable mixed phase wavelet.

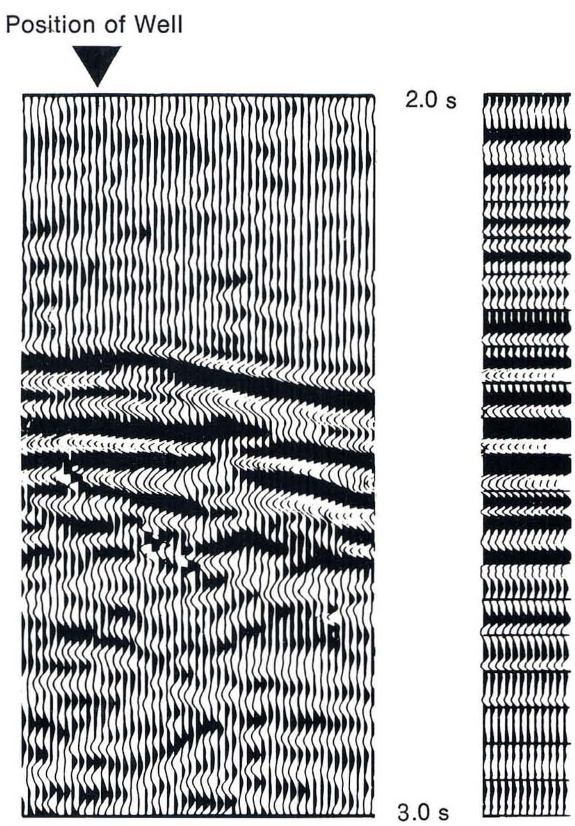


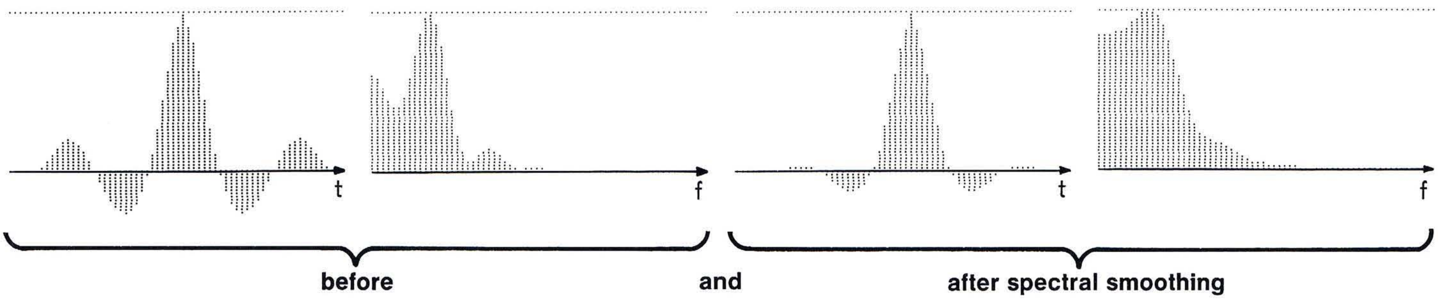
Fig. 1: Comparison: actual seismic line through well position (left) — impulse seismogram, convolved with derived wavelet (right)

After application of different shaping- and deconvolution filters a quality control is again possible: the existing wavelet in the processed time section can be recomputed at the well position and should be identical with the desired minimum delay wavelet.

The minimum delay wavelet section, either filtered or unfiltered, may be considered as a final result (see last page, output A). There are, however, certain advantages if **the minimum delay wavelet is replaced by its zero-phase correspondent** (i. e. a zero-phase wavelet with the same amplitude spectrum), by a spike, or "something inbetween". This transformation, the second part of wavelet processing, leads to improvement of seismic resolution, since zero-phase wavelets or spikes concentrate the energy at the origin of the reflection (see last page, output B and C). The front cover shows a wavelet with its minimum delay correspondent and zero-phase correspondent.

If the zero-phase correspondent shows undesirable side lobes, these side lobes may be attenuated by a spectral smoothing procedure, leading to the wavelet defined by the term "something inbetween" mentioned above. Zero-phase wavelets and their frequency spectra before and after spectral smoothing are shown in Fig. 2.

Fig. 2: Zero-phase wavelets and their frequency spectra



In Fig. 3 for demonstration of wavelet processing a synthetic example is given. Starting with an impulse seismogram (Fig. 3 a) and using a given mixed delay wavelet as additional information, the convolution of this wavelet with the impulse seismogram is shown (Fig. 3 b). This trace now represents our input, so to say the equivalent of the stacked trace in our processing scheme. The result of minimum delay shaping is shown in the next row (Fig. 3 c, this would be output A), and finally, the result of zero-phase shaping (Fig. 3 d, output B) and the corresponding filter operator (Fig. 3 e). By comparing these traces with the impulse seismogram the superior result of wavelet processing can be seen.

Fig. 3: Synthetic example for wavelet processing

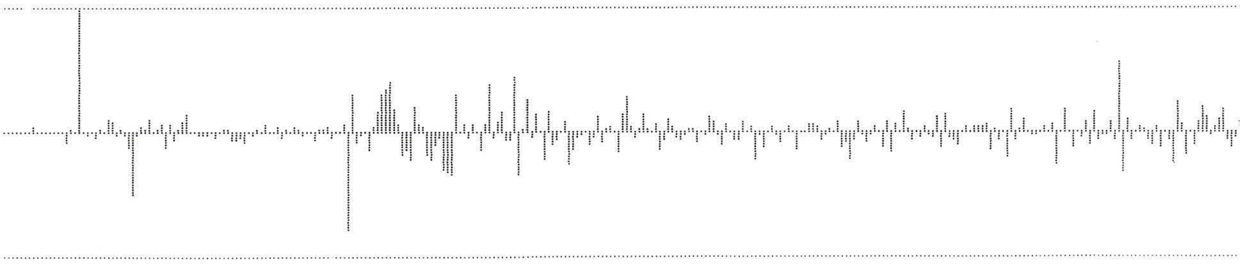


Fig. 3 a: Impulse seismogram

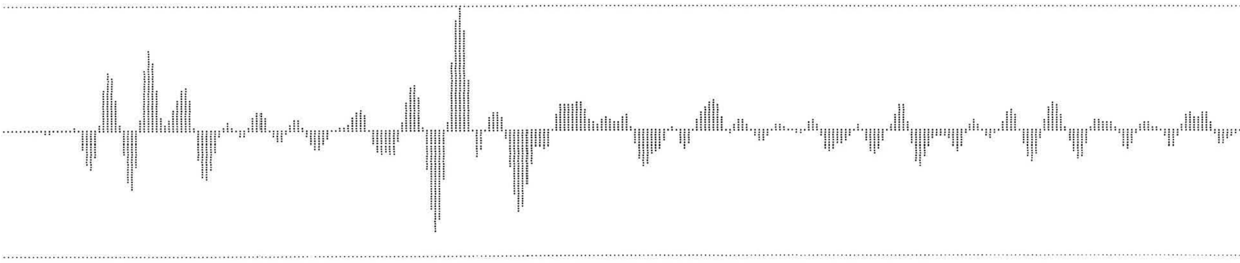


Fig. 3 b: Synthetic "stacked trace"

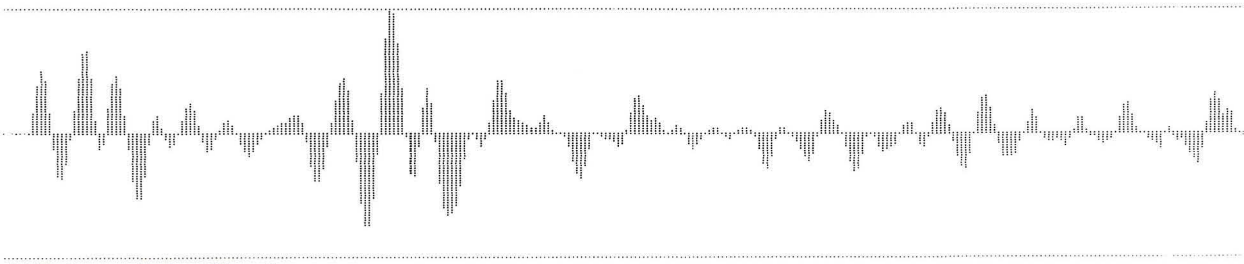


Fig. 3 c: Result of Minimum Delay Shaping

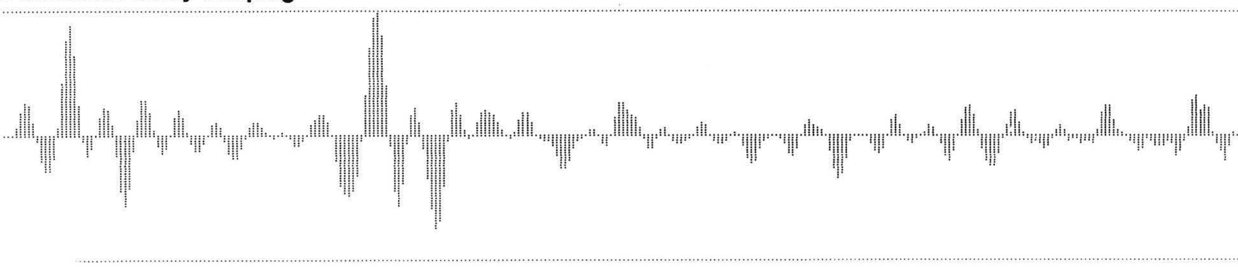


Fig. 3 d: Result of additional Zero-Phase Shaping

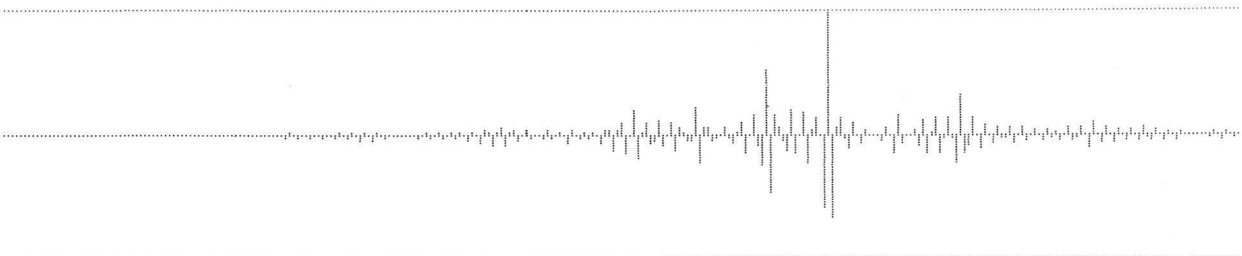


Fig. 3 e: The filter operator for shaping from minimum delay wavelet to zero-phase wavelet

The procedures described above have been successfully applied to seismic data and the results confirm the expected improvement. In the last figure a real example is shown which demonstrates the advantage of wavelet processing in a geologically complicated area (Fig. 4). The improvement of resolution is evident.

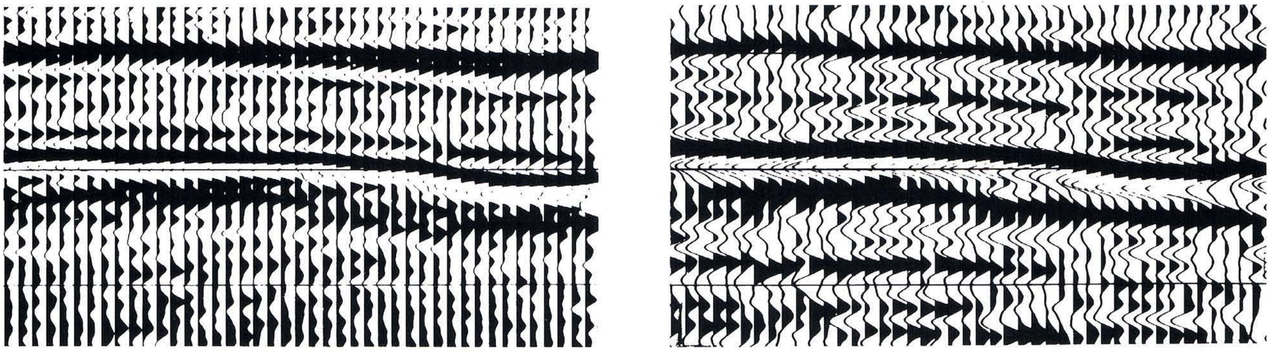
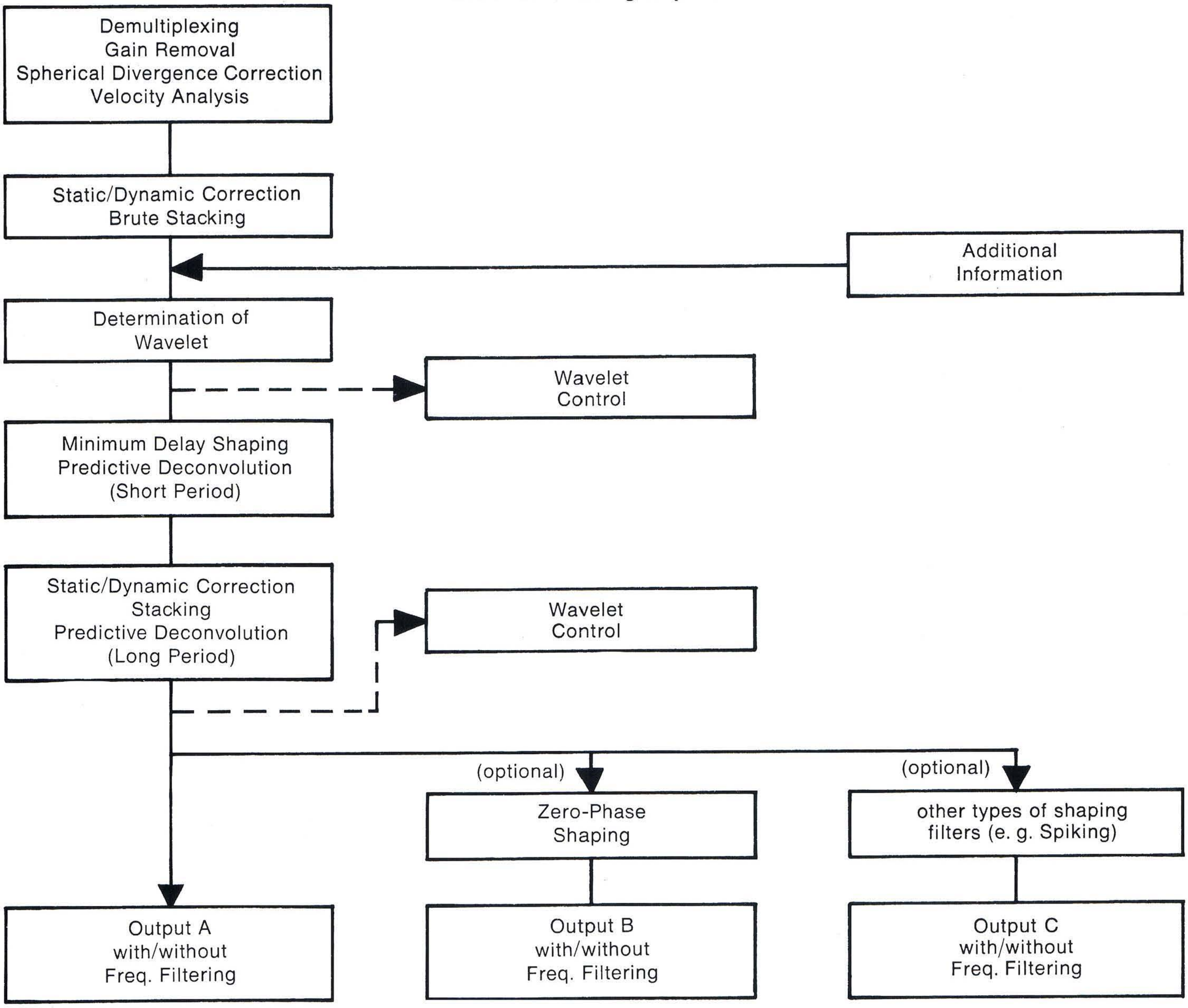


Fig. 4: Section without and with wavelet processing

Wavelet Processing Sequence



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