PRAKLA-SEISMOS INFORMATION No.24

IAMP - Interactive Modelling

In general synthetic seismic sections are derived with the help of the elastic or acoustic wave equation. At present the solution of these equations for arbitrary models, taking into account all the seismic phenomena important in exploration work, is very time-consuming, even on modern high speed computers. However, a series of numerical methods has been developed, permitting partial solutions or solutions for simplified models. The choice of the method to be applied depends on the problems involved. PRAKLA-SEISMOS offers various programs which allow the calculation of model sections and synthetic seismograms according to the

- modified Kunetz-Baranov method
- Kirchhoff summation method
- solution in the frequency – wavenumber domain
- finite difference method in the time-distance domain
- finite difference method in the frequency-distance domain
- asymptotic ray method.

Some of these techniques have been described in PRAKLA-SEISMOS Information No. 16. This brochure deals with an interactive modelling package rendering solutions to the elastic wave equation by the employment of asymptotic ray series.

IAMP (Interactive Asymptotic Modelling Package) was developed by PRAKLA-SEISMOS in order to assist the seismic interpreter in his modelling work.

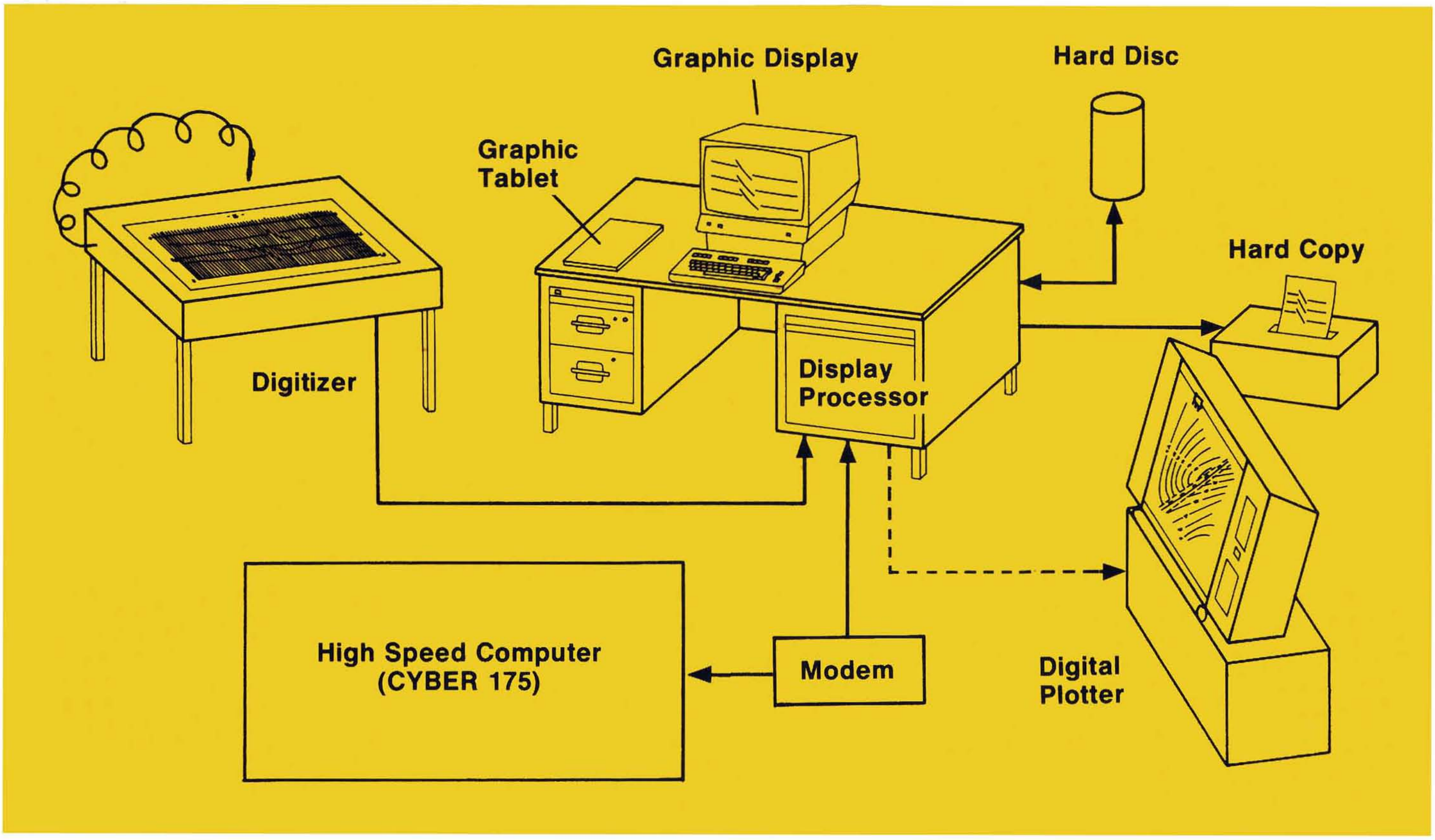
Using IAMP in an interactive fashion it is possible

- to define or change geologic depth models
- to evaluate the seismic response for a given receiver configuration
- to analyze the computed data.

IAMP can be briefly characterized as follows:

- IAMP is cost effective:
  the package comprises two major programs, developed for a Tektronix 4081 computer with its associated peripheral devices (see fig. 1) and for a high performance host computer. In the course of model calculations both programs interchange data, however, the host computer is only used when its greater computational speed or its storage capacity are needed. Many of the modelling functions, e. g. the definition of the depth model or most of the analysis of the computed data, can be performed on the inexpensive Tektronix machine. Furthermore, all calculations may be performed on a horizon by horizon basis – in many casesit suffices to calculate and analyze the response of only a few reflectors of interest.
- IAMP can be used without any prior knowledge of programming languages or of the operating systems involved. Where data or codes for decisions are requested, information will be supplied via the digitizing tablet or via the keyboard in free format mode. The program recognizes incorrectly defined data and provides hints in the form of lists of relevant options and codes wherever possible.
- the seismic response is obtained by employing zero order asymptotic series solutions to the elastic wave equation. For any seismic event the res-

Fig. 1: IAMP – Technical Configuration



ponse consists of traveltimes, amplitudes and phases. The most significant amplitude effects considered by IAMP incorporate full spherical divergence (spreading, focussing, defocussing), angle dependent reflection, transmission and conversion losses at boundaries as well as buried focus effects (all these phenomena can be observed in fig. 4).

- computations can be performed for both zero and non zero offset sections.
- offset data, computed according to the continuous profiling technique, may be sorted into CMP-gathers and applied with the appropriate dynamic corrections, again interactively.
- Calcomp plots and VAR-displays may be produced offline.

To illustrate these items, a typical application of interactive modelling is presented in the flow chart (fig. 2): Suppose some data obtained from field surveys or from seismic processing is to be compared with information derived from model calculations: The original depth model is digitized at the graphic terminal and transmitted to the host computer where zero offset information, or the response for a few isolated shots, is computed for one or more of the reflecting horizons of interest.

The results obtained are analyzed from the screen of the terminal and the model is altered where necessary. Afterwards, the response of a sequence of shots is calculated, sorted into CMP-gathers and corrected. Comparison with real data shows whether the model has to be changed or whether one can proceed with a deeper reflector.

Finally, for the verified model, Calcomp plots or VAR displays may be produced offline (see figs. 3–6).

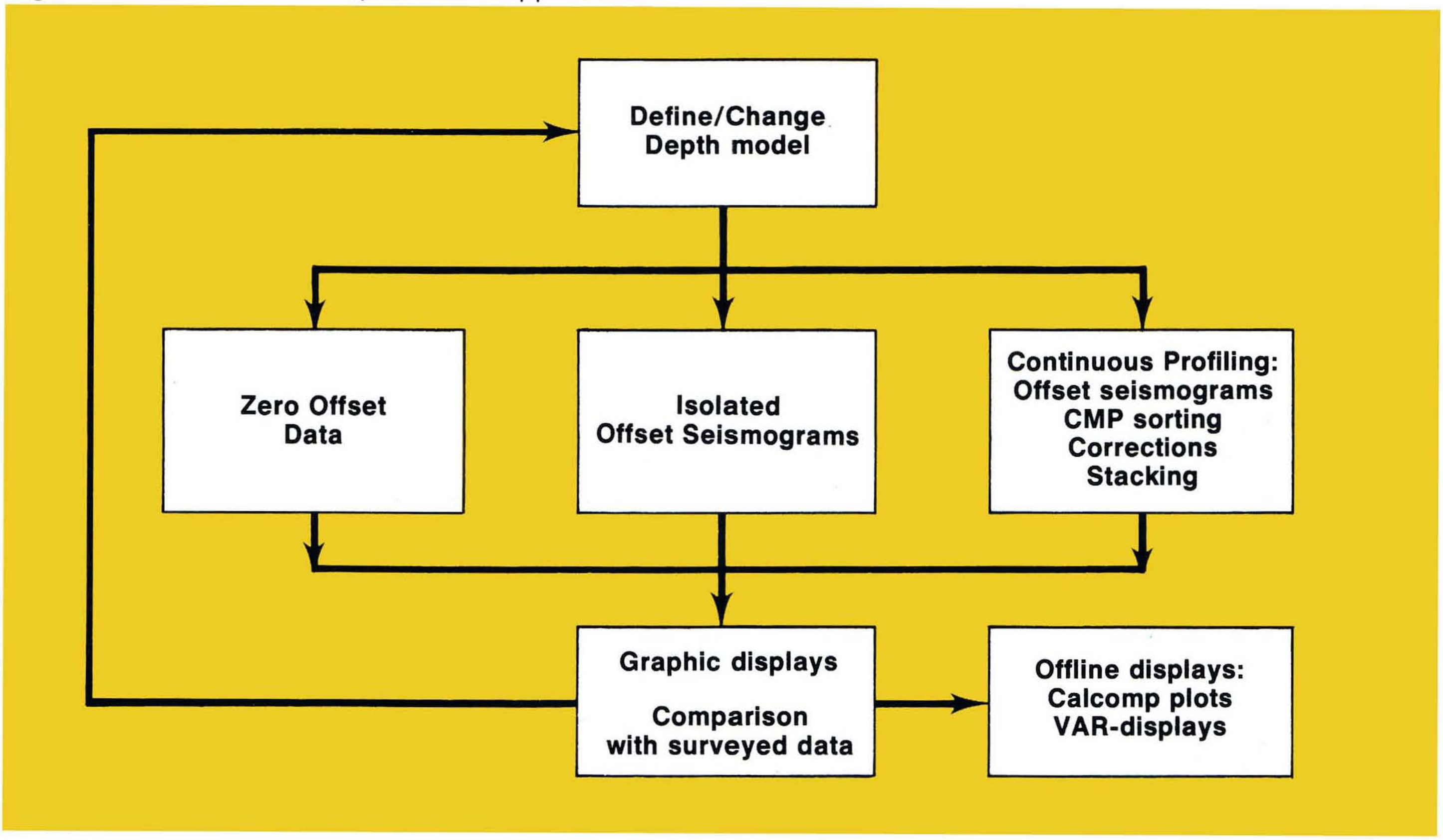
In detail, at present the following information can be provided by IAMP:

a. Zero Offset
- CMP-traveltime sections (fig. 8b)
- amplitude distributions corresponding to traveltime sections
- ray diagrams for both CMP- and image-rays (fig. 8a)
- distributions of stacking velocities (method due to Hubral and Krey)
- image-ray traveltime sections
- Kirchhoff-migration velocities (Hubral's method , fig. 16)

b. Offset
- single seismograms (traveltime sections) (fig. 9b)
- CMP-gathers (corrected and uncorrected traveltime sections) (fig. 10b)
- ray diagrams for both offset sections and CMP-gathers (fig. 9a, 10a)
- shot-near-trace displays (traveltime sections) (fig. 13)
- single coverages (traveltime sections) (fig. 14)
- stacks (traveltime sections) (fig. 15)
- distributions of stacking velocities (obtained from L.M.S. schemes) (fig. 11, 12)
- amplitude distributions for offset sections, shot-near-trace displays, CMP-gathers, single coverages.

c. Special Studies (not all of the following can be computed interactively)
- multiple events (both water-bottom and intra-horizonal)
- converted waves, pure shear waves
- inhomogenous interval velocity distributions: a distribution of the form v(x,z)=f(x) · g(z) is assumed, where f(x) and g(z) are arbitrary functions of the depth and distance coordinates, respectively. (Solutions are obtained from fourth order Runge-Kutta procedures.)
- diffraction patterns
- investigations of variable densities.

Fig. 2: Flow Chart for a typical IAMP application



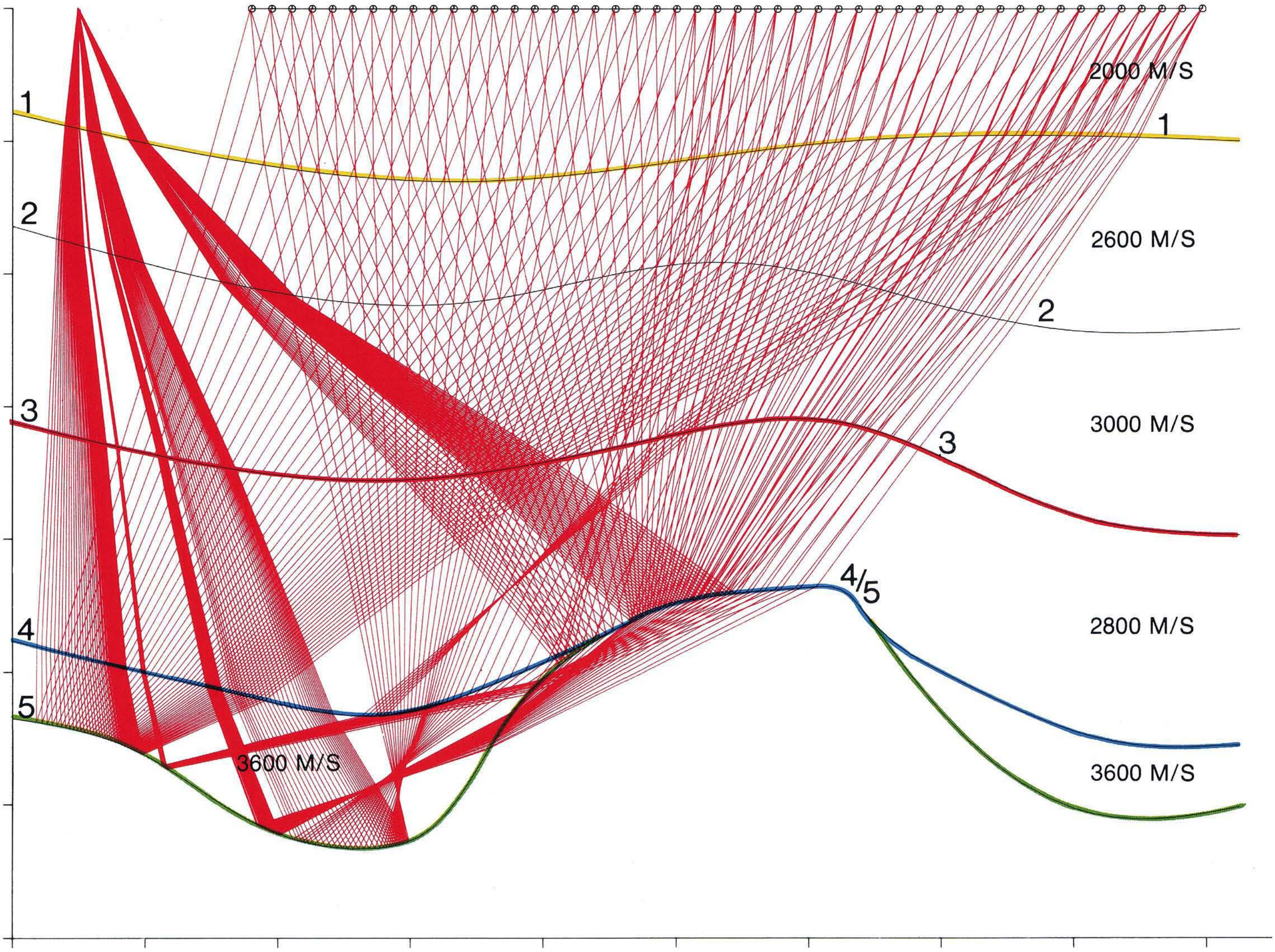


Fig. 3: Model A

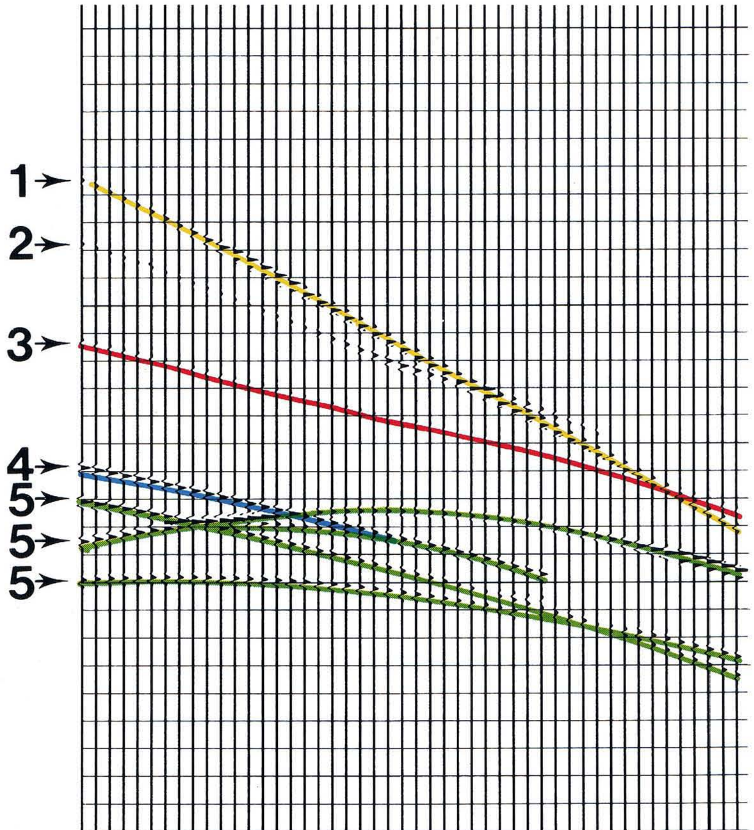


Fig. 4:

Offset Seismogram for reflected P-waves corresponding to fig. 3 (amplitudes and phase effects are included)

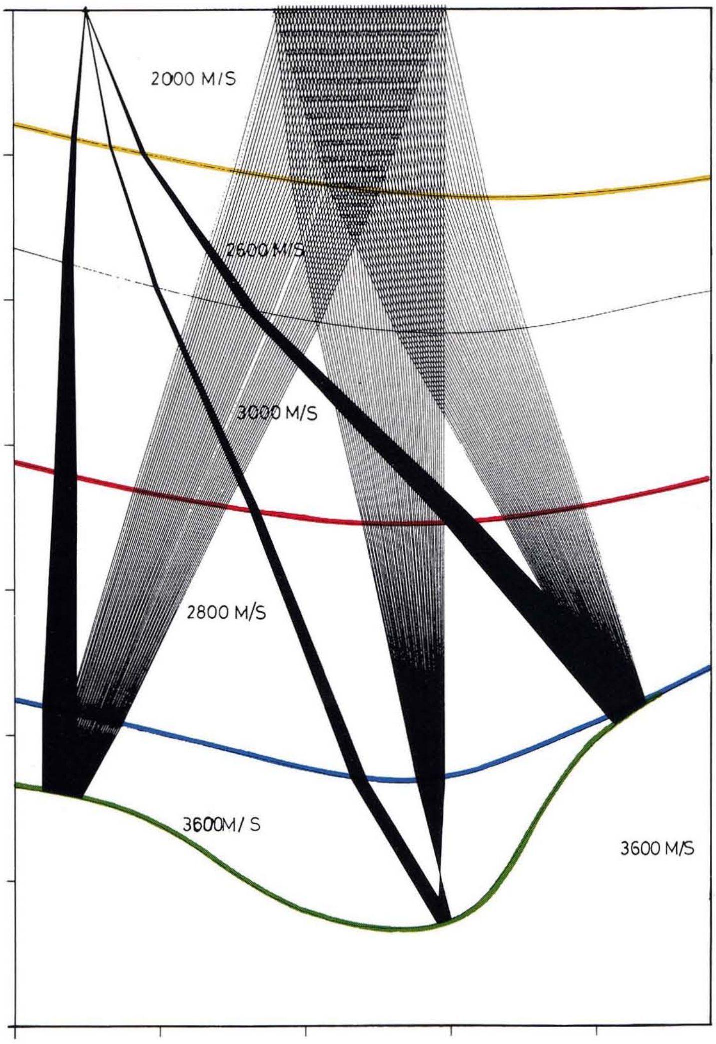


Fig. 5a: Model A – homogeneous velocity distribution

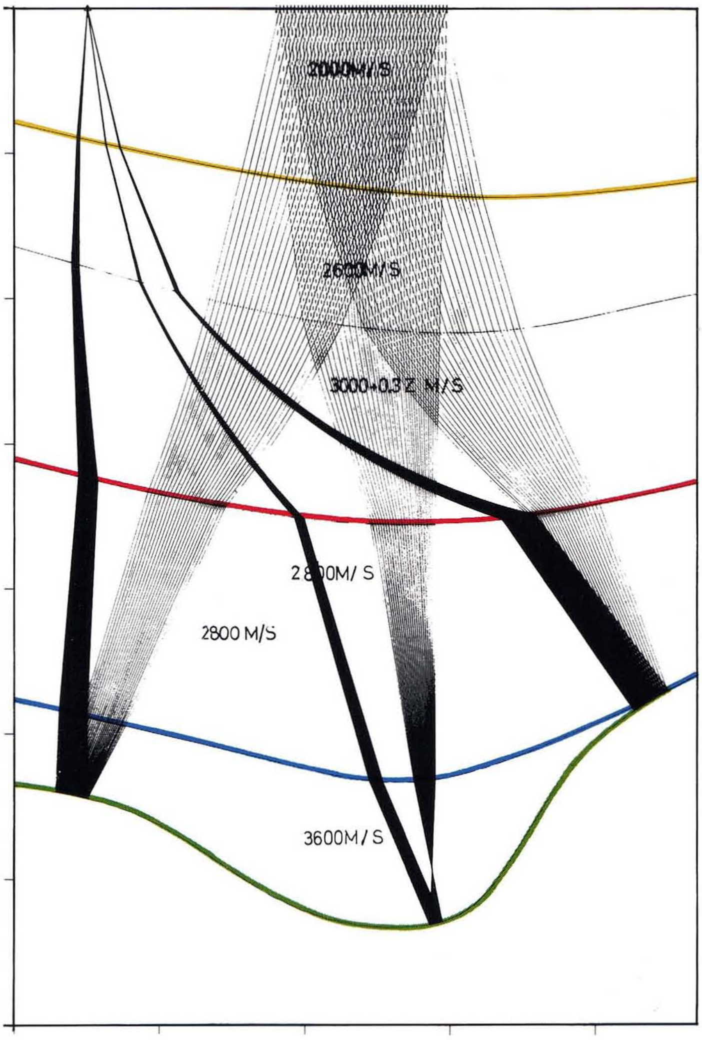


Fig. 5b: Model A – constant velocity gradient of 0.3 m/s between 2nd and 3rd reflector

Fig. 6a: Offset Seismogram corresponding to Fig. 5a (amplitude effects have not been considered)

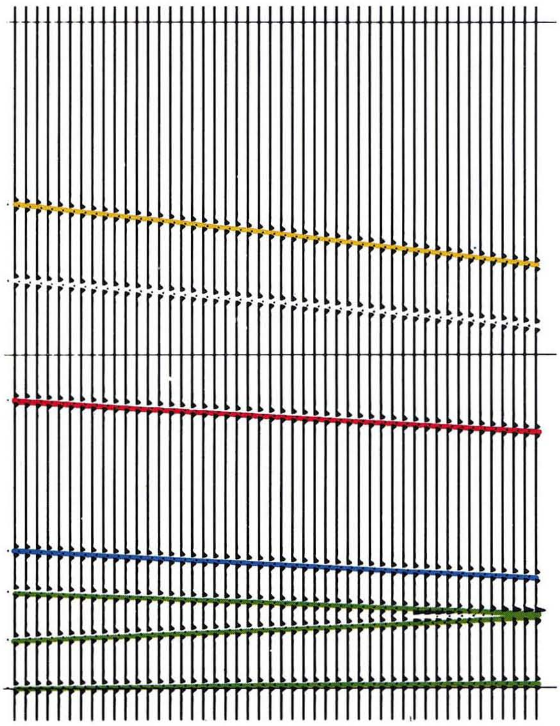
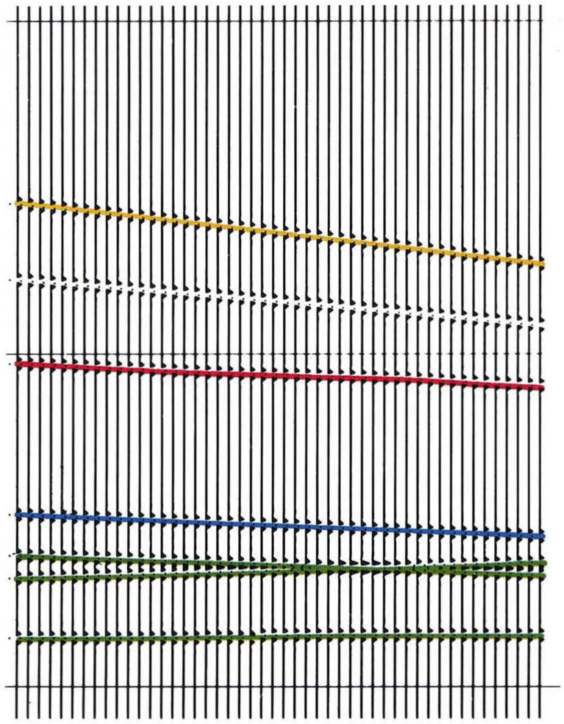


Fig. 6b: Offset Seismogram corresponding to Fig. 5b



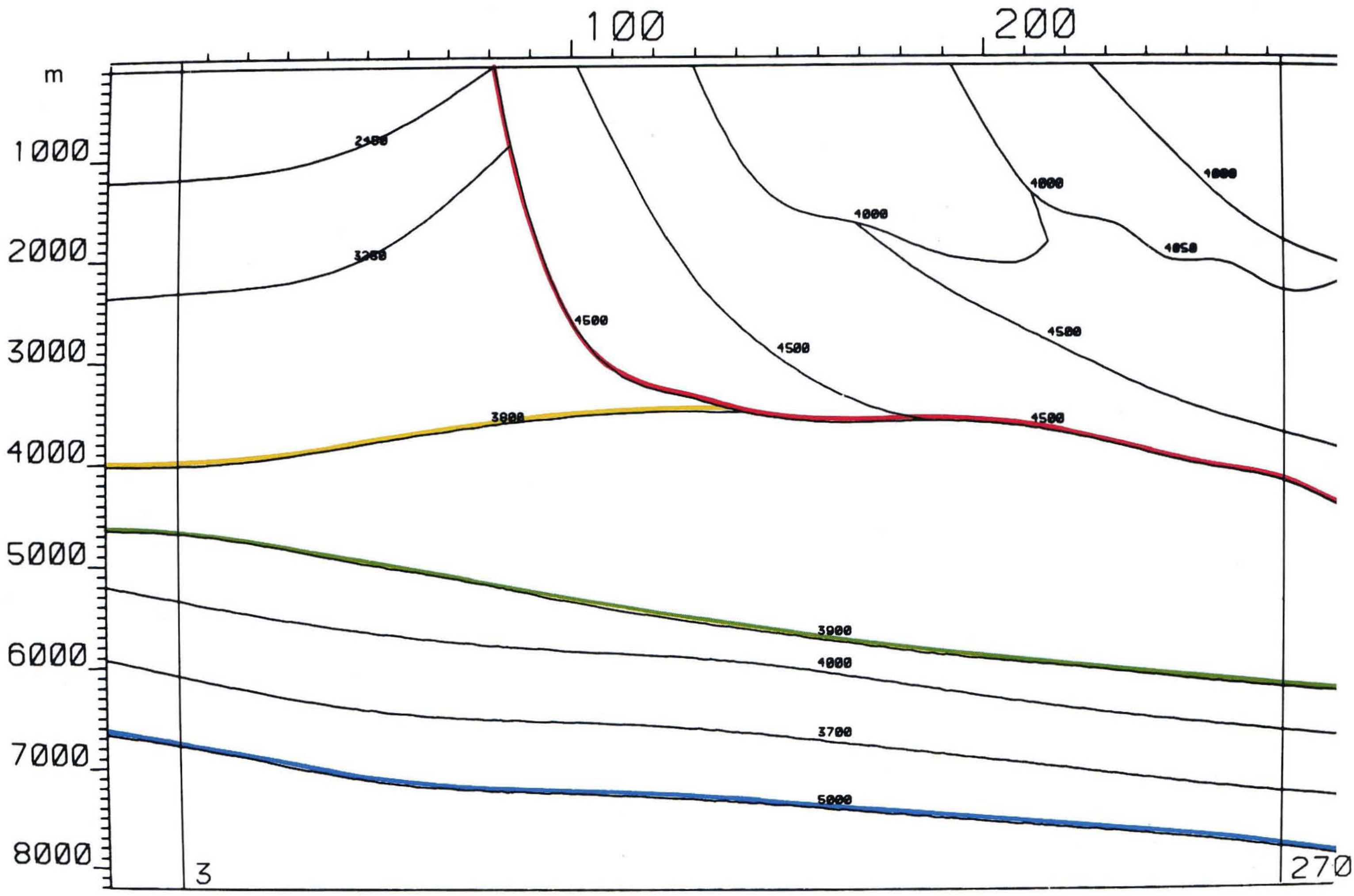


Fig. 7: Model B with indicated velocities

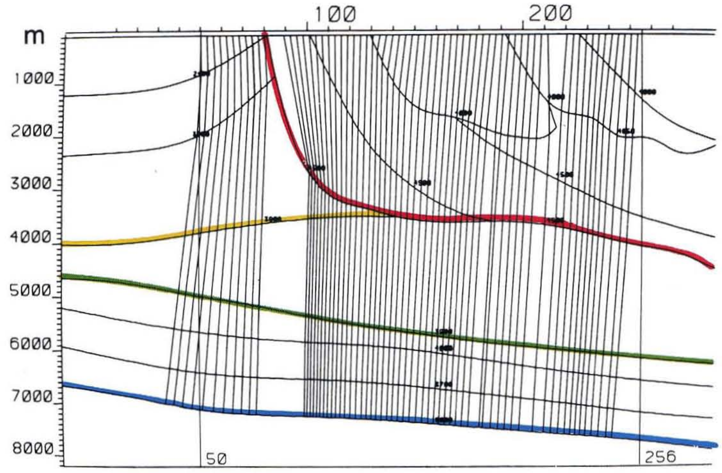


Fig. 8a: Model B with zero offset rays for CMP 50 to 256

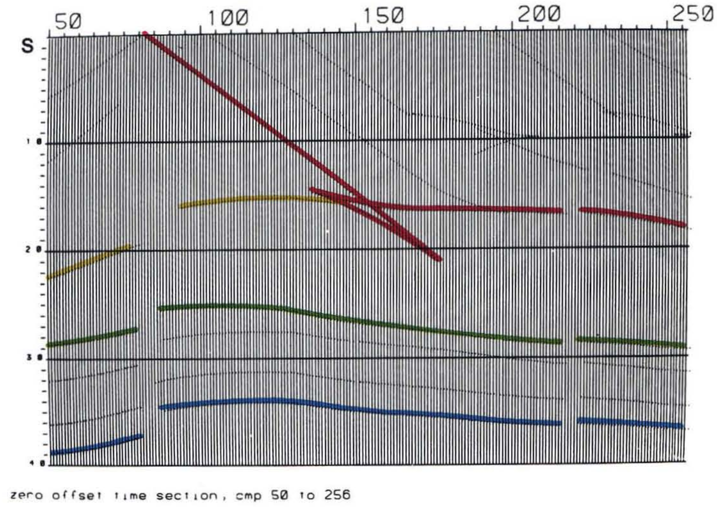


Fig. 8b: Corresponding zero offset time section

Assumption for Model B: 6-fold coverage based on 63 24-trace seismograms with shot-receiver distances of 200-4800 m.

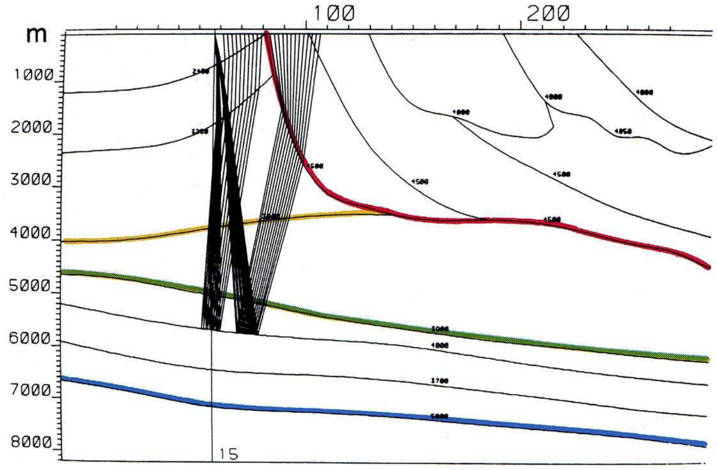


Fig. 9a: Presentation of rays for shot no. 15

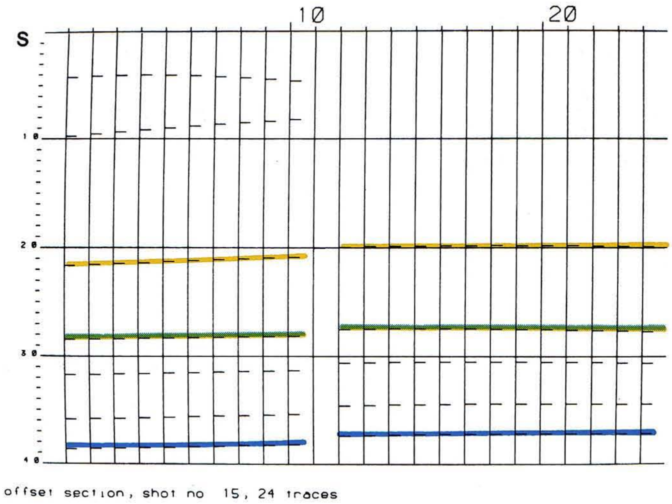


Fig. 9b: Corresponding seismogram

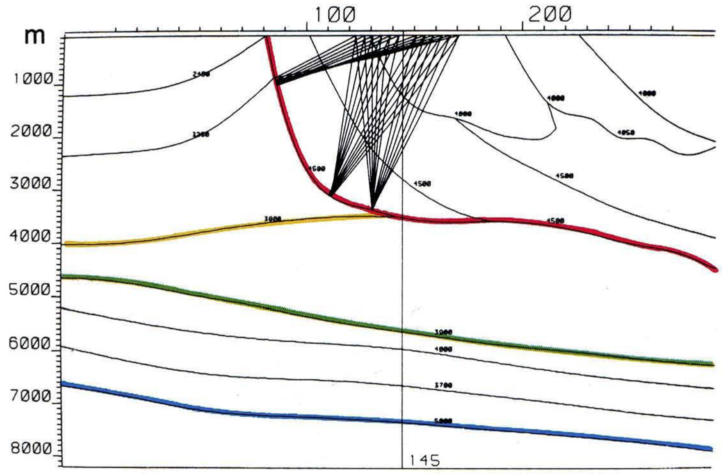


Fig. 10a: Presentation of rays (6-fold covered) for CMP no. 145

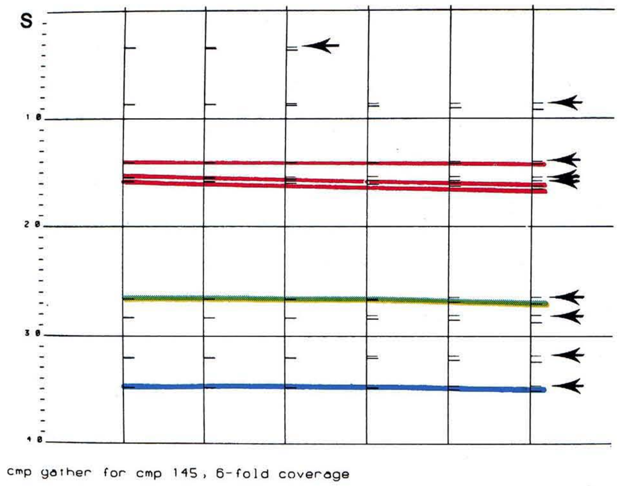


Fig. 10b: Trace gather for CMP 145 (6-fold coverage), containing uncorrrected and dynamically corrected events (corrected events are marked at the shot-far trace)

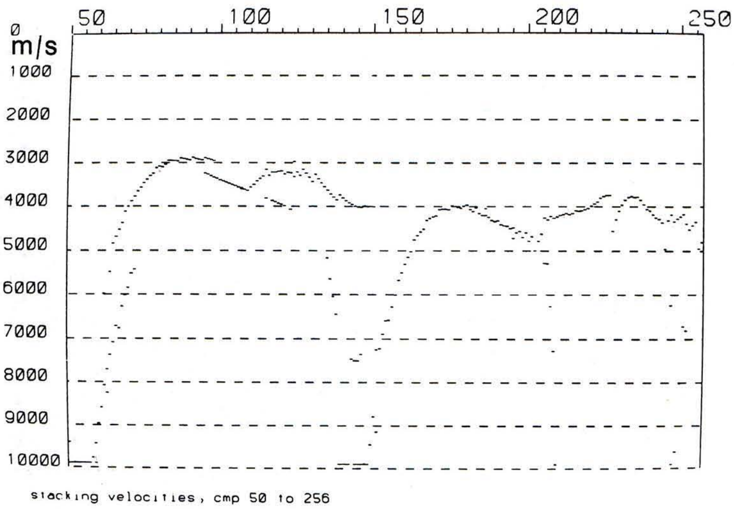


Fig. 11: Presentation of stacking velocities for the deepest horizon (basement) computed from trace gathers by employing L.M.S. schemes

Fig. 12: Presentation of stacking velocities for the third reflector above the basement

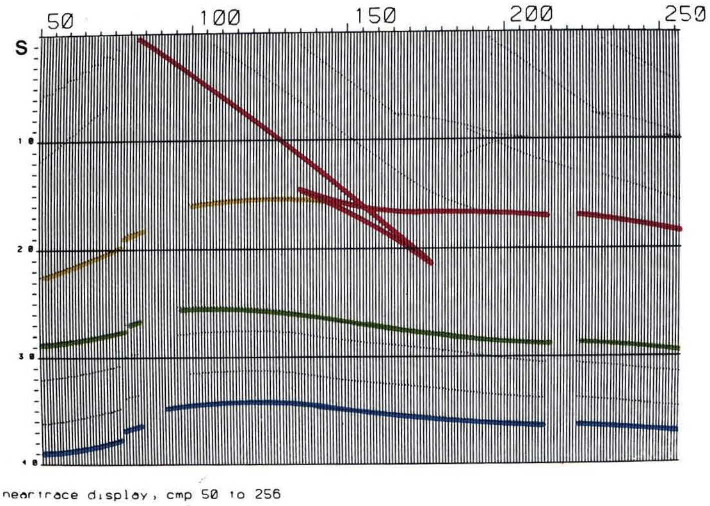


Fig. 13: Single coverage, display of the four shot-nearest traces of all seismograms without application of dynamic corrections

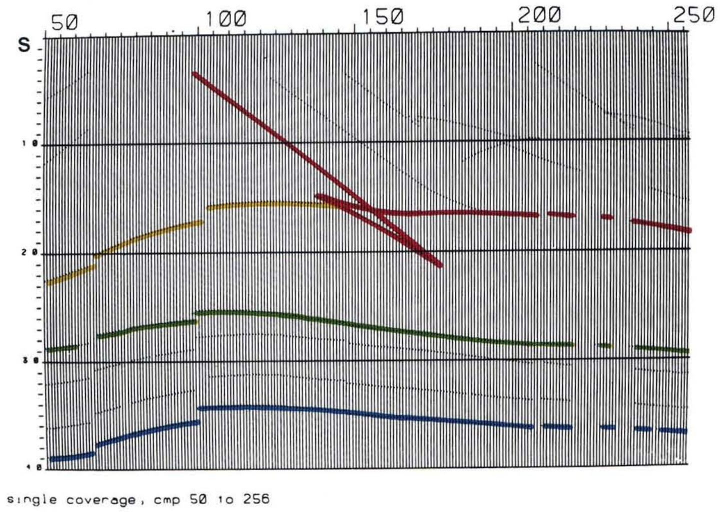


Fig. 14: Single coverage, display of every sixth seismogram after dynamic corrections

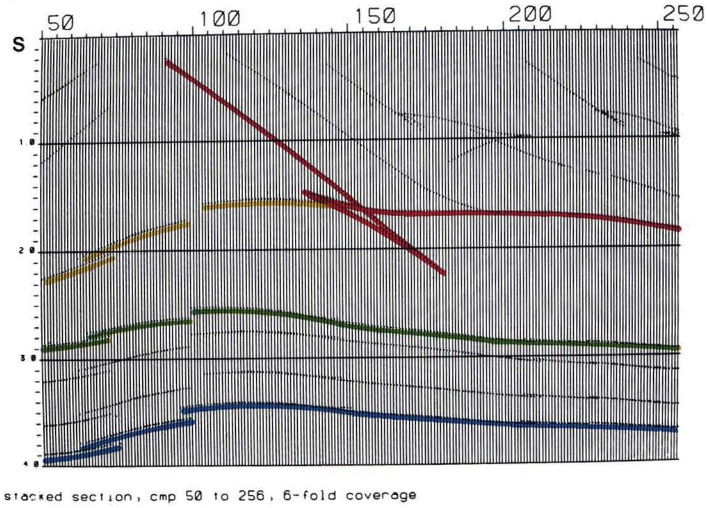


Fig. 15: Six-fold stack after dynamic corrections according to stacking velocities derived from L.M.S. schemes (see fig. 11)

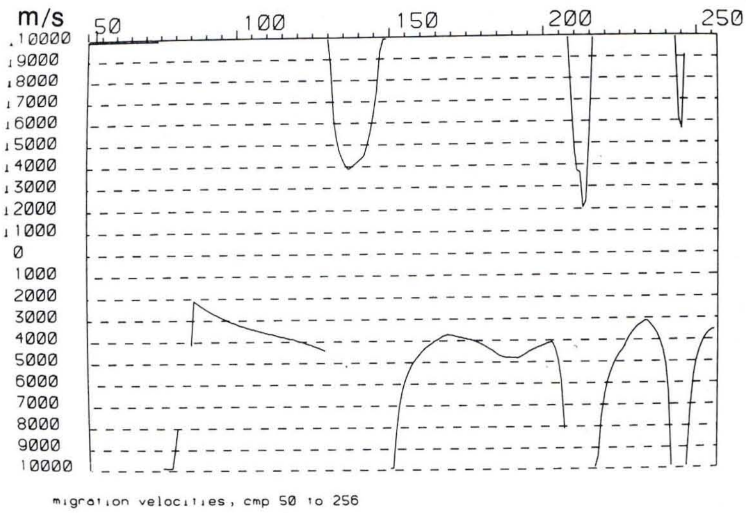


Fig. 16: Presentation of migration velocities for the basement computed along image rays (Hubral's method). Imaginary migration velocities can be observed where the upper reflectors exhibit large curvatures

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

50001080