

Tunnel Excavation Disturbed Zone (EDZ) imaging with Rayfract® version 3.35 :

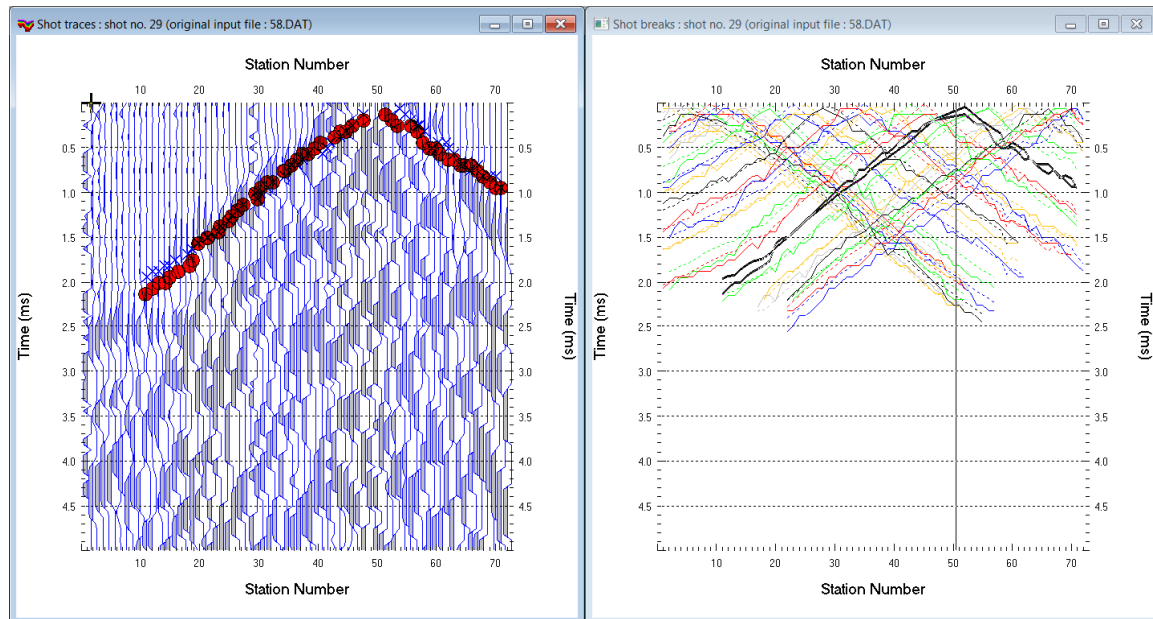


Fig. 1 : left : *Trace|Shot gather*, right : *Refractor|Shot breaks*. Shows fit between picked times (solid colored curves) and modeled times (dashed colored curves) obtained by forward modeling over Fig. 2.

- *File|New Profile...*, set *File name* to TUNNEL16 and click *Save button*
- set *Station spacing* to 0.2m in *Header|Profile*. See Fig. 8. Set *Line type* to Borehole spread/line.
- set *Cell size* to 0.05m. Check box *Force grid cell size*. Click button *OK*.
- unzip [tunnel16_seg2_input.zip](#) with SEG-2 .DAT files in C:\RAY32\TUNNEL16\INPUT
- check *File|Import Data Settings|Import circular borehole survey*
- check *File|Import Data Settings|X coordinate is corrected for topography already*
- select *File|Import Data...* and set *Import data type* to SEG-2
- leave *Default spread type* at 10: 360 channels.
- click *Select button*, navigate into C:\RAY32\TUNNEL16\INPUT, select file 30.DAT & click *Open button*
- click *.HDR batch button* and select batch file ...\INPUT\TUNNEL16.HDR. Check box *Batch import*.
- click *Import shots button*. All .DAT listed in TUNNEL16.HDR are imported.
- select *File|Update header data|Update Station Coordinates...*
- click *Select button* and select ...\INPUT\TUNNEL16.COR. Click button *Import and Reset*.
- select *File|Update header data|Update shotpoint coordinates...* & ...\INPUT\TUNNEL16.SHO.
- select *File|Update header data|Update First Breaks...* & ...\INPUT\TUNNEL16.LST
- click *Open button* and confirm prompt
- select *Trace|Shot gather*, *Window|Tile* and browse with F7/F8 to shot no. 29 to obtain Fig. 1
- click title bar of *Shot traces window*, press ALT+P, set *Maximum time* to 5 ms and hit ENTER key
- press SHIFT+Q shortcut. Check boxes *Filter active* & *Bidirectional filter*. Set *Low corner frequency* to 2000Hz. Set *High corner frequency* to 2000Hz. Click button *Filter*.
- click title bar of *Refractor|Shot breaks*. Press ALT+P, set *Maximum time* to 5ms and hit ENTER key
- uncheck *Mapping|Display raytraced traveltimes*. Check *Mapping|Color picked traveltimes curves*
- check *WET Tomo|WET tomography Settings|Blank|Blank no coverage after last iteration*
- check *WET Tomo|WET tomography Settings|Blank|Blank no coverage on top of borehole tomogram*
- check *WET Tomo|WET tomography Settings|Edit maximum valid WET velocity*
- select *Smooth invert|Custom 1D-gradient velocity profile* and check *Force grid limits*. See Fig. 5.
- set *Grid bottom elevation* to -2m, *Grid top elevation* to 10m, *Left limit of grid* to -7m, *Right limit of grid* to 7m. Check *Force constant velocity* and set *Forced velocity* to 5000m/s. Click button *OK*.

- uncheck *Smooth invert*|*Smooth inversion Settings*|*Beydoun weighting for borehole WET*
- select *WET Tomo*|*WET Velocity constraints*. Click *Select blanking file* & ...\\INPUT\\digitized.bln
- check *Polygon blanking active*. Uncheck *Pad polygon border*. Check *Extrapolate to top* & *Extrapolate to bottom* & *Extrapolate to left* & *Extrapolate to right*. Click button *OK*. See Fig. 6.
- select *Smooth invert*|*WET with constant-velocity initial borehole model* & confirm prompts for default interpretation. Select *Grid*|*Surfer plot Limits*. See Fig. 7.
- click *Reset to grid* & select C:\\RAY32\\TUNNEL16\\HOLETOMO\\CONSTVEL.GRD. Check *Plot limits active*.
- set *Min. velocity* to 2000m/s & *Max. velocity* to 6500m/s. Check *Proportional XY scaling*. Click *OK*.
- set *WET Tomo*|*Interactive WET tomography*|*Number of iterations* to 20. Set *Wavepath frequency* to 500Hz, *Wavepath width* to 5%, *Min. velocity* to 3500m/s and *Max. velocity* to 6000m/s. See Fig. 4.
- set *Width of Gaussian for one period [sigma]* to 50. Click button *Edit velocity smoothing*. See Fig. 4.
- to **disable WET smoothing** check box **No smoothing**
- for older 3.36 builds of our software *disable WET smoothing* by setting **Smooth nth iteration : n** = to 100, unchecking **Smooth velocity update** and unchecking **Smooth last iteration**
- click buttons *Accept parameters* & *Start tomography processing* to obtain Fig. 2 & 3.

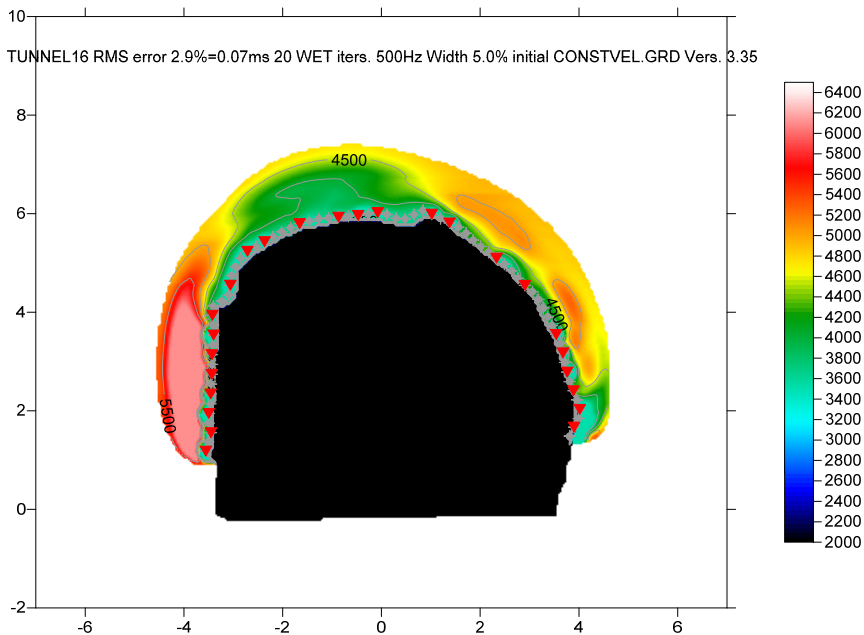


Fig. 2 : WET tomogram obtained with WET settings as in Fig. 4, starting model grid limits and velocity as in Fig. 5, velocity constraints as in Fig. 6, constant-velocity starting model. *WET Tomo*|*WET tomography Settings*|*Blank no coverage after last iteration* checked. *Blank no coverage on top of borehole tomogram* checked.

- for *WET parameters* used see archive [TUNNEL16 HoleTomo Mar14.rar](#) with starting model files CONSTVEL.GRD & CONSTVEL.PAR, VELOIT20.GRD & .PAR and .SRF Surfer 11 plots
- pick the ...\\INPUT\\DIGITIZED.BLN blanking file in Golden Software Surfer on CONSTVEL.SRF starting model plot with Surfer **Map**|**Digitize** **command** as described in <https://support.goldensoftware.com/hc/en-us/articles/226661208-How-can-I-create-a-BLN-file-in-Surfer>. Pick points (polygon corners) a little bit inside the circular spread for *WET inversion* and *blanking* to work reliably.
- once you imported SEG-2 .DAT files with ...\\INPUT\\TUNNEL16.HDR batch file you can export station coordinates with *File*|*Export header data*|*Export Station Coordinates...* to file COORDS.COR.
- edit COORDS.COR with any editor e.g. Microsoft WordPad and specify correct x & z coordinates in columns 2 & 4 for all station numbers listed in column 1. y coordinate (column 3) is all 0.0.
- export shotpoint coordinates with *File*|*Export header data*|*Export Shot Point Coordinates...* to file SHOTPTS.SHO
- edit SHOTPTS.SHO with Microsoft WordPad and specify correct x & z coordinates in columns 2 & 4 for all shot numbers listed in column 1. y coordinate (column 3) is 0.0 for all shots.

For help on *WET inversion* parameters see *Help menu|Contents|WET tomography processing* and [.pdf reference](#) chapter *WET Wavepath Eikonal Traveltime tomography*.

TUNNEL16 RMS error 2.9%=0.07ms 20 WET iters. 500Hz Width 5.0% initial CONSTVEL.GRD Vers. 3.35

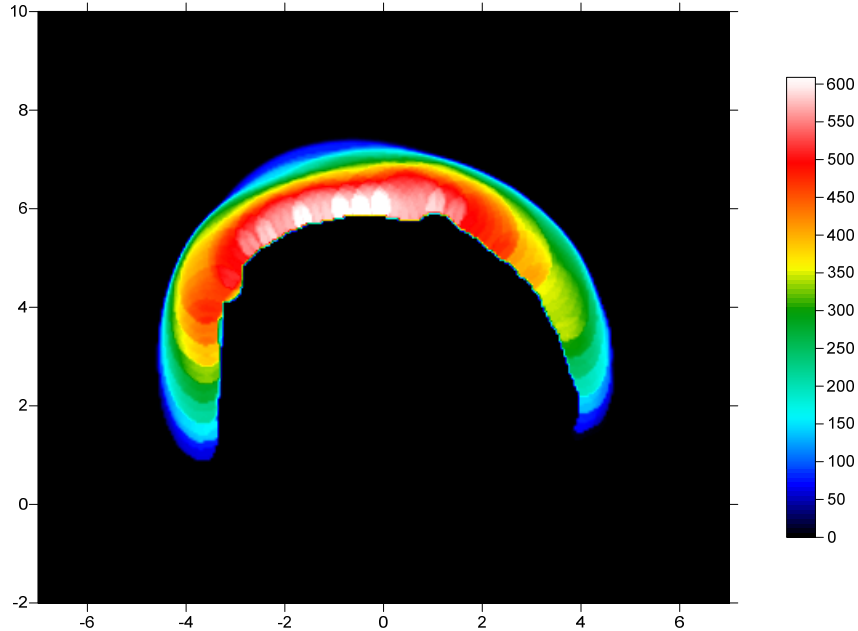


Fig. 3 : WET wavepath coverage plot obtained with Fig. 2. Shows number of wavepaths per pixel.

Edit WET Wavepath Eikonal Traveltime Tomography Parameters

Specify initial velocity model
 D:\ray32\TUNNEL16\HOLETOMO\CONSTVEL.GRD

Stop WET inversion after
 Number of WET tomography iterations : iterations
☐ or RMS error gets below percent
☐ or RMS error does not improve for n = iterations
☐ or WET inversion runs longer than minutes

WET regularization settings
 Wavepath frequency : Hz
 Ricker differentiation [-1:Gaussian,-2:Cosine] : times
 Wavepath width [percent of one period] : percent
 Wavepath envelope width [% of period] : percent
 Min. velocity : Max. velocity : m/sec.
 Width of Gaussian for one period [sigma] : sigma

Gradient search method
☒ Steepest Descent ☐ Conjugate Gradient

Conjugate Gradient Parameters
 CG iterations Line Search iters.
 Tolerance Line Search tol.
 Initial step ☐ Steepest Descent step

Edit WET Tomography Velocity Smoothing Parameters

Determination of smoothing filter dimensions
☒ Full smoothing after each tomography iteration
☐ Minimal smoothing after each tomography iteration
☐ Manual specification of smoothing filter, see below

Smoothing filter dimensions
 Half smoothing filter width : columns
 Half smoothing filter height : grid rows

Suppress artefacts below steep topography
☒ Adapt shape of filter. Uncheck for better resolution.

Maximum relative velocity update after each iteration
 Maximum velocity update : percent

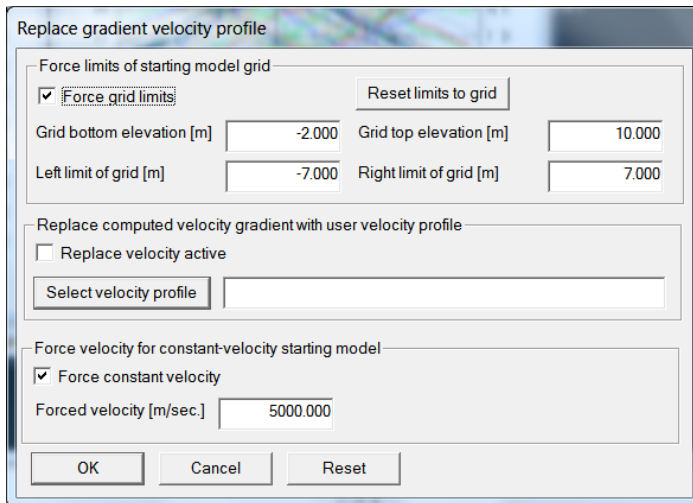
Smooth after each nth iteration only
 Smooth nth iteration : n = iterations

Smoothing filter weighting
☐ Gaussian ☒ Uniform ☒ No smoothing
 Used width of Gaussian sigma
 Uniform central row weight [1..100]

Smooth velocity update before updating tomogram
☒ Smooth velocity update ☒ Smooth last iteration

Damping of tomogram with previous iteration tomogram
 Damping [0..1] ☐ Damp before smoothing

Fig. 4 : WET parameter settings for Fig. 2 & 3. left : main interactive WET dialog. right : edit velocity smoothing



Replace gradient velocity profile

Force limits of starting model grid

☒ Force grid limits Reset limits to grid

Grid bottom elevation [m] Grid top elevation [m]

Left limit of grid [m] Right limit of grid [m]

Replace computed velocity gradient with user velocity profile

☐ Replace velocity active

Select velocity profile

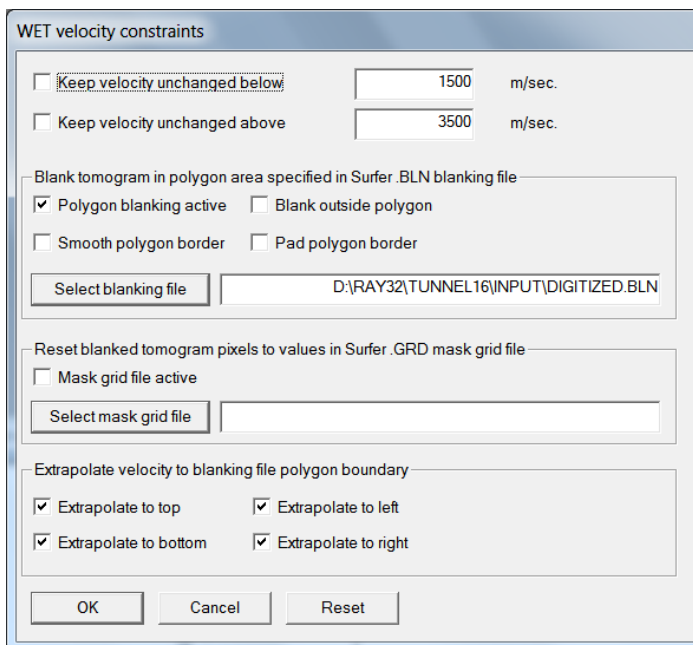
Force velocity for constant-velocity starting model

☒ Force constant velocity

Forced velocity [m/sec.]

OK Cancel Reset

Fig. 5 : *Smooth invert|Custom 1D-gradient velocity profile* dialog. Specify starting model grid limits and velocity.



WET velocity constraints

☐ Keep velocity unchanged below m/sec.

☐ Keep velocity unchanged above m/sec.

Blank tomogram in polygon area specified in Surfer .BLN blanking file

☒ Polygon blanking active ☐ Blank outside polygon

☐ Smooth polygon border ☐ Pad polygon border

Select blanking file

Reset blanked tomogram pixels to values in Surfer .GRD mask grid file

☐ Mask grid file active

Select mask grid file

Extrapolate velocity to blanking file polygon boundary

☒ Extrapolate to top ☒ Extrapolate to left

☒ Extrapolate to bottom ☒ Extrapolate to right

OK Cancel Reset

Fig. 6 : *WET Tomo|WET Velocity constraints* dialog. Specify blanking file with *Select blanking file* button.

Picking first breaks for this data set was difficult because of noisy traces; see Fig. 1.

You can reuse the same recording geometry, import routine and interpretation approach for imaging columns or tree trunks. Plant the circular receiver spread on circumference/perimeter of column or around tree trunk. In Fig. 6 check *Blank outside polygon*. When picking the .BLN boundary polygon on CONSTVEL.SRF plot pick the polygon points a little bit outside the circular receiver spread.

Edit Surfer plot limits

Plot Limits

☒ Plot limits active

Min. offset: -7.000 [m]

Max. offset: 7.000 [m]

Min. elevation: -2.000 [m]

Max. elevation: 10.000 [m]

Min. velocity: 2000 [m/sec.]

Max. velocity: 6500 [m/sec.]

Plot Scale

☒ Proportional XY Scaling

☐ Page unit is centimeter. Uncheck for inch.

X Scale length: 6.000 [inch]

Y Scale length: 4.000 [inch]

Color Scale

☐ Adapt color scale

Scale height: 4.000 [inch]

Velocity interval: 500 [m/sec.]

Coverage interval: 5 [paths/pixel]

OK Cancel Reset Reset to grid

Fig. 7 : Grid|Surfer plot Limits dialog. Click button *Reset to grid* and select ...\\HOLETOMO\\CONSTVEL.GRD

Edit Profile

Line ID: TUNNEL16

Line type: Borehole spread/line

Job ID: test import SEG-2 with geometry

Instrument: Geometrics SeisModules

Client:

Company:

Observer:

Note:

Station spacing [m]: 0.2000

Min. horizontal separation [%]: 25

Profile start offset [m]: 0.0000

Time of Acquisition:

Date:

Time:

Time of Processing:

Date:

Time:

Units: meters

Sort: As acquired

Const:

☐ Left handed coordinates

☒ Force grid cell size

Cell size [m]: 0.0500

Add borehole lines for WET tomography

Borehole 1 line: Select

Borehole 2 line: Select

Borehole 3 line: Select

Borehole 4 line: Select

OK Cancel Reset

Fig. 8 : Header|Profile dialog. Check *Force grid cell size* and set *Cell size* to 0.05m