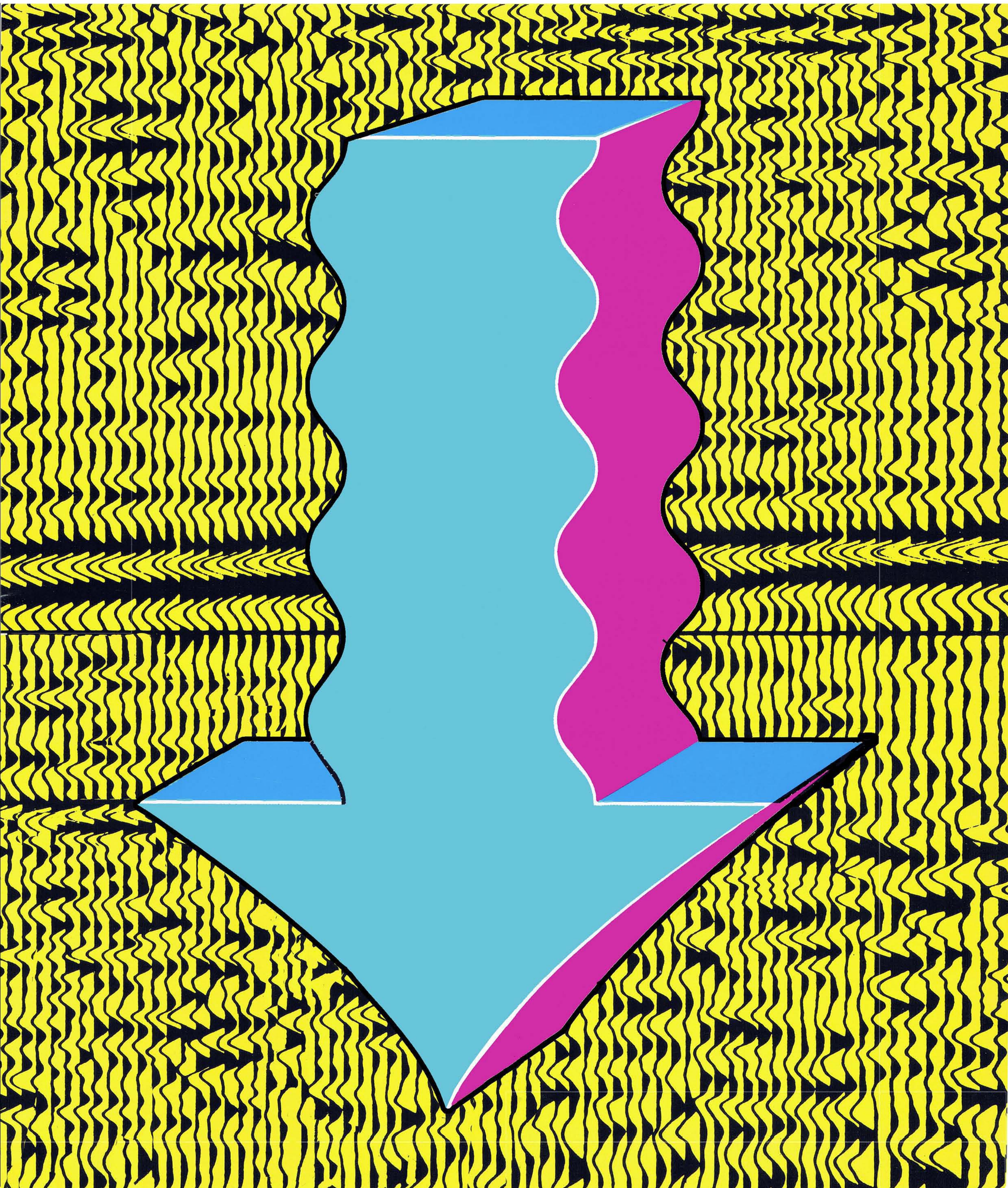
PRAKLA-SEISMOS INFORMATION No. 33

Shear Wave Downhole Surveys



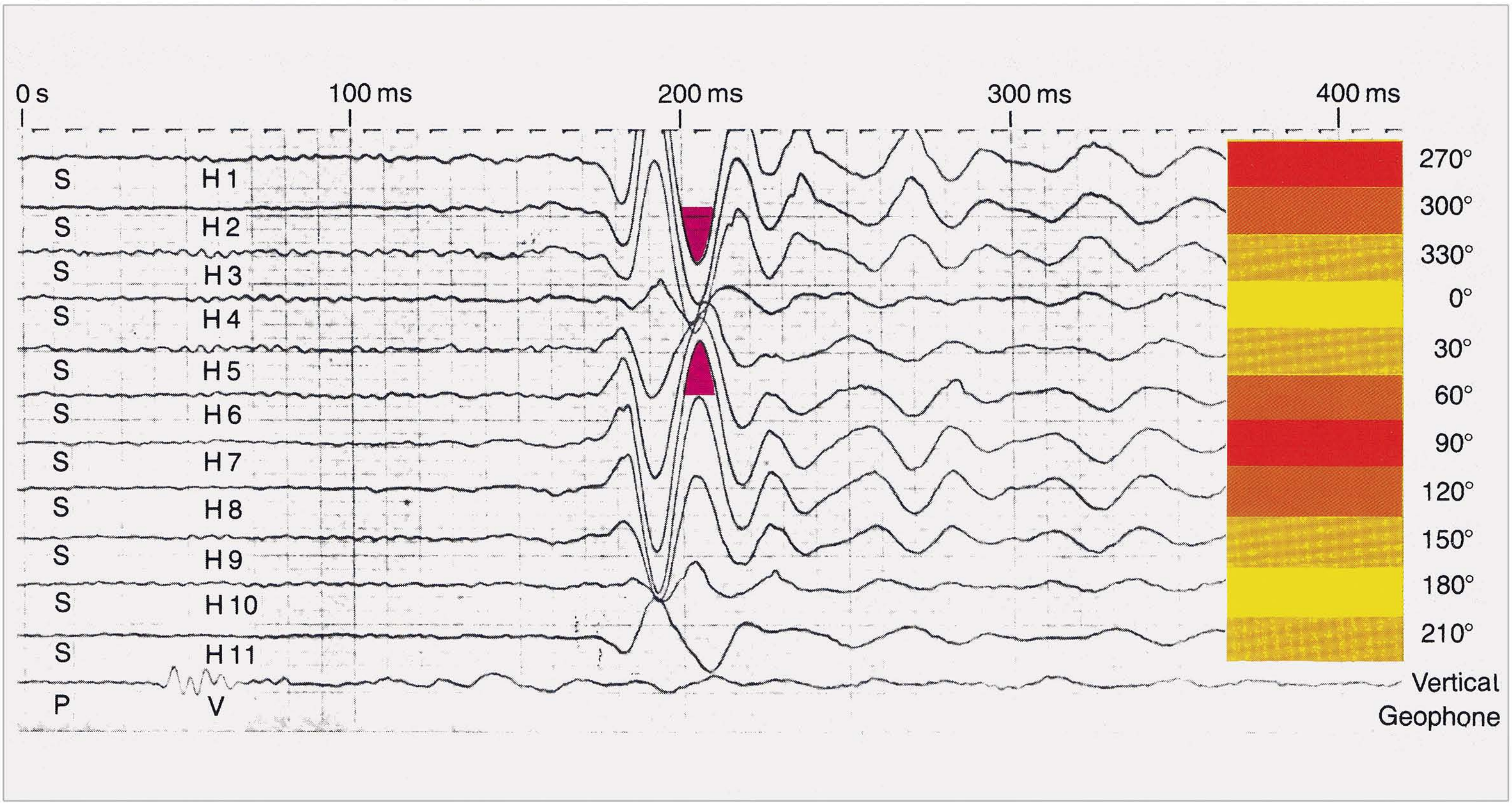
Shear Wave Downhole Surveys:

today's must for tomorrow's Shear Wave Reflection Surveys

As S-wave measurements can give valuable back-up to P-wave seismic interpretation, increasing interest is shown in shear-wave seismic reflection surveys. A prerequisite for processing and interpretation of S-wave data is the tie-in to well information by means of reliable S-wave velocities. These velocities can be determined from downhole surveys.

As shown in this brochure PRAKLA-SEISMOS offers shear wave surveys in shallow as well as in deep holes. They do not demand additional processing to distinguish S-wave arrivals from p-wave and tube-wave arrivals. By recording later arrivals, even vertical seismic profiling of shear-waves can be displayed.

Fig. 1: Hammer Blow Recording using Azimuth Sonde



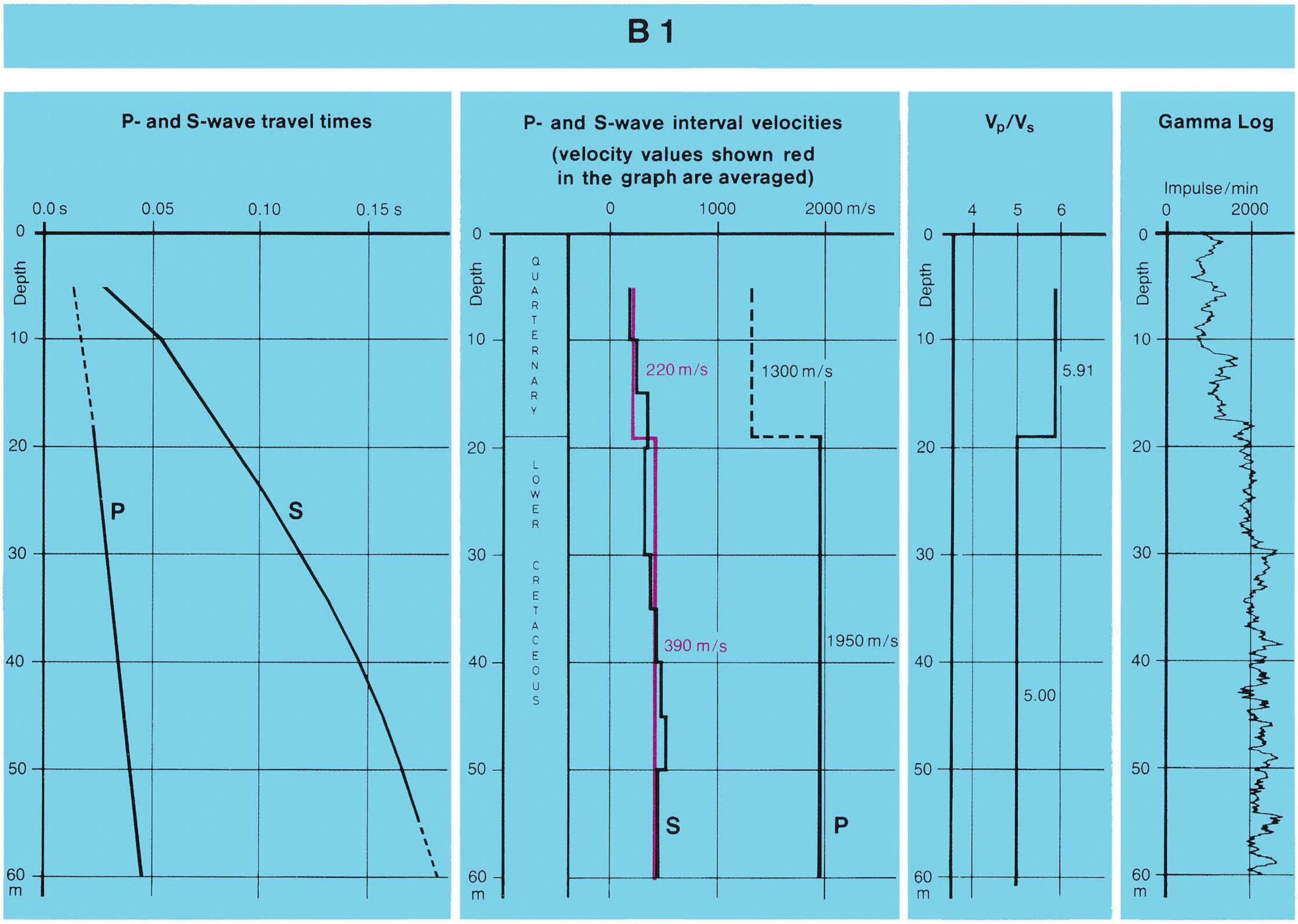
P- and S-Wave Downhole Surveying with the Azimuth Sonde

It is a characteristic of downhole surveys that only those parts of a wave front which are nearly vertical are evaluated. While P-wave fronts have 3 degrees of freedom – namely in X-, Y- und Z-direction – for S-waves at least one degree of freedom must be added, i. e. the direction of particle movement, which is perpendicular to the direction of propagation. For linear polarized shear-waves, the maximum of shear-wave energy is concentrated in the plane of polarization. For downhole surveys this plane of polarization can be attributed to a certain azimuth angle, measured against magnetic north. The different far field displacement amplitudes of a single horizontal force at the surface can be seen in fig. 7 (by courtesy of W. Schott, Westfälische Berggewerkschaftskasse, Bochum).

A corresponding field recording (fig. 1), for which a hammer blow was used as the horizontal force, shows that there is one azimuth angle for which the amplitude of horizontal particle velocity is a maximum. This energy maximum can be clearly distinguished even at greater dephts, although attenuation of high frequency components can be stronger for S-waves than for P-waves. The colour code indicates that the recorded particle velocities in fig. 1 correspond to the displacement amplitudes in fig. 7.

Fig. 2: Results from Shallow Borehole Surveys

The resulting P- and S-wave velocities can be attributed to specific geological strata. The ratio of compressional to shear-wave velocity (V_p/V_s) can be compared with the gamma log recording.



SH-Wave Source

Fig. 3: SH-Wave Generator HRMH in Working Position ▲

▼ Fig. 4: Base-Plate of SH-Wave Generator HRMH

SH-Wave Receiver

Shear-waves can be generated in different ways. Each shear-wave source has its specific radiation characteristic. For downhole surveys a source, which generates a maximum amplitude in the vertical direction is desirable. The horizontal reaction mass hammer (HRMH) has proved to be well suited as an SH-wave generator for this purpose. This hammer is shown in figs. 3 and 4. The hammer generates horizontal displacement of a pre-determined polarization.

The borehole sonde, called "azimuth sonde", records the compressional wave arrivals with one vertical geophone and the shear-wave arrivals with 12 horizontal geophones, which have different azimuthal orientation (see fig. 5). Due to the orientation of the source, the 12 geophones show different amplitudes, recorded as individual traces. Comparison of these traces allow the separation of shear-wave arrivals from other disturbing events.

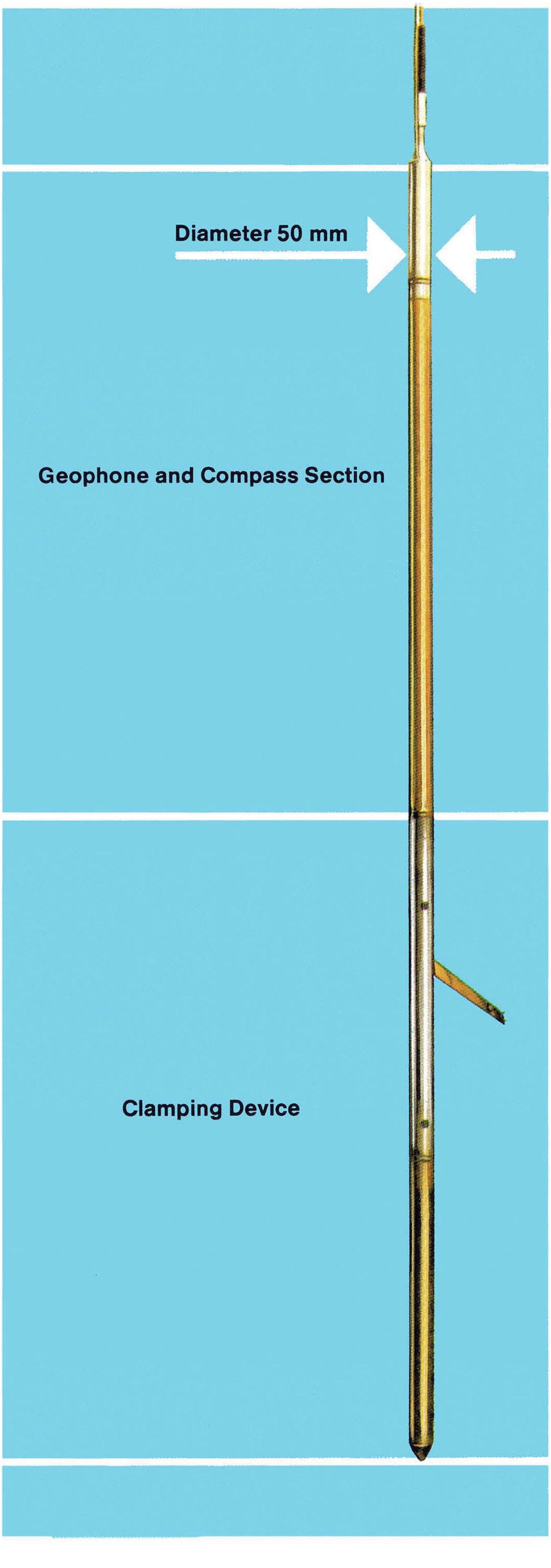


Fig 5: Azimuth Sonde

An interpretation of shear-wave and compressional wave velocities in a deeper hole is to be seen in fig. 6. The interval velocities show typical anomalies in the Tertiary and a strong velocity increase in the Zechstein formation for both P- and S-wave velocity. The V_p/V_s ratio for interval velocities has typically high values (approaching 5) for shallow strata, decreasing to about 2 for deeper strata.

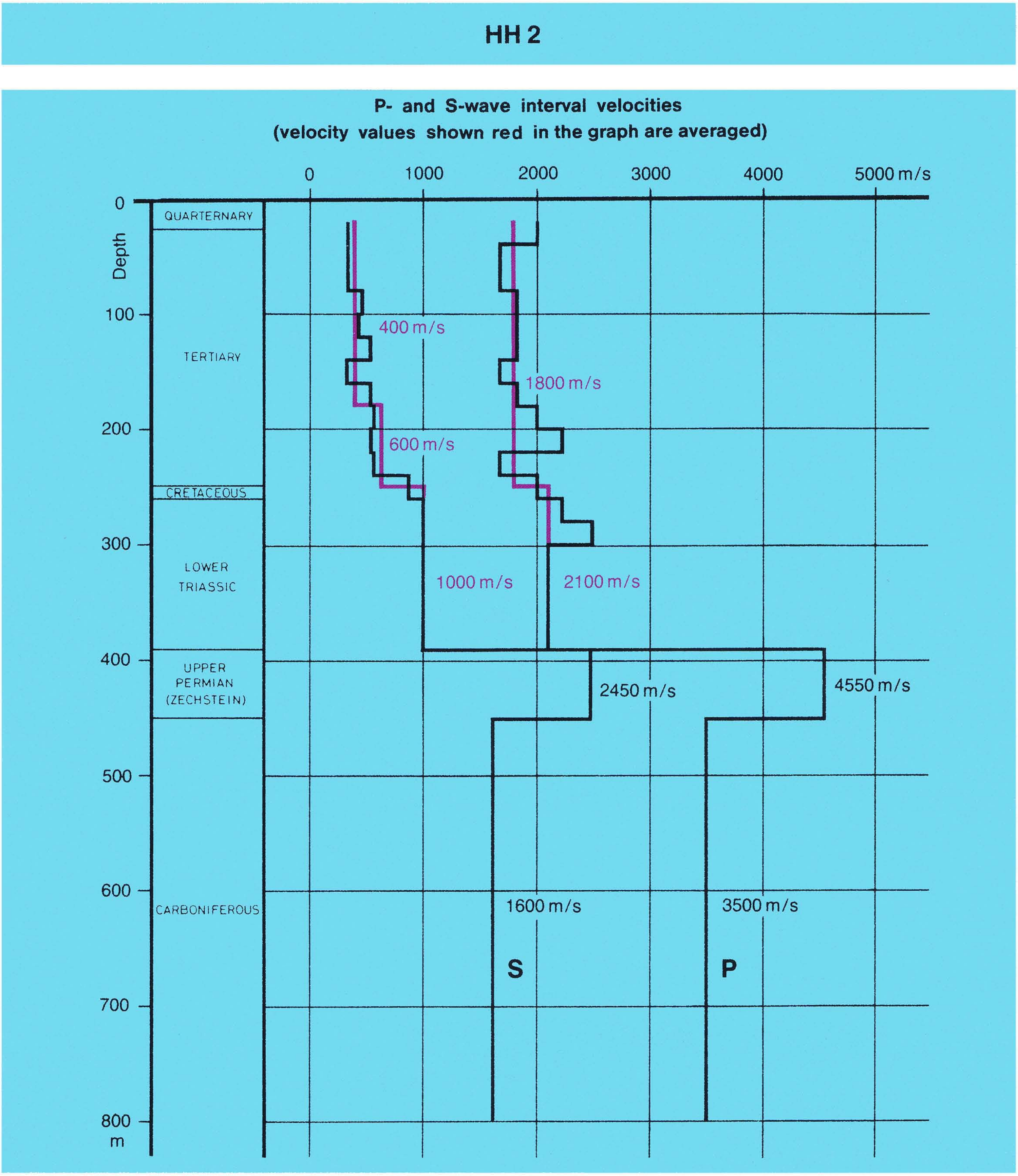
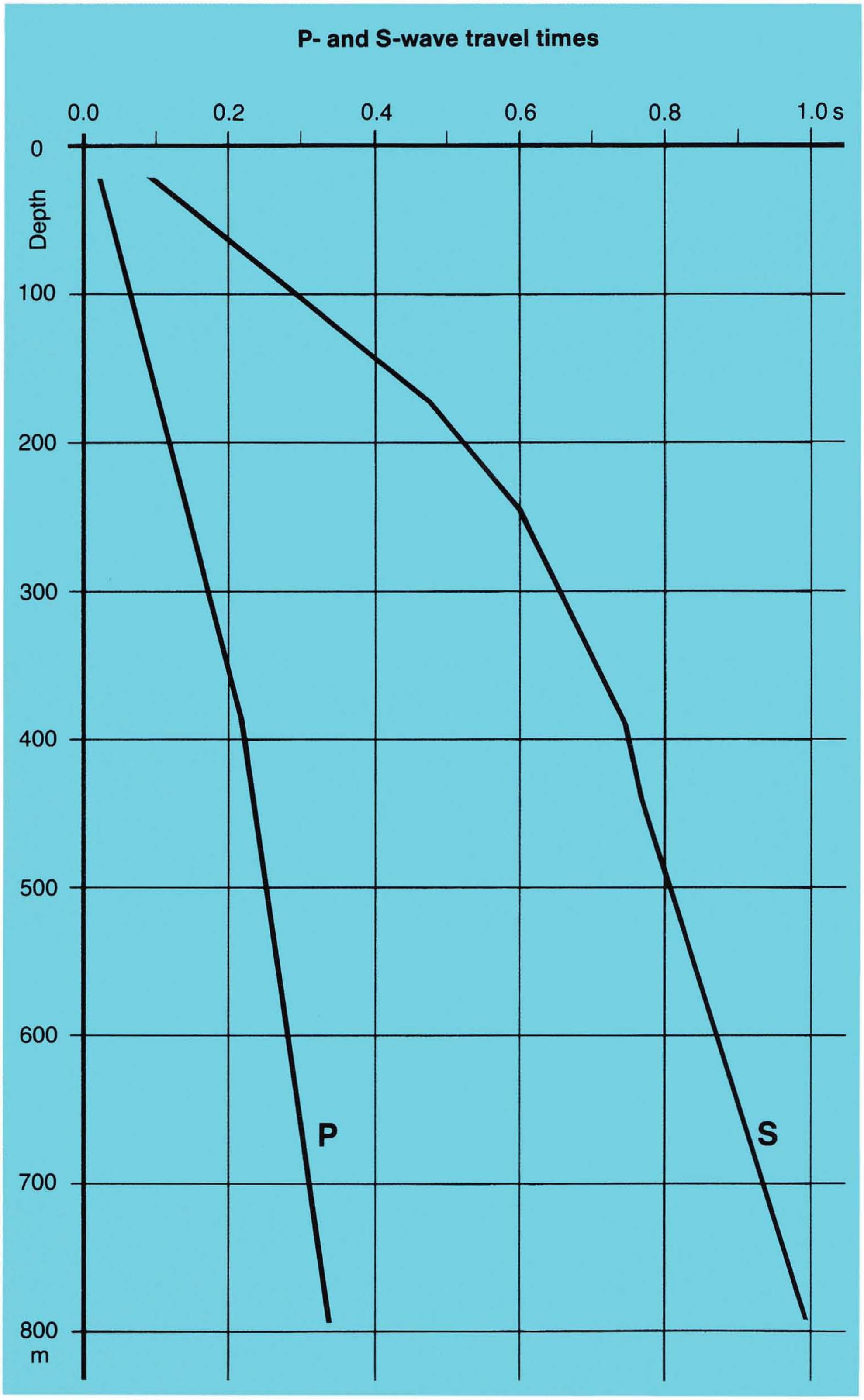


Fig. 6: Results from Deep Borehole Surveys

HH 2



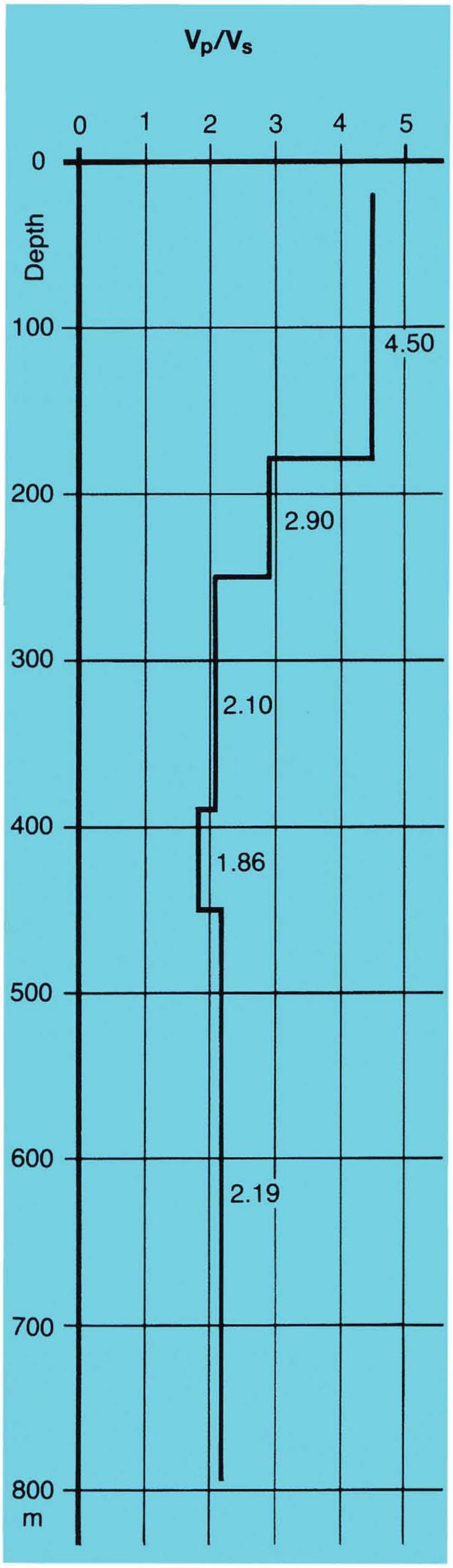
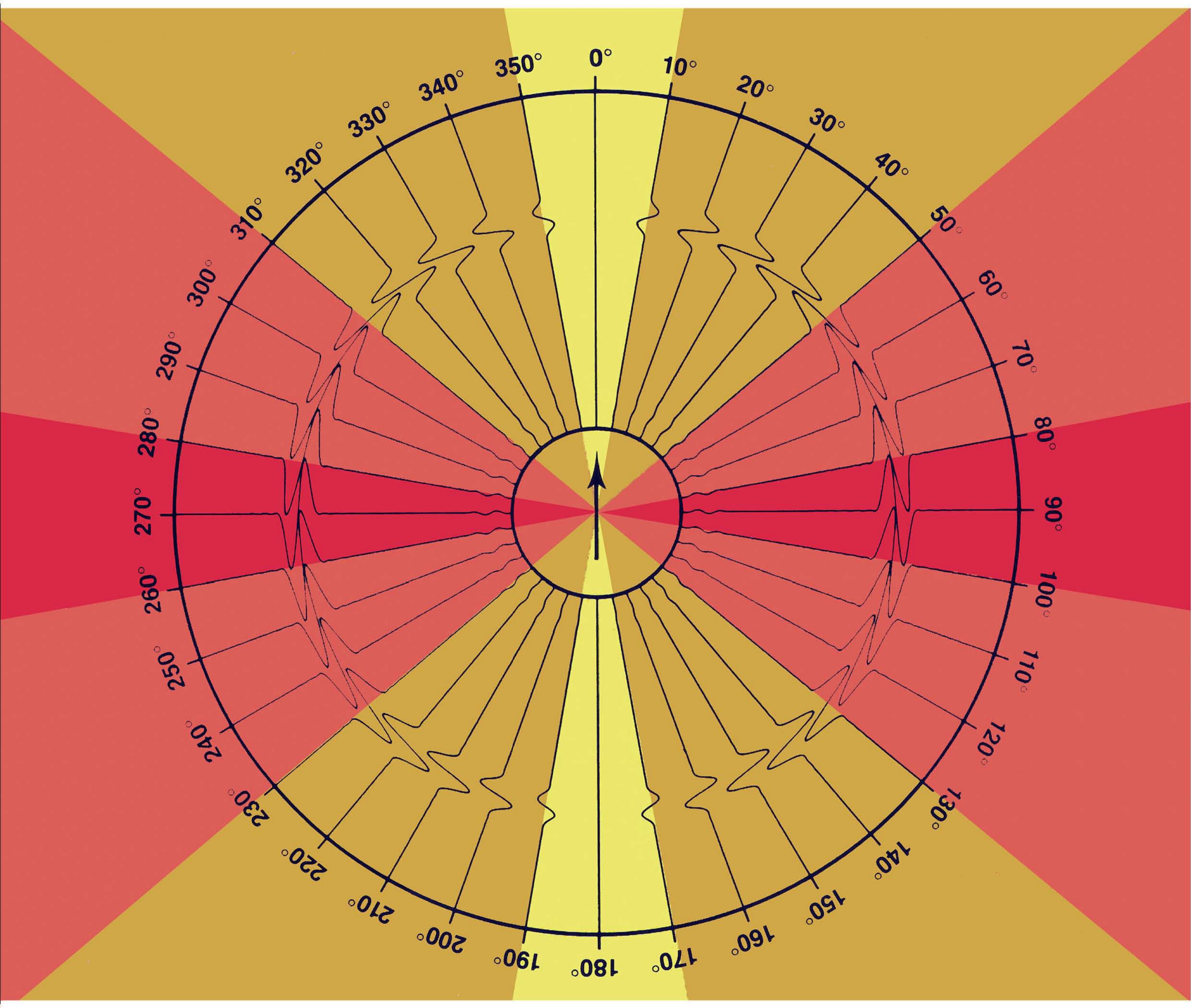


Fig. 7: Signature Rosette

Horizontal displacement produced by a single force



PRAKLA-SEISMOS GMBH · HAARSTRASSE 5 · P.O.B. 4767 · D-3000 HANNOVER 1
PHONE: (5 11) 80 72-1 · TELEX: 9 22 847/9 22 419 · CABLE: PRAKLA · GERMANY

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