

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

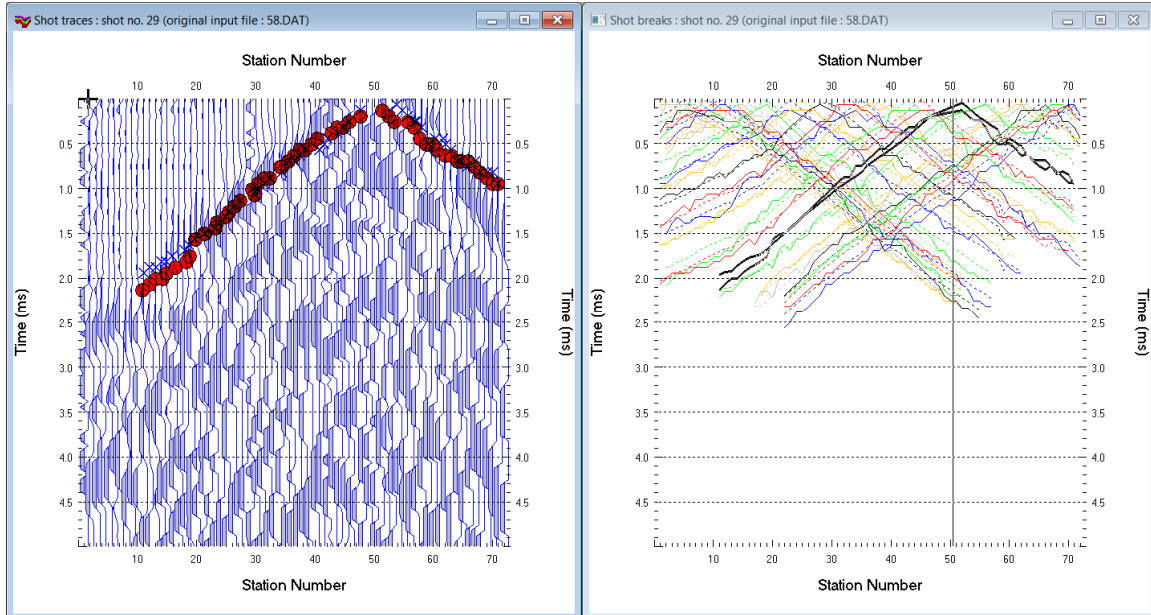


Fig. 1 : left : *Trace|Shot gather*, right : *Refractor|Shot breaks*. Shows fit between picked times (solid colored curves) and modeled times (dashed colored curves) obtained by forward modeling over Fig. 2.

- *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|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.blm*
- 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** set *Smooth nth iteration : n=* to 100 & uncheck box *Smooth last iteration*
- click buttons *Accept parameters & Start tomography processing* to obtain Fig. 2 & 3.

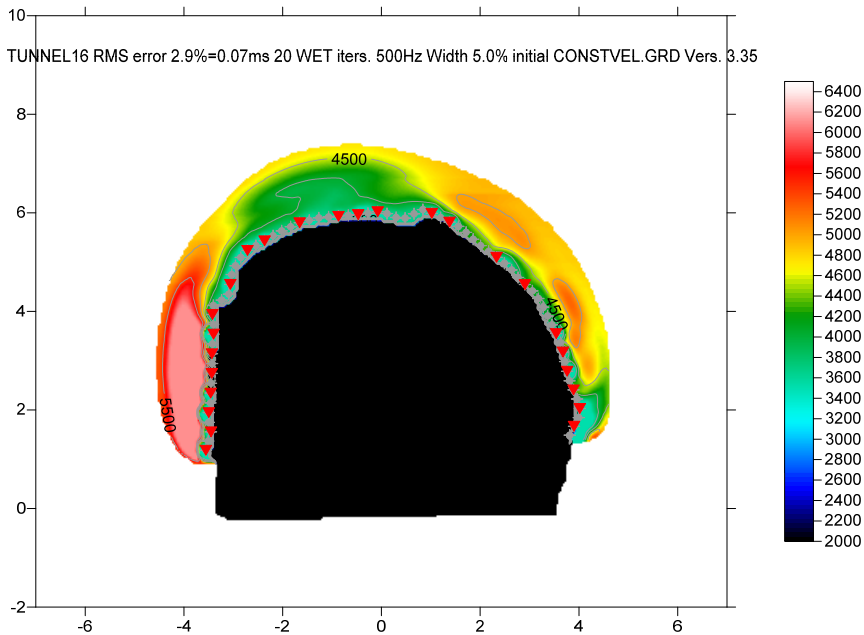


Fig. 2 : WET tomogram obtained with WET settings as in Fig. 4, starting model grid limits and velocity as in Fig. 5, velocity constraints as in Fig. 6, constant-velocity starting model. *WET Tomo|WET tomography Settings|Blank no coverage after last iteration* checked.

- 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.BLM* 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

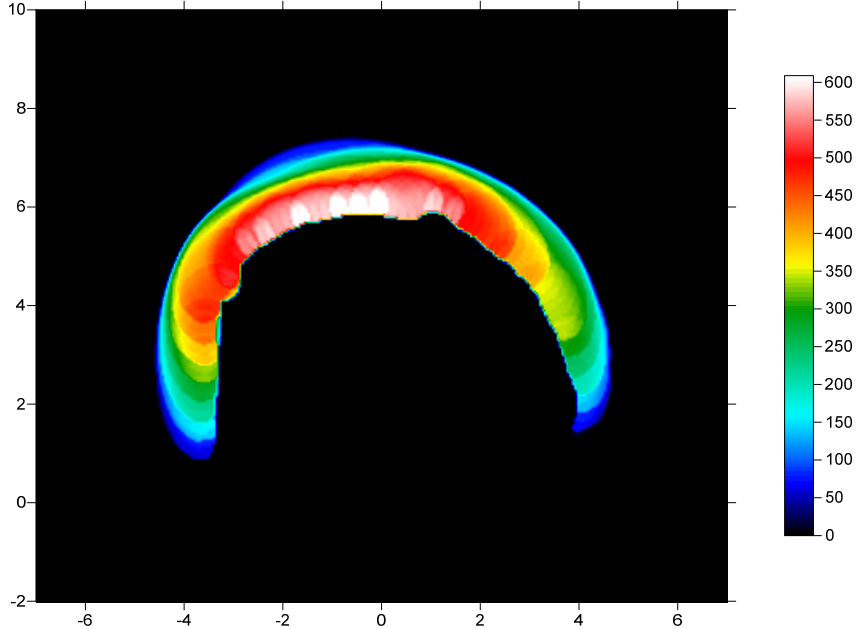


Fig. 3 : WET wavepath coverage plot obtained with Fig. 2. Shows number of wavepaths per pixel.

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 is Gaussian bell] : 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

Filter shallow dipping wavepath artefacts from model

Automatically adapt shape of rectangular filter matrix

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

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

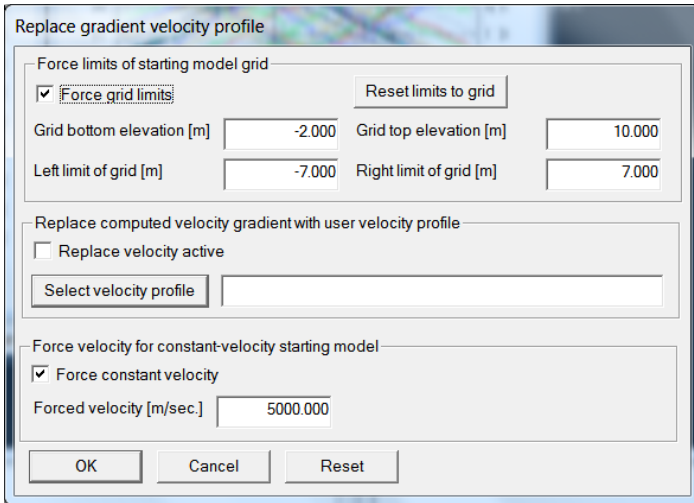


Fig. 5 : *Smooth invert*|*Custom 1D-gradient velocity profile* dialog. Specify starting model grid limits and velocity.

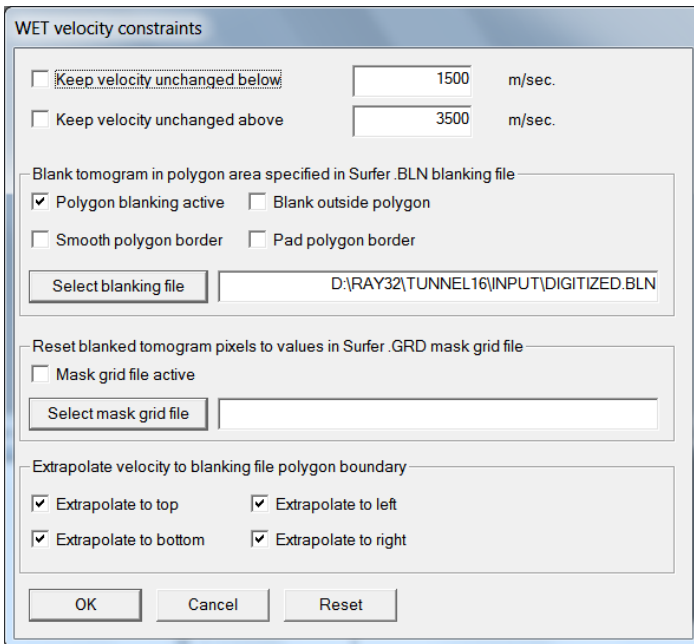


Fig. 6 : *WET Tomo*|*WET Velocity constraints* dialog. Specify blanking file with *Select blanking file* button.

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: [m]

Max. offset: [m]

Min. elevation: [m]

Max. elevation: [m]

Min. velocity: [m/sec.]

Max. velocity: [m/sec.]

Plot Scale

Proportional XY Scaling

Page unit is centimeter. Uncheck for inch.

X Scale length: [inch]

Y Scale length: [inch]

Color Scale

Adapt color scale

Scale height: [inch]

Velocity interval: [m/sec.]

Coverage interval: [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:

Line type:

Job ID:

Instrument:

Client:

Company:

Observer:

Note:

Station spacing [m]:

Min. horizontal separation [%]:

Profile start offset [m]:

Time of Acquisition
Date:
Time:

Time of Processing
Date:
Time:

Units:

Sort:

Const:

Left handed coordinates

Force grid cell size

Cell size [m]:

Add borehole lines for WET tomography

Borehole 1 line:

Borehole 2 line:

Borehole 3 line:

Borehole 4 line:

OK Cancel Reset

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