PRAKLA-SEISMOS INFORMATION No.7

Frequency Analysis

Frequency Analysis of Seismic Measurements

Data Control

- frequency characteristics of sweeps
- effectiveness of deconvolution process

Data Analysis

- horizontal frequency analysis
- attenuation studies

Frequency Analysis

The computation of spectra plays an important role in modern seismics. Spectra are used for data control (e.g. frequency characteristics of VIBROSEIS* sweeps) and for data analysis.
For control purposes **conventional techniques** such as Fast Fourier Transform or Autocorrelation Methods are recommended. Frequency resolution and confidence limits of spectral amplitudes are linked to the length of the gate or to the length of the autocorrelation function. These methods give good results **when the length of the time series is long compared with the periods of dominant signal components.**
These methods usually fail when very high resolution is desired or when the series contains only a few (one to four) periods (compare back cover, left and middle). In seismic data analysis very often **short time gates** have to be chosen. Here **highly sophisticated techniques** are needed to ensure fine resolution and reliable results. Especially in the analysis of the frequency content of seismic signals and its change in time and space — a parameter which gains more and more importance as an additional tool for detailed lithologic studies — spectral techniques have to meet very high standards.

Modern data adaptive methods such as Maximum Likelihood Spectral Analysis and Maximum Entropy Spectral Analysis fulfill these requirements (compare back cover, right).

The **Maximum Likelihood Technique s**till needs to be investigated more thoroughly, while the statistical properties of **Maximum Entropy Spectral Analysis (MESA)** are well understood. The choice of parameters is governed by statistical criteria which allow an application of MESA without any subjective choice of the analyst.
MESA is based on prediction error filter theory and on statistical model fitting. The optimum filter length is controlled by a statistical error criterion after Akaike and is chosen automatically. MESA gives a power density spectrum which has to be integrated when power values are desired. Using the Akaike-criterion the MESA spectrum is computed with optimal resolution and with optimal reliability of spectral amplitudes.
The application of MESA to horizontal frequency analysis offers a promising tool for the extraction of reliable frequency information from seismic data. The length of the selected time gates should not be less than about twice the period of dominant signal components. A corresponding example for the application of MESA in combination with amplitude analyses (as usual for Real Amplitude Processing) is shown on the next page.

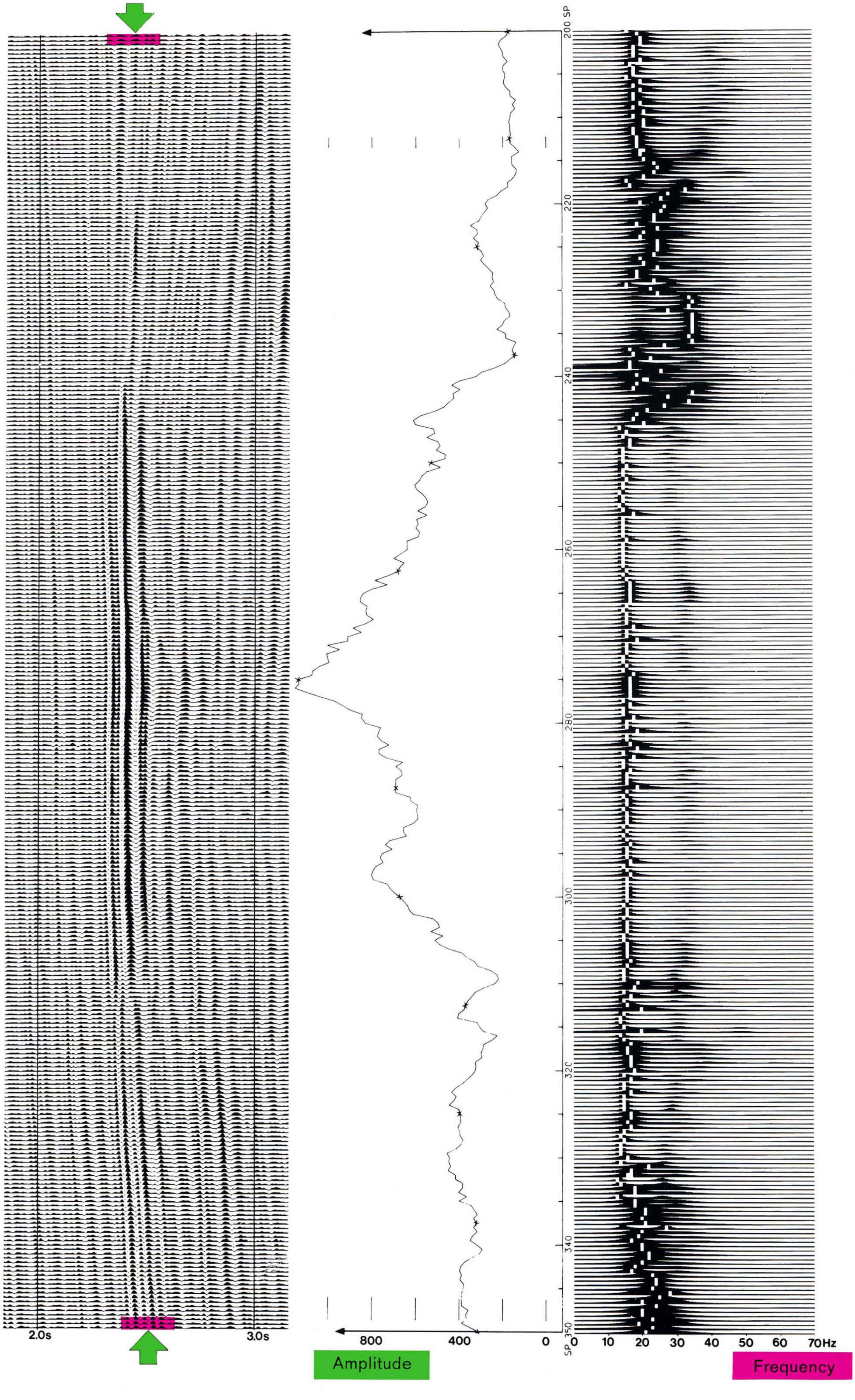
* Trade Mark of Continental Oil Comp.

Combined Horizontal Frequency and Amplitude Analysis

Left: part of a record section
showing a pronounced high amplitude anomaly

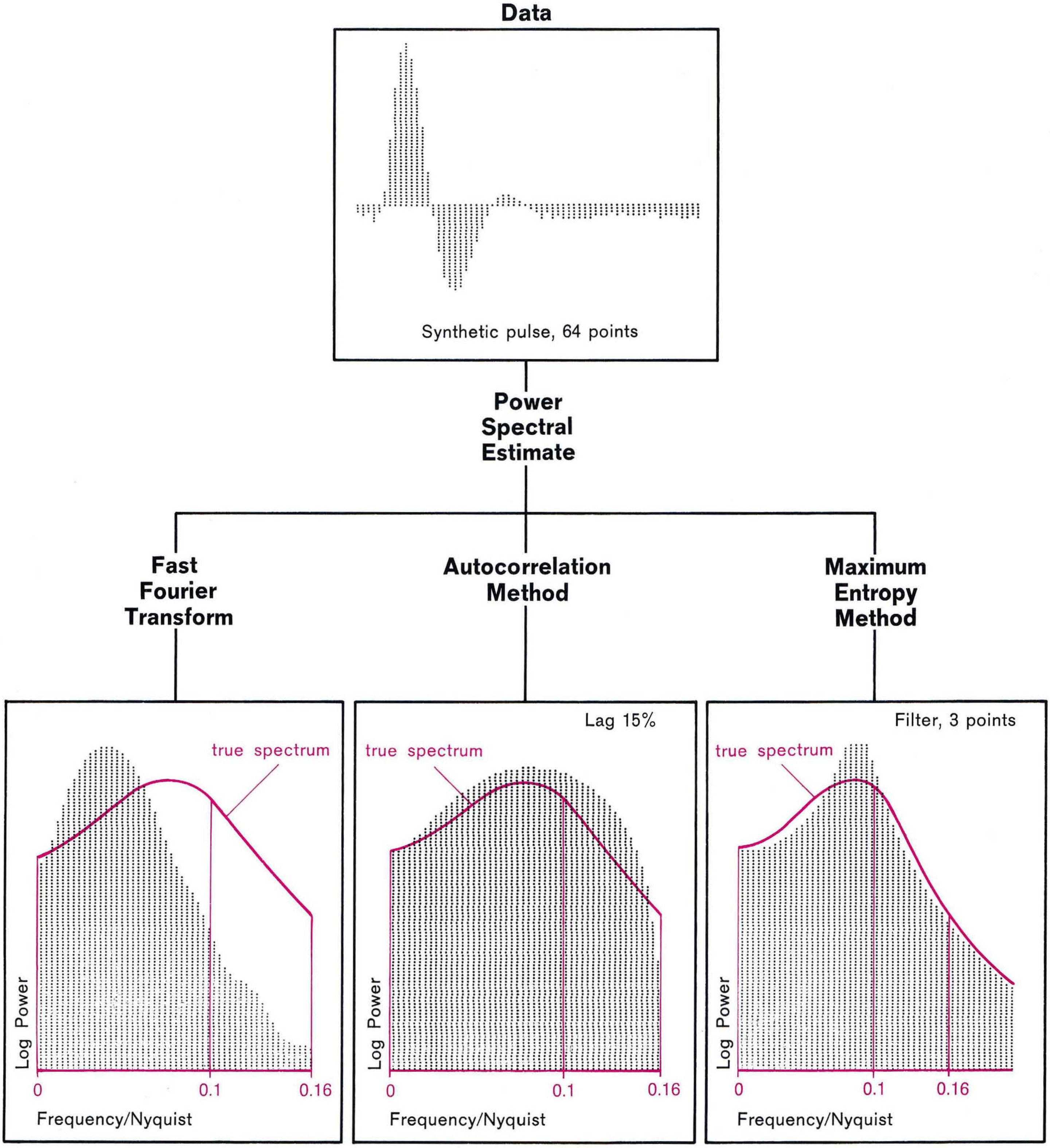
Middle: mean reflection amplitudes
picked in a 40 ms gate along the horizon
marked by green arrows in the record section

Right: Maximum Entropy power spectra
within a gate of 240 ms (60 samples) marked in
red on the record section. Main frequency indicated
as white peaks.
The amplitude anomaly coincides with a significant
shift towards lower frequencies


2.0s
3.0s
800
400
0
Amplitude
200 SP
220
240
260
280
300
320
340
SP 350
0
10
20
30
40
50
60
70Hz
Frequency

Power Spectra of a Synthetic Pulse with known spectrum computed with different methods.

The Maximum Entropy Method models the true spectrum very well even if the gate contains only the first half of the data. In this case the other two methods fail entirely to give reliable results.



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