IXRefraX Tutorial

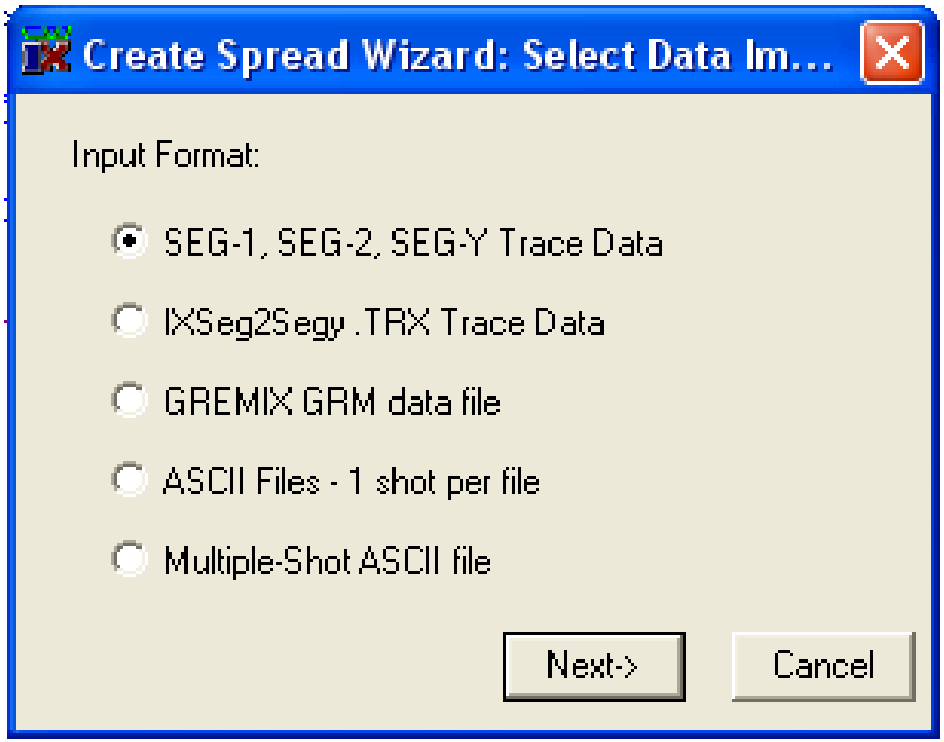
Version 1.02

How to import and interpret seismic refraction data using IXRefraX

Import & Interpretation Sequence

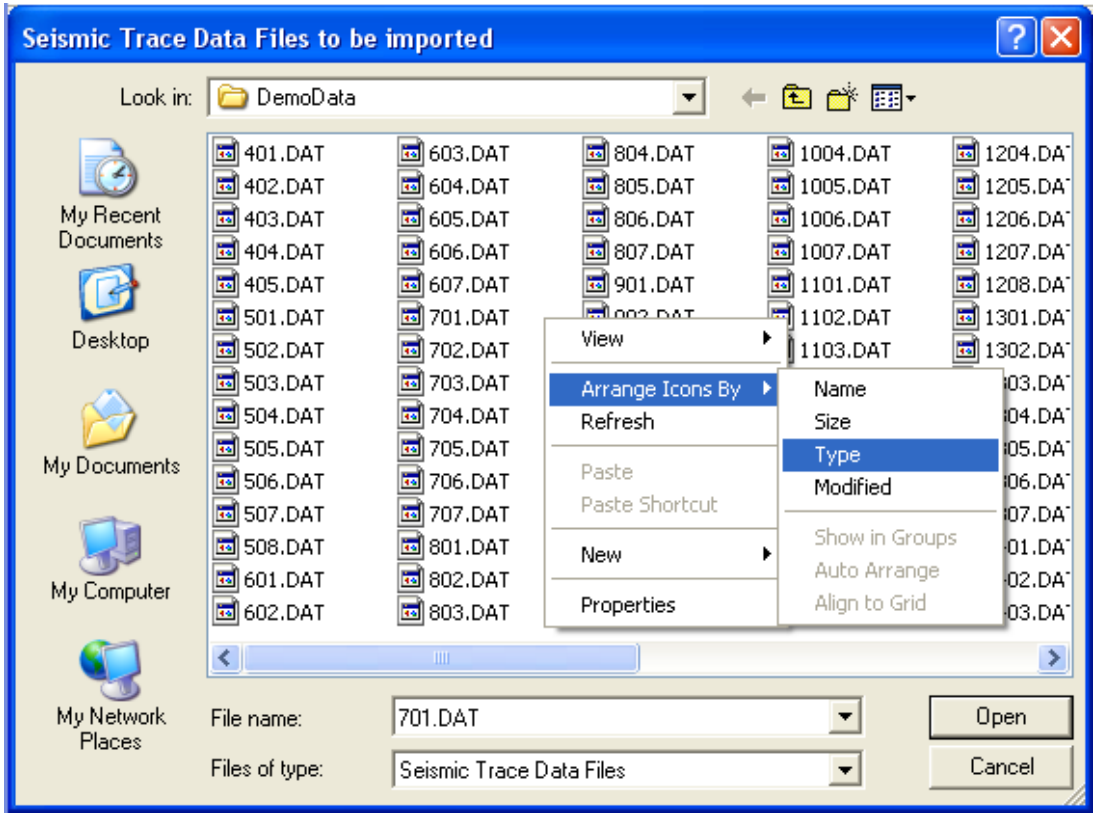
- Use File/Create Spread to import data. 
- Use Edit/Pick Breaks to verify picks; in trace window, use Edit Shot Header to correct geometry. 
- Examine data to estimate layered model.
- Use Calculate/Estimate Model to generate a 2-D model of the section. 
- Use Calculate/Estimate Layer Assignments and Estimate Reciprocal Times.  
- Use Calculate/GRM Interpretation to generate GRM Section. 

Use File/Create Spread to import data.



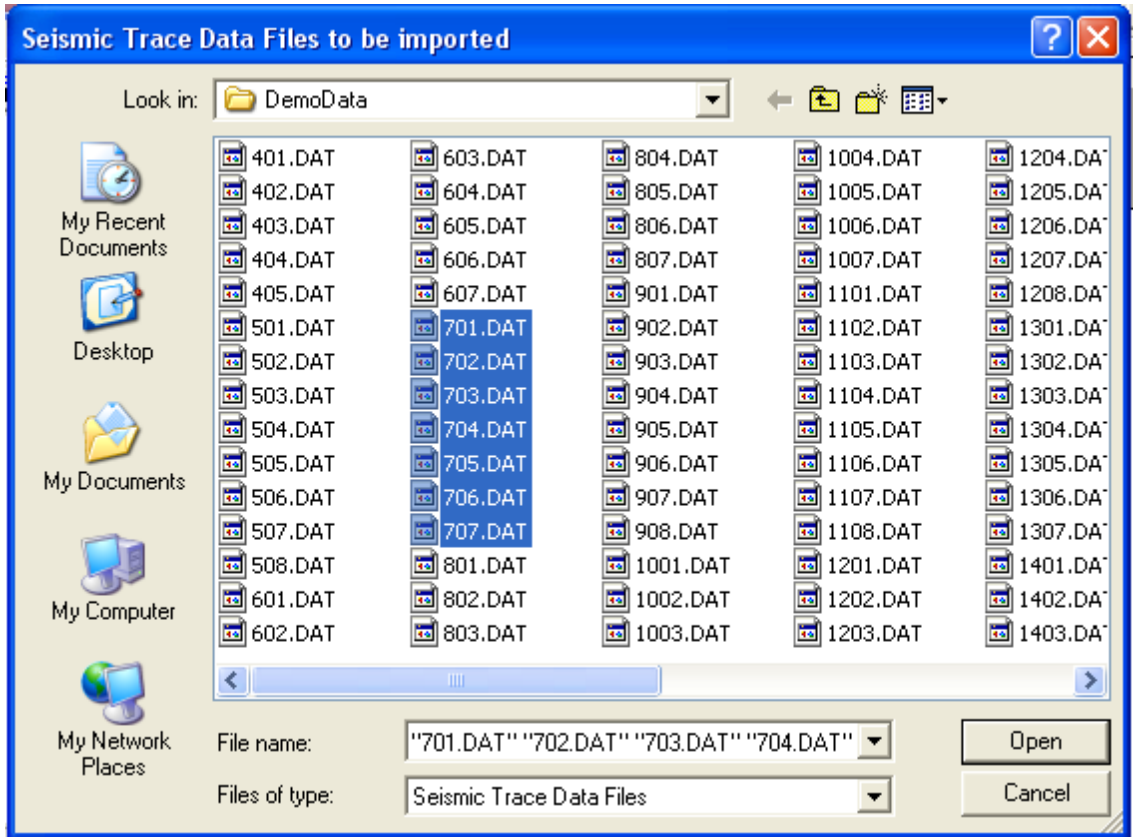
First, select input format

Use File/Create Spread to import data.



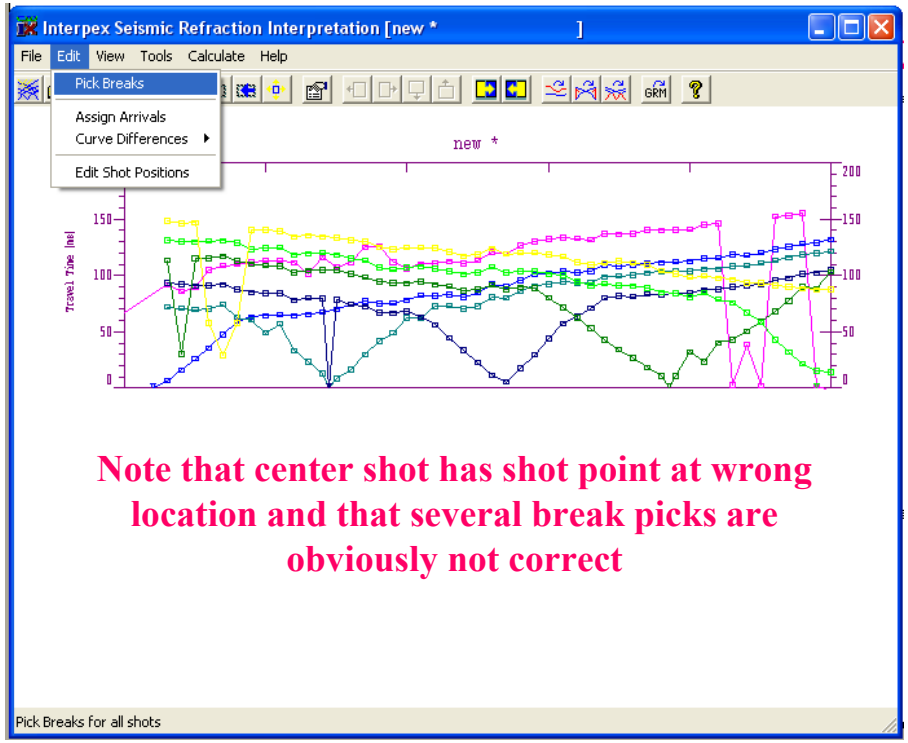
Second, select file ordering to make selection easier.

Use File/Create Spread to import data.



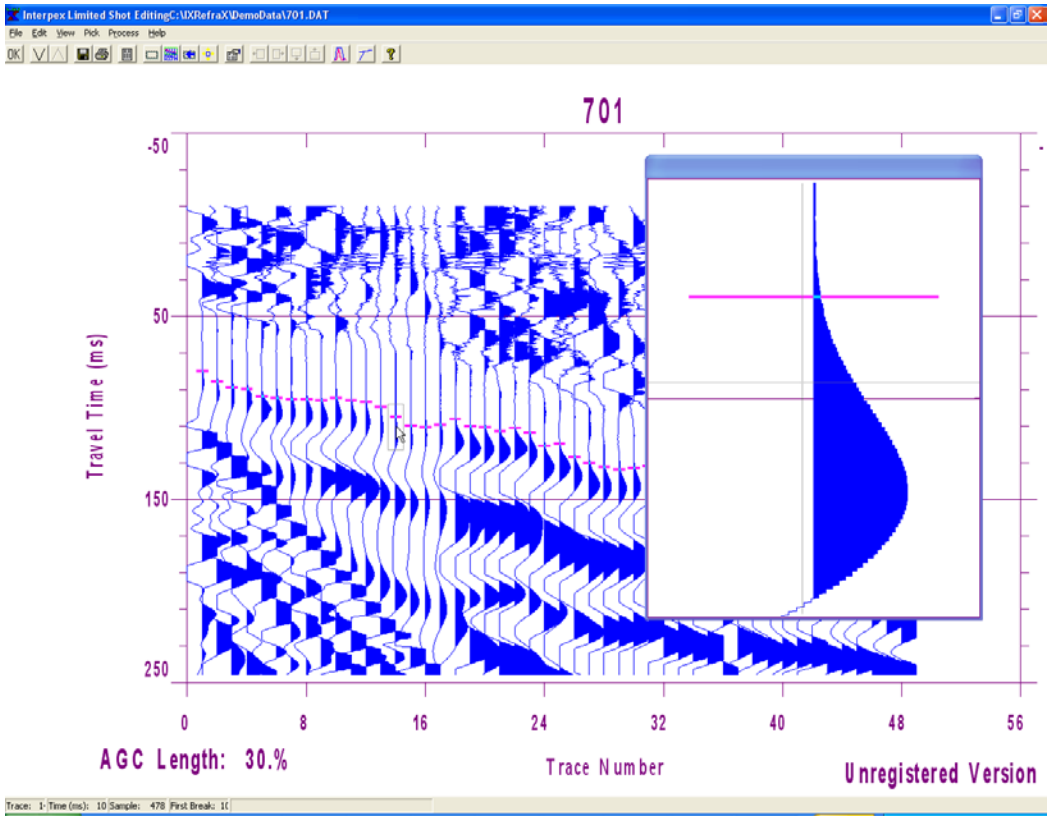
Third, select files to import, then press Open. You can select all shots along the profile line. We will select one Spread in this tutorial for brevity.

Use Edit/Pick Breaks to verify picks



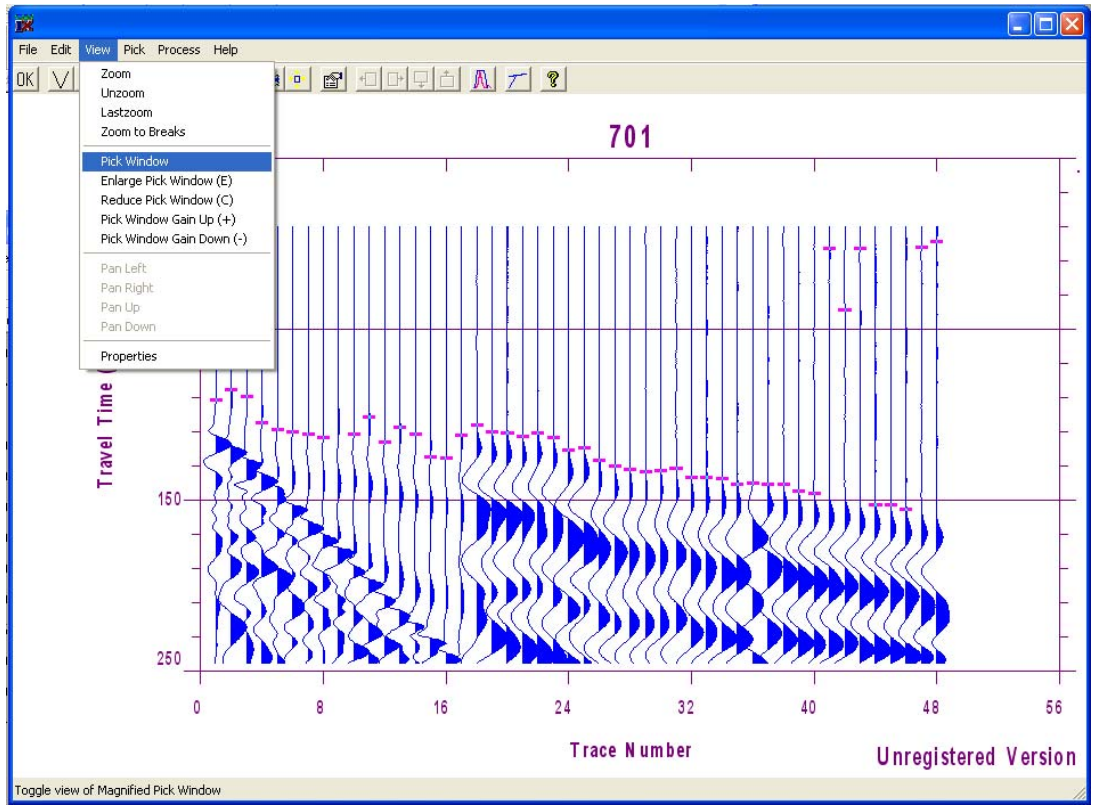
Break picks are read from trace file. If not available, auto picking takes place. Edit/Pick Breaks starts with first file in sequence. Not applicable if tabulated ASCII data were read.

Use Edit/Pick Breaks to verify picks



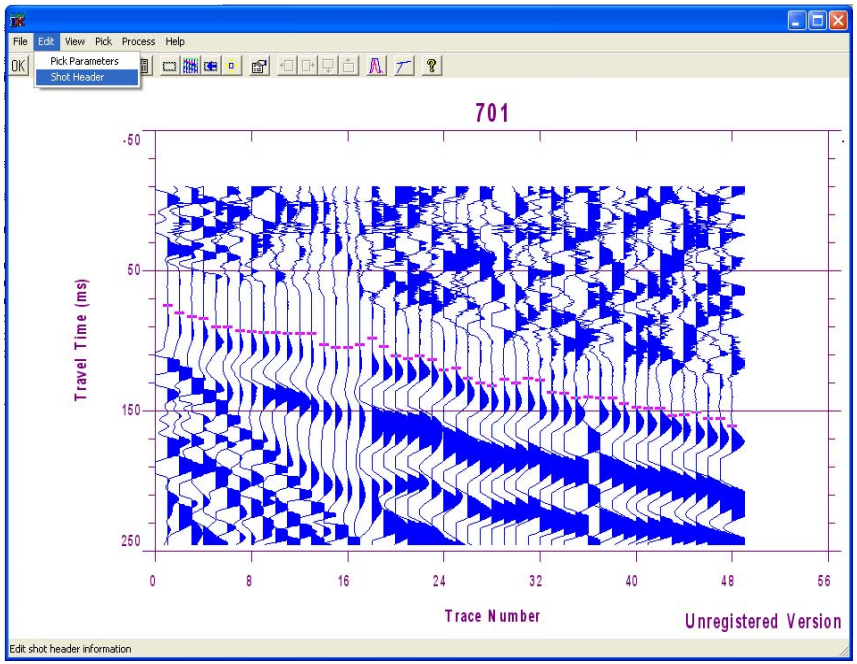
Pop-up window magnifies trace at mouse cursor. Clicking or pressing space bar picks break. Moving mouse or using up/down arrow selects sample, moving mouse or using left/right arrow selects trace. File/Next (Previous) Shot selects next (previous) shot in sequence.

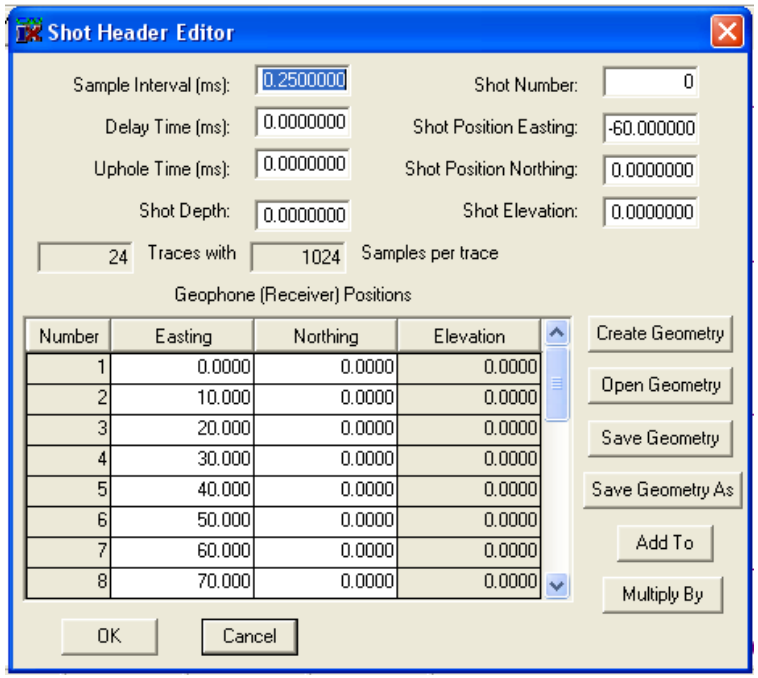
Use Edit/Pick Breaks to verify picks



Use View/Pick Window to toggle pop-up window on or off.
Use C or E to Contract or Expand trace area magnified.
Use + or – to increase or decrease gain of trace in window.
Use View/Properties to change gain method & AGC length for best display

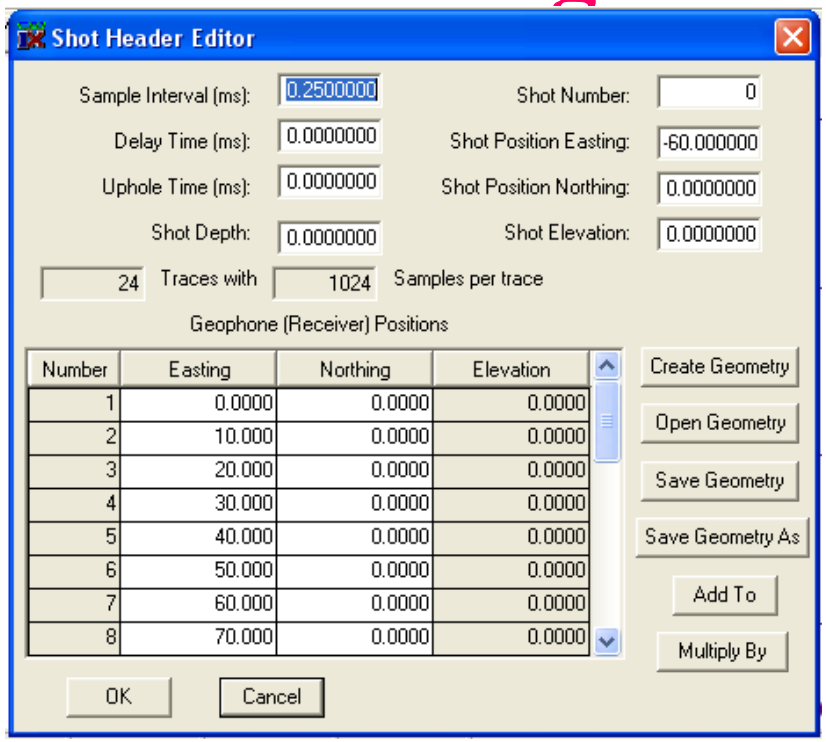
Use Edit/Shot Header to verify geometry

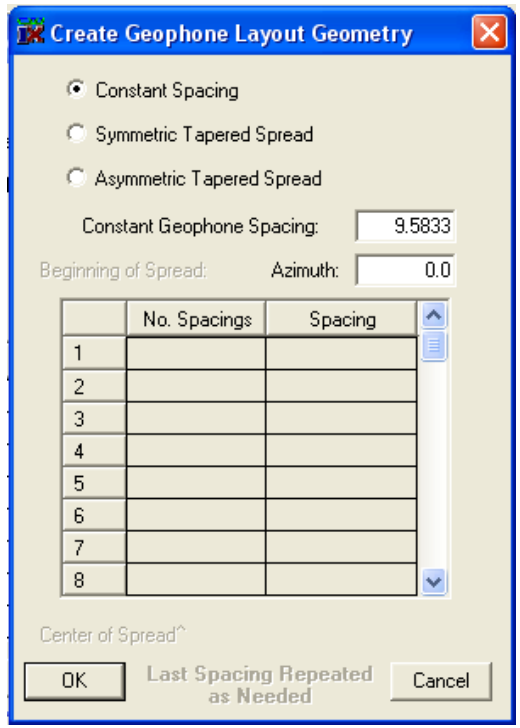




We have adjusted the gain to AGC, 30% window length, trace width to 5 and clip to 2. If the geometry read from the trace file was not correct (or never was entered) you can edit the geometry in the shot header by selecting Edit/Shot Header. You can also do this by right-clicking on the travel time curve and selecting Edit Shot Header.

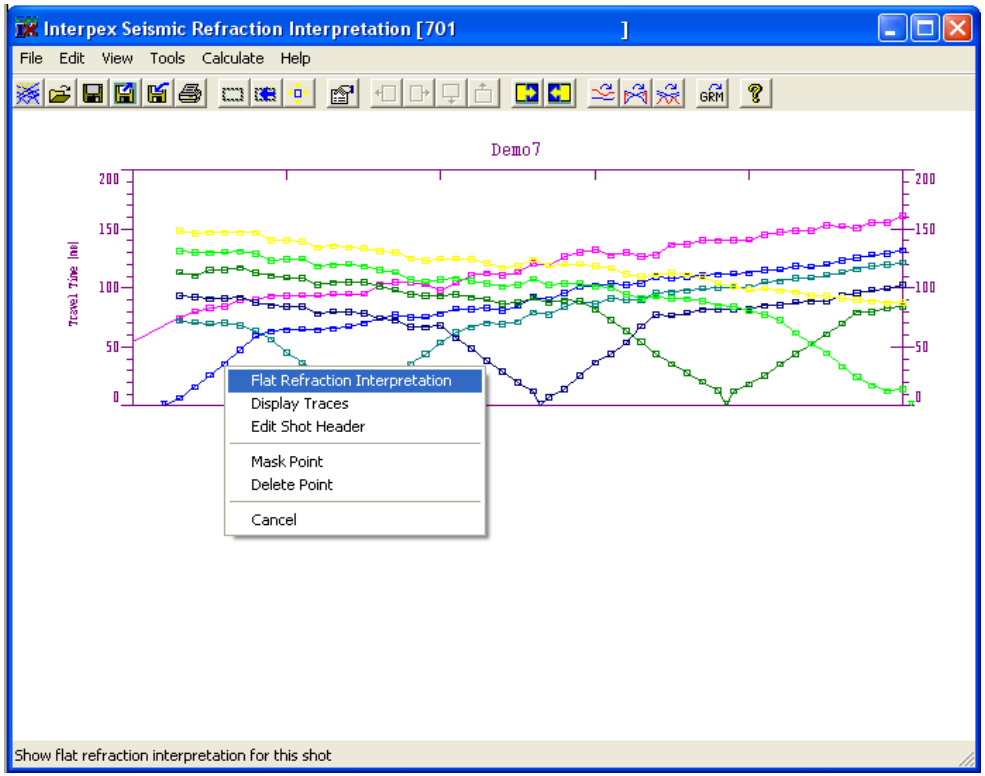
Use Edit/Shot Header to verify geometry

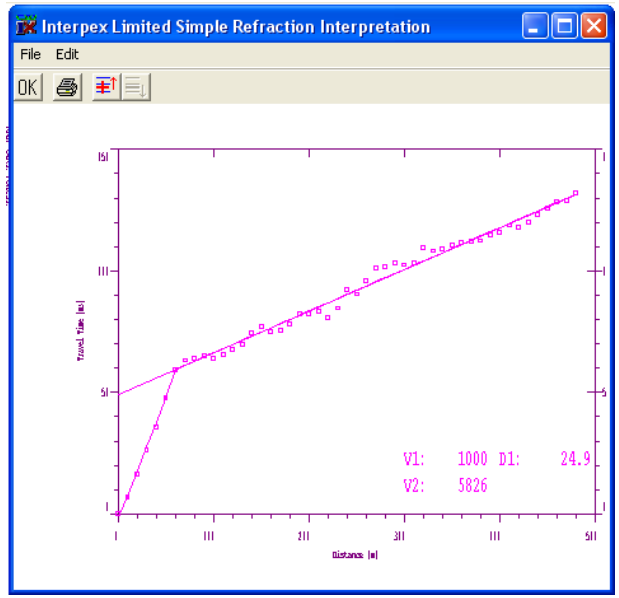




Most geometries can be created using the Create Geometry dialog, including constant spacing, symmetric or asymmetric tapered spreads. Geometries can be saved for later use and can be moved laterally by using the Add To feature. Geometry can also be copy/pasted into the grid from a Windows spreadsheet

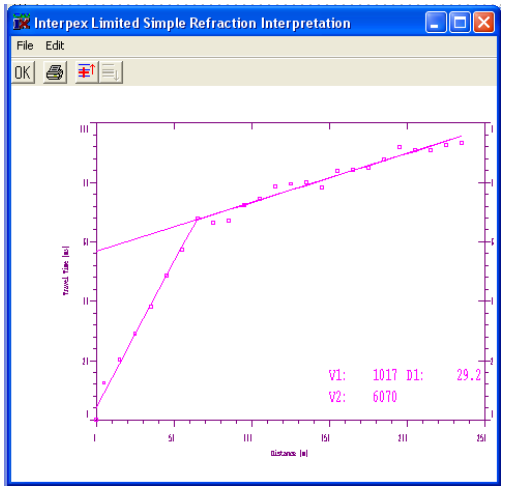
Examine data to estimate model.

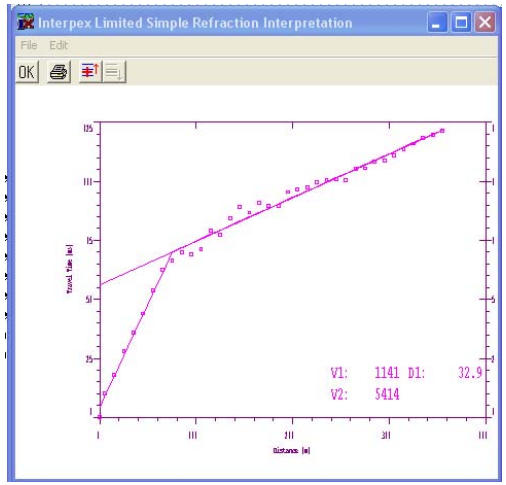


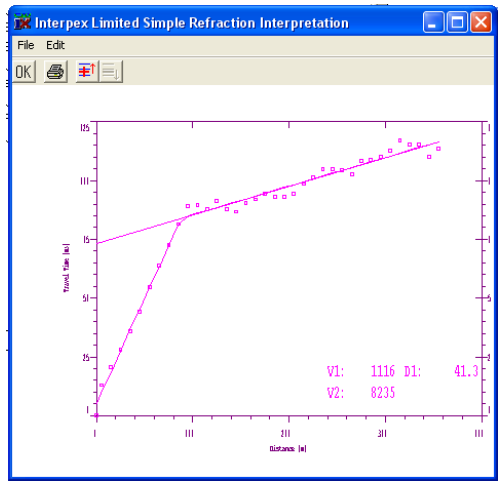


Right-clicking on a travel time curve pops up a menu. Select Flat Refraction Interpretation to estimate velocities and depths from Time-Intercept analysis. Select Display Traces to repick the breaks or Edit Shot Header to change the geometry. For interior shots, click on a point to the right or left of the shot to interpret the respective side using TI analysis.

Examine data to estimate model.

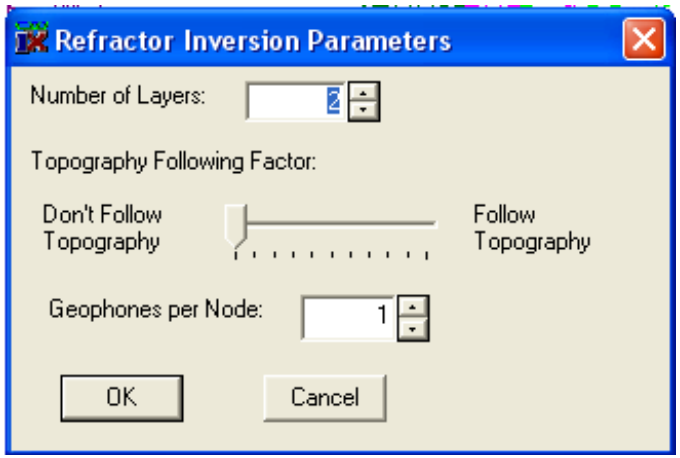


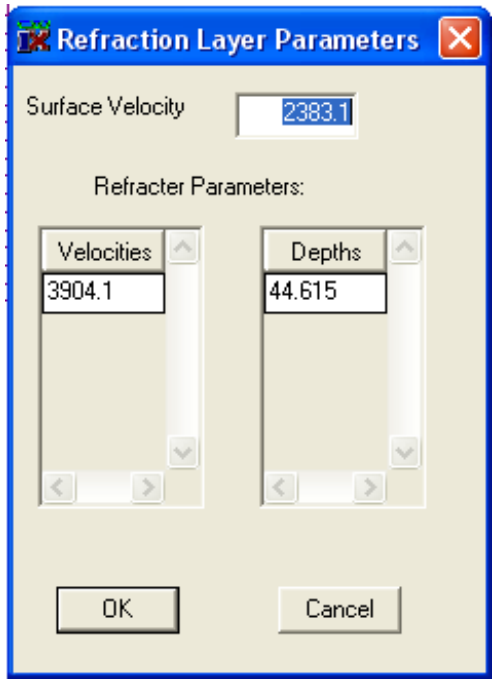




Examine a number of the travel time curve segments, trying to determine the number of layers, their velocities and thicknesses, Be careful to look at curves which are most representative of a layered earth. For dipping layers, average the results from forward and reverse curves to get a more reasonable estimate.

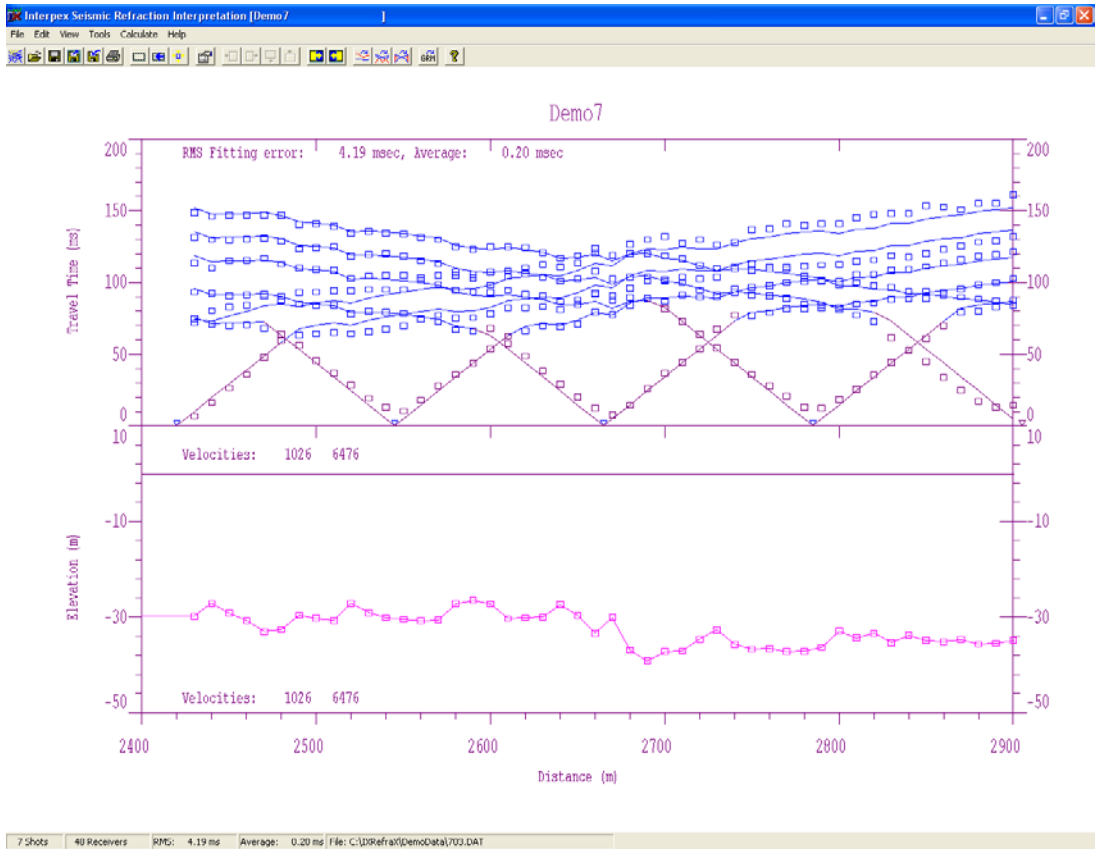
Estimate the Model





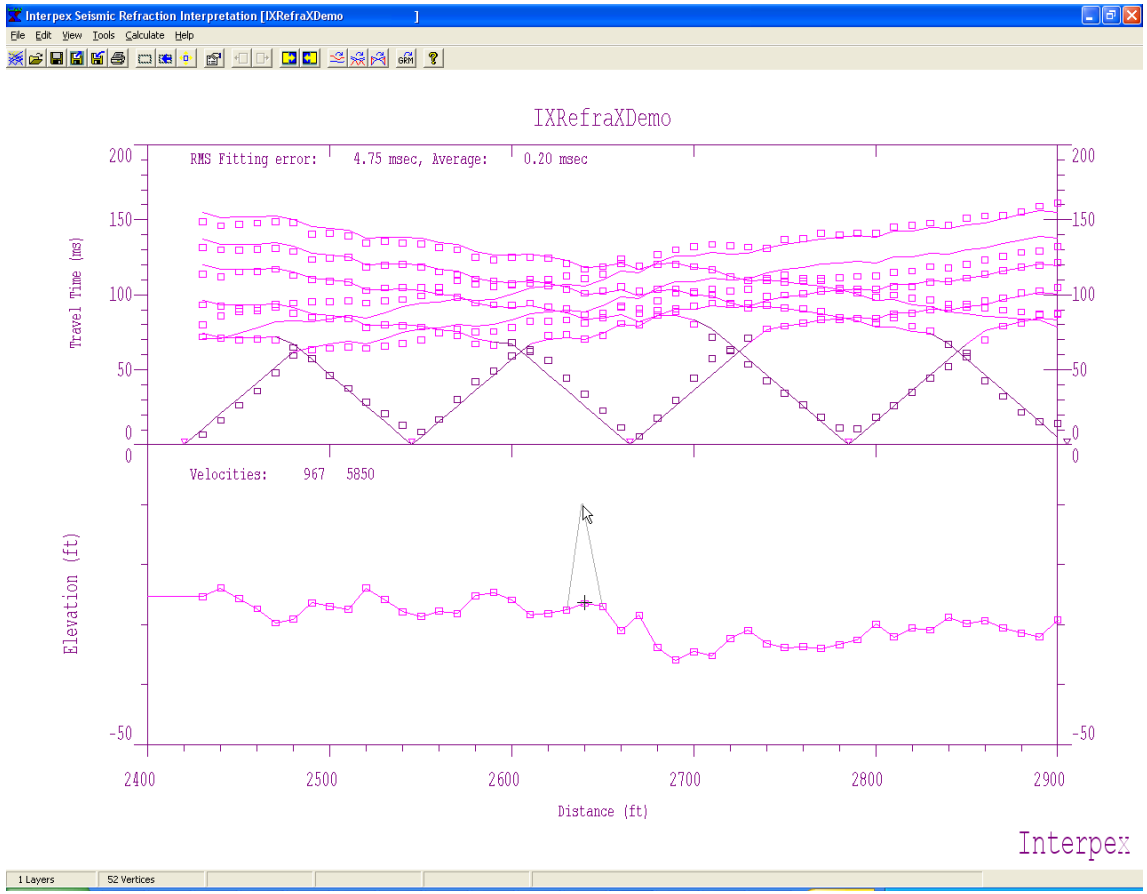
Use Calculate/Estimate Model to select number of layers, topography following factor and the number of geophones per node in the model. Then press OK and enter your estimates of the surface and layer velocities and layer thickness. An inversion process will find the best possible fit from these starting values.

Results of Model Estimation



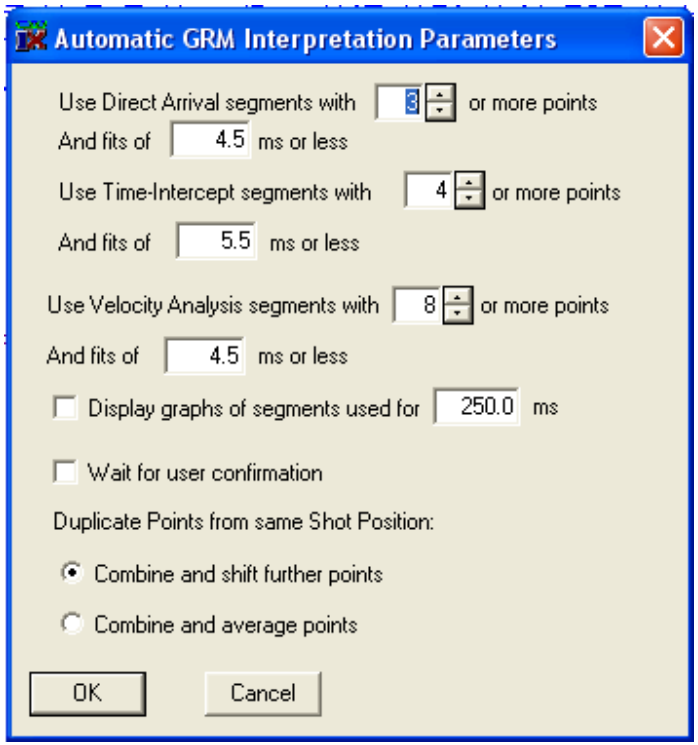
When the iterations are finished, the final result is displayed and the layers are indicated by color on the traveltime vs. distance display. The main point is that the synthetic curves are a good fit to the data curves and the velocities and depths are not too far from the starting values.

Graphically Editing the Model



The vertices in the model can be moved vertically by pointing at them and dragging them. The cursor turns to a crosshair when you point at a vertex and back to an arrow as you drag it. After editing the model, use the Forward and Inverse options to get the synthetic and improve it.

Estimate Layer Assignments and Reciprocal Times – Perform GRM Analysis



The dialog shows that the surface velocity will be determined from segments with at least 3 points and an RMS error of fit to a line of 4.5 ms or less.

Time-Intercept results require a length of 4 points and RMS fit of 5.5 ms or less.

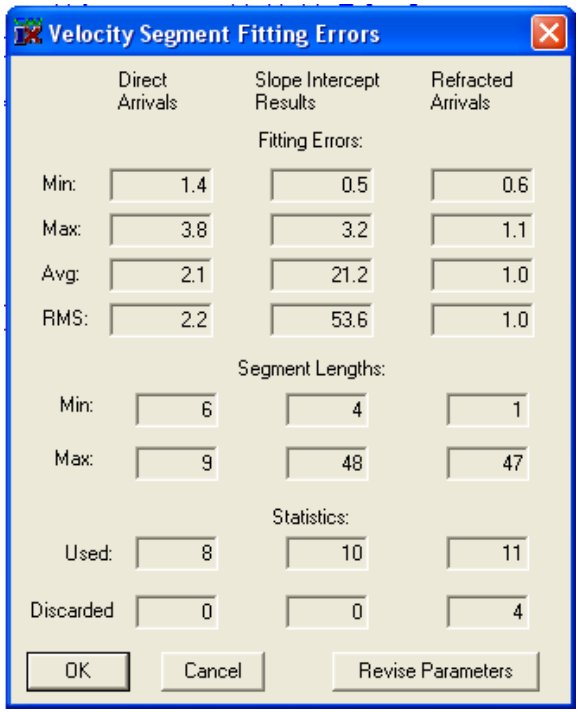
GRM velocity analysis segments require at least 8 points and RMS fit of 4.5 ms or less.

Velocity analysis graphs will not be displayed.

Duplicate points (overlap) will result in a shift of the far offset data.

The next three steps are in the menu Calculate category: Estimate Layer Assignments Estimate Reciprocal Times Create GRM interpretation from Data GRM The first dialog in the GRM interpretation is the Automatic GRM parameters dialog.

Time-Intercept and GRM Velocity Analysis Statistics



The surface velocity was determined from 8 segments with 6 to 9 points and RMS fit of 1.4 to 3.8 ms and all 8 were used.

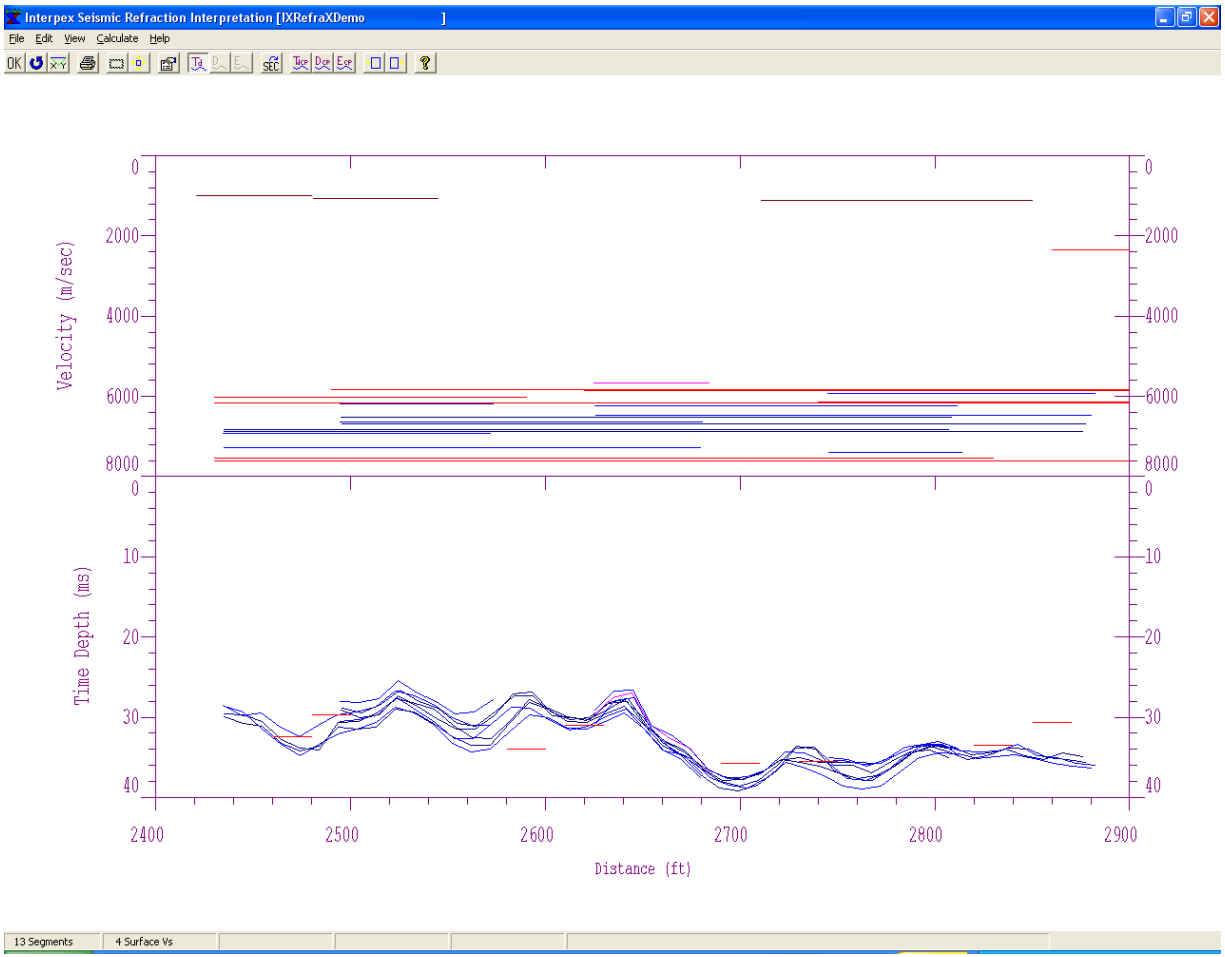
Refractor velocities were determined from 10 segments with 4 to 48 points and RMS fit of 0.5 to 3.2 ms and all 10 were used.

There were 15 velocity analysis segments with 1 to 47 points and RMS fit of 0.6 to 1.1 ms 11 of these were used and 4 were discarded (for too few points).

This information is useful in case too many segments were discarded. You can rerun the GRM analysis with revised parameters.

The next dialog shows the statistics from the automatic Time-Intercept and GRM analyses.

GRM Velocity & Time-Depth Results

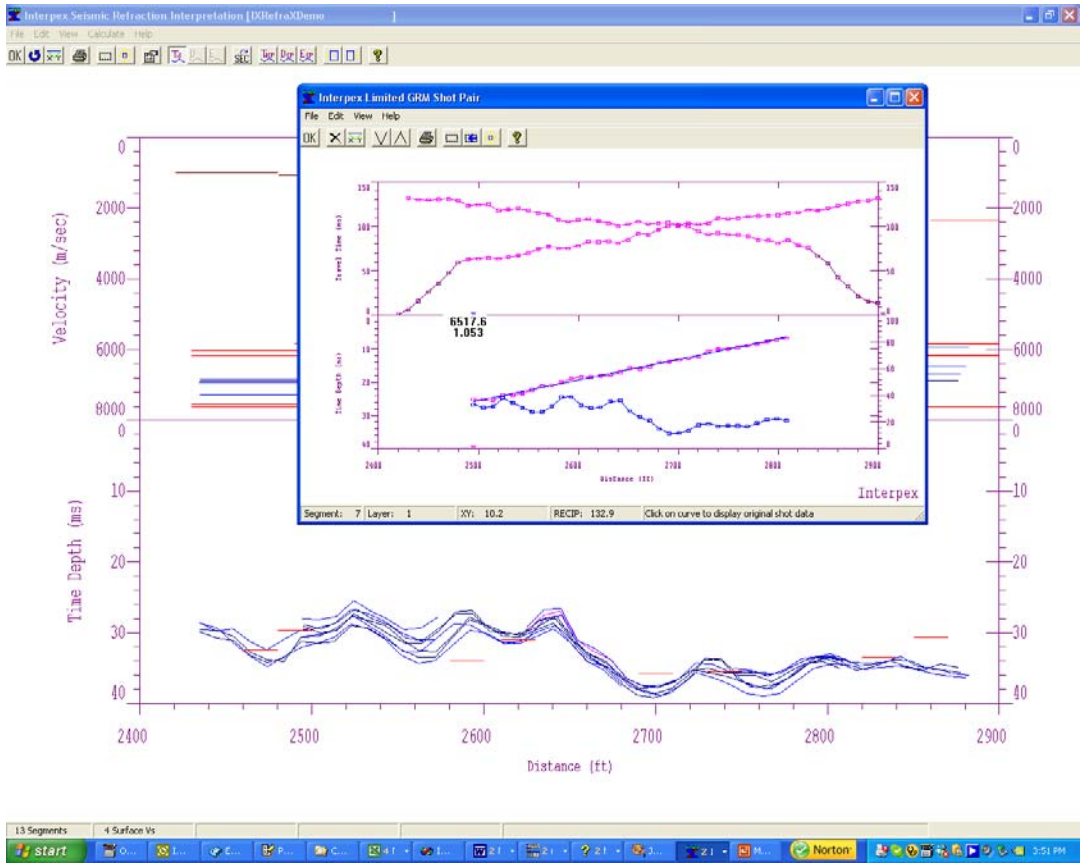


Top graph shows velocities. Surface velocities are the dark lines shown near the top (1000-1250 m/s). The red lines show the velocities determined from time-intercept analysis and the blue and dark blue lines are determined from GRM velocity analysis.

Bottom graph shows time-depths. Flat red lines are determined from time-intercept (TI) analysis. Wavy lines are from GRM velocity analysis curves.

Pointing at lines from TI analysis changes the cursor to a vertical up arrow. Pointing at lines from GRM analysis changes the cursor to a crosshair.

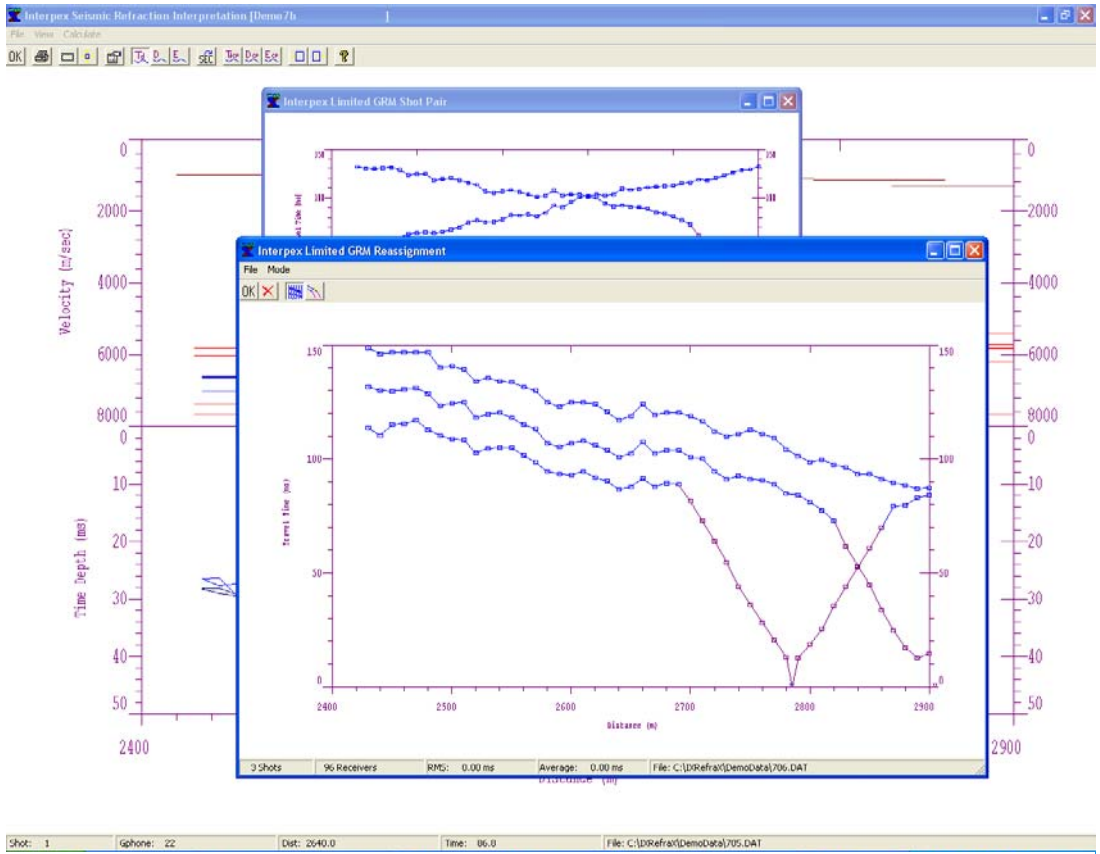
GRM Velocity Analysis Curves



Pointing at one of the GRM time-depth or velocity lines brings up a window showing the travel time (TT) data, the velocity analysis and time depth curves. The velocity and fit error is displayed.

Pointing at one of the TT curves changes the cursor to crosshairs. Click to bring up original TT curves. Note TT curves shown may consist of two or more original shot records.

Original Shot Data for GRM Analysis



One mode allows for reassigning arrivals by left or right clicking, second mode allows for display of original shot data for first break picking. OK saves changes, Cancel discards changes.

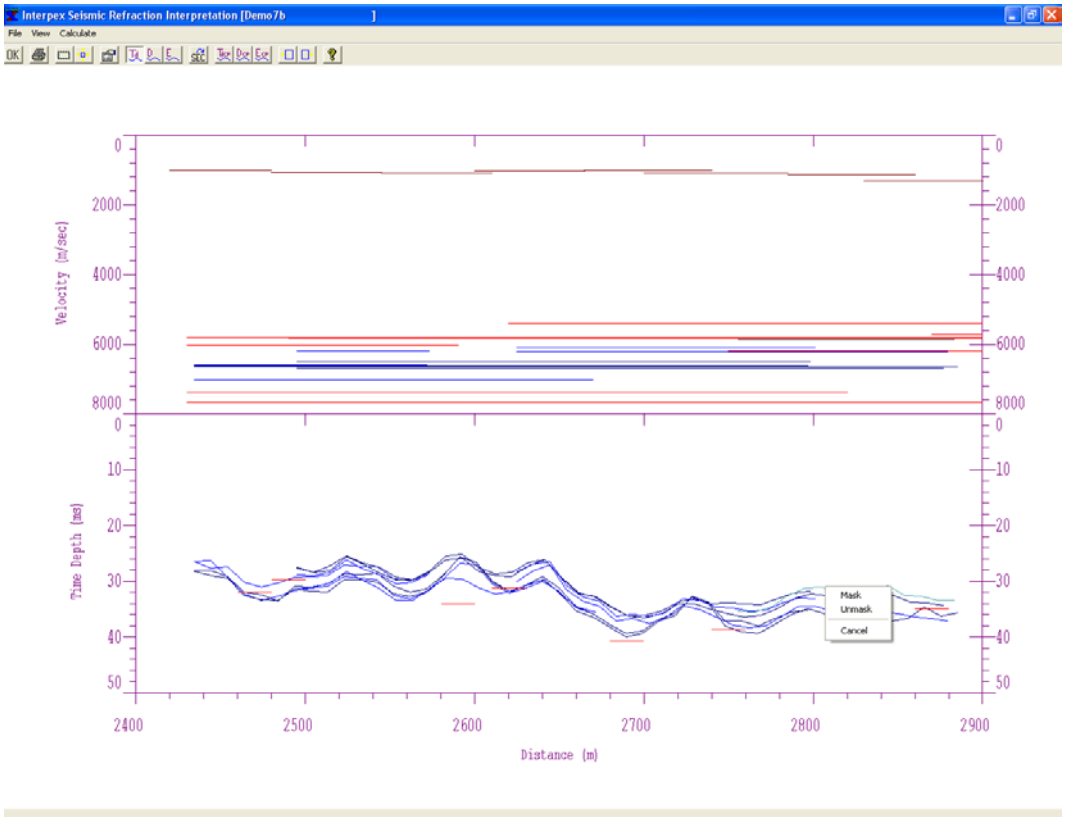
Clicking on a TT curve will bring up all curves used to make up the shot shown with the velocity analysis and time-depth curves. It will also display all overlapping curves which are in the same direction as the selected TT curve.

The toolbar and Mode menu allow for two modes of operation:

1)clicking on a TT curve brings up the original shot data for repicking.

2)Right clicking on a point makes it the first on that layer while left clicking makes it the last point on that layer.

Masking Selected Segments

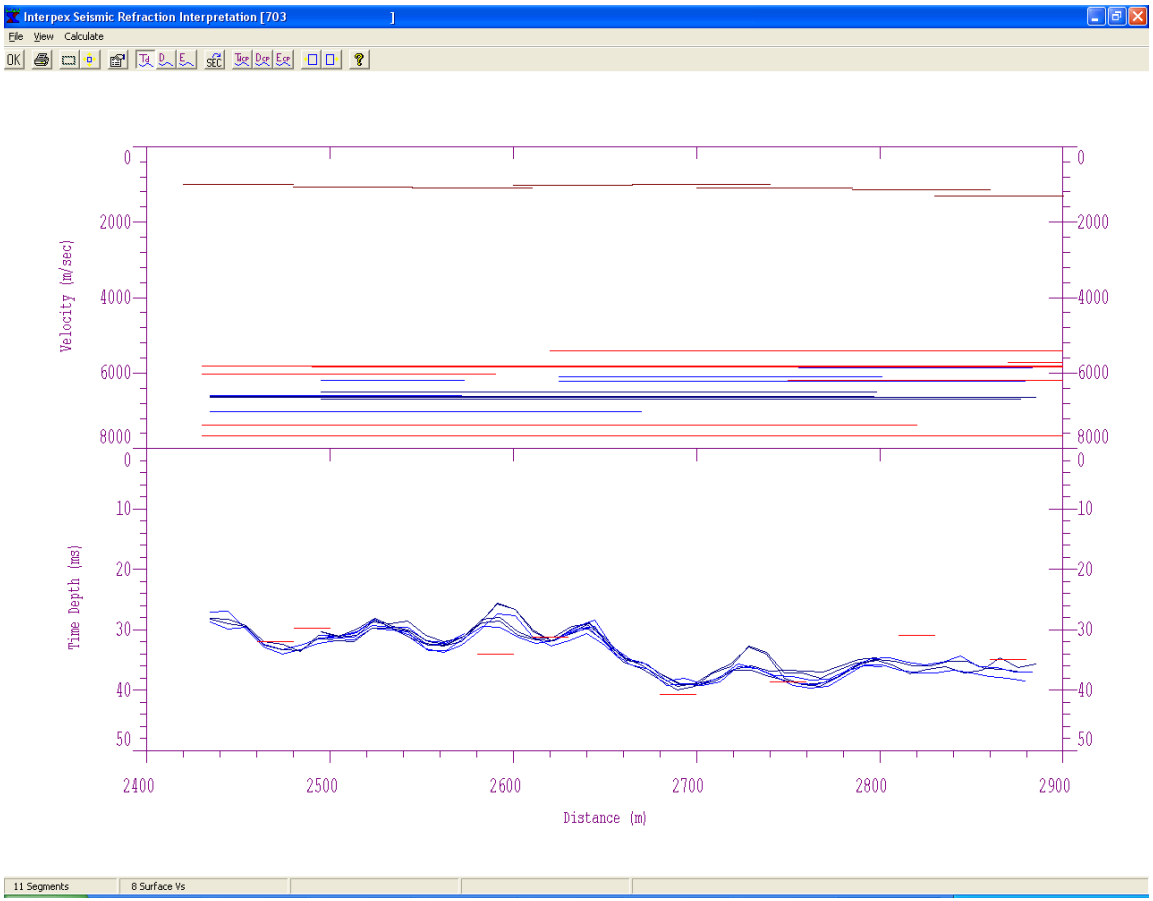


Right click on a Time-Depth or a Velocity segment to mask or un-mask the segment.

Masked segments will not be used in the combination of segments to form composite section.

Both GRM and Time-Intercept segments can be masked.

Adjust Time Depths to Match



Adjust Time-Depth curves to remove scatter in reciprocal time estimates.

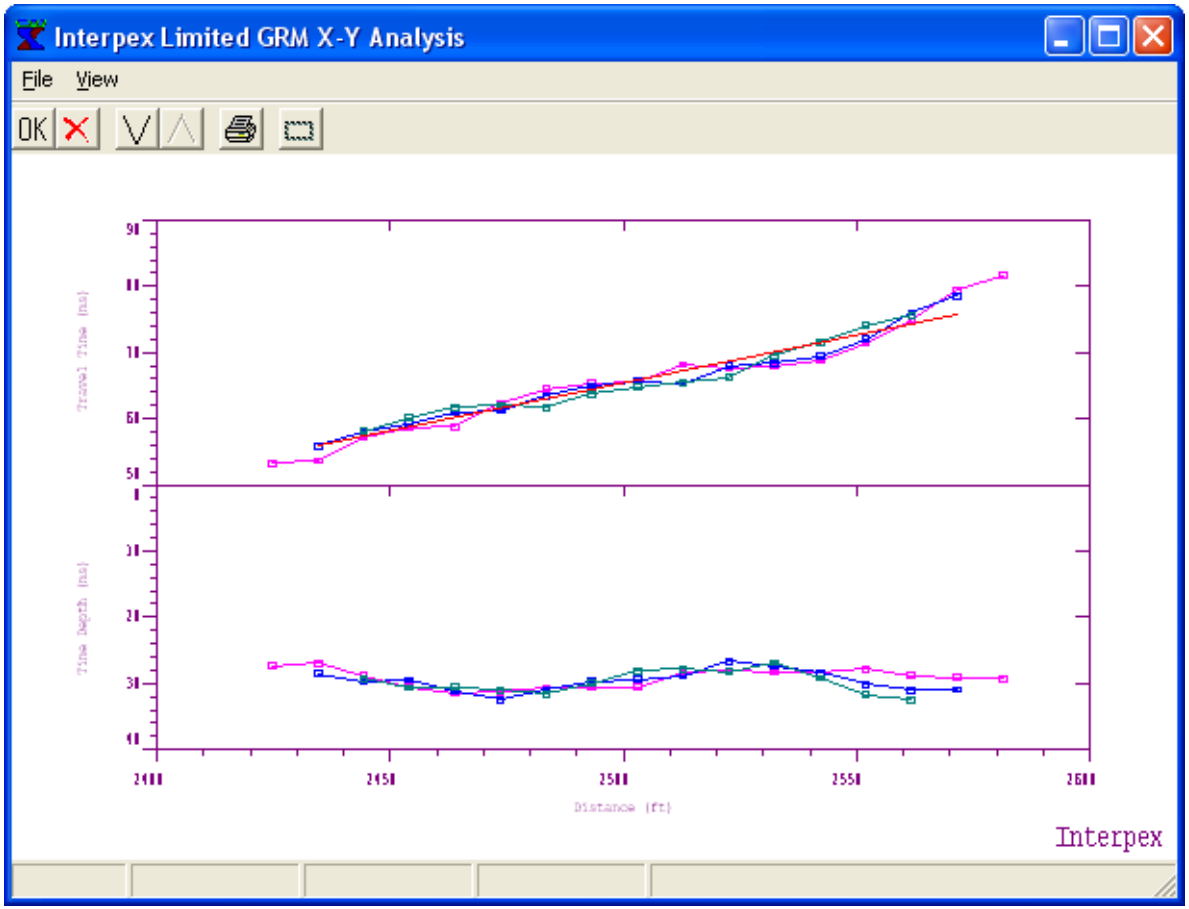
Scatter in Time-Depth curves is due to errors in estimates of Reciprocal Time (Tr) values.

Point at curves to see which Tr values were estimated from model.

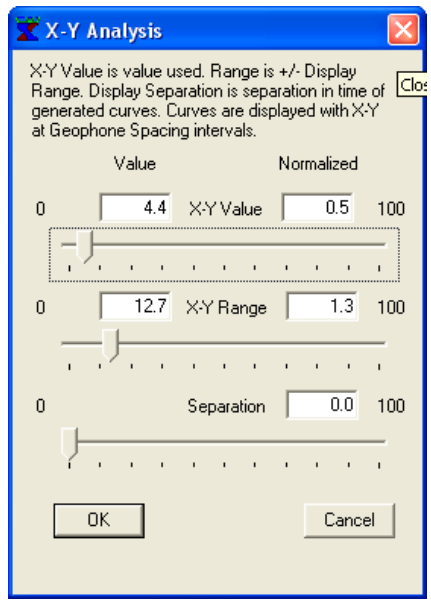
Decide which segments have the more valid Tr estimates and move other curves to match them.

When mouse cursor changes to crosshair, press left button and drag segment up or down to match other curves.

Perform Detailed X-Y Analysis

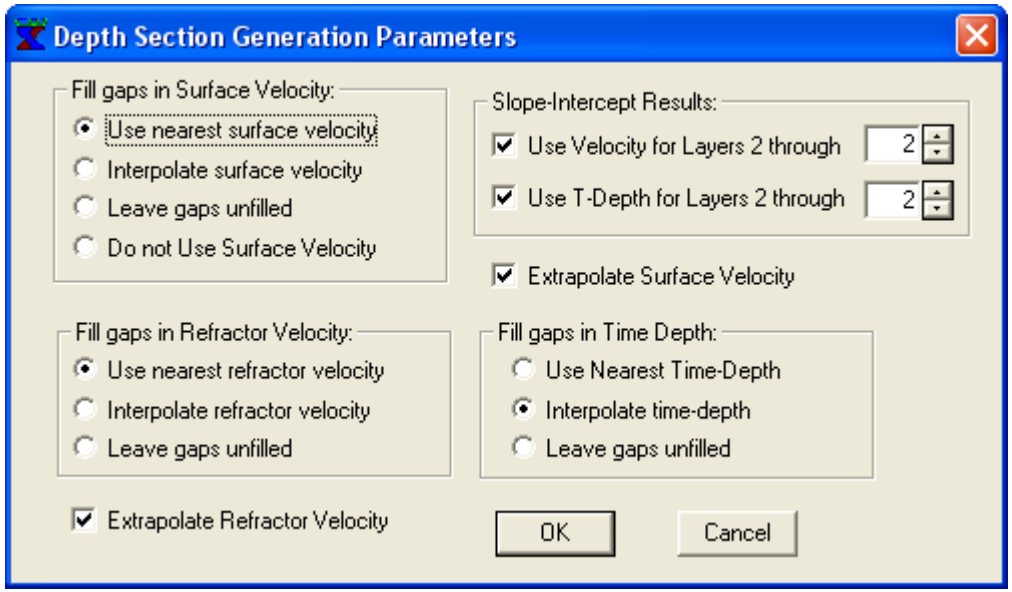


A range of X-Y values can be used to generate a suite of velocity analysis and time-depth curves. These can be separated from each other by constant time values.



Adjust X-Y value for simplest velocity analysis curve and sharpest time-depth curve

Combine Segments to make Composite



Slope-Intercept Results can be used to fill in missing values for refractors.

Velocities, Time-Depths or both can be used.

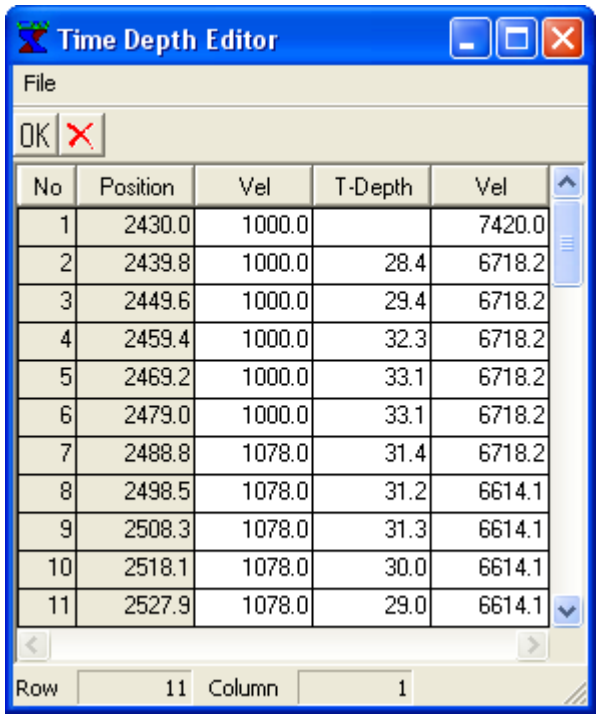
Can be used for all layers or just for near-surface layers.

Velocity and Time-Depth profiles may contain gaps.
Gaps can be filled by

- **Using the nearest value to the undefined value**
- **Interpolating to find undefined value**

Or, gaps can be left unfilled.
Surface velocity can be ignored, and the Average Velocity concept is then used (velocity found from XY value).

Preview and Edit Section if Desired

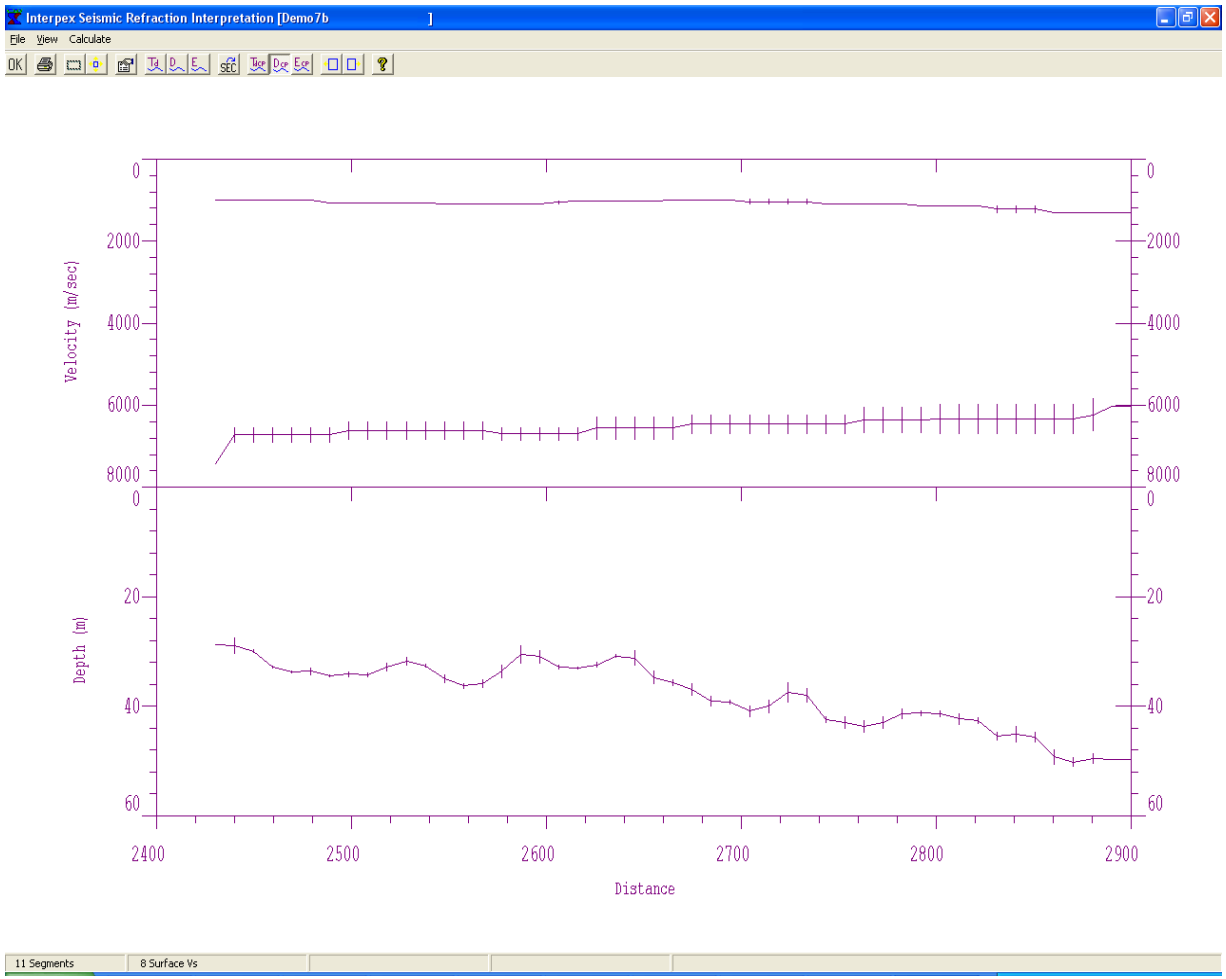


Section is shown with gaps where values are undefined.

Velocity and Time-Depth values can be edited.

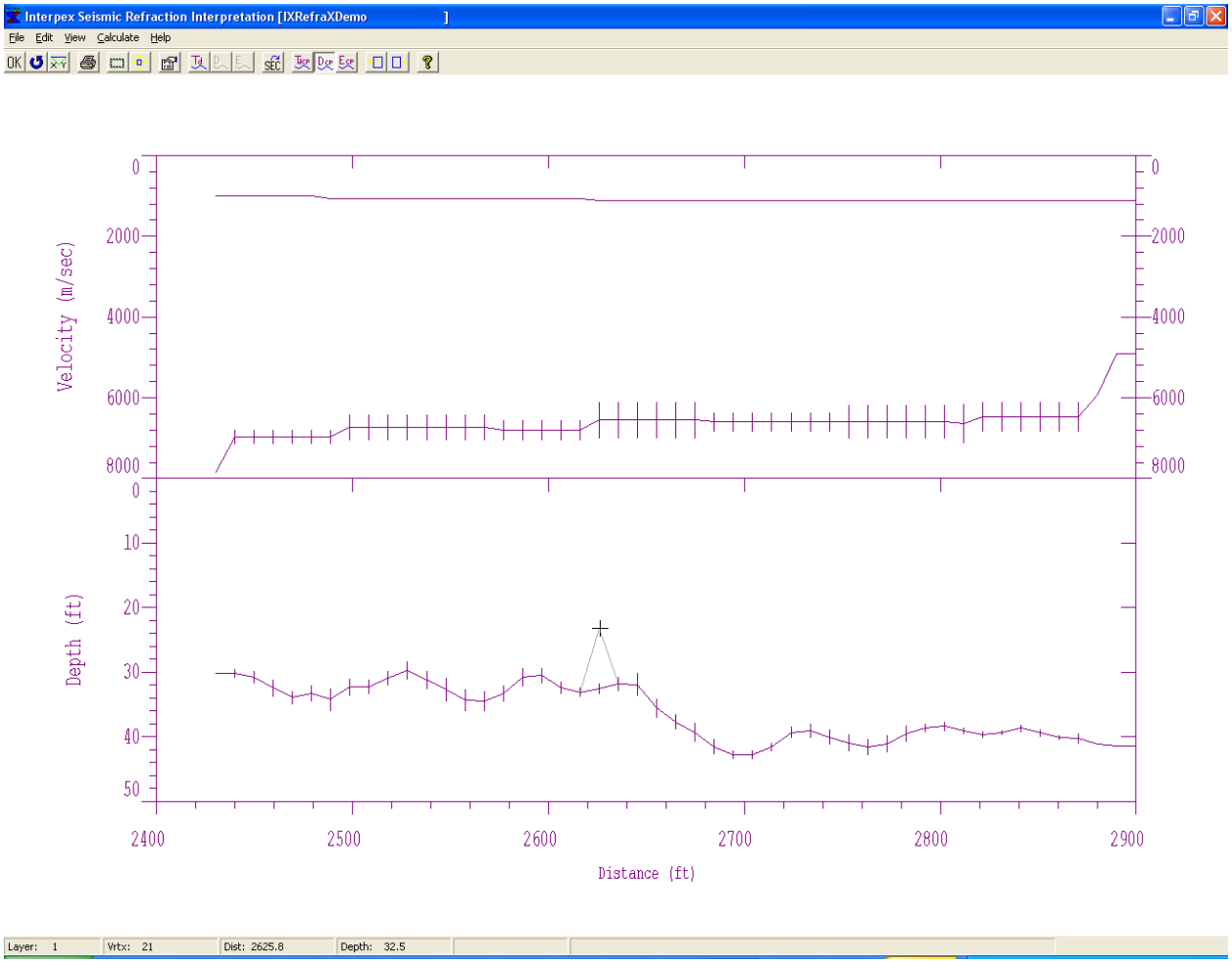
Press OK to interpolate as selected on previous dialog.

View Composite Section



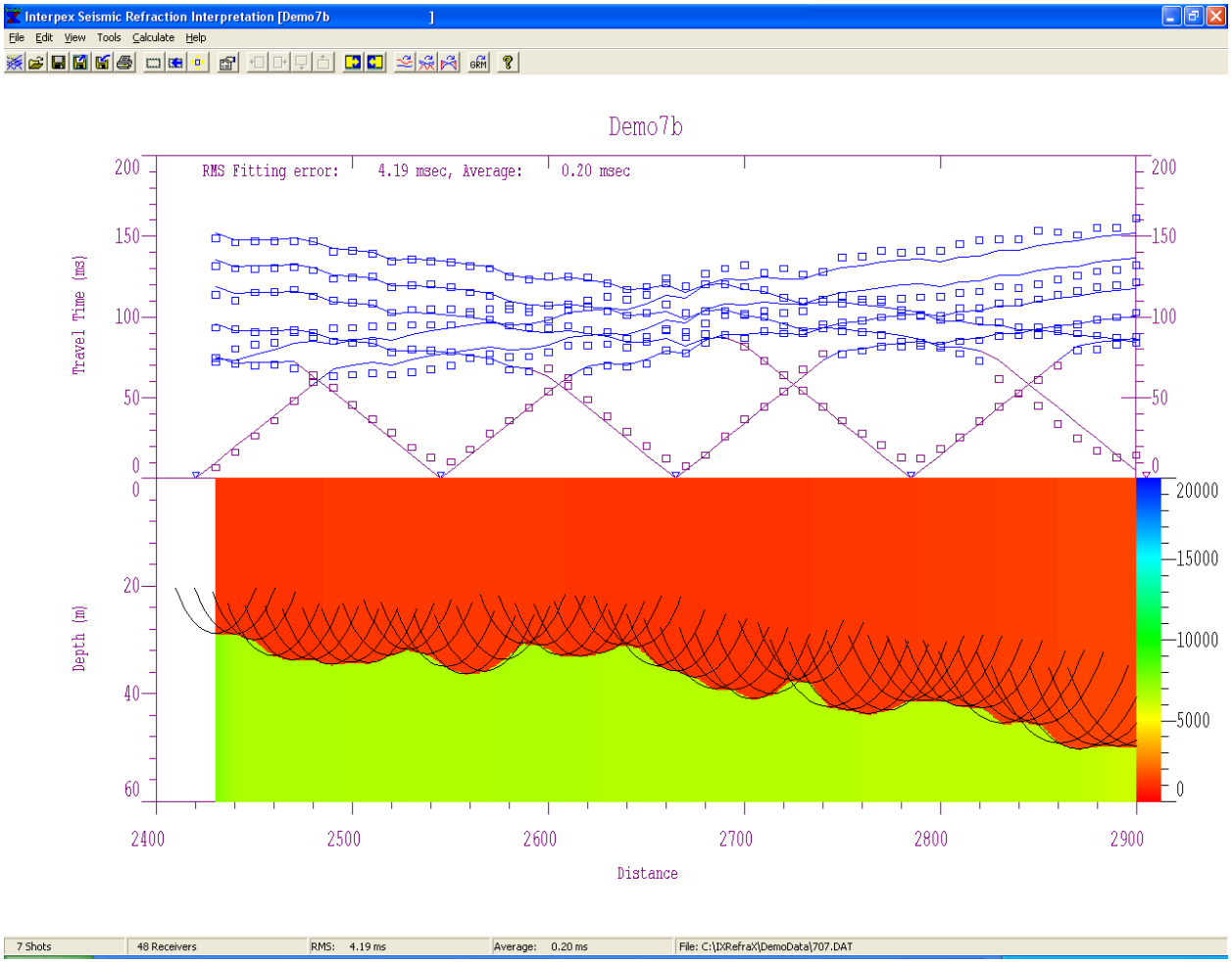
Composite section is averaged from available results. Vertical lines show error bars where more than one value was averaged to get the composite result. Press OK to return to main screen.

Edit Depth Values Graphically



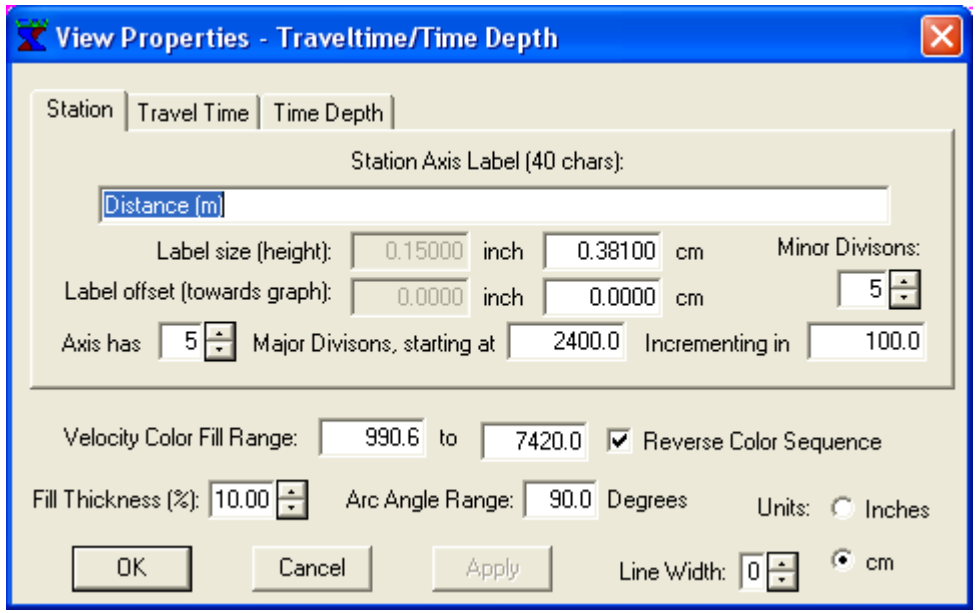
Pointing at a vertex in the composite section changes the mouse cursor to a crosshair. Pressing and holding the left mouse button allows you to drag the vertex to a new depth value.

Add Color Fill for Velocity and Arcs for Depths



Use View/Draw Arcs to display the wavefronts. Use View/Color Fill Velocity to color fill the velocity information in the model.

Edit Velocity Range and Fill Thickness



Use View/Properties to control the parameters for velocity color fill and the wavefront arcs.

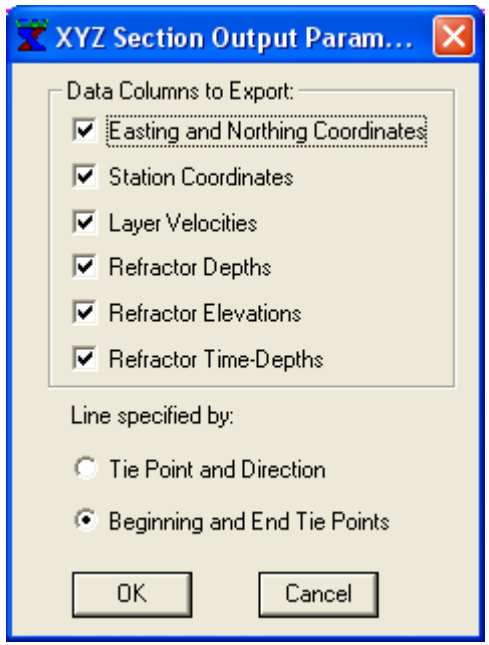
Velocity fill range should be specified to give good color indication of velocity and to be consistent with other profiles in the same project.

Color sequence can be reversed so that low velocities are blue and high velocities are red.

Fill thickness for previous slide is 100%. You can select a smaller fill thickness if desired.

The angle through which the wavefront arcs are drawn can also be changed.

Output Results to XYZ file



Easting and northing coordinates can be written so that each point has a map coordinate.

Station or profile coordinates can also be written for distance coordinate (cross-section display).

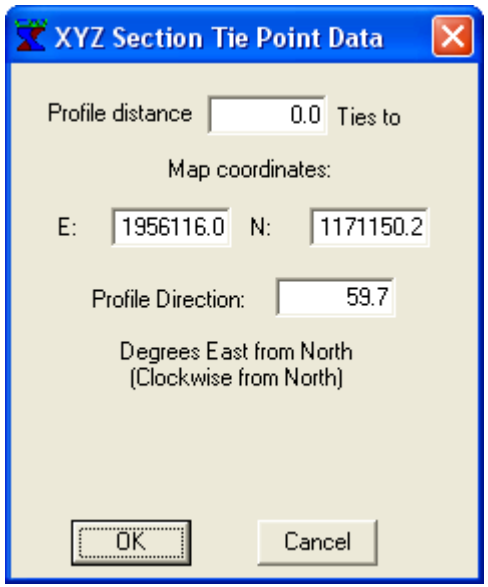
Velocities, depths, elevations and/or time-depths can be selected according to your requirements.

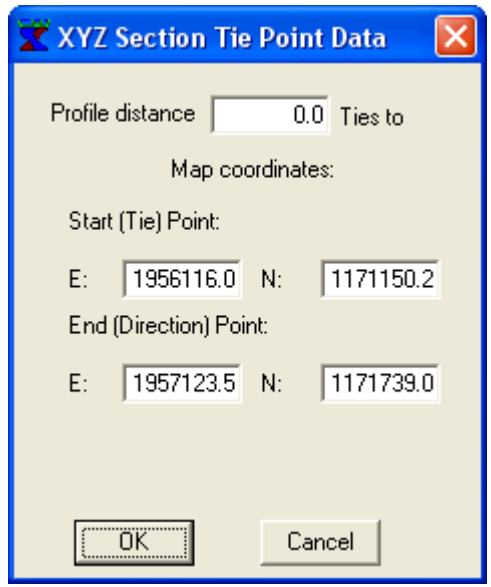
For easting and northing coordinates, the line direction can be specified by tie point and direction or by beginning and end tie points.

Note the end tie point is only used to calculate the angle and is offered as an alternative to using the angle. It is not used to stretch or compress the line.

Use File/Export/Results as XYZ File to write the results to an ASCII file so they can be imported into third party graphics software, for instance.

Output Results to XYZ file



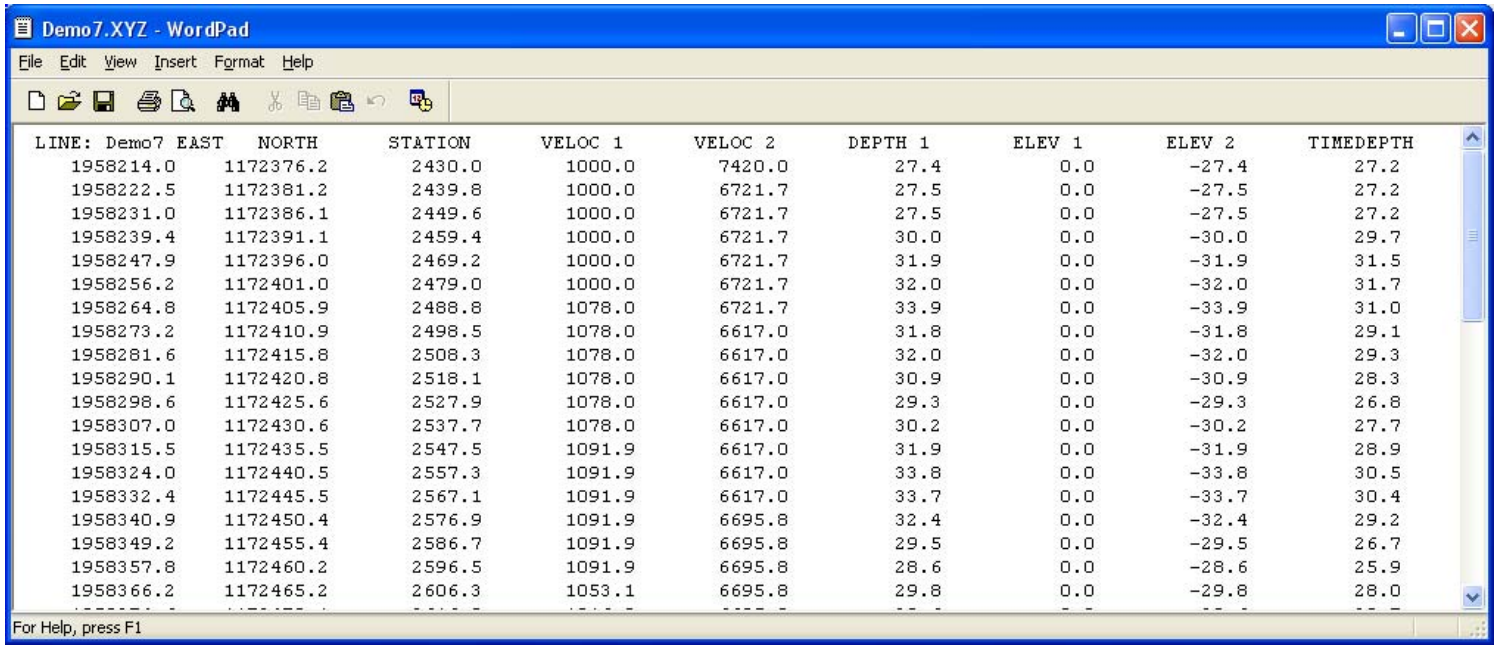


The profile distance must tie to a map point. Here, the map point 1956116.0E, 1171150.2N ties to the beginning of the profile at distance zero.

The profile direction can be specified as an angle clockwise from north (left dialog). In this case, the profile direction is approximately ENE. 0 is north, 90 is east, 180 is south, 270 is west.

The profile direction can be specified using the end point of the profile or any point along the profile or in the same direction beyond the profile.

Output Results to XYZ file



LINE: Demo7 EAST	NORTH	STATION	VELOC 1	VELOC 2	DEPTH 1	ELEV 1	ELEV 2	TIMEDEPTH
1958214.0	1172376.2	2430.0	1000.0	7420.0	27.4	0.0	-27.4	27.2
1958222.5	1172381.2	2439.8	1000.0	6721.7	27.5	0.0	-27.5	27.2
1958231.0	1172386.1	2449.6	1000.0	6721.7	27.5	0.0	-27.5	27.2
1958239.4	1172391.1	2459.4	1000.0	6721.7	30.0	0.0	-30.0	29.7
1958247.9	1172396.0	2469.2	1000.0	6721.7	31.9	0.0	-31.9	31.5
1958256.2	1172401.0	2479.0	1000.0	6721.7	32.0	0.0	-32.0	31.7
1958264.8	1172405.9	2488.8	1078.0	6721.7	33.9	0.0	-33.9	31.0
1958273.2	1172410.9	2498.5	1078.0	6617.0	31.8	0.0	-31.8	29.1
1958281.6	1172415.8	2508.3	1078.0	6617.0	32.0	0.0	-32.0	29.3
1958290.1	1172420.8	2518.1	1078.0	6617.0	30.9	0.0	-30.9	28.3
1958298.6	1172425.6	2527.9	1078.0	6617.0	29.3	0.0	-29.3	26.8
1958307.0	1172430.6	2537.7	1078.0	6617.0	30.2	0.0	-30.2	27.7
1958315.5	1172435.5	2547.5	1091.9	6617.0	31.9	0.0	-31.9	28.9
1958324.0	1172440.5	2557.3	1091.9	6617.0	33.8	0.0	-33.8	30.5
1958332.4	1172445.5	2567.1	1091.9	6617.0	33.7	0.0	-33.7	30.4
1958340.9	1172450.4	2576.9	1091.9	6695.8	32.4	0.0	-32.4	29.2
1958349.2	1172455.4	2586.7	1091.9	6695.8	29.5	0.0	-29.5	26.7
1958357.8	1172460.2	2596.5	1091.9	6695.8	28.6	0.0	-28.6	25.9
1958366.2	1172465.2	2606.3	1053.1	6695.8	29.8	0.0	-29.8	28.0

The profile distance for these data starts at 2,400 so the original tie point given in the previous slide for station zero does not appear in the output.

Note that all of the data need not be written. In this case, all data were selected for writing.