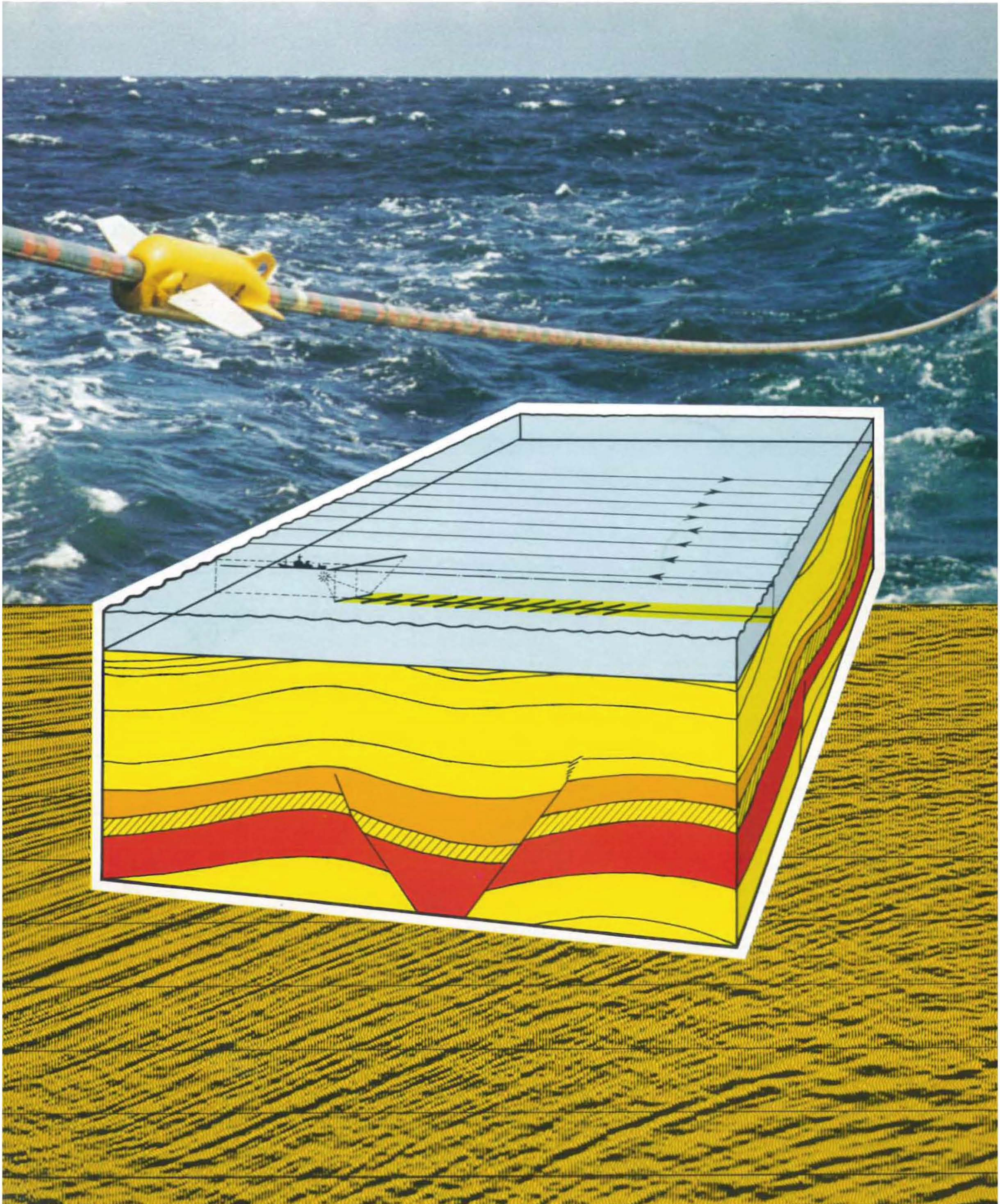
# PRAKLA-SEISMOS INFORMATION No. 32

# 3-D Offshore Seismics



## Streamer Positioning

### Introduction

3-D surveys have become an integral part of today's seismic exploration. For marine 3-D surveys the single boat method is usually employed.

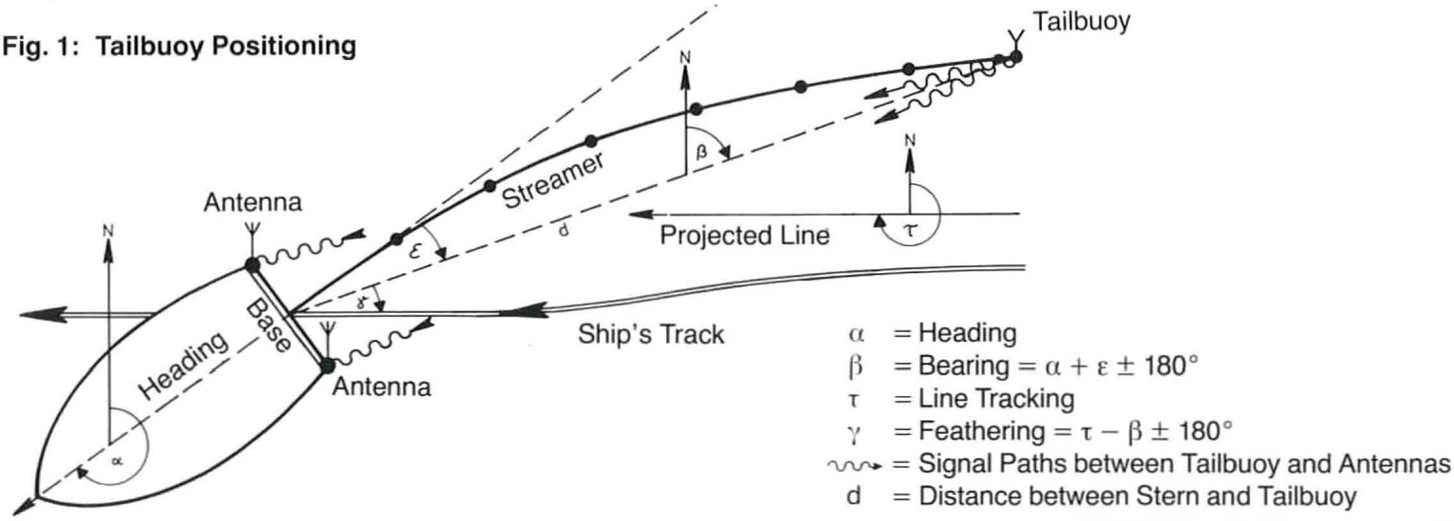
Before starting the seismic processing, positions for each subsurface point have to be precisely calculated from the streamer attitude using streamer compass headings and tailbuoy bearings. Streamer positioning is therefore the initial stage of 3-D marine data processing and is closely conjuncted with both survey and seismic processing.

Real-time positional **processing during the survey** aims to obtain uniform coverage in providing offset navigation and coverage plots. **Post mission processing** is to determine the streamer polygon and thus to derive most accurate subsurface positions for further seismic processing.

### Survey

1. Equipment
   - Tailbuoy positioning system
     type: PRAKLA-SEISMOS, PDF
     Method: Phase difference measurement
     Resolution: ± 0.1°
     Internal sampling rate: 0.1 sec
   - Heading sensors (with compasses)
     type: Digi Course, Model 318
     Internal sampling rate: 30 msec
     Resolution: ± 0.35°
     Built-in interval: 400 m
     Quantity: depends on streamer length (e.g. 6 for 2400 m cable)
2. Recording
   - 3-D positioning data integrated in navigation tape format:
     – streamer layout in profile headers
     – compass and tailbuoy azimuths in shot records
   - Magnetic tape recording at every pop
   - Selective print-out on teletype
   - Display
3. Navigation
   - 3-D navigational requirements controlled by navigation computer
     – computation of navigation offset
     – tracking of CDP midpoints on projected line
     – track-plot with subsurface scattering

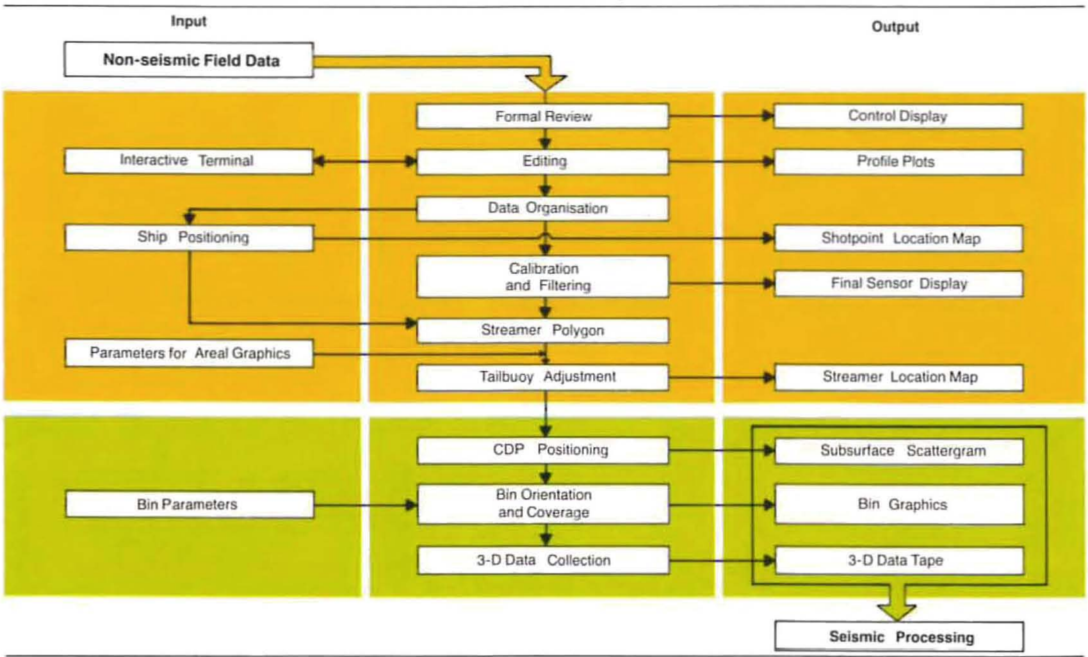
**Fig. 1: Tailbuoy Positioning**




### Processing

Built-in streamer compasses are strongly influenced by varying torsion and tension forces. Thus, even the most careful editing, filtering and calibration of heading sensor data can only provide a relative streamer polygon (see Streamer Positioning Sequence). However, the precise (and absolute) adjustment of the pre-calculated streamer polygon is only possible since the introduction of an independent and **highly accurate tailbuoy positioning system,** a PRAKLA-SEISMOS development (see Fig. 1).

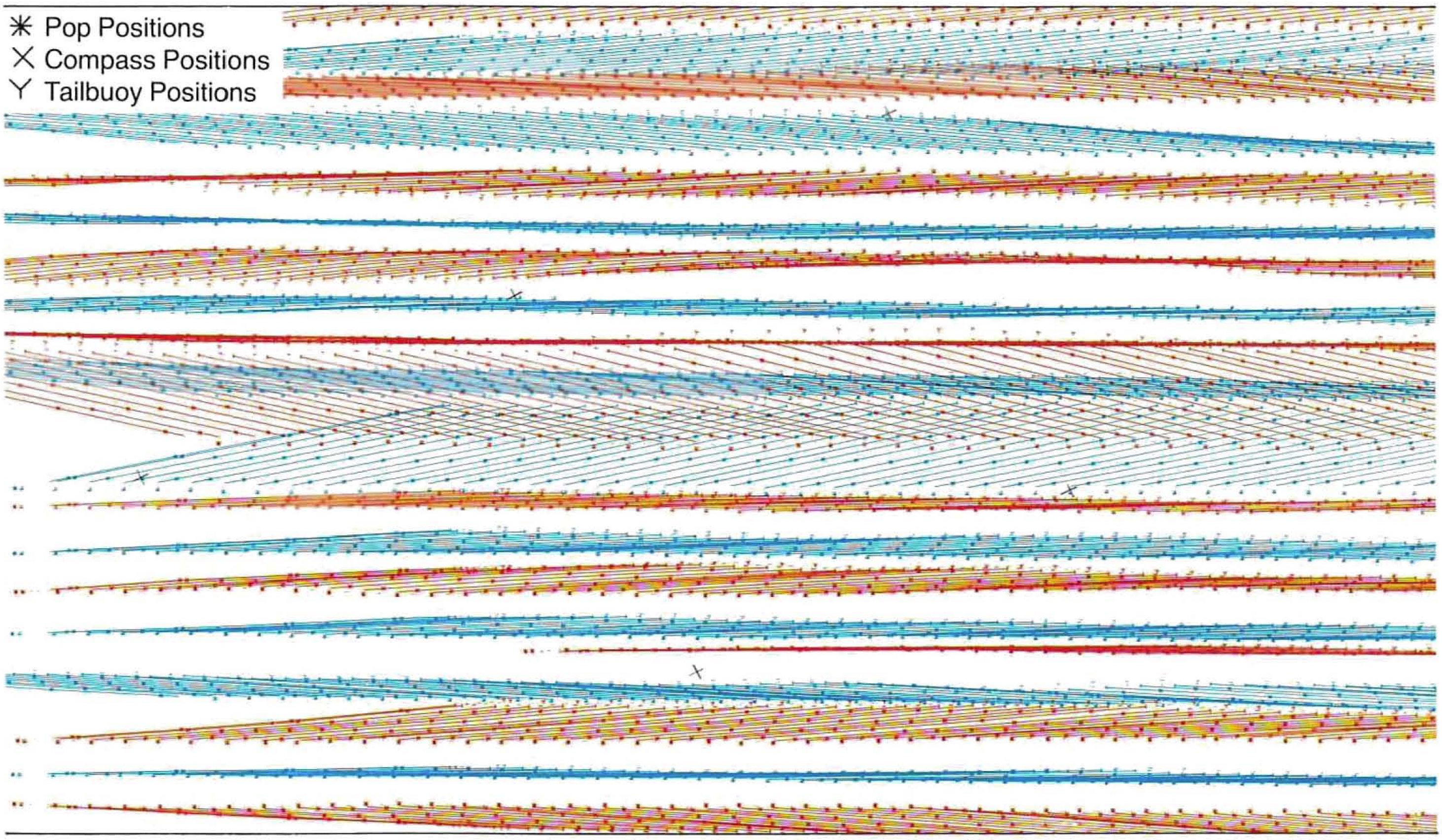
**Streamer Positioning Sequence**



### Areal Graphics

For control purposes streamer positions are plotted to a suitable scale; the streamer location map shows shotpoint, streamer lead-in, first and last trace of the active streamer part, heading sensors, tailbuoy connection and tailbuoy. To avoid crowding, the streamer positions are plotted selectively. The geodetic grid is marked in the plots and indicated at the map margins (see Fig. 2).

To get an idea of the degree of subsurface coverage within the 3-D area, a subsurface scattergram (fig. 3) is plotted to the same scale as the streamer location map; to improve the clarity of the plot, blue, green, red and orange pens are alternately used for plotting. Shotpoint, subsurface track and midpoint of subsurface coverage are marked together with the geodetic grid, which is indicated at the map margins.




500 m Scale

**Fig. 2: Streamer Location Map (presentation of odd lines only)**

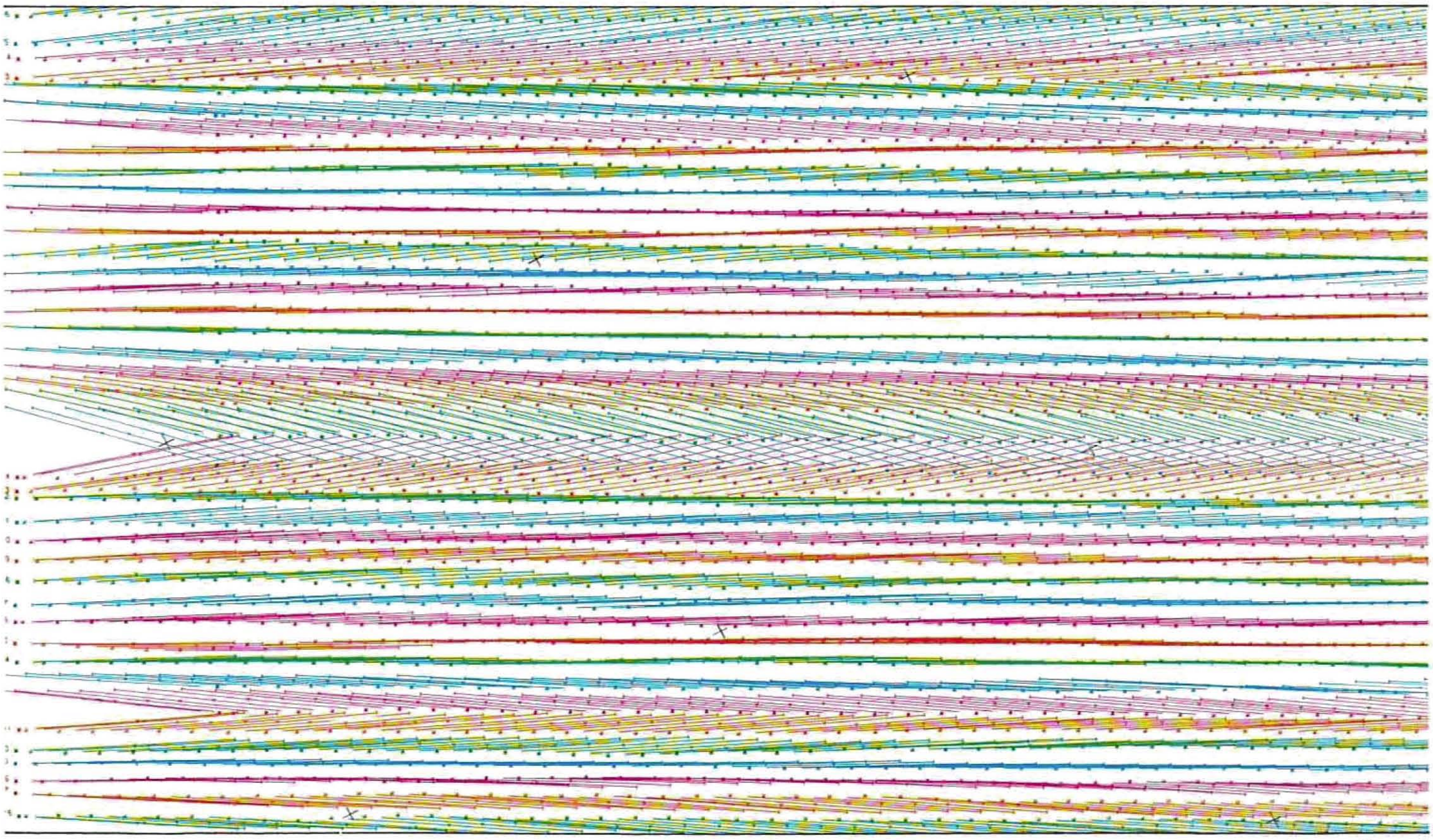


**Fig. 3: Subsurface-Scattergram (presentation of odd and even lines)**

Additionally bin graphics can be obtained. A second version of the subsurface coverage can be presented in the form of **bin color plots,** colors representing the degree of coverage. A general idea of the coverage distribution are given within macro bins (e.g. 12.5 x 75 m, see fig. 4, **Bin Coverage Map**); an automatic bin adjustment provides an even as possible coverage over the whole area. To provide detailed information, a scattergram is prepared showing the distribution of all subsurface points within micro bins (e.g. 12.5 x 15 metres), increasing the resolution in this case by a factor of 5 (see Fig. 5, **Bin Coverage Scattergram**). The scattergram is underlayed with the **bin boundary map.** This can be used as an independent plot or as an overlay to the colored bin coverage map.

A **bin center location map** can be produced to facilitate rapid cross reference between maps and sections; this display contains velocity-analysis locations and serves as an overprint for the seismic contour maps.

The resulting positioning data file (3-D Data Tape) is then available for the subsequent seismic processing.

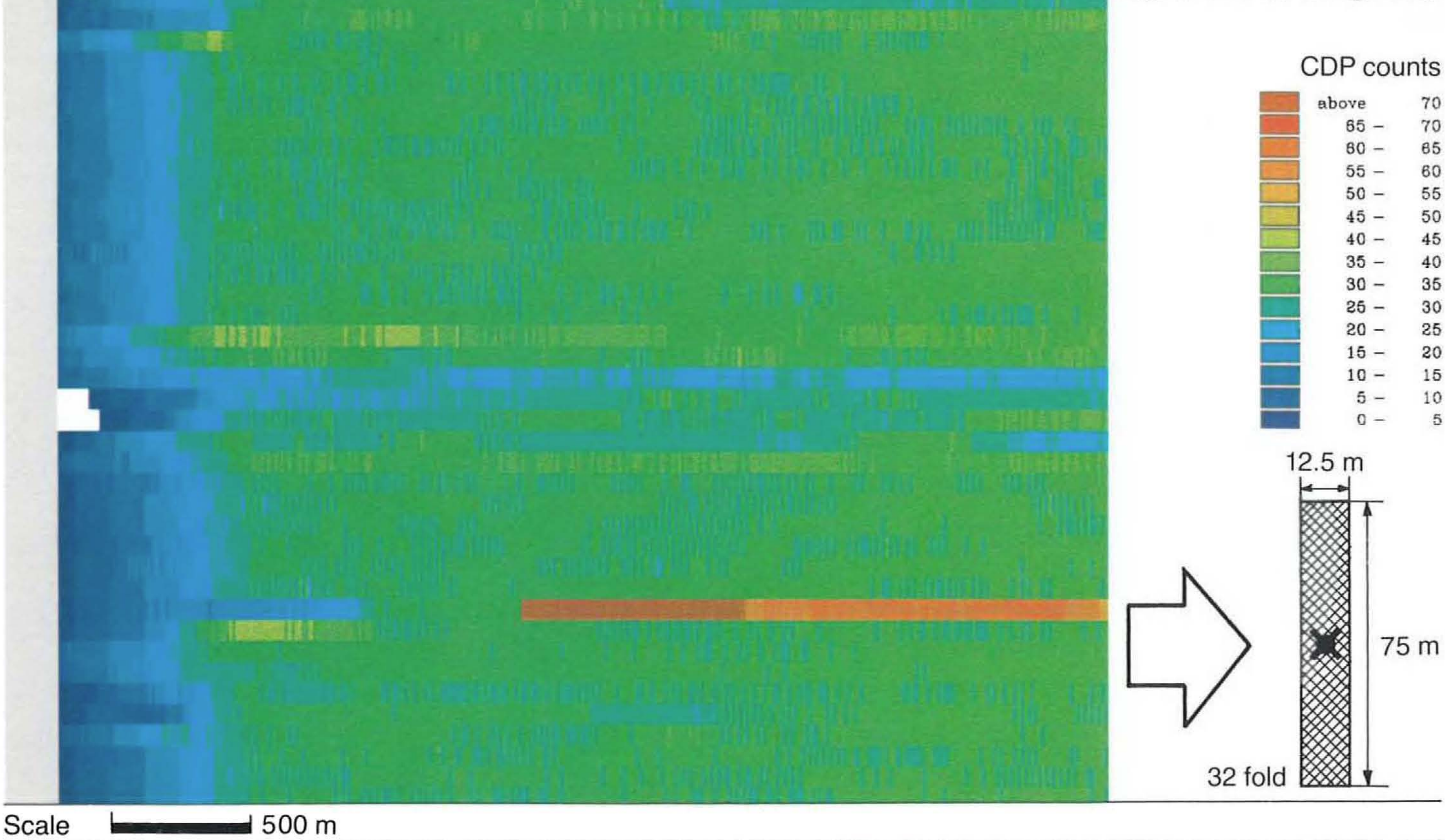



**Fig. 4: Bin Coverage Map**

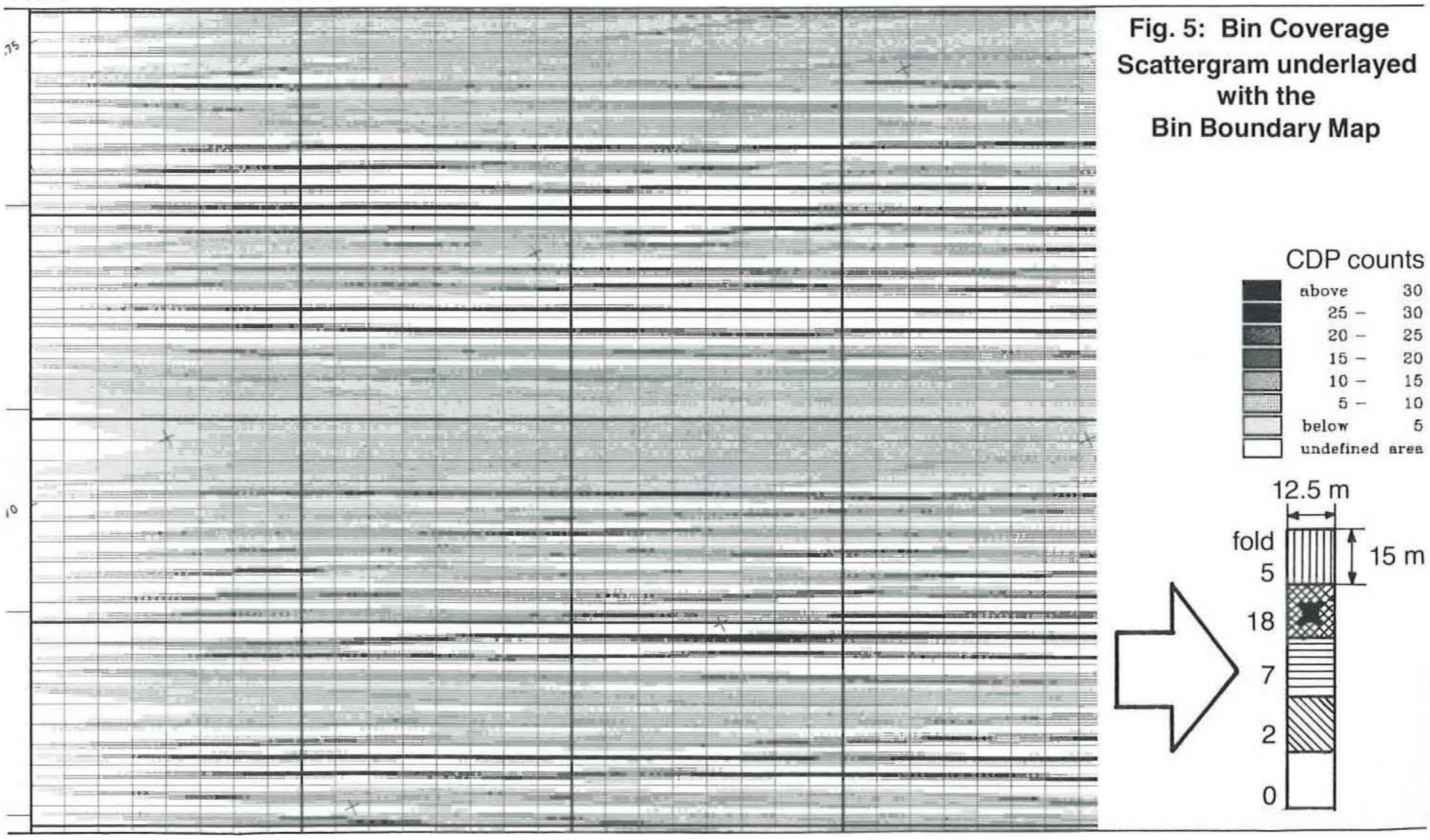
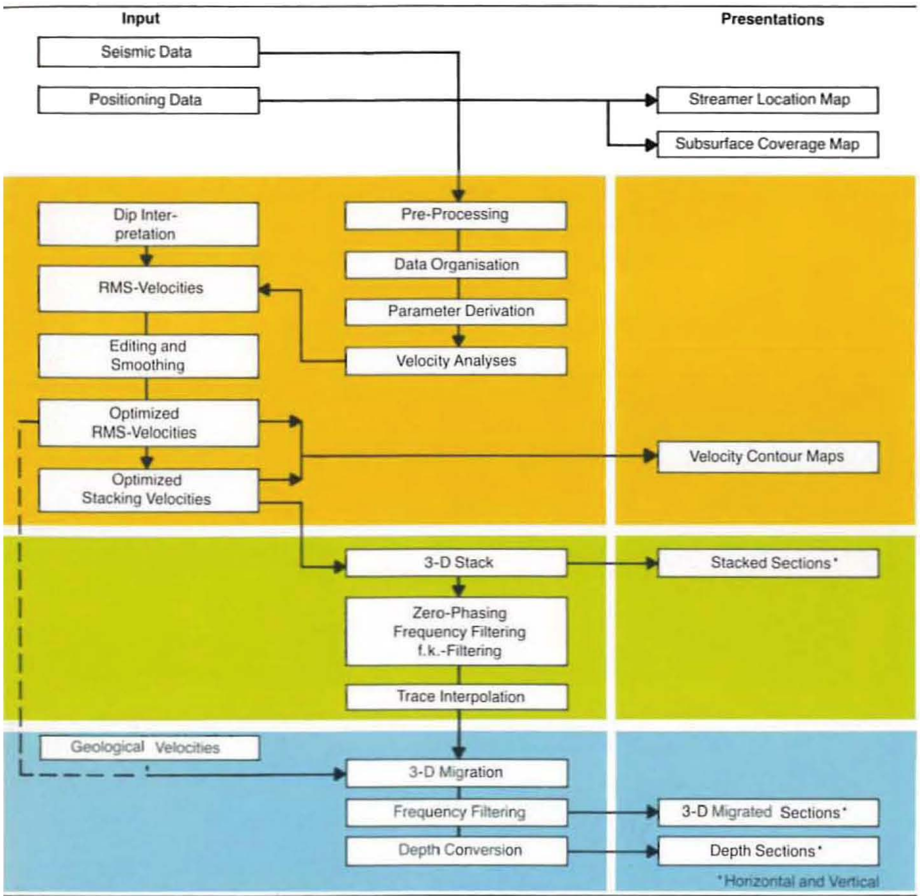



**Fig. 5: Bin Coverage Scattergram underlayed with the Bin Boundary Map**

### 3-D Processing Sequence




The 3-D processing sequence consists of 3 main phases as can be seen from the flow diagram:

1. Pre-Stack Processing, including velocity analyses and 2-D test stacks
2. Pre-Migration Processing
3. 3-D Migration

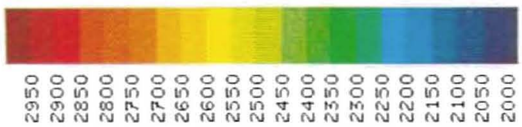
## Pre-Stack Processing

In the pre-processing phase the data are sorted in the conventional 2-D mode, each individual trace being marked with the corresponding shot- and receiver identification for later 3-D processing.

After parameter derivation and further pre-stack processing (e.g. filtering etc.), the velocity analyses are performed on a grid of e.g. 500 x 500 m. The resulting velocities are used for conventional 2-D processing of some selected lines, in order to check the data quality and for test purposes.

These velocities are only valid for the actual positions of the velocity analyses. In order to obtain stacking velocities for intermediate locations, RMS-velocities are calculated (under consideration of dip and feathering information), smoothed and then used for the derivation of stacking velocity fields.

Velocity contour maps are produced for requested horizons or constant travel times (see Fig. 6 and 7).



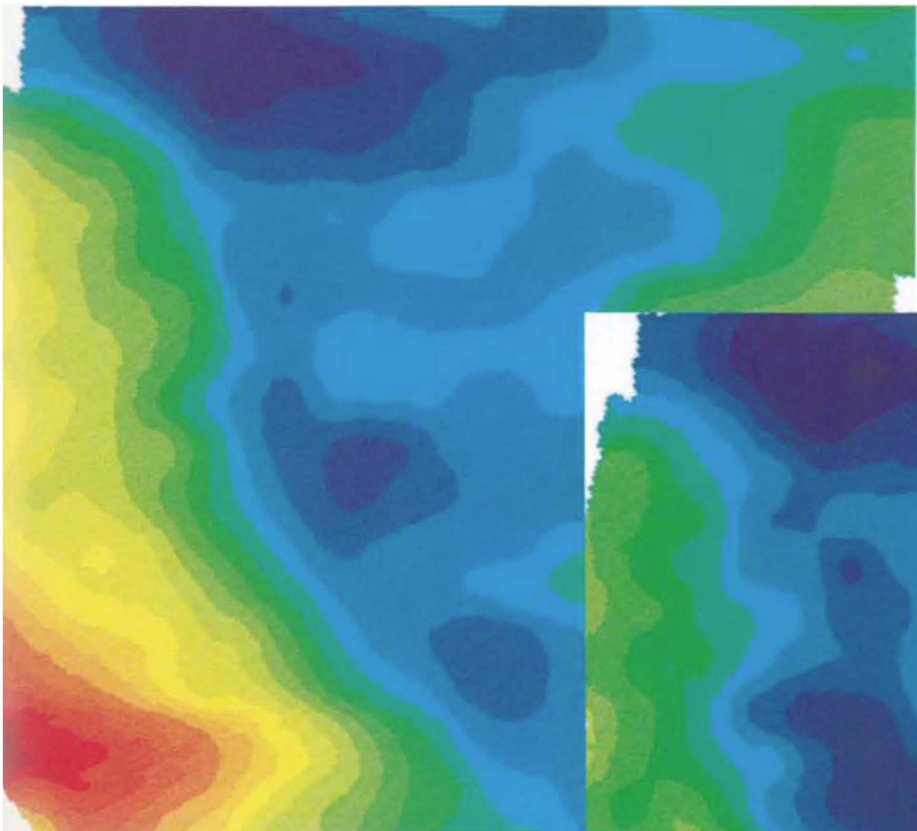



**Fig. 6: Stacking Velocities (azimuth-consistent)**

Scale 1000 m

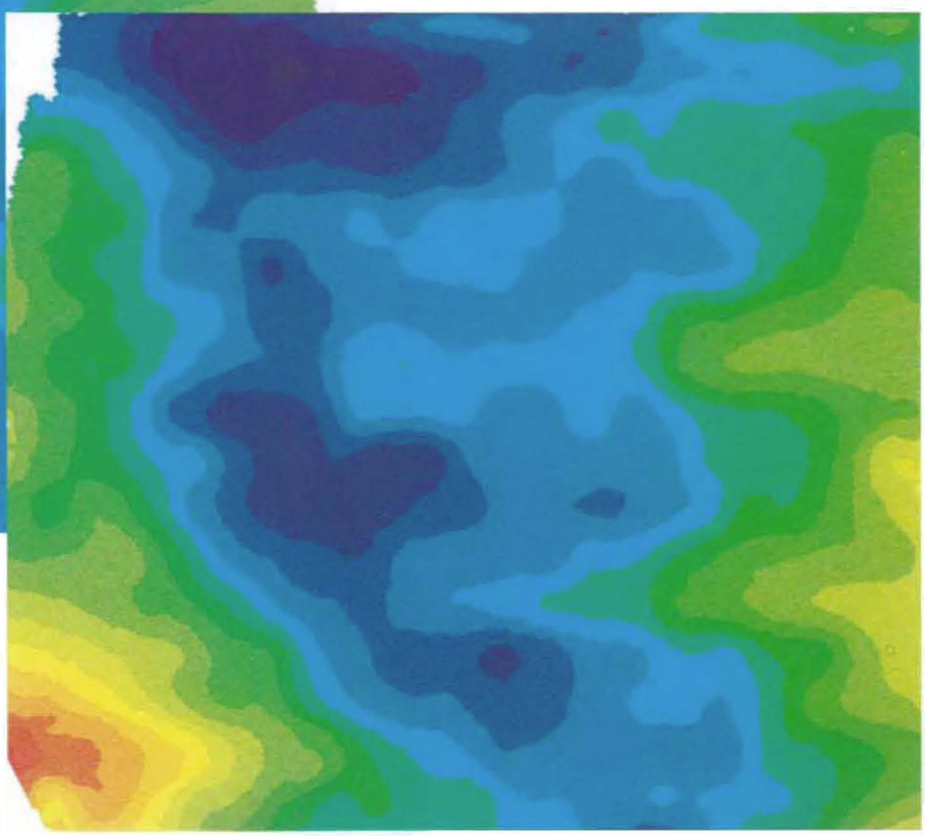


**Fig. 7: Migration Velocities (dip-independent)**

## Pre-Migration Processing

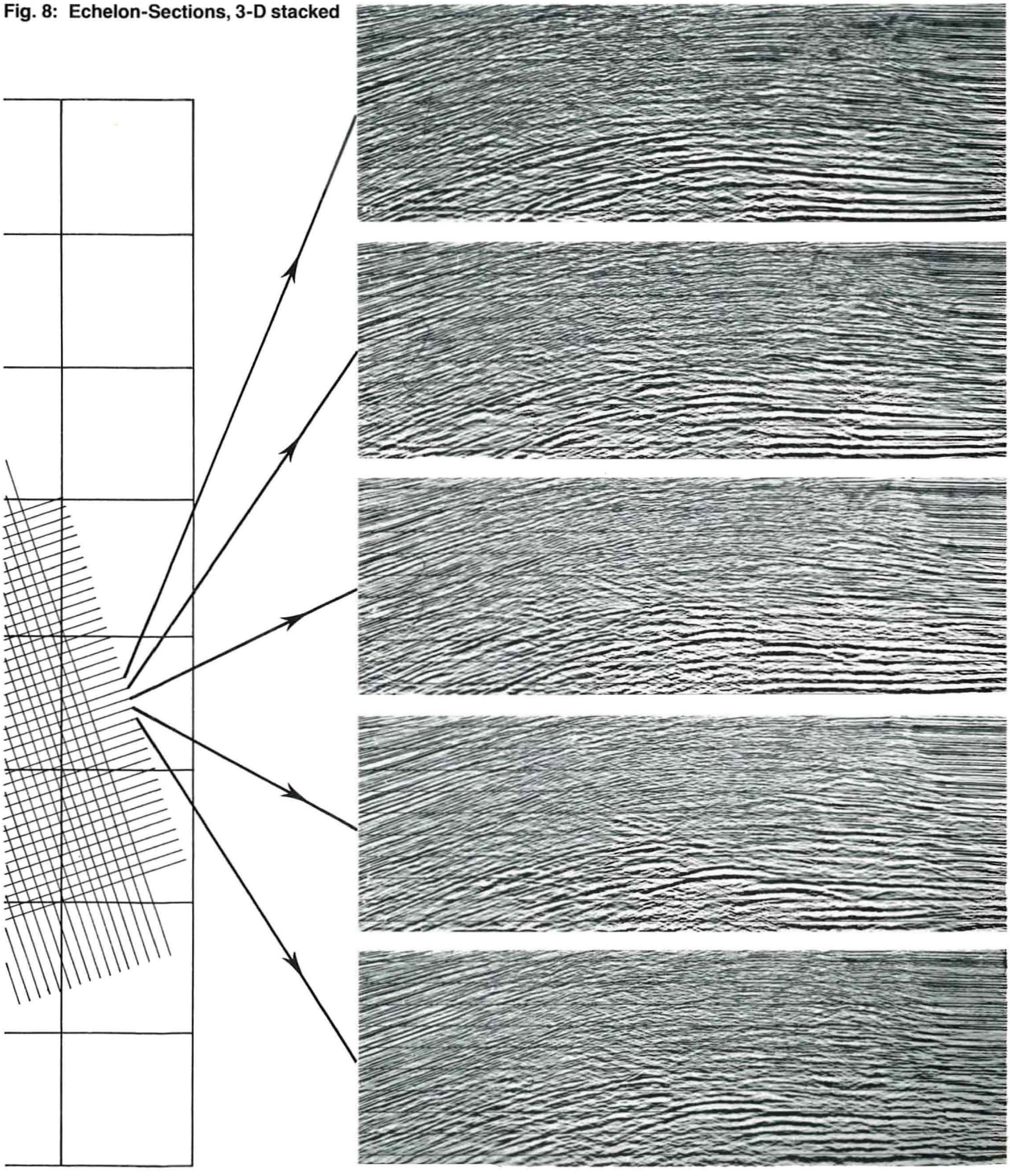
This sequence of processing steps is distinguished by the introduction of streamer positioning results in order to sum the data in a bin-mode.

The stacking position of each CDP is consigned to the center of corresponding bins. Thus a parallel line presentation (echelon sections) of three dimensionally stacked data can be achieved, if wanted for selected time gates only (s. Fig. 8).

To improve the signal/noise ratio of stacked data several filtering procedures are optional, such as zero phasing or f,k-filter for attenuation of steeply dipping diffraction effects, often caused by near surface anomalies.

Spatial sampling in 3-D marine surveys is directly influenced by the cost of data acquisition, thus usually resulting in a bad relationship of line spacing to CDP spacing. To avoid spatial aliasing of data which degrades migration results, a sophisticated interpolation procedure can be applied to generate intermediate traces.

**Fig. 8: Echelon-Sections, 3-D stacked**



## 3-D Migration

The reconstruction of true subsurface geometries requires 3-D migration techniques as they are outlined in PRAKLA-SEISMOS Information No. 31.

According to the commonly used profiling method of marine 3-D surveys, CDP-data will be unevenly spaced in x- and y-directions. To achieve an adequate lateral resolution power of 3-D migration operators in both directions, they are adapted to this special sampling situation.

Proper estimation of dip-corrected 3-D velocity fields (RMS-velocities) or the incorporation of geological velocities supports the effectiveness of the 3-D migration process.

A blockwise data organisation enables **full flexibility in displaying sections** of the imaged data volume **in any orientation.**

**Fig. 9: Echelon-Sections, 3-D migrated**

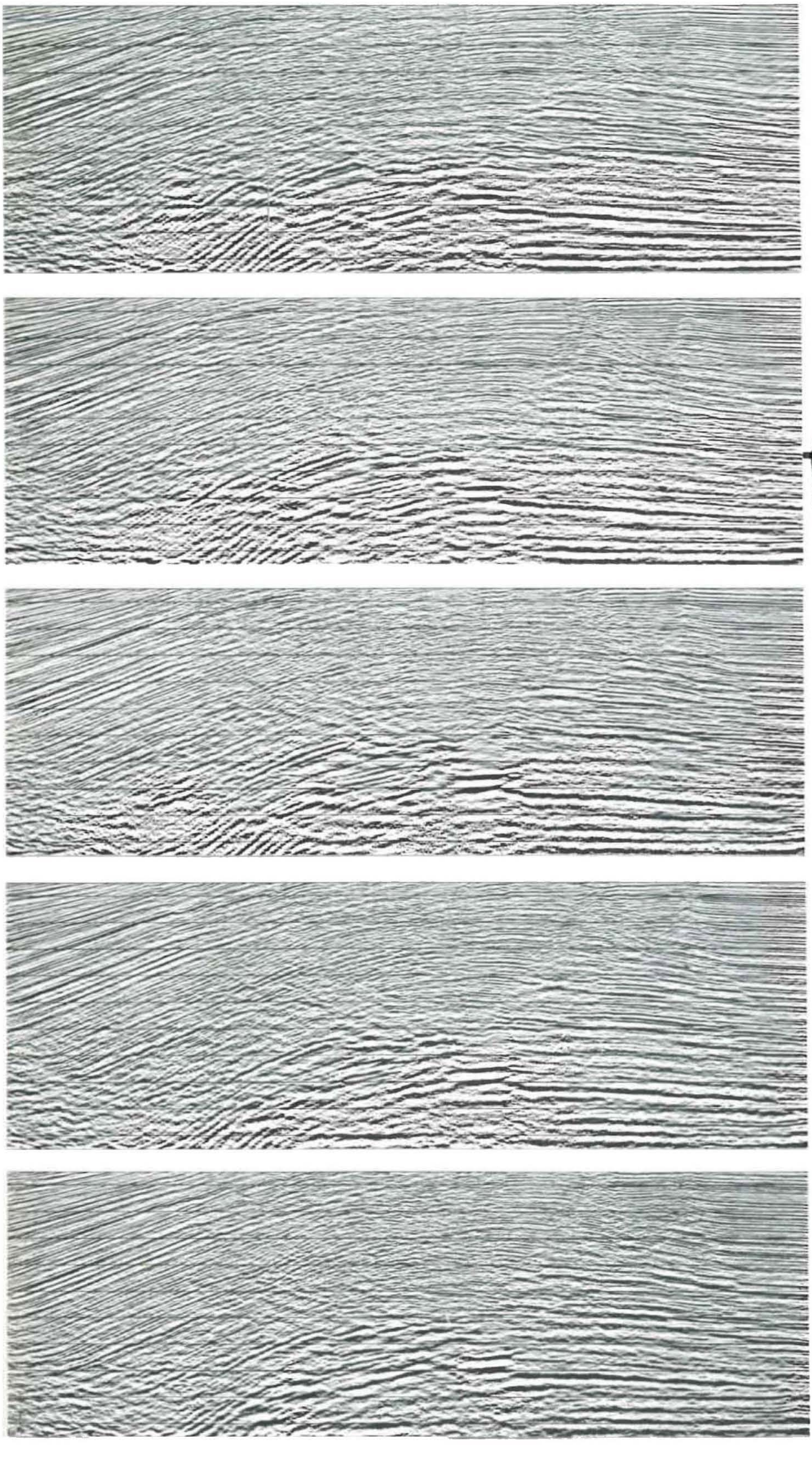
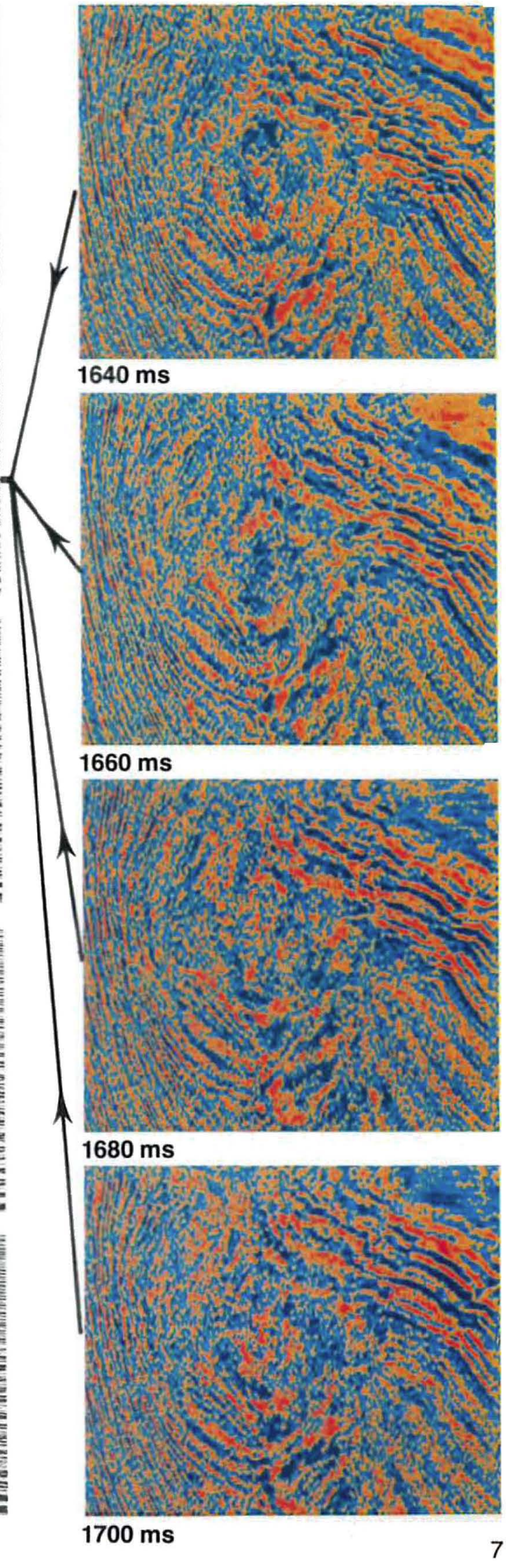
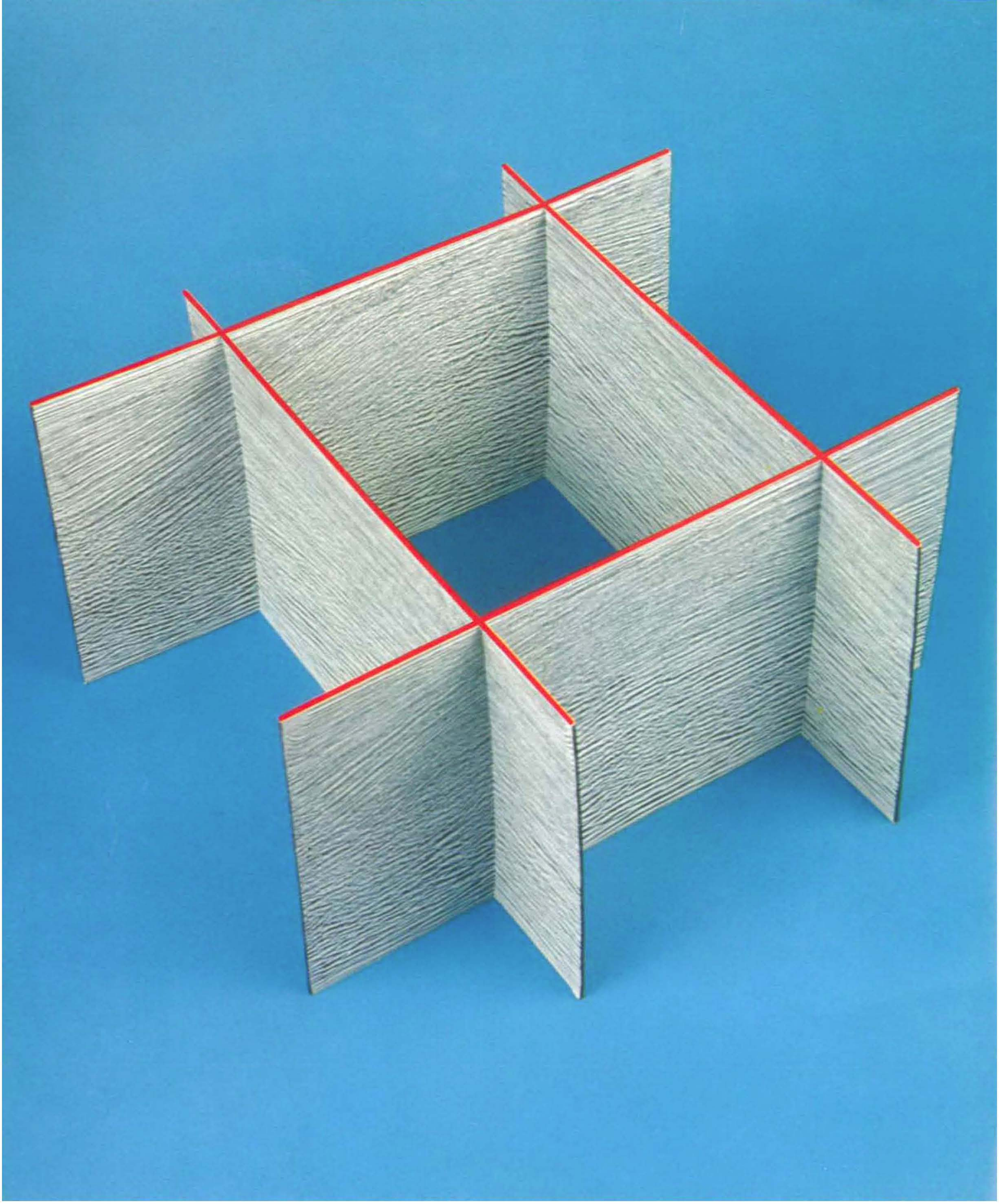


**Fig. 10: Horizontal Sections of 3-D migrated data**





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