Import SEG-2 .SG2 / WET inversion of S-Wave VSP SH27_TEST in Rayfract® 5.03 Jan 2026 :

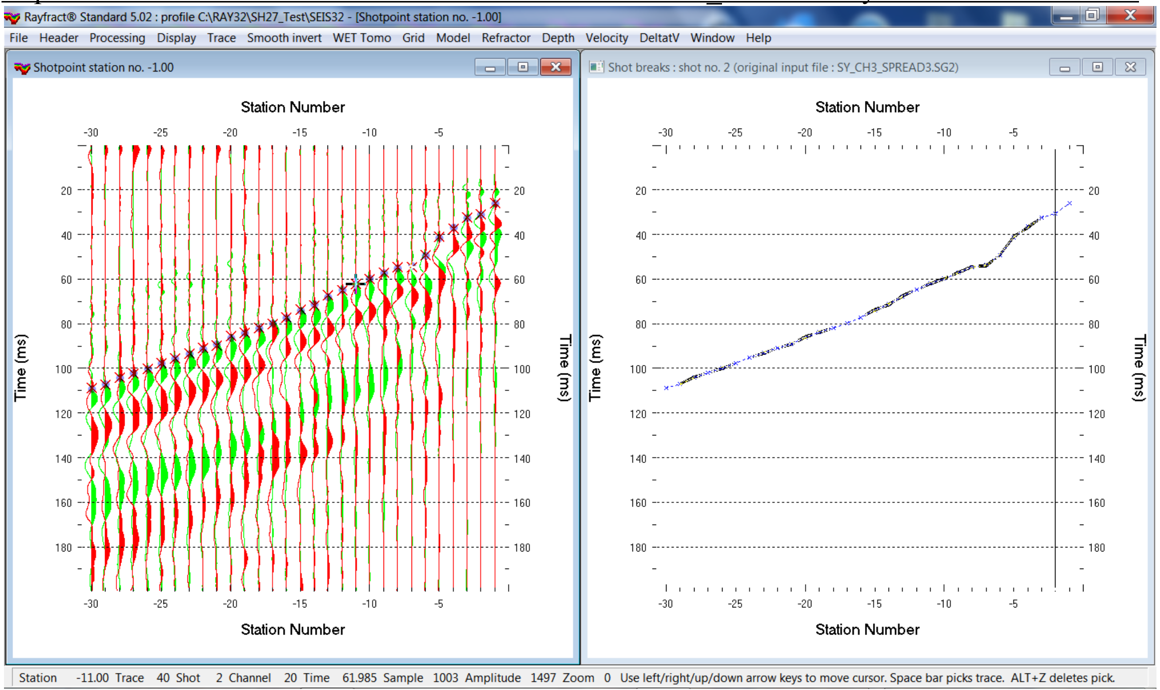


Fig. 1 : Left : *Trace|Shot point gather*, right : *Refractor|Shot breaks*. Shows fit between picked times (solid curve, red crosses) and modeled times (dashed blue curve, blue dots). For zoomed up first break picks see Fig. 19.

To create the profile database, gather the SEG-2 channels and import and view the aggregated .SG2 shots :

1. ***File|New Profile***..., set *File name* to **SH27_TEST** and click *Save*
2. in the prompt shown next (Fig. 4) click ***No*** button .
3. in ***Header|Profile***... set *Line type* to **Borehole spread/line** . Set *Station spacing* to 1.0m. See Fig. 2.
4. unzip archive **https://rayfract.com/tutorials/SH27_TEST.zip** with **SEG-2 .SG2** receiver channel files & files **COORDS.COR & SHOTPTS.SHO & BREAKS.LST** in profile directory **C:\RAY32\SH27_TEST**
5. download installer **https://rayfract.com/tools/SEG2HoleMerge.exe** and run on your PC where you are running our Rayfract® version 5.01 or 5.02 or 5.03
6. open SEG2 HoleMerge 5.02 program via desktop icon. See Fig. 5 .
7. click on file icon besides uppermost field ***Select one SEG-2 file in INPUT directory***
8. navigate into **C:\RAY32\SH27_TEST\SH27_DX**. At right bottom of dialog select **ABEM files (*.SG2)**
9. click on one file e.g. **-1sx.SG2** (receiver channels for elevation -1.0) and click *Open* button
10. in frame ***Determine geophone channel number to be merged*** click radio button ***S-wave horizontal channel 2/x***. See Fig. 5.
11. in frame ***Determine distance unit : meters or feet*** click radio button ***Meters***
12. in frame ***Determine aggregated receiver geometry for vertical borehole*** set ***Deepest receiver depth below topo [m]*** to 30. Set next field ***Receiver spacing [m]*** to 1. See Fig. 5.
13. in frame ***Determine source position : horizontal and vertical offset from top of hole*** set ***Source x offset from top-of-hole [m]*** to 3. Leave ***Source depth below top-of-hole [m]*** at 0.0.
14. click button ***Setup output directory*** to set frame *Select output directory* to **C:\RAY32\SH27_TEST\INPUT2.**
15. click button ***Aggregate SEG-2 files***. Confirm prompts (Fig. 6). Click ***Close*** button.
16. the aggregated SEG-2 receiver spread file **sx_ch2_Spread2.SG2** is written into folder **C:\RAY32\SH27_TEST\INPUT2.**
17. repeat steps 6. to 16 for **C:\RAY32\SH27_TEST\SH27_DY**. See Fig. 9. In step 8. navigate into **C:\RAY32\SH27_TEST\SH27_DY** . In step 9. select **-1sy.SG2**. In step 10. click radio button ***S-wave horizontal channel 3/y***. See Fig. 9. In step 16. the aggregated SEG-2 file **sy_ch3_Spread3.SG2** is written into folder **C:\RAY32\SH27_TEST\INPUT2.**
18. click on title bar of our opened Rayfract® 5.02/5.03
19. select import option *File|SEG-2 import settings and commands|**Receiver coordinates specified***
20. select ***File|Import Data***... . Set *Import data type* to **SEG-2**. See Fig. 3.

21. click *Select button* and navigate into `C:\RAY32\SH27_TEST\INPUT2`
22. set *Files of type* to **`ABEM files (*.SG2)`** and select file `sx_ch2_Spread2.SG2` & click *Open*
23. set *Take shot record number from* to **`Job number`**
24. leave *Default spread type* at **`10: 360 channels.`** Click *radio button* ***Overwrite all.***
25. click ***Import shots button*** and confirm prompt
26. in Fig. 7 if necessary click *Skip* to skip other `.SG2` files until the updated dialog title says `Import C:\RAY32\SH27_TEST\INPUT2\sx_ch2_Spread2.SG2…` . Set ***Shot Number*** to 1 and click ***Read*** button.
27. with updated title `Import C:\RAY32\SH27_TEST\INPUT2\sy_ch3_Spread3.SG2…` set ***Shot Number*** to 2 and click ***Read*** button again. Click *Skip* or *End* button to skip all other aggregated `.SG2` files.
28. select *File|Update header data|Update First Breaks*. Select file **`BREAKS.LST`** & click *Open*.
29. select *Trace|Shot gather*. Use F7/F8 to browse to shot no. 1. Select ***Processing|Reverse Shot polarity*** for the displayed shot no. 1 to enable shear-wave picking in *Trace|Shot point gather*.
30. select ***Trace|Shot point gather*** and ***Refractor|Shot breaks*** and ***Window|Tile*** to obtain Fig. 1
31. click on title bar of *Refractor|Shot breaks* window (Fig. 1 right). Press ALT+P. Edit ***Maximum time*** to 200 ms. Press **`ENTER`** key to redisplay. Do the same for *Trace|Shot point gather* window (Fig. 1 left).
32. click on title bar of *Trace|Shot point gather* window and press CTRL+F1 to zoom trace amplitude
33. press CTRL+F3 to toggle trace wiggle display mode. Uncheck ***Display|Color trace outline***.
34. press SHIFT+Q and edit *band pass filter* as in Fig. 8 . Click *Filter* button.
35. select ***Processing|Pick all shots***, *in shot point gather*. Select ***Display|Show picks on time axis***.

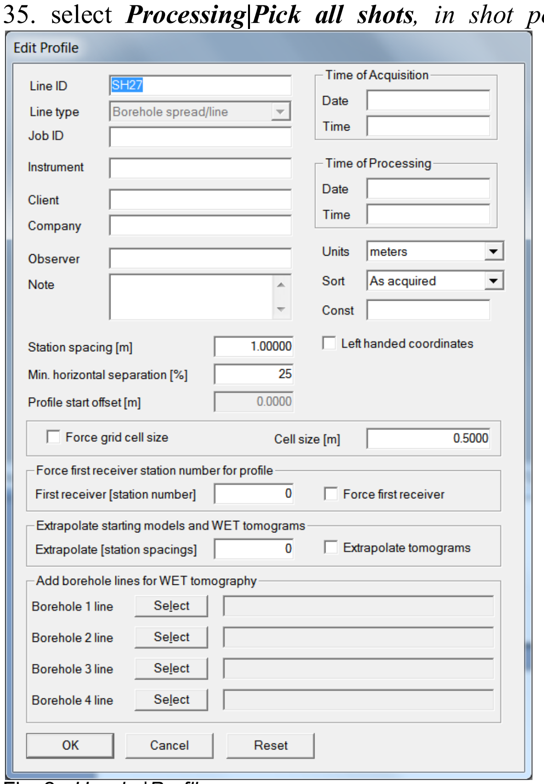


Fig. 2 : *Header|Profile*

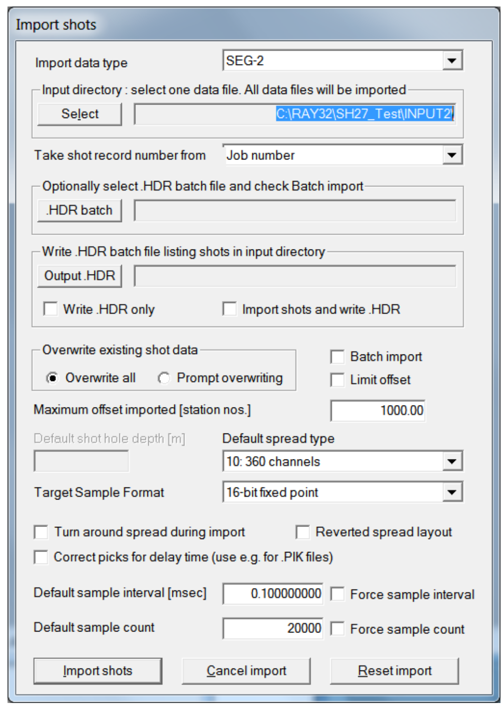


Fig. 3 : *File|Import Data*

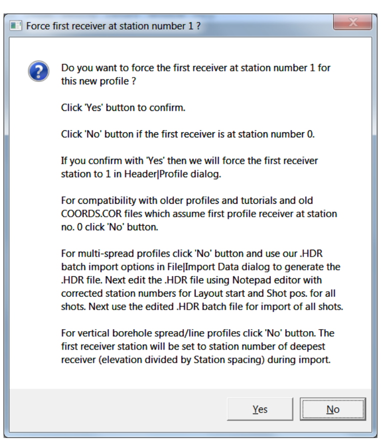


Fig. 4 : click *No* button.

For vertical borehole/spread line profiles click 'No' button. The first receiver station will be set to station number of deepest receiver (elevation divided by *Station spacing*) during import.

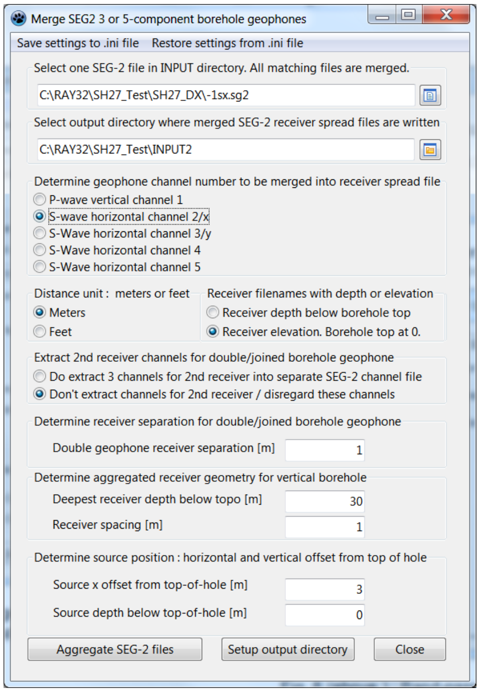
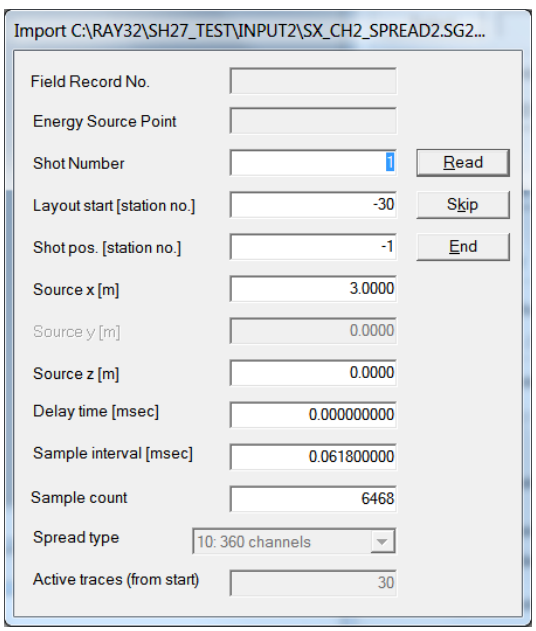


Fig. 5 : click SEG2 HoleMerge 5.02 icon. Edit as shown. Click buttons *Setup output directory* and ***Aggregate SEG-2 files***.



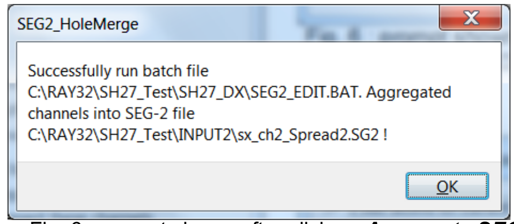


Fig. 6 : prompt shown after click on ***Aggregate SEG-2 files*** button. Click OK to dismiss prompt.

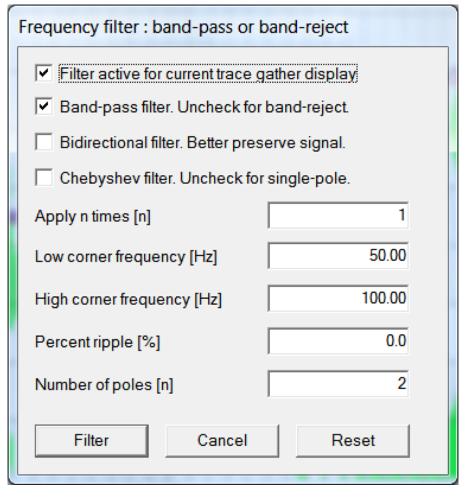


Fig. 8 (above) : ***Band-pass filter*** dialog shown with SHIFT+Q. Edit as shown and click *Filter* button.

Fig. 7 (left) : Edit the ***Shot number*** to 1 and 2 and click ***Read*** button to import the two aggregated .SG2

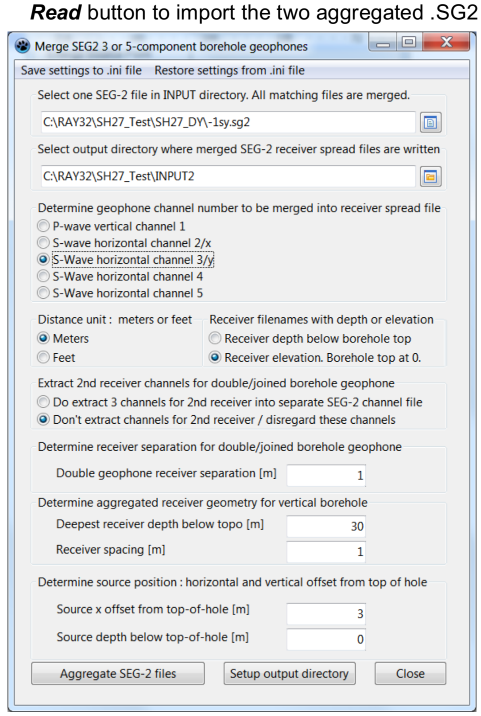


Fig. 9 : click SEG2 HoleMerge 5.02 icon. Edit as shown. Click buttons *Setup output directory* and ***Aggregate SEG-2 files***.

Configure and obtain constant-velocity starting model and run interactive WET inversion (Schuster 1993, Rohdewald 2025) :

- edit *Grid|Surfer plot Limits* as in Fig. 10
- check *Grid|Vertical plot title*. Check *Grid|GS CENTERED FONT* to fix Surfer 11 plot display.
- select ***Smooth invert|WET with constant-velocity initial model***
- wait for the constant-velocity starting model to show as in Fig. 13 (left)
- in prompt to continue with WET inversion click *No* button
- uncheck all blanking options in *WET Tomo|WET tomography Settings|Blank* menu
- select *Model|WDVS Smoothing*. Click radio button ***restore WET smoothing*** (Fig. 11). Click *OK*.
- check option *WET Tomo|WET tomography Settings|**Scale wavepath width***
- check option *WET Tomo|WET tomography Settings|**Scale WET filter height***
- select *WET Tomo|**Interactive WET***. Edit main dialog as in Fig. 12 left.
- set ***Number of WET tomography iterations*** to 500
- click *Select* button. Navigate into folder **`C:\Ray32\SH27_Test\HOLETOMO`**. Select **`CONSTVEL.GRD`** starting model grid.
- set ***Max. velocity*** to 3,000 m/s
- click button ***Edit velocity smoothing***. Edit as in Fig. 12 right. Click button *Accept parameters*.
- click button ***Start tomography processing*** and confirm prompts to obtain Fig. 13 (center and right)

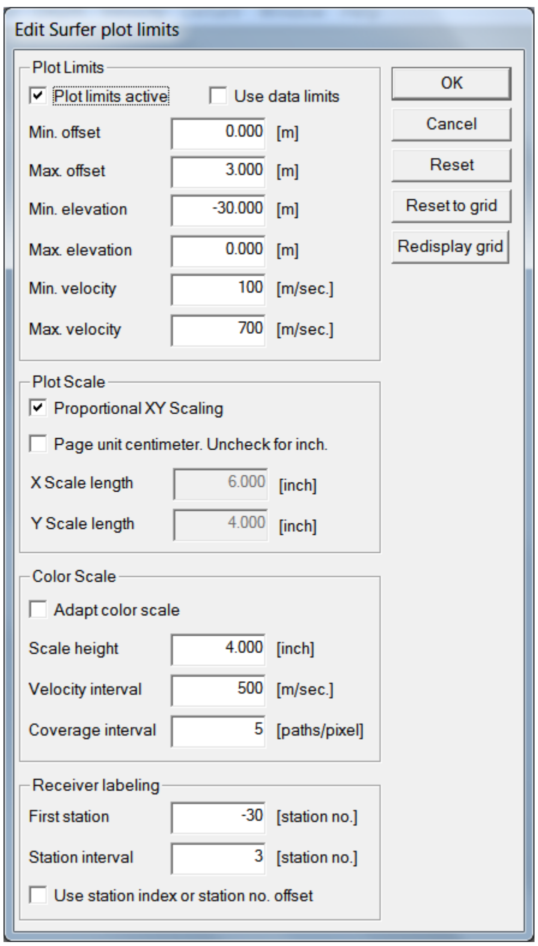


Fig. 10 : *Grid|Surfer plot Limits* dialog. Check box ***Limits active*** and ***Proportional XY scaling***. Edit as shown. Set ***Max. velocity*** to 700 m/s. Click OK button.

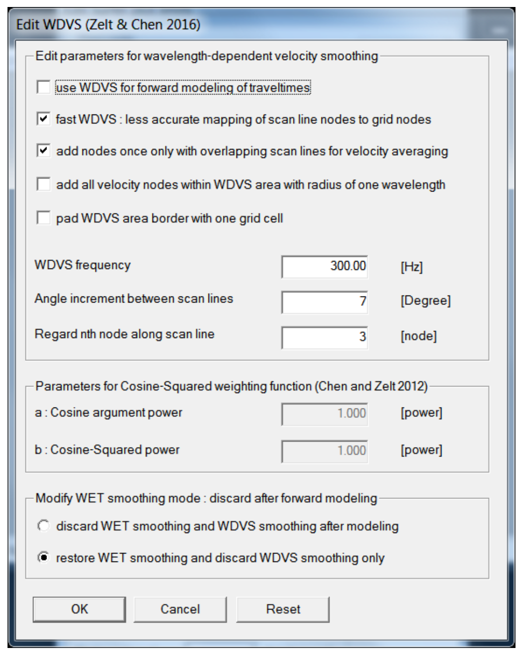


Fig. 11 : *Model|WDVS Smoothing* dialog. Click option ***restore WET smoothing discard WDVS smoothing only***. Click OK.

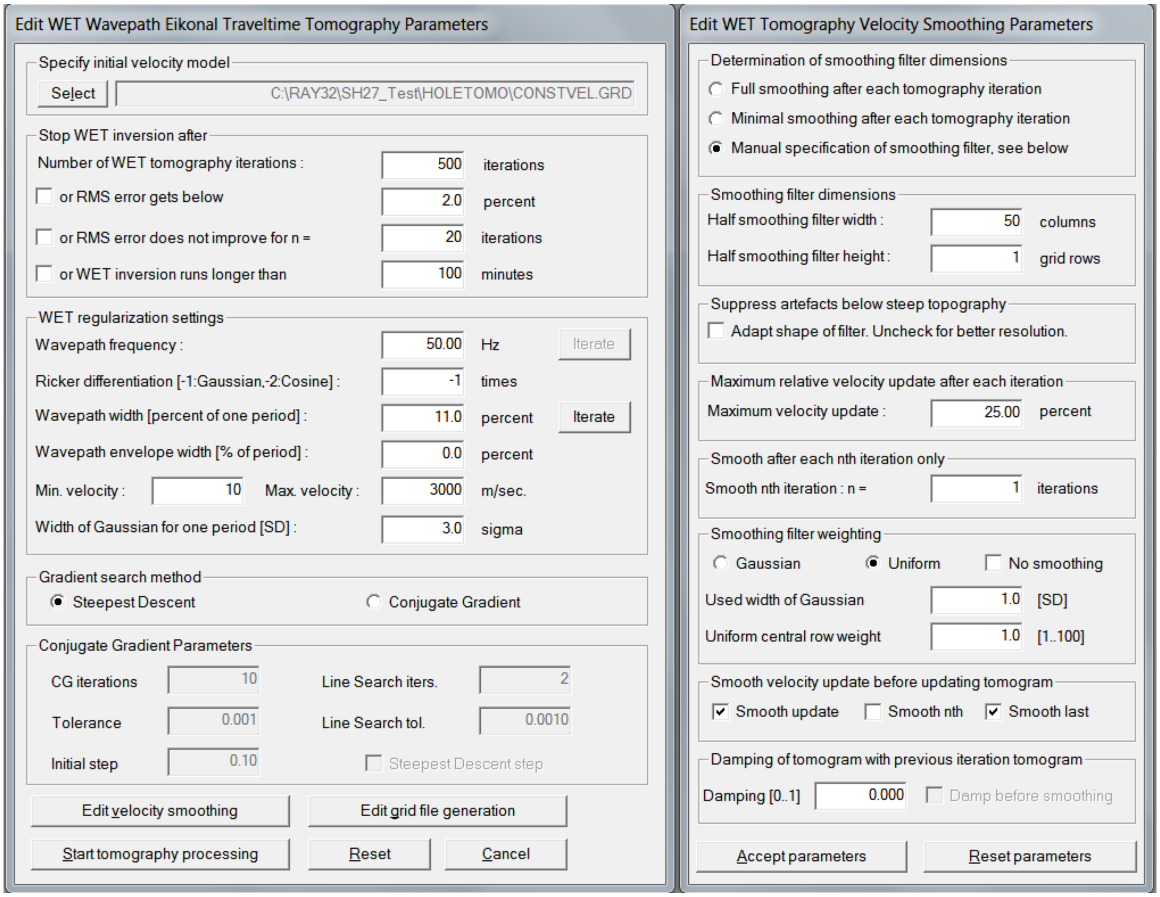


Fig. 12 : ***WET Tomo|Interactive WET*** main dialog (left). Edit as shown. Click *Select* button. Navigate into folder **`C:\Ray32\SH27_Test\HOLETOMO`**. Select **`CONSTVEL.GRD`** starting model grid. Click ***Edit velocity smoothing*** and edit as shown (right). Click buttons *Accept parameters* and ***Start tomography processing*** to obtain Fig. 13.

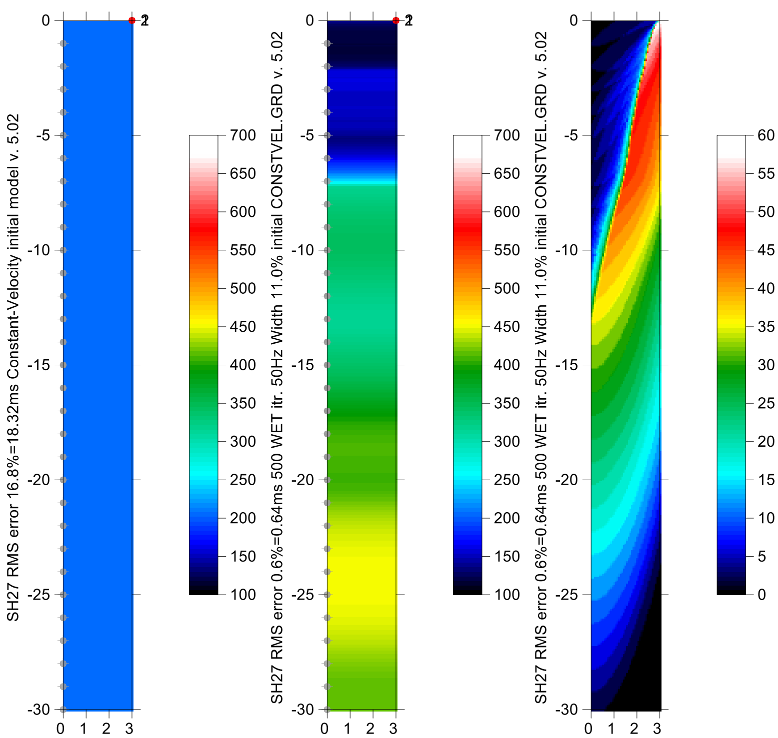


Fig. 13 : constant-velocity initial model (left). Steepest-Descent WET inversion (Schuster 1993) after 500 iterations (center) with ***restore WET smoothing*** checked in *Model|WDVS Smoothing* (Fig. 11).

We left the WET ***wavepath frequency*** at 50Hz and left the WET ***wavepath width*** at 11 percent (Fig. 12 left). We increased the ***Number of WET iterations*** to 500 from default 20 iterations. We limited the ***Max. WET velocity*** to 3,000 m/s.

We use a default ***Gaussian wavelet*** for WET velocity update weighting across the wavepath (***Ricker differentiation*** -1 in Fig. 12 left) and ***manual WET smoothing*** (Fig. 12 right) with smoothing filter ***half-width*** 50 grid columns and ***half-height*** 1 grid row. We uncheck option ***Adapt shape of filter***. This manual WET smoothing filter results in horizontal layering in the WET tomogram (center). Surfer plot limits as in Fig. 10.

The WET wavepath coverage plot is shown at right. The unit is wavepaths per grid cell.

In menu *WET Tomo|WET tomography Settings* we checked the two options

- ***Scale wavepath width***
- ***Scale WET filter height***

Optimized WET inversion (Schuster 1993, Rohdewald 2025) of S-wave VSP survey :

- edit *Grid|Surfer plot Limits* as in Fig. 14. Click button OK.
- check *Grid|Vertical plot title*. Check *Grid|GS CENTERED FONT* to fix Surfer 11 plot display.
- select ***Smooth invert|WET with constant-velocity initial model***
- wait for the constant-velocity starting model to show as in Fig. 18 (left)
- in prompt to continue with WET inversion click *No* button
- uncheck all blanking options in *WET Tomo|WET tomography Settings|Blank* menu
- select *Model|WDVS Smoothing*. Click radio button ***discard WET smoothing and WDVS smoothing*** (Fig. 15). Click button *OK.*
- check option *WET Tomo|WET tomography Settings|**Scale wavepath width***
- check option *WET Tomo|WET tomography Settings|**Scale WET filter height***
- select *WET Tomo|**Interactive WET***. Edit main dialog as in Fig. 16 left.
- set ***Number of WET tomography iterations*** to 999.
- click *Select* button. Navigate into folder **`C:\Ray32\SH27_Test\HOLETOMO`**. Select **`CONSTVEL.GRD`** starting model grid.
- set ***Ricker differentiation*** to 0 times to weight the WET velocity update with a Ricker wavelet across the WET wavepath. This can help to increase the vertical resolution with velocity inversions present.
- set ***Max. velocity*** to 3,000 m/s.
- click button ***Edit velocity smoothing***. Edit as in Fig. 16 right. Click radio button ***Manual specification of smoothing filter***. Set ***Half smoothing filter width*** to 50 columns. Set ***Half smoothing filter height*** to 0 grid rows. Uncheck box ***Adapt shape of filter***. Click button *Accept parameters.*
- click button ***Edit grid file generation***. Edit as in Fig. 17. Set field ***Store each nth iteration only: n*** = to 50 to preserve disk space. Click button *Accept parameters*.
- click button ***Start tomography processing*** and confirm prompts to obtain Fig. 18 (center and right)

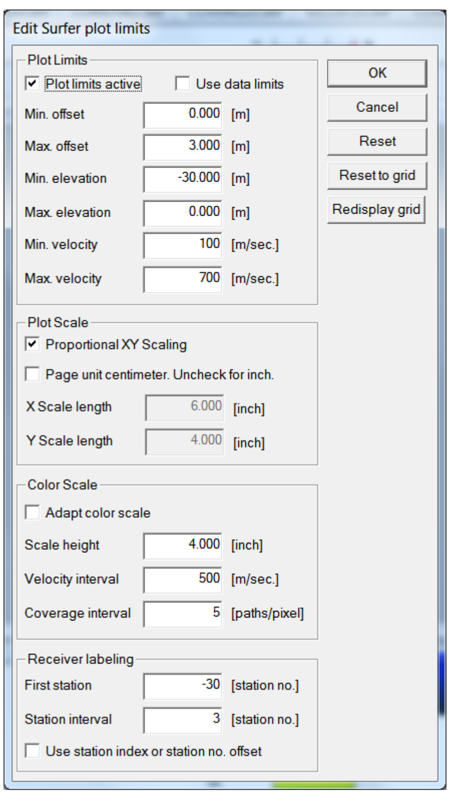


Fig. 14 (left) : select ***Grid|Surfer plot Limits***. Edit as shown. Set ***Max. velocity*** to 700 m/s. Click button OK.

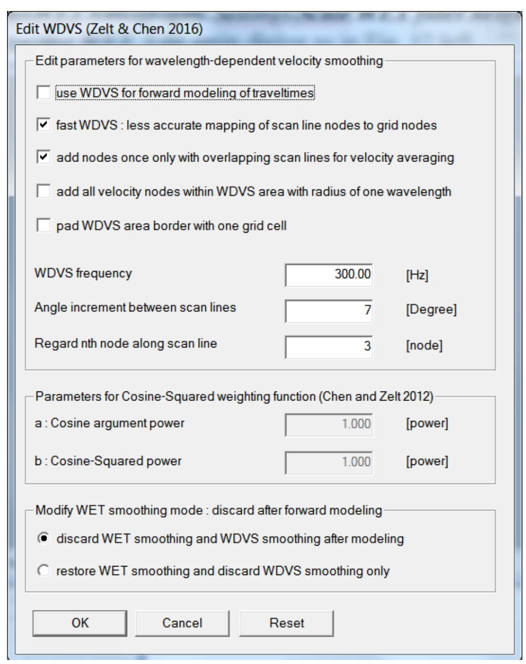


Fig. 15 (above) : ***Model|WDVS Smoothing***. Check radio button ***discard WET smoothing and WDVS smoothing***. Click OK button.

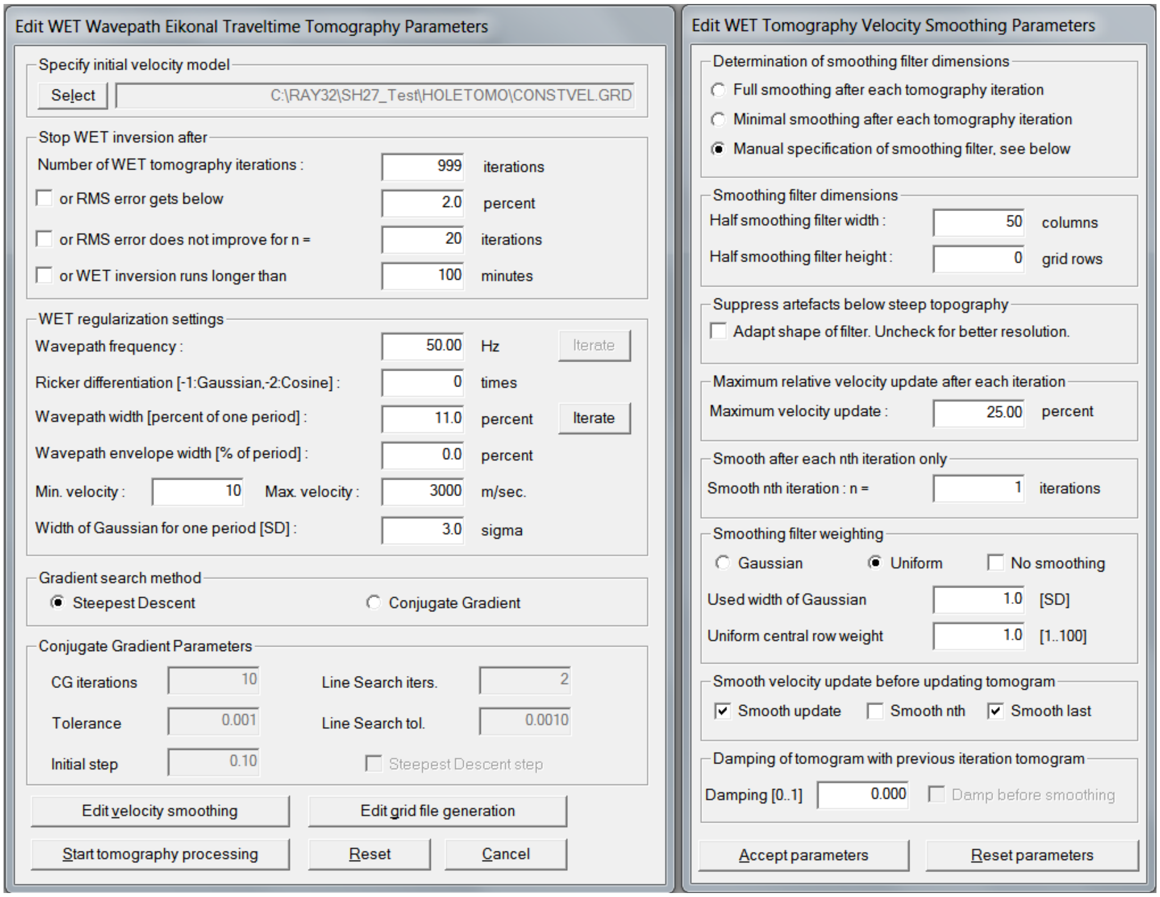


Fig. 16 : ***WET Tomo|Interactive WET*** main dialog (left). Edit as shown. Click *Select* button. Navigate into folder **`C:\Ray32\SH27_Test\HOLETOMO`**. Select **`CONSTVEL.GRD`** starting model grid. Set ***Ricker differentiation*** to 0 [Ricker wavelet]. Click button ***Edit velocity smoothing*** (right). Edit as shown. Click radio button ***Manual specification of smoothing filter***. Set ***Half smoothing filter width*** to 50 columns. Set ***Half smoothing filter height*** to 0 grid rows. Uncheck box ***Adapt shape of filter***. Click button *Accept parameters*. Click button ***Edit grid file generation***. Edit as in Fig. 17. Finally click button ***Start tomography processing*** to obtain Fig. 18.

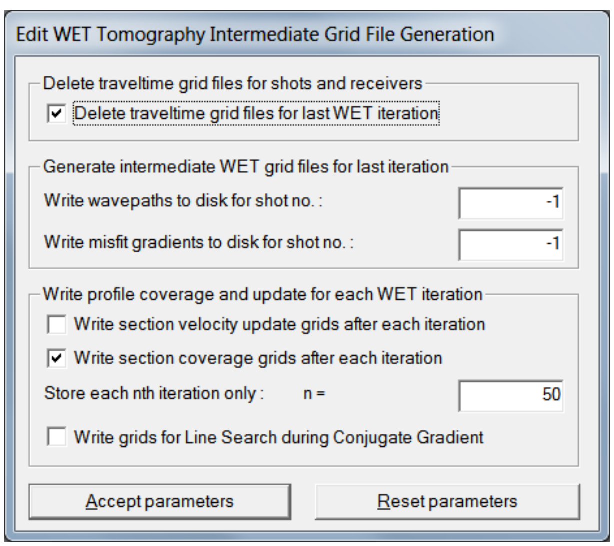


Fig. 17 : in ***WET Tomo|Interactive WET*** main dialog (Fig. 16 left) click button ***Edit grid file generation***. Edit as shown. Set field ***Store each nth iteration only: n =*** to 50 to preserve disk space. Click button *Accept parameters*. Click button ***Start tomography processing*** to obtain Fig. 18.

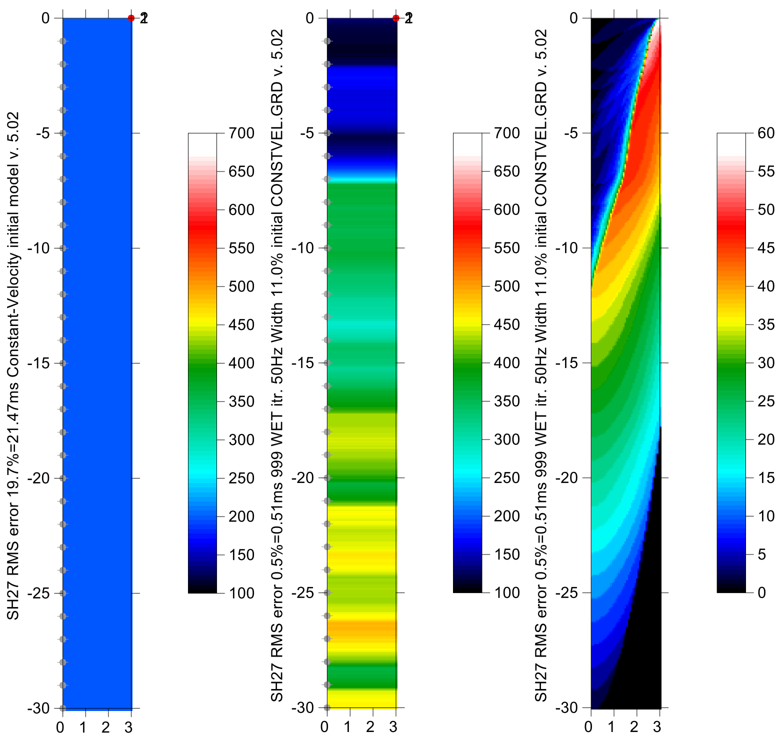


Fig. 18 : constant-velocity initial model (left). Steepest-Descent WET inversion (Schuster 1993, Rohdewald 2025) after 999 WET iterations (center) with ***discard WET smoothing*** checked in ***Model|WDVS Smoothing*** (Fig. 15).

We left the WET ***wavepath frequency*** at 50Hz and left the WET ***wavepath width*** at 11 percent (Fig. 16 left). We increased ***Number of WET iterations*** to 999 from default 20 iterations. We limited the ***Max. WET velocity*** to 3,000 m/s.

We use a ***Ricker wavelet*** for WET update weighting across the wavepath (***Ricker differentiation*** 0 in Fig. 16 left) and ***manual WET smoothing*** (Fig. 16 right) with smoothing filter ***half-width*** 50 grid columns and ***half-height*** 0 grid rows. We uncheck option ***Adapt shape of filter***. This manual WET smoothing filter results in horizontal layering in the WET tomogram (center). Surfer plot limits as in Fig. 14.

The WET wavepath coverage plot is shown at right. Unit is wavepaths per grid cell.

In menu ***WET Tomo|WET tomography Settings*** we checked the two options

- ***Scale wavepath width***
- ***Scale WET filter height***

Here we compare the WET tomogram obtained in Fig. 18 (center) with Fig. 13 (center) :

- note the apparently higher vertical resolution of horizontal layering in the final WET tomogram after 999 WET iterations (Fig. 18 center) compared to Fig. 13 (center) using 500 WET iterations
- the RMS error of 0.51ms for Fig. 18 (center) is significantly smaller than the RMS error of 0.64ms for Fig. 13 (center). So the apparently better vertical resolution for Fig. 18 may be realistic assuming that our S-wave first break picks (Fig. 19) are good.
- for Fig. 18 we use a ***Ricker wavelet*** for updating of the WET velocity across the WET wavepath (Fig. 16 left; Schuster 1993) instead of a ***Gaussian*** used for Fig. 13. See ***Ricker differentiation*** 0 in Fig. 16 (left) vs. ***Ricker differentiation*** -1 in Fig. 12 (left). Using a Ricker wavelet can help to improve the WET velocity resolution in case of velocity inversions (velocity decreasing with increasing depth below topography)
- we discard the WET smoothing after forward modeling (Fig. 15) for Fig. 18 instead of restoring the WET smoothing (Fig. 11) after forward modeling for Fig. 13
- we use a custom WET smoothing filter with ***half-height*** of 0 grid rows (Fig. 16 right) for Fig. 18 instead of ***half-height*** 1 grid row used for Fig. 13 (Fig. 12 right)
- the low-velocity layer in elevation range -5m to -6m matches the sliding surface of the landslide detected by Dr. Carabella with an inclinometer in the S2 borehole survey at 4.5m depth (see Acknowledgements paragraph)

Download the .rar archive of the profile folder obtained with above processing for Fig. 18 from DropBox link

https://www.dropbox.com/scl/fi/y7o0lvdosfcpe8gudezzc/SH27_Test_Dec2_25.rar?rlkey=nnvue2tl0ggjlm6azqdy7vg1p&st=xerzr6xo&dl=0

Unzip the downloaded .rar archive in root folder C:\Ray32 .

Pick S-wave first breaks in Trace, Shot point gather :

Based on valuable feedback from a long-time client we propose picking the S-wave first break picks as shown in Fig. 19 for station numbers -6 to -1.

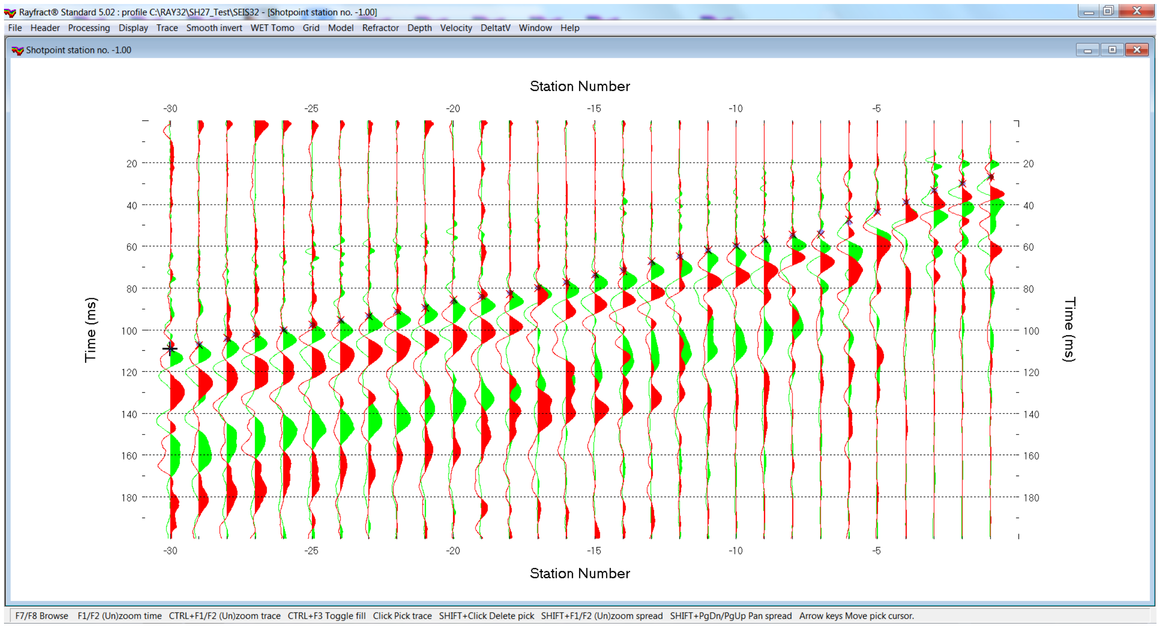


Fig. 19 : Pick S-wave first breaks in Trace, Shot point gather. Use left mouse click to pick first breaks. Red crosses are your first break picks. Blue dots are the modeled first breaks after 999 Steepest-Descent WET iterations (Schuster 1993, Rohdewald 2025).

As explained by our client, the apparent phase shift by 180 degrees (phase reversal or phase flip) between station number -7 and station number -6 and higher station numbers may be caused by a rotated borehole receiver probe at station number -6 while pulling up the probe.

There is another phase reversal at station number -17 (red phase), possibly also caused by a rotated borehole receiver probe.

2nd run WET inversion (Schuster 1993, Rohdewald 2025) of repicked S-wave VSP survey :

Next we show further improvement of the vertical resolution in our previous downhole VSP tomogram (Fig. 18) by using the `..\HOLETOMO\VELOIT999.GRD` obtained during the first WET run (described in previous paragraph) as the starting model for a 2nd interactive WET run using the exactly same WET and WDVS settings and parameters as used for the first WET run (Fig. 16) :

- select *WET Tomo*|***Interactive WET***. Edit main dialog as in Fig. 20 left.
- click ***Select*** button. Navigate into folder `C:\Ray32\SH27_Test\HOLETOMO`. Select `VELOIT999.GRD` as our new starting model grid for a 2nd WET run.
- click button ***Start tomography processing*** to obtain Fig. 21

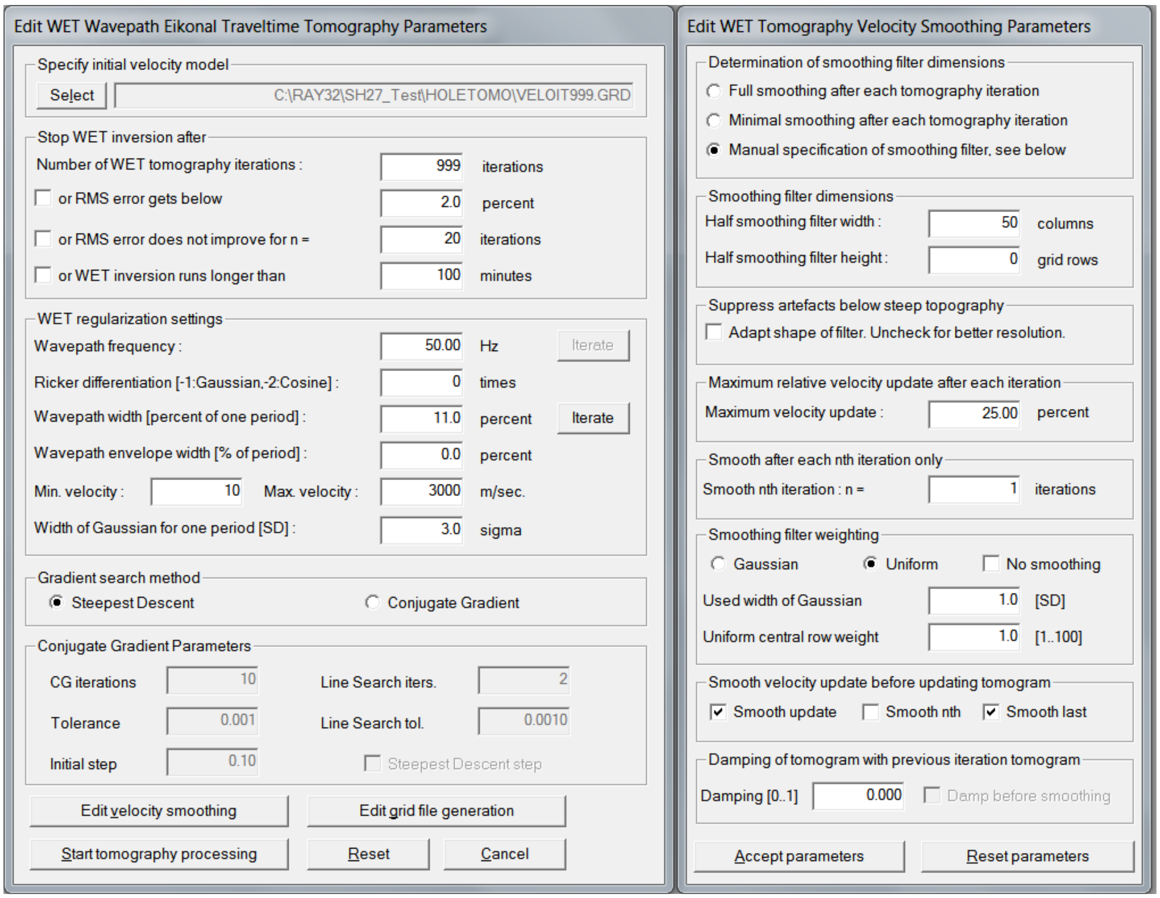


Fig. 20 : select ***WET Tomo, interactive WET*** to display the interactive WET main dialog (left). Click ***Select*** button and select `C:\RAY32\SH27_Test\HOLETOMO\VELOIT999.GRD` as starting model for a 2nd WET run. Click button ***Start tomography processing*** to obtain Fig. 21.

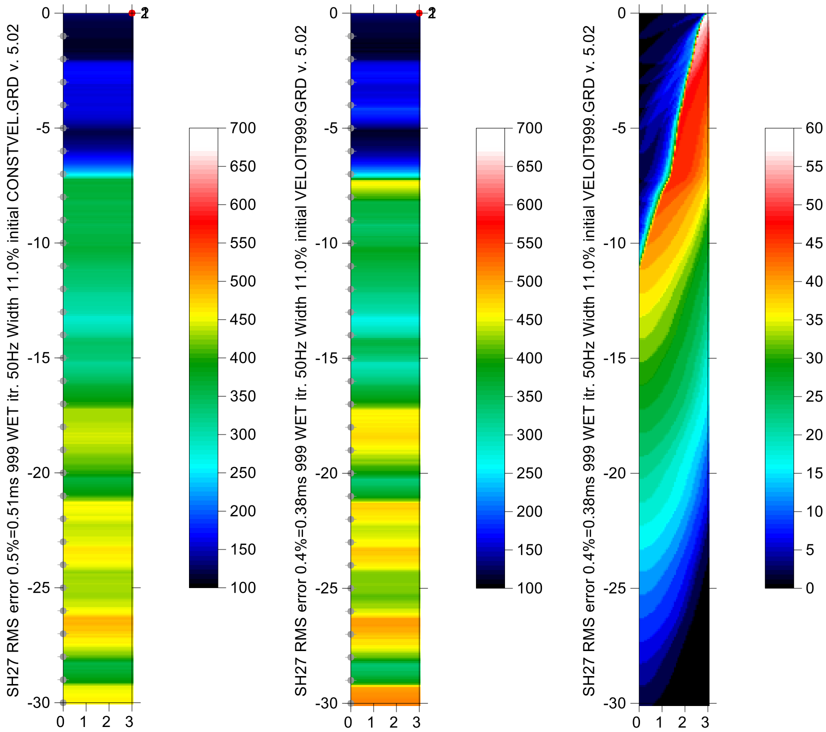


Fig. 21 : optimized WET tomogram (center) obtained when using our previous ..\HOLETOMO\VELOIT999.GRD (left) obtained with the first WET run (Fig. 16) as the starting model for a 2nd WET run (Fig. 20).

At right we show the WET wavepath coverage plot obtained with our 2nd WET run (Fig. 20). The unit is wavepaths per grid cell.

We compare the tomogram obtained in Fig. 21 (center) with our previous tomogram (Fig. 21 left, Fig. 18 center) :

- an apparent high-velocity layer with S-wave velocity 450 m/s at elevation range -7m to -8m has become visible in Fig. 21 (center) which is based on our picked S-wave first breaks (Fig. 19) and using our previous WET tomogram as a starting model (Fig. 21 at left and Fig. 18 center)
- to justify this apparent high-velocity layer at elevation range -7m to -8m open file **`C:\Ray32\SH27_Test\INPUT\BREAKS.LST`** in Microsoft Notepad editor. View the almost identical picked first break times at trace_pos (column 3) station number -7 (54.446 ms) and station number -8 (54.384 ms) listed in column 4.
- see also station numbers -7 and -8 in Fig. 19 showing the almost identical picked first break times explaining this high-velocity layer at elevation range -7m to -8m
- the low-velocity layer in elevation range -5m to -6m matches the sliding surface of the landslide detected by Dr. Carabella with an inclinometer in the S2 borehole survey at 4.5m depth (see Acknowledgements paragraph). This low-velocity layer is shown with better contrast in Fig. 21 (center) than in our starting model grid **`C:\RAY32\SH27_Test\HOLETOMO\VELOIT999.GRD`** (Fig. 21 left and Fig. 18 center).
- the RMS error of 0.38ms for Fig. 21 (center) is significantly smaller than the RMS errror of 0.51ms for Fig. 21 (left). So the apparently better vertical resolution in Fig. 21 (center) may be realistic assuming that our S-wave first break picks (Fig. 19) are good and physically consistent with the subsurface.

Download the .rar archive of the profile folder obtained with above processing for Fig. 21 from DropBox link

https://www.dropbox.com/scl/fi/mgjgx4i50txa5at32y9fn/SH27_Test_Dec3_DefaultSize_2ndRun.rar?rlkey=v5ph1cwoctgmsguxfll1mibmd&st=77vdk3a9&dl=0

and unzip in your C:\Ray32 root directory.

Plot VSP interval velocity for S-wave VSP survey in Golden Software Surfer 11 :

Next we show how to plot the shear-wave VSP velocity for one grid column of the final `..\HOLETOMO\VELOIT999.GRD` WET tomogram (Fig. 21 center) in our latest version 5.03 software released in Jan 2026 calling into Golden Software Surfer 11 :

1. select ***Grid|Export grid file to ASCII.TXT*** … . See Fig. 22 .
2. click ***Select grid file*** button and navigate into `C:\RAY32\SH27_Test\HOLETOMO\` folder
3. select file `VELOIT999.GRD` and click *Open* button
4. click radio button ***Export velocities for leftmost grid column only for downhole VSP plot***
5. click button ***Export to .TXT***
6. select ***Grid|Surfer plot Limits*** and edit as in Fig. 23
7. check new 5.03 option ***Grid|Plot downhole VSP interval velocity only without tomogram***. See Fig. 24.
8. select command ***Grid|Select VELOITXY.TXT for downhole VSP interval velocity plot***
9. navigate into `C:\RAY32\SH27_Test\HOLETOMO\` folder
10. select the exported file `VELOIT999.TXT` and click ***Open*** button
11. select command ***Grid|Image and contour velocity and coverage grids*** shown in Fig. 24
12. select grid file `C:\RAY32\SH27_Test\HOLETOMO\VELOIT999.GRD` and click *Open* to obtain Fig. 25

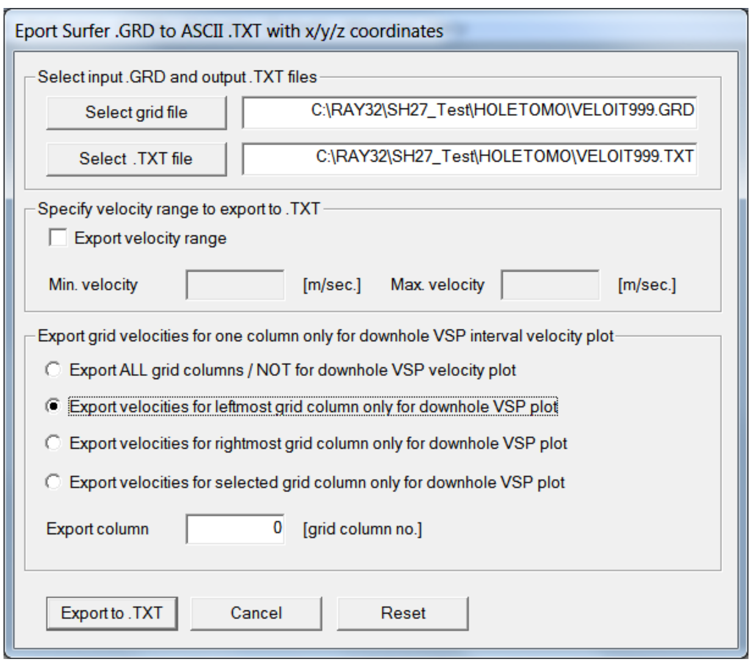


Fig. 22 : ***Grid|Export grid file to ASCII.TXT*** dialog. Edit as shown and click button ***Export to .TXT*** .

Configure VSP interval velocity plot for S-wave VSP survey in Golden Software Surfer 11 :

Now we edit the labeling of the x/y axes for our VSP velocity plot in Golden Software Surfer 11 :

13. left-click on Surfer 11 icon in Windows 7/10/11 taskbar (Fig. 26)
14. select *View|Managers|Object Manager*
15. select *View|Managers|Property Manager*
16. in *Object Manager* window left-click ***Left Axis*** label
17. in *Property Manager* window left-click *General* tab
18. edit field ***Title text*** to "Elevation (m)" without the enclosing "" and press return or enter key
19. in *Object Manager* window left-click ***Bottom Axis*** label
20. in *Property Manager* window left-click *General* tab
21. edit field ***Title text*** to "S-wave velocity (m/s)" without the enclosing "" and press return or enter key (Fig. 26)

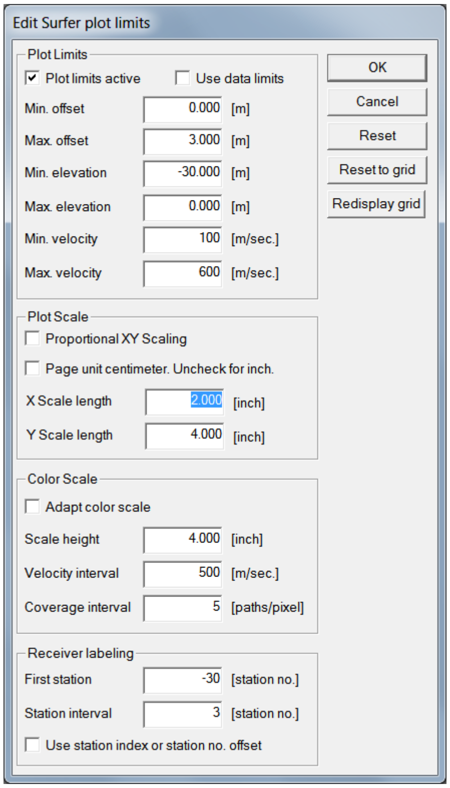


Fig. 23 (left) : select ***Grid|Surfer plot Limits***. Edit as shown and click button OK.

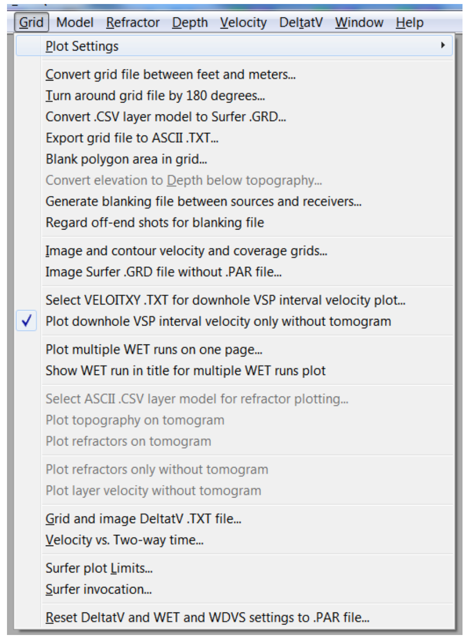


Fig. 24 (right) : select new version 5.03 Grid menu option ***Plot downhole VSP interval velocity only without tomogram***

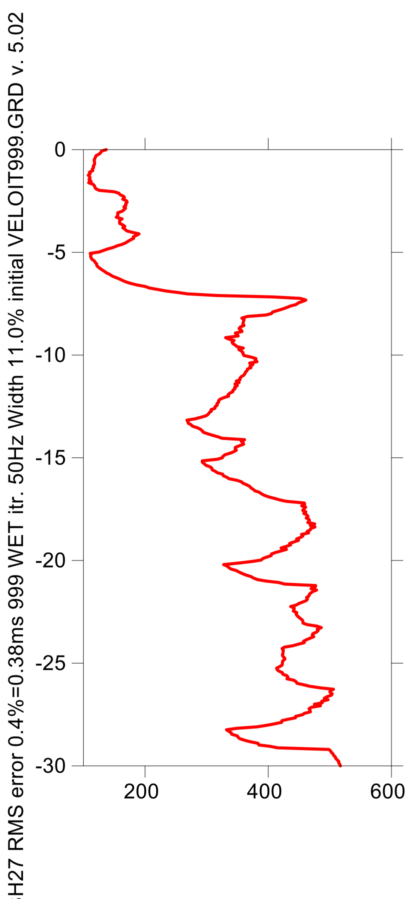


Fig. 25 : VSP velocity plot obtained in our latest version 5.03 software for final WET tomogram shown in Fig 21 (center)

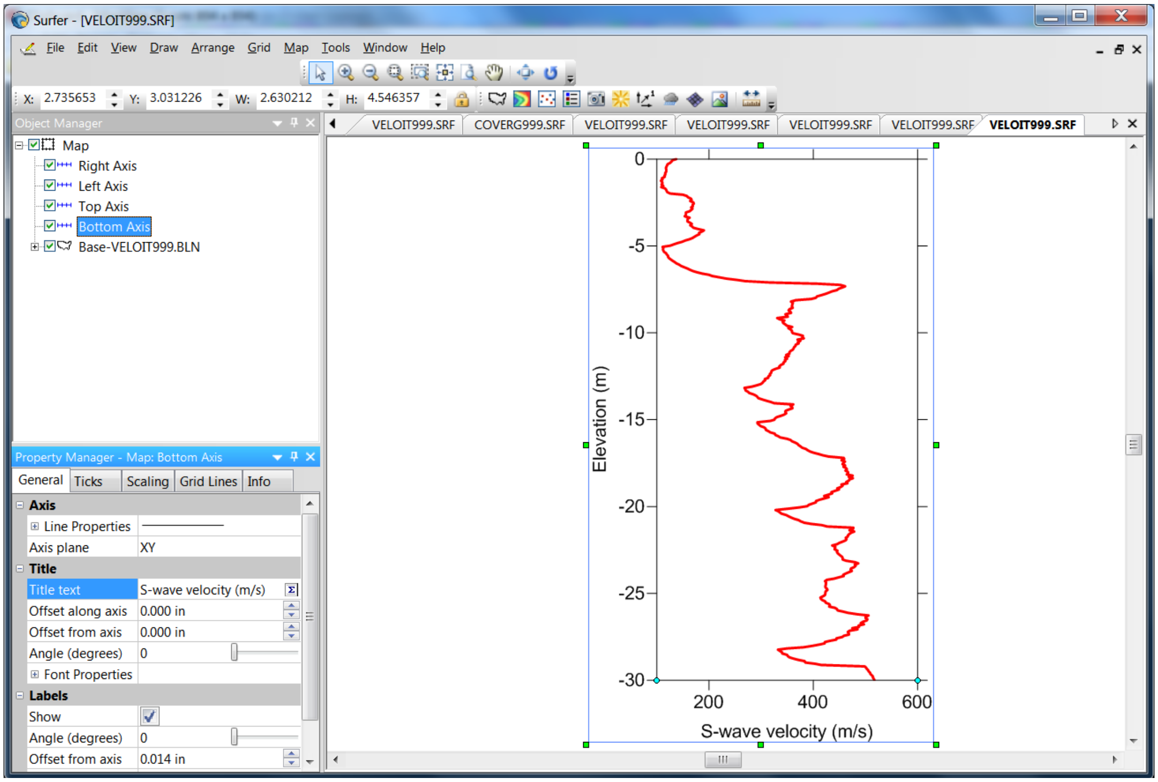


Fig. 26 : edit axis title text for VSP velocity plot in Golden Software Surfer 11.

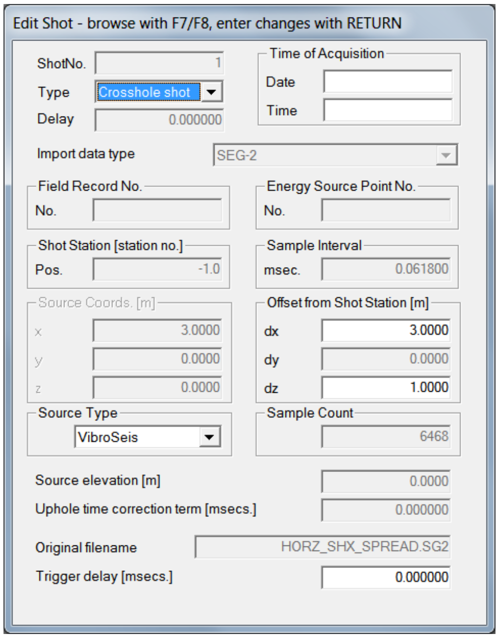


Fig. 27 : *Header|Shot*. Check if fields x and z in frame *Source Coords. [m]* match the *Source x-offset from top-of-hole* and *Source depth below top-of-hole* as specified in SEG2_HoleMerge program (Fig. 5).

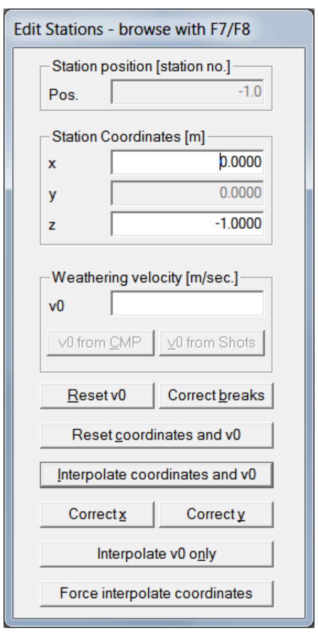


Fig. 28 : *Header|Station*. Use F7/F8 keys to browse to *Station position [station no.]* -1.0 as referenced in above *Header|Shot* (Fig. 27).

See also our updated 2025 manual (Rohdewald 2025) at

https://rayfract.com/help/rayfract.pdf

chapter ***Crosshole survey interpretation*** and chapter ***Downhole VSP interpretation*** and chapter ***Aggregate AMBROGEO or PASI 3-component borehole geophone channels into SEG-2 borehole spread files***.

See also our twin VSP tutorial https://rayfract.com/tutorials/PW27_Test.pdf showing P-wave VSP processing for the same borehole.

See also our 2024 VSP tutorials https://rayfract.com/tutorials/TTBM6.pdf and https://rayfract.com/tutorials/TTBM4.pdf and our earlier VSP tutorial https://rayfract.com/tutorials/vsp.pdf

See also our crosshole tutorials https://rayfract.com/tutorials/MDW2011_23.pdf and https://rayfract.com/tutorials/b8b9.pdf and our walkaway VSP tutorial https://rayfract.com/tutorials/walkaway.pdf . See also our joint inversion of surface refraction spread with borehole receiver spread tutorial at https://rayfract.com/tutorials/11REFR.pdf and our tutorial with receivers in 3 boreholes at https://rayfract.com/tutorials/KING17.pdf .

- Doug Crice describes cross-hole and down-hole shear wave recording geometry in his paper http://geostuff.com/Downhole_Shearwaves.pdf
- we allow picking of shear waves on shot traces recorded with reversed shot polarity in our ***Trace|Shot point gather*** display. See above and our manual https://rayfract.com/help/rayfract.pdf chapter ***Shear wave picking*** and our tutorial https://rayfract.com/tutorials/SH_60m.pdf .

- for the Free Pascal source files and Lazarus project files for our standalone SEG2_HoleMerge program see .RAR archive at https://rayfract.com/tools/SEG2_HoleMerge.rar .
- our SEG2_HoleMerge program calls into a modified version of the SEG2_EDIT program with permission given by its author Karl J. Ellefsen at USGS in his email dated Sep 8, 2025 to distribute this modified SEG2_EDIT build to our Rayfract® software clients. See https://rayfract.com/tools/SEG2_EDIT_SIR_July2_2025.zip for the Microsoft Visual Studio 2005 project files and C++ source files for our modified SEG2_EDIT version.
- for a description of the SEG2_EDIT program see https://www.usgs.gov/publications/seg2edit-a-program-editing-and-manipulating-seg-2-files

Discussion

We show gathering of SEG-2 channels recorded with AMBROGEO 3-component borehole geophone into SEG-2 receiver spread files sorted by channel number and receiver elevation. ***We assume that the 3-channel receiver trace files are named <receiver_elevation><optional wave identifier>.DAT / .SG2 / .SEG2.*** -1.SG2 / -1sx.SG2 / -1sy.SG2 means the borehole receiver was located at elevation -1m with the borehole top at elevation 0m.

-30.SG2 / -30sx.SG2 / -30sy.SG2 means the borehole receiver was positioned at elevation -30m. ***Rename your SEG-2 receiver channel files in Windows Explorer to match this file naming convention***.

Next we import the two aggregated SEG-2 borehole receiver spread files into a Rayfract(R) borehole profile database. Next we apply frequency filtering and pick the shear-wave first breaks. Finally we run our WET inversion using 500 or 999 Steepest-Descent iterations. We weight the velocity update across the wavepath using a Gaussian wavelet or with a Ricker wavelet (Schuster 1993). We use a custom/manual WET smoothing filter to obtain a horizontal layering in the final WET velocity tomogram. We scale the WET wavepath width with the picked time for each trace for improved weathering resolution. Also we scale the WET smoothing filter height with the grid row depth below topography.

See Fig. 19 for our horizontal S-wave first break picks. We assume that the borehole receiver probe rotated by 180 degrees at station number -6 while pulling it up and that the probe remained rotated for station numbers -5 to -1.

Also please note that we are just demonstrating usage of our new SEG2_HoleMerge program for gathering of borehole receiver channels and of our latest Rayfract® version 5.02/5.03 software. Precise and consistent first break picking is difficult and subjective and assumes that the horizontal S-wave traces have been recorded consistently in the field. Usually borehole receiver probes do not allow for the operator to fix the rotation of the probe in the borehole. This makes picking the horizontal S-wave first breaks consistently even more difficult and subjective.

Our long-time client recommends picking and following the first polarized event showing on both traces (red and green polarizations) in our Trace, Shot point gather display instead of following a specific phase in any of the polarizations (red or green). We followed these recommendations in our first break picking session shown in Fig. 19 at station numbers -6 to -1.

Acknowledgements

We thank our client Dr. Carabella at Studio GeoCar Explorer di Carabella Antonio for making available this nice S-wave downhole VSP survey and geotechnical core details and for giving us permission to use the above SEG-2 files for this tutorial and to make them available on our website. Also we thank him for giving us the impulse to write our new SEG2_HoleMerge program and for his feedback regarding interpretation of this borehole VSP data set with our latest version 5.02/5.03 software. I quote : “The sliding surface of the landslide, according to inclinometer data of the S2 survey, was detected at - 4.5 meters. In general, the consistency of the clay formation increases with depth. During the drilling phase, in the S1 survey, a possible aquifer was detected in a sandy level between -9 and -12 meters.” See Fig. 29 and Fig. 30 for the annotated geotechnical core stratigraphy for this S-wave downhole VSP survey.

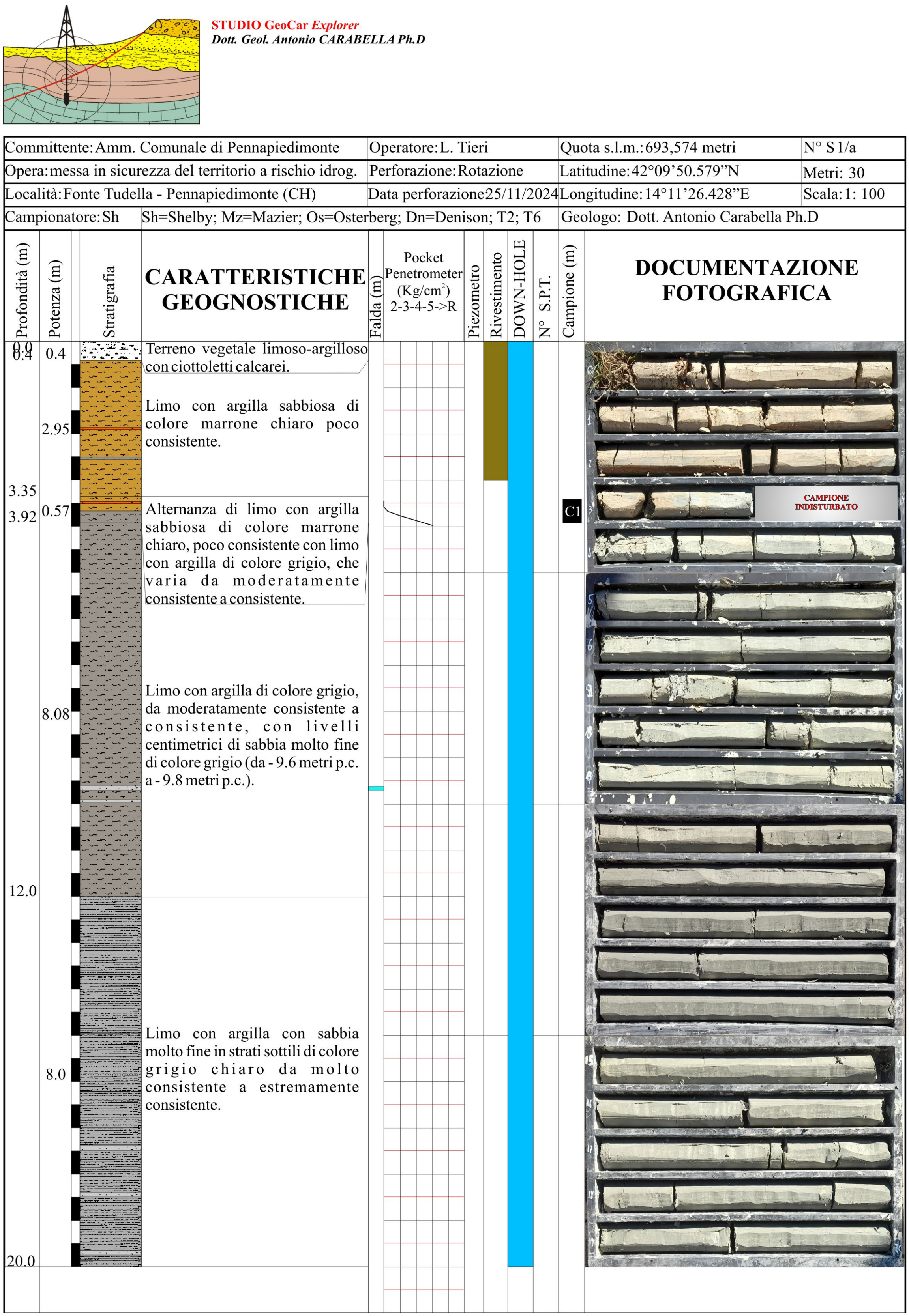


Fig. 29 : geotechnical core stratigraphy for S1 downhole VSP seismic survey. Included with permission given by Dr. Carabella.

STUDIO GeoCar *Explorer*
Dott. Geol. Antonio CARABELLA Ph.D

Committente: Amm. Comunale di Pennapiedimonte	Operatore: L. Tieri	Quota s.l.m.: 693,574 metri	N° S 1/b
Opera: messa in sicurezza del territorio a rischio idrog.	Perforazione: Rotazione	Latitudine: 42°09'50.579"N	Metri: 30
Località: Colle - Pennapiedimonte (CH)	Data perforazione 25/11/2024	Longitudine: 14°11'26.428"E	Scala: 1: 100
Campionatore: Sh	Sh=Shelby; Mz=Mazier; Os=Osterberg; Dn=Denison; T2; T6	Geologo: Dott. Antonio Carabella Ph.D	

Profondità (m)	Potenza (m)	Stratigrafia	CARATTERISTICHE GEOGNOSTICHE	Falda (m)	Pocket Penetrometer (Kg/cm^2) 2-3-4-5->R	Piezometro	Rivestimento	DOWN-HOLE	N° S.P.T.	Campione (m)	DOCUMENTAZIONE FOTOGRAFICA
20.0 – 30.0	N.D.		Limo con argilla da molto consistente a estremamente consistente con strati sottili di sabbia molto fine di colore grigio chiaro.							C2	
30.0			**FONDO FORO**								

Fig. 30 : geotechnical core stratigraphy for S1 downhole VSP seismic survey. Continuation of Fig. 24. Included with permission given by Dr. Carabella.

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