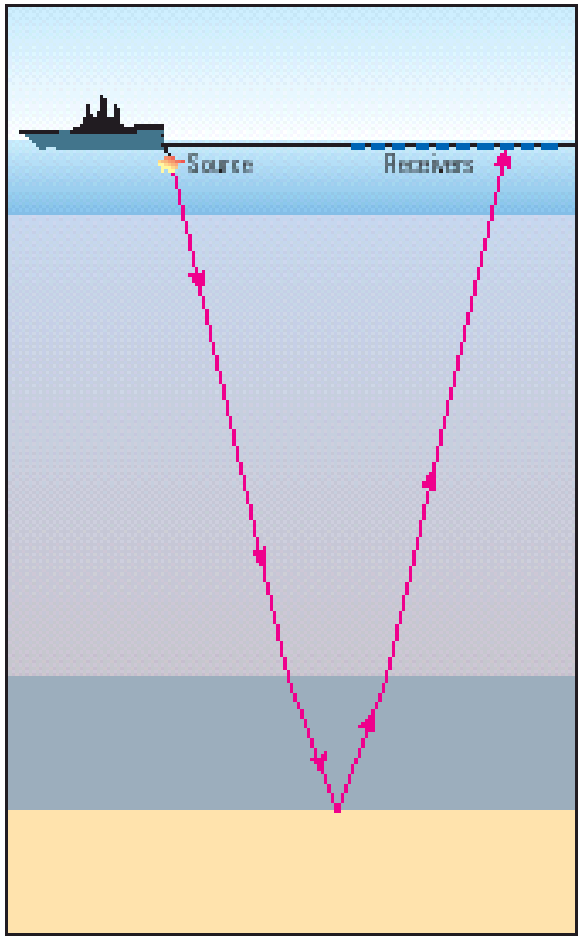
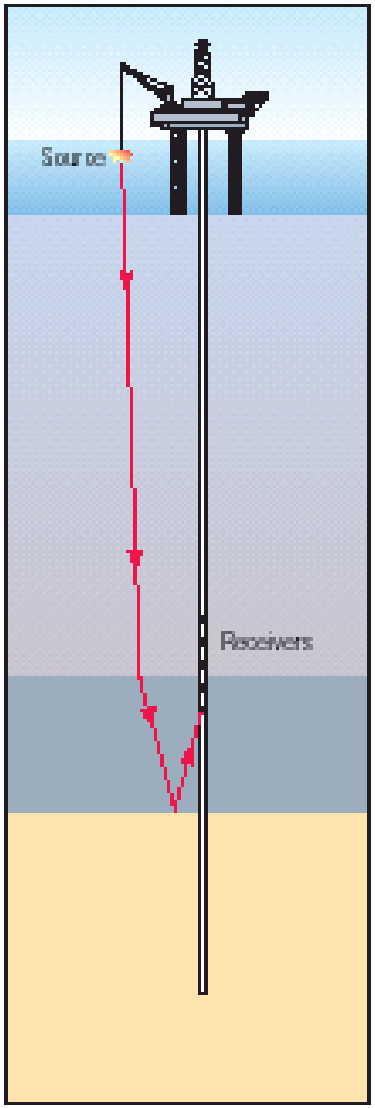
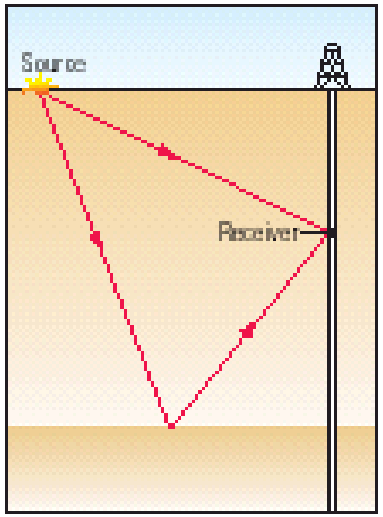
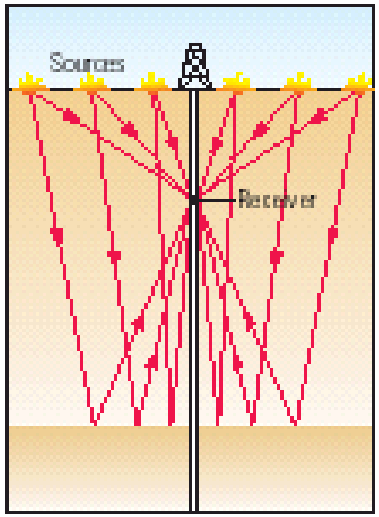
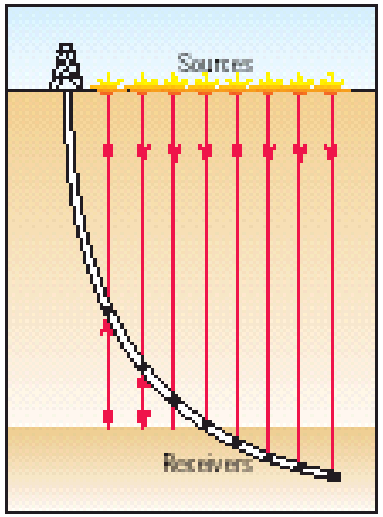


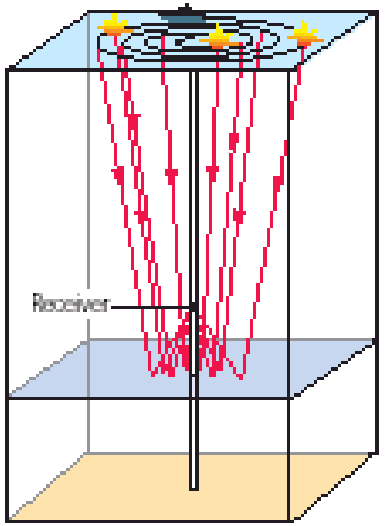
^ Surface seismic acquisition, with a seismic source on or near the surface and receivers also located on or near the surface.





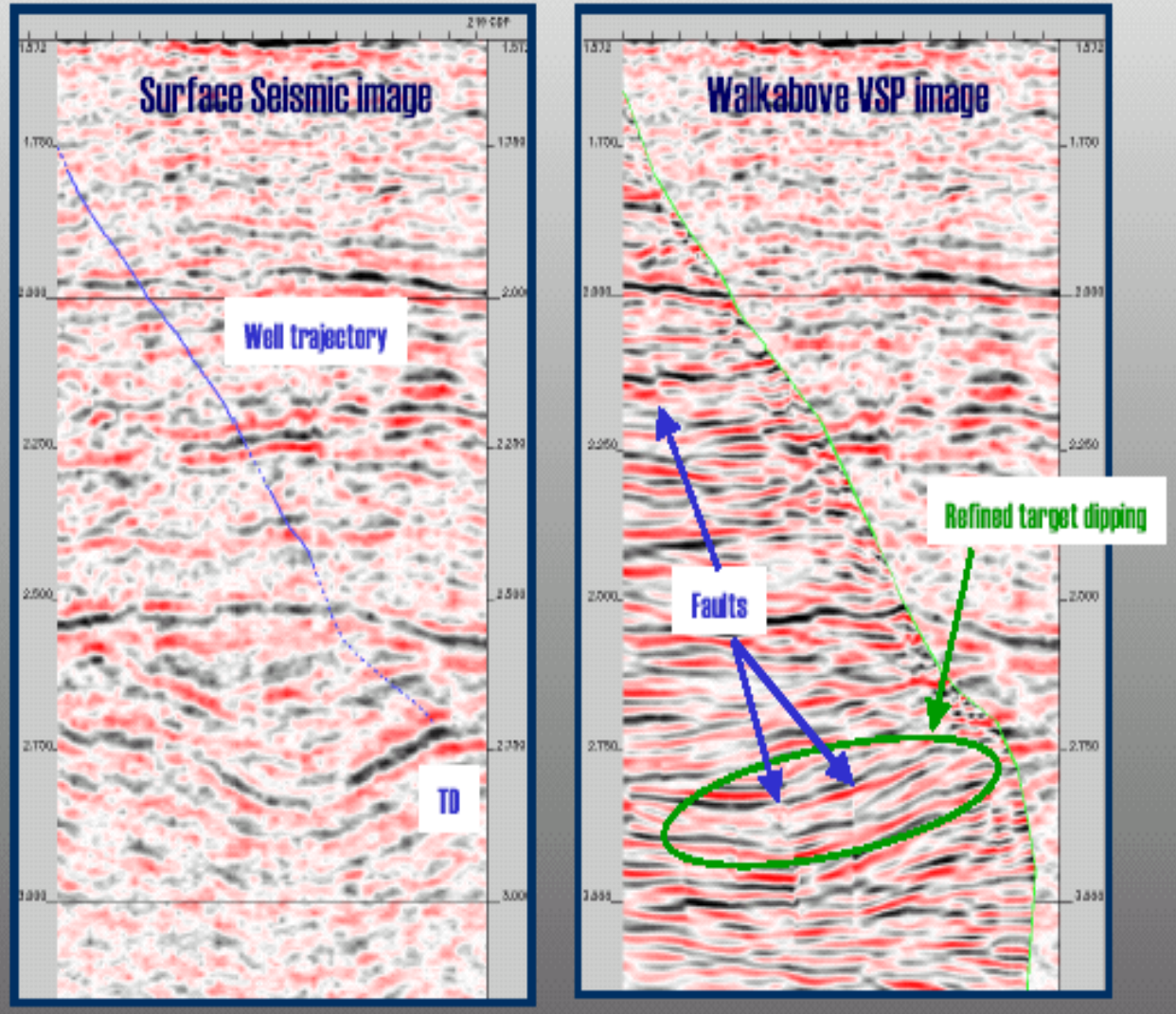


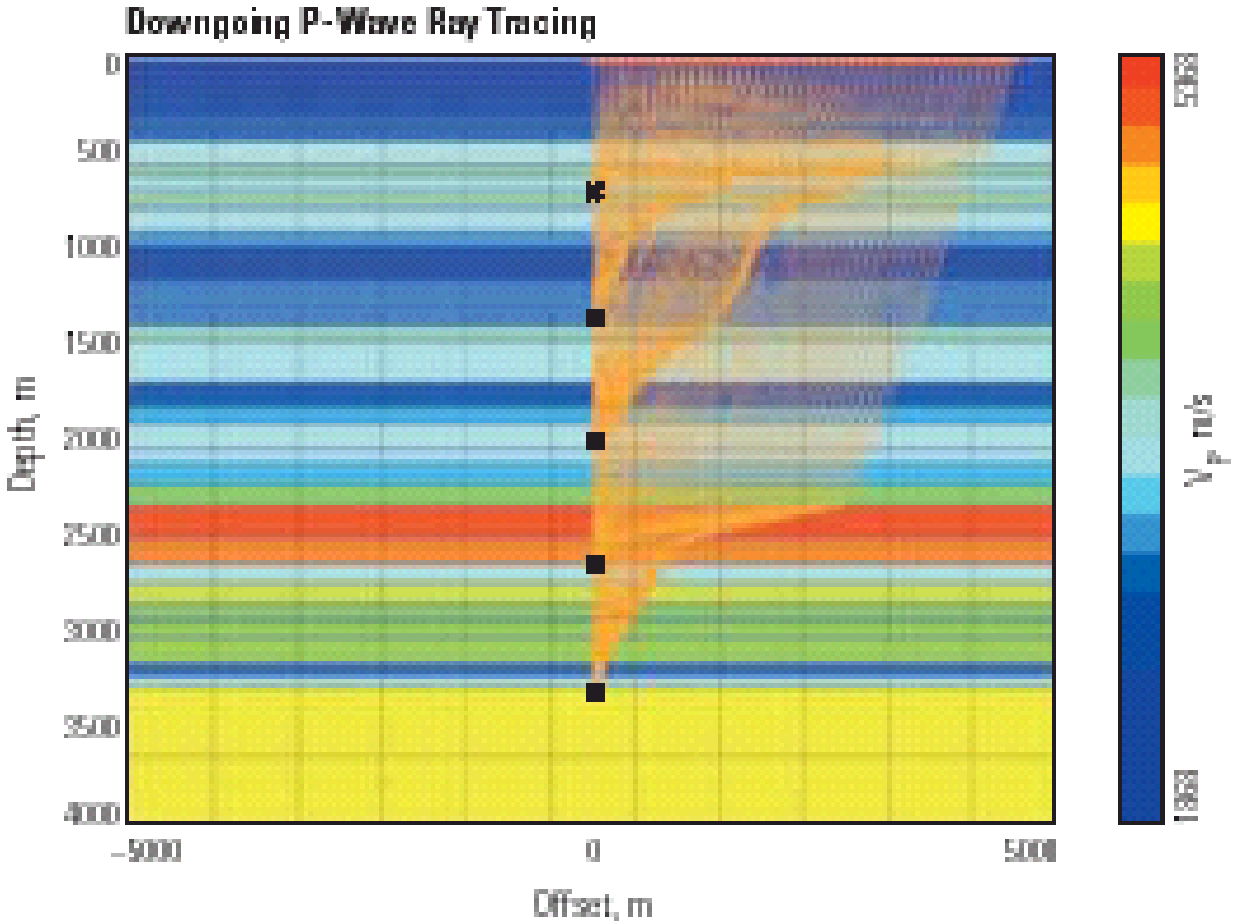




^ Borehole seismic acquisition, with an array of receivers in the borehole. In a zero-offset vertical seismic profile (VSP), the source is located near the rig (*left*). Other borehole seismic survey configurations include offset VSPs with the source offset from the well position; walkaways, with multiple source offsets in a line; deviated-well VSPs, sometimes called vertical-incidence VSPs, with the source vertically above multiple positions of the receiver in a deviated borehole; and 3D VSPs, with source lines in a grid or spiral above the target.

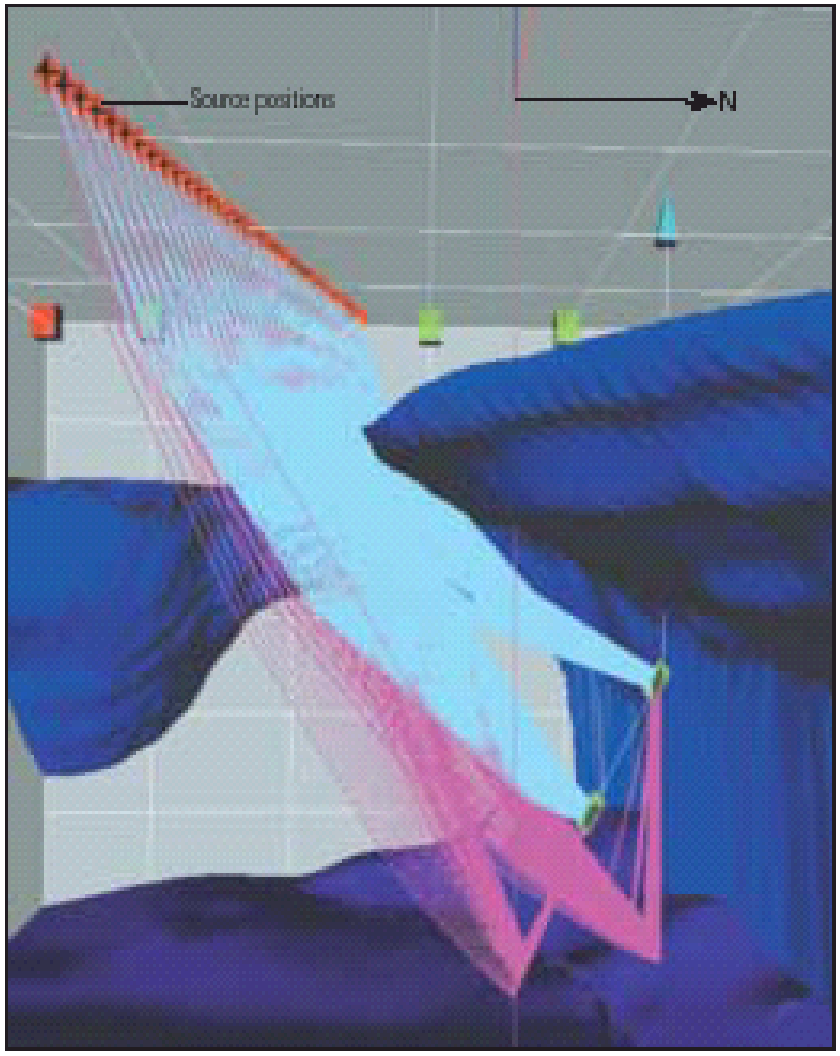
Figure 1- High resolution VSI imaging allows to re-interpret horizon dipping and fault location



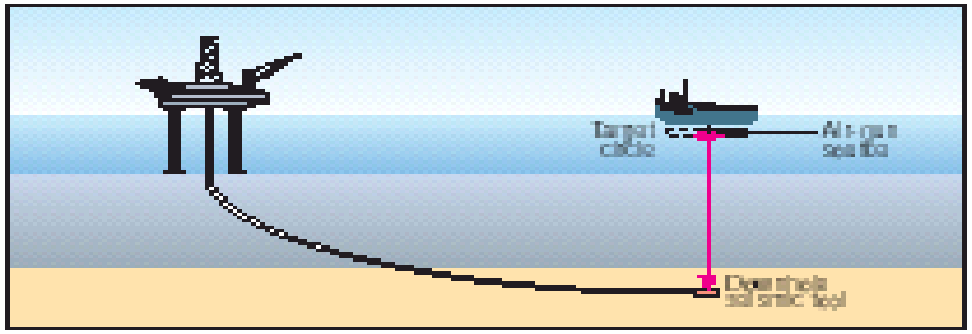


Ray tracing through high-velocity layers to model borehole seismic acquisition in Algeria. The high-velocity layers bend rays (orange lines) severely, forcing survey planners to take care in positioning borehole receiver arrays (black x).

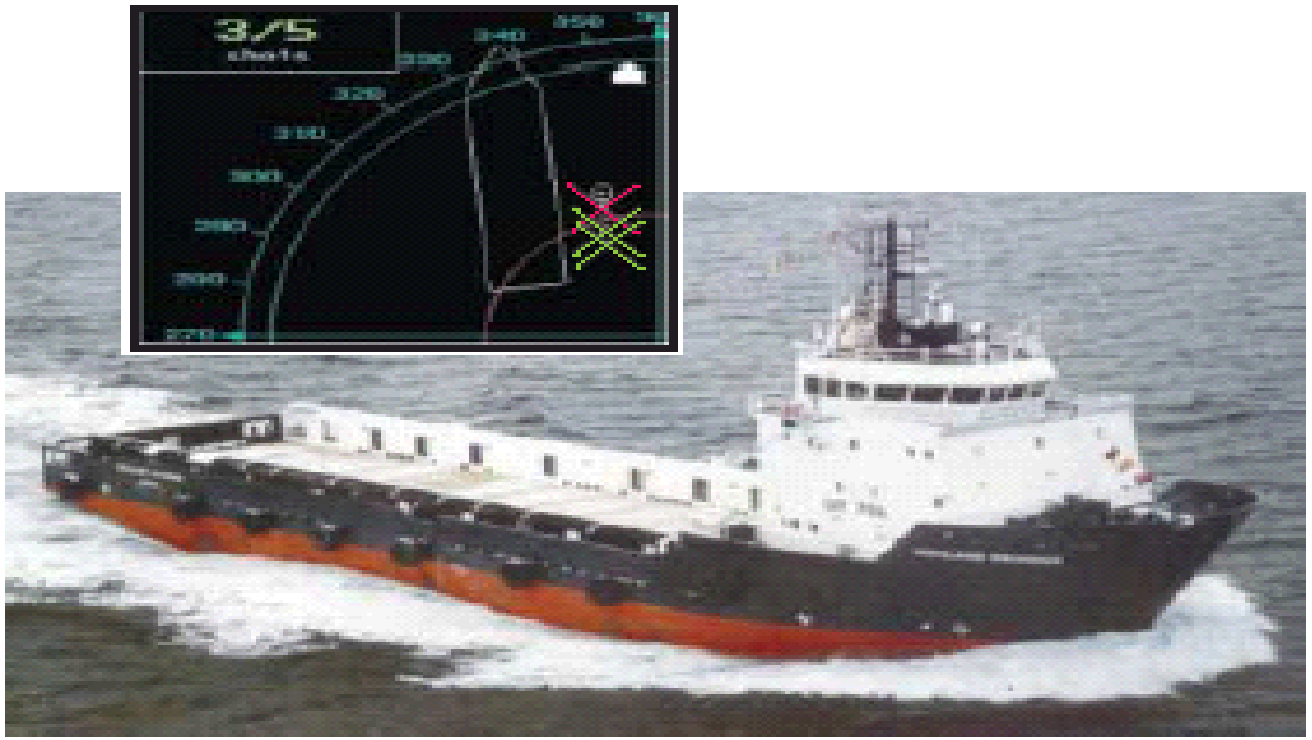
Direct and Reflected Rays



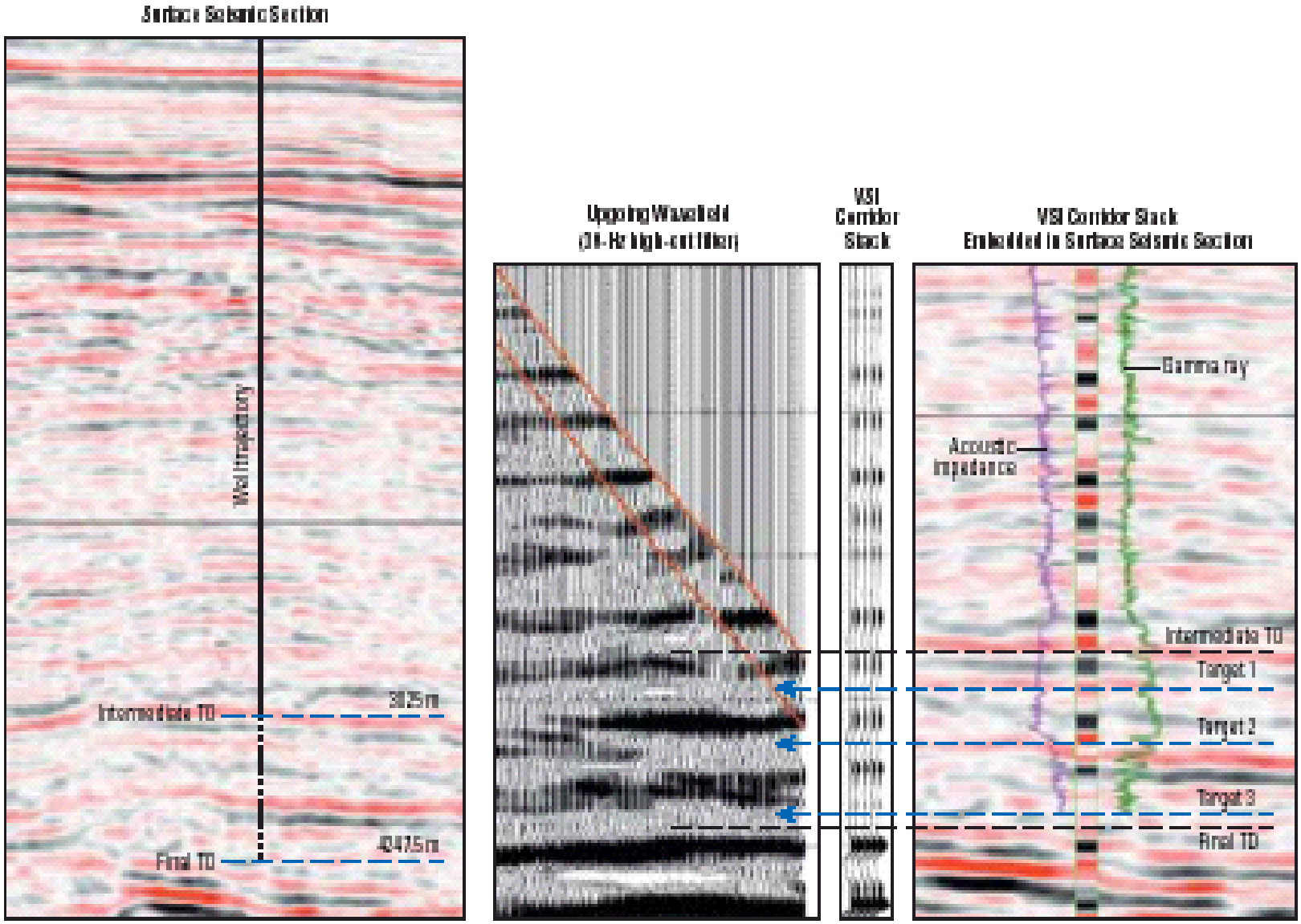
Three-dimensional ray tracing for a borehole seismic survey designed to image under a salt overhang in the Gulf of Mexico. Direct rays (blue lines) and reflected rays (pink lines) leave the sources (line of red cubes) and arrive at two receiver arrays in the borehole (green boxes).



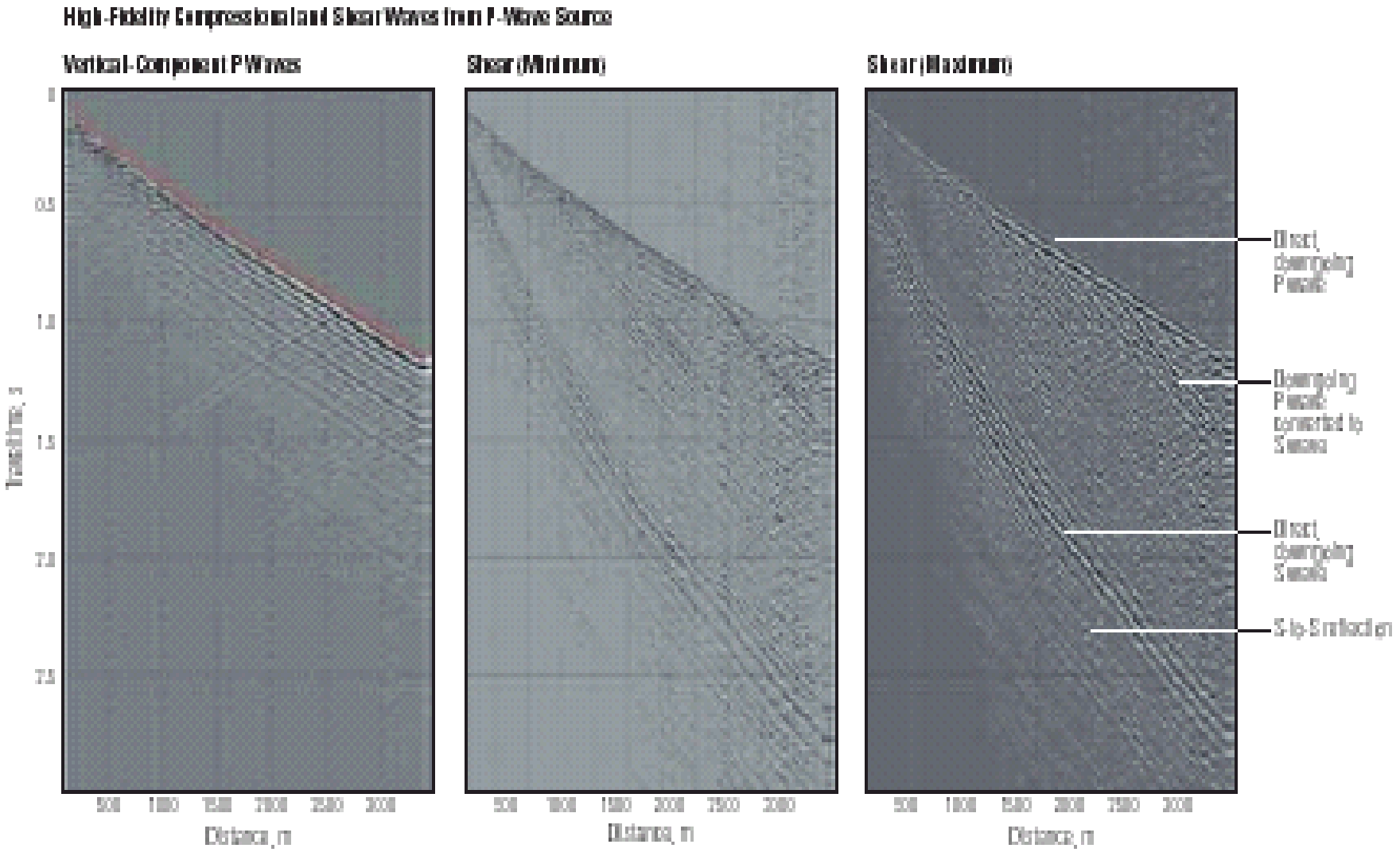
^ Positioning the source vessel over a borehole seismic tool for a deviated-well VSP. The vessel must navigate into positions exactly above the receiver, for all positions the receiver array takes in the borehole.



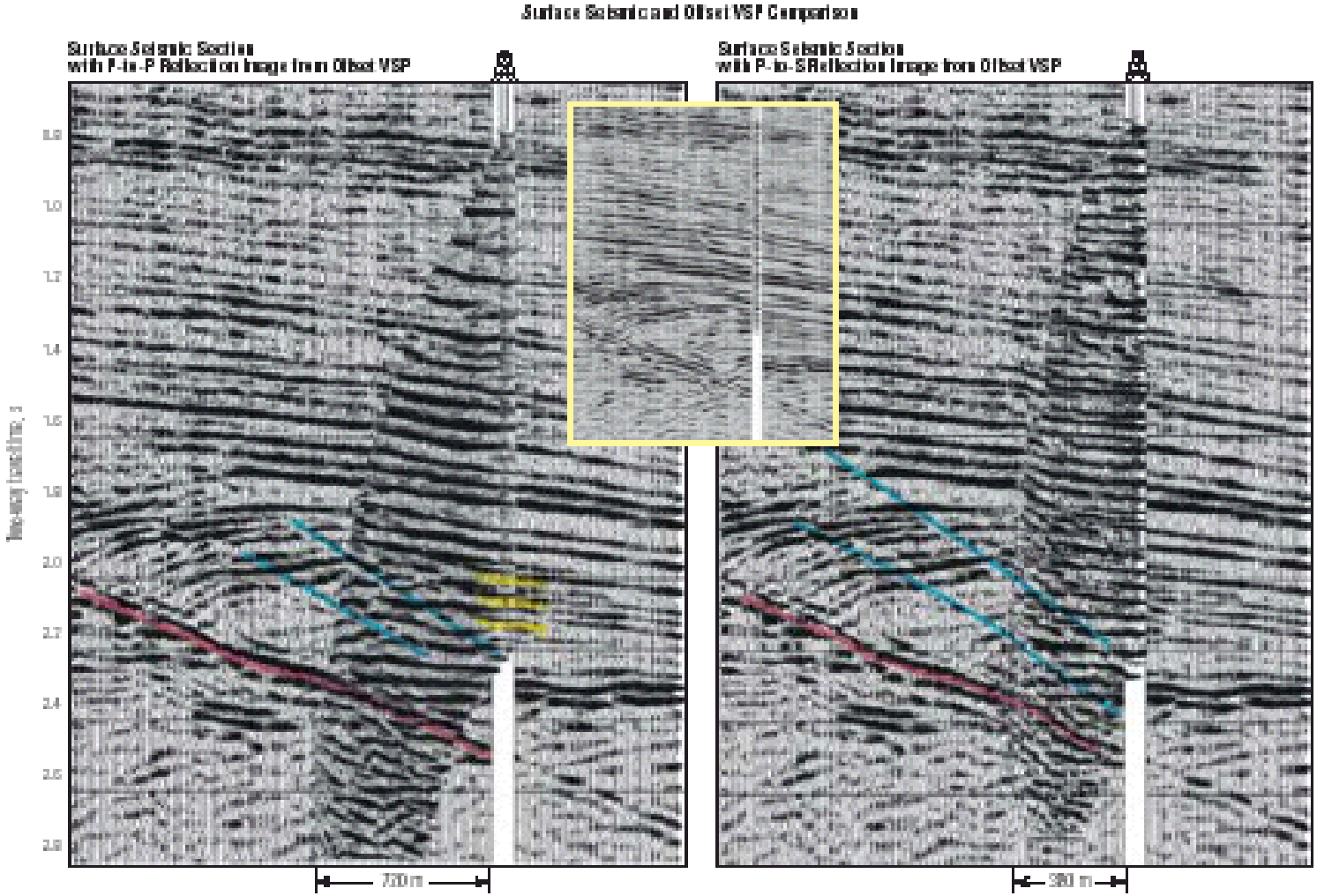
^ Display from the SWINGS seismic navigation and positioning system (top left), showing two source points on-target (green x) and one off-target (red x). The circle indicates the maximum distance from the planned source point the vessel may be for a shot to be considered on-target.



^ Improving upon surface seismic results with an intermediate look-ahead VSP acquired with a VSI tool. The look-ahead VSP, acquired at an intermediate well depth (overlay), shows three main events ahead of the bit and predicts final TD to be 4247.5 m [13,933 ft]. Final TD was reached at 4245.5 m [13,925 ft], within 2 m [7 ft] of the depth predicted by the intermediate VSP.

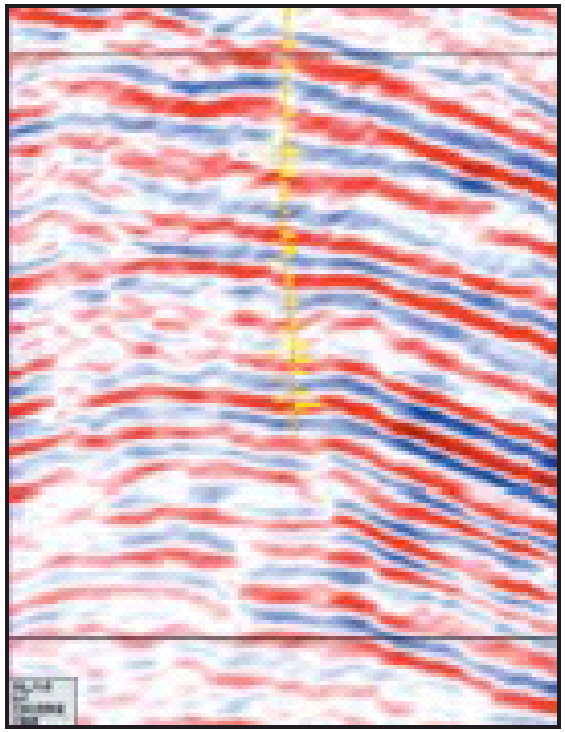


Multicomponent data from zero-offset, vertical-well VSP, processed to yield P and S wavefields. The acquisition configuration, with the source near the rig and the receivers in a vertical well, is not ideal for recording shear-wave energy. However, the VSI tool acquires excellent multicomponent data. The vertical component (*left*) contains P-wave arrivals. The tool's two horizontal components have been mathematically rotated to produce one component aligned with the direction of minimum (*center*) and maximum (*right*) S-wave energy.

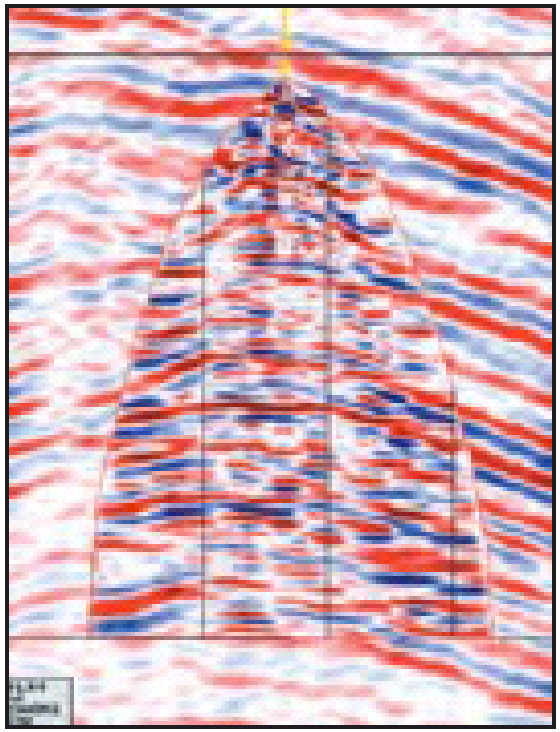


^ Comparison of surface seismic section and offset-VSP images from P-to-P reflections and P-to-S reflections. Productive sands are shown in yellow where they intersect the borehole. A regional fault is interpreted in red. The VSP images give clearer indications of smaller scale faults (blue) and broken reflections that are only implied in the surface seismic section (*inset*). The image derived from S-wave reflections (*right*) has higher vertical resolution, and therefore images finer scale features than the P-wave reflection image (*left*).

West Africa Surface Seismic Section



Walkaway Image



^ Surface seismic section from an offshore West Africa 3D seismic volume and a high-resolution walkaway image along the corresponding line. A corridor-stack trace (yellow) marks the borehole trajectory along the surface seismic image (left). The walkaway data (right), migrated using an anisotropic velocity model, appear to illuminate faults and other layer discontinuities that are not seen in the surface seismic section.