Import SEG-2 .SG2 & Update header data & WET Shear-Wave VSP line SH27_TEST v. 5.02 :

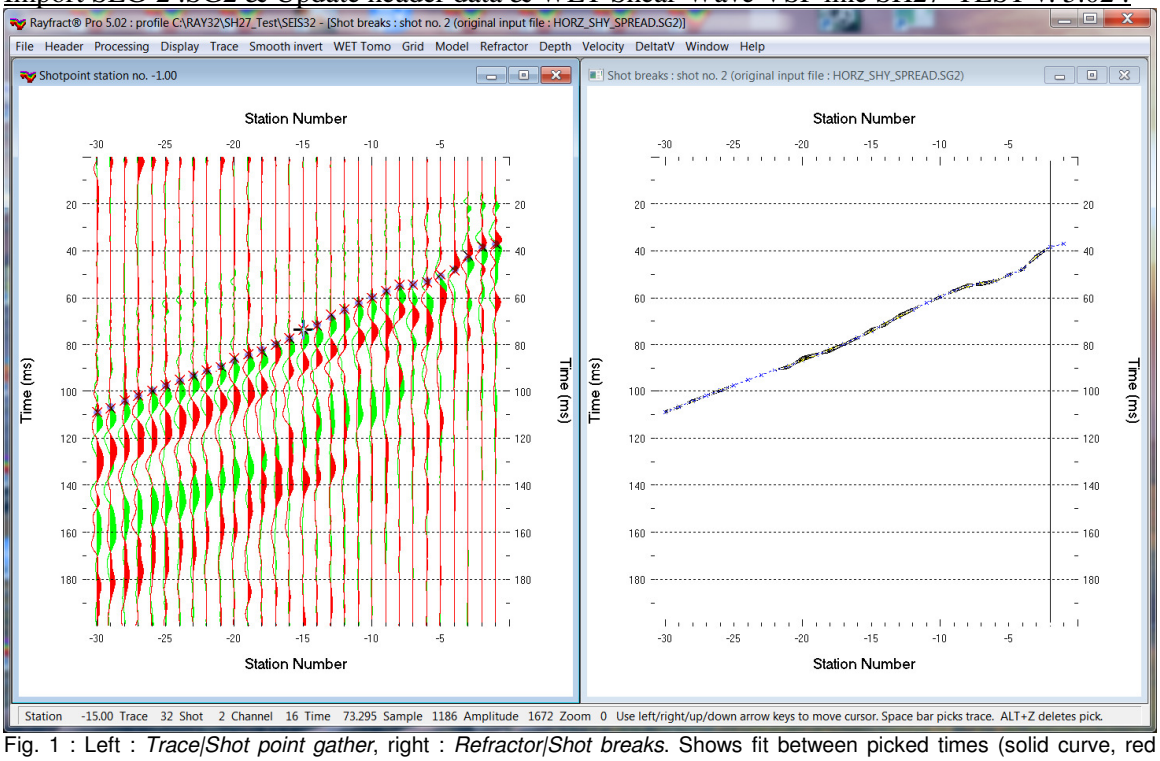


Fig. 1 : Left : *Trace|Shot point gather*, right : *Refractor|Shot breaks*. Shows fit between picked times (solid curve, red crosses) and modeled times (dashed blue curve, blue dots).

To create the profile database, aggregate the SEG-2 channels, import the aggregated .SG2 and view the two imported aggregated .SG2 shear-wave shots do these steps :

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
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 recorded with second horizontal x channel***. 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 **`Horz_SHX_Spread.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 recorded with third horizontal y channel***. See Fig. 9. In step 16. the aggregated SEG-2 file **`Horz_SHY_Spread.SG2`** is written into folder **`C:\RAY32\SH27_TEST\INPUT2.`**
18. click on title bar of our opened Rayfract® 5.02

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 **`Horz_SHX_Spread.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 with title **`Import C:\RAY32\SH27_TEST\INPUT2\Horz_SHX_Spread.SG2…`** set *Shot Number* to 1 and click *Read* button.
27. with updated title **`Import C:\RAY32\SH27_TEST\INPUT2\Horz_SHY_Spread.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.*

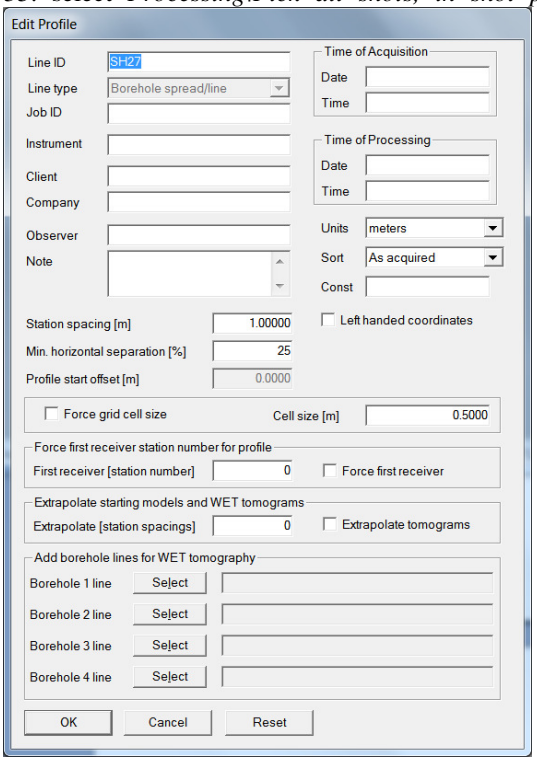


Fig. 2 : *Header|Profile*

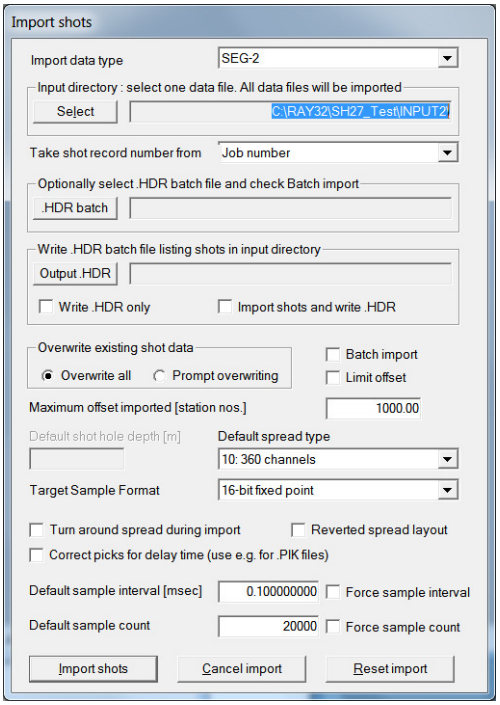


Fig. 3 : *File|Import Data*

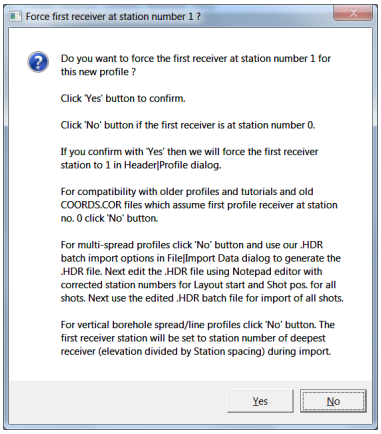


Fig. 4 : click *No* button.

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.

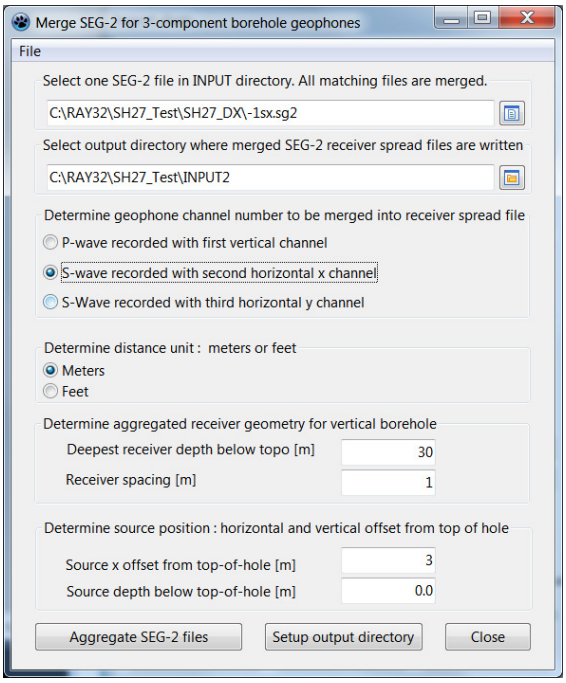
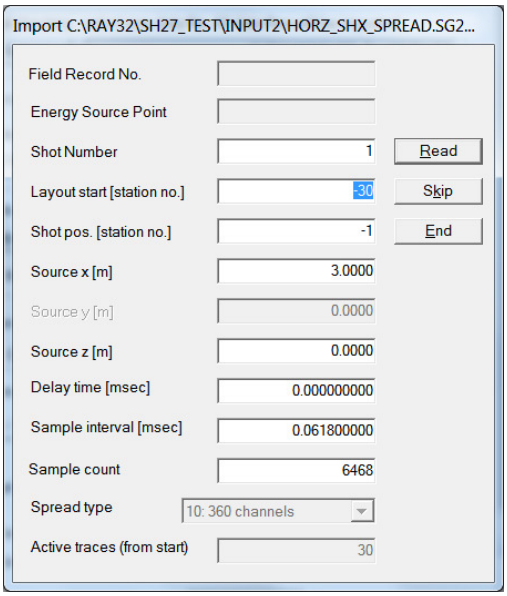


Fig. 5 : click SEG2 HoleMerge 5.02 icon. Edit as shown. Click buttons *Setup output directory* and ***Aggregate SEG-2 files***.



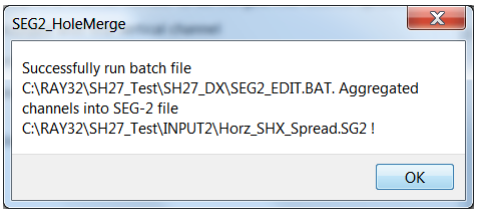


Fig. 6 : prompt shown after click on Aggregate SEG-2 files button. Click OK to dismiss prompt.

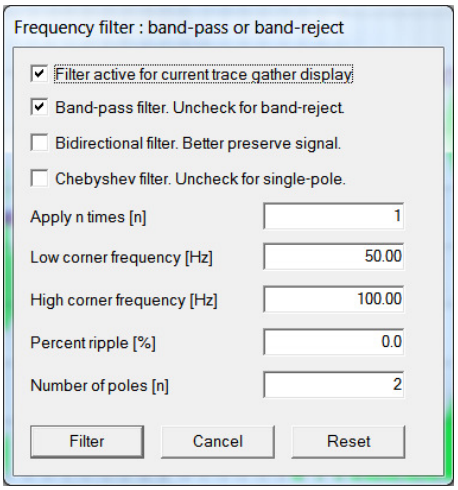


Fig. 8 (above) : Band-pass filter dialog shown with SHIFT+Q. Edit as shown and click *Filter* button.

Fig. 7 (left) : click *Read* button twice to import the two aggregated .SG2 borehole receiver spreads.

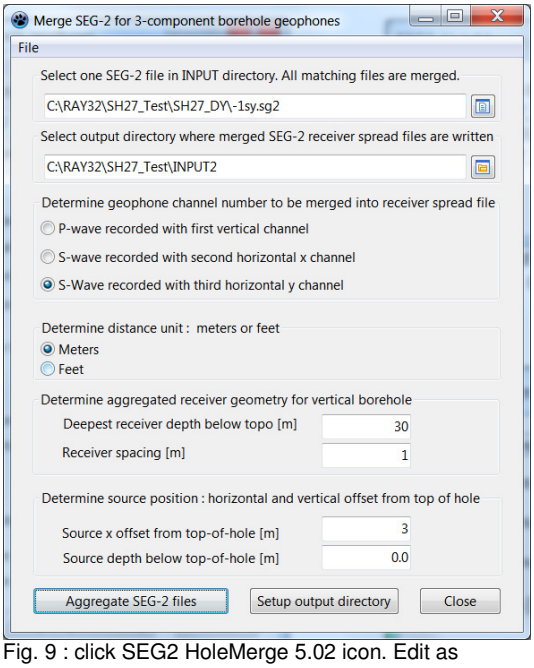


Fig. 9 : click SEG2 HoleMerge 5.02 icon. Edit as shown. Click buttons *Setup output directory* and ***Aggregate SEG-2 files***.

Configure and obtain constant-velocity starting model and run interactive WET inversion :

- 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.
- click *Select* button. Navigate into folder **`C:\Ray32\SH27_Test\HOLETOMO`**. Select **`CONSTVEL.GRD`** starting model grid.
- 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)

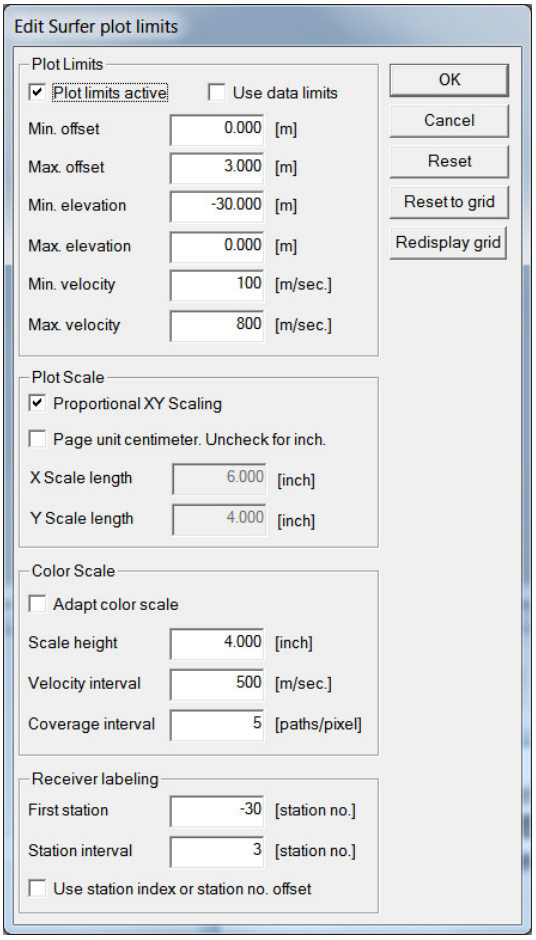


Fig. 10 : *Grid|Surfer plot Limits* dialog. Check box ***Limits active*** and ***Proportional XY scaling***. Edit as shown. Click OK button.

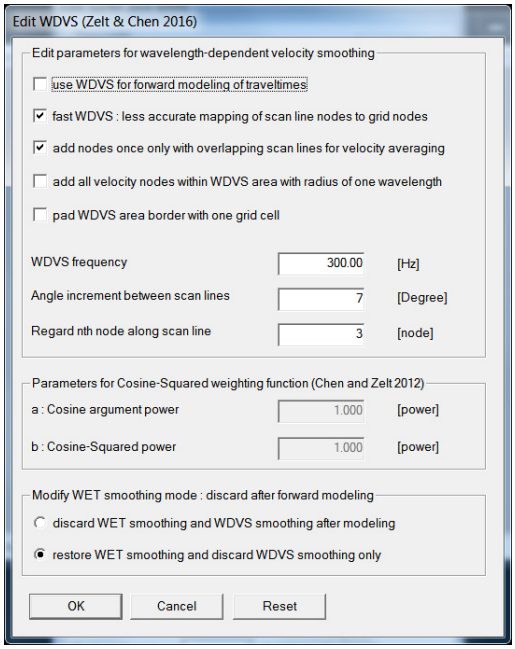


Fig. 11 : *Model|WDVS Smoothing* dialog. Click option ***restore WET smoothing discard WDVS smoothing only***. Click OK.

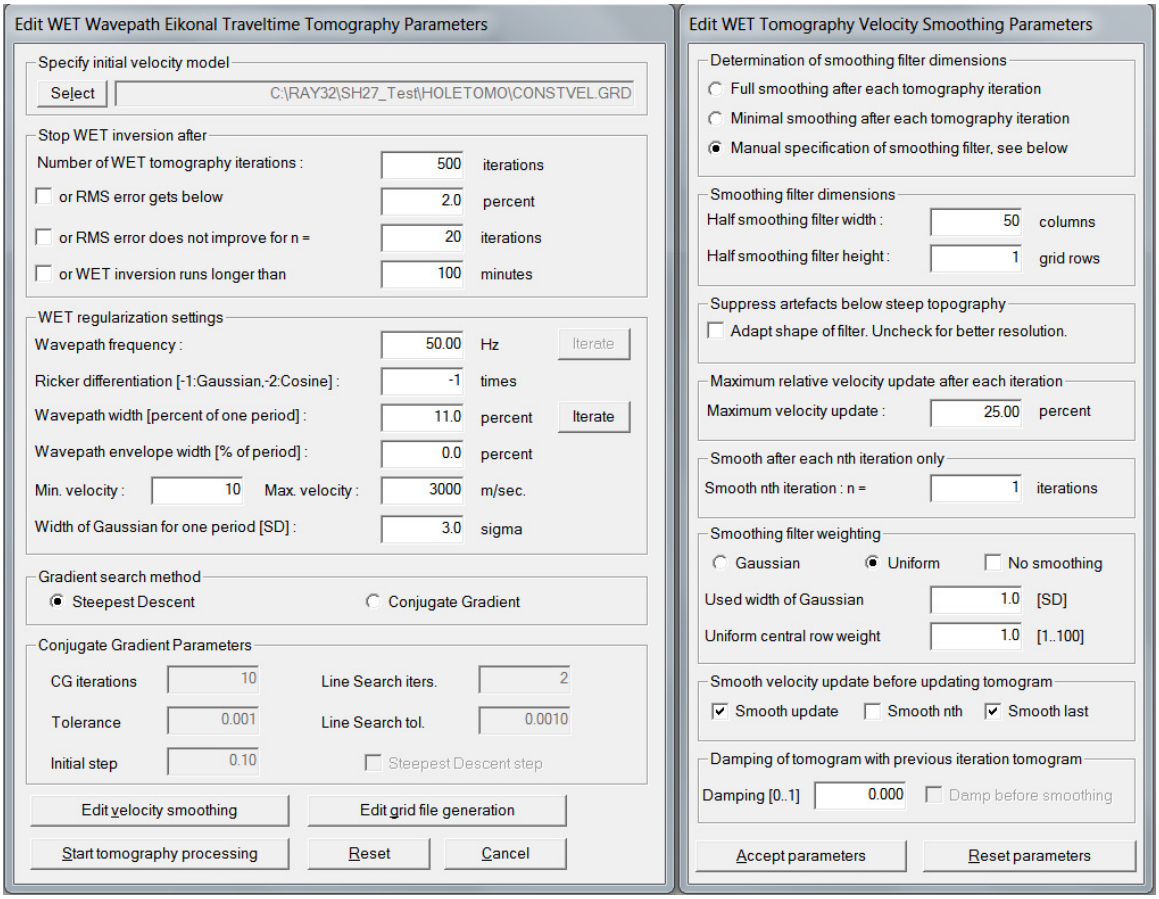


Fig. 12 : *WET Tomo|Interactive WET* main dialog (left). Click *Select* button. Navigate into folder C:\Ray32\SH27_Test\HOLETOMO. Select CONSTVEL.GRD starting model grid. Edit velocity smoothing (right).

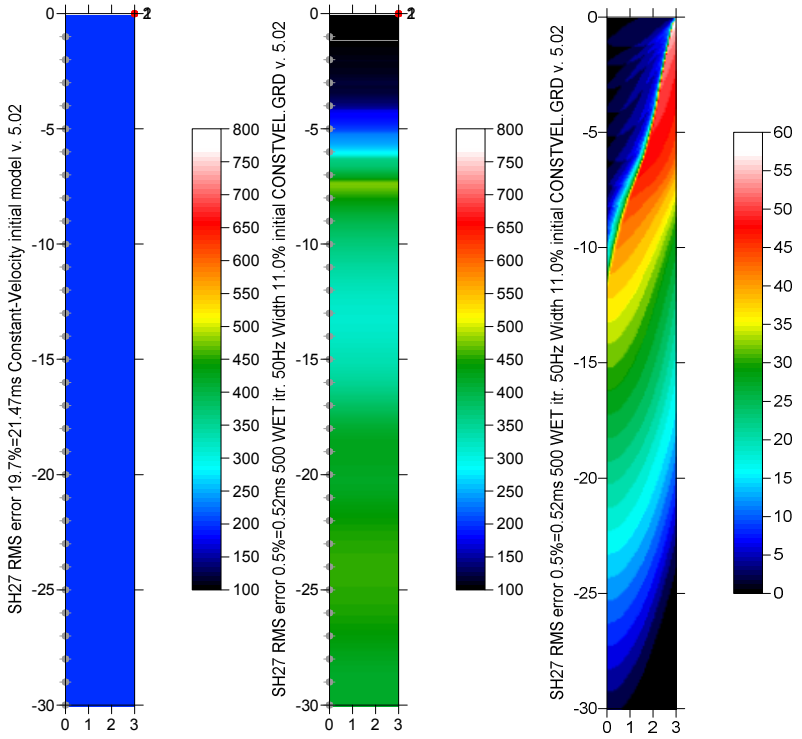


Fig. 13 : constant-velocity initial model (left). Steepest-Descent WET inversion after 500 iterations (center) with ***restore WET smoothing*** checked in *Model|WDVS Smoothing* (Fig. 11).

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

We use a ***Gaussian wavelet*** for WET 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 WET tomogram (center). Surfer plot limits as in Fig. 10.

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***

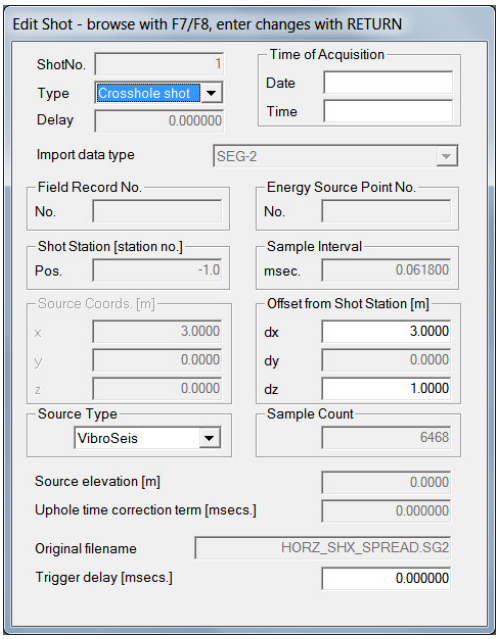


Fig. 14 : *Header|Shot*. Check if fields x and z in frame *Source Coords. [m]* match the *Source x-offset from top-of-hole* and *Source depth below top-of-hole* as specified in SEG2_HoleMerge program (Fig. 5).

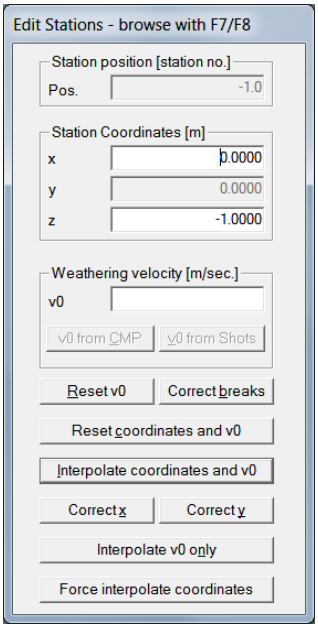


Fig. 15 : *Header|Station*. Use F7/F8 keys to browse to *Station position [station no.]* -1.0 as referenced in above *Header|Shot* (Fig. 14).

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

https://www.dropbox.com/scl/fi/er9c2n33v2m34nndepho7/SH27_Test.rar?rlkey=va7mwtexnh8up2ufy931ix97p&st=xhgjc0xs&dl=0

See also our updated 2024 manual

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

chapter ***Crosshole survey interpretation*** and chapter ***Downhole VSP interpretation***.

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

and our joint inversion of surface refraction spread with borehole receiver spread tutorial

https://rayfract.com/tutorials/11REFR.pdf

and our tutorial with receivers in 3 boreholes 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 .

Discussion

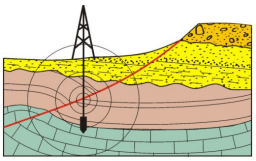
We show gathering of SEG-2 channels recorded with AMBROGEO STRUMENTI PER LA GEOFISICA DI ALESSANDRO AMBROGIO 3-component borehole geophone into SEG-2 receiver spread files sorted by channel number and receiver elevation. ***We assume that the 3-channel receiver trace files are named <receiver_elevation><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 Steepest-Descent iterations. We weight the velocity update across the wavepath using a Gaussian wavelet (Schuster 1993). Also we use a custom 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.

Acknowledgements

We thank our client Dr. Carabella at Studio GeoCar Explorer di Carabella Antonio 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 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. 16 and Fig. 17 for the annotated geotechnical core stratigraphy for this downhole VSP survey.

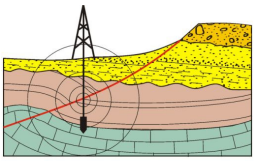


STUDIO GeoCar *Explorer*
Dott. Geol. Antonio CARABELLA Ph.D

Committente: Amm. Comunale di Pennapiedimonte	Operatore: L. Tieri	Quota s.l.m.: 693,574 metri	N° S 1/a
Opera: messa in sicurezza del territorio a rischio idrog.	Perforazione: Rotazione	Latitudine: 42°09'50.579"N	Metri: 30
Località: Fonte Tudella - 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/cm²) 2-3-4-5->R	Piezometro	Rivestimento	DOWN-HOLE	N° S.P.T.	Campione (m)	DOCUMENTAZIONE FOTOGRAFICA
0.0											
0.4	0.4		Terreno vegetale limoso-argilloso con ciottoletti calcarei.								
	2.95		Limo con argilla sabbiosa di colore marrone chiaro poco consistente.								
3.35											
3.92	0.57		Alternanza di limo con argilla sabbiosa di colore marrone chiaro, poco consistente con limo con argilla di colore grigio, che varia da moderatamente consistente a consistente.							C1	CAMPIONE INDISTURBATO
	8.08		Limo con argilla di colore grigio, da moderatamente consistente a consistente, con livelli centimetrici di sabbia molto fine di colore grigio (da - 9.6 metri p.c. a - 9.8 metri p.c.).								
12.0											
	8.0		Limo con argilla con sabbia molto fine in strati sottili di colore grigio chiaro da molto consistente a estremamente consistente.								
20.0											

Fig. 16 : 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/cm²) 2-3-4-5->R	Piezometro	Rivestimento	DOWN-HOLE	N° S.P.T.	Campione (m)	DOCUMENTAZIONE FOTOGRAFICA
20.0	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. 17 : geotechnical core stratigraphy for S1 downhole VSP seismic survey. Continuation of Fig. 16. Included with permission given by Dr. Carabella.

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https://www.researchgate.net/publication/242072938 .

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https://www.researchgate.net/publication/242159023

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https://dx.doi.org/10.1190/1.1820777

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Zelt, C.A., Haines, S., Powers, M.H. et al. 2013. Blind Test of Methods for Obtaining 2-D Near-Surface Seismic Velocity Models from First-Arrival Traveltimes, JEEG, Volume 18(3), 183-194. https://www.researchgate.net/publication/267026965