IV. SPIKINESS

A. Non-Gaussianness and Spikiness

One school of earth-scientists believe major changes in the earth's history, those that can be inferred from the stratigraphic column, happen relatively quickly. They maintain geological history can be modeled as an impulsive process (10): relative quiet for millions of years, then suddenly a drastic change.

This impulsive process is evidenced by the spiky character of most reflectivity series. These series generally have a probability distribution which is "far" from Gaussian. Claerbout and Muir (11) pointed this out and were perhaps first to advocate the need for non-Gaussian analysis of seismic data.

The method of deconvolution proposed in this thesis relies on a measure of non-Gaussianness. It is assumed the observed seismogram is the result of time and spatial averaging of the reflectivity series, the time averaging representing the source waveform and the spatial averaging, diffraction. By the central limit theorem (12), this averaging tends to make the seismogram's amplitude distribution more Gaussian. To remove the averaging an inverse filter is designed to maximize a measure of non-Gaussianness.

Non-Gaussianness is an ambiguous concept. In the continuum of probability distributions the Gaussian occupies a central position. On one side are distributions such as the uniform, where all events are clustered into a given range and are equally likely. On the other side

are structured, spiky distributions with the certain event being the extreme example. Reflectivity series are generally on the spiky side of the Gaussian as shown by Figure 4-1.

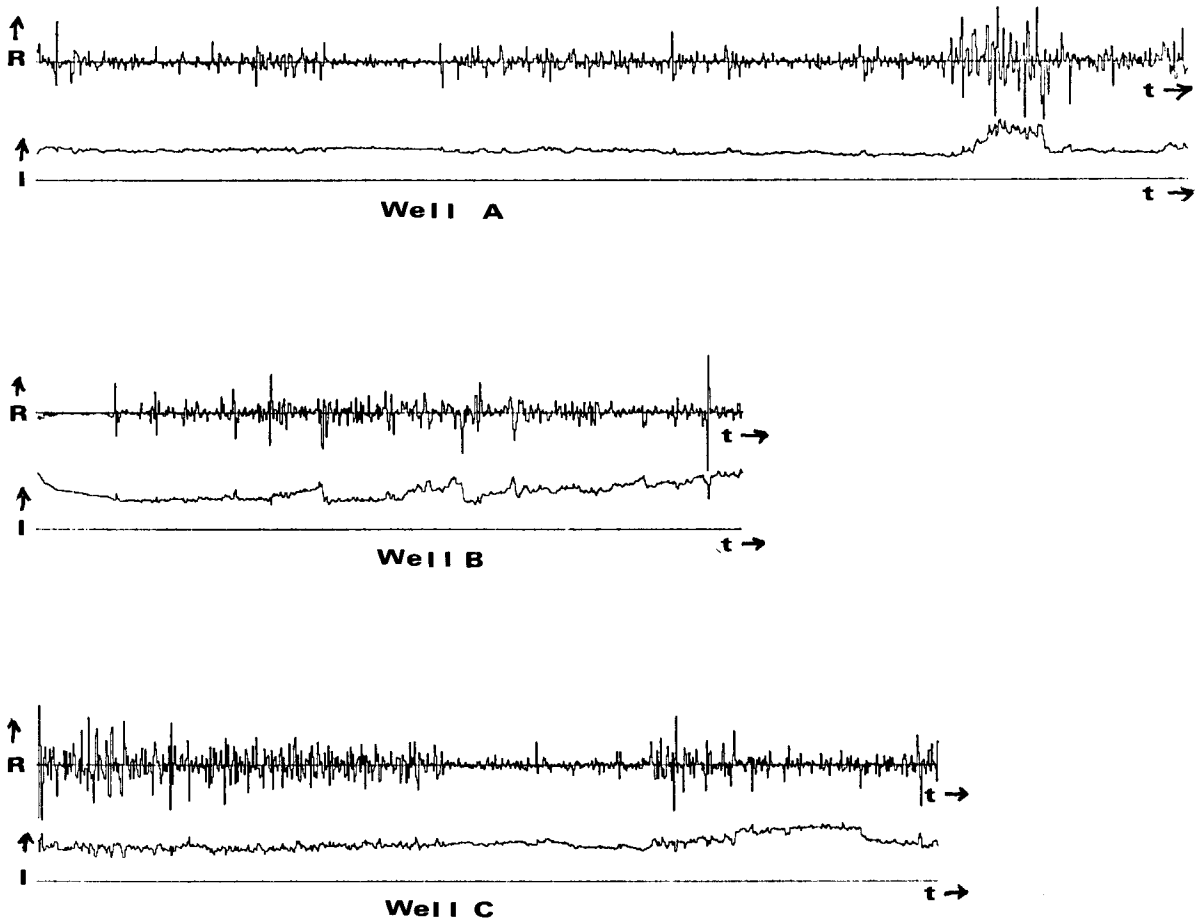

FIGURE 4-1. Reflectivity series derived using sonic logs obtained from wells in three sedimentary basins. Below each reflectivity series is its estimated acoustic impedance function. The reflectivity series exhibit spiky, non-Gaussian distributions. The series are sampled at a one-millisecond rate, and were provided by the Chevron Oil Field Research Company.

B. Equivalent Spikiness Concepts

A spiky reflectivity series is one with several randomly located large events separated by many near-zero events which can be interpreted as noise. If some constraint is imposed, such as the variance of the

seismogram and its estimated reflectivity series being equal, then the probability distribution of the reflectivity series will have less entropy. This is strictly true only if the reflectivity series is uncorrelated. Entropy is a measure of unpredictability. It is a function of both the color and amplitude distribution of a given sample. To say the reflectivity series has less entropy requires knowledge of first and second order statistics.

Claerbout used the concept of parsimony to describe spikiness. The law of parsimony is related to economy of description. Loosely applied to deconvolution it requires no more events than necessary be allowed to account for the recorded data. One deconvolution is said to be more parsimonious than another when it contains fewer events and has the same residual error. A paper by Ferguson (13) gives an excellent discussion relating parsimony and entropy in factor analysis.

The concepts of non-Gaussianness, spikiness, and parsimony are vague, and largely intuitive. In the next chapter a family of probability distributions is introduced which will give quantitative meaning to these concepts.