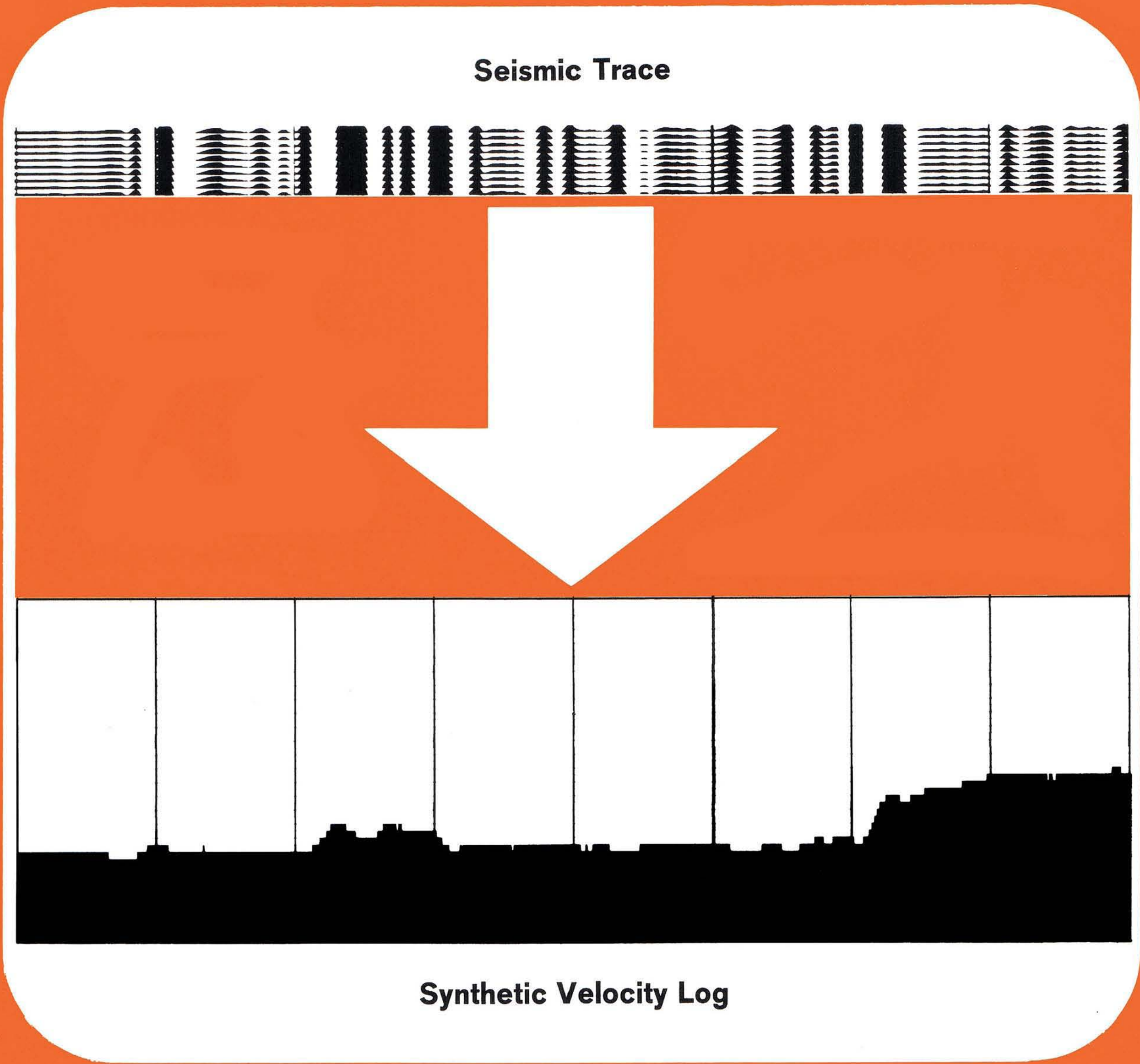
PRAKLA-SEISMOS INFORMATION No. 5

Synthetic Velocity Logs



Outline of the Problem

A measured velocity log is given (Fig. 1a). The corresponding impulse trace can be calculated for plane and parallel layers at vertical incidence of waves (Fig. 1b). Filtering such an impulse trace with a zero-phase wavelet, we obtain, in a first approximation, a synthetic seismic trace (Fig. 1c). This synthetic seismic trace should correspond more or less to seismic field traces.

The inverse procedure is indicated in the lower part of Fig. 1. The computation of synthetic velocity logs (Fig. 1d) from seismic traces is called the inversion procedure. This procedure is difficult because the seismic field traces – compared with impulse traces – contain many disturbing factors.

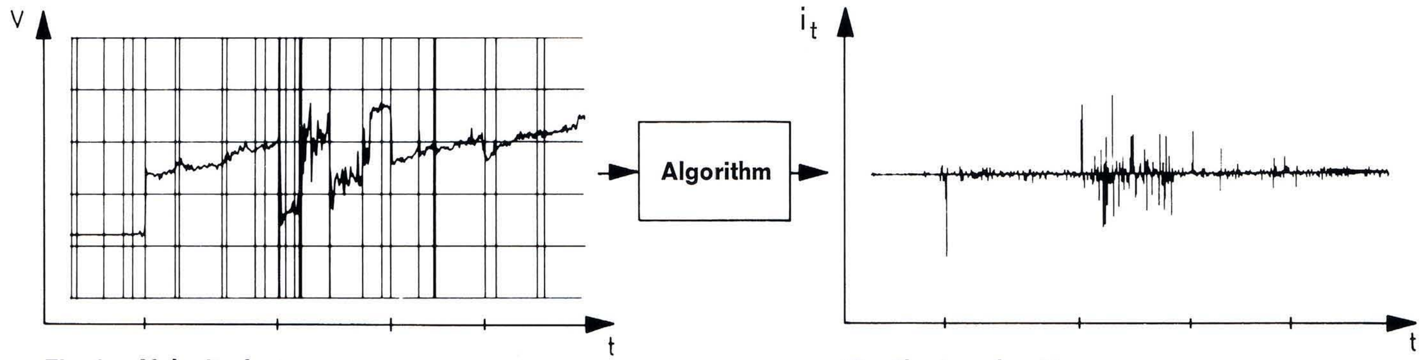


Fig. 1a: Velocity Log

Fig. 1b: Impulse Trace

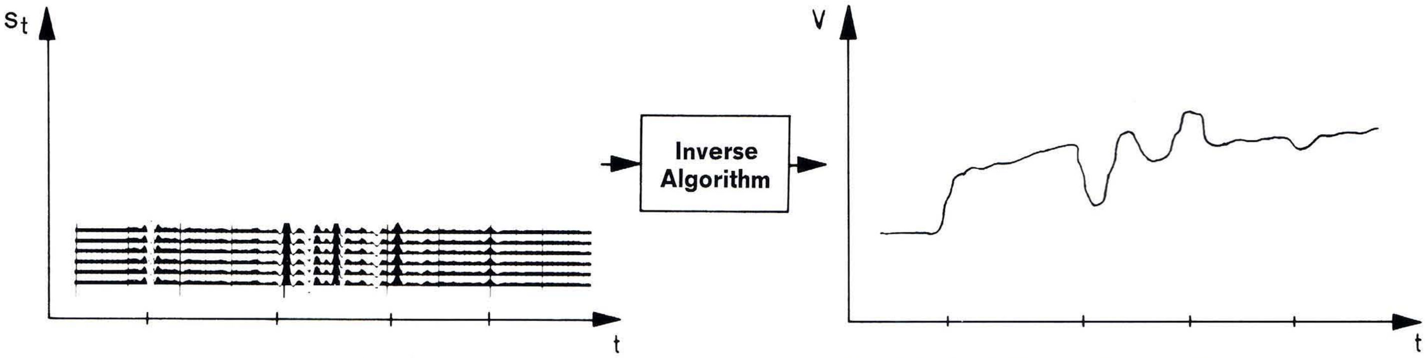


Fig. 1c: Synthetic Seismic Trace

Fig. 1d: Synthetic Velocity Log

High-frequency and Low-frequency Information

The frequency content of a velocity log and of its corresponding impulse trace differ from each other in that the lower frequencies in the impulse trace are suppressed. The attenuation of the lower frequencies of the impulse trace can clearly be seen from Fig. 2a. As, however, the spectrum of a real velocity log contains all frequencies (Fig. 2b), a synthetic velocity log can only be estimated from a real seismic trace, if in addition to a seismic measurement the missing low-frequency information is given. For instance, averaged velocities (e.g. stacking velocities, RMS-velocities) can be used as low-frequency information (see Fig. 2c, spectrum of RMS-velocities). The adaption of velocity information is realized by means of a special calibration.

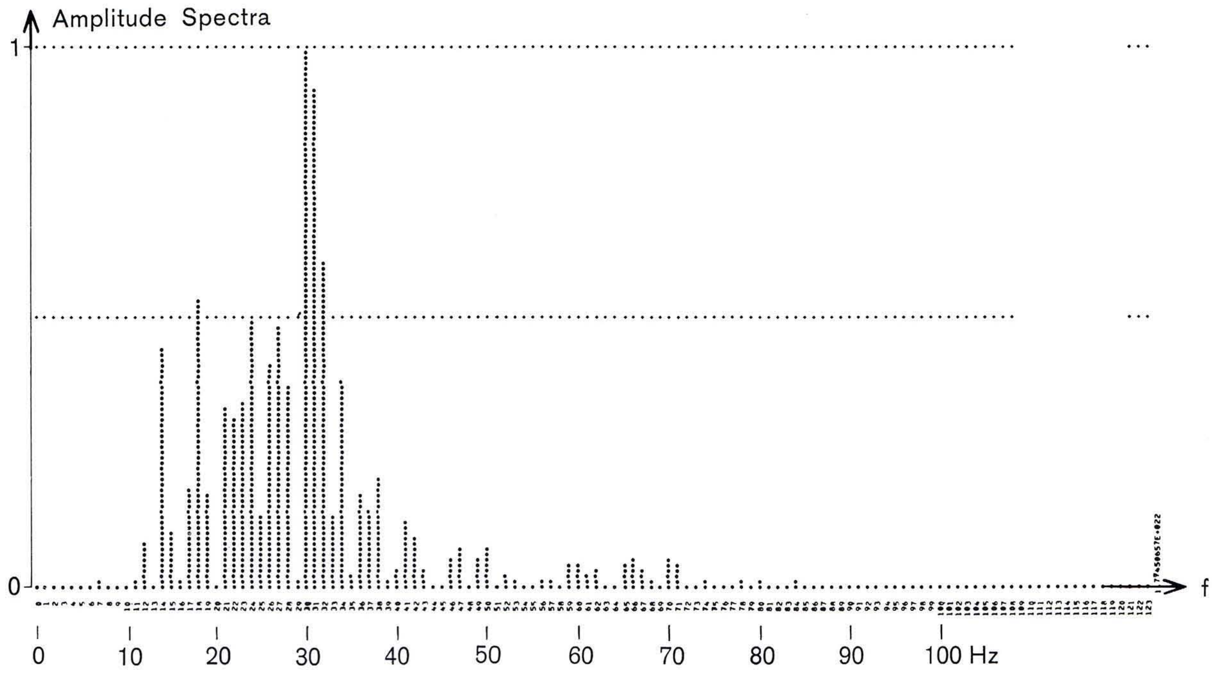


Fig. 2a:
Impulse Trace
(compare Fig. 1b)

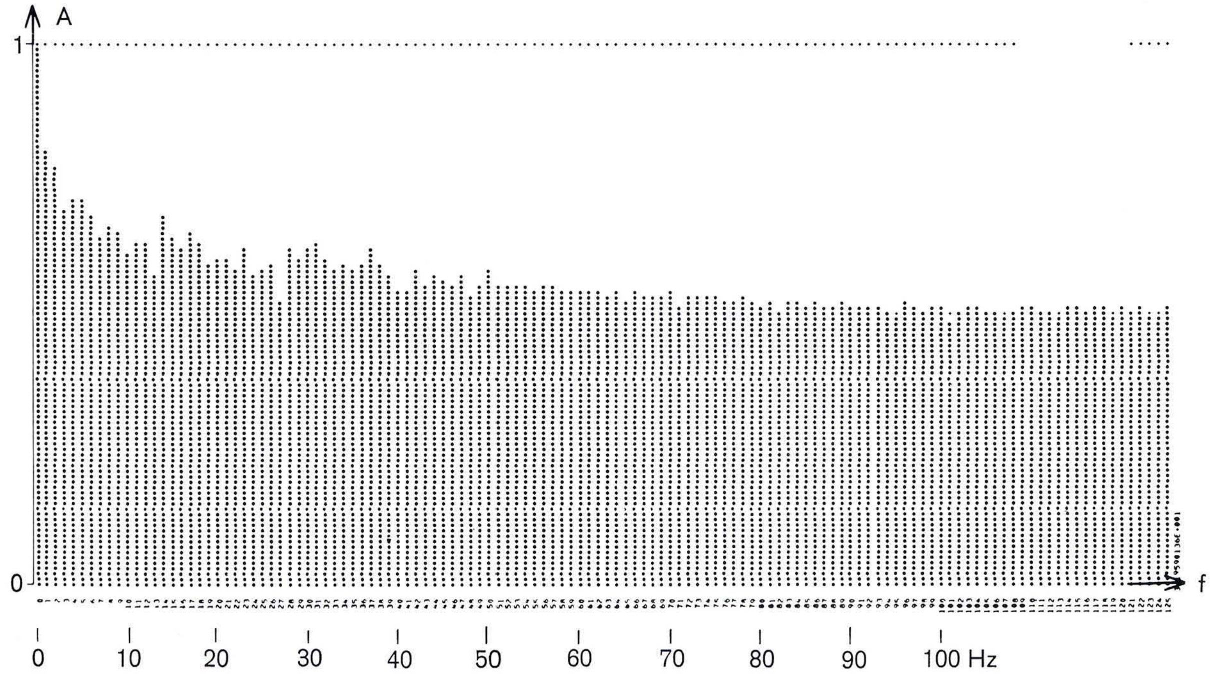


Fig. 2b:
Real Velocity Log
(compare Fig. 1a)

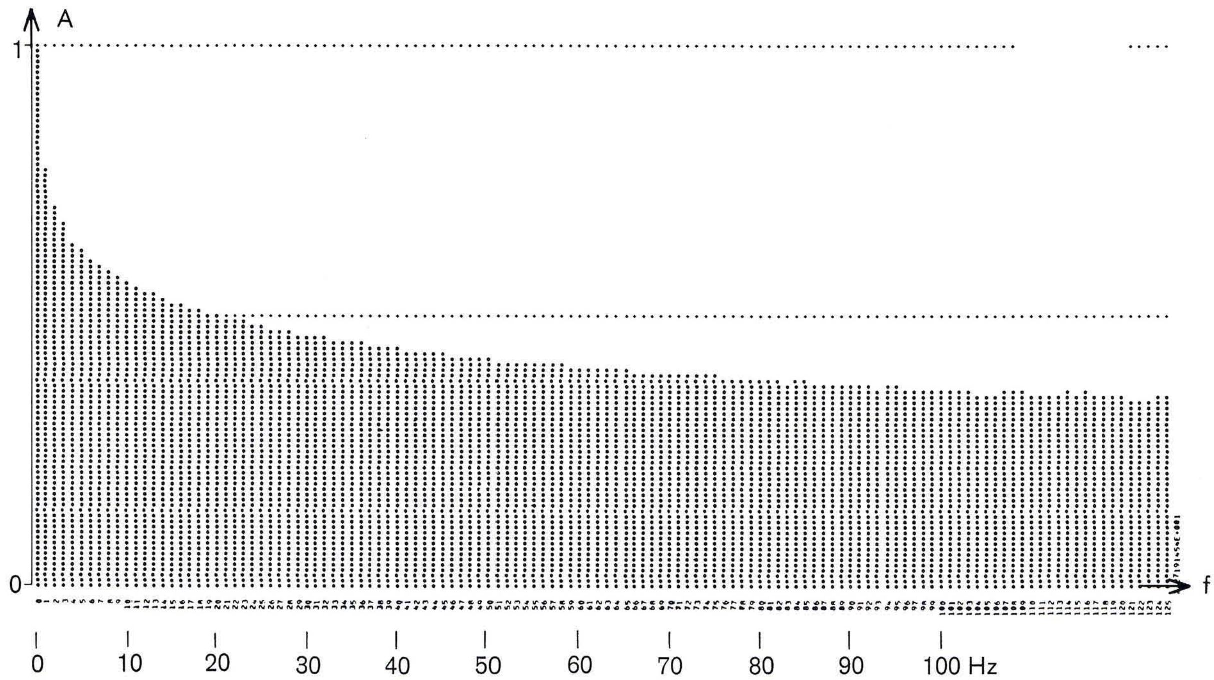


Fig. 2c:
RMS-Velocities

Disturbing Factors

Seismic field traces must be processed in such a way that all influences which reduce the coherence between field trace and impulse trace are recognized and eliminated. The most important influences are:

- Noise
- Wavelets
- Multiples
- Absorption

Noise on seismic traces can be reduced by optimal filtering, stacking and coherency filtering.
Wavelets on seismic traces are estimated and transformed to zero-phase signals by a special wavelet processing.
Multiples can be suppressed by various linear methods, e.g. conventional deconvolution, time-variant adaptive deconvolution, multichannel filtering etc. Non-linear procedures for the suppression of multiples make use of certain inherent properties (e.g. amplitude and coherency properties).
Absorption can be estimated by Real Amplitude Processing, whereby spectral analyses play an important part.

Examples

Estimation of synthetic velocity logs is carried out according to Fig. 3 in the following way: the seismic trace is processed, whereby all mentioned disturbing influences should be eliminated; the corresponding result and the averaged velocities (for instance obtained from stacking velocities) are combined with the help of an inverse algorithm.

Fig. 3

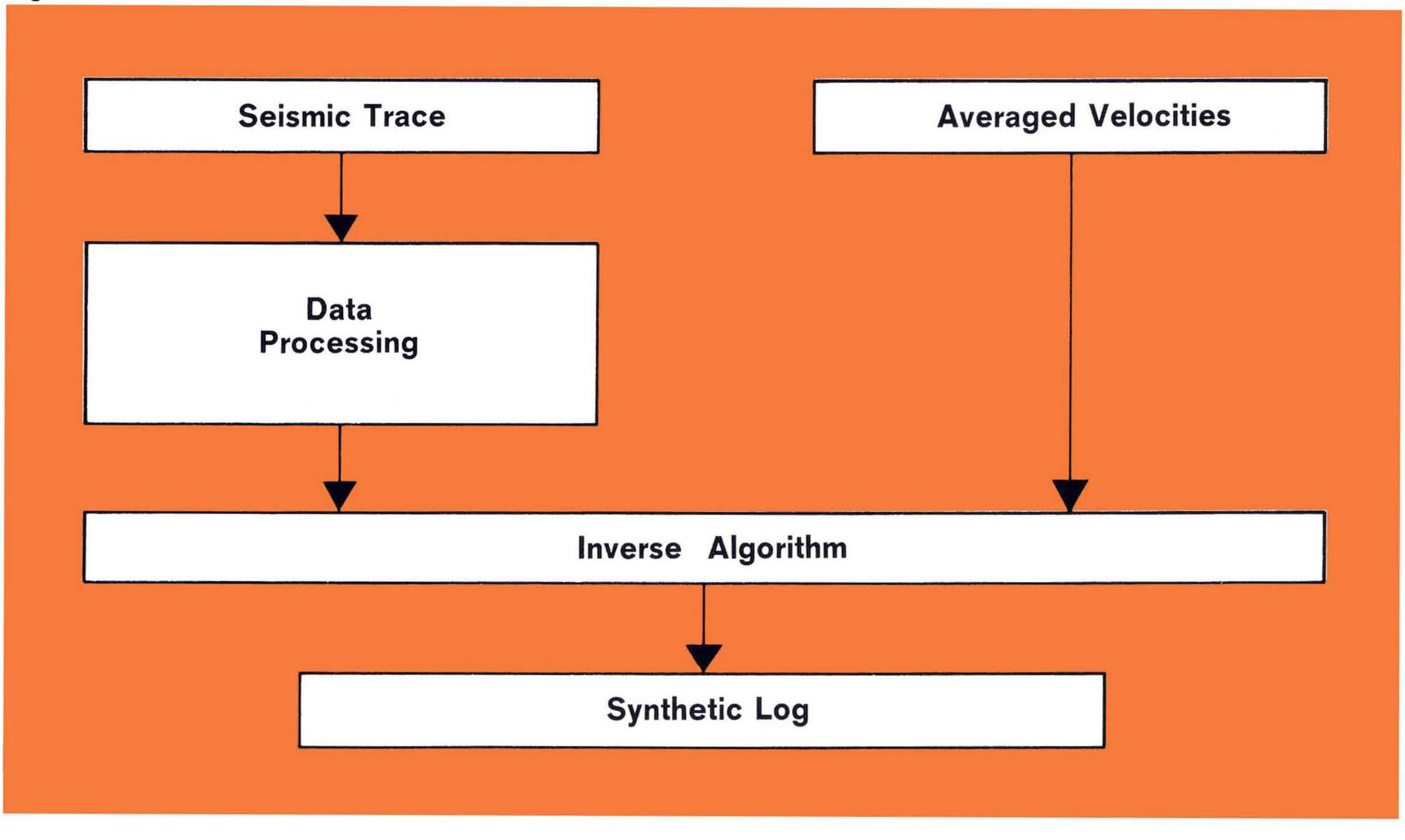


Fig. 4 presents a theoretical example with the help of which the reliability of the inverse algorithm can be checked. In Fig. 4a a measured velocity log is plotted; below are the corresponding impulse traces without multiples. Filtering the impulse seismogram with a zero-phase wavelet yields a synthetic seismic trace. This synthetic trace and the RMS-velocities represent the input for the inverse algorithm. In Fig. 4e the synthetic velocity log is shown which has great similarity to the given velocity log except for the higher frequencies (the plot of the velocity logs was performed using a sampling rate of 140 m/sec).

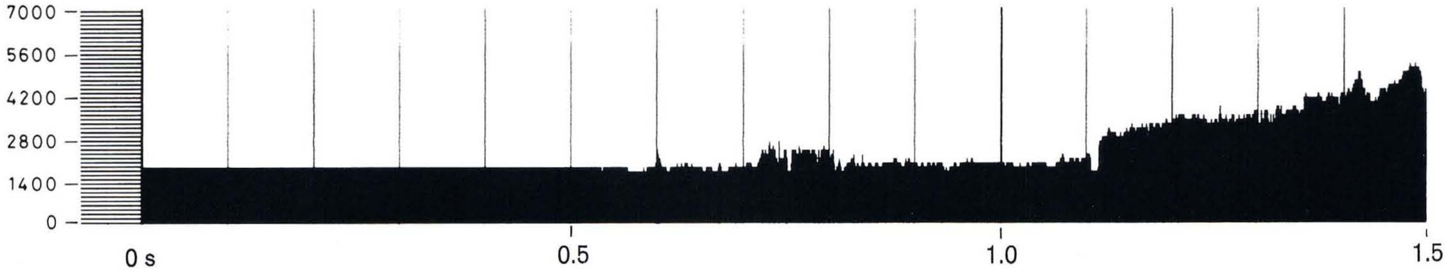


Fig. 4a: Measured Velocity Log [m/s]

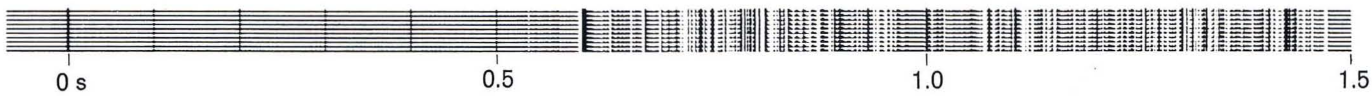


Fig. 4b: Impulse Traces

Fig. 4c: Synthetic Seismic Traces

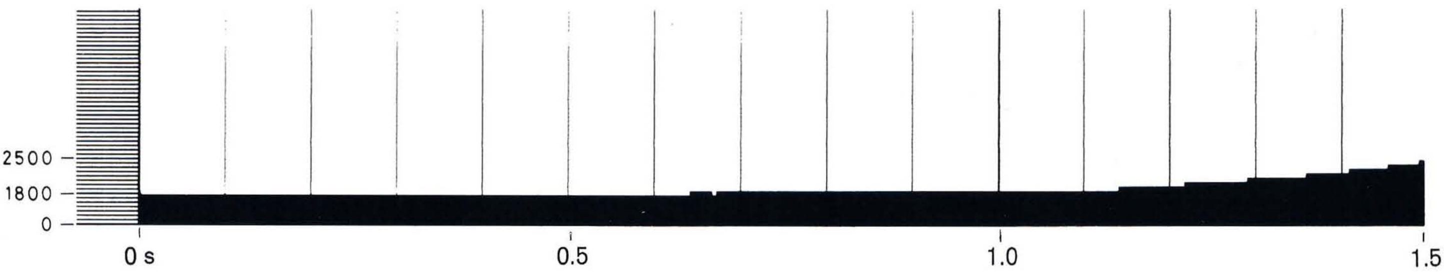


Fig. 4d: RMS Velocities [m/s]

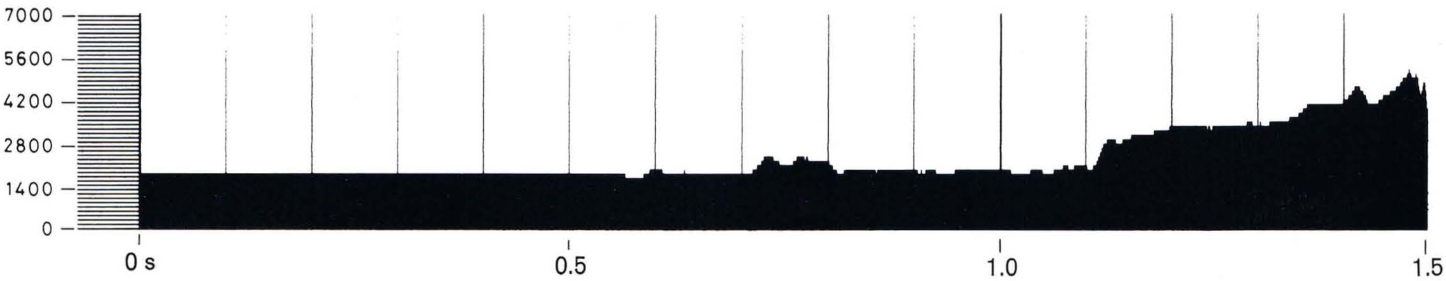


Fig. 4e: Synthetic Velocity Log [m/s]

Fig. 5 presents a practical example using seismic field traces. The procedure was applied to neighbouring stacked traces (Fig. 5a, Fig. 5b), where at the location marked by an arrow well information is available. Fig. 5c presents the synthetic velocity log at that place in another scale and in another display mode, Fig. 5d the actual well velocity log. A rather good conformity is evident.
(the plot of the velocity logs was performed using a sampling rate of 170 m/sec).

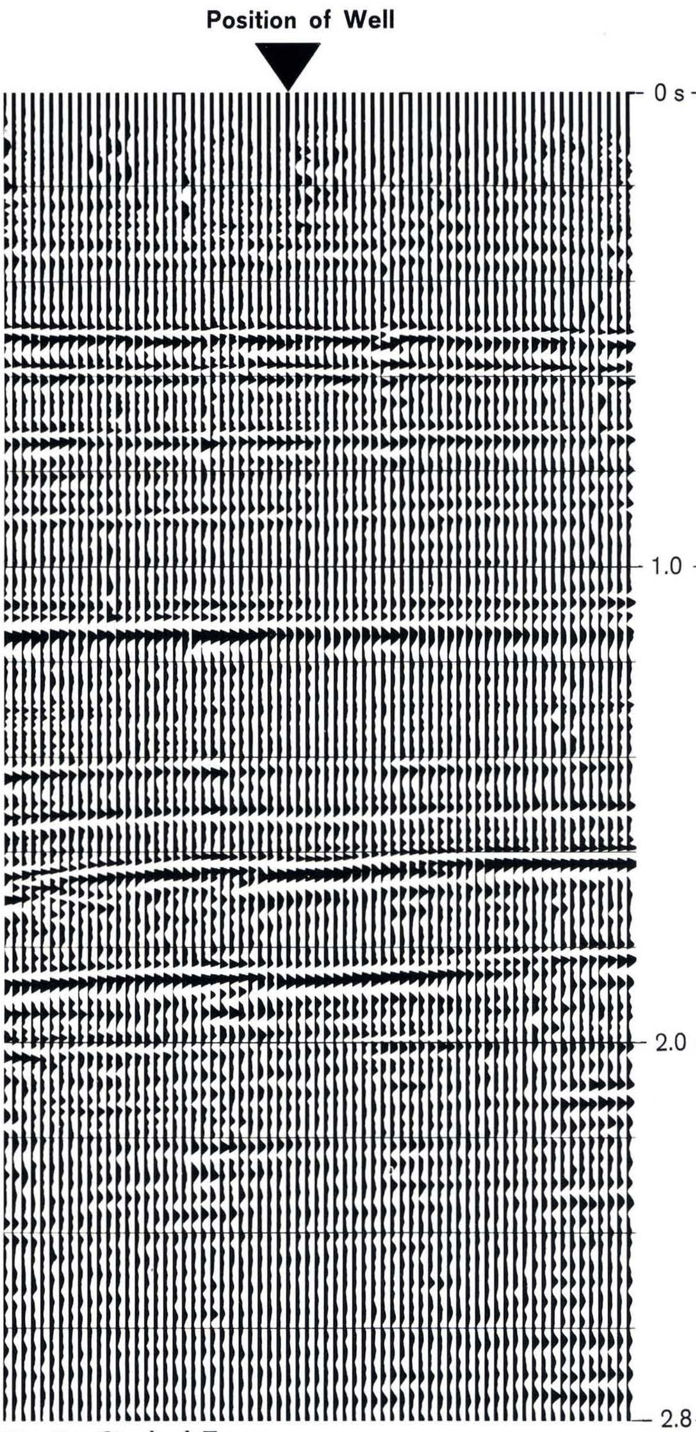


Fig. 5a: Stacked Traces

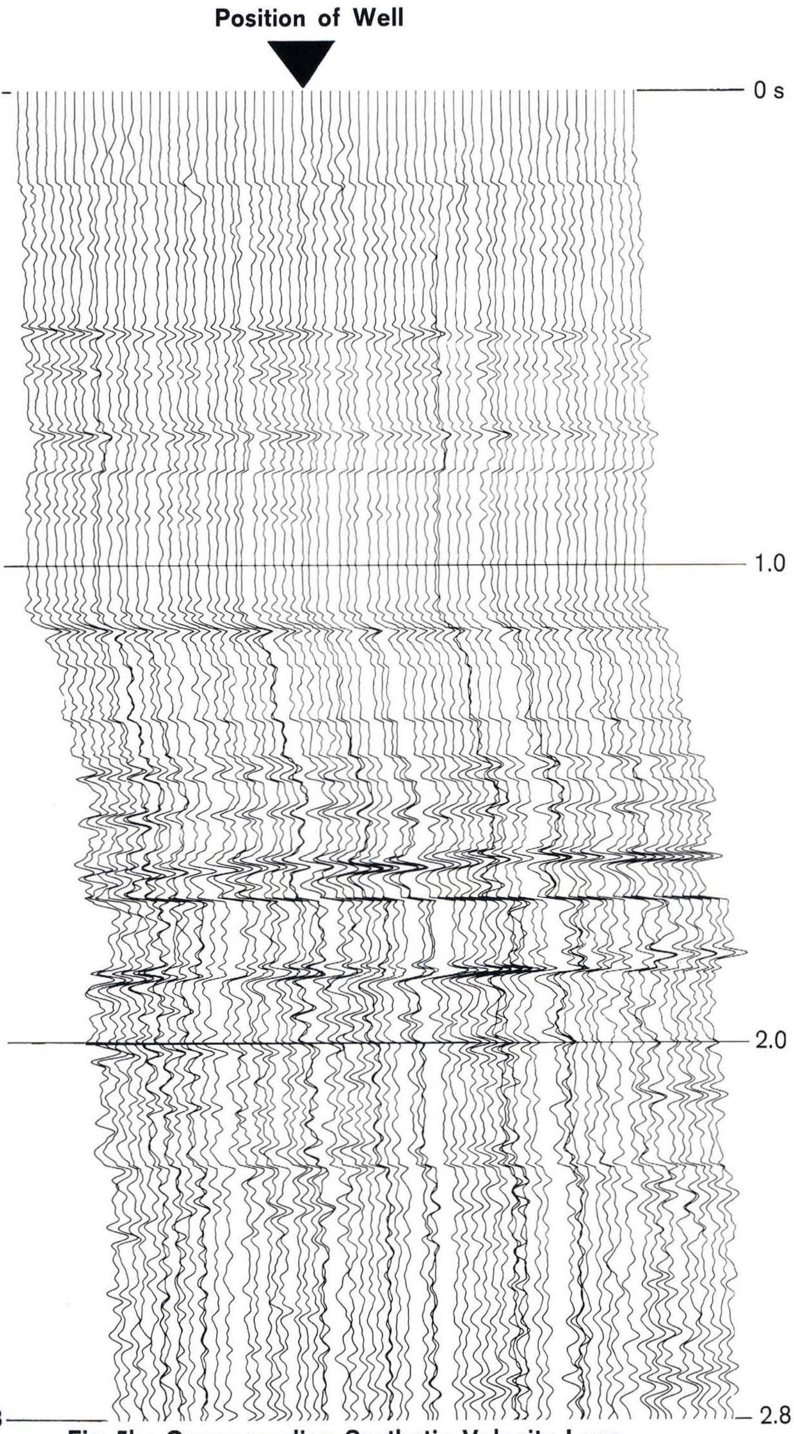


Fig. 5b: Corresponding Synthetic Velocity Logs
(Display by Calcomp Plotter.
Colour presentation of Velocity Scanning possible)

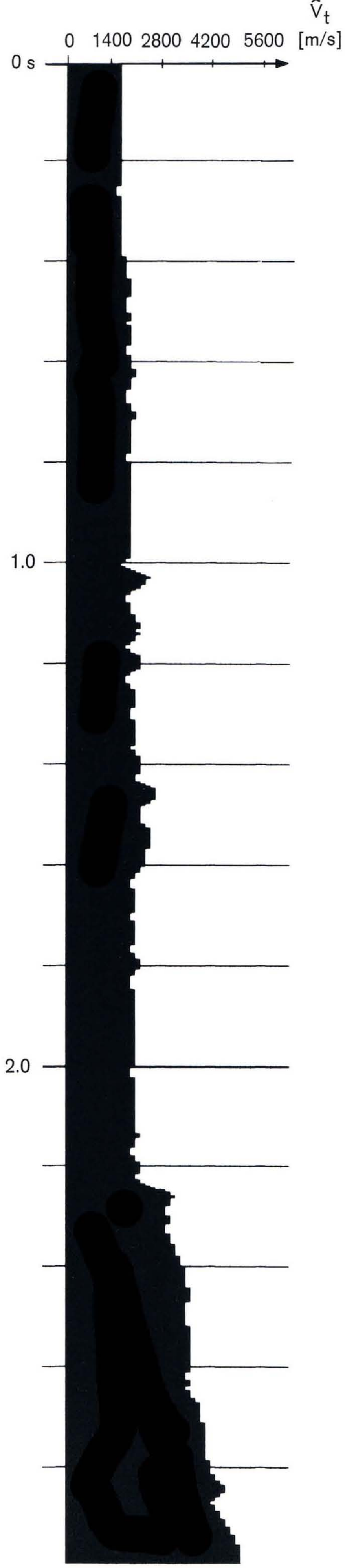


Fig. 5c: Synthetic Velocity Log at well

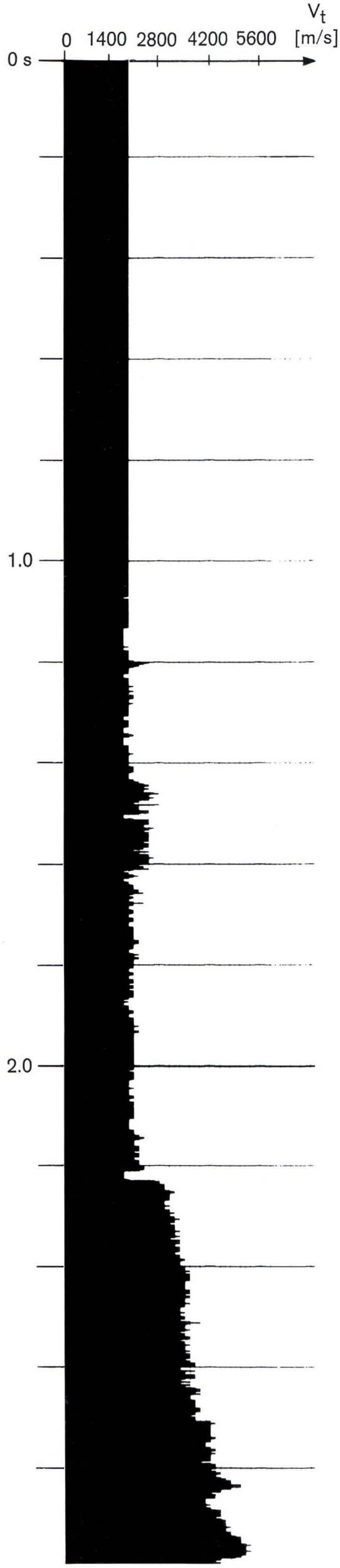


Fig. 5d: Actual Well Velocity Log

Fig. 6 represents another example of good conformity of real and synthetic logs, obtained from another area.

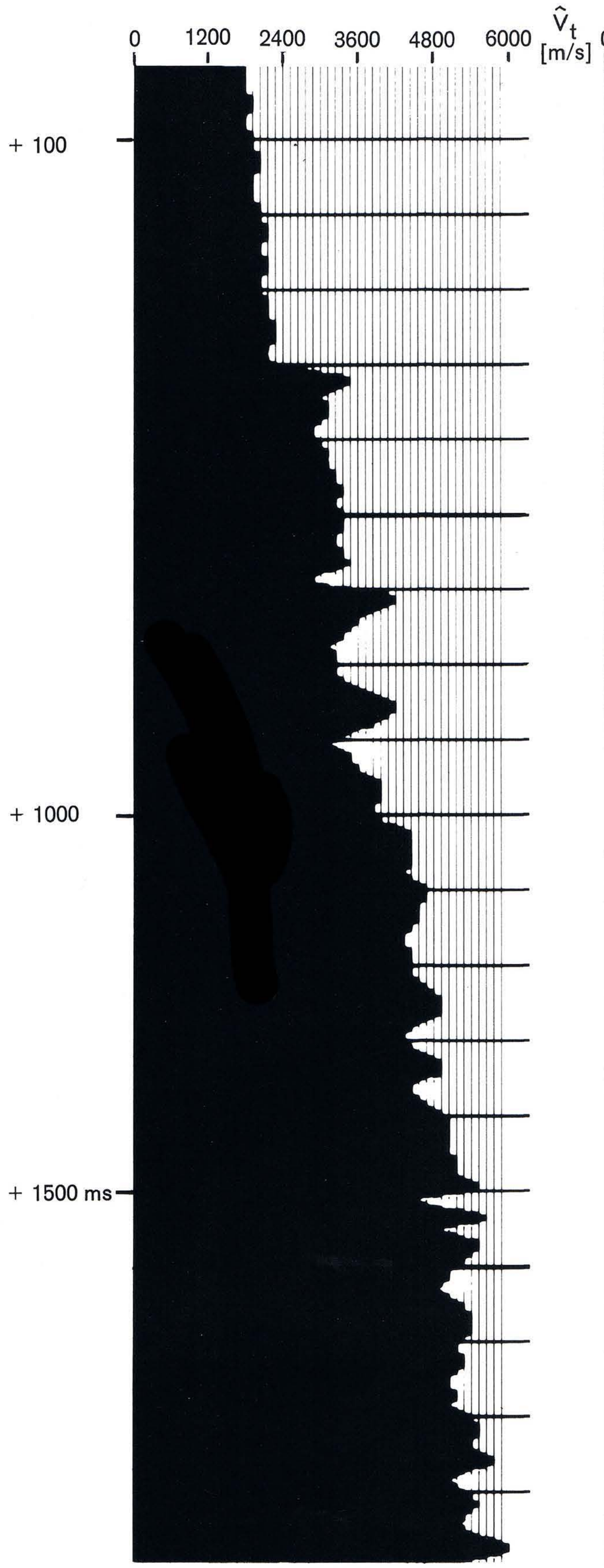


Fig. 6a: Synthetic Velocity Log

Fig. 6b: Real Velocity Log

PRAKLA-SEISMOS GMBH · HAARSTRASSE 5 · P.O.B. 4767 · D-3000 HANNOVER 1
PHONE: 8 07 21 · TELEX: 9 22 847 · CABLE: PRAKLA · GERMANY

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