RAYFRACT™ IN MARINE SURVEYS

As part of a geotechnical assessment and feasibility planning of channel improvement a shallow marine seismic refraction survey was undertaken. The data was initially processed and interpreted by the contractor. The data was subsequently reprocessed and modelled using RAYFRACT™ Seismic Refraction Tomography software, in an attempt to highlight shallow high velocity zones.

The previous processing and modelling results suggested the presence of a 1 to 3 metre thick lower velocity layer (1500 – 1750 m/sec) of material overlying higher velocity rock (2500 to 4000 m/sec). The low velocity could represent broken or fractured rock that was drilled and blasted, during prior dredging program. The results suggest that the lower velocity rock is still present below the earlier dredged level (up to 1.5 metres below the dredged line).

The data provided by the contractor needed total re-picking and reinterpretation.

Some changes and adjustments were undertaken in order to make Rayfract work with the marine survey geometry: 1. Uneven spread configuration (different receiver spacing); 2. Different spread orientations and survey line directions; 3. Variable coverage dependant on the towing boat speed; 4. "0 water layer".

Two different hydrophone streamers were used in the survey. 1. Seafloor hydro streamer (28m long - supposedly dragged along the seafloor surface), and 2. Floating one (50m long - kept floating on 1-3m above seabed level). At the same time the distance between the receivers was varying from 0.5m (closer to the air gun source up to 2m at the very end of the streamer).

Specific character of the marine survey methodology (very close distance between the seismic source and nearest spread receivers) demanded for the trigger time delay of 5 milliseconds to be entered during the signal recordings.

The time delay was already stored in the records' digital file headers. This time shift in recording of the seismic traces, when the data firstly processed with Rayfract, caused unrealistically short time residuals between the first and last arrivals (maximum time residual was 20 ms for the longer – 50m streamer) (Figure 1).

In order to fix this, a five-millisecond trigger delay correction has been applied to all records. The corrected traces are shown in Figure 2.

In marine seismic surveys it is common for hundreds / thousands of digital seismic signals to be recorded per each seismic line. Rayfract successfully "consumed" the data and besides extended processing time we have not experienced greater processing difficulties. As an example, 120-280 shots per line (both bottom dragged and floating) have been processed. In the beginning the longer lines had to be partitioned and each partition individually processed as a single line. In the updated version of the program we received by courtesy of Intelligent Resources Inc., this problem was successfully overcome by installing a new program memory module which allows for multiple shot line processing by using an optimized computer memory allocation algorithm.

The depths and the coverage extent obtained in the processing were satisfying considering targeted interpretation depth of maximum 2 metres below the streamer level. The tomography results obtained by Rayfract generally correlated well with the previous interpretation results and boreholes drilled in the area.

However, the tomograms created appear to offer better results at imaging shallow sharp velocity changes. This is generally not seen in the previous interpretation output as the data was laterally smoothed.

Depths and the coverage extent obtained in the processing were satisfying considering targeted interpretation depth (maximum 2 metres below the streamer level) and the length of the streamers. In case of the bottom dragged hydrophone streamer (28m long) the maximum interpreted depth in the final Rayfract tomograms was 12m, whilst in case of the floating streamer (50m long) (Figure 6) the depth was approximately 20m. The final iteration output showed minimum unsigned errors.

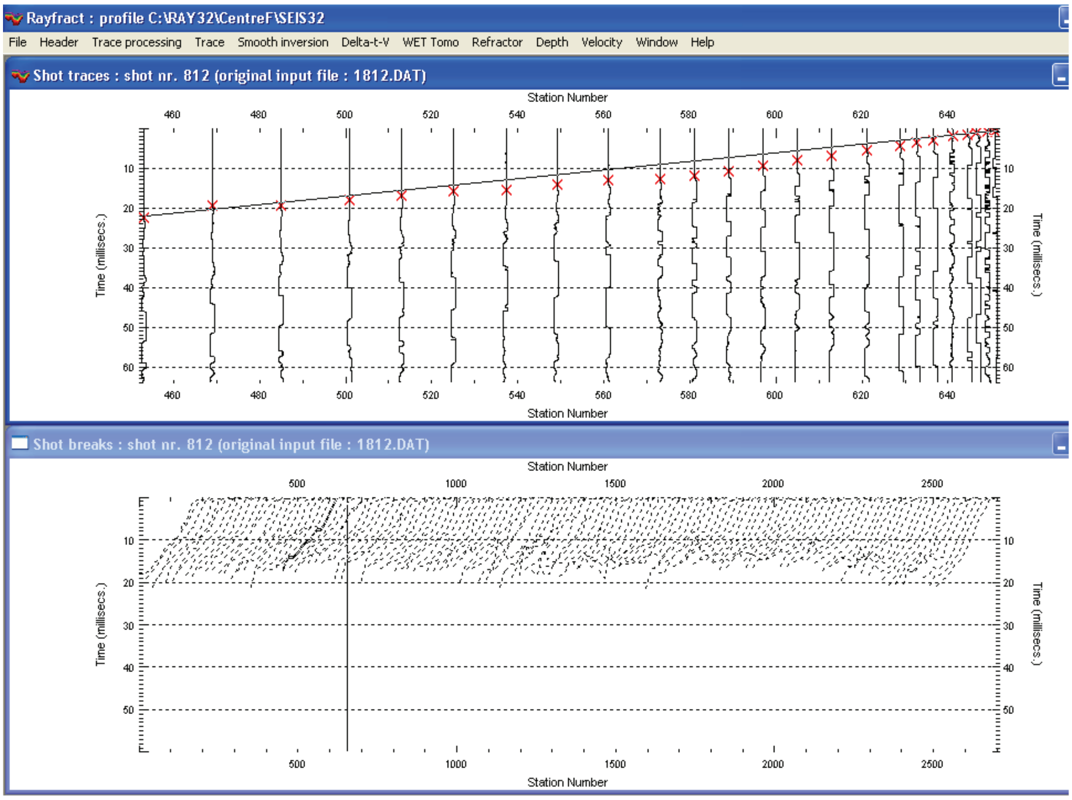

Figure 1. Shot Gather view with unrealistically short time residuals.

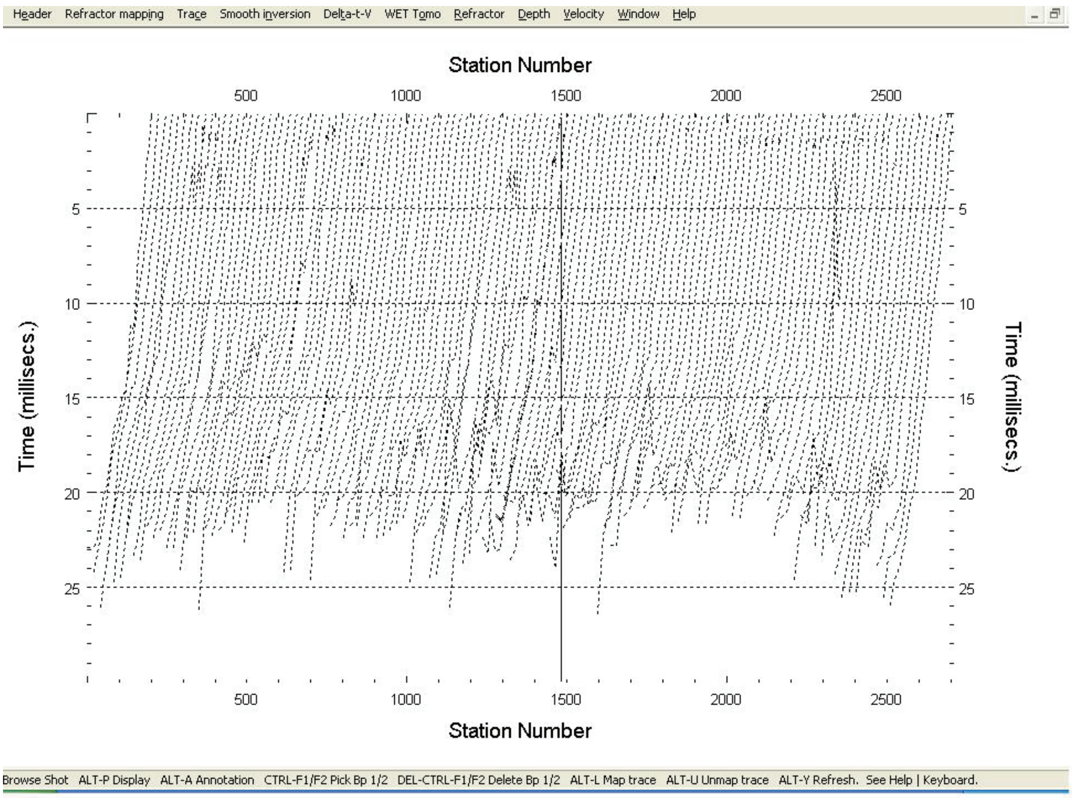

Figure 2. The time residuals after the 5-millisecond correction entered and preliminary pickings.

The final interpretation result for the "Centerline" obtained by reprocessing of the data recorded with the floating streamer is shown in Figure 6.

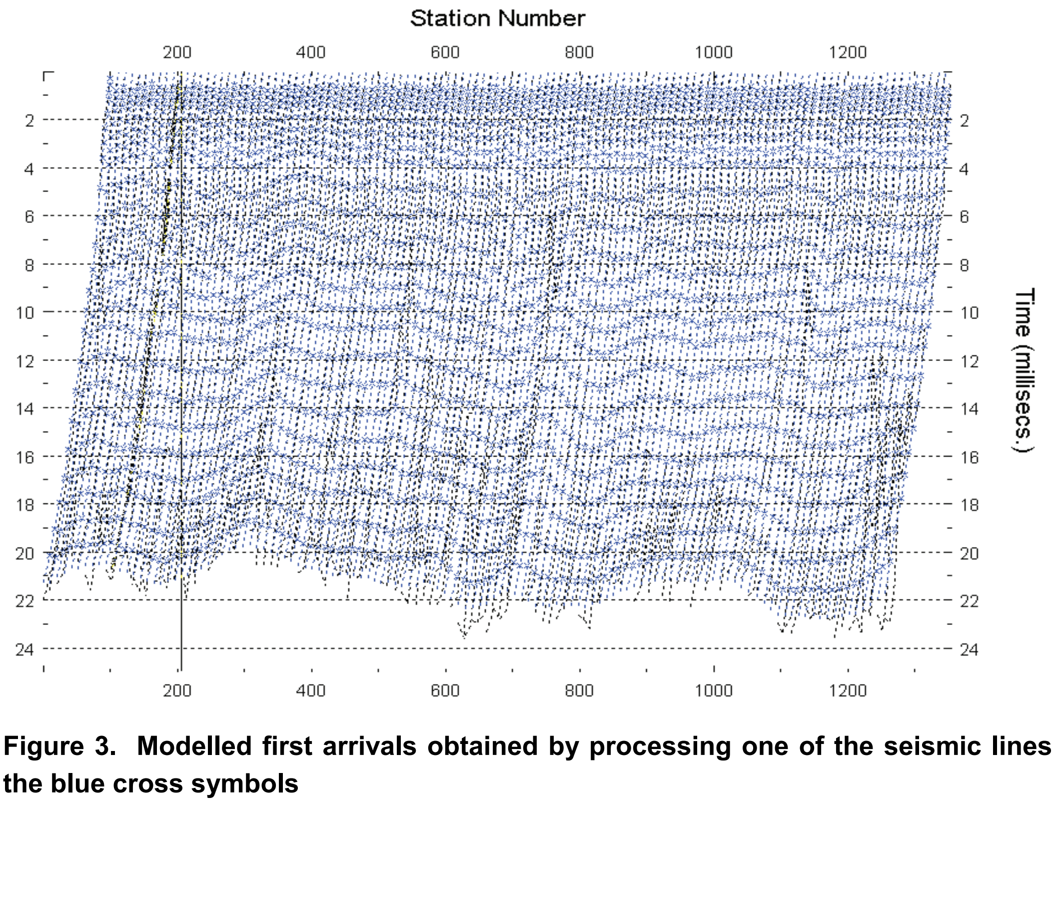

Figure 3. Modelled first arrivals obtained by processing one of the seismic lines indicated with the blue cross symbols

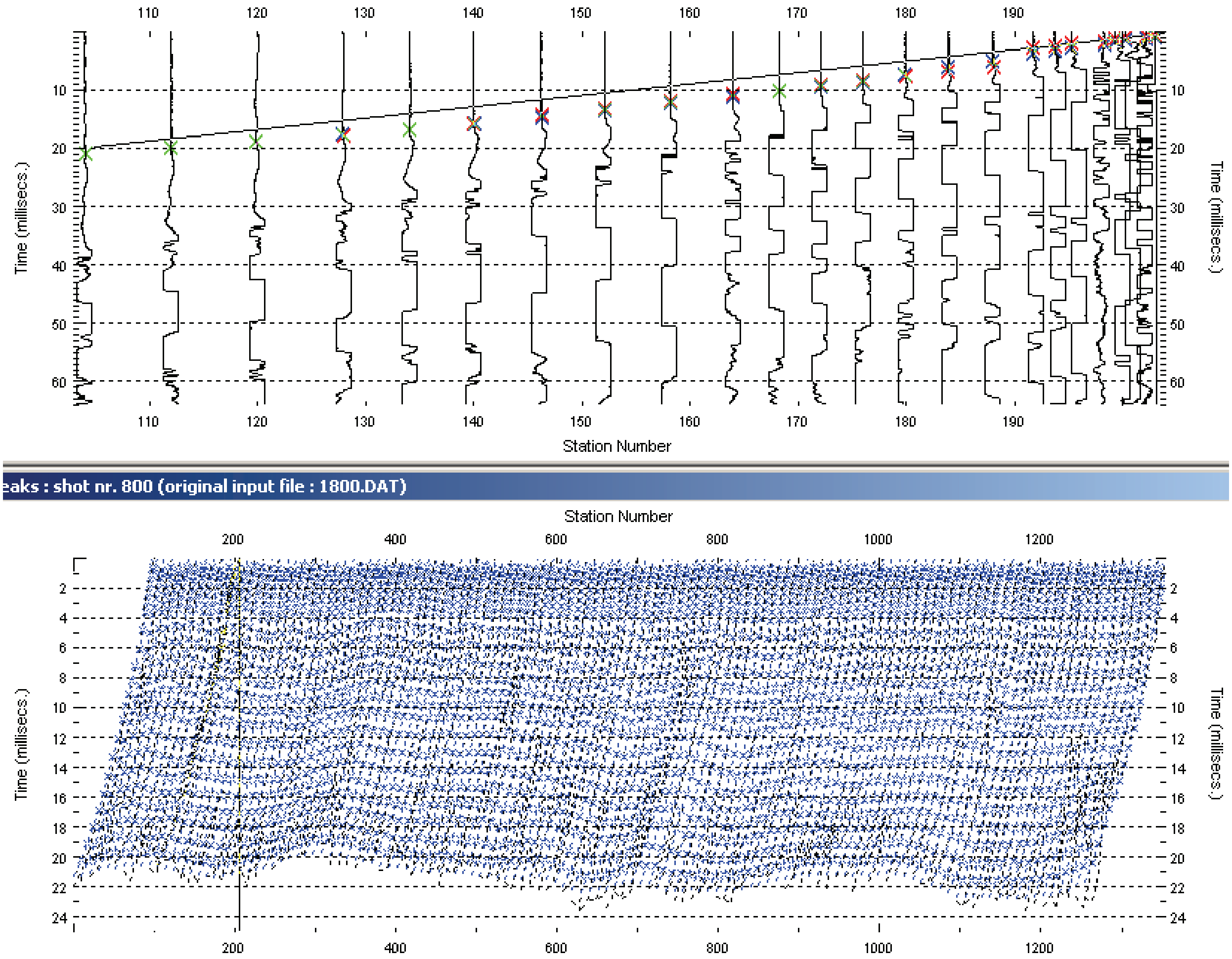

Figure 4. Shot Gather view with indicated picked and modelled first arrivals.

The tomogram is obtained by using 100 WET iterations and central ricker wavelet frequency of 100 Hz.

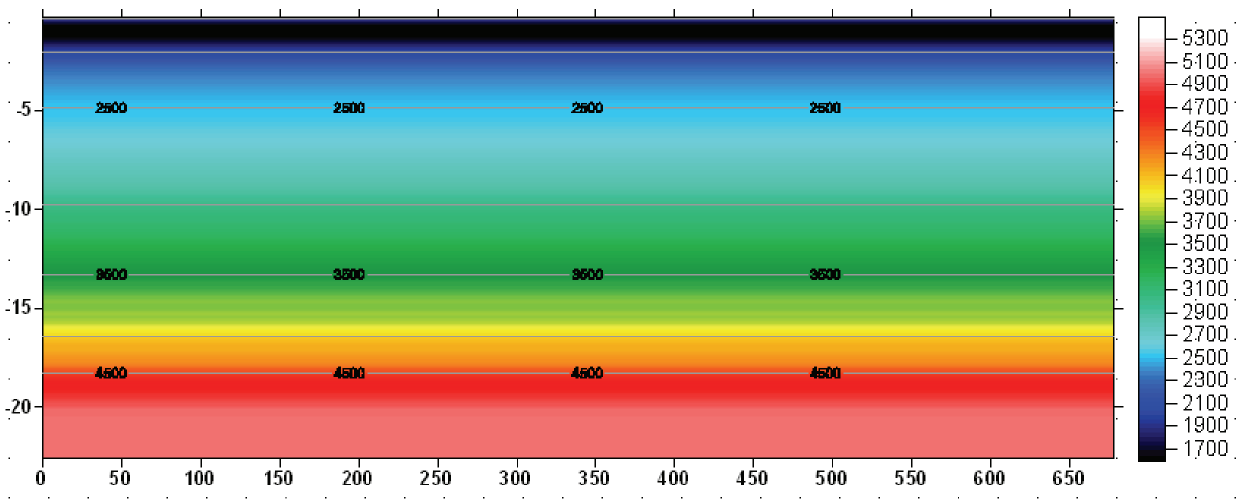

Figure 5. Initial 1-D velocity model

After the high number of iterations the residual anomalies are more credible and are generally more realistic.

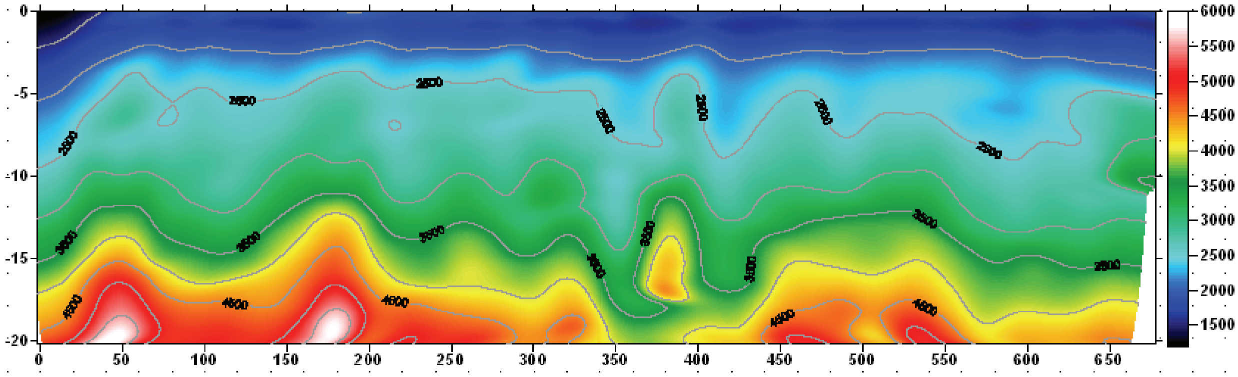

Figure 6. Final tomogram obtained by 70 WET iterations, with Delta–t–V initial model.

Note the water velocity layer in the first 2-3m below the streamer line. This coincides with the water seismic velocity of 1500 m/s. In the tomogram obtained by processing data recorded with the bottom dragged hydro streamer, there is an obvious sharp velocity boundary starting from 2 - 3m below the streamer level. This indicates the presence of high velocity refractors.