Import SEG-2 .SG2 & Update header data & WET P-Wave VSP profile PW27_TEST v. 5.02 :

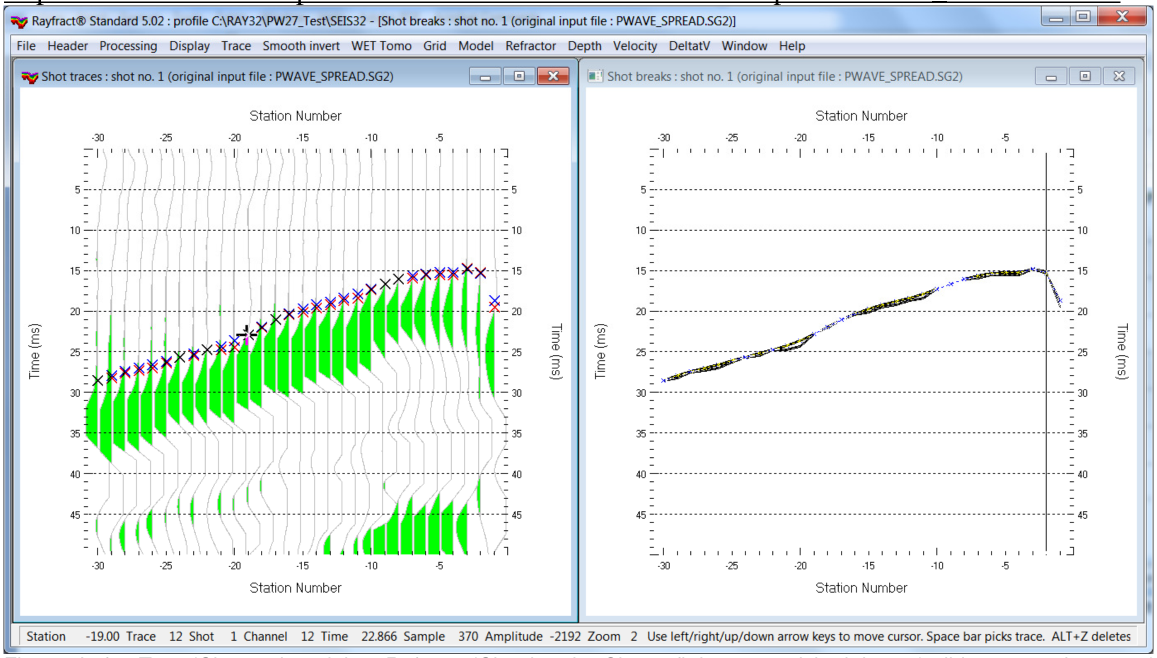

Fig. 1 : Left : *Trace|Shot gather*, right : *Refractor|Shot breaks*. Shows fit between picked times (solid curve, red crosses) and modeled times (dashed blue curve, blue crosses).

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

- ***File|New Profile***…, set *File name* to **`PW27_TEST`** and click *Save button*
- in the prompt shown next (Fig. 4) click ***No*** button .
- in ***Header|Profile***… set *Line type* to **`Borehole spread/line`** . Set *Station spacing* to 1.0m. See Fig. 2.
- unzip archive https://rayfract.com/tutorials/PW27_TEST.zip with **`SEG-2 .SG2`** receiver channel files & files **`COORDS.COR & SHOTPTS.SHO & BREAKS.LST`** in directory **`C:\RAY32\PW27_TEST\INPUT`**
- 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
- open SEG2 HoleMerge 5.02 program via desktop icon. See Fig. 5
- click on file icon besides uppermost field ***Select one SEG-2 file in INPUT directory***
- navigate into folder **`C:\RAY32\PW27_TEST\INPUT`**. At right bottom of dialog select **`ABEM files (*.SG2)`**
- click on one file e.g. **`-1.SG2`** (receiver channels for elevation -1.0) and click *Open* button
- in frame ***Determine geophone channel number to be merged*** click radio button ***P-wave recorded with first vertical channel***. See Fig. 5.
- in frame ***Determine distance unit : meters or feet*** click radio button ***Meters***
- 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.
- 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.
- click button ***Setup output directory*** to set frame *Select output directory* to **`C:\RAY32\PW27_TEST\INPUT2`**.
- click button ***Aggregate SEG-2 files***. Confirm prompts (Fig. 6).
- the aggregated SEG-2 receiver spread file **`PWave_Spread.SG2`** is written into folder **`C:\RAY32\PW27_TEST\INPUT2`**.
- click on title bar of our opened Rayfract® 5.02
- select import option *File|SEG-2 import settings and commands|**Receiver coordinates specified***
- select ***File|Import Data***… . Set *Import data type* to **`SEG-2`**. See Fig. 3.

- click *Select button* and navigate into **`C:\RAY32\PW27_TEST\INPUT2`**
- set *Files of type* to **`ABEM files (*.SG2)`** and select file **`PWave_Spread.SG2`** & click *Open*
- leave *Default spread type* at **`10: 360 channels.`** Click *radio button **Overwrite all.***
- click ***Import shots button*** and confirm prompt
- in Fig. 7 dialog with title **`Import C:\RAY32\PW27_TEST\INPUT2\PWave_Spread.SG2…`** click *Read* button. Use *Skip* or *End* button to skip all other aggregated .SG2 receiver spreads files.
- select *File|Update header data|Update First Breaks*. Select file **`BREAKS.LST`** & click *Open*.
- select *Trace|Shot gather* and *Window|Tile* to obtain Fig. 1
- click on title bar of *Refractor|Shot breaks* window (Fig. 1 right) and press ALT+P. Edit *Maximum time* to 50 ms & press ENTER key to redisplay. Do the same for *Trace|Shot gather* window (Fig. 1 left).
- click on title bar of *Trace|Shot gather* window and press CTRL+F1 to zoom trace amplitude
- press CTRL+F3 to toggle trace wiggle display mode in *Trace|Shot gather* window.
- press SHIFT+Q and edit *band pass filter* as in Fig. 8 . Click *Filter* button.
- select *Display|Show picks on time axis*

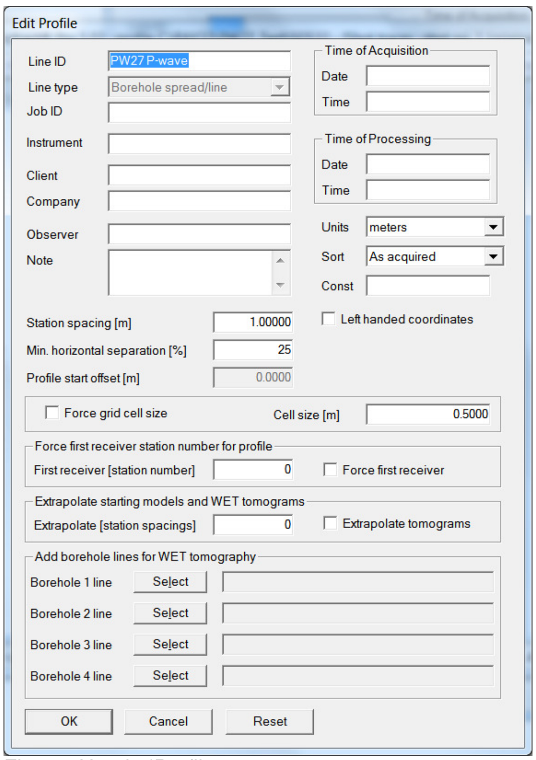

Fig. 2 : *Header|Profile*

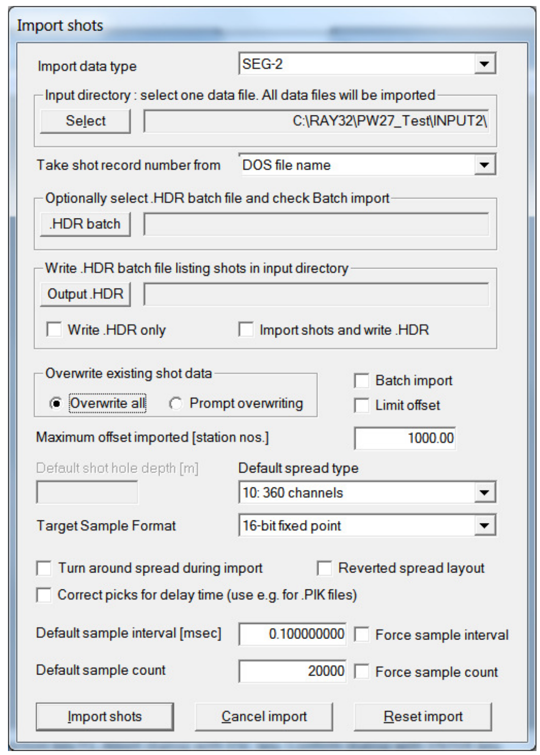

Fig. 3 : *File|Import Data*

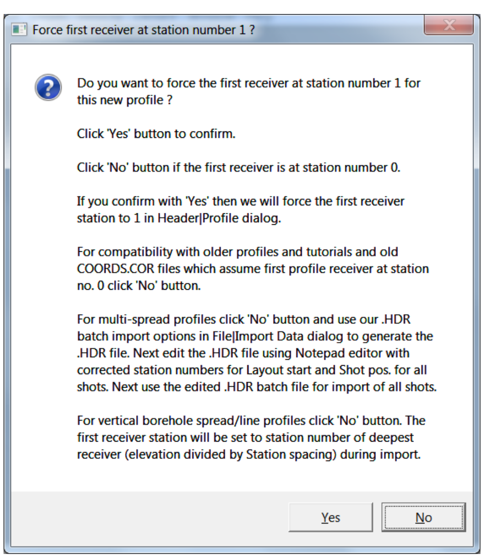

Fig. 4 : click *No* button.

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.

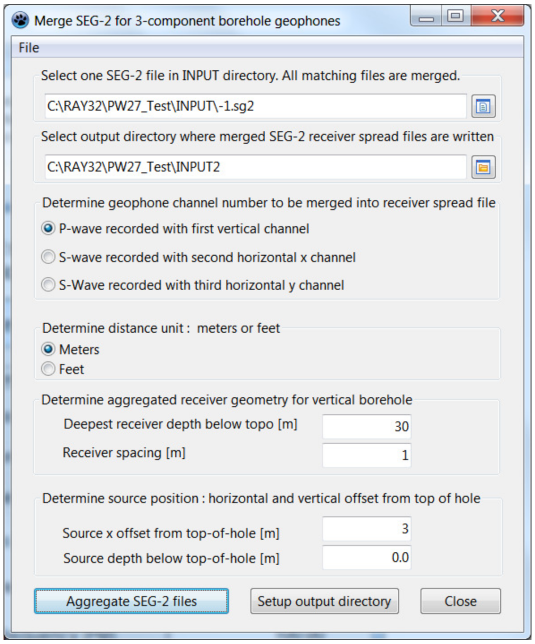

Fig. 5 : click SEG2 HoleMerge 5.02 icon. Edit as shown. Click buttons *Setup output directory* and ***Aggregate SEG-2 files***.

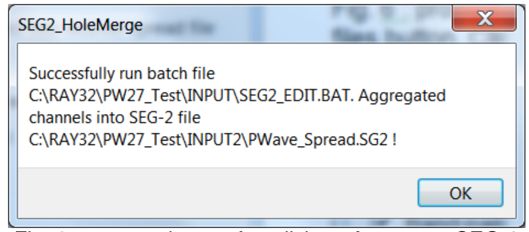

Fig. 6 : prompt shown after click on Aggregate SEG-2 files button. Click OK to dismiss prompt.

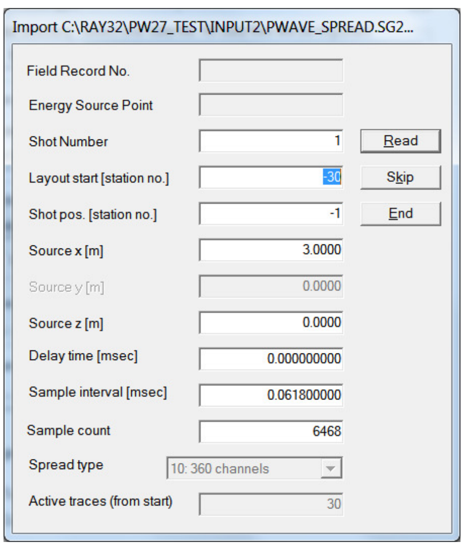

Fig. 7 : Import shot dialog. Click *Read* button. Then click *End* to skip all other aggregated .SG2.

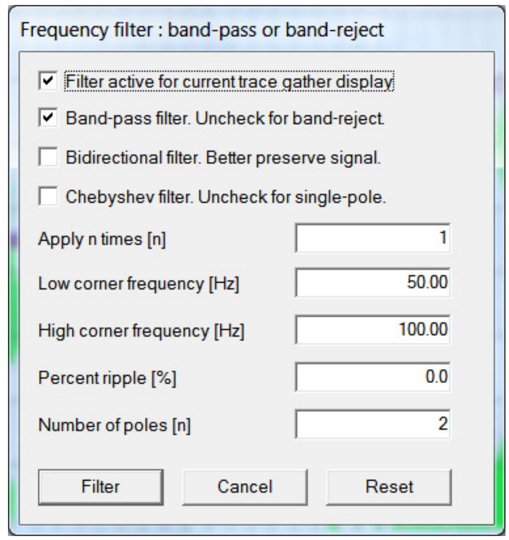

Fig. 8 : Band-pass filter dialog shown with SHIFT+Q. Edit as shown and click *Filter* button.

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

- check *Grid|Vertical plot title*. Check *Grid|GS CENTERED FONT* to fix Surfer 11 plot display.
- edit *Grid|Surfer plot Limits* as in Fig. 9
- select ***Smooth invert|WET with constant-velocity initial model***
- wait for the constant-velocity starting model to show as in Fig. 12 (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*** (Fig. 10). 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. 11 left.
- click *Select* button. Navigate into folder **C:\Ray32\PW27_Test\HOLETOMO**. Select **CONSTVEL.GRD** starting model grid.
- click button *Edit velocity smoothing*. Edit as in Fig. 11 right. Click button *Accept parameters*.
- click button *Start tomography processing* and confirm prompts to obtain Fig. 12 (center and right)

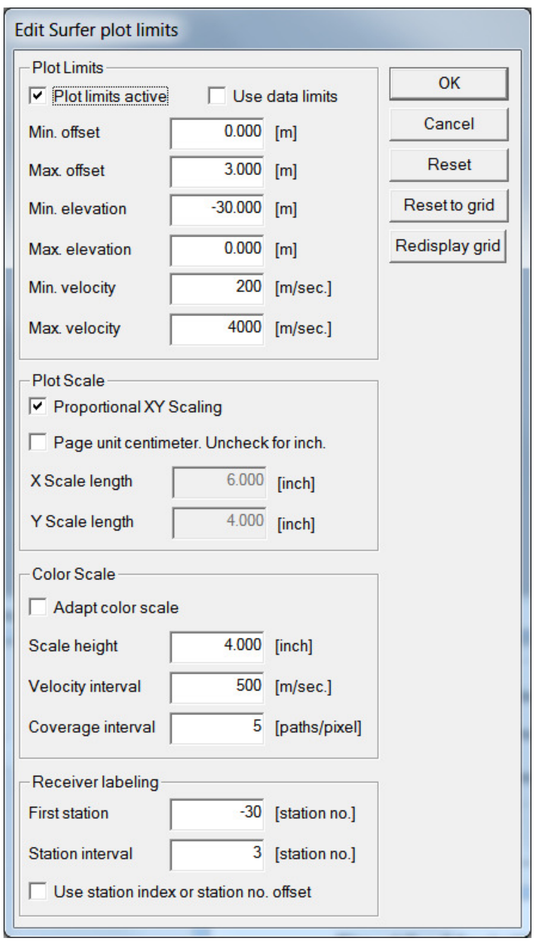

Fig. 9 : Grid|Surfer plot Limits dialog. Check box ***Limits active*** and ***Proportional XY scaling***. Edit as shown. Click OK button.

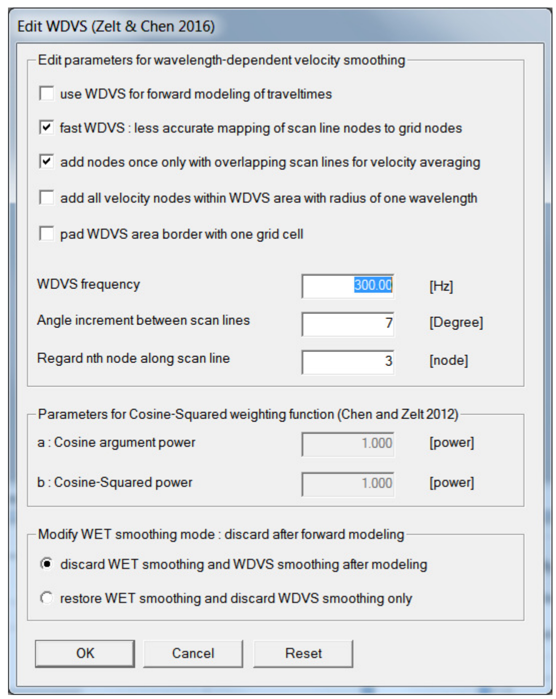

Fig. 10 : Model|WDVS Smoothing dialog. Click option ***discard WET smoothing and WDVS smoothing after modeling***. Click OK.

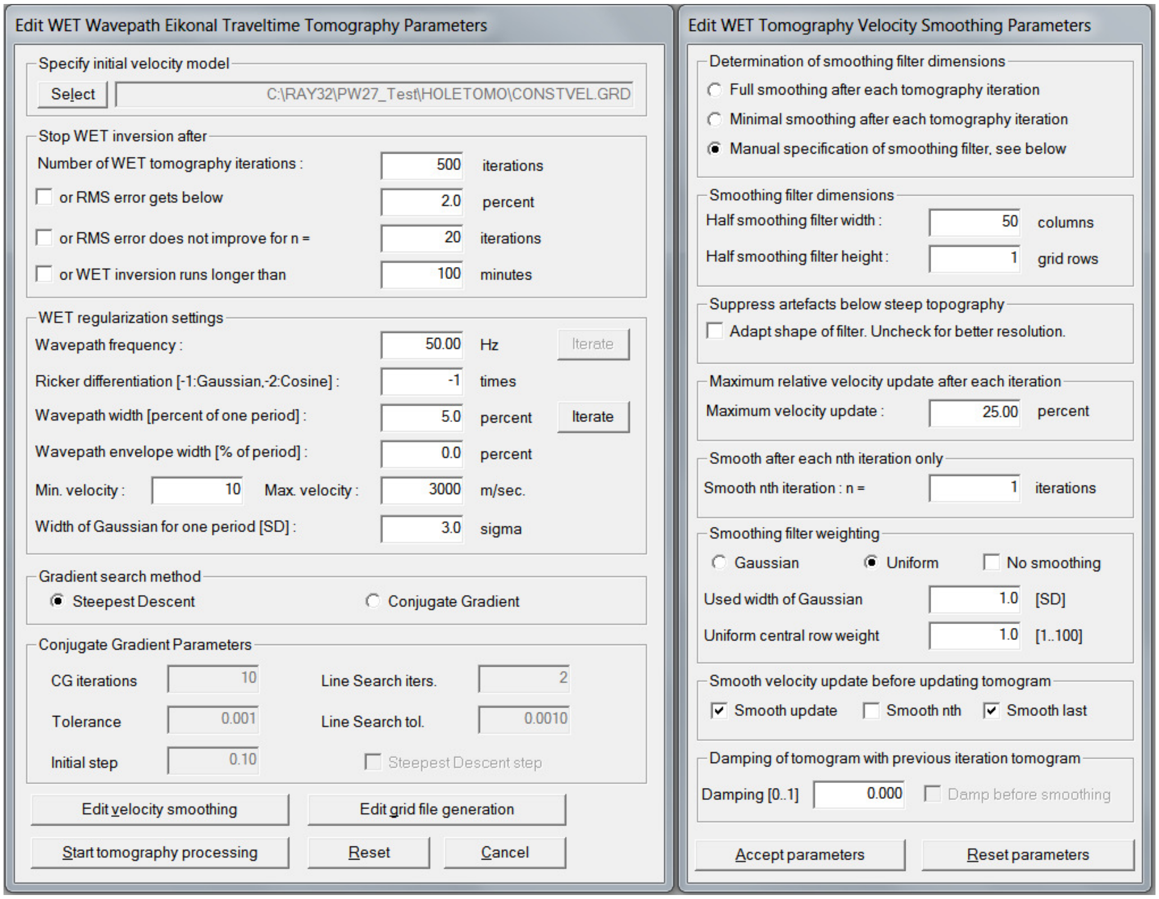

Fig. 11 : *WET Tomo|Interactive WET* main dialog (left). Click *Select* button. Navigate into folder C:\Ray32\PW27_Test\HOLETOMO. Select CONSTVEL.GRD starting model grid. Edit velocity smoothing (right).

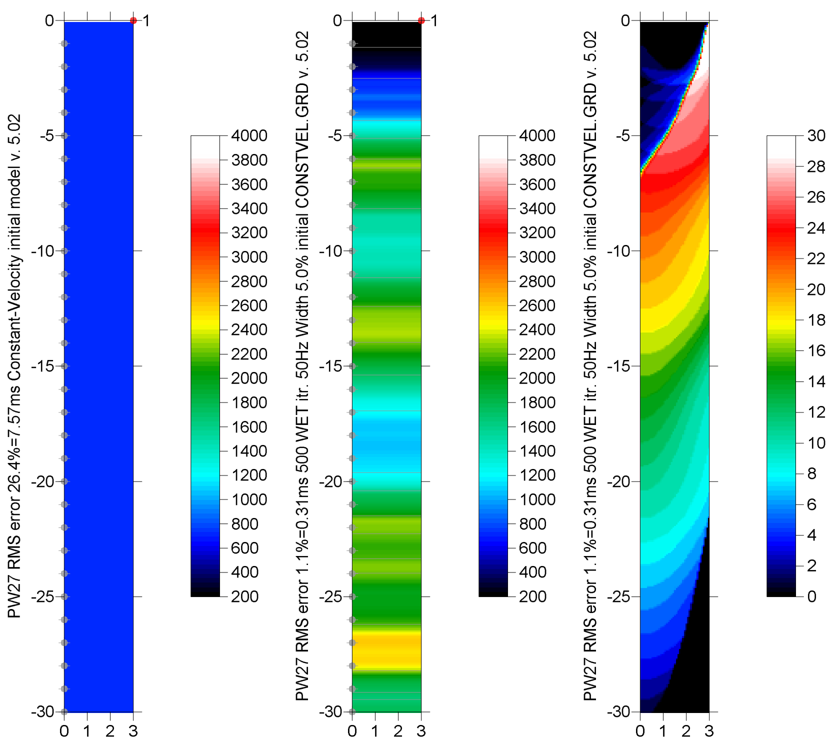

Fig. 12 : constant-velocity initial model (left). Steepest-Descent WET inversion after 500 iterations (center) with ***discard WET smoothing*** checked in *Model|WDVS Smoothing* (Fig. 10).

We left WET ***wavepath frequency*** at 50Hz and left WET ***wavepath width*** at 5 percent (Fig. 11 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. 11 left) and ***manual WET smoothing*** (Fig. 11 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. 9.

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***

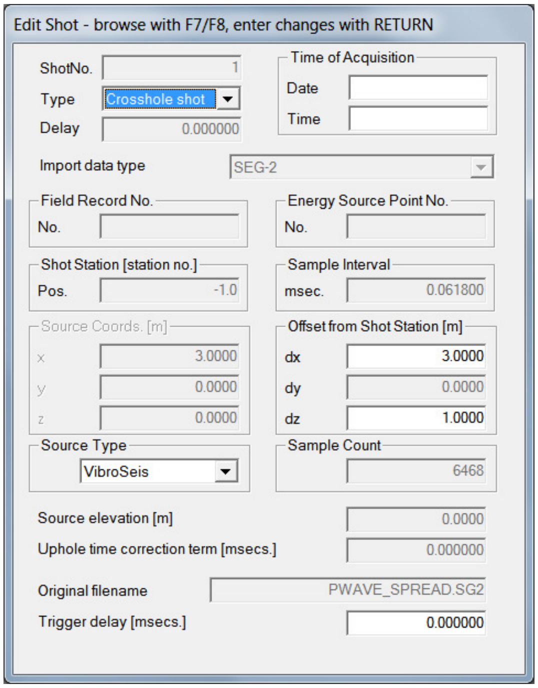

Fig.13 : *Header|Shot*. Check if fields x and z in frame *Source Coords. [m]* match the *Source x-offset from top-of-hole* and *Source depth below top-of-hole* as specified in SEG2_HoleMerge program (Fig. 5).

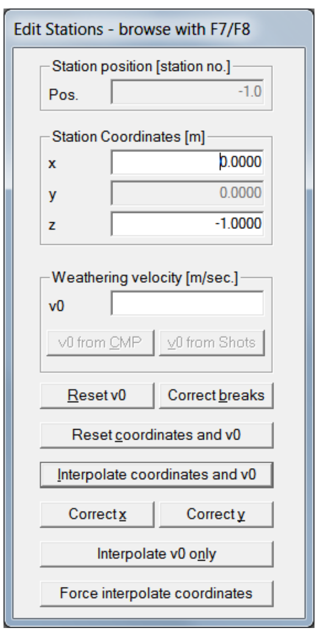

Fig. 14 : *Header|Station*. Use F7/F8 keys to browse to *Station position [station no.]* -1.0 as referenced in above *Header|Shot* (Fig. 13).

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

https://www.dropbox.com/scl/fi/wz60q1r4kt69otulrw4wa/PW27_Test.rar?rlkey=fnjw01xq6s7xyoviyzjdovhww&st=kzqah887&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/SH27_Test.pdf showing shear-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 our shear-wave VSP tutorial https://rayfract.com/tutorials/SH27_Test.pdf and our manual https://rayfract.com/help/rayfract.pdf chapter ***Shear wave picking*** and our refraction shear-wave 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 type identifier>.DAT / .SG2 / .SEG2.*** -1.SG2 means borehole receiver was located at elevation -1m with the borehole top at elevation 0m. -30.SG2 means 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 aggregated SEG-2 files into a Rayfract(R) borehole profile database. Next we apply frequency filtering and pick the P-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. 15 and Fig. 16 for the annotated geotechnical core stratigraphy for this downhole VSP survey.

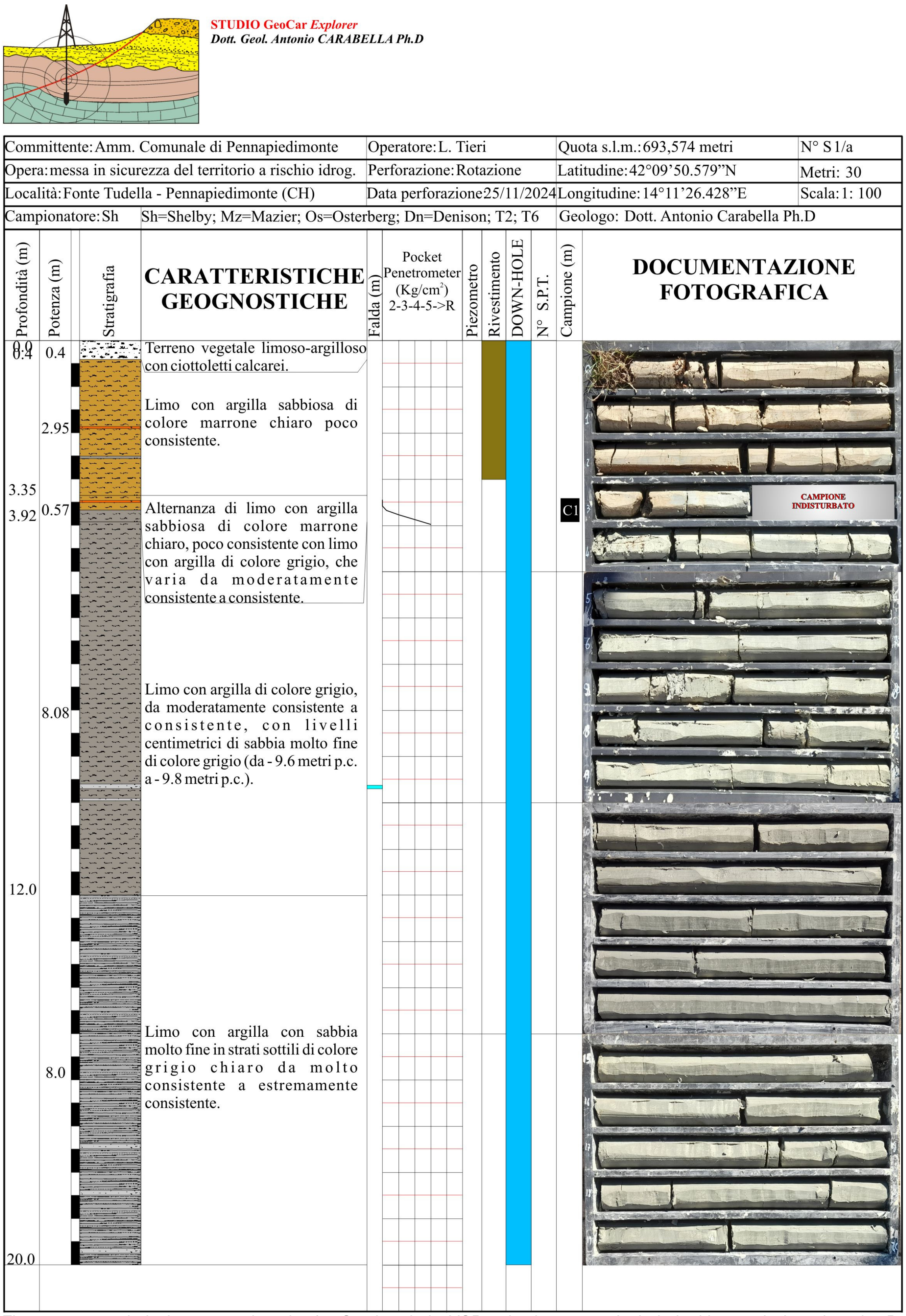

Fig. 15 : geotechnical core stratigraphy for S1 downhole VSP seismic survey. Included with permission given by Dr. Carabella.

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° S1/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	
			FONDO FORO								

Fig. 16 : geotechnical core stratigraphy for S1 downhole VSP seismic survey. Continuation of Fig. 15. Included with permission given by Dr. Carabella.

References

Hiltunen, D. R., Hudyma, N., Quigley, T. P., & Samakur, C. 2007. Ground Proving Three Seismic Refraction Tomography Programs. Transportation Research Record, 2016(1), 110–120. https://doi.org/10.3141/2016-12
https://www.researchgate.net/publication/242072938 .

Rohdewald, S.R.C. 2021a. Improving the resolution of Fresnel volume tomography with wavelength-dependent velocity smoothing, Symposium on the Application of Geophysics to Engineering and Environmental Problems Proceedings : 305-308. https://doi.org/10.4133/sageep.33-169 . Slides at https://rayfract.com/pub/SAGEEP%202021%20slides.pdf

Rohdewald, S.R.C. 2021b. Improved interpretation of SAGEEP 2011 blind refraction data using Frequency-Dependent Traveltime Tomography, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-4214, https://doi.org/10.5194/egusphere-egu21-4214

Schuster, Gerard T. and Quintus-Bosz, Aksel 1993. Wavepath eikonal traveltime inversion : Theory. Geophysics, volume 58, pp. 1314-1323. https://dx.doi.org/10.1190/1.1443514

Sheehan J.R., Doll W.E. and Mandell W.A. 2005a. An Evaluation of Methods and Available Software for Seismic Refraction Tomography. Journal of Environmental and Engineering Geophysics, volume 10, pp. 21-34. ISSN 1083-1363, Environmental and Engineering Geophysical Society. JEEG March 2005 issue. https://dx.doi.org/10.2113/JEEG10.1.21 . https://rayfract.com/srt_evaluation.pdf
https://www.researchgate.net/publication/242159023

Watanabe Toshiki et al. 1999. Seismic traveltime tomography using Fresnel volume approach. SEG Houston 1999 Meeting, Expanded Abstracts. https://www.researchgate.net/publication/240735641 .
https://dx.doi.org/10.1190/1.1820777

Zelt, C. A. and J. Chen 2016. Frequency-dependent traveltime tomography for near-surface seismic refraction data, Geophys. J. Int., 207, 72-88, 2016. See https://dx.doi.org/10.1093/gji/ggw269 and https://www.researchgate.net/publication/305487180 .

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