WET tomographic inversion and dynamic Poisson's ratio imaging for data sets WAVE_P and WAVE_SH as sent by Dr. Anibaldi, Geomethodo s.r.l. in 2004 with Rayfract® 4.04 and Surfer 23 in June 2023 :

Data import into Rayfract™ profile database

Download ASCII .ASC formatted files WAVE_P.ASC and WAVE_SH.ASC from our web site :

https://rayfract.com/tutorials/poisson.zip .

Now create two new Rayfract™ profile databases named WAVE_P and WAVE_SH, as described in our short manual as available at https://rayfract.com/help/manual.pdf . When prompted in version 4.05 to force first receiver station number to 1 click *Yes* button (Fig. 24).

Specify a *Station spacing* of 5 meters in *Header|Profile*.

Then copy file WAVE_P.ASC into directory \RAY32\WAVE_P\INPUT, and copy WAVE_SH.ASC into directory \RAY32\WAVE_SH\INPUT using Windows Explorer.

Now import these ASCII .ASC files into their respective profile databases, as described in above manual. Specify import data type ASCII column format, and use the default receiver spread type 01: 24 channels. Check option "Batch import", so you don't need to confirm layout start and shot position etc. for each individual shot.

WET tomography processing WAVE_P line with 1D-gradient initial model and 50 WET iterations

- open profile C:\RAY32\WAVE_P with *File|Open Profile*
- select *Header|Profile* and check box *Force grid cell size.* Set *Cell size* to 0.1m (Fig. 12)
- select *Model|WDVS Smoothing* and uncheck option ***use WDVS*** (Fig. 13)
- check option ***Discard WET smoothing and WDVS smoothing after modeling***. Click button OK.
- select *Smooth invert|Custom 1D-gradient velocity profile* and edit as in Fig. 14
- check option *Force grid limits*. Set field *Grid bottom elevation [m]* to -12.5m. Click button OK.
- select *Smooth invert|WET with 1D gradient initial model*
- confirm the following prompt to obtain our default interpretation based on 20 WET iterations
- select *Grid|Surfer plot Limits* and edit as in Fig. 15
- select *WET Tomo|Interactive WET tomography...* and set parameter *Number of WET tomography iterations* to 50. Set *Wavepath envelope width* to 2% (Fig. 16).
- click button *Start tomography processing*. You will obtain the following P-wave tomogram :

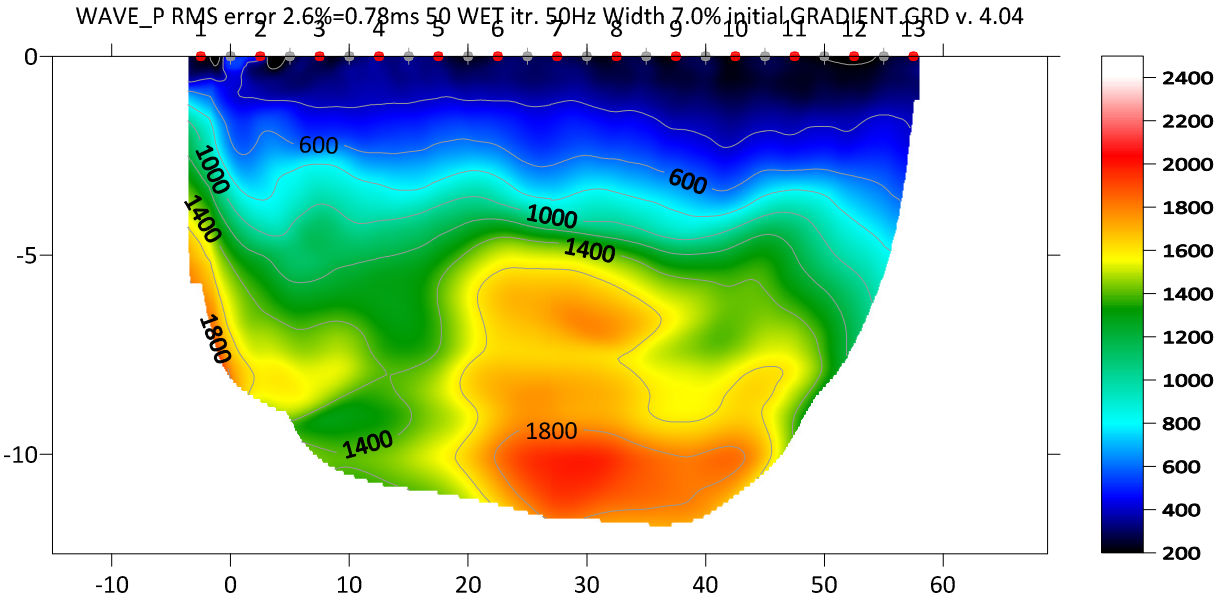


Fig. 1 : 50 WET iterations with 1D-gradient initial model for line WAVE_P. Discard WET smoothing. WDVS disabled. Full WET smoothing (Fig. 16). WET frequency 50Hz. Wavepath width 7%. Envelope width 2%. WET wavepath coverage plot shown in Fig. 19.

Next we compute the S-wave tomogram with profile WAVE_S opened

- open profile C:\RAY32\WAVE_SH with *File|Open Profile*
- select *Header|Profile* and check box *Force grid cell size.* Set *Cell size* to 0.2m (Fig. 12)
- select *Smooth invert|WET with 1D gradient initial model*
- confirm the following prompt to obtain our default interpretation based on 20 WET iterations
- select *Grid|Surfer plot Limits* and edit as in Fig. 18.
- select *WET Tomo|Interactive WET tomography...* and set parameter *Number of WET tomography iterations* to 50 (Fig. 17)
- click button *Start tomography processing*. You will obtain the following S-wave tomogram :

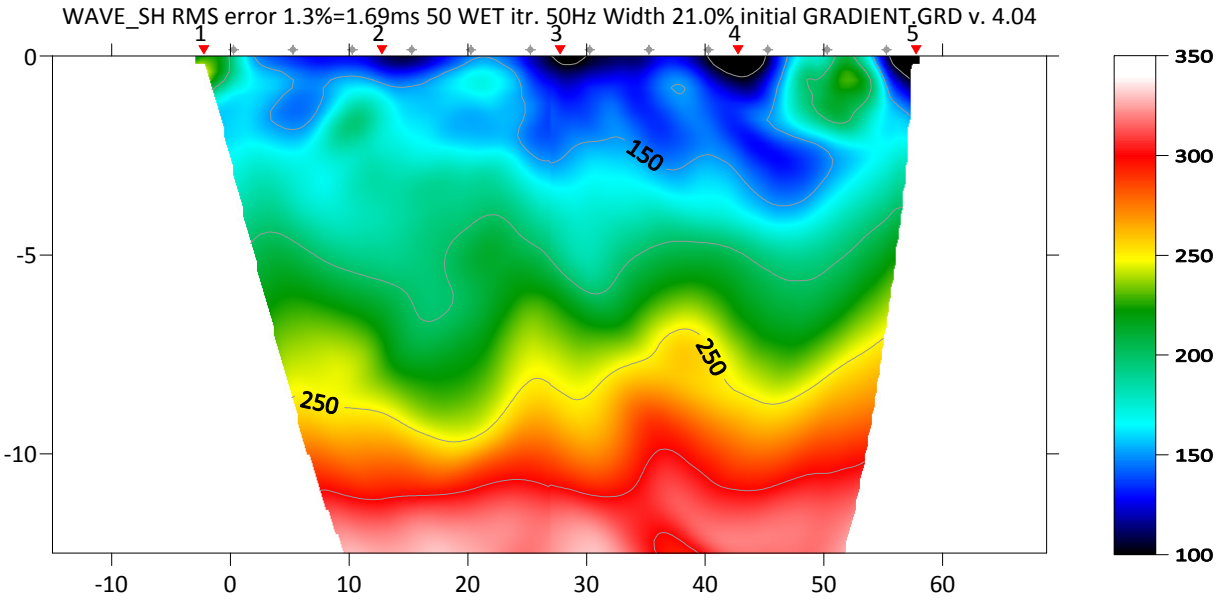


Fig. 2 : 50 WET iterations with 1D-gradient initial model for line WAVE_SH. Discard WET smoothing. WDVS disabled. Full WET smoothing. WET wavepath width 21%. WET frequency 50Hz. WET wavepath coverage plot shown in Fig. 20.

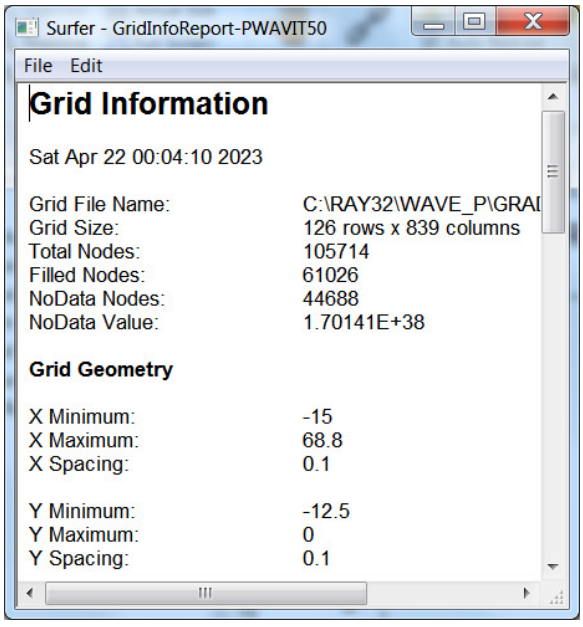


Fig. 3 : Grid Info PWAVIT50.GRD

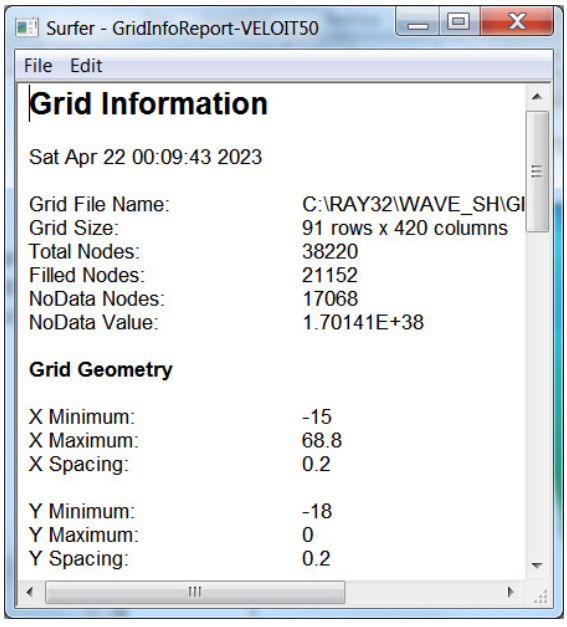


Fig. 4 : Grid Info SHWVIT50.GRD

Construction of dynamic Poisson's ratio image map for lines WAVE_P and WAVE_SH

Here we show how to image dynamic Possion's ratio with Surfer 23 operations Extract Grid, Grid Mosaic and Grid Math. See your Surfer 23 manual for more details on these grid operations.

- open a Windows Explorer window with Windows Start menu / magnifier search icon in Start menu
- change into directory \RAY32\WAVE_P\GRADTOMO and copy file VELOIT50.GRD to PWAVIT50.GRD.
- change into directory \RAY32\WAVE_SH\GRADTOMO and copy file VELOIT50.GRD to SHWVIT50.GRD.
- start up Surfer 23 via desktop icon
- in box ***Search commands and help*** at top of Surfer main window enter search term **`grid info`**
- select topmost match **`Grid Info`**. Click *Browse* button and select above PWAVIT50.GRD.
- click Open button and OK button to obtain Fig. 3.
- repeat the last 3 steps with above SHWVIT50.GRD to obtain Fig. 4.

To be able to carry out Grid Math operations based on above two grids, we first need to resize and resample SHWVIT50.GRD to the size and density (row, column count and cell size) of PWAVIT50.GRD.

- in Surfer main window select *File\New\Plot Document*
- enter search term **`Extract`** at top and select topmost match **`Extract`**
- click Browse and select SHWVIT50.GRD and edit field „First row" to 28, as shown below. I.e. vary this field until „Minimum y" optimally fits the minimum y value of PWAVIT50.GRD amounting to -12.5.
- click on the Folder icon to the right of edit field Output Grid and enter file name SHWVCLIP.GRD.
- click on Save, and then click on OK to generate the clipped grid file (Fig. 5)

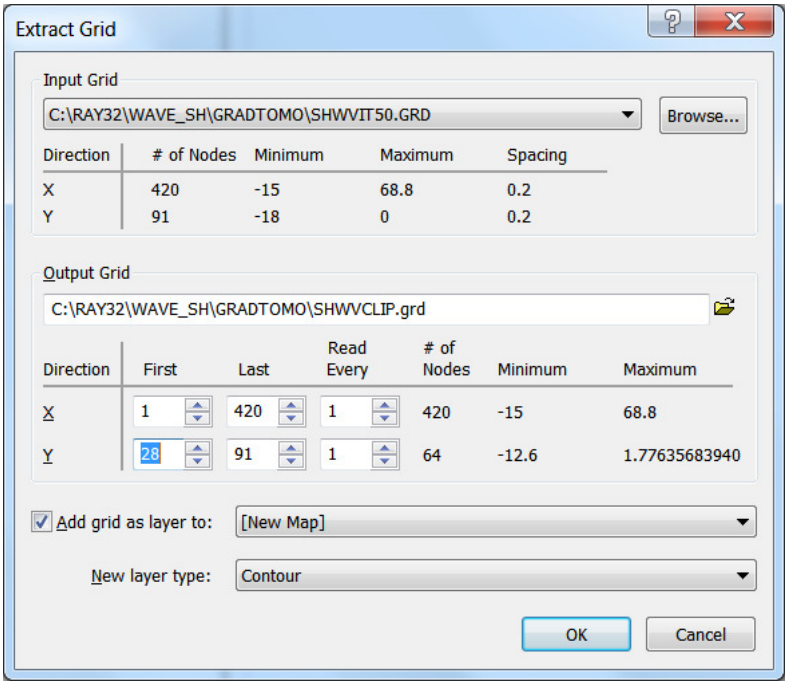


Fig. 5 : Extract S-wave grid matching size of P-wave grid.

- select *File\New\Plot Document*
- enter search term **`Mosaic`** at top and select topmost match **`Mosaic`**
- select SHWVCLIP.GRD and click Open button
- edit the dialog as shown below in Fig. 6 : set Output Grid to SHWVSIZE.GRD.
- set X # of Nodes to 839, and set Y # of Nodes to 126, i.e. to the same values as for PWAVIT50.GRD. Then click on OK to generate the resampled grid file :

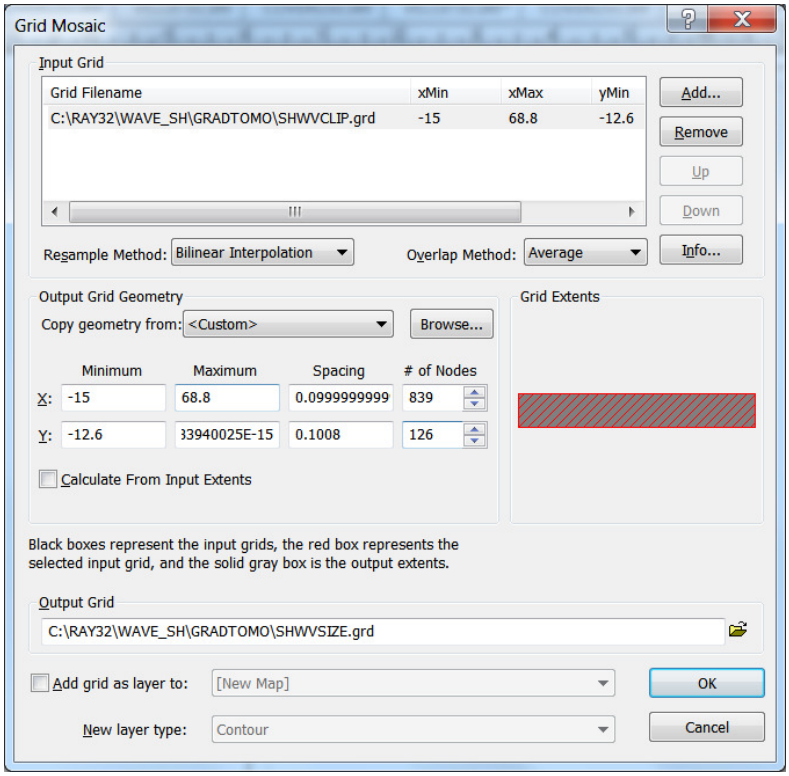


Fig. 6 : resample clipped S-wave grid to P-wave grid cell size of 0.1m using Mosaic dialog.

- select *File\New\Plot Document*
- enter search term **`Math`** at top and select topmost match **`Math`**
- click button Add Grids and select PWAVIT50.GRD (Fig. 7)
- click Add Grids again and select SHWVSIZE.GRD
- set Output Grid to C:\RAY32\WAVE_SH\GRADTOMO\RATIO.GRD
- set "Enter a function of the form f(A,B) " to A / B and click on OK. Confirm the following prompt to generate a grid containing the ratio of P-wave velocity to S-wave velocity :

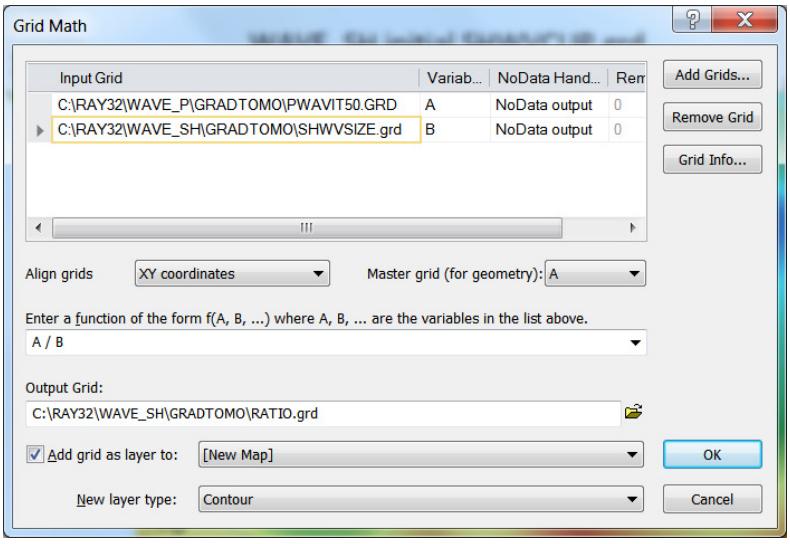


Fig 7 : determine ratio of P-wave grid to S-wave grid and save to RATIO.GRD

- in our Grid menu select command Surfer plot Limits
- check new option ***Use data limits*** and click OK button (Fig. 18)
- in same Grid menu select new command ***Image Surfer .GRD file without .PAR file***
- select C:\RAY32\WAVE_SH\GRADTOMO\RATIO.GRD to obtain Fig. 8 showing the velocity ratio

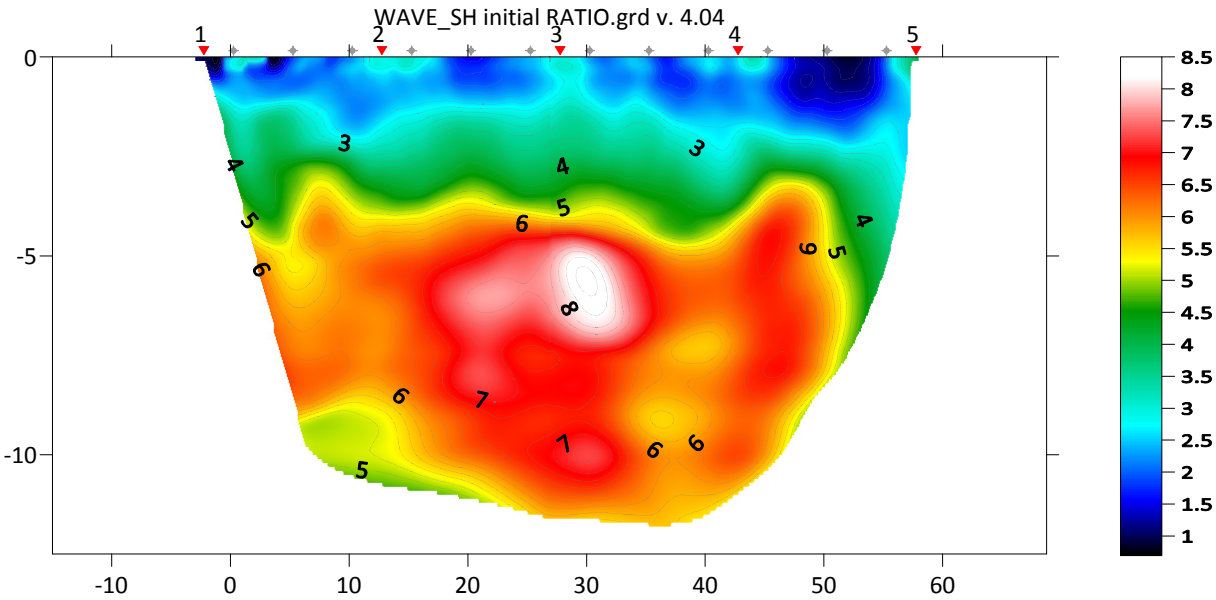


Fig. 8 : image P-wave to S-wave velocity ratio obtained as in Fig. 7. Compare to our original tutorial https://rayfract.com/tutorials/poisson.pdf .

- select *File\New\Plot Document*
- enter search term **`Math`** at top and select topmost match **`Math`**
- click button Add Grids and select PWAVIT50.GRD (Fig. 9)
- click Add Grids again and select SHWVSIZE.GRD
- set Output Grid to C:\RAY32\WAVE_SH\GRADTOMO\POISSON.GRD
- set "Enter a function of the form f(A,B) " to (pow(A,2) - 2*pow(B,2)) / (2*(pow(A,2) - pow(B,2))) and click on OK
- confirm the prompt to generate a grid containing the Dynamic Poisson's ratio (Fig. 10)

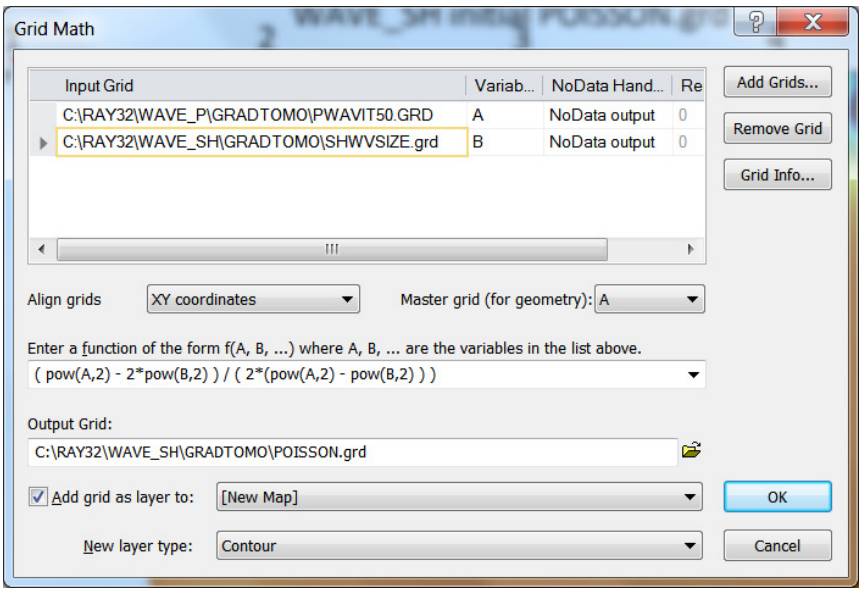


Fig 9 : determine dynamic Poisson's ratio of velocity grids and save to POISSON.GRD

- in our Grid menu select command Image Surfer .GRD file without .PAR file
- select C:\RAY32\WAVE_SH\GRADTOMO\POISSON.GRD to obtain Fig. 10 showing the dynamic Poisson's ratio
- in Surfer plot / Contents tab select item Color Relief-POISSON.GRD (Fig. 11 at left)
- in Properties window / General tab click button … at end of Colors row
- uncheck option "Use data limits". Set Minimum to 0 and Maximum to 0.7. Of course the real maximum value is 0.5, but the display looks better with 0.7.
- move the "Color spectrum" nodes for yellow and red closer together, to obtain a display as in Fig. 10

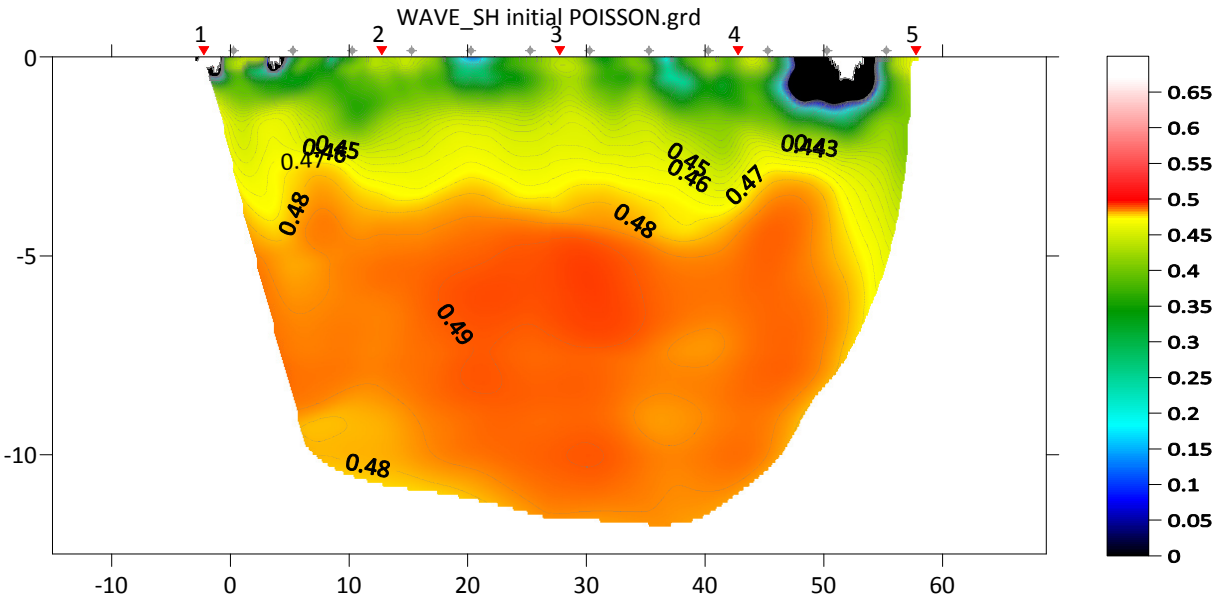


Fig. 10 : Dynamic Poisson's ratio of velocity grids determined as in Fig. 9

Move the yellow and red color spectrum nodes, until the Poisson's ratio is shown with optimum contrast, in the deeper half of above plot. Note the similarity of above dynamic Poisson's ratio plot to the simple P-wave to S-wave velocity ratio plot (Fig. 8). When you are done, select File|Save As and specify file name POISSON.SRF.

The abnormally low Poisson's ratio (approaching 0) just below the topography at the right end of the section can be explained by too early picks for traces 10 & 11 of shot nr. 5 of line WAVE_SH. The corresponding high velocity anomaly is clearly visible in the earlier S-wave velocity tomogram.

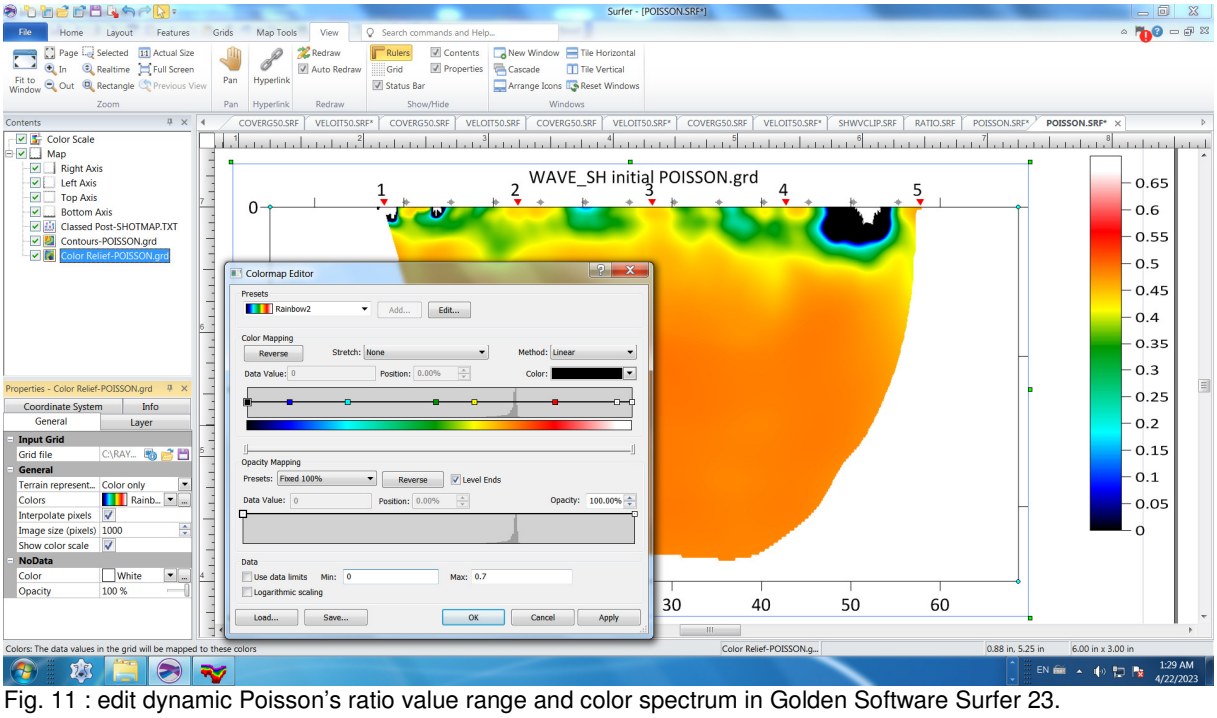


Fig. 11 : edit dynamic Poisson's ratio value range and color spectrum in Golden Software Surfer 23.

We thank Dr. Anibaldi at Methodo s.r.l. for making available in 2004 above consistently picked .ASC profiles.

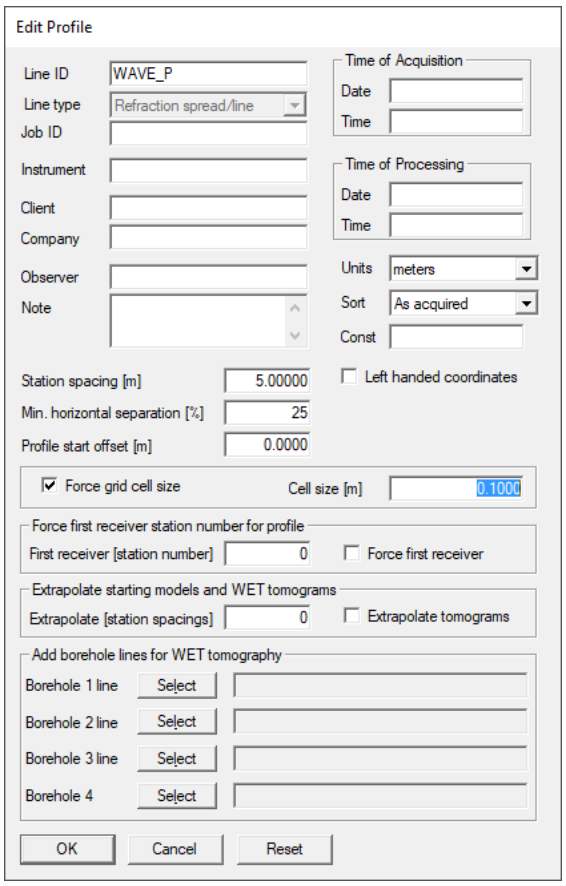


Fig. 12 : *Header|Profile*

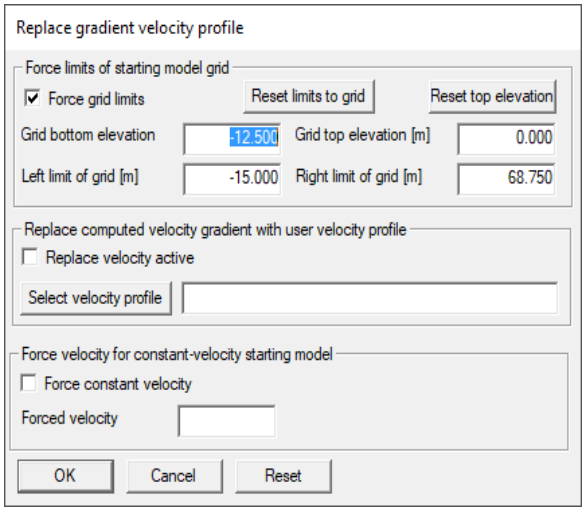


Fig. 14 (above) : *Smooth invert|Custom 1D-gradient velocity profile* for profile WAVE_P

Fig. 15 (right) : *Grid|Surfer plot Limits* for profile WAVE_P

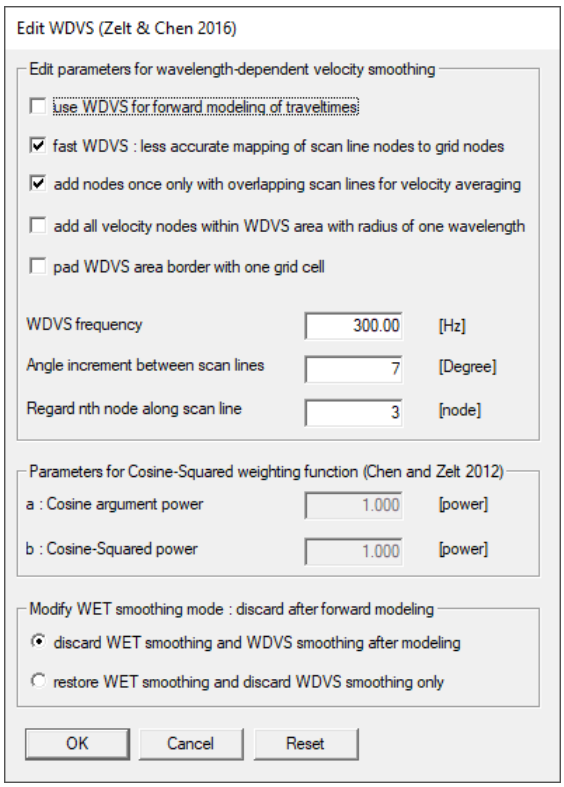
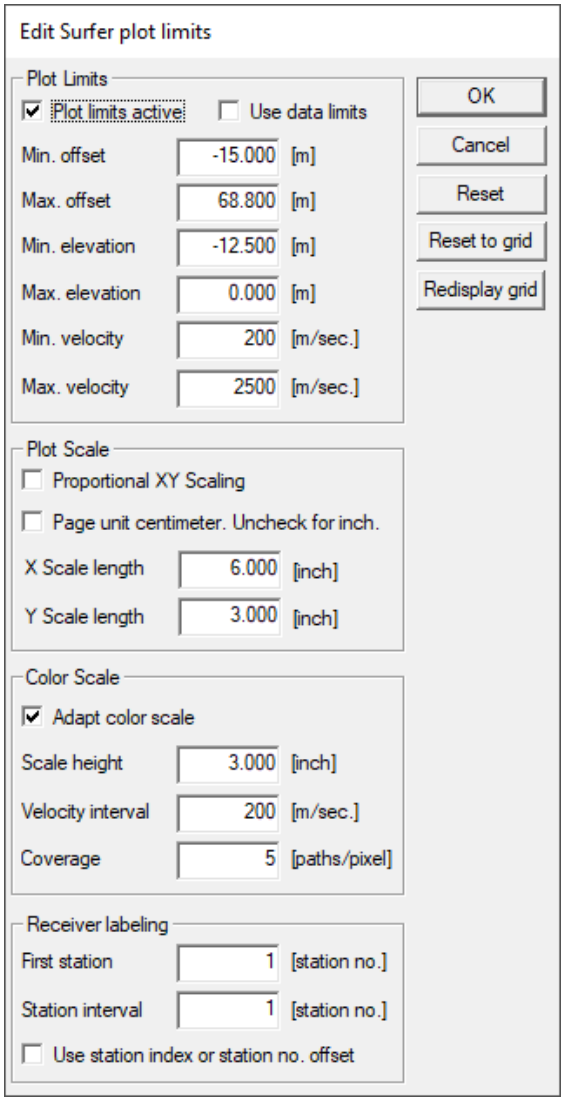


Fig. 13 : *Model|WDVS Smoothing*



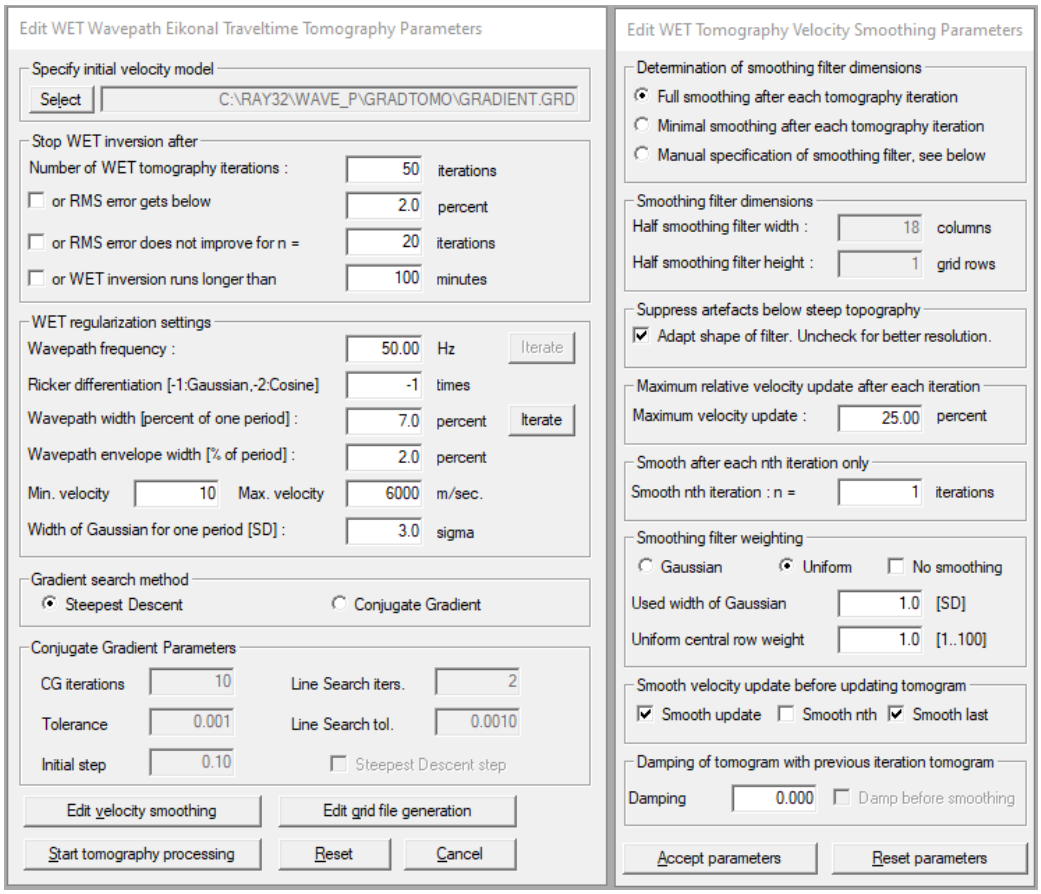


Fig. 16 : *WET Tomo|Interactive WET tomography* main dialog for WAVE_P (left). *Edit velocity smoothing* (right).

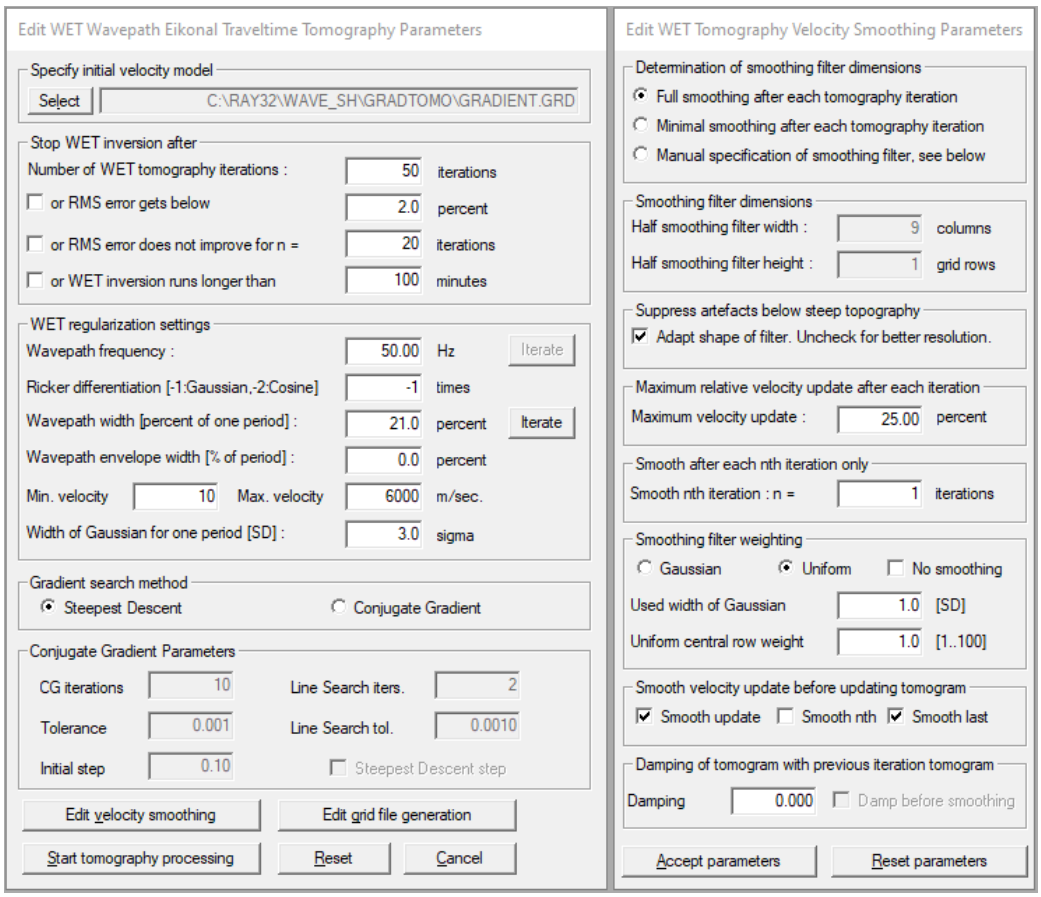


Fig. 17 : *WET Tomo|Interactive WET tomography* main dialog for WAVE_SH (left). *Edit velocity smoothing* (right).

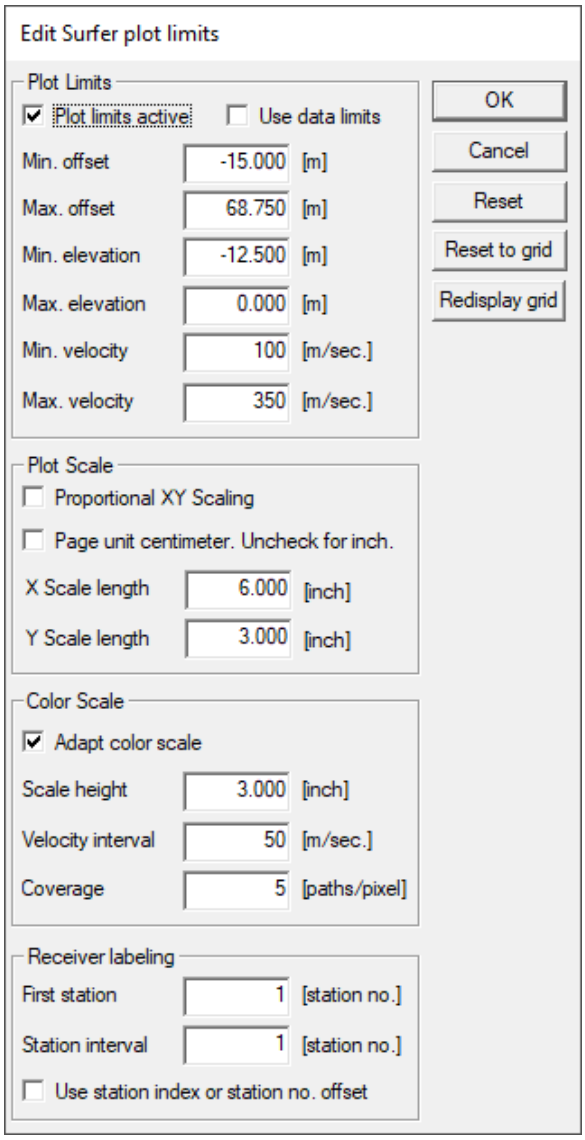


Fig. 18 (left) : *Grid\Surfer plot Limits* for line WAVE_SH

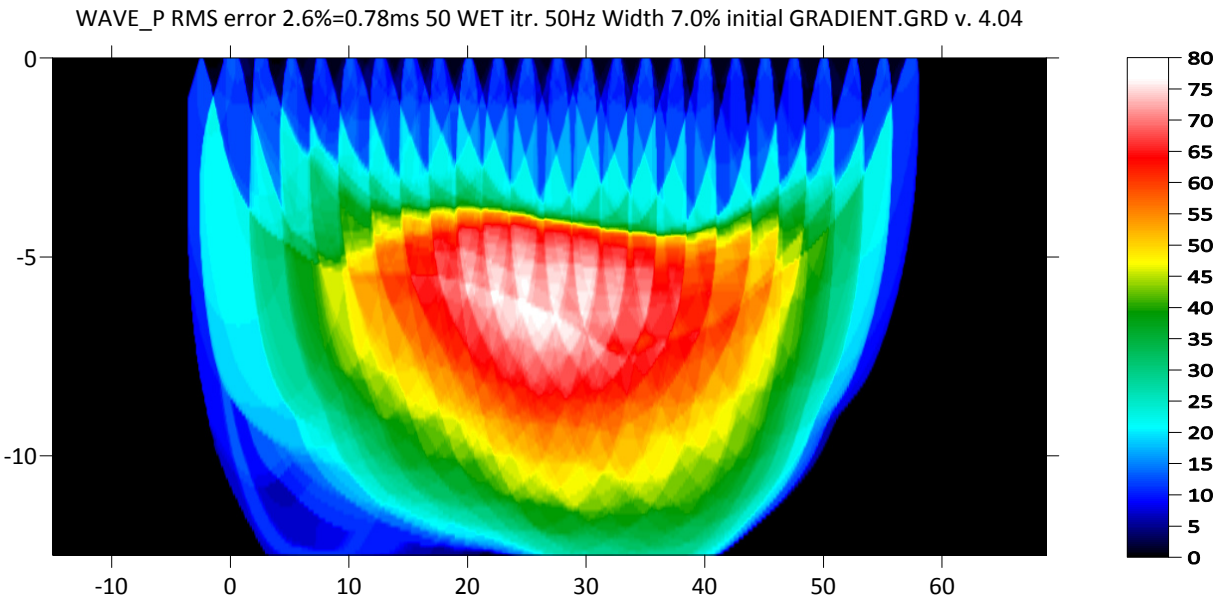


Fig. 19 : WET wavepath coverage plot line WAVE_P obtained with Fig. 1. Unit is wavepaths per pixel.

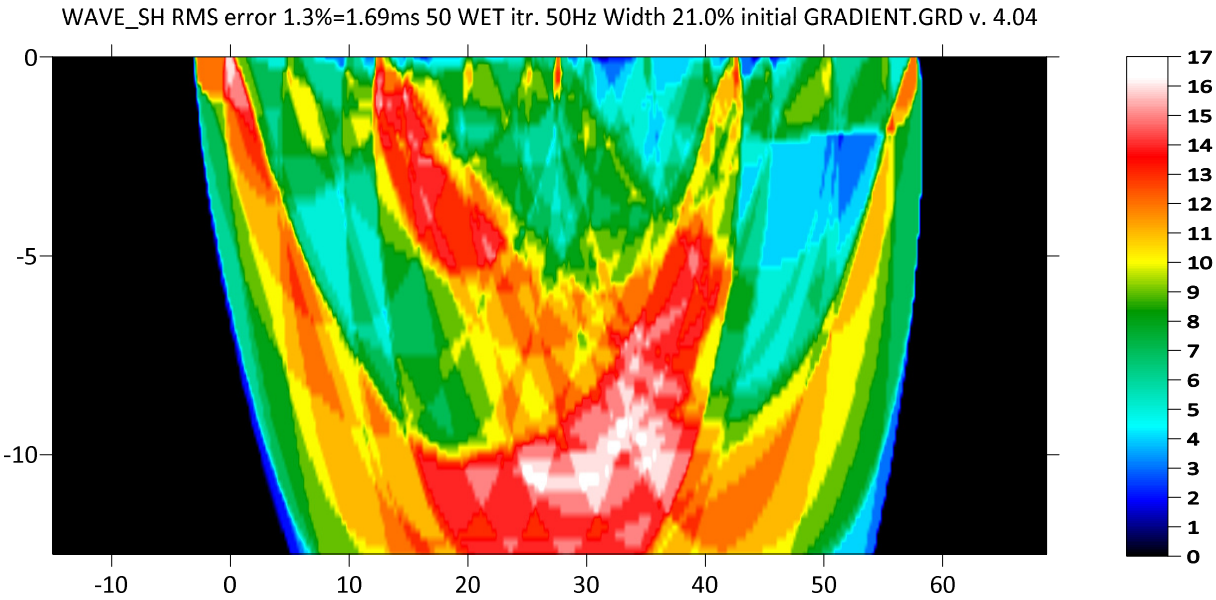


Fig. 20 : WET wavepath coverage plot line WAVE_SH obtained with Fig. 2. Unit is wavepaths per pixel.

See also our original tutorial https://rayfract.com/tutorials/poisson.pdf created in 2004 and edited in 2009.

Here is the Dropbox link https://www.dropbox.com/s/q986gnnda4927hn/WAVE_P.rar?dl=0 to profile folder for line WAVE_P .

Here is the Dropbox link https://www.dropbox.com/s/vb4t8cgnh3wavlx/WAVE_SH.rar?dl=0 to profile folder for line WAVE_SH .

Next we show how to plot your reciprocal traveltime picks on shot-sorted trace gathers. This lets you quality-control your first break picks and check the validity of your recording geometry specification (shot station numbers and receiver station numbers). See (Whiteley J. et al. 2020) : Landslide monitoring using seismic refraction tomography – The importance of incorporating topographic variations at https://www.researchgate.net/publication/339280163 :

- select ***Trace\|Export reciprocal traveltime picks and update database***
- click button *Select error file* and click *Save* button (Fig. 23)
- click button *Export to .ERR*
- optionally check new option ***Trace\|Open Refractor\|Shot CMP breaks with Shot gather***
- select *Trace\|Shot gather*
- check new version 4.04 option ***Display\|Show reciprocal picks on Shot Gather***
- browse and zoom trace gathers with function keys F7/F8, F1/F2 etc. as usual
- navigate traces for current shot gather with arrow-left and arrow-right keys
- if a reciprocal pick was matched to the current trace then this is plotted as a green dot on the trace
- also we show ***Reciprocal Shot/Channel*** and ***Reciprocal offset[m]/CMP*** in status bar at bottom of window if a reciprocal pick is available in the .ERR file for the current trace

Fig. 21 shows reciprocal traveltime picks for profile WAVE_P. Fig. 22 shows reciprocal traveltime picks for profile WAVE_SH.

The Shot CM breaks display was described by (Brueckl 1987) : The Interpretation of Traveltime Fields in Refraction Seismology at https://dx.doi.org/10.1111/j.1365-2478.1987.tb00855.x . First breaks for shot-sorted traveltime curves are displayed at CMP station positions instead of receiver station positions.

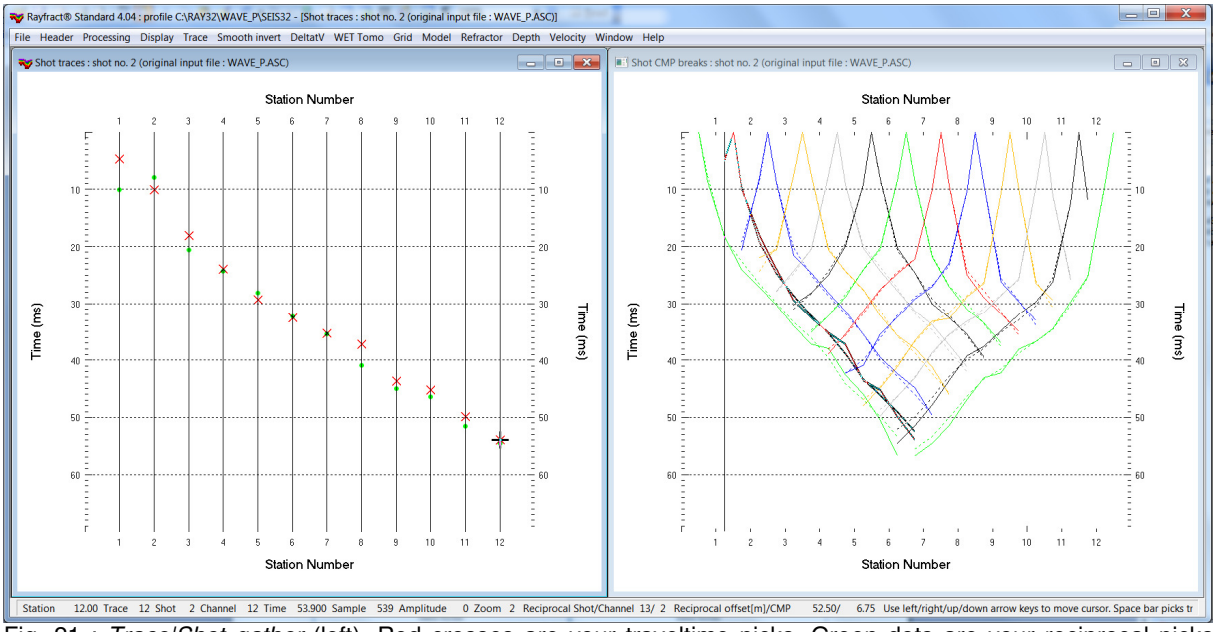


Fig. 21 : *Trace|Shot gather* (left). Red crosses are your traveltime picks. Green dots are your reciprocal picks matched to traces via *Trace|Export reciprocal errors and update database. Refractor|Shot CMP breaks* (right).

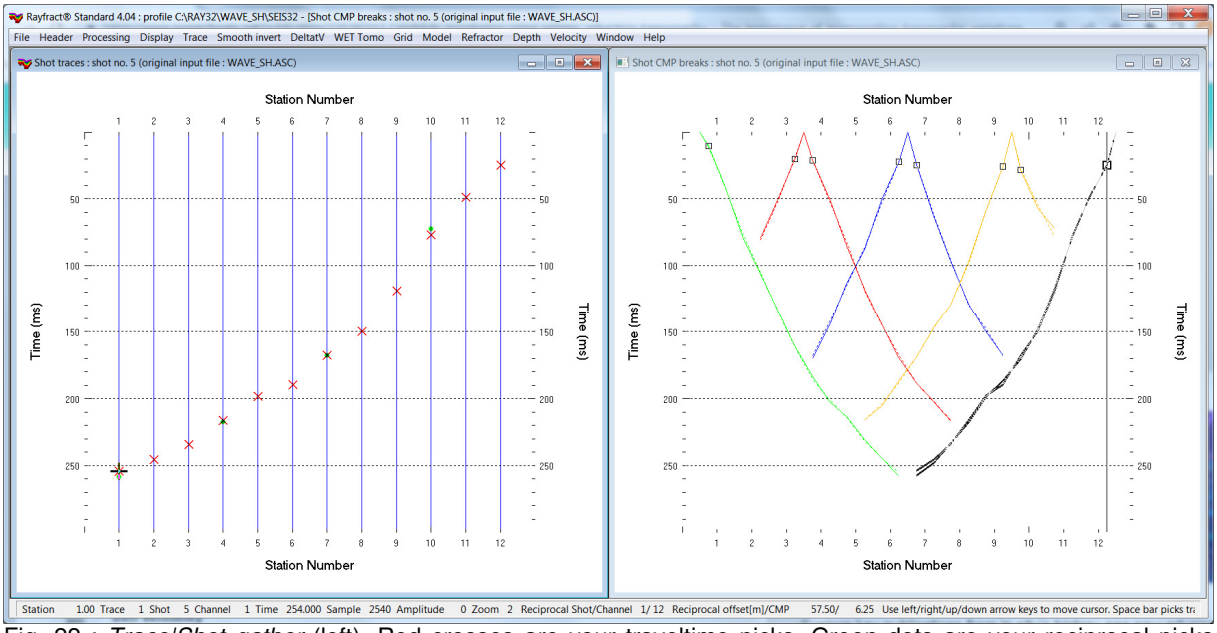


Fig. 22 : *Trace|Shot gather* (left). Red crosses are your traveltime picks. Green dots are your reciprocal picks matched to traces via *Trace|Export reciprocal errors and update database. Refractor|Shot CMP breaks* (right).

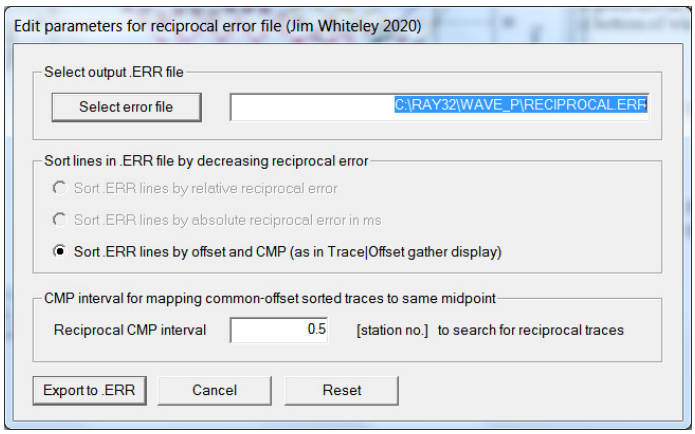


Fig. 23 : *Trace|Export reciprocal errors and update database .*

Increase parameter *Reciprocal CMP interval* for wide shot spacing to 1.0 or 2.0 station numbers so approximately reciprocal trace pairs can still be determined. This may not work in case of strong topography or with strongly undulating refractors.

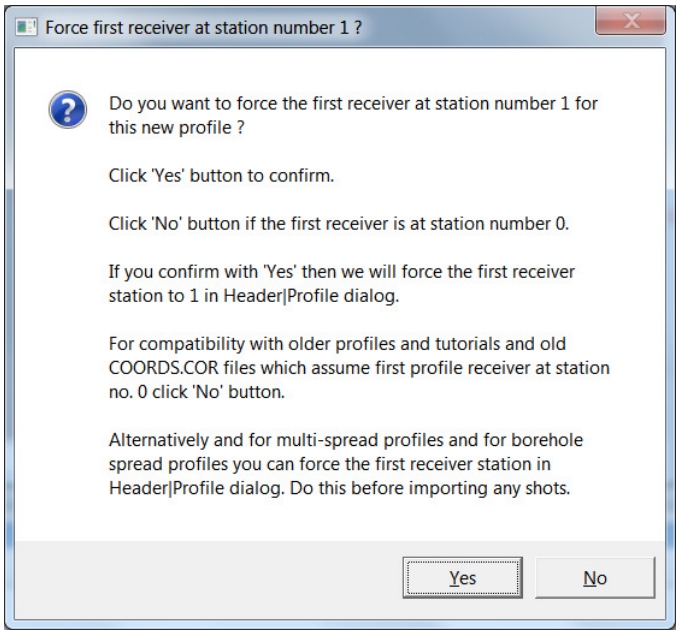


Fig. 24 : click Yes button to force profile start / first receiver station number at station no. 1.

For compatibility with older profiles and tutorials and old COORDS.COR files which assume first profile receiver at station no. 0 click No button.

Alternatively force the first receiver station in Header|Profile dialog. Do this before importing any shots via File|Import Data dialog.

We thank Dr. Anibaldi at Methodo s.r.l. for making available in 2004 above consistently picked .ASC profiles.