

# Import aggregated SEG-2 .SG2 & Update header data & WET for VSP profile TTBM6 v. 5.01 :

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 ттвм6 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 2.0m. See Fig. 2.
- unzip archive <u>https://rayfract.com/tutorials/TTBM6 INPUT.zip</u> with seg-2 .sg2 shot files & files coords.cor & shotpts.sho & breaks.lst in directory C:\ray32\TTBM6\INPUT
- download installer <u>https://rayfract.com/tools/SEG2Aggregate.exe</u> and run on your PC where you are running our Rayfract®
- open SEG2 Aggreg 5.01 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\TTBM6\INPUT. At right bottom of dialog select ABEM files (\*.SG2).
- click on one file e.g. DAT\_5850.sg2 and click Open button.
- tab to field *Deepest receiver depth below topo [m]* and enter value 64.
- for next field *Receiver spacing [m]* enter 2.
- in frame *Determine DDS geophone positions* click radio button *Pull up from hole bottom by 2m then 2m etc. Skip RX2 channel.* 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 2.4. Leave Source depth below top-of-hole [m] at 0.0.
- click button Setup output directory to set field Select output directory to C:\ray32\ttbm6\input2.
- click button Aggregate SEG-2 files. Confirm prompts successfully run batch file (Fig. 6).
- 9 aggregated SEG-2 files are written into folder C:\RAY32\TTBM6\INPUT2.
- click on title bar of our opened Rayfract® 5.01
- 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\TTBM6\INPUT2
- set Files of type to ABEM files (\*. SG2) and select a file e.g. HORZXPWAVE. 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\TTBM6\INPUT2\HORZXPWAVE.SG2... click Read button
- skip all other aggregated .SG2 by next clicking *End* button
- 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 80 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.
- press ALT+M and edit Trace processing parameters as in Fig. 9. Click Filter button.

Line ID	TTBM6 P-Wave	ing with	Date	isition
Job ID			Time	
nstrument			Time of Proce	essing
Client			Date	
Company			Time	
Observer			Units mete	rs
Note		~	Sort As a	quired
		Ŧ	Const	
Station spacin	g (m)	2.00000	🗌 Left hande	d coordinates
Min. horizontal	separation [%]	25		
Profile start off:	set [m]	0.0000		
Force g	rid cell size	Cells	size [m]	0.5000
Force first red	ceiver station numbe	er for profile		
First receiver	[station number]	0	Force first	receiver
Extrapolate s	tarting models and	WET tomogram	s	
Extrapolate [	station spacings]	0	Extrapolat	e tomograms
Add borehol	e lines for WET tom	ography		
Borehole 1 lin	e Select			
Borehole 2 lin	e Select			
Borehole 3 lin	e Select			
	e Select			
Borehole 4 lin	e <u>Select</u>	1		

Import shots				
Import data type	SEG-2			
Input directory : select one data	file. All data files will be imported			
Select	C:\RAY32\TTBM6\INPUT2\			
Take shot record number from	DOS file name			
Optionally select .HDR batch file	e and check Batch import			
.HDR batch				
Write .HDR batch file listing sho	ts in input directory			
Output .HDR				
Write .HDR only	Import shots and write .HDR			
Overwrite existing shot data	Batch import			
Overwrite all     O Prompt	overwriting			
Maximum offset imported [station	nos.] 1000.00			
Default shot hole depth [m]	Default spread type			
	10: 360 channels			
Target Sample Format	16-bit fixed point			
Turn around spread during import Reverted spread layout				
Correct picks for delay time (use e.g. for .PIK files)				
Default sample interval [msec]	0.100000000 Force sample interval			
Default sample count	20000 Force sample count			
Import shots Ca	ancel import <u>R</u> eset import			

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.

le	e	
	Select one SEG-2 file in INPUT directory. All matching files are aggregated.	
	C:\RAY32\TTBM6\INPUT\DAT_5850.sg2	
	Select output directory where aggregated SEG-2 spread files are written	
	C:\RAY32\TTBM6\INPUT2	
Determine aggregated receiver geometry for vertical borehole		
	Deepest receiver depth below topo [m] 64	
	Receiver spacing [m] 2	
Determine DDS geophone positions starting recording at hole bottom		
Pull up from hole bottom by 1m then 3m then 1m then 3m etc.		
Pull up from hole bottom by 2m then 2m etc. Skip RX2 channels.		
Determine source position : horizontal and vertical offset from top of hole		
	Source x offset from top-of-hole [m] 2.4	
	Source depth below top-of-hole [m] 0.0	
1	Aggregate SEG 2 files	

Fig. 5 : click SEG2 Aggreg 5.01 icon. Edit as shown. Click Setup output directory / Aggregate SEG-2 files.

Import C:\RAY32\TTBM6\INPUT2\HORZXPWAVE.SG2				
Field Record No.				
Energy Source Point				
Shot Number	1	<u>R</u> ead		
Layout start [station no.]	-32	S <u>k</u> ip		
Shot pos. [station no.]	-1	<u>E</u> nd		
Source x [m]	2.4000			
Source y [m]	0.0000			
Source z [m]	0.0000			
Delay time [msec]	0.00000000			
Sample interval [msec]	0.10000000			
Sample count	4096			
Spread type	360 channels 💌			
Active traces (from start)	32			
L				



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

Frequency filter : band-pass or band-reject			
Filter active for current trace gather display			
<ul> <li>Band-pass filter. Uncheck for</li> </ul>	band-reject.		
<ul> <li>Bidirectional filter. Better pres</li> </ul>	erve signal.		
Chebyshev filter. Uncheck for	single-pole.		
Apply n times [n] 1			
Low corner frequency [Hz]	50.00		
High corner frequency [Hz] 100.00			
Percent ripple [%] 0.0			
Number of poles [n]	2		
Filter Cancel	Reset		

- Fig. 8 (top) : Band-pass filter dialog shown with SHIFT+Q. Edit as shown and click *Filter* button.
- Fig. 7 (left) : Import shot dialog. Click *Read* button. Then click *End* to skip all other aggregated .SG2.

Trace processing parameters			
AGC parameters AGC window [msecs.] 50.000			
✓ Do AGC for current trace gather display			
Clip amplitude peaks for current trace display			
Trace clip [traces]			
Trace signal smoothing			
Filter width [msecs.] 5.000			
Central filter weight 5			
Remove systematic dc offset from traces			
Color every nth trace : n = 0			
Filter Cancel Reset			

Fig. 9 : Trace processing parameters shown with ALT+M. Edit as shown and click *Filter* button.

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

- select option *Grid*|*Vertical plot title*
- edit Grid|Surfer plot Limits as in Fig. 10
- 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
- select *Model* | WDVS Smoothing. Click radio button **Discard 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 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)

Edit Surfer plot limit	S		
Plot Limits			OK
Plot limits active	🗌 Use	data limits	
Min. offset	0.000	[m]	Cancel
Max. offset	2.400	[m]	Reset
Min. elevation	-64.000	[m]	Reset to grid
Max. elevation	0.000	[m]	Redisplay grid
Min. velocity	100	[m/sec.]	
Max. velocity	3500	[m/sec.]	
Plot Scale	Scaling		
Page unit centim	eter. Uncheck	for inch.	
X Scale length	6.000	[inch]	
Y Scale length	4.000	[inch]	
-Color Scale			
Adapt color scal	e		
Scale height	4.000	[inch]	
Velocity interval	500	[m/sec.]	
Coverage interval	5	[paths/pixel]	
Receiver labeling			
First station	-32	[station no.]	
Station interval	3	[station no.]	
Use station index or station no. offset			

Ec	Edit WDVS (Zelt & Chen 2016)			
ſ	Edit parameters for wavelength-dependent velocity smoothing			
	use WDVS for forward modeling of traveltimes			
	✓ fast WDVS : less accurate mapping of scan line nodes to grid nodes			
	I add nodes once only with overlapping scan lines for velocity averaging			
	add all velocity nodes within WDVS area with radius of one wavelength			
	pad WDVS area border with one grid cell			
	WDVS from one rulei			
	Angle increment between scan lines 7 [Degree]			
	Regard nth node along scan line 3 [node]			
	Parameters for Cosine-Squared weighting function (Chen and Zelt 2012)			
	a : Cosine argument power 1.000 [power]			
	b : Cosine-Squared power 1.000 [power]			
	⊂Modify WET smoothing mode : discard after forward modeling			
	Idiscard WET smoothing and WDVS smoothing after modeling			
	C restore WET smoothing and discard WDVS smoothing only			
	OK Cancel Reset			

Fig. 11 : Model|WDVS Smoothing dialog. Click option discard WET smoothing and WDVS smoothing after modeling. Click OK.

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

Edit WET Wavepath Eikonal Traveltime Tomography Parameters	Edit WET Tomography Velocity Smoothing Parameters
Specify initial velocity model Select C:\RAY32\TTBM6\HOLETOMO\CONSTVEL.GRD	C Full smoothing after each tomography iteration
Stop WET inversion after	Minimal smoothing after each tomography iteration     Manual specification of smoothing filter, see below
or RMS error gets below     2.0     percent       or RMS error does not improve for n =     20     iterations	Smoothing filter dimensions Half smoothing filter width :4 columns
or WET inversion runs longer than 100 minutes	Half smoothing filter height : 9 grid rows
WET regularization settings Wavepath frequency: 20.00 Hz Iterate	Adapt shape of filter. Uncheck for better resolution.
Ricker differentiation [-1:Gaussian,-2:Cosine] :     0     times       Wavepath width [percent of one period] :     20.0     percent     Iterate	Maximum relative velocity update after each iteration Maximum velocity update : 25.00 percent
Wavepath envelope width [% of period] :     0.0     percent       Min. velocity :     10     Max. velocity :     6000	Smooth after each nth iteration only Smooth nth iteration : n = 1 iterations
Width of Gaussian for one period [SD]: 3.0 sigma	-Smoothing filter weighting
Gradient search method © Steepest Descent C Conjugate Gradient	Gaussian © Uniform No smoothing Used width of Gaussian 1.0 [SD]
Conjugate Gradient Parameters CG iterations 10 Line Search iters. 2	Uniform central row weight 1.0 [1100] Smooth velocity update before updating tomogram
Tolerance         0.001         Line Search tol.         0.0010           Initial step         0.10         Steepest Descent step	Damping of tomogram with previous iteration tomogram
Edit velocity smoothing Edit grid file generation	Damping [01] 0.000 Damp before smoothing
Start tomography processing Reset Cancel	Accept parameters Reset parameters

Fig. 12 : WET Tomo|Interactive WET main dialog (left). Edit velocity smoothing (right).



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

We set WET *wavepath frequency* to 20Hz and WET
 *wavepath width* to 20 percent (Fig. 12 left).

We use a *Ricker wavelet* for WET update weighting across the wavepath (*Ricker differentiation* 0 in Fig. 12 left) and *minimal WET smoothing* (Fig. 12 right). Surfer plot limits as in Fig. 10.

WET wavepath coverage plot is shown at right. Unit is wavepaths per pixel.

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

- Scale wavepath width
- Scale WET filter height

Edit Shot - browse with F7/F8, enter changes with RETURN		
ShotNo. 1 Type Crosshole shot ✓ Delay 0.000000	Time of Acquisition       Date     31/Jul/2024       Time     01:34:17	
Import data type SEG	-2 💌	
Field Record No.	Energy Source Point No.	
Shot Station [station no.]	Sample Interval	
Pos1.0	msec. 0.100000	
Source Coords. [m]	Offset from Shot Station [m]	
× 2.4000	dx 2.4000	
у 0.0000	dy 0.0000	
z 0.0000	dz 2.0000	
Source Type Sample Count		
Hammer 💌	4096	
Source elevation [m]	0.0000	
Uphole time correction term [msecs	3.] 0.000000	
Original filename	HORZXPWAVE.SG2	
Trigger delay [msecs.]	0.00000	





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

<u>Click here</u> for the .rar archive of the profile folder obtained with above processing.

See also our updated 2024 manual

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

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

Our new SEG2\_Aggregate program is described in above rayfract.pdf paragraph Aggregate Geotomographie DDS borehole geophone traces into SEG-2 borehole spread files.

See also our twin tutorial <u>https://rayfract.com/tutorials/TTBM4.pdf</u> and our earlier tutorial <u>https://rayfract.com/tutorials/vsp.pdf</u>.

See also our crosshole tutorials <u>https://rayfract.com/tutorials/MDW2011\_23.pdf</u> and <u>https://rayfract.com/tutorials/b8b9.pdf</u>

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 .

- for the Geotomographie GmbH DDS borehole geophone manual see <u>https://geotomographie.de/assets/equipment/Manual2023-DDS.pdf</u>
- the Geotomographie GmbH test data set is available in archive <u>https://geotomographie.de/exchange/DDS\_Example\_SEG2\_Files.zip</u>. Download and unzip in above input directory.
- for a description of the SEG-2 file set format of the above test data showing the VSP recording geometry see <u>https://rayfract.com/tools/Downhole\_Test\_DDS\_Example\_SEG2\_Files.pdf</u>
- 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 <a href="https://rayfract.com/help/rayfract.pdf">https://rayfract.com/help/rayfract.pdf</a> chapter *Shear wave picking*.

## Discussion

We show aggregation of DDS recorded SEG-2 channels into SEG-2 receiver spread files. Then 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 Ricker wavelet (Schuster 1993). 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 Rajko Vasić at Jaroslav Cerni Water Institute 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\_Aggregate program and for his feedback regarding interpretation of this borehole VSP data set with our latest version 5.01 software. Rajko Vasić describes the geological subsurface setting as "all the boreholes go through quaternary sedimentary dusty clays, clays, marly clays alternating with marls, loams and sometimes marls and limestones that appear only in a few boreholes mainly at the bottom of the borehole. This project is tied to TBM (Tunnel boring machine) which will go through marly clayey sediments and "soft" rocks (marls and limestones rocks)". See also Wikipedia.

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