


Sinalunga 2018 Rayfract® Workshop
By
IGS IdroGeoStudi
&
Intelligent Resources Inc.

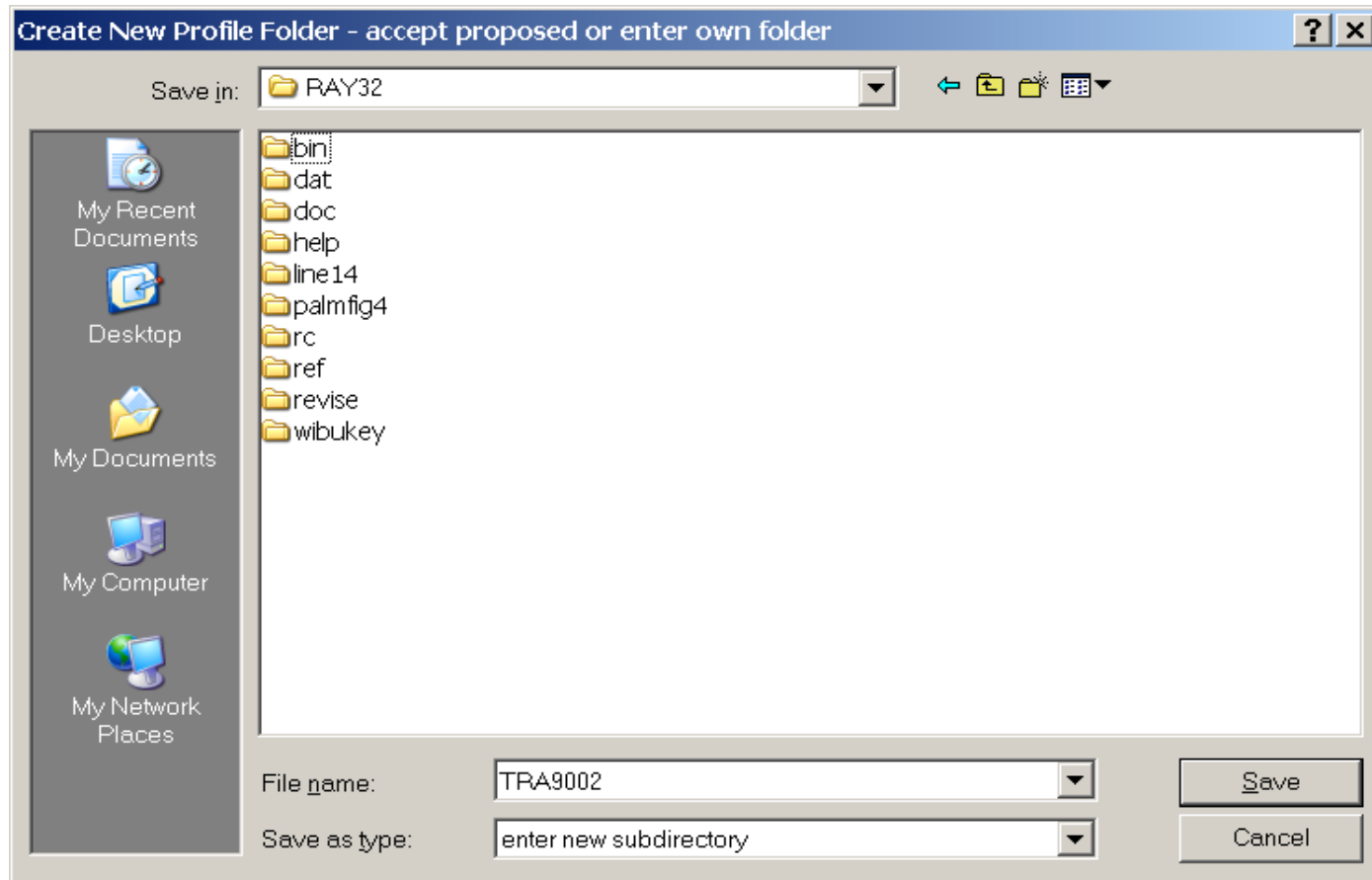
Presenters :



Mario Foresta
Siegfried Rohdewald

Tutorial for Val de Travers line
TRA9002 : vary starting model

Create new profile



- 1 Start up Rayfract software with *desktop icon* or *Start menu*
- 2 Select *File|New Profile...*
- 3 Set *File name* to TRA9002 and click *Save*

Fill in profile header

The screenshot shows a software window titled "Edit Profile" with a blue header bar. The window contains several input fields and controls arranged in two main columns. On the left, there are fields for "Line ID" (containing "TRA9002"), "Line type" (a dropdown menu showing "Refraction spread/line"), "Job ID" (containing "Tutorial"), "Instrument" (containing "Bison-2 9000 Series"), "Client", "Company", "Observer", and "Note" (a text area). On the right, there are sections for "Time of Acquisition" and "Time of Processing", each with "Date" and "Time" input fields. Below these are "Units" (a dropdown menu showing "meters"), "Sort" (a dropdown menu showing "As acquired"), and "Const" (an empty input field). At the bottom left, there are three input fields: "Station spacing [m]" (containing "5.0000"), "Min. horizontal separation [%]" (containing "25"), and "Profile start offset [m]" (containing "0.0000"). To the right of these is a checkbox labeled "Left handed coordinates". At the very bottom, there is a section titled "Select borehole lines for WET tomography" with two rows: "Borehole 1 line" and "Borehole 2 line", each with a "Select" button and an empty input field.

Line ID	TRA9002	Time of Acquisition	Date	
Line type	Refraction spread/line	Time of Acquisition	Time	
Job ID	Tutorial	Time of Processing	Date	
Instrument	Bison-2 9000 Series	Time of Processing	Time	
Client		Units	meters	
Company		Sort	As acquired	
Observer		Const		
Note		<input type="checkbox"/> Left handed coordinates		
Station spacing [m]	5.0000			
Min. horizontal separation [%]	25			
Profile start offset [m]	0.0000			
Select borehole lines for WET tomography				
Borehole 1 line	Select			
Borehole 2 line	Select			

- 1 Select *Header/Profile...*
- 2 Set *Line ID* to TRA9002 and *Job ID* to Tutorial
- 3 Set *Instrument* to Bison-2 9000 and *Station spacing* to 5m
- 4 Hit ENTER, and confirm the prompt

Seismic data import

Import shots

Import data type: Bison-2 9000 Series

Input directory: C:\RAY32\TRA9002\INPUT\

Take shot record number from: DOS file name

Overwrite existing shot data:
☐ Overwrite all ☒ Prompt overwriting

☐ Batch import
☐ Limit offset

Maximum offset imported [station nrs.]: 1000.00

Default shot hole depth [m]: 0.00

Default spread type: 10: 360 channels

Target Sample Format: 16-bit fixed point

☐ Turn around spread by 180 degrees during import
☐ Correct picks for delay time (use e.g. for .PIK files)

- 1 Copy files from \RAY32\TUTORIAL with Windows Explorer, or unzip <http://rayfract.com/tutorials/TRA9002.ZIP> to \RAY32\TRA9002\INPUT
- 2 Select *File/Import Data...* for *Import shots dialog*, see above
- 3 Set *Import data type* to Bison-2 9000 Series
- 4 Click *Select button*, select file TRAV0201 in \RAY32\TRA9002\INPUT
- 5 Click on *Open, Import shots*, and confirm the prompt

Import each shot

Import shot(s) from C:\RAY32\TRA9002\INPUT\TRAV0201...

Shot Number	<input type="text" value="201"/>	<input type="button" value="Read"/>
Layout start [station nr.]	<input type="text" value="1"/>	<input type="button" value="Skip"/>
Shot pos. [station nr.]	<input type="text" value="0.50"/>	<input type="button" value="End"/>
Shot inline offset [m]	<input type="text" value="0.00"/>	
Shot lateral offset [m]	<input type="text" value="0.00"/>	
Shot depth [m]	<input type="text" value="0.00"/>	
Delay time [msec]	<input type="text" value="0.000000000"/>	
Sample interval [msec]	<input type="text" value="1.000000000"/>	
Sample count	<input type="text" value="500"/>	
Spread type	<input type="text" value="10: 360 channels"/>	
Active traces (from start)	<input type="text" value="48"/>	

Click on *Read* for all shots shown in *Import Shot dialog*, see above.
Don't change *Layout start* and *Shot pos.*, these are correct already

Update geometry and first breaks

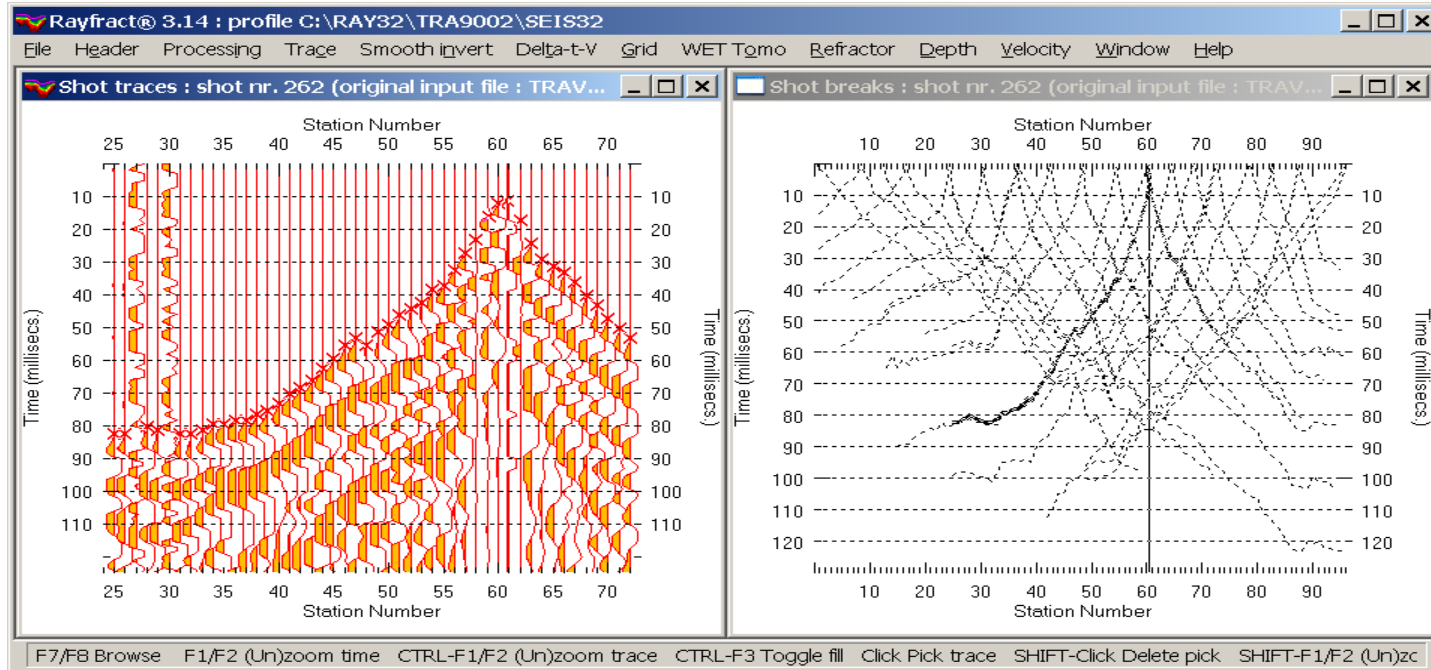
The dialog box is titled "Edit coordinate file import parameters and import coordinates". It contains three main sections:

- Select coordinate file to be imported:** A text field containing the path "C:\RAY32\TRA9002\INPUT\TRA9002.COR" with a "Select" button to its left.
- Adjustment of station coordinates:** Three radio buttons:
 - ☒ Do not adjust. Always give error message.
 - ☐ Adjust X coordinate to fit Y coordinate and elevation
 - ☐ Adjust Y coordinate to fit X coordinate and elevation
- Tolerance for variation in station spacing:** A text field labeled "Maximum tolerance :" containing the value "25", followed by the word "percent".

At the bottom, there are three buttons: "Import file", "Reset parameters", and "Cancel import".

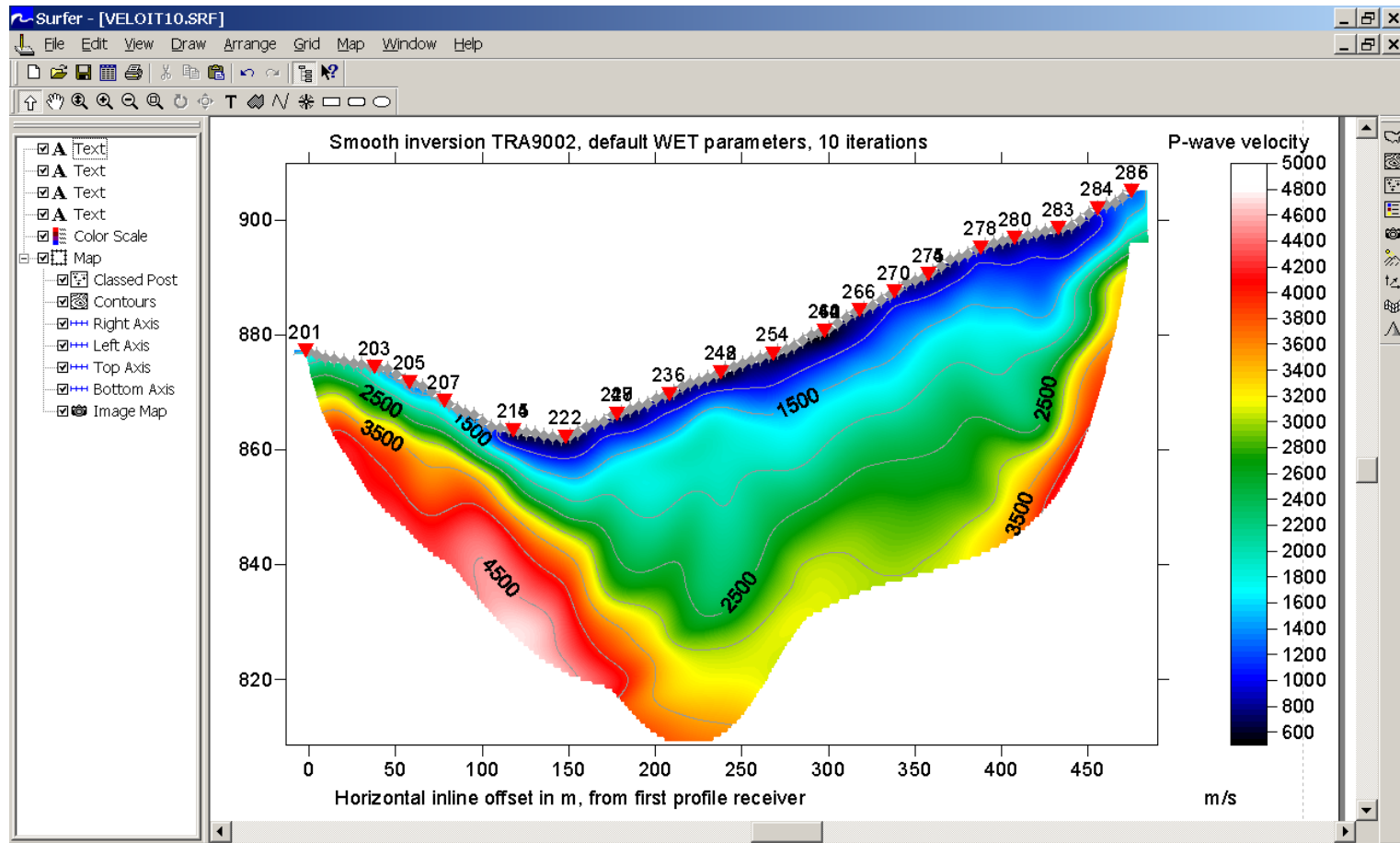
- 1 Select *File/Update header data/Update Station Coordinates...*
- 2 Click on *Select* and \RAY32\TRA9002\INPUT\TRA9002.COR
- 3 Click on *Open, Import File* and confirm the prompt
- 4 Select *File/Update header data/Update First Breaks* and \RAY32\TRA9002\INPUT\TRA9002.LST and click *Open*

View and repick traces, display travelttime curves



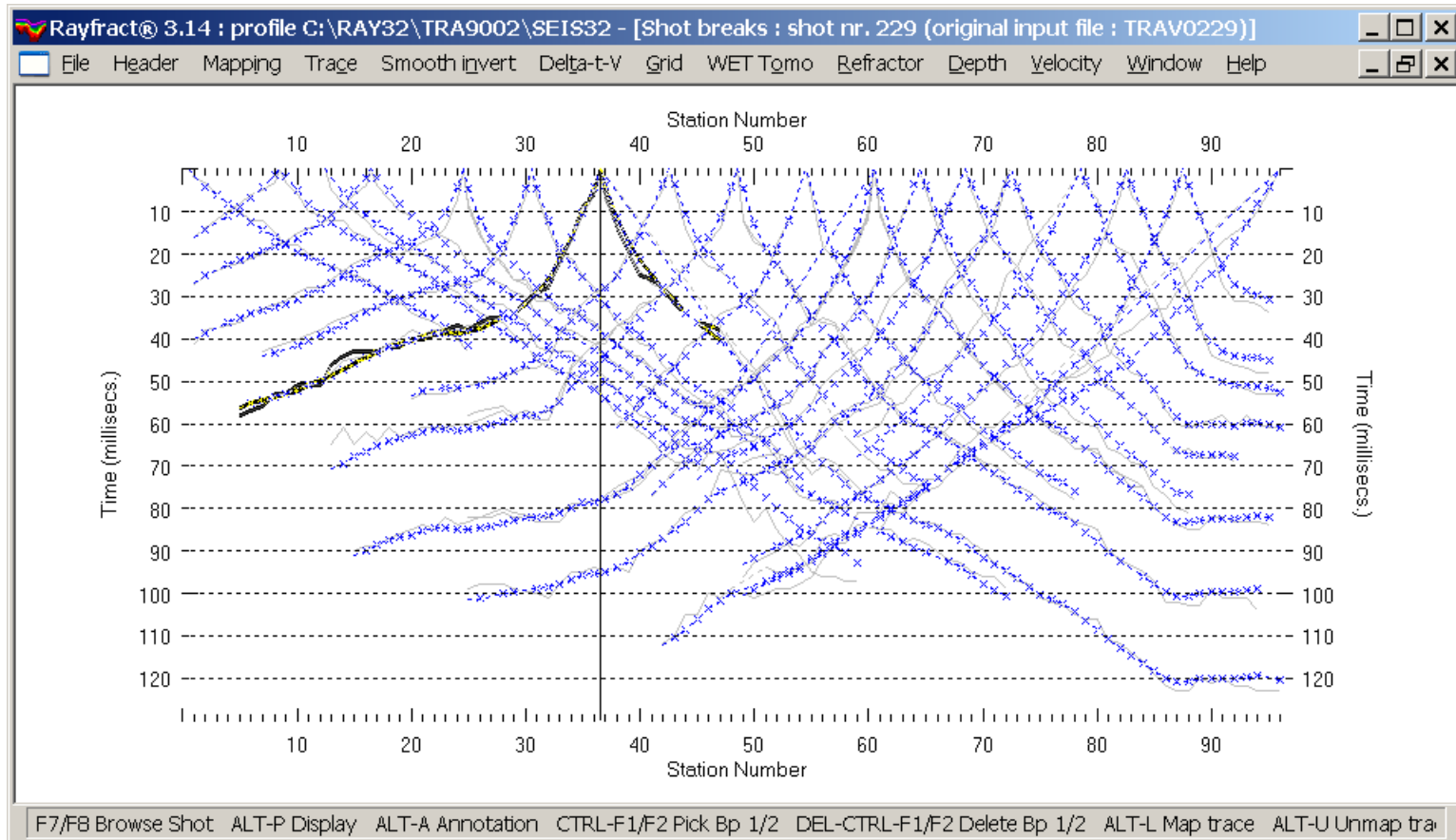
- 1 Select *Trace/Shot gather* and *Window/Tile*. Browse shots with F7/F8
- 2 Click on *Shot breaks window* and press ALT-P
- 3 Set *Maximum time* to 130 msec. and hit ENTER
- 4 Click on *Shot traces window* and press F1 twice to zoom time
- 5 CTRL-F1 twice to zoom amplitude, CTRL-F3 twice to toggle trace fill mode
- 6 Select *Processing/Color traces* and *Processing/Color trace outline*
- 7 Use up/down/left/right arrow keys to navigate along and between traces
- 8 Zoom spread with SHIFT-F1. Pan zoomed sections with SHIFT-PgDn/PgUp
- 9 Optionally repick trace with left mouse key or space bar, delete first break with ALT-DEL or SHIFT-left mouse key. Press ALT-Y to redisplay travelttime curves

Smooth inversion of first breaks



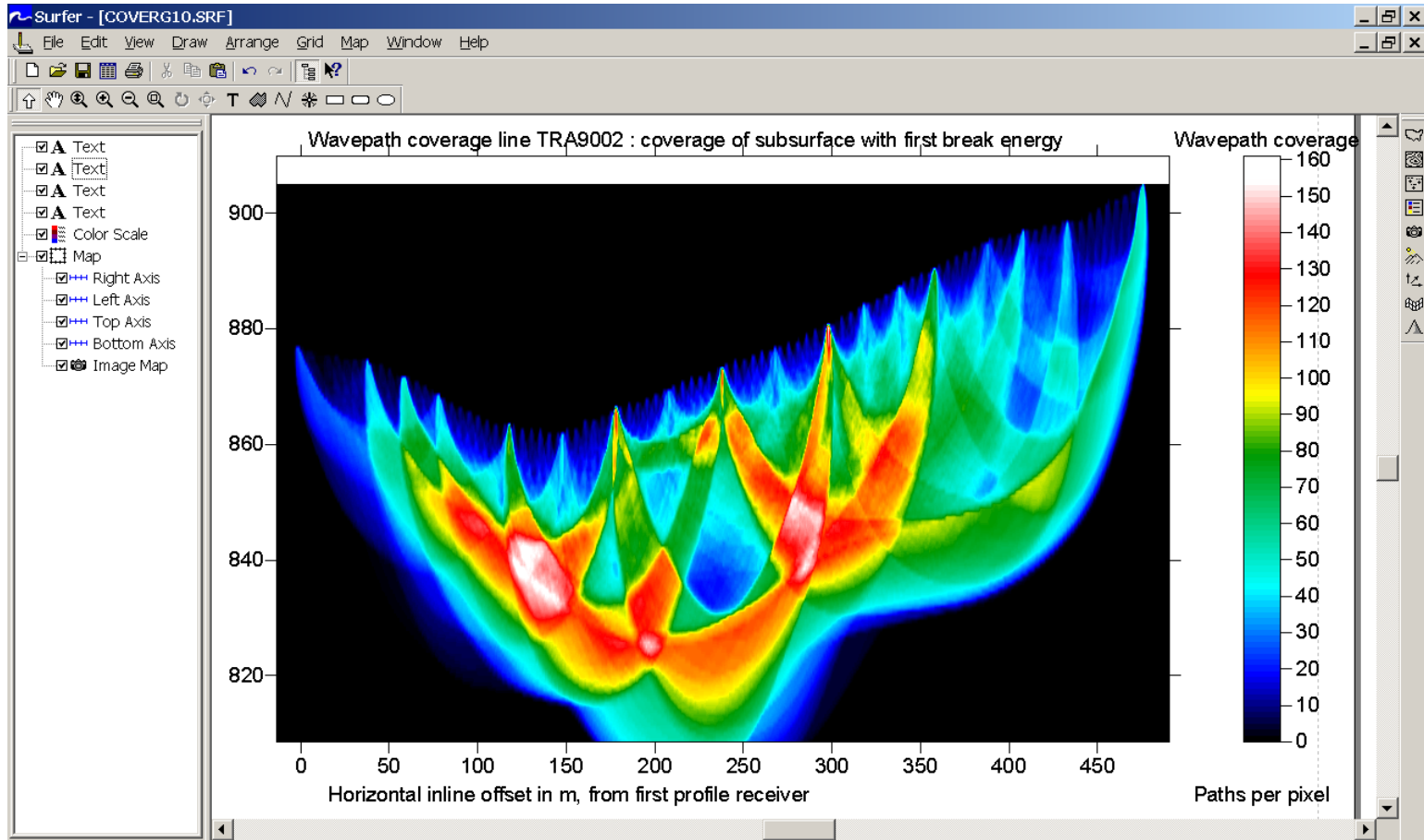
- 1 Select *Smooth invert|WET with 1D gradient initial model*
- 2 Once the 1D gradient model is shown in Surfer™, click on *Rayfract icon* at bottom of screen, to continue. Confirm following prompts
- 3 Click on *Surfer icon* and add text legends with Surfer *Draw|Text*

Display modeled picks and traveltimes curves



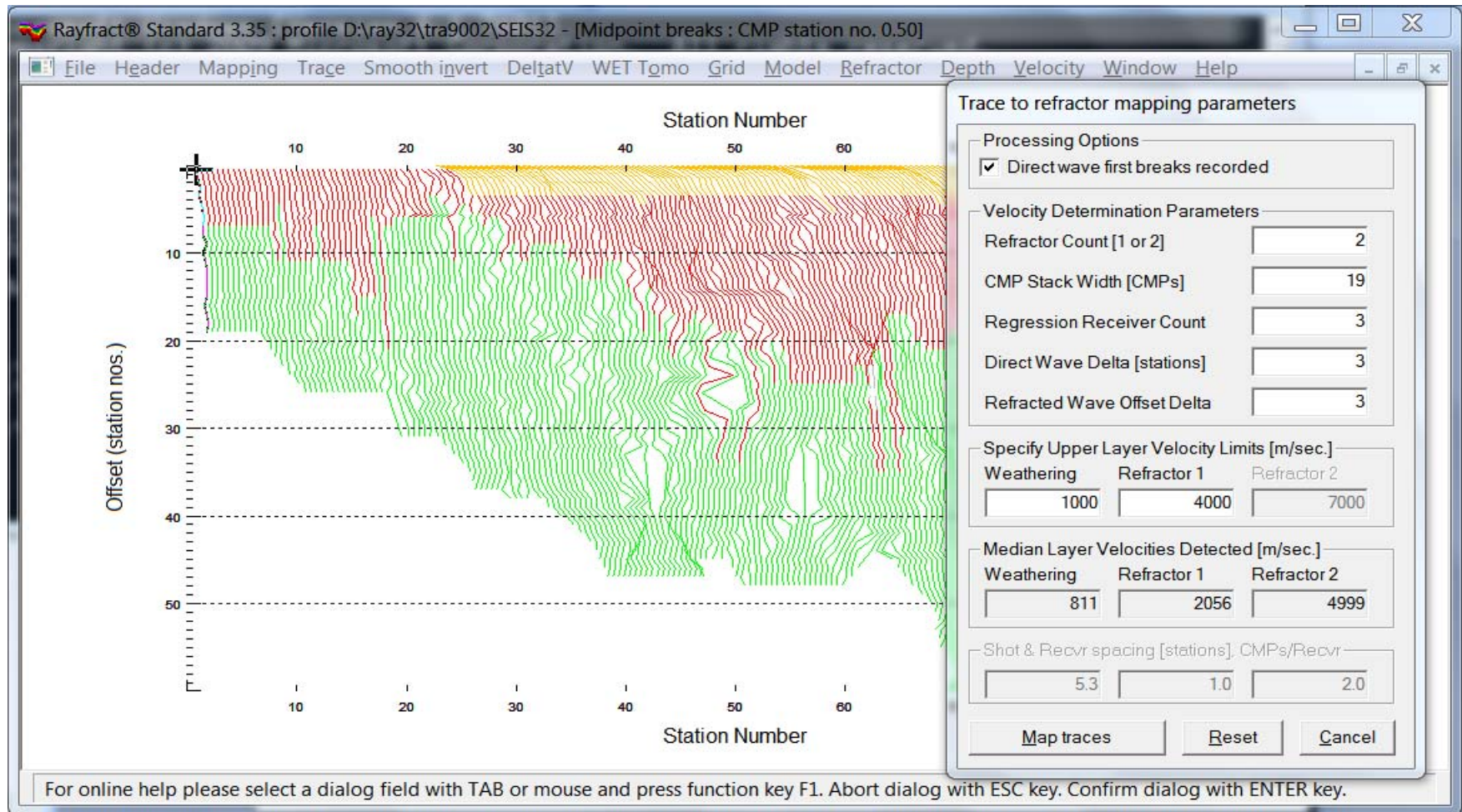
- 1 Click on *Rayfract icon* at bottom of screen
- 2 Select *Refractor/Shot breaks* to view picked and modeled (blue) times
- 3 Press F7/F8 keys to browse through shot-sorted traveltime curve
- 4 Use *Mapping/Gray picked traveltime curves* to toggle curve pen style

Display WET wavepath coverage



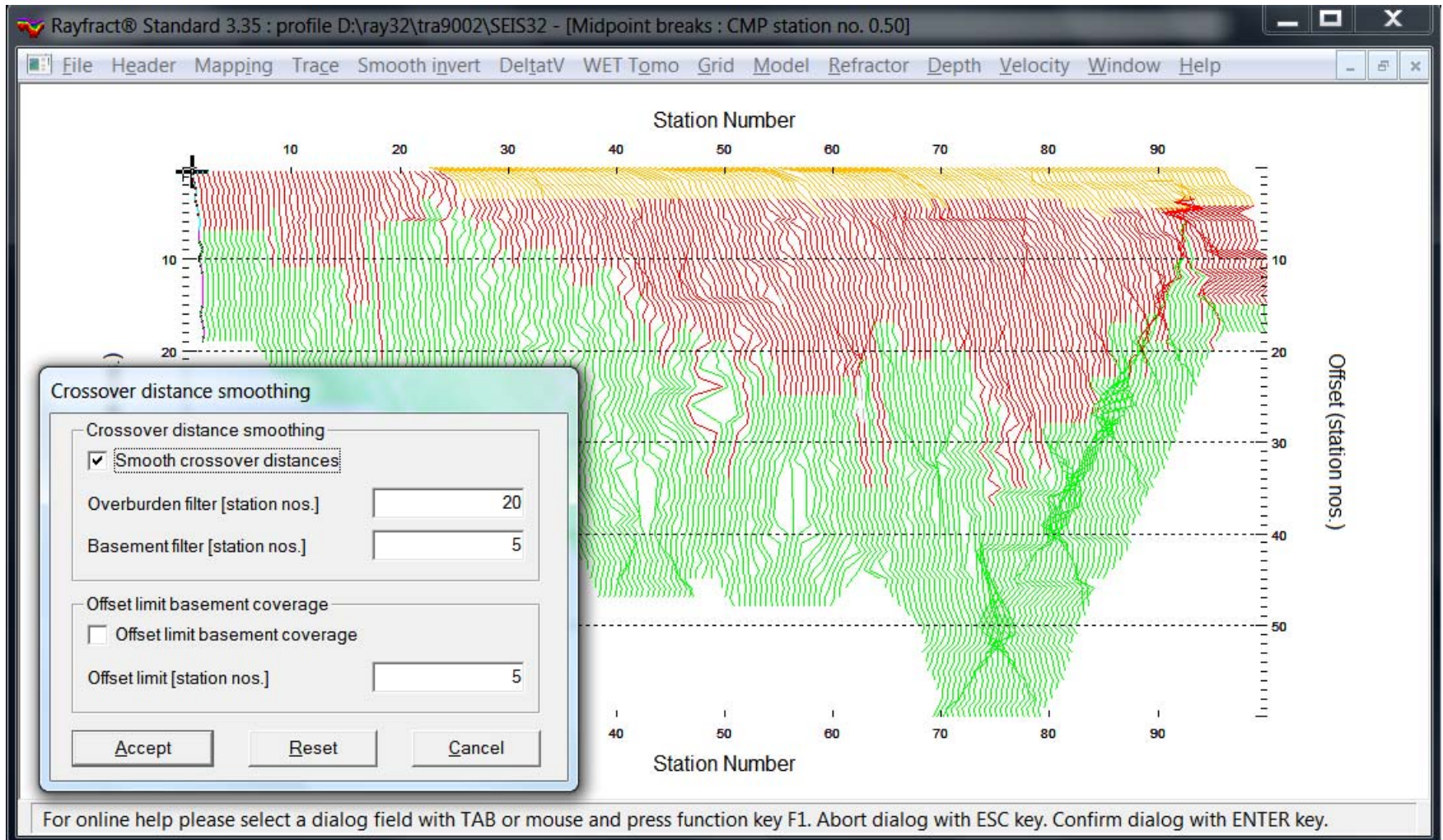
- 1 Click on *Surfer icon* at bottom of screen
- 2 Use CTRL-TAB to cycle between WET tomogram, wavepath coverage plot and 1D gradient initial model
- 3 Add text legends as shown above, with Surfer *Draw/Text* command

Map traces to refractors in Midpoint breaks



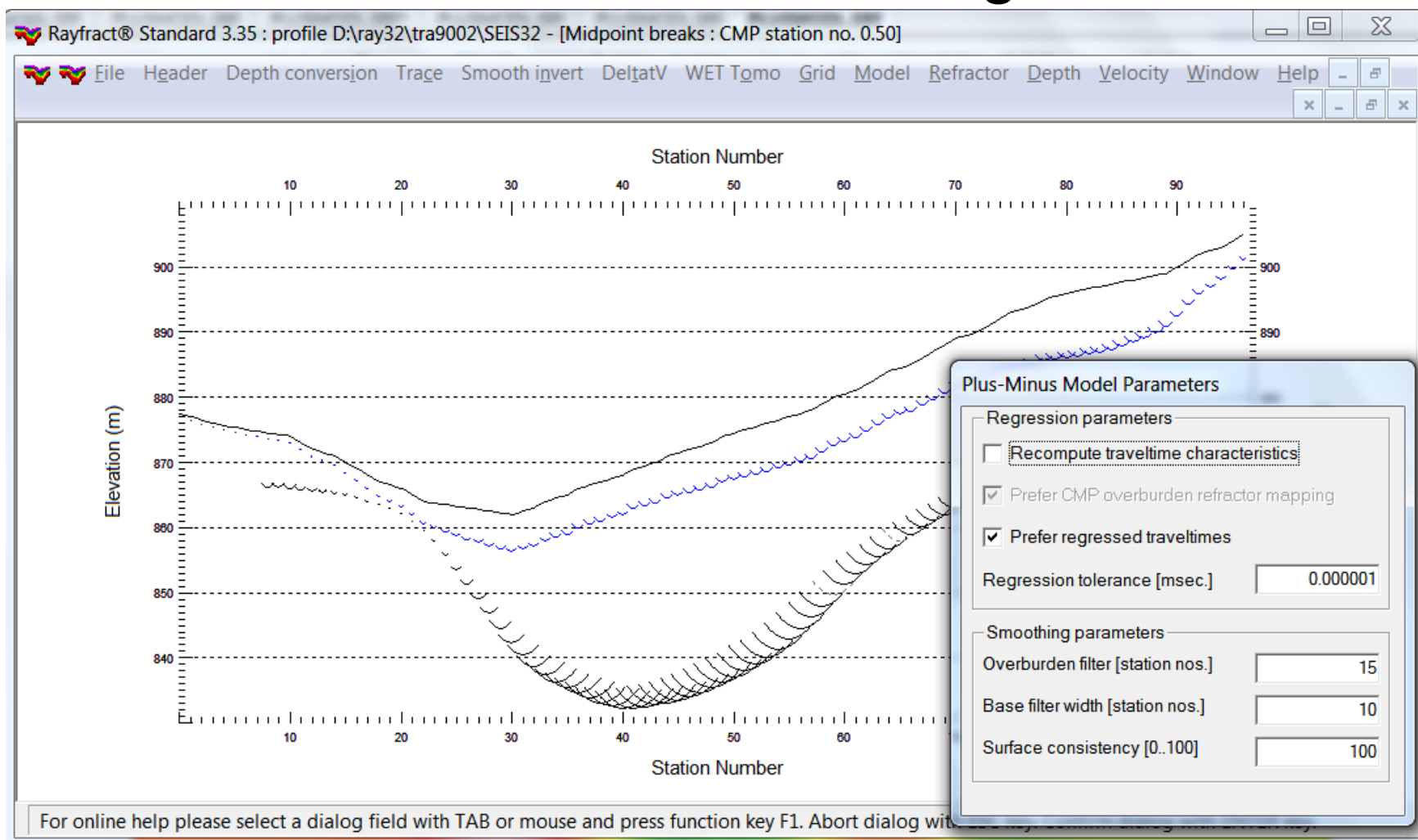
- 1 Select *Refractor/Midpoint breaks*. Zoom/Unzoom dip : CTRL+F1/CTRL+F2
- 2 Press ALT+M for mapping dialog. Edit as above. Click *Map traces button*.

Smooth crossover distance



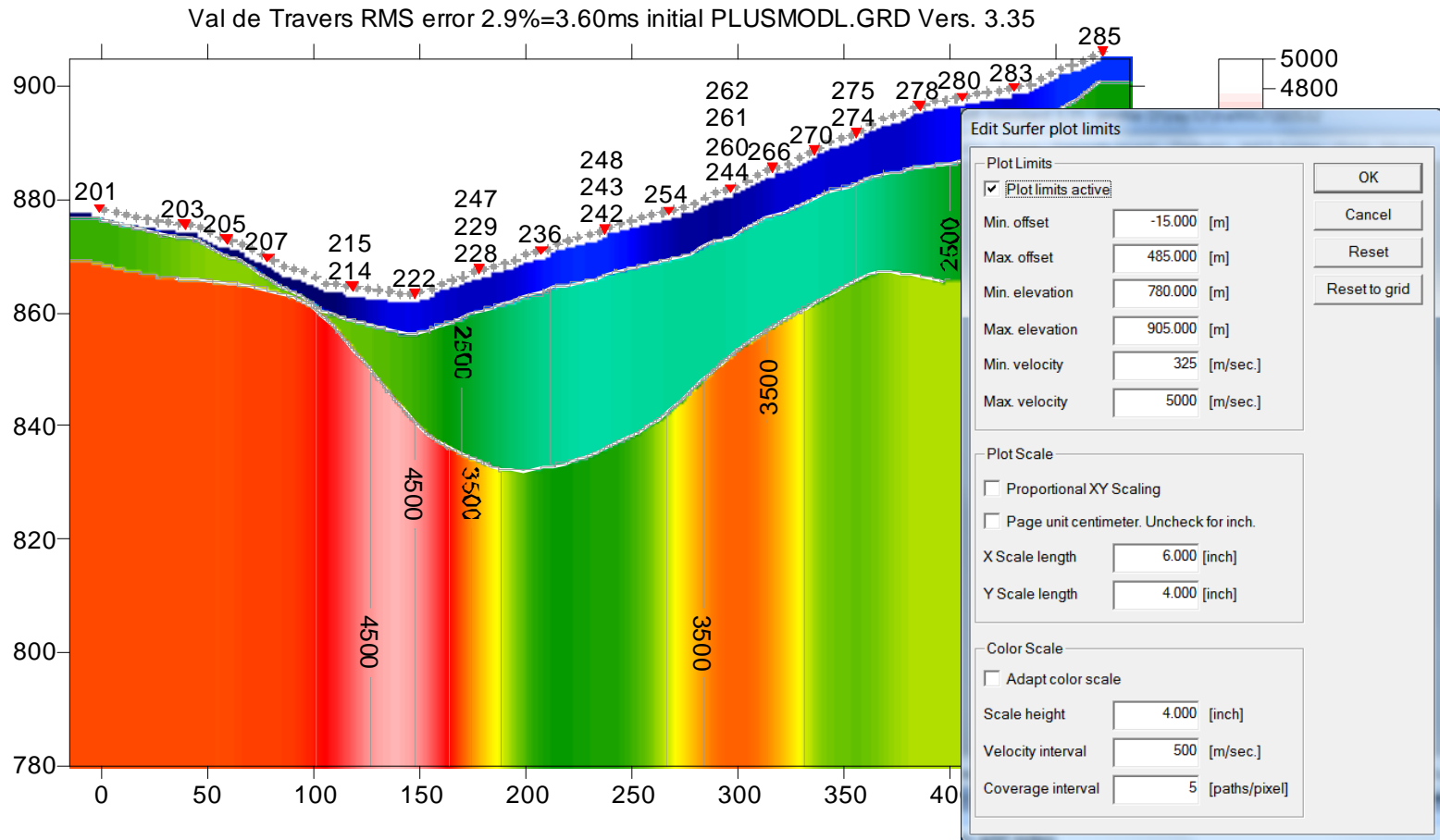
- 1 Press ALT+G to show Crossover distance smoothing dialog
- 2 Set *Overburden filter* to 20. Set *Basement filter* to 5. Click *Accept button*.

Create Plus-Minus starting model



- 1 Select *Depth/Plus-Minus*. In prompt *Continue with WET* click *No* button.
- 2 Press ALT+M for *Model Parameters* dialog.
- 3 Set *Overburden filter* to 15. Set *Base filter width* to 10. Hit ENTER key.

Display Plus-Minus model in Surfer



- 1 Select *Grid/Surfer plot Limits*. Click *Reset to grid* button.
- 2 Select C:\RAY32\TRA9002\LAYRTOMO\PLUSMODL.GRD. Click *Open*.
- 3 Edit grid limits as above. Set *Min/Max velocity* to 325/5000 m/sec. Click *OK*.
- 4 Check *Grid/Stack shot labels*. Uncheck *Grid/Label receiver stations*.
- 5 Select *Grid/Image and Contour velocity and coverage grids*.
- 6 Select C:\RAY32\TRA9002\LAYRTOMO\PLUSMODL.GRD. Click *Open*.

Run WET with Plus-Minus starting model

Edit WET Wavepath Eikonal Traveltime Tomography Parameters

Specify initial velocity model
Select

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
Used width of Gaussian sigma
Uniform central row weight [1..100]

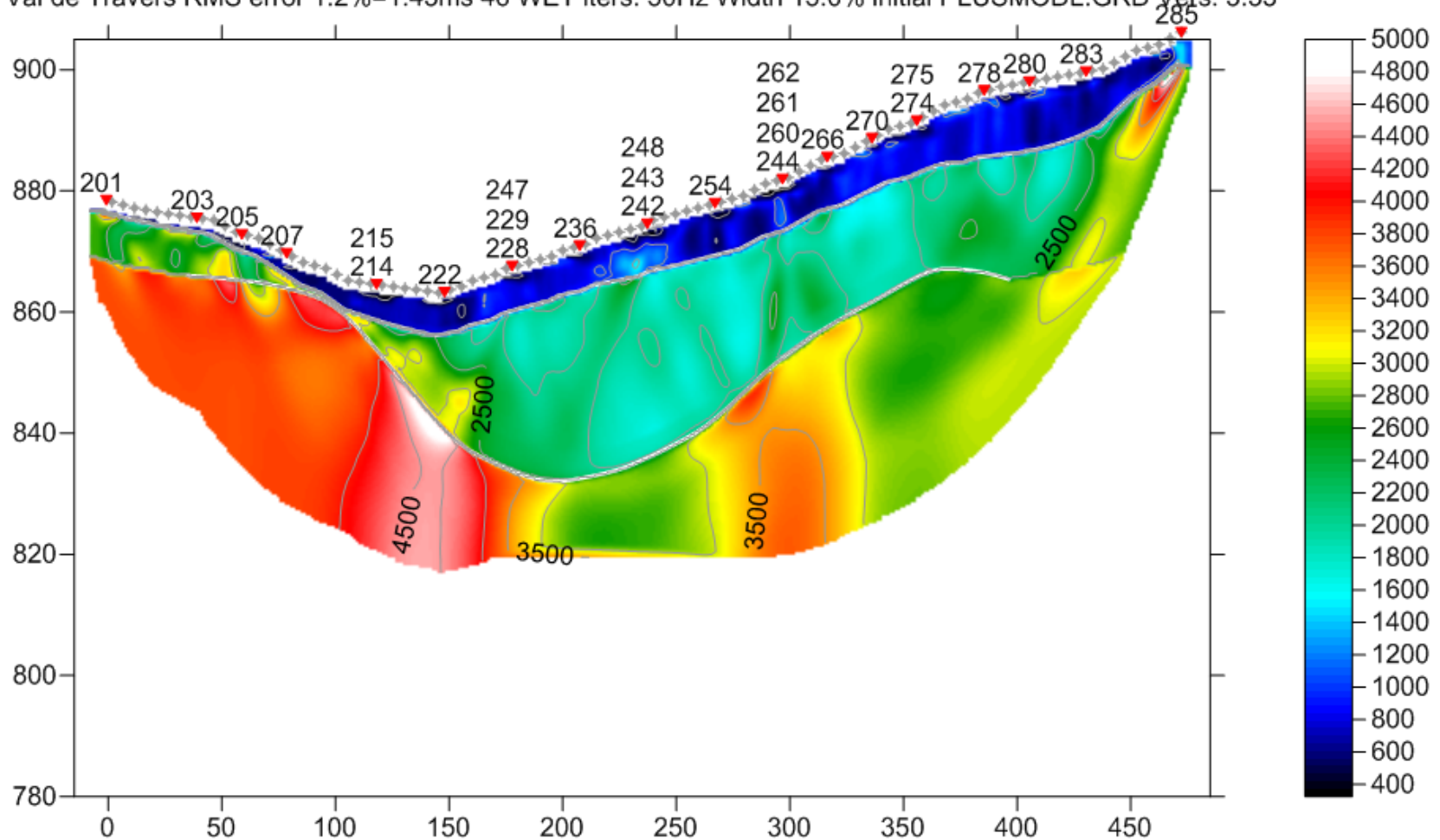
Smooth velocity update before updating tomogram
☒ Smooth velocity update ☒ Smooth last iteration

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

- 1 Check *WET Tomo/WET tomography Settings/Blank/Blank after last iteration*
- 2 Uncheck all other blanking flags in *WET Tomo/WET tomography Settings/Blank*
- 3 Select *WET Tomo/Interactive WET tomography*. Select ... \PLUSMODL.GRD.
- 4 Fill in as above. Click button *Edit velocity smoothing*. Fill in as above at right.
- 5 Click *Accept parameters* and *Start tomography processing*.

View WET with Plus-Minus starting model

Val de Travers RMS error 1.2%=1.45ms 46 WET iters. 50Hz Width 15.0% initial PLUSMODL.GRD Vers. 3.35



Configure DeltatV Settings

	Output <u>M</u> easured CMP Velocities
<input checked="" type="checkbox"/>	Output <u>H</u> orizontal offset of CMP pos. in meters
	Output DeltatV results in <u>F</u> eet
<input checked="" type="checkbox"/>	CMP is <u>z</u> ero time trace
<input checked="" type="checkbox"/>	Reduced offset 0.0 is valid trace with time <u>0</u> .0
	Enforce <u>M</u> onotonically increasing layer bottom velocity
<input checked="" type="checkbox"/>	Suppress velocity <u>a</u> rtifacts
<input checked="" type="checkbox"/>	<u>P</u> rocess every CMP offset
<input checked="" type="checkbox"/>	Prefer <u>A</u> verage over minimum interface velocity
<input checked="" type="checkbox"/>	<u>T</u> aper velocity steps at layer interfaces
	<u>S</u> mooth CMP traveltimes curves
<input checked="" type="checkbox"/>	<u>W</u> eigh picks in CMP curves
	<u>E</u> xtrapolate output to all receivers
	Extra-large cell size
	<u>I</u> ncrease cell size
	Decrease cell size
	Extra-small cell size
<input checked="" type="checkbox"/>	<u>E</u> dit cell size
	Limit DeltatV velocity exported to maximum <u>1</u> D-gradient velocity
	Limit DeltatV velocity exported to <u>5</u> ,000 m/s
	<u>R</u> eset DeltatV settings to default

- 1 Set options in *DeltatV/DeltatV Settings* as above
- 2 Check *Process every CMP offset* to get better vertical resolution
- 3 Check *Taper velocity steps at layer interfaces* to get better vertical resolution

Run interactive DeltatV method

The image shows a software dialog box for the DeltatV method, divided into two main sections.

Parameters for DeltatV method

- CMP curve stack width [CMPs]: 19
- Regression over offset stations: 5
- Linear regression method:
 - ☒ least squares
 - ☐ least deviations
- Weathering sub-layer count: 2
- Maximum valid velocity [m/sec.]: 6000
- Process all CMP curves:
 - ☒ process all CMP
 - ☐ skip every 2nd
- Shot & Recvr spacing [Stations], CMPs/Recvr:
 - 5.3
 - 1.0
 - 2.0

Buttons at the bottom of the left panel: Static Corrections, Export Options, DeltatV Inversion, Reset, Cancel.

Static first break corrections

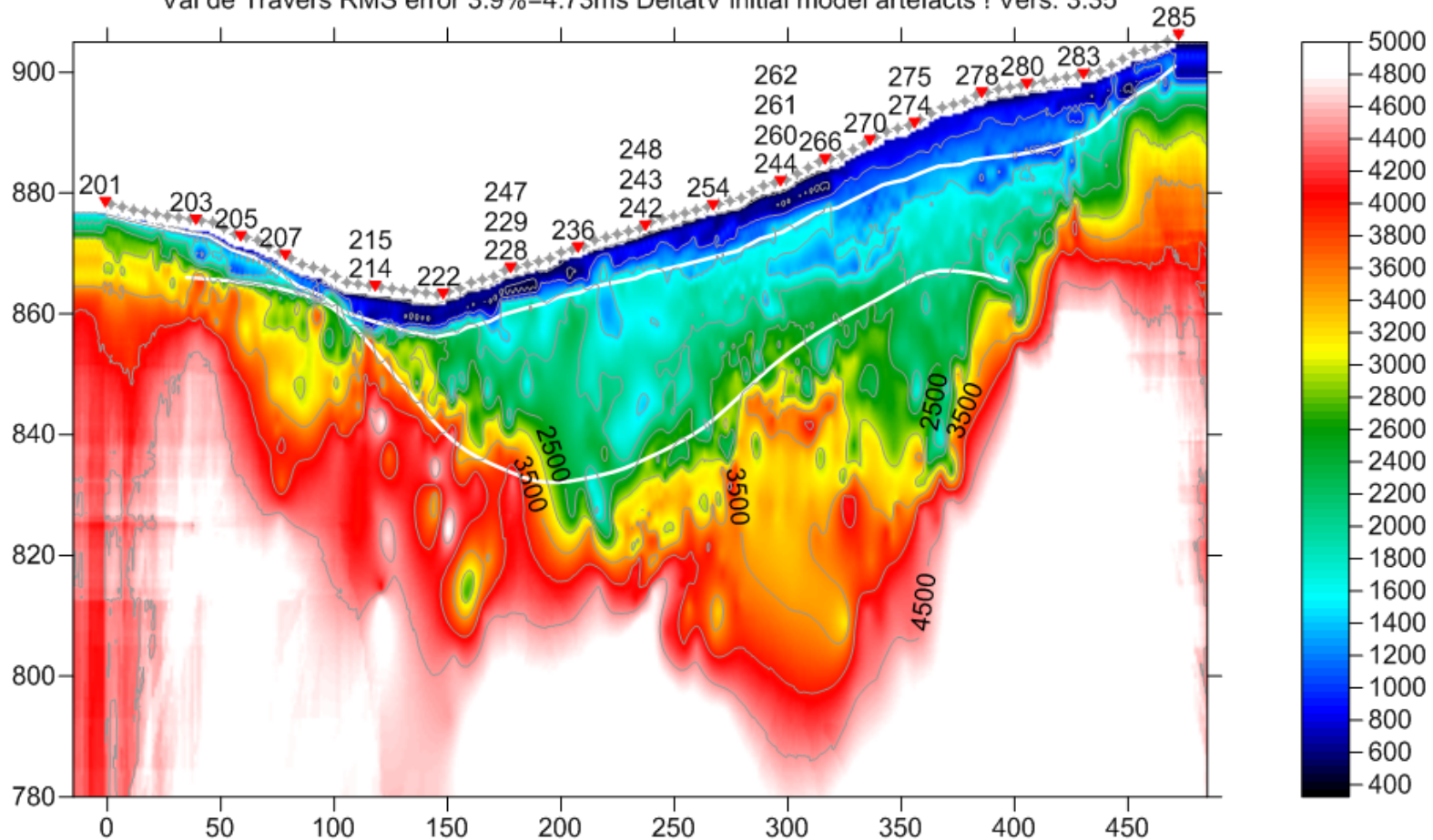
- What static corrections:
 - ☐ No static corrections applied
 - ☐ Surface consistent corrections
 - ☒ CMP Gather datum specific
- Determination of weathering velocity:
 - ☐ Copy v0 from Station editor
 - ☒ Automatically estimate v0
- Station number intervals [station nos.]:
 - Weathering crossover: 10
 - Topography filter: 50
- Trace weighting in CMP stack [1/stat.nos.]:
 - Inverse CMP offset power: 0.20

Buttons at the bottom of the right panel: Accept, Reset.

- 1 Select *DeltatV|XTV parameters*. Click *Gradient model* & *Accept* buttons.
- 2 Select *DeltatV|Interactive DeltatV (CMP Velocity vs. Depth)*. Confirm prompt.
- 3 Edit parameters as above. Click *Static Corrections*. Edit as above at right.
- 4 Click *button DeltatV inversion*.
- 5 In dialog *Save DeltatV output* click Folder icon & set folder name to *DeltatVXTV*
- 6 Enter *DeltatV*Sep15 subdirectory by double-clicking it
- 7 Set *File name* to *DeltatVXTV* and click *Save button*. Confirm prompt.

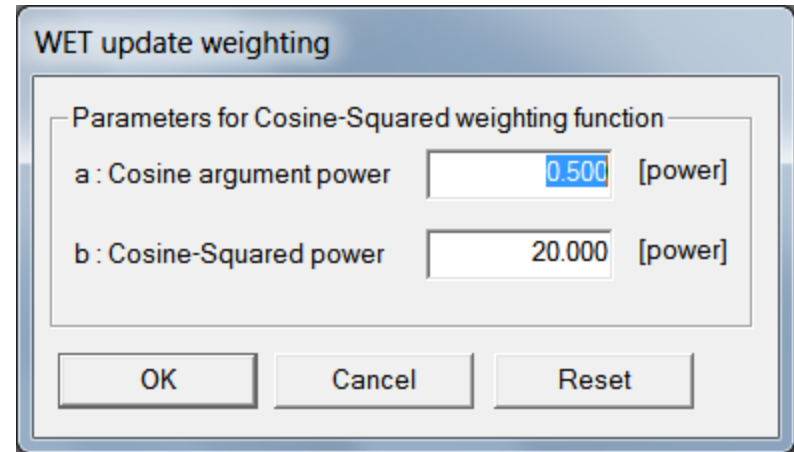
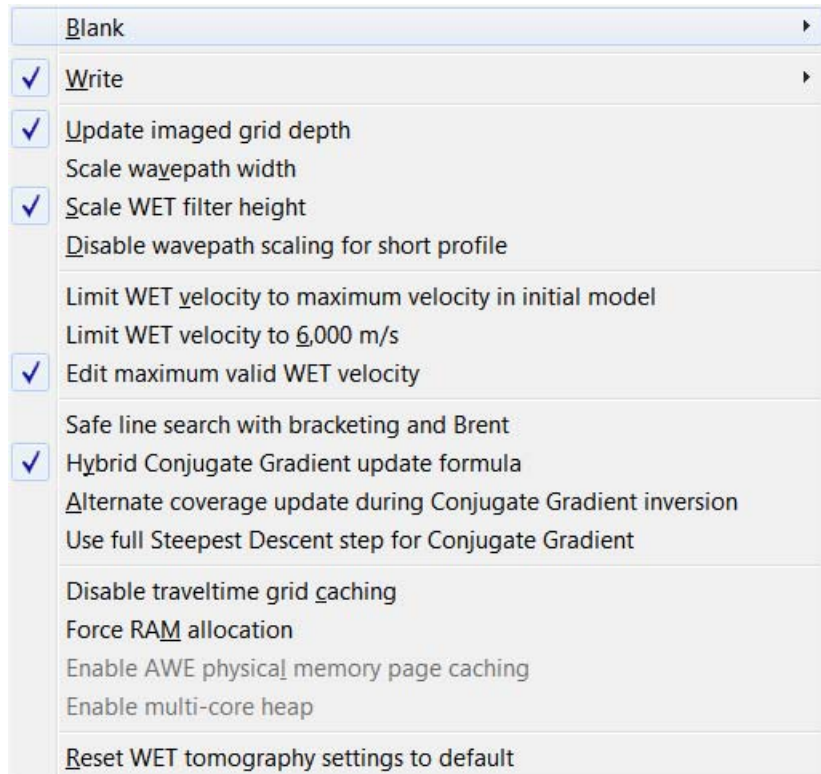
View DeltatV starting model in Surfer

Val de Travers RMS error 3.9%=4.73ms DeltatV initial model artefacts ! Vers. 3.35



- 1 Select *Model/Forward model traveltimes...* & DeltatVXTV\DeltatVXTV.GRD
- 2 Select *Grid/Image and contour* & DeltatVXTV\DeltatVXTV.GRD
- 3 Click *Surfer icon* in Windows taskbar to view DeltatV+XTV output as above

Edit WET settings and update weighting



- 1 Check/uncheck options in *WET Tomo/WET tomography Settings* as above
- 2 Select *WET Tomo/WET Update weighting*. Edit as above and click OK.

Edit WET with DeltatV starting model

Edit WET Wavepath Eikonal Traveltime Tomography Parameters

Specify initial velocity model
Select

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
Used width of Gaussian sigma
Uniform central row weight [1..100]

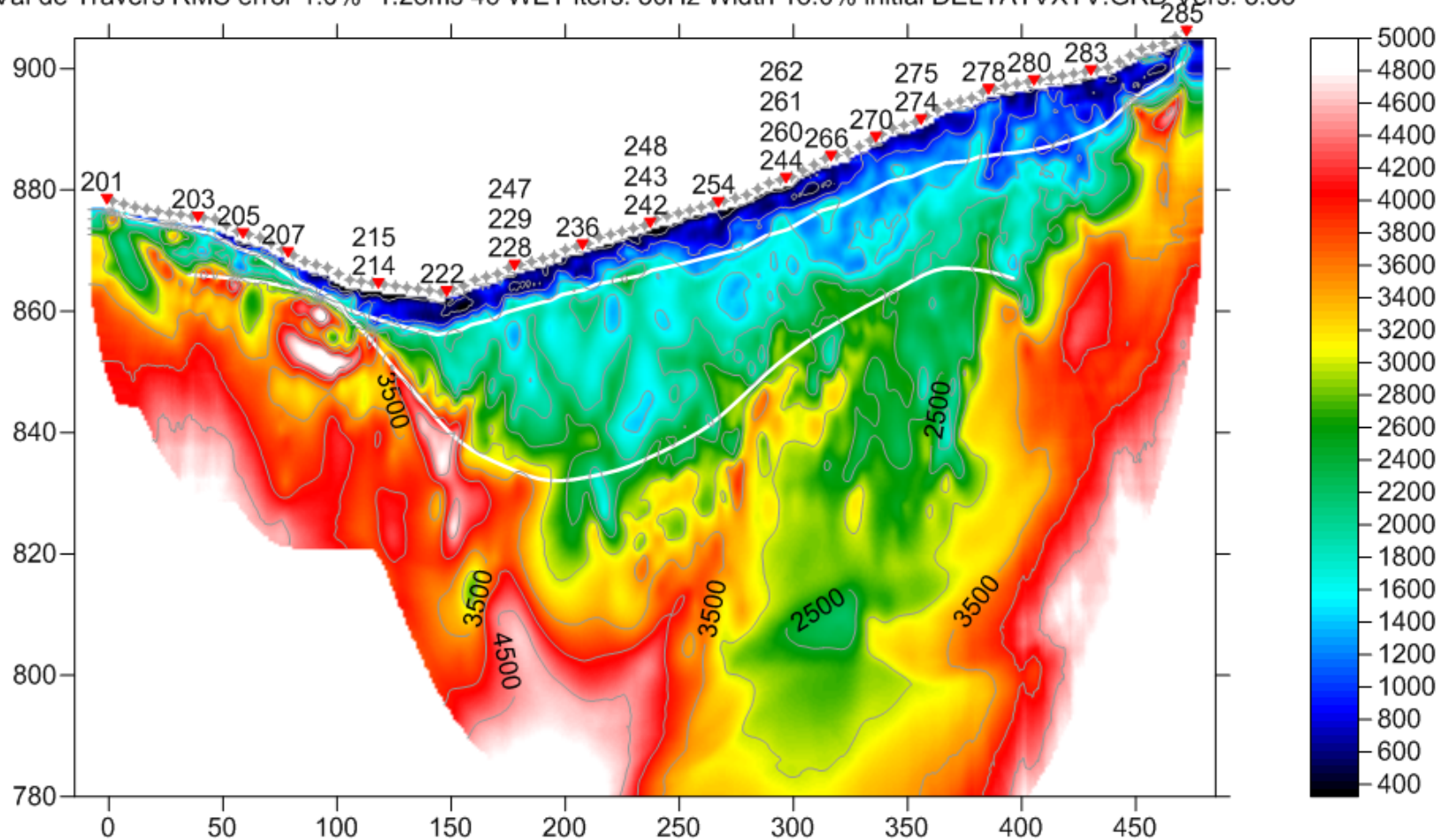
Smooth velocity update before updating tomogram
☒ Smooth velocity update ☒ Smooth last iteration

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

- 1 Select *WET Tomo/Interactive WET tomography & DeltatVXTV\DeltatVXTV.GRD*
- 2 Edit main WET dialog as above. Click *Edit velocity smoothing* & edit as above right.
- 3 Click *Start tomography processing* & wait until WET output is shown in Surfer

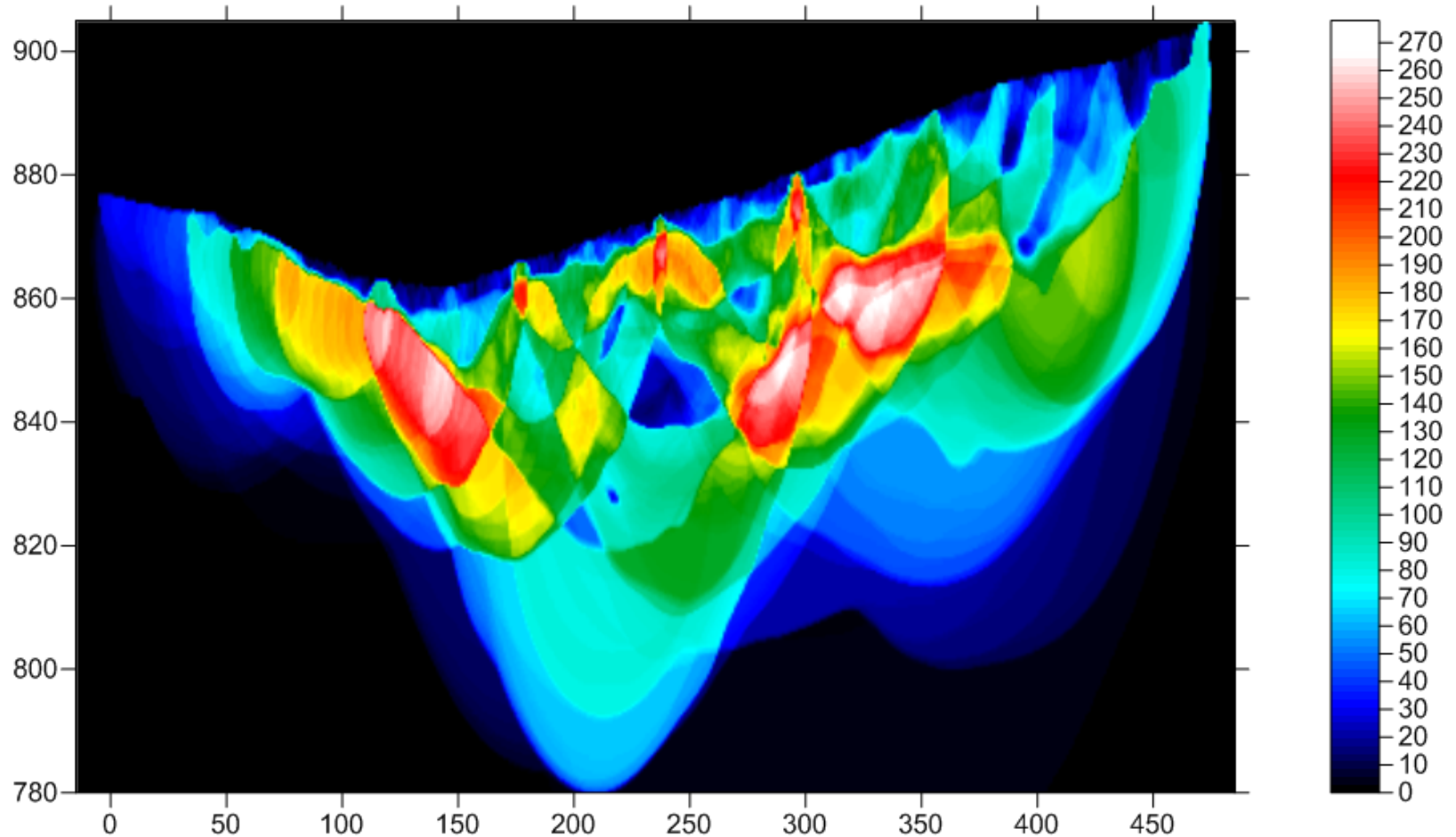
View WET with DeltatV starting model

Val de Travers RMS error 1.0%=1.28ms 46 WET iters. 50Hz Width 15.0% initial DELTATVXTV.GRD Vers. 3.35



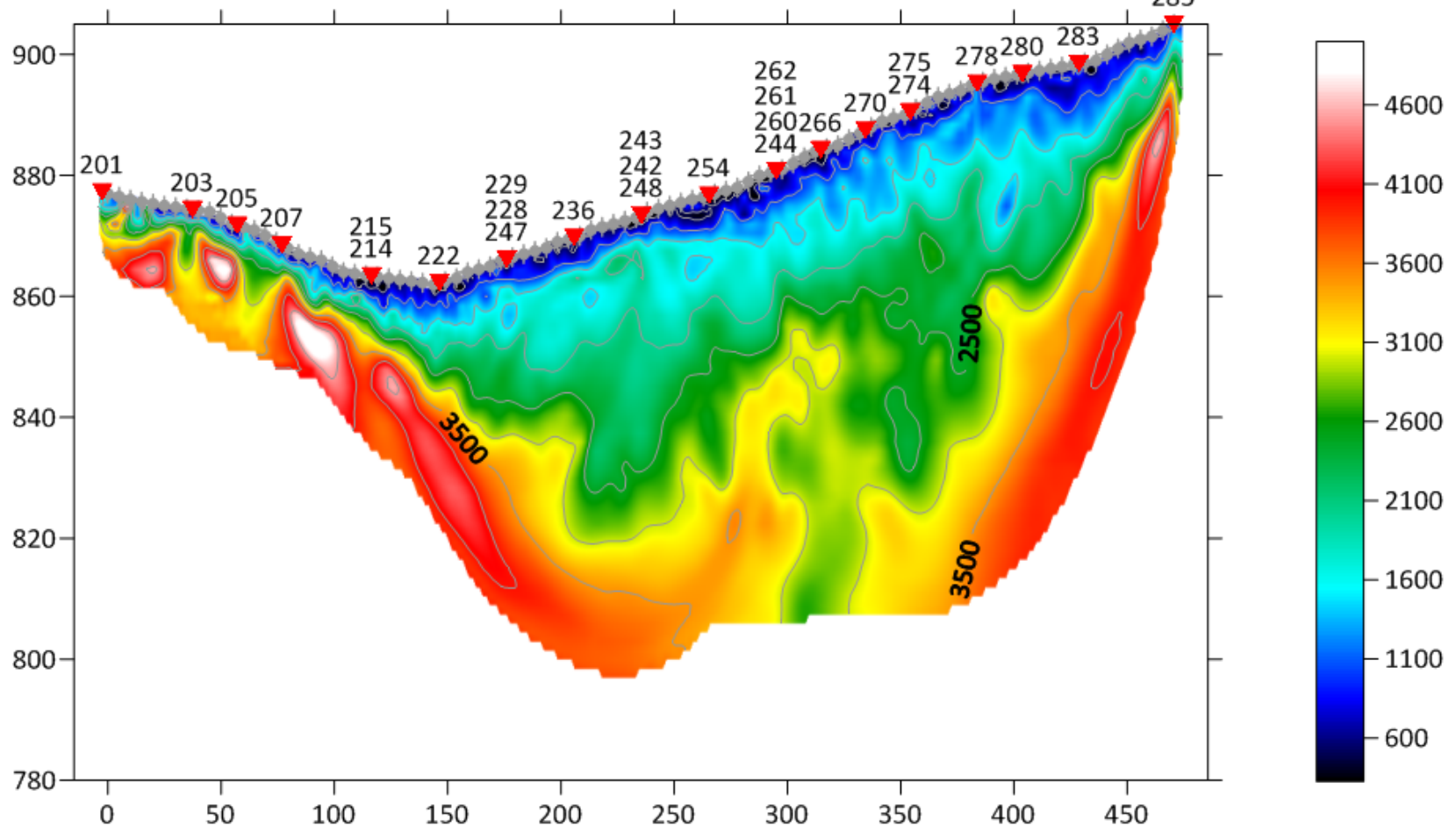
View WET with DeltatV coverage plot

Val de Travers RMS error 1.0%=1.28ms 46 WET iters. 50Hz Width 15.0% initial DELTATVXTV.GRD Vers. 3.35

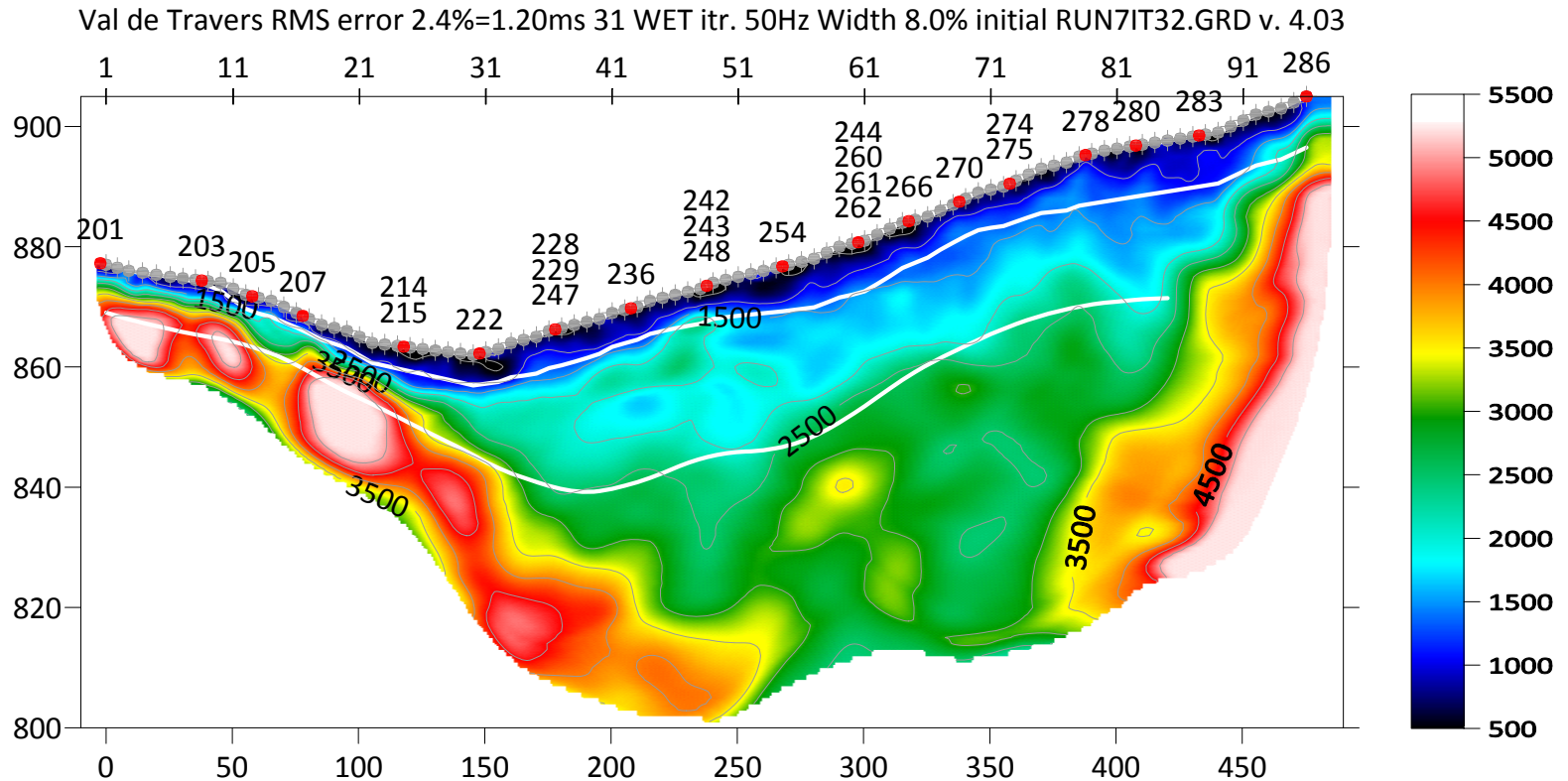


Multirun Conjugate-Gradient WET with DeltatV starting model

Val de Travers RMS error 0.9%=1.13ms 31 WET iters. 50Hz Width 8.0% initial RUN7IT32.GRD Vers. 3.35



Multiscale CG WET, DeltatV starting model & WDVS @250Hz (Wavelength-Dependent Velocity Smoothing, Zelt & Chen 2016)



We show 10th WET run of multiscale WET inversion. WDVS was enabled at 250Hz. We used minimal WET smoothing and WET damping 0.2.

Here is the .rar archive with [10 WET runs](#)

Here is the .rar archive with [seis32.* profile database files](#)