

Uphole refraction survey with Rayfract® version 3.35 :

Fig. 1 : left : *Trace*|*Shot gather*, right : *Refractor*|*Shot breaks*. Shows fit between picked times (solid colored curves) and modeled times (dashed colored curves) obtained by forward modeling over Fig. 4

- File|New Profile..., set File name to SUBS19 and click Save button
- set Station spacing to 3.0m in Header | Profile.... Set Line type to Refraction spread/line.
- set Cell size [m] to 0.5m in Header|Profile.. Check box Force grid cell size. Click button OK.
- unzip <u>subs19 input.rar</u> with seg-2 .dat files and batch.hdr in c:\ray32\subs19\input
- check File|Import Data Settings|Profile start is default layout start
- check File Import Data Settings Default layout start is 1
- select *File*|*Import Data*... and set *Import data type* to sEG-2. See Fig. 5.
- click button .HDR batch and select file C:\ray32\subs19\input\batch.HDR
- check box *Batch import* and click radio button *Overwrite all*. See Fig. 5.
- leave Default spread type at 10: 360 channels
- click Select button, navigate into C:\RAY32\SUBS19\INPUT and select one . DAT file e.g. 40. DAT
- click Open button and Import shots button
- confirm Reset model and geometry data prompt with Yes button.
- select File|Update header data|Update First Breaks and C:\ray32\subs19\input\breaks.lst
- select *Trace*|*Shot gather* and *Window*|*Tile* to obtain Fig. 1
- for each window click title bar, press ALT+P, set *Maximum time* to 50 ms and hit ENTER key
- for *Trace*|*Shot gather* click title bar. Press SHIFT+Q and check boxes *Filter active*, *Band-pass filter* and *Bidirectional filter*. See Fig. 6.
- set Low corner frequency [Hz] and High corner frequency [Hz] both to 200Hz. Click Filter button.
- in *Header*|Shot set Type to Uphole shot for shots no. 40 to 69. See Fig. 7. Browse shots with F7/F8. Uphole shots are not regarded when determining the 1D-gradient starting model. Leave shots no. 70 to 72 with default Type Refraction shot selected.
- select Smooth invert|Custom 1D-gradient velocity profile... . See Fig. 9.
- edit starting model grid limits as in Fig. 9. Check box *Force grid limits* and click button *OK*.
- uncheck WET Tomo|WET tomography Settings|Blank|Blank below envelope after last iteration
- check Smooth invert|Smooth inversion Settings|Allow XTV inversion for 1D initial model
- check Smooth invert|Smooth inversion Settings|Optimize XTV for layered starting model

- select *Smooth invert*|*WET with 1D-gradient initial model* and confirm prompts for default interpretation shown in Fig. 2
- select *Grid*|*Surfer plot Limits*... and click *button Reset to grid*. See Fig. 8.
- navigate into C:\RAY32\SUBS19\GRADTOMO directory and select VELOIT20.GRD
- check box Plot limits active. Set Min. velocity to 500 m/s and Max. velocity to 3,000 m/s.
- click button OK
- select WET Tomo Interactive WET tomography...
- set Number of WET tomography iterations to 100. Set Ricker differentiation to -2 and click button Edit velocity smoothing. See Fig. 4.
- click radio button Minimal smoothing after each tomography iteration
- uncheck box Automaticlly adapt shape of rectangular filter matrix
- click button Accept parameters and button Start tomography processing to obtain Fig. 3
- Fig. 4 shows WET parameters used to obtain Fig. 3
- for help on *WET inversion* parameters see updated <u>.pdf reference</u> chapter *WET Wavepath Eikonal Traveltime tomography*



SUBS19 RMS error 1.6%=0.64ms 20 WET iters. 50Hz Width 3.0% initial GRADIENT.GRD Vers. 3.35

Fig. 2a : Smooth invert|WET with 1D-gradient initial model. 20 WET iterations. XTV inversion enabled.



SUBS19 RMS error 1.6%=0.64ms 20 WET iters. 50Hz Width 3.0% initial GRADIENT.GRD Vers. 3.35

Fig. 2b : WET wavepath coverage plot obtained with Fig. 2a. Unit is wavepaths per pixel.



Fig. 3a : Tomogram with 1D-gradient starting model, 100 Steepest Descent WET iterations. Wavepath width 3%, Max. velocity 6,000 m/s. Minimal smoothing, don't adapt shape of rectangular filter. WET settings as in Fig. 4.



SUBS19 RMS error 1.5%=0.58ms 100 WET iters. 50Hz Width 3.0% initial GRADIENT.GRD Vers. 3.35

Fig. 3b : WET wavepath coverage plot obtained with Fig. 3a. Shows number of wavepaths per pixel.

Edit WET Wavepath Eikonal Traveltime Tomography Parameters	Edit WET Tomography Velocity Smoothing Parameters
Specify initial velocity model Select D:\ray32\SUBS19\GRADTOM0\GRADIENT.GRD	Determination of smoothing filter dimensions C Full smoothing after each tomography iteration Minimal smoothing after each tomography iteration
Stop WET inversion after Number of WET tomography iterations : 100 iterations	Manual specification of smoothing filter, see below Smoothing filter dimensions
Image: Sellow 2.0 percent Image: Sellow 2.	Half smoothing filter width : 2 columns Half smoothing filter height : 0 grid rows
WET regularization settings Wavepath frequency : 50 Hz Iterate	Filter shallow dipping wavepath artefacts from model
Ricker differentiation [-1:Gaussian2:Cosine]: -2 times Wavepath width [percent of one period]: 3.0 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 m/sec.	Smooth after each nth iteration only Smooth nth iteration : n = 1 iterations
Gradient search method	Smoothing filter weighting C Gaussian Used width of Gaussian
Conjugate Gradient Parameters	Uniform central row weight 1.0 [1100]
CG iterations 10 Line Search iters. 2 Tolerance 0.001 Line Search tol. 0.0010	Smooth velocity update before updating tomogram
Initial step 0.10 Steepest Descent step	Damping of tomogram with previous iteration tomogram Damping [01] 0.000 Damp before smoothing
Start tomography processing Reset Cancel	Accept parameters Reset parameters

Fig. 4 : WET parameter settings for Fig. 3. left : main interactive WET dialog. right : edit velocity smoothing

Import shots			
Import data type	SEG-2		
Input directory : select one data file. All data files will be imported			
Select	D:\RAY32\SUBS19\INPUT\		
Take shot record number from	DOS file name		
Optionally select .HDR batch file	and check Batch import		
.HDR batch E	D:\RAY32\SUBS19\INPUT\BATCH.HDR		
-Write HDP batch file listing shats in input directory			
Output .HDR			
	import shots and write .HDR		
Overwrite existing shot data	Ratch import		
Overwrite all Prompt of	overwriting		
Maximum offset imported [station r	nos.] 1000.00		
Default shot hole depth [m]	Default spread type		
0.00	10: 360 channels 💌		
Target Sample Format	16-bit fixed point		
, , <u> </u>			
Turn around spread by 180 degrees during import			
Correct picks for delay time (use e.g. for .PIK files)			
Default sample interval [msec]	0.10000000		
Default sample count	20000		
Import shots Ca	ancel import <u>R</u> eset import		

1

Fig. 5 : import shots with File|Import Data...

Frequency filter : band-pass or band-reject			
Filter active for current trace gather display			
Band-pass filter. Uncheck for band-reject.			
✓ Bidirectional filter. Better preserve signal.			
Chebyshev filter. Uncheck for single-pole.			
Apply n times [n]			
Low corner frequency [Hz] 200.00			
High corner frequency [Hz] 200.00			
Percent ripple [%] 0.0			
Number of poles [n] 2			
Filter Cancel Reset			

Edit Shot - browse with F7/F8, enter changes with RETURN		
ShotNo. 54 Type Uphole shot Delay 0.000000	Time of Acquisition Date 14/Mar/2017 Time 01:29:13	
Import data type SEG-2		
Field Record No.	Energy Source Point No.	
Shot Station [station no.]	Sample Interval	
Pos. 17.5	msec. 0.125000	
Offset from Shot Station [m]		
Inline 0.0000	dx 0.0000	
Lateral 0.0000	dy 0.0000	
Depth 19.0000	dz 0.0000	
Source Type	Sample Count	
Hammer	2048	
Source elevation [m]	-19.0000	
Uphole time correction term [msec	cs.] 0.010000	
Original filename	54.DAT	
Trigger delay [msecs.]	0.000000	

Fig. 7 : edit shot data in *Header*|Shot

We support importing uphole shots with the source positioned in more than one borehole, into the same Refraction spread/line profile. This should give a laterally more continuous and higher-resolution tomogram.

Also import surface-based refraction shots into the same profile, positioned along the receiver spread. See e.g. our tutorial <u>Coffey04</u>.

Fig. 6 : Bandpass filter. Press SHIFT+Q in *Trace|Shot gather*.

Edit Surfer plot limits			
Plot Limits		ОК	
Plot limits active	Plot limits active		
Min. offset	0.000	[m]	Cancel
Max. offset	70.000	[m]	Reset
Min. elevation	-33.000	[m]	Reset to grid
Max. elevation	0.000	[m]	
Min. velocity	500	[m/sec.]	
Max. velocity	3000	[m/sec.]	
- Plot Scale			
Proportional XY Scaling			
Page unit centimeter. 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]	
L			1

Fig. 8 : edit Surfer plot limits and velocity scale with Grid|Surfer plot Limits...

Replace gradient velocity profile		
Force limits of starting model grid		
Force grid limits	Reset limits to grid	
Grid bottom elevation [m] -33.000	Grid top elevation [m] 0.000	
Left limit of grid [m] 0.000	Right limit of grid [m] 70.000	
Replace computed velocity gradient with user velocity profile Replace velocity active Select velocity profile		
Force velocity for constant-velocity starting model Force constant velocity Forced velocity [m/sec.]		
OK Cancel Reset		

Fig. 9 : force limits of starting model grid with Smooth invert|Custom 1D-gradient velocity profile...

We thank our Malaysian client Subsurface Engineering Sdn Bhd for this high-resolution data set and giving us permission to use these data for this tutorial.

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