# GC What Is Deconvolution?*

By
Robert E. Sheriff[1]

Search and Discovery Article #40131 (2004)

*Adapted from the Geophysical Corner column in AAPG Explorer, April, 2004, entitled "A Demystifying of Deconvolution" and prepared by the author. Appreciation is expressed to the author, to Alistar R. Brown, editor of Geophysical Corner, and to Larry Nation, AAPG Communications Director, for their support of this online version.

[1]Professor, University of Houston (RESheriff@Houston.RR.edu)

## General Statement

Deconvolution is a process universally applied to seismic data, but is one that is mysterious to many geoscientists. Deconvolution compresses the basic wavelet in the recorded seismogram and attenuates reverberations and short-period multiples. Hence, it increases resolution and yields a more interpretable seismic section.

Note the differences in the Figure 1. The quality of modern seismic data owes a great deal to the success of deconvolution. Seismic processing often involves several stages of deconvolution, each of a different type and with a different objective.

Deconvolution usually involves convolution with an inverse filter. The idea is that this will undo the effects of a previous filter, such as the earth or the recording system. The difficulty in designing an inverse filter is that we hardly ever know the properties of the filter whose effects we are trying to remove.

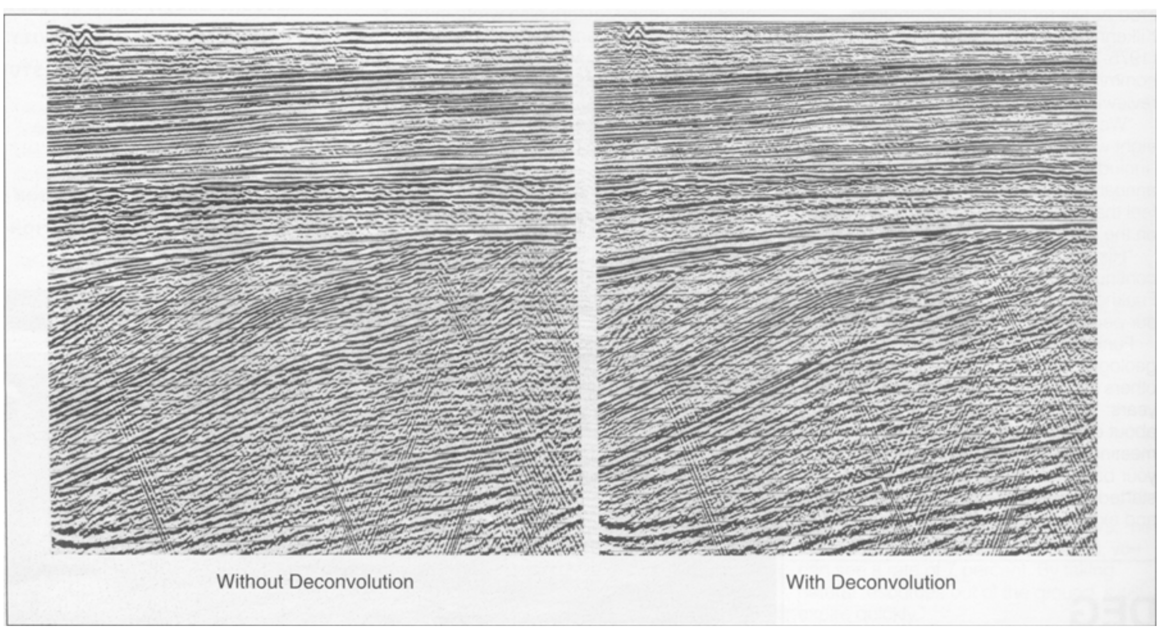


**Figure 1. Seismic line without deconvolution (A) and with deconvolution (B).**

## Types of Deconvolution

Different kinds of deconvolution are generally described by the different adjectives. They usually designate the type of assumptions made in the process.

**Deterministic deconvolution** can be used to remove the effects of the recording system, if the system characteristics are known. This type also can be used to remove the ringing that results from waves undergoing multiple bounces in the water layer, if the travel time in the water layer and the reflectivity of the seafloor are known.

In the case of the earth, the previous filtering that was applied is not known, and thus the deconvolution takes on a statistical nature. In this situation the needed information comes from an autocorrelation of the seismic trace. Because the embedded wavelet from the source is repeated at each reflecting interface, this repetition is captured by the autocorrelation and used to design the inverse filter.

The embedded wavelet ordinarily dominates the early part of an autocorrelation, whereas multiples dominate the later part. Hence different parts of the autocorrelation are used to determine different filters for different types of deconvolution. The embedded wavelet then can be recovered from the early part of the autocorrelation, but, because the autocorrelation contains amplitude information only, an assumption about phase is required. Minimum phase in the recorded data is usually assumed, and normally this is a good assumption. The output of the deconvolution, however, is normally zero phase. The enormous interpretive benefits of zero phase data have been discussed in previous Geophysical Corner columns ("Seismic/Geology Links Critical," *AAPG Explorer* November 1996, also Search and Discovery Article #40130 (2004), and "Zero Phase Can Aid Interpretation," *AAPG Explorer* April 1997, also in “Understanding the Seismic Wavelet,” by Steven G. Henry, Search and Discovery Article #40028 (2001)).

Autocorrelations may be calculated over several time windows in an attempt to allow for changes in the shape of the embedded wavelet as it travels through the earth. This is called **adaptive deconvolution**.

**Spiking deconvolution** shortens the embedded wavelet and attempts to make it as close as possible to a spike. The frequency bandwidth of the data limits the extent to which this is possible. This is also called **whitening deconvolution**, because it attempts to achieve a flat, or white, spectrum. This kind of deconvolution may result in increased noise, particularly at high frequencies.

**Predictive deconvolution** uses the later portions of the autocorrelation to remove the effects of some multiples. Predictability means that the arrival of an event can be predicted from knowledge of earlier events. Different formulations are used, including maximum and minimum entropy, a measure of disorder.

**Sparse-spike deconvolution** attempts to minimize the number of reflections, thus emphasizing large amplitudes.