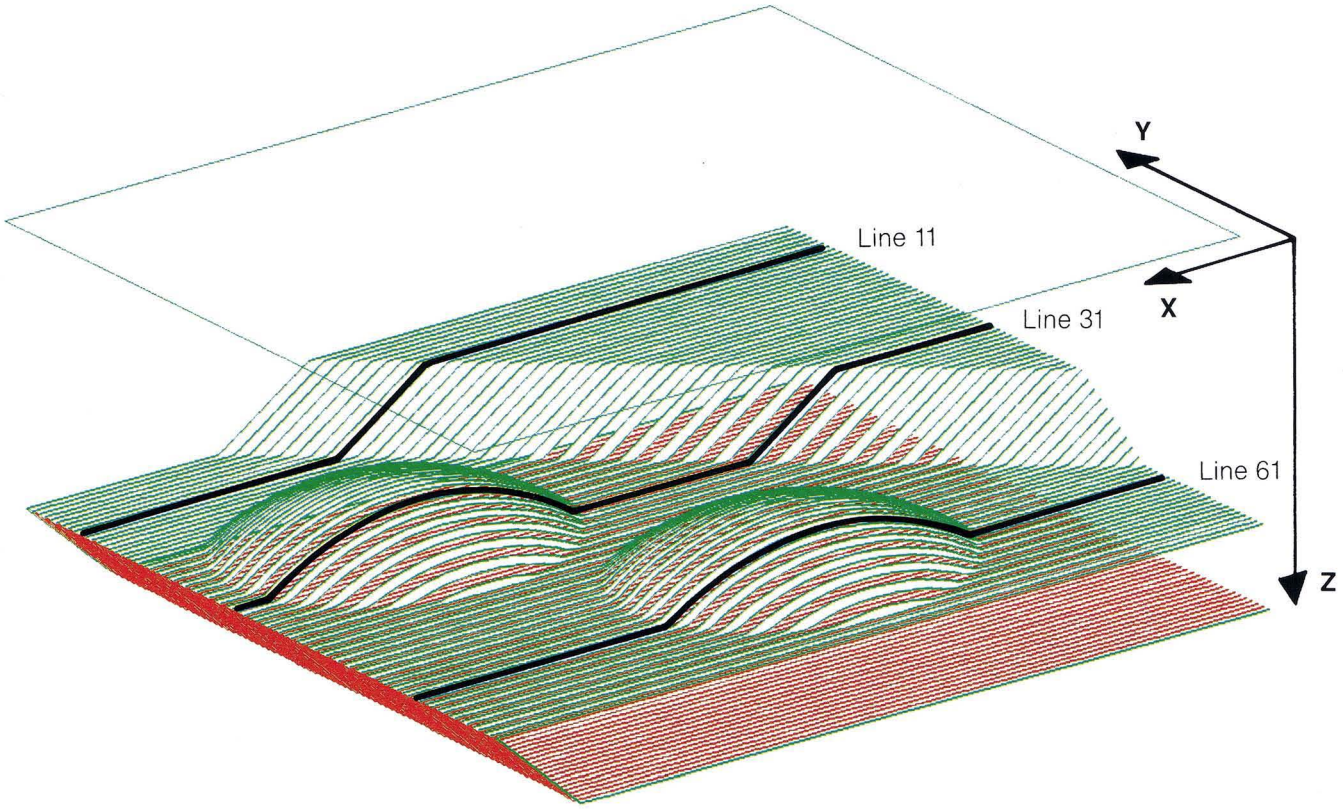
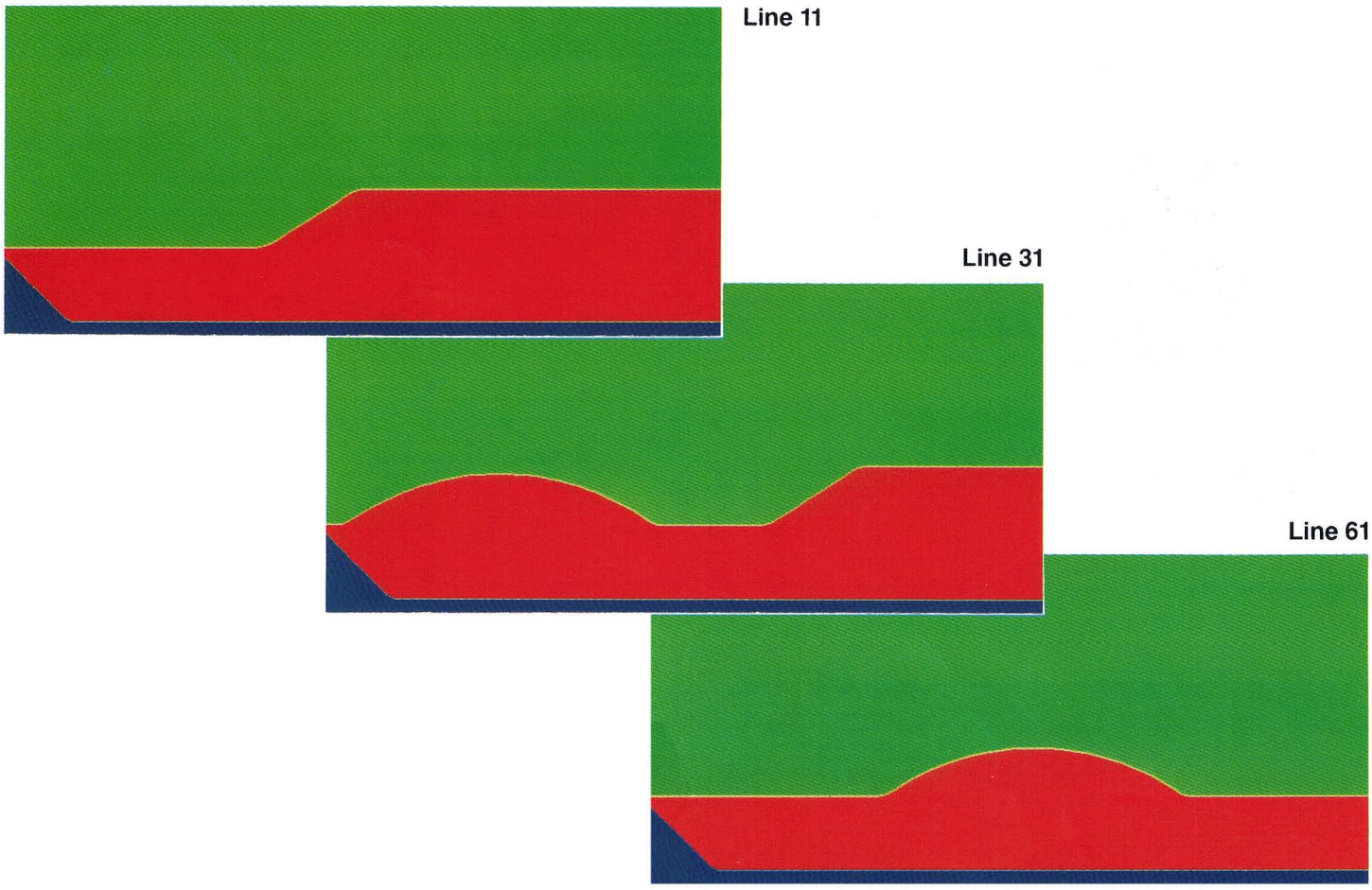
PRAKLA-SEISMOS INFORMATION No. 63

One-Pass 3D Depth Migration





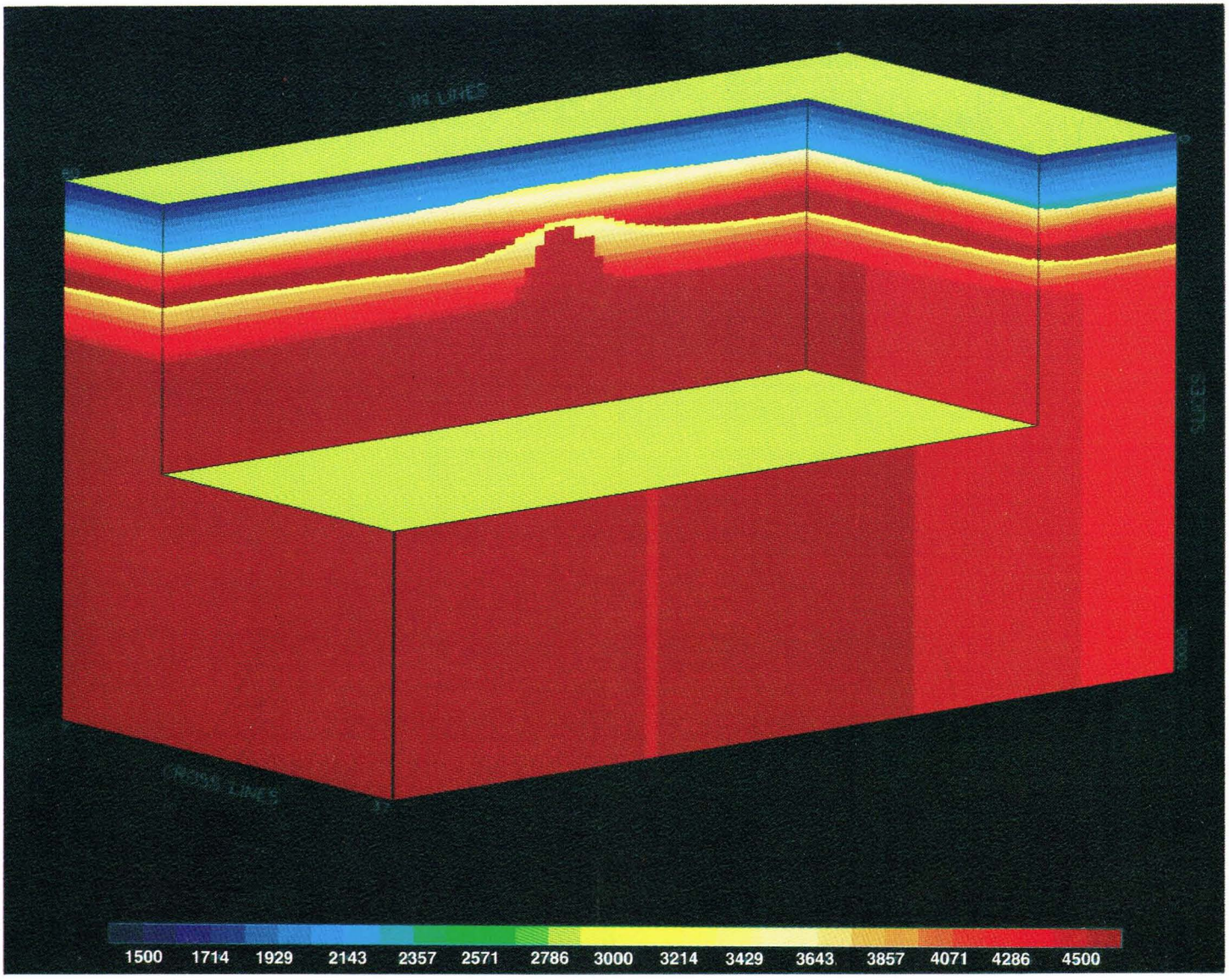
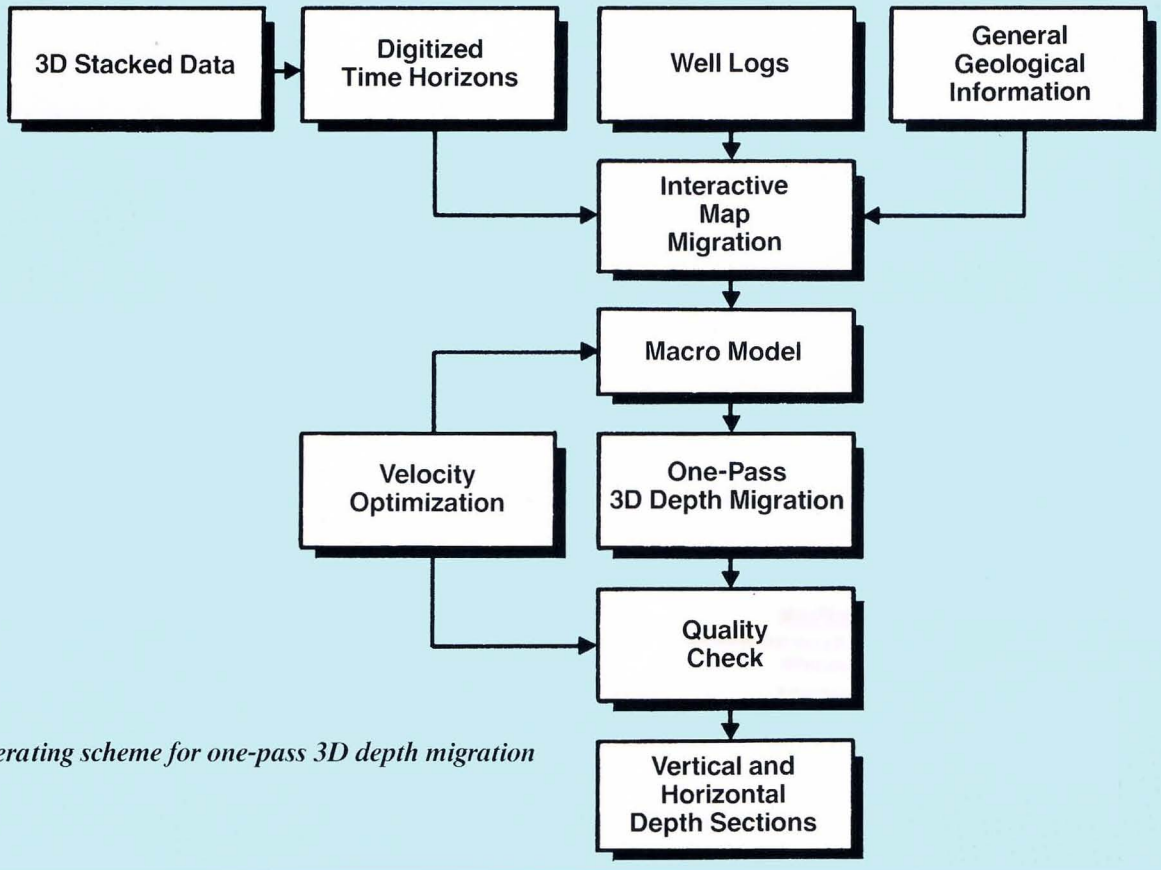


Fig. 1: Velocity cube presentation from COMSEIS



Operating scheme for one-pass 3D depth migration

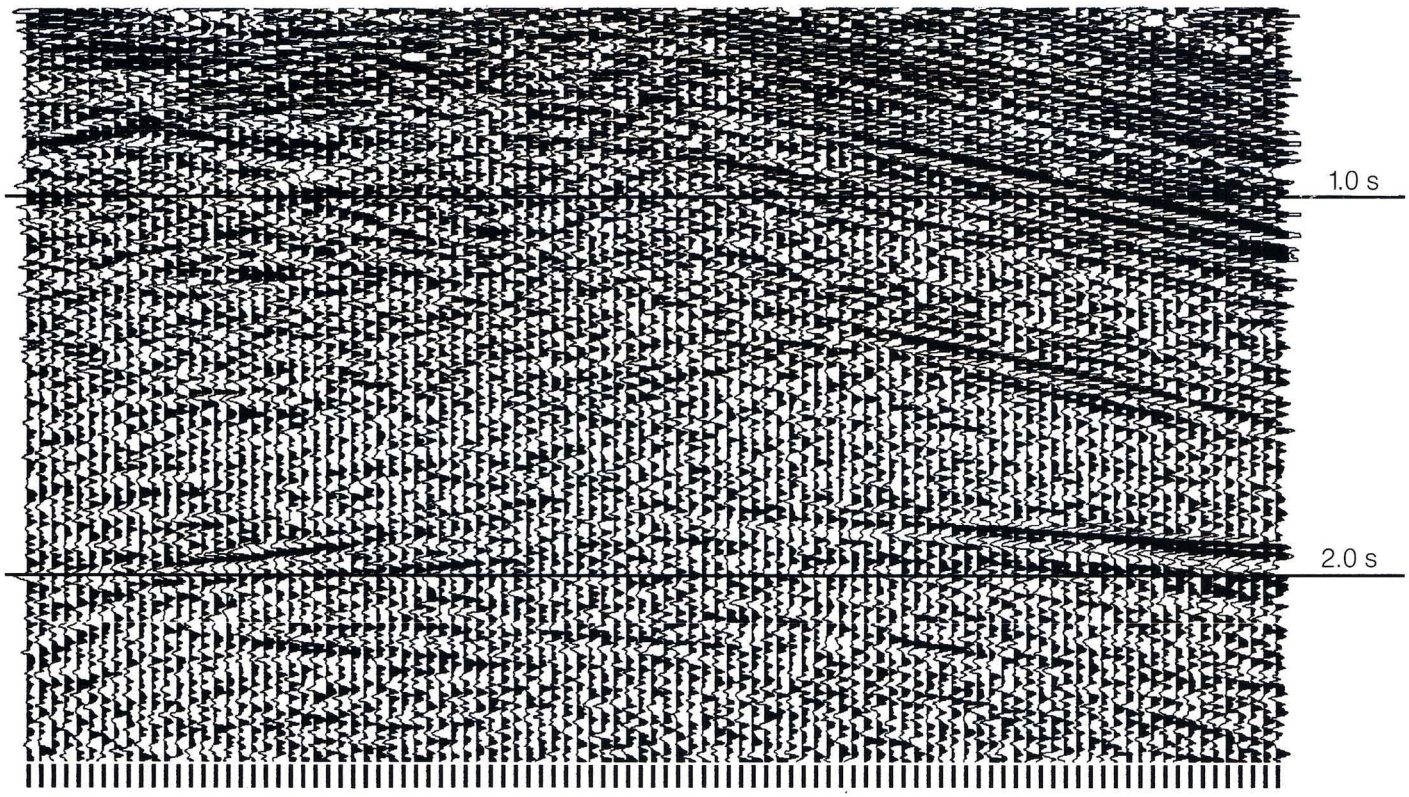


Fig. 2: Inline stacked section of a 3D land data volume

One-pass 3D Depth Migration

3D seismic techniques were introduced to respond to the three dimensional nature of seismic wavefields enabling the complex structure and layering of the subsurface to be revealed and reconstructed.

3D migration has proved to be an indispensable step in processing 3D seismic data volumes for imaging the stratified earth to obtain a reliable geological interpretation. However, it has been realized that the mathematical treatment of the three dimensional elastic wave equation requires efficient approximations in order to economically implement a routine procedure.

The growing demand to achieve a high resolution output and also to extract all the information available in recorded data has led to the development of a variety of 3D migration methods. The two-pass approach, applicable if the 3D migration operator is fully separable into two orthogonal directions, and the one-pass method, in which the separation of the operator is performed by splitting techniques, are two alternatives which have meanwhile become standards in the geophysical industry.

Different algorithms are used in different domains for attacking different problems such as lateral velocity variation, steeply dipping reflection and diffraction energy, and high-frequency losses.

Output of 3D migration procedures are commonly data volumes in the space/time domain (x/y/t) in order to minimize computation efforts. Standard time migration, however, is not capable of considering refractions. Experience has shown that in the presence of complex layering refractions may cause drastic positional errors. The amount of refraction depends on the velocity contrast at the refracting layer boundary and its dip.

Post-stack depth migration has worked well for several years in 2D processing and is now available as a one-pass procedure for 3D data volumes.

The algorithm incorporates the so-called »thin-lens term«, which can easily be realized as a shift-operation in the space/frequency domain ($x/z/\omega$). Thus downward continuation of the wavefield consists altogether of three operations:

- application of thin-lens term
- application of diffraction term
- imaging

In 3D depth migration special attention has to be paid to the preparation of the velocity model.

As shown in the operating scheme an initial interpretation on stacked data provides time maps of selected horizons which are then migrated to depth using 3D map migration (ray tracing). Different types of velocity information can be utilized for establishing the macro model. The COMSEIS interpretation workstation facilitates the editing of velocities and depths and their display for quality control. Fig. 1 illustrates the velocity cube after fine tuning. A quality check after the one-pass 3D depth migration at predefined increments enables an iterative optimization of the velocity model.

The field data used for illustrating the effect of 3D post-stack depth migration indicate a salt dome above Permian layers. The following sections show a relevant part of the data beneath the salt dome flank.

The stacked data in Fig. 2 exhibit an apparent curvature of the deep reflector. The 3D time migration (Fig. 3) does not allow a reliable interpretation of this interface as it is interfered by artifacts and not correctly imaged.

The result of the one-pass 3D depth migration is shown in Fig. 4. Since lateral velocity variation effects are incorporated in the frequency/space procedure the image of the target reflector is obviously improved.

Figs. 5, 6 and 7 permit a comparison of horizontal sections of stacked, time migrated and depth migrated data respectively.

The model data on the front page were calculated using the software package of SIERRA GEOPHYSICS.

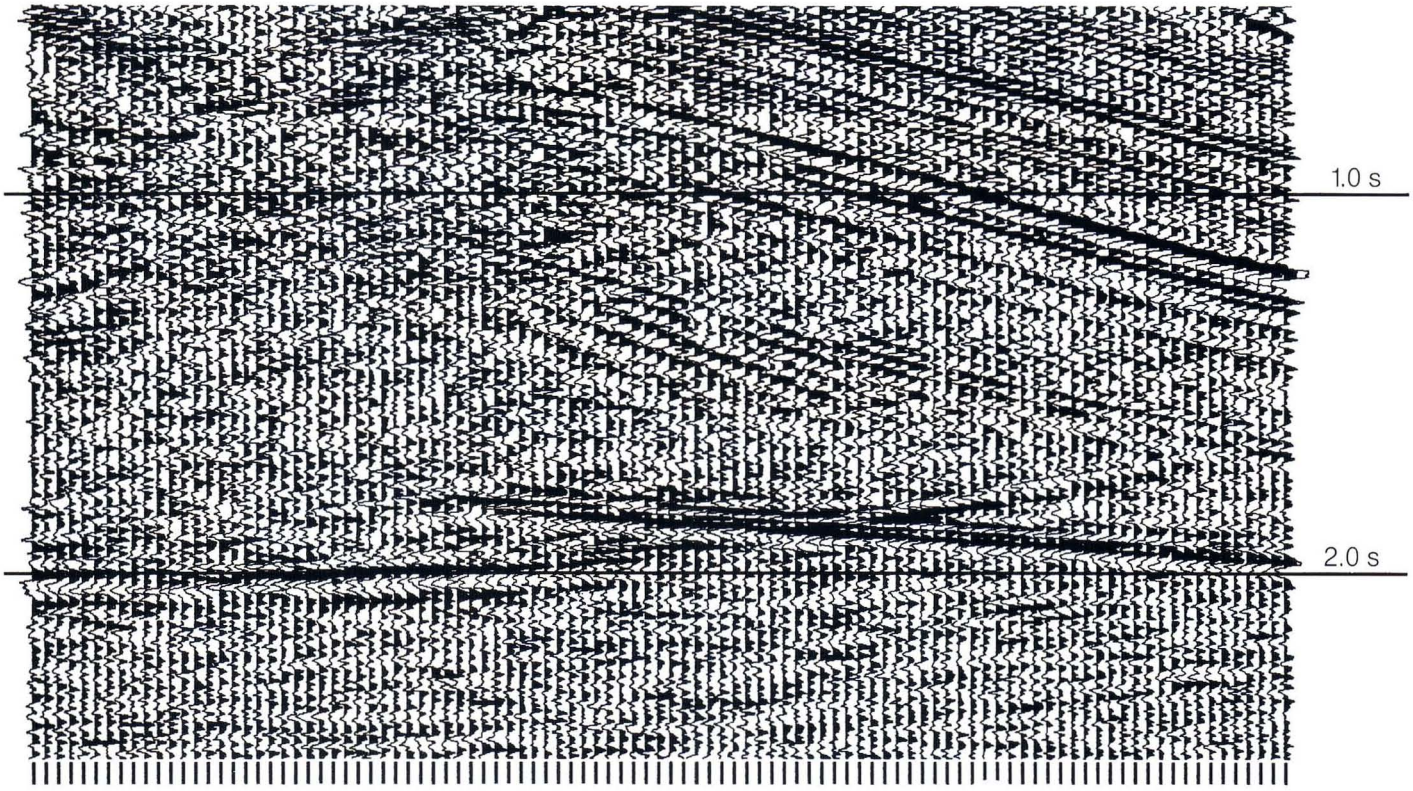


Fig. 3: Result of one-pass 3D time migration

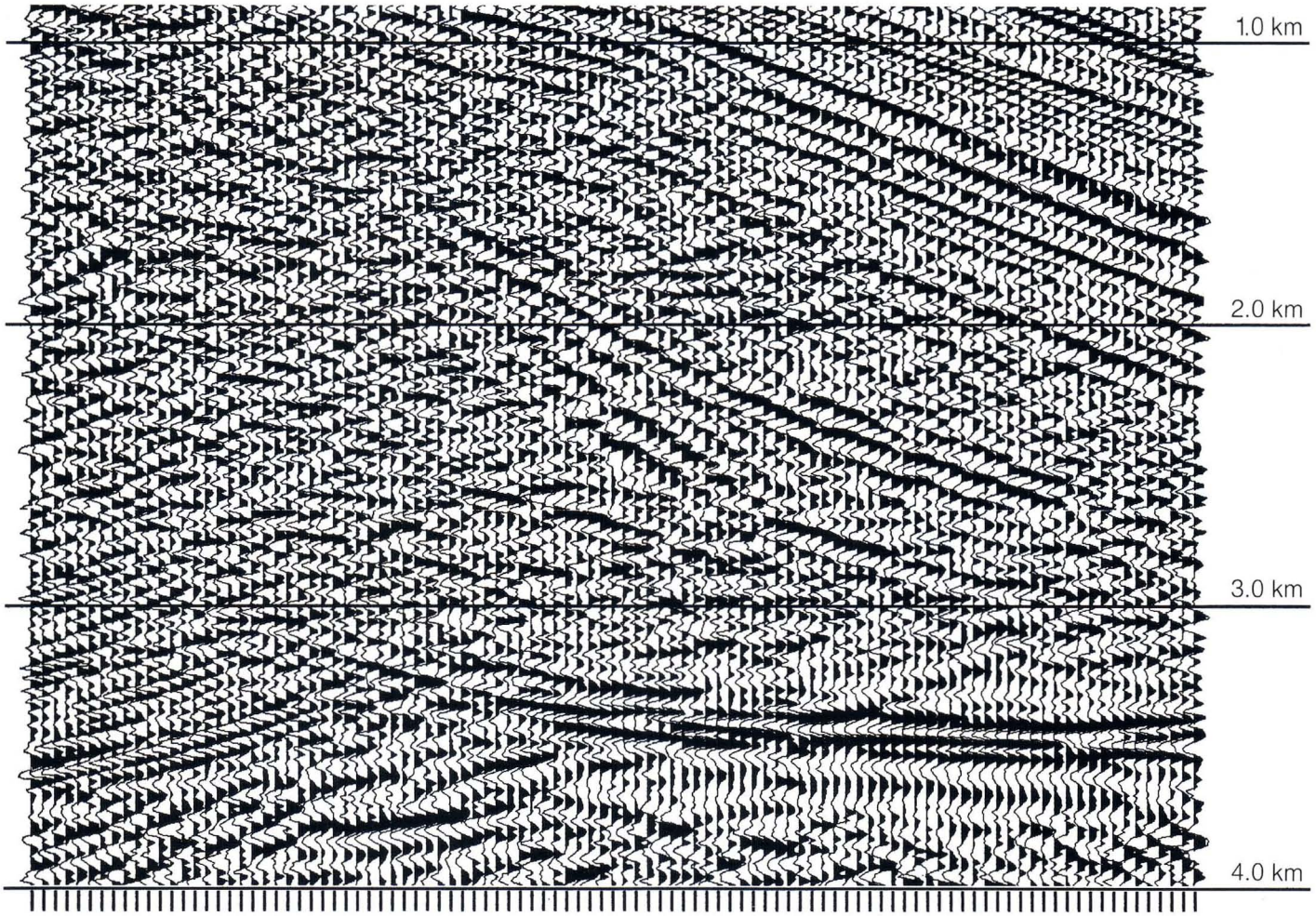


Fig. 4: Result of one-pass 3D depth migration

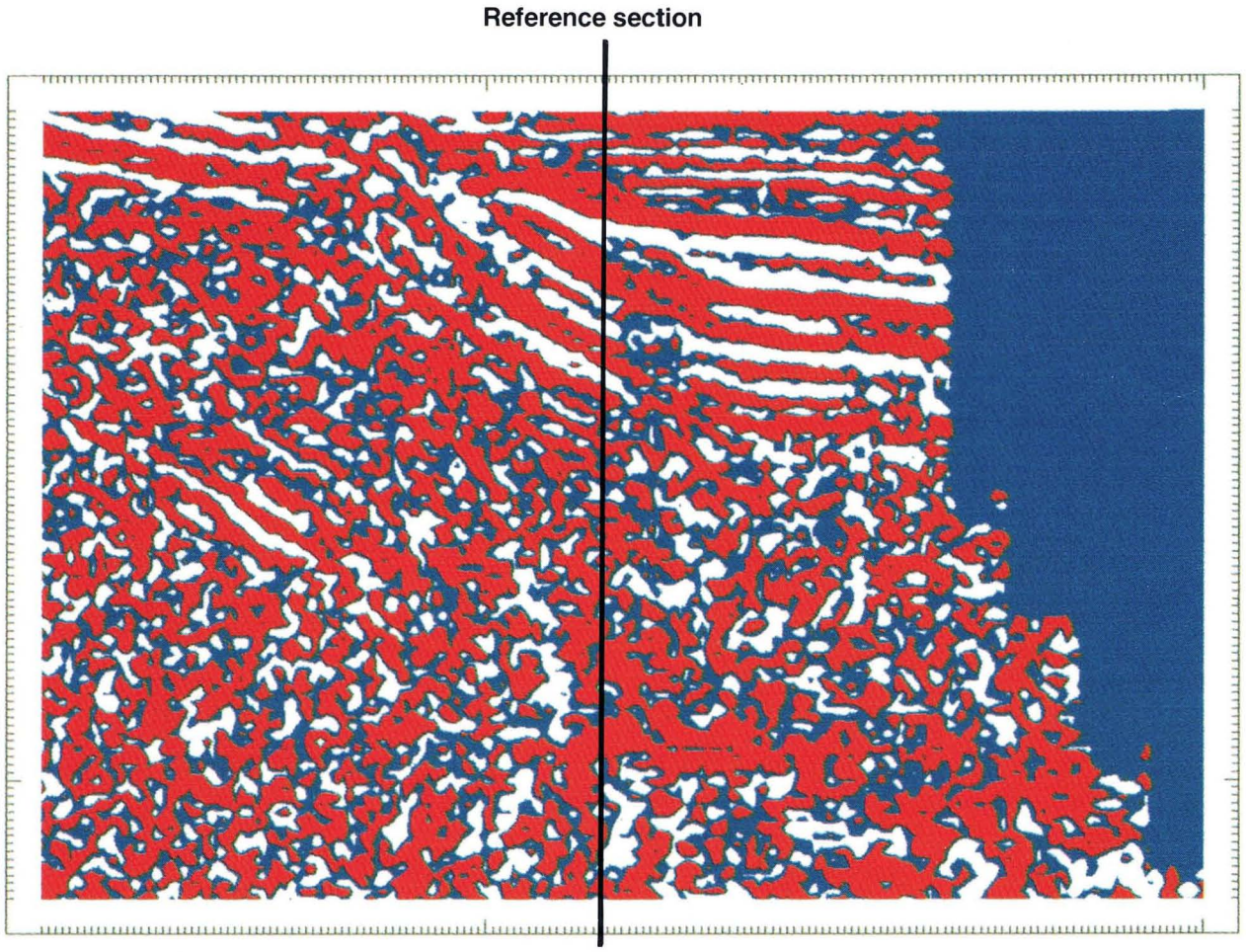


Fig. 5: Horizontal section of stacked data at 1000 ms

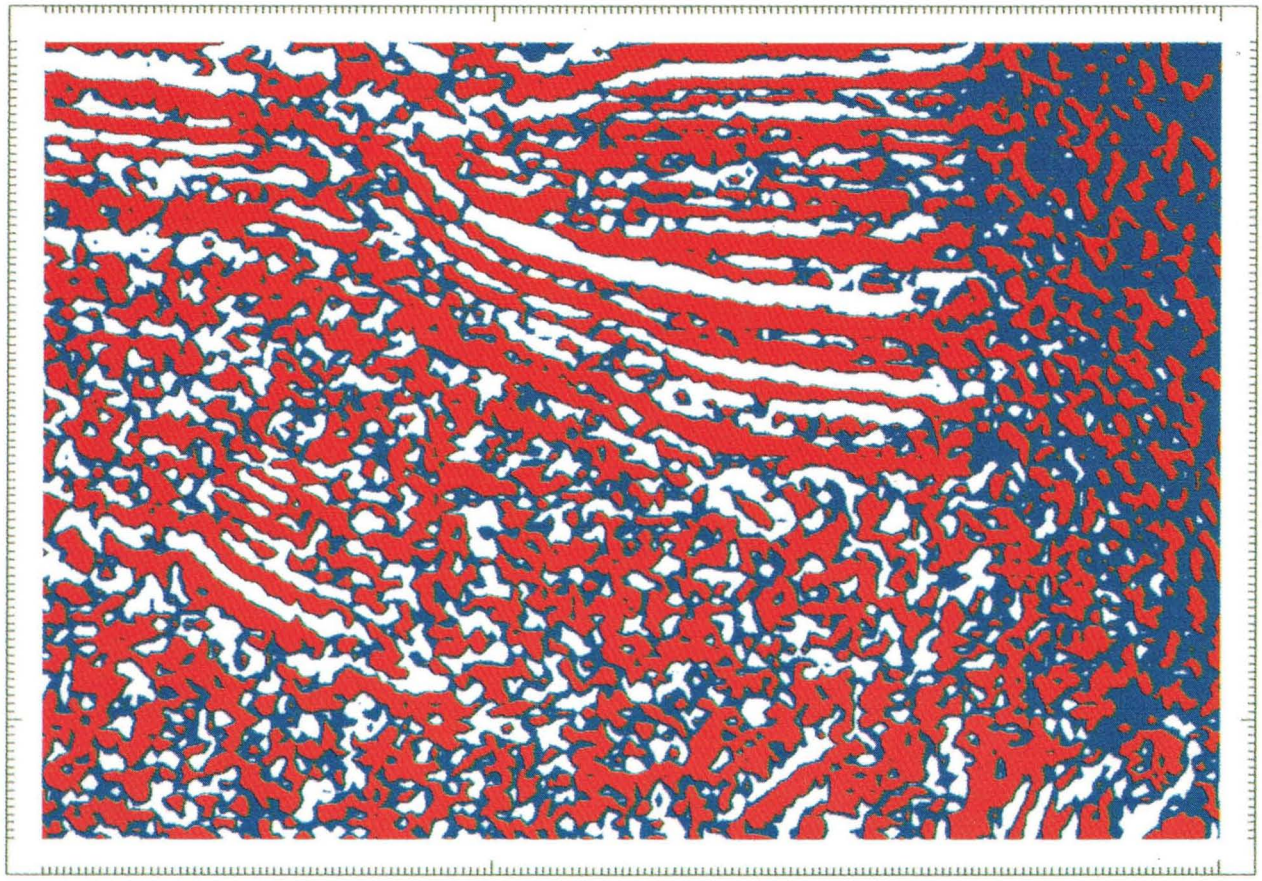


Fig. 6: Horizontal section of one-pass 3D time-migrated data at 1000 ms

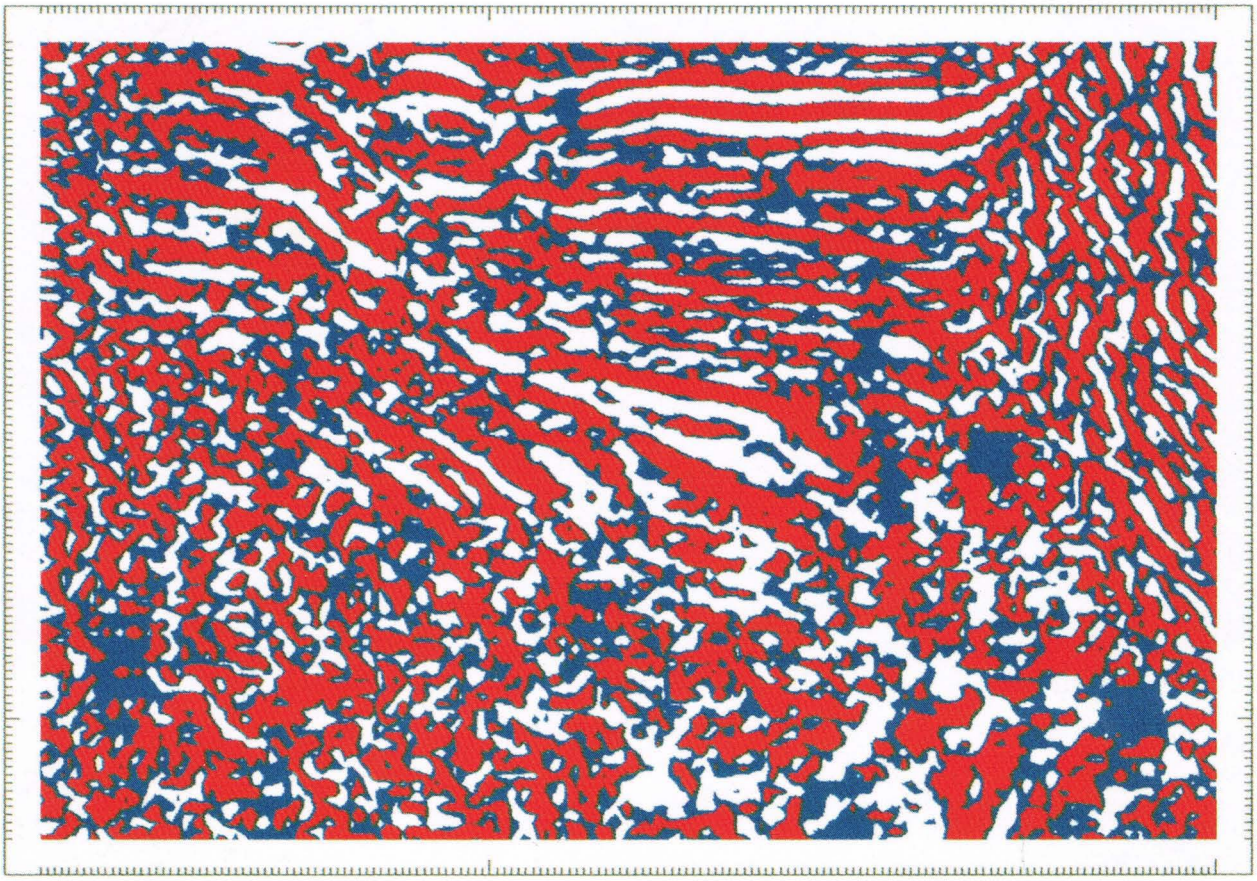


Fig. 7: Horizontal section of one-pass 3D depth-migrated data at 1000 m

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