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DELINEATE SUBSURFACE STRUCTURES WITH GROUND PENETRATING RADAR (U)

by

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Delineate subsurface structures with ground penetrating radar

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SUMMARY

High resolution ground penetrating radar (GPR) surveys were conducted at the Savannah River Site in South Carolina in late 1991 to demonstrate the radar techniques in imaging shallow utility and soil structures. Targets of interest at two selected sites, designated as H- and D-areas, were a buried backfilled trench, buried drums, geologic stratas, and water table.

Multiple offset 2-D and single offset 3-D survey methods were used to acquire high resolution radar data. This digital data was processed using standard seismic processing software to enhance signal quality and improve resolution. Finally,using a graphics workstation, the 3D data was interpreted.

In addition, a small 3D survey was acquired in The Woodlands,Texas, with very dense spatial sampling. This data set adequately demonstrated the potential of this technology in imaging subsurface features.

Total time for data acquisition was 8 days.The average rate of data collection was 400 traces/hour. With better weather conditions upto 600 traces/hour would have been possible.

DATA PROCESSING

2-D processing

As indicated in the flow chart in Figure-2, three main processing steps are necessary:

1)Preprocessing to suppress noise,remove direct air-wave,reduce hardware noise etc. As there were significant topographic variations in the H-area, datum statics were attempted. However the fluctuations in the near surface velocity made the datum static solution unstable.

2)CDP analysis to obtain stacking velocities that were used to generate a stack profile and migration velocities. Representative CDP gathers and velocitys panel are shown in Figure-3. Note the decreasing velocities with increasing depths. This is due to increased water content in the deeper strata. Figure-4 shows the final stack of the H-area line. Also seen is what the line would have looked like had it been single fold. Notice the dipping event at CDP's 240-340.

3)Migration of the stack profile is the last step.The input is assumed to be corrected for attenuation and free of noise.Migration collapses diffractions and also positions events correctly. Figure -5 shows the migrated section from the D-area.

3-D processing and visualization

The processing is similar to the 2D case. By assuming that the earth is 2D in the inline direction , velocity analysis is simplified. Velocity information in the cross line direction is obtained by interpolation.

The NEC/SX3 supercomputer was used for 3D migration.The results are shown in Figure-6.This display was was generated on the Silicon Graphics 310VGX graphics workstation. Figure-7 shows time slices of the 3D survey. The buried trench is quite apparent. Figure-8 shows a comparison of 2D and 3D data.

HARC Survey

A small 3D survey was conducted near HARC, in The Woodlands, Texas, over some gas pipelines. The survey consisted of 31 lines 1 foot apart, with a 3inch station spacing in each of the 50 feet long lines.Figure-9 and Figure-10 clearly show that the 3D method can lead to significant improvements in image quality.

CONCLUSIONS

Conventional radar surveys for imaging subsurface targets can be improved using multiple offset 2-D and/or 3-D methods. With the multiple offset 2-D method, velocities for stacking and migration can be obtained.

The GPR survey at SRS demontrated the above. The very dense sampling at the HARC 3D survey verified the potential benefits of the 3D method. The graphics workstation is invaluable in interpreting results especially in the case of 3D data.

ACKNOWLEDGEMENTS

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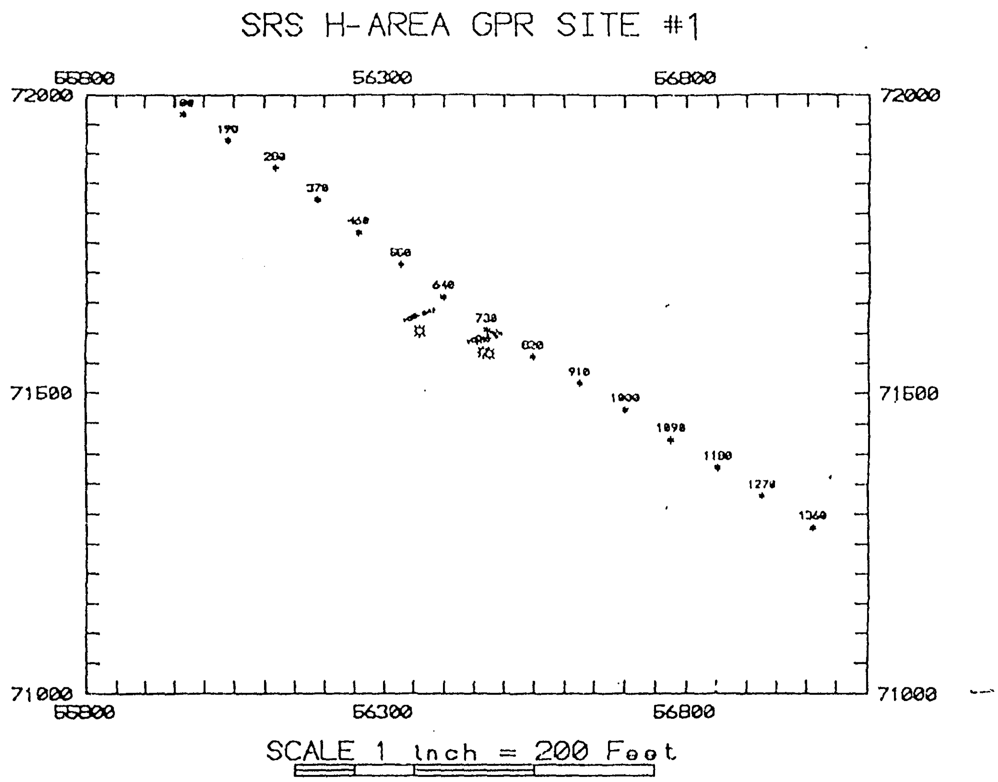
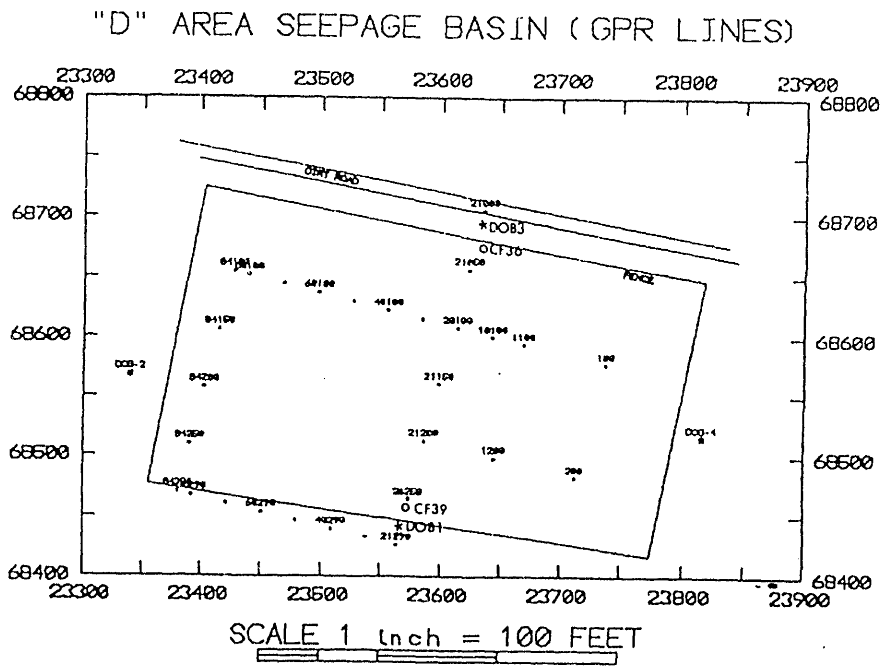


Aerial map of the 2-D GPR survey line In H-area.



Aerial map of the 2-D and 3-D GPR surveys in D-area. The 2-D data are collected along straight line between wells DOB1 and DOB3. The 3-D data are collected within the rectangular area bounded by a metal fence.

Figure 1

Radar Data Processing Flow

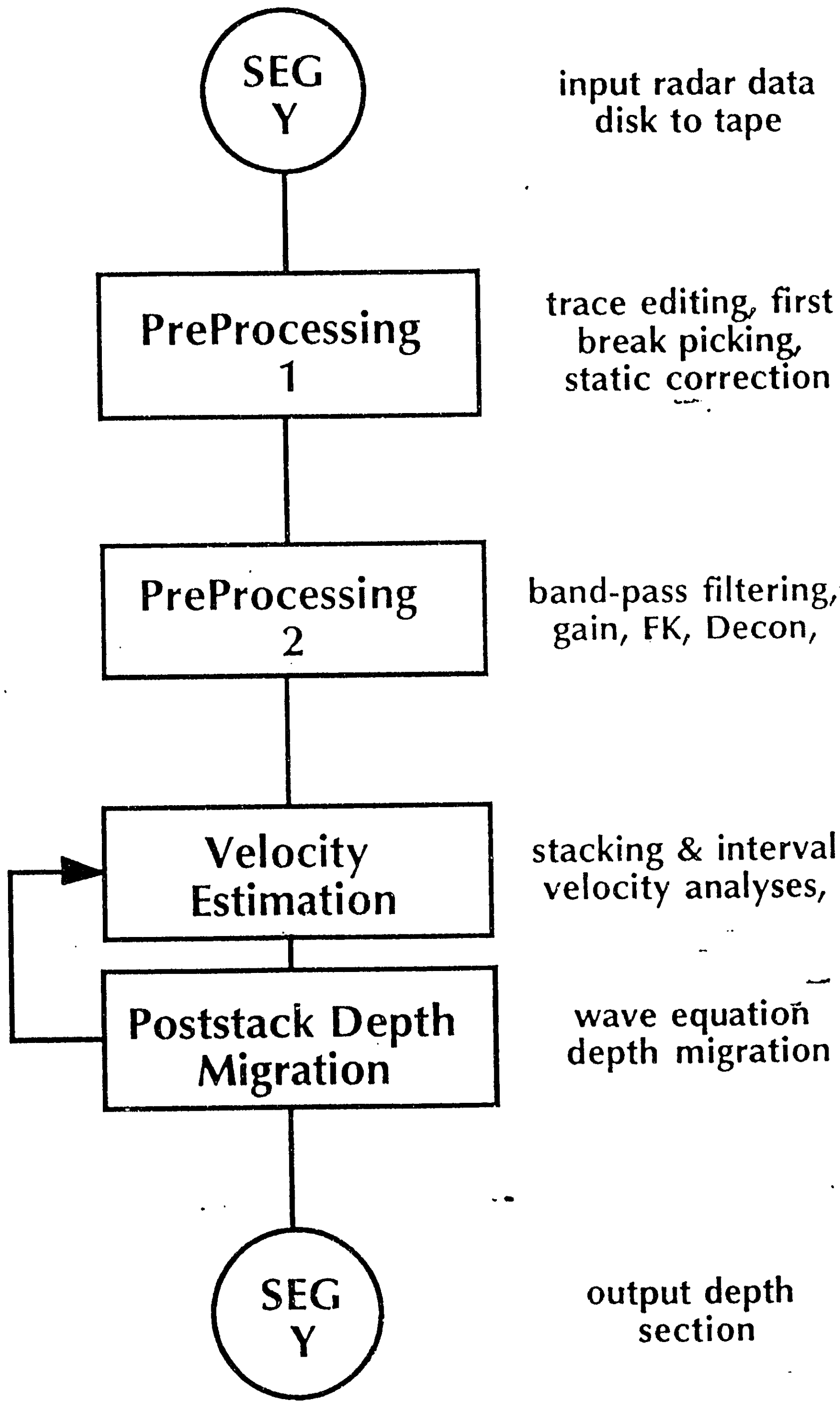
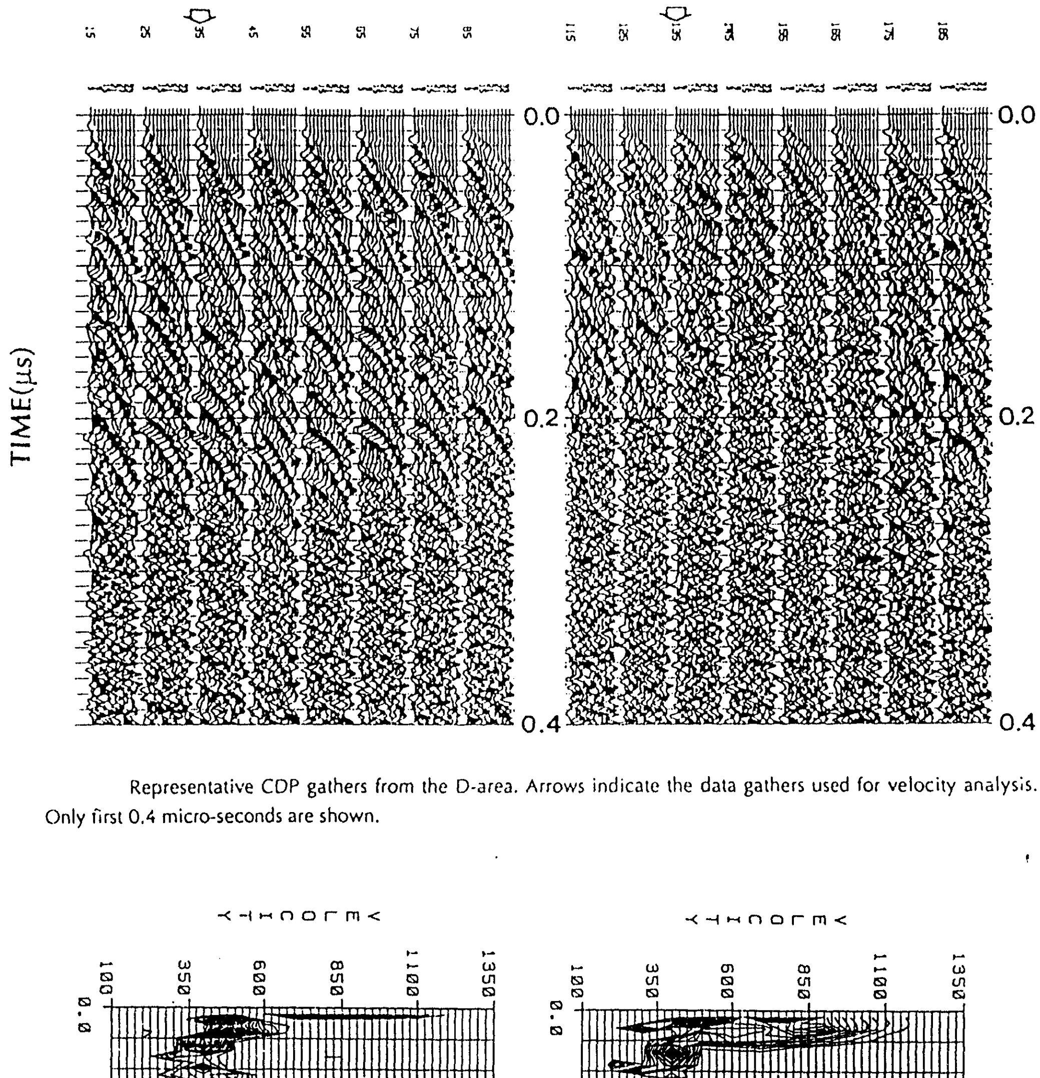
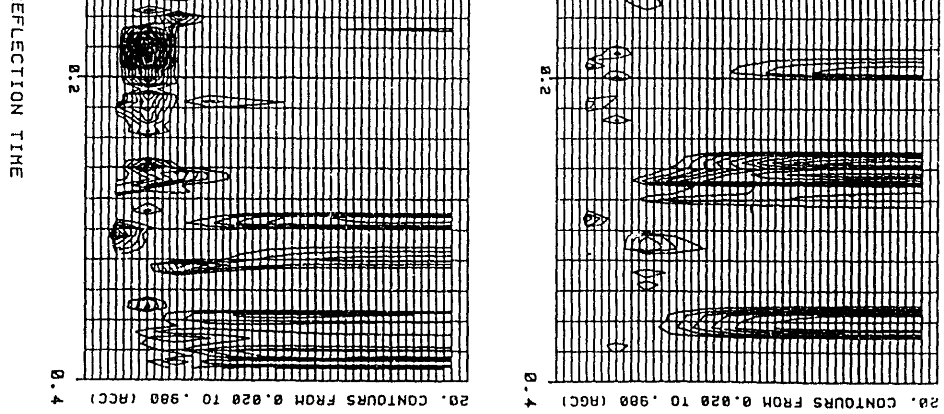


Figure 2 Data processing flow for radar data.

CDP GATHER



Representative CDP gathers from the D-area. Arrows indicate the data gathers used for velocity analysis. Only first 0.4 micro-seconds are shown.



Velocity panels of CDP 35 and 135. Velocity spectrum displayed with contours have a decreasing trend with increasing travel times. The unit of velocity values are in feet per 1,000 nano-second.

Figure 3

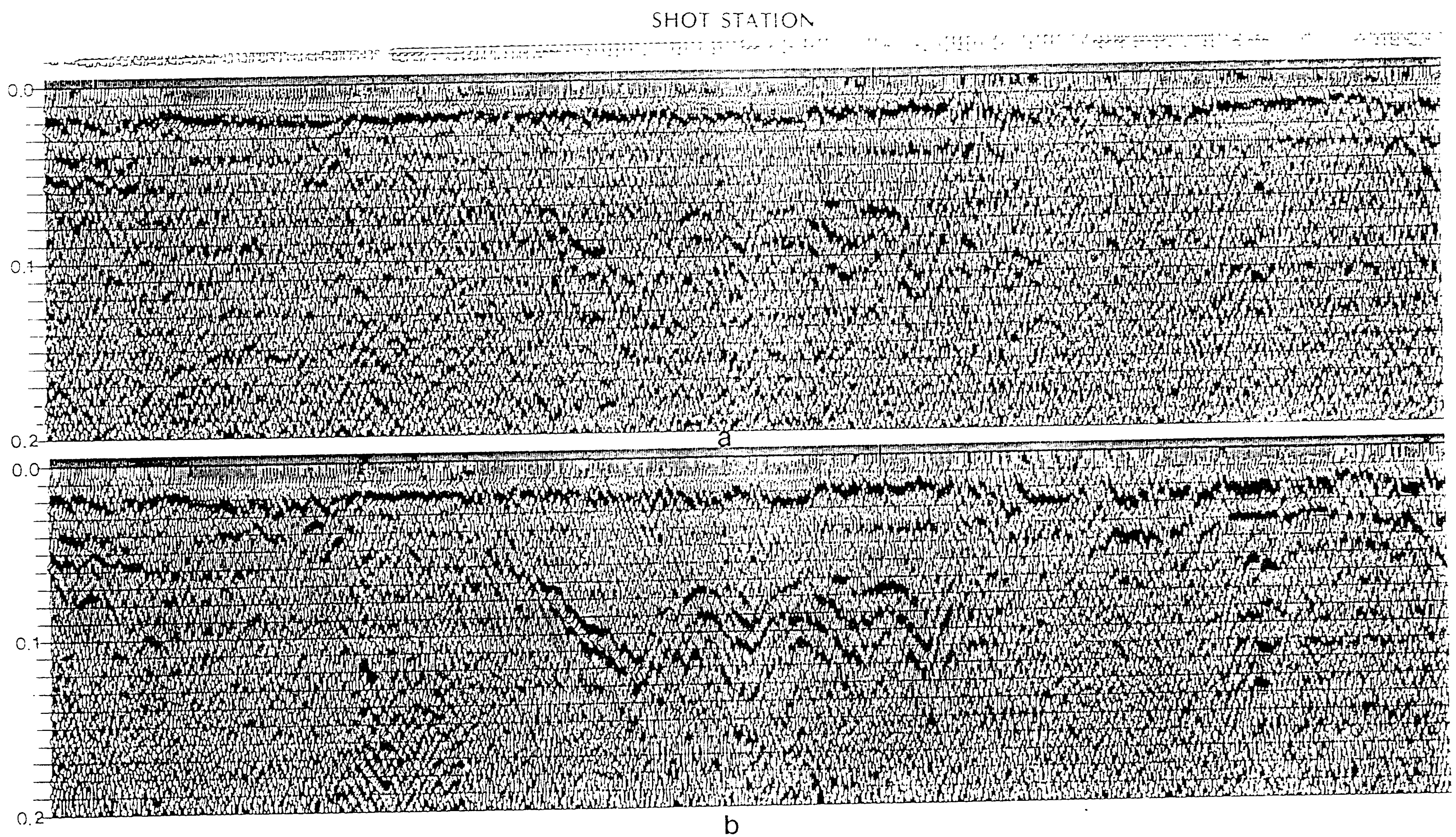


Figure 4 Single offset vs. CDP stacked section. Panel a is the near offset trace plot of all CDP gathers from the m-data. Signal-to-noise (S/N) ratio is improved after stacking over all offsets within each CDP shown in panel b, with the best stacking velocities.

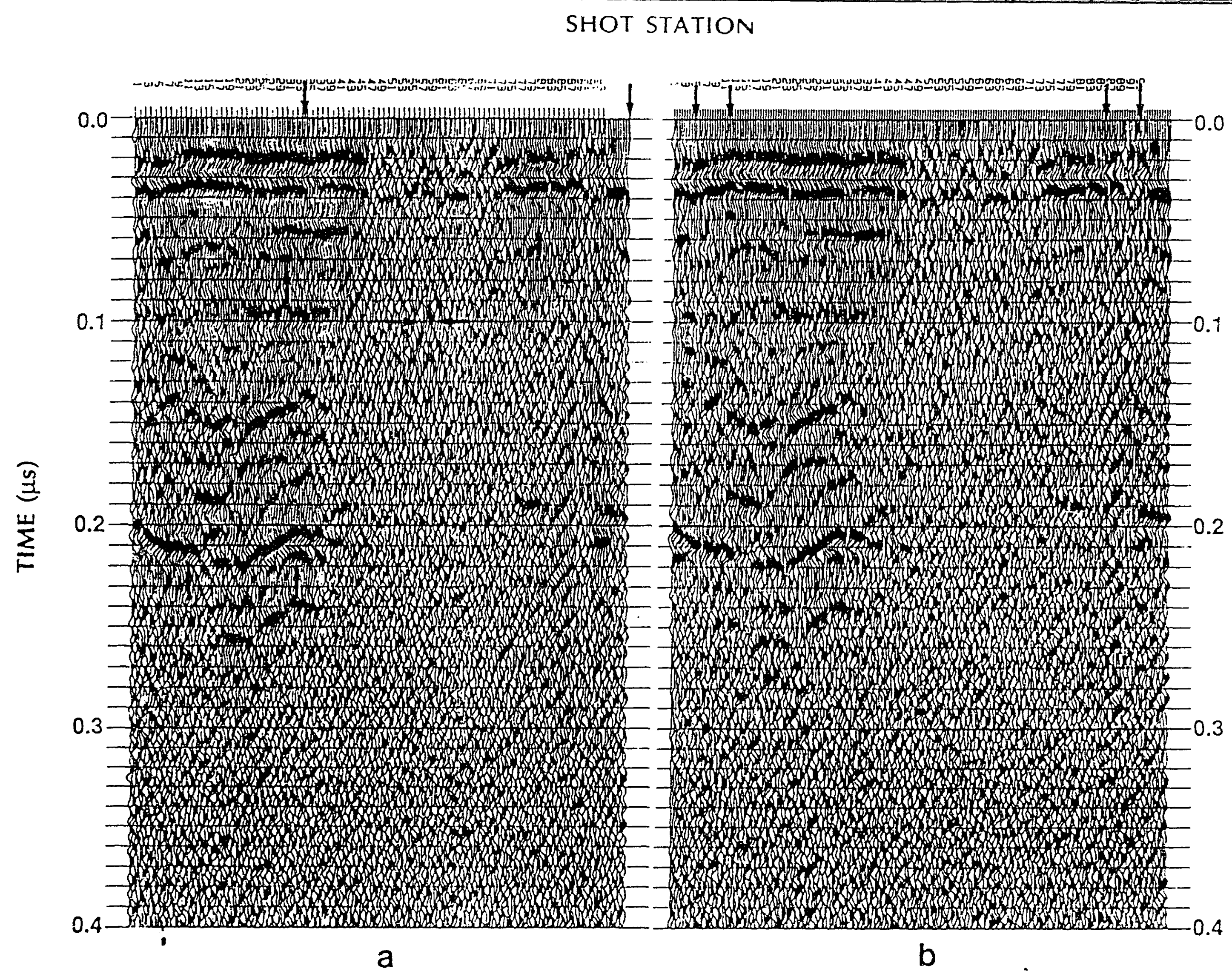


Figure 5 Migration of the 2-D data from the D-area. Figure a is the input data for migration. Figure b is the migrated data using the 1-D velocity model. Diffractions originating from buried objects marked by arrows are mostly focused to a single point. Arrows in left panel show the boundaries of the 3-D survey. Arrows in right panel show well locations for DOB1, CPT35, CPT39, DOB3, from left to right.

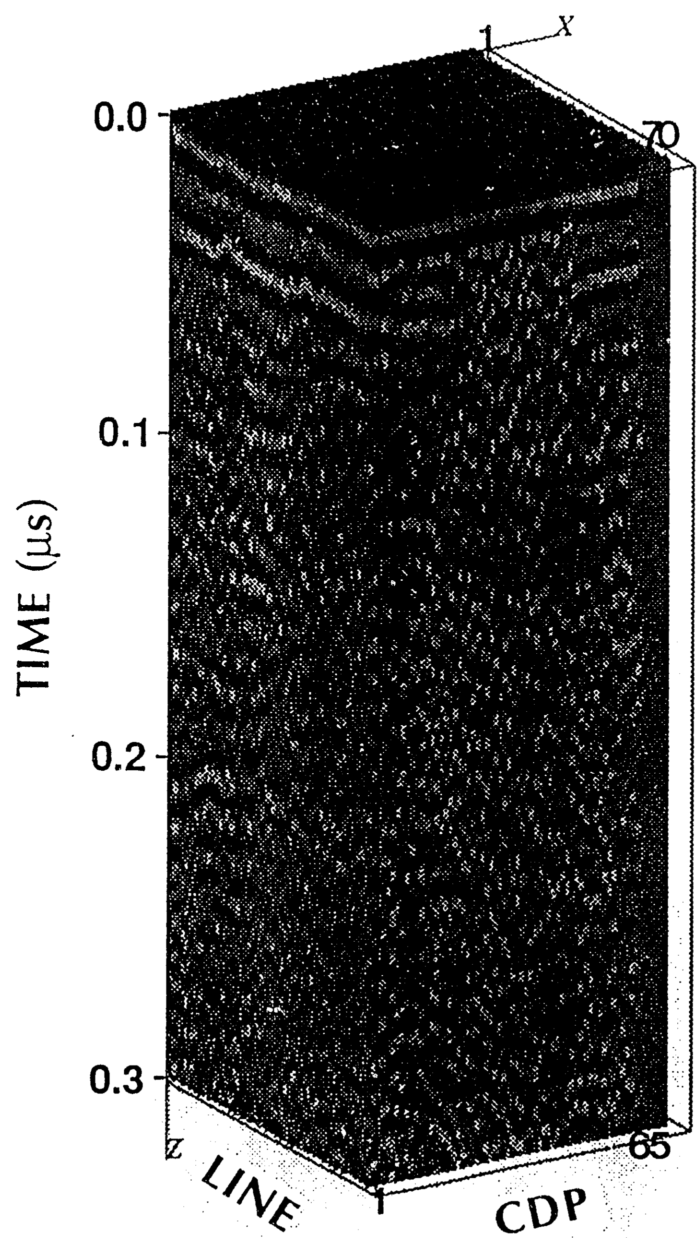


Figure 6 | Migration of 3-D data from the D-area. The migrated data cube has a total of 70 lines with 65 traces per line. Shallow trench features are only presented along the CDP axis. Subsurface layers are continuous in the crossline direction. Reflections at 0.2 ns (25 to 30 ft) are the water table.

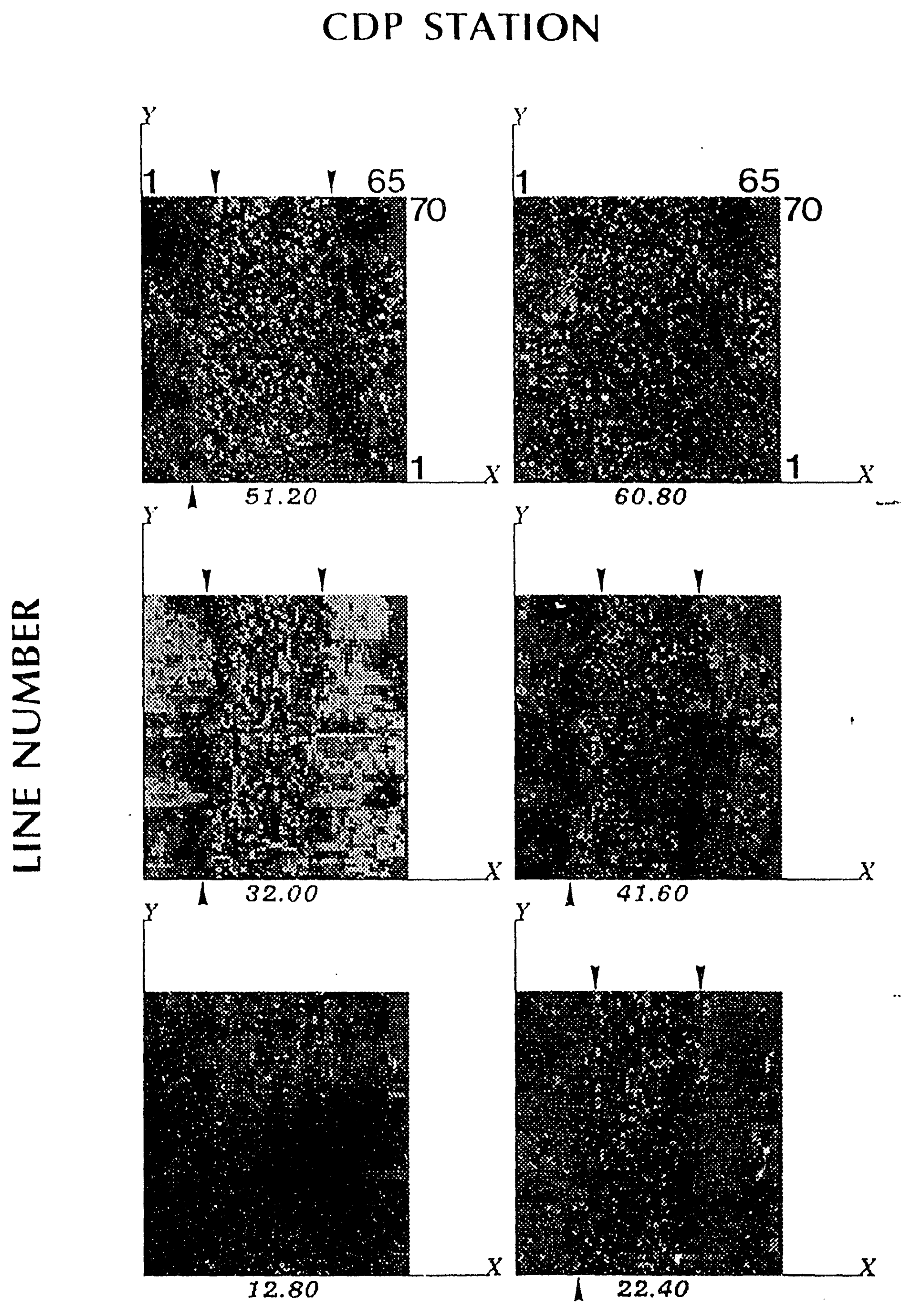


Figure 7 Constant time slices of 3-D data. Buried trench becomes significant in the top view between 22.4 and 60.8 nano-seconds. This trench thus has a rectangular shape, and has its main axis oriented to the north in this display.

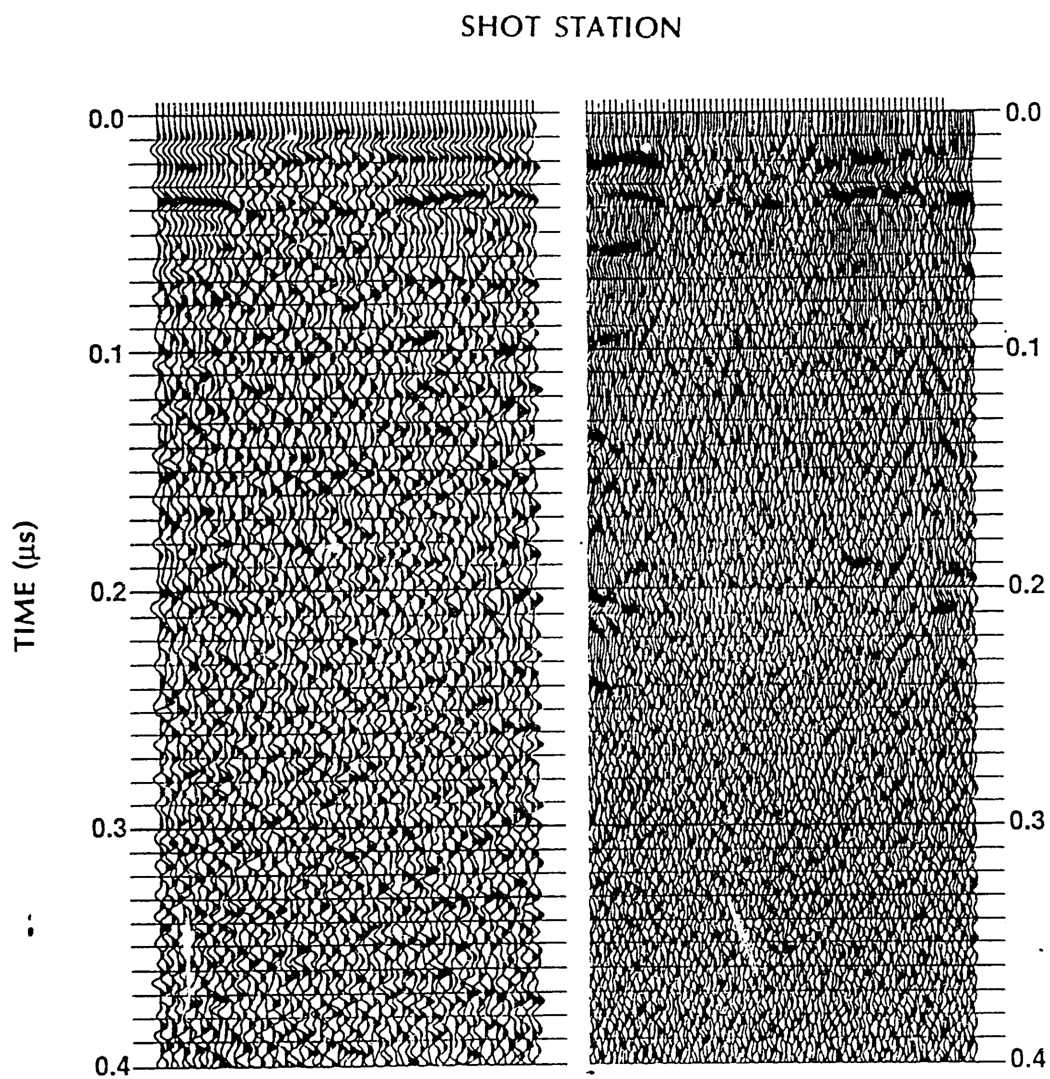


Figure 8 Left panel shows the single offset 3-D data; right panel is the 2-D stacked data. Both panels have similar global features such as reflections at 0.02, 0.04, 0.06, 0.1, and 0.2 μs. The 2-D data show more detailed information than 3-D, as trace interval is half of the 3-D data (especially the diffractions in the trench).

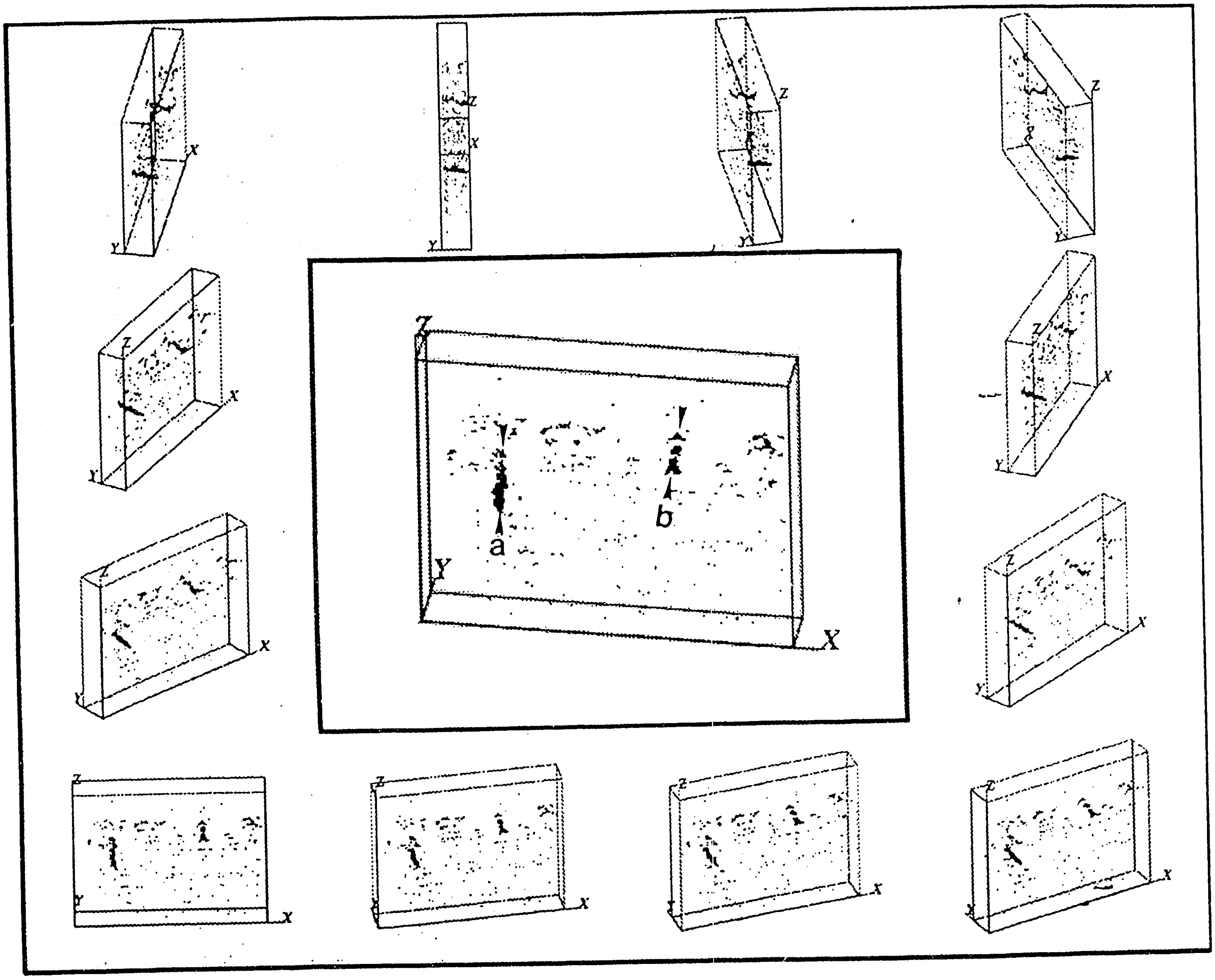


Figure 10 3-D visualization of buried pipelines. The pipeline features can be further enhanced using 3-D visualization hardware and software. With spatial convolution of the migrated data cube, pipeline images become more distinct from surrounding soil formations, and show correct linear features. These linear features can be observed in all figures viewed from various perspective angles in the 3-D space.

END

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