SEISMIC REFRACTION DATA QUALITY CONTROL IN SEISIMAGER/2D

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One limitation of using geophysical methods to image the subsurface is that for a given dataset there are multiple subsurface models that can fit the acquired data. Therefore extra caution needs to be put in data processing in order to constrain the final geophysical model as much as possible. One way is by quality checking the dataset and also ensuring that the processing steps and results comply with the laws of science that govern the geophysical technique being implemented. In the case of seismic refraction surveys there are two major steps during which human error can be introduced, picking of arrivals and editing of travel-times. By paying close attention to these steps we can increase the reliability of the final model. This handout will discuss the tests and tools one can utilize in Geometrics' SeisImager/2D for quality checking during refraction data processing. Below is a list of the tests in the order which they will be discussed.

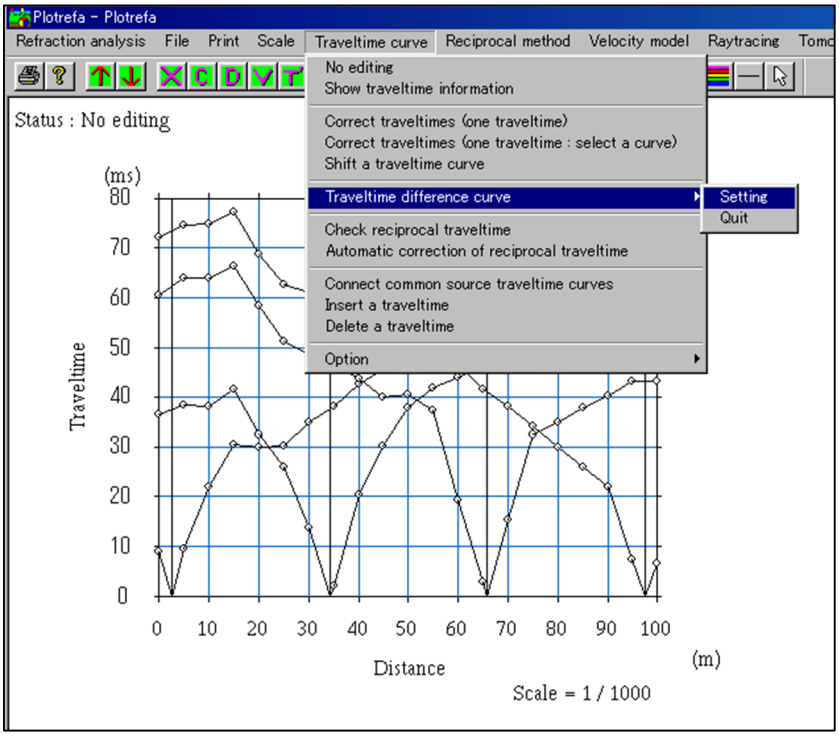
- i. Parallelism
- ii. Reciprocal travel-time
- iii. Crossover distance
- iv. Intercept time
- v. Ray Tracing

i. Parallelism

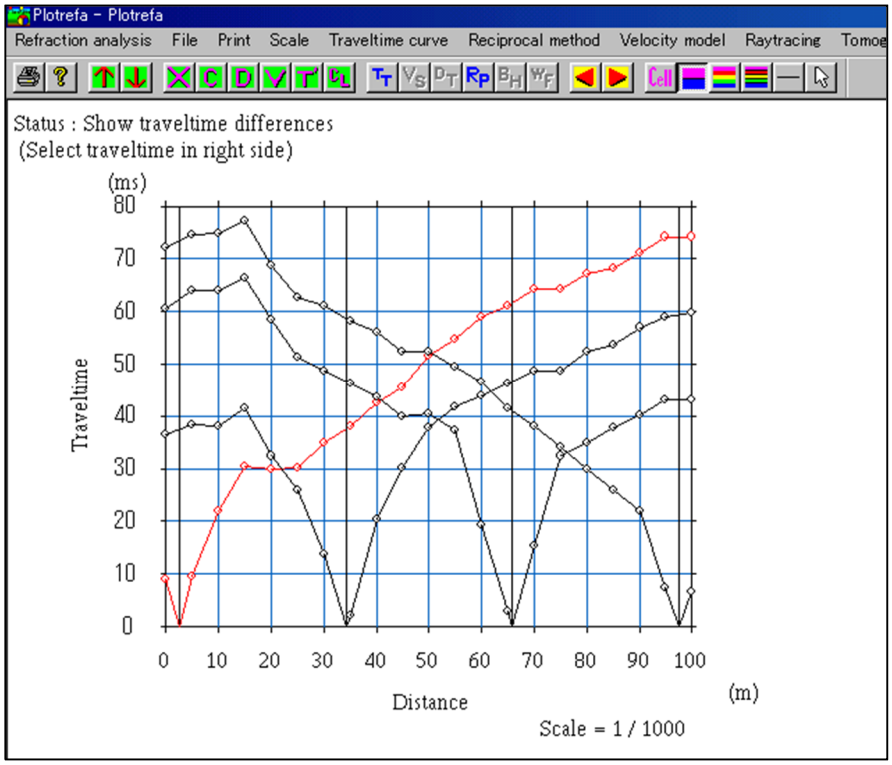
The parallelism test is based on the assumption we make in refraction seismology that in a layered model each layer has a specific velocity, and that velocity increases with depth. That said, the travel-times from the same layer should be parallel. A change in slope between two travel-times from the same layer would imply change in velocity thereby violating the assumptions of the layered model.

Checking the parallelism of travel-time curves in SeisImager/2D

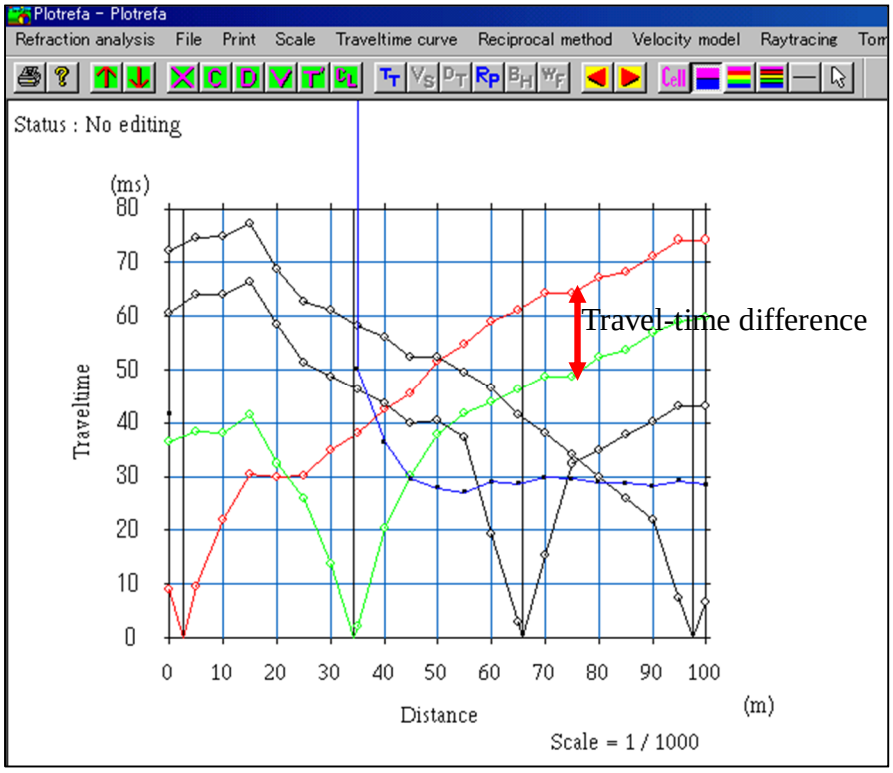
1. Select Travel-time curves >> Travel-time difference curve >> Setting. Or click the D button.



2. You want to select two travel-time curves whose travel-time difference you want to calculate. Start by right clicking the mouse to selecting the travel-time curve on the left side between the two. Hover your mouse on the travel-time and right click. The travel-time curve color changes to red.

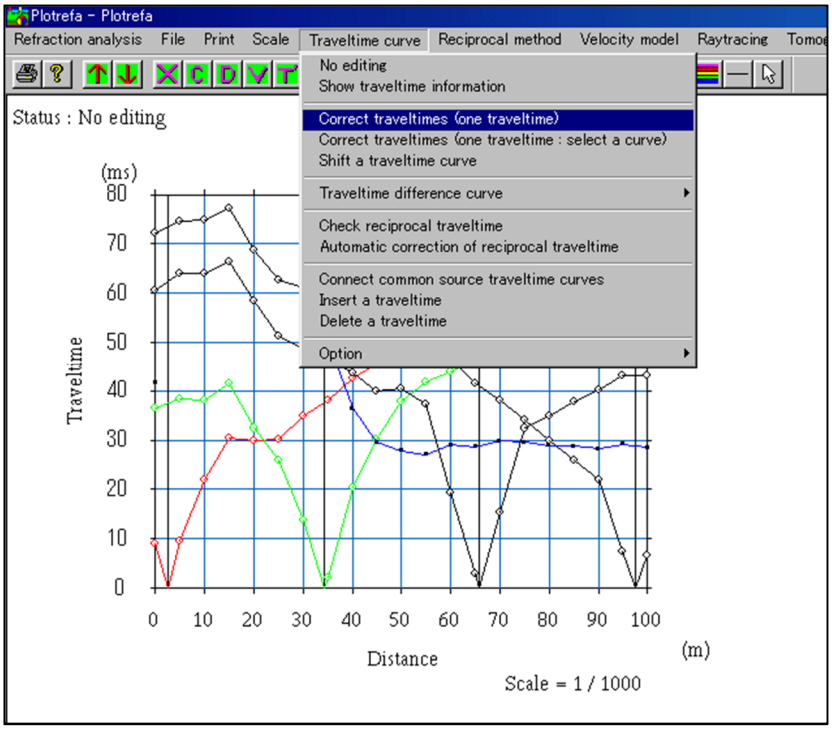


3. Next, select the travel-time curve on the right side. The travel-time curve color changes to green and travel-time difference curve is shown as a blue line

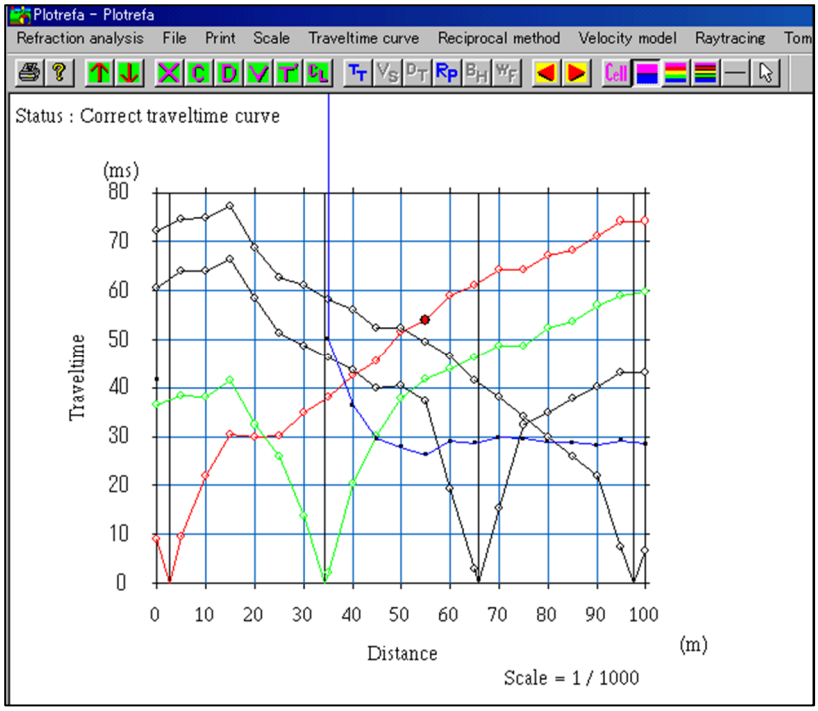


Plotrefa calculates the travel-time difference between the left travel-time (red) and the right (green). In the screen shot above the travel-time difference curve exponentially decreases until it becomes near horizontal, which means very small difference. Good data will have either a decreasing or constantly flat travel-time difference curves. Use this principal to correct travel-times.

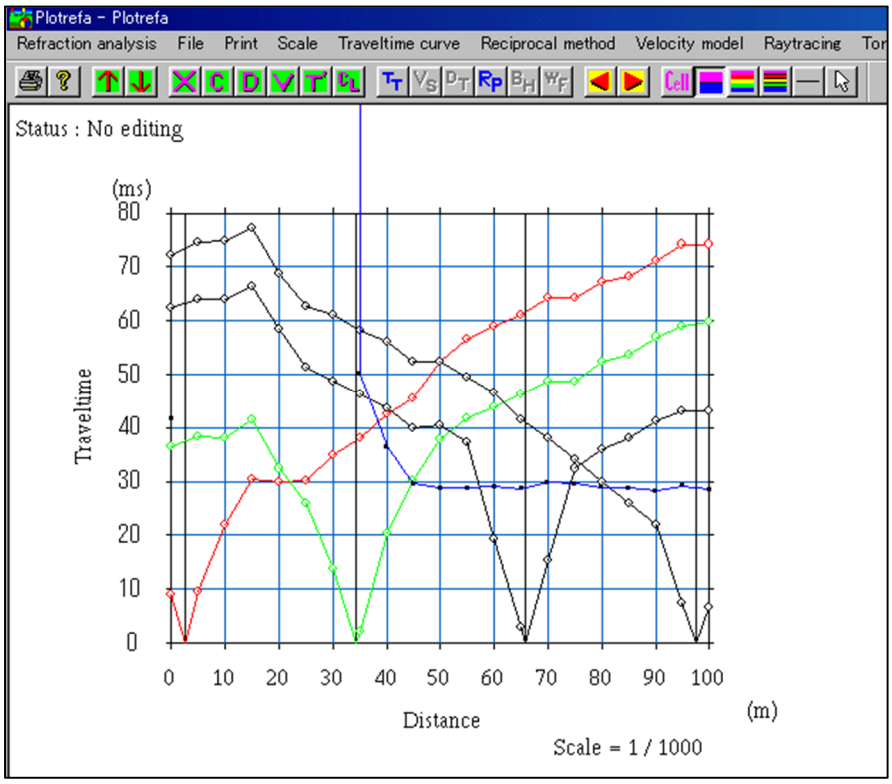
4. To correct travel-times either select Travel-time curve >> Correct travel-times (one travel-time) or click the C button.



5. Click the travel-time to be corrected using the mouse left button (the travel-time changes to red), then drag the mouse to the location that travel-time should be placed, and release the button.



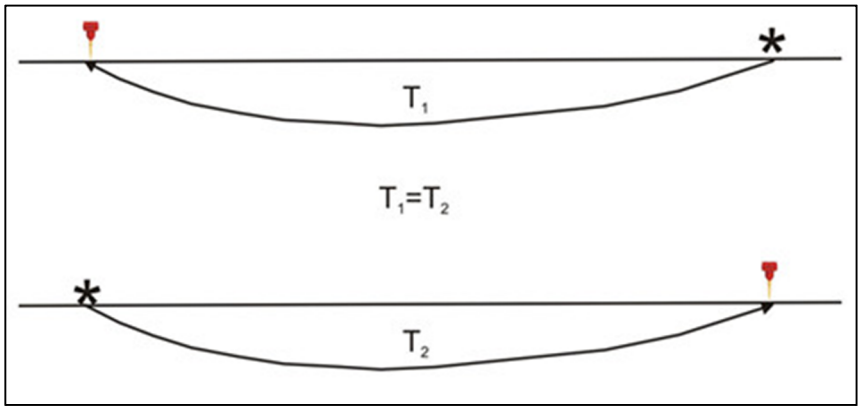
6. The travel-time will move to a new position and the difference curve will also reflect the changes.



7. All travel-times should be checked similarly and corrected if necessary. Typically you should not be significantly editing the travel-times as this means you are changing the location of your first breaks. So if you need to correct travel-time curves significantly, you are advised to back to PickWin and edit your picks in the waveform data.

ii. Reciprocal travel-time

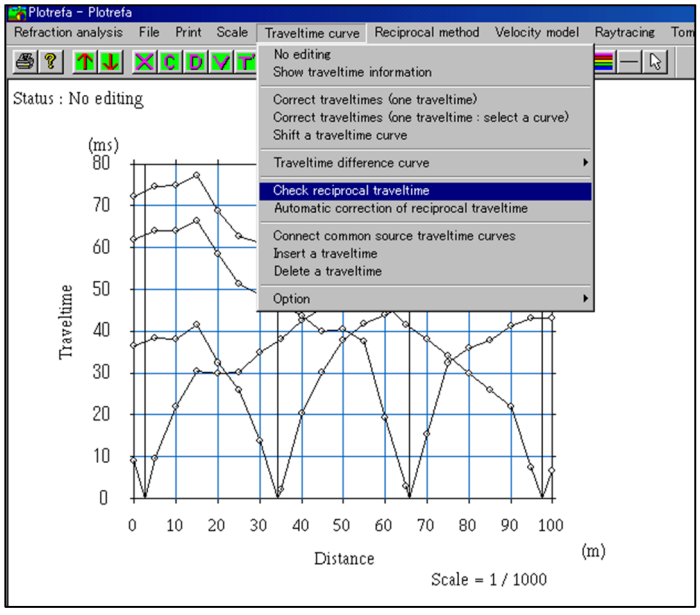
The principal of reciprocity states that the time required for seismic energy to travel between two points is independent of the direction it is traveling. This is illustrated in the diagram below where interchanging the geophone and shot location does not change the travel-time.



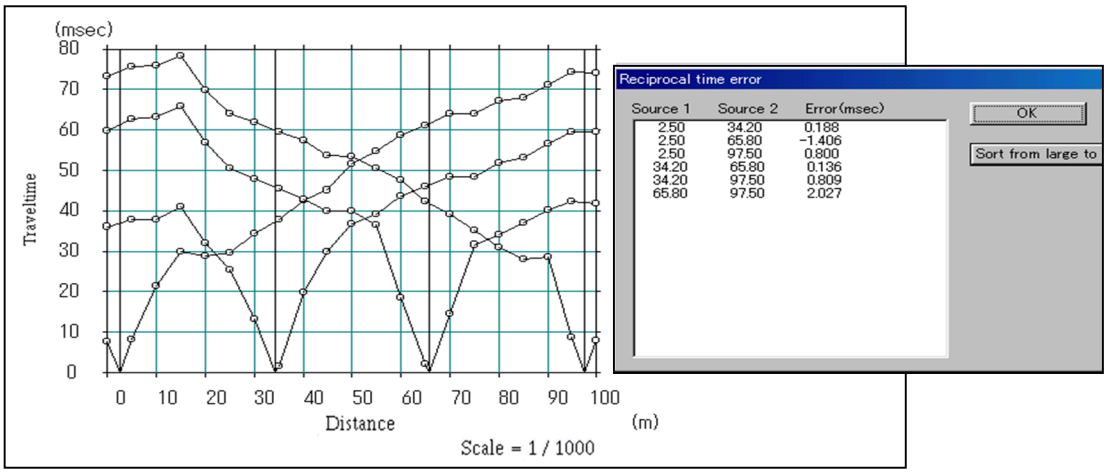
SeisImager has a built in function that allows you to calculate the reciprocal time error between all your shots in a given survey.

Calculating Reciprocal Traveltime in SeisImager

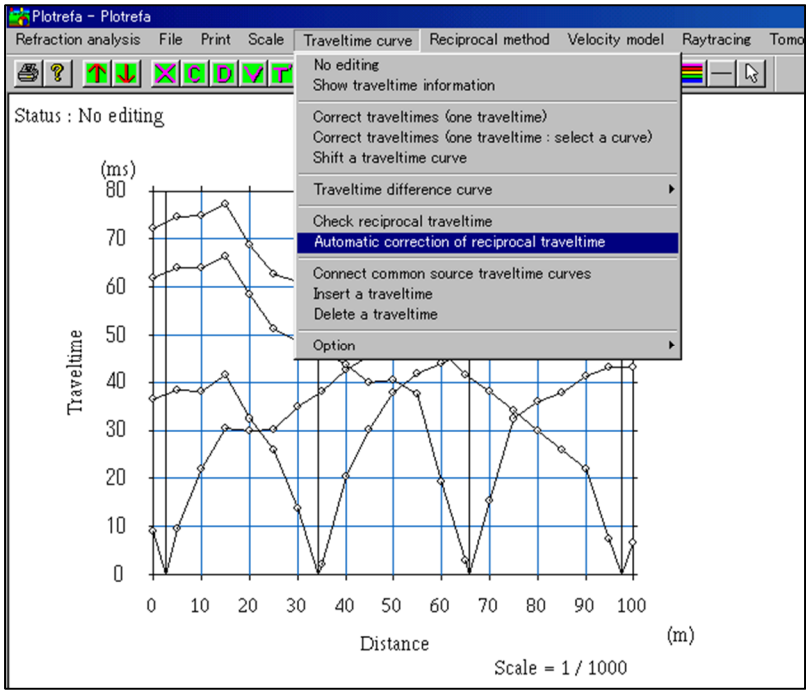
1. Select 'Travel-time curve >> Check reciprocal travel-times.



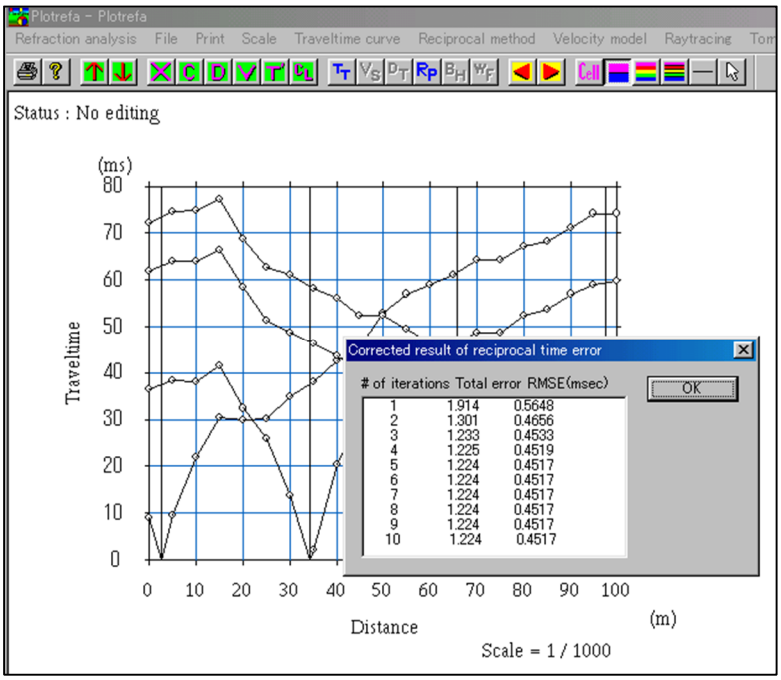
2. Reciprocal times for all travel-time curve pairs are shown. You can use this information to correct reciprocal travel-times. You can either correct them automatically or manually by shifting travel-time curves.



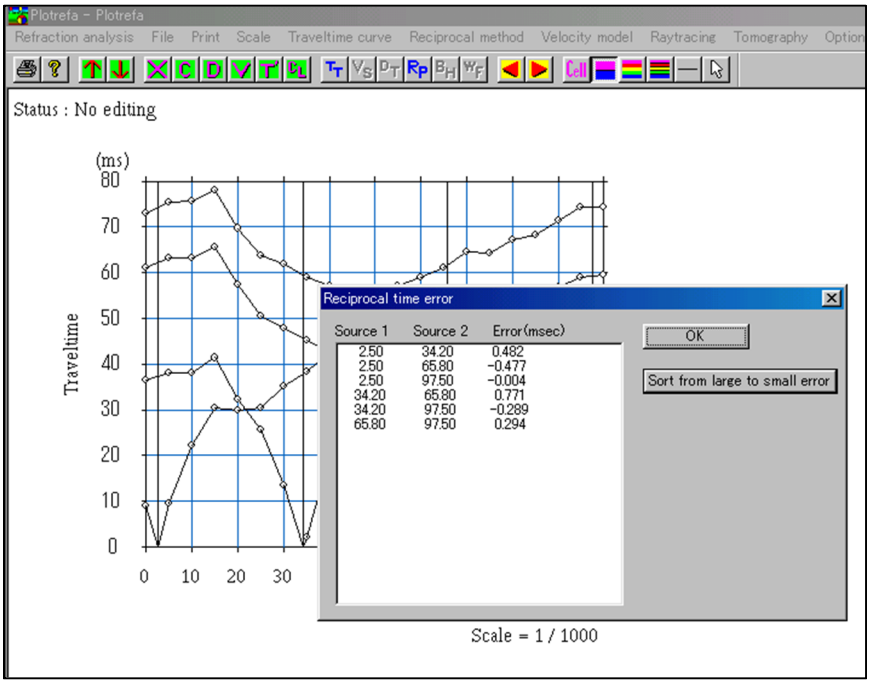
3. To correct automatically Select Travel-time curve >> Automatic correction of reciprocal travel-time.



4. Travel-times will be corrected iteratively and you should see the total error and residual time (RMSE) decreasing.



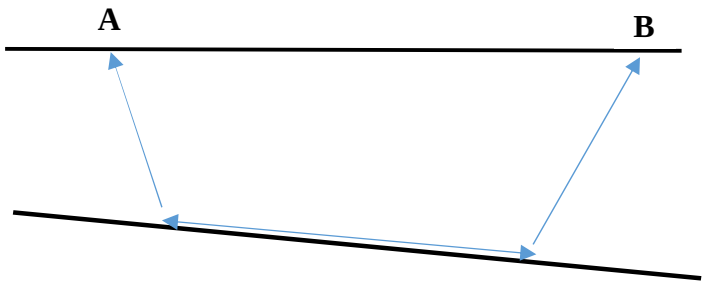
5. A new dialogue box will pop up showing the recalculated reciprocal travel-time difference. The new travel-time differences should be smaller than the initial ones before correction. You will get a message that automatic correction of travel-times is done and the corrected travel-time curves will be displayed.



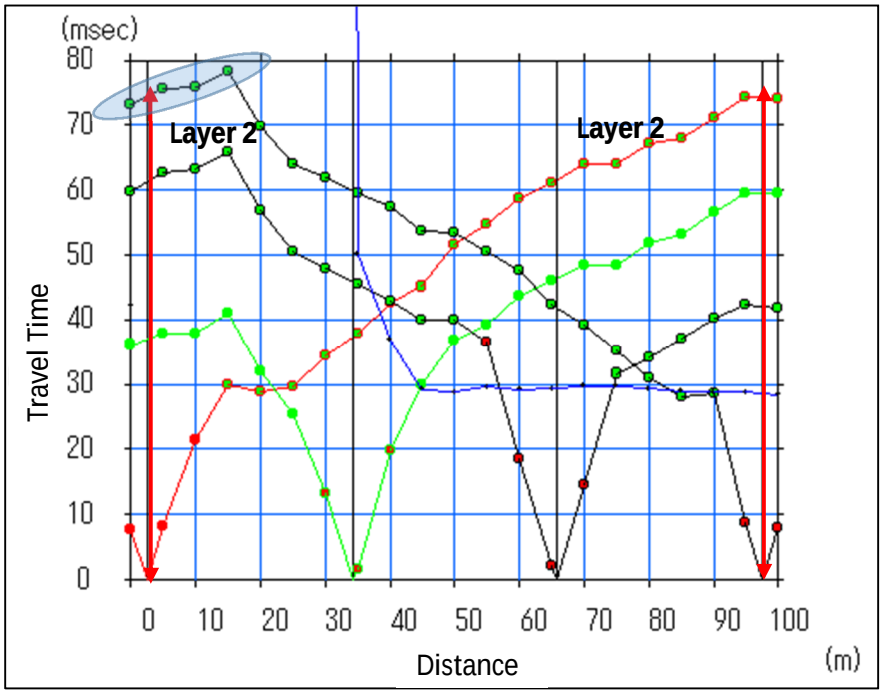
6. If you would like to manually shift a travel-time curve, use Travel-time curve >> Shift a travel-time curve. Then go on to left click and drag the travel-time to a new position. You can vertically shift travel-time curves up or down. Shift all travel-times that need correction and then click the  button to exit the edit mode.

Crossover distance (layer Assignment)

This principle states that the layer assignment should be same in reciprocal travel-times because in both the forward and reverse shot the head wave ray is coming from the same layer boundary. Looking at the diagram below we see that in the reciprocal times T_{AB} and T_{BA}, the ray arriving at the geophone in both cases is from the refraction at the boundary of layer two and one. This principal holds regardless of the number of layers.

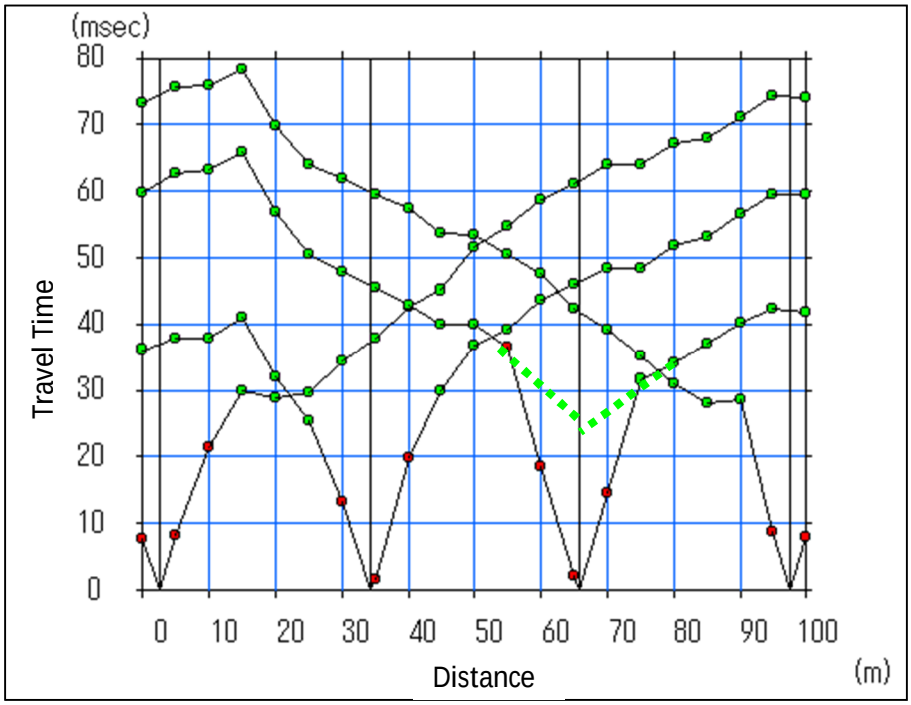


In the example below from SeisImager, the layer assignment is the same for the reciprocal times. Use this principle to help you with layer assignment. Below one could have interpreted the circled segment of the travel-time below as a third layer, but based off the principle of cross over distances we know that it is actually still layer two.



Intercept time

Intercept time from both sides of travel-time curves should be same or at least be very close as shown in the example below.



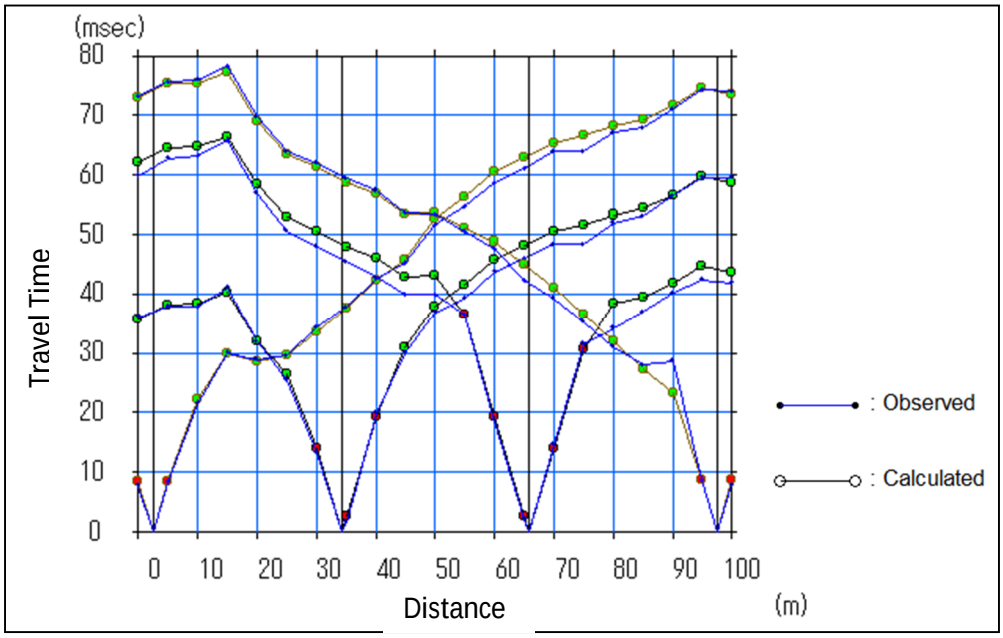
When not sure where to place layer assignment use this rule to find the cross over distances on travel-times from one shot.

Ray tracing

After computing a velocity model in SeisImager one can ray trace in order to understand the distribution of ray coverage in the computed model space. This is important because ray density positively correlates with reliability of the model space. Areas with increased ray coverage are more reliable than those with less.

Raytracing in SeisImager/2D

1. Execute the ray tracing by going to Raytracing >> Execute. SeisImager will execute the ray tracing and display both the observed and calculated rays. Additionally a box will pop up with the RMSE error between the observed and calculated rays.



If there is large RMSE error between your observed and calculated data then you should go back and edit your travel time curves and picks for first breaks.

2. Go back to the velocity model then choose View >> Show raypath to display the ray paths on the velocity model. The rays will be plotted on the calculated velocity model. In the example below we can see that there is good ray coverage across the whole velocity model, which is good.