

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

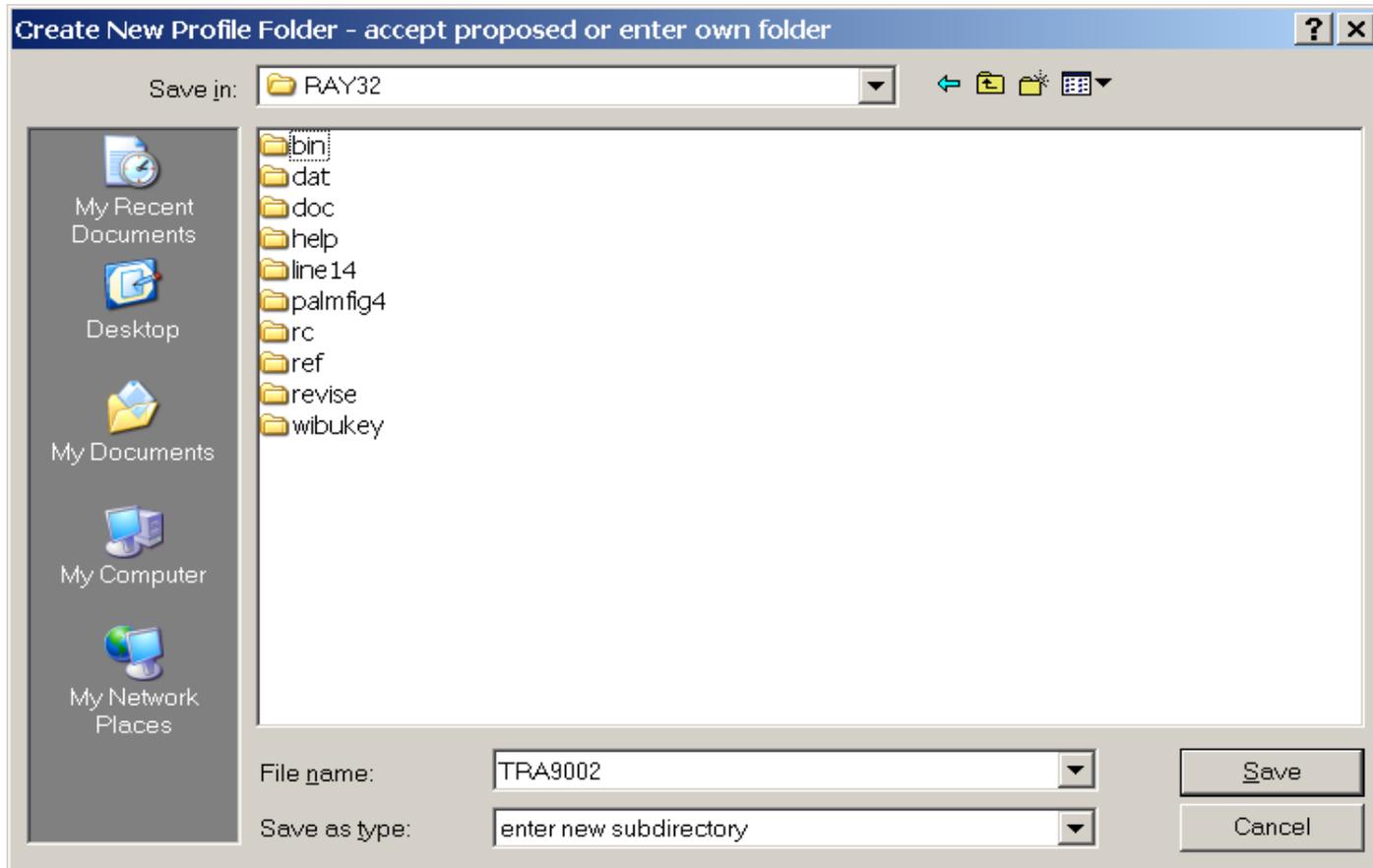
Presenters :



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

Edit Profile

Line ID: TRA9002

Line type: Refraction spread/line

Job ID: Tutorial

Instrument: Bison-2 9000 Series

Client:

Company:

Observer:

Note:

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

Time of Acquisition: Date: , Time:

Time of Processing: Date: , Time:

Units: meters

Sort: As acquired

Const:

Left handed coordinates

- 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: Select 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)

Import shots Cancel import

- 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="0.00000000"/>	
Sample interval [msec]	<input type="text" value="1.00000000"/>	
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

Edit coordinate file import parameters and import coordinates

Select coordinate file to be imported

Select C:\RAY32\TRA9002\INPUT\TRA9002.COR

Adjustment of station coordinates

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

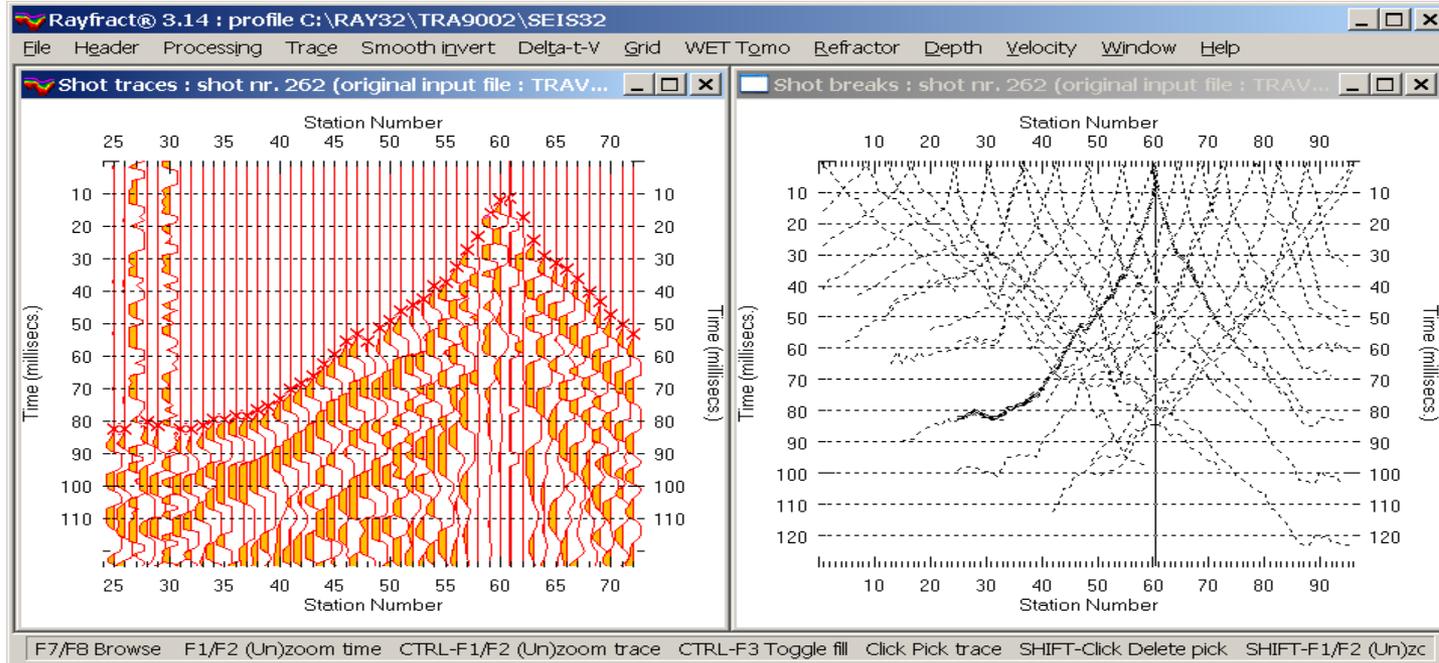
Tolerance for variation in station spacing

Maximum tolerance : 25 percent

Import file Reset parameters Cancel import

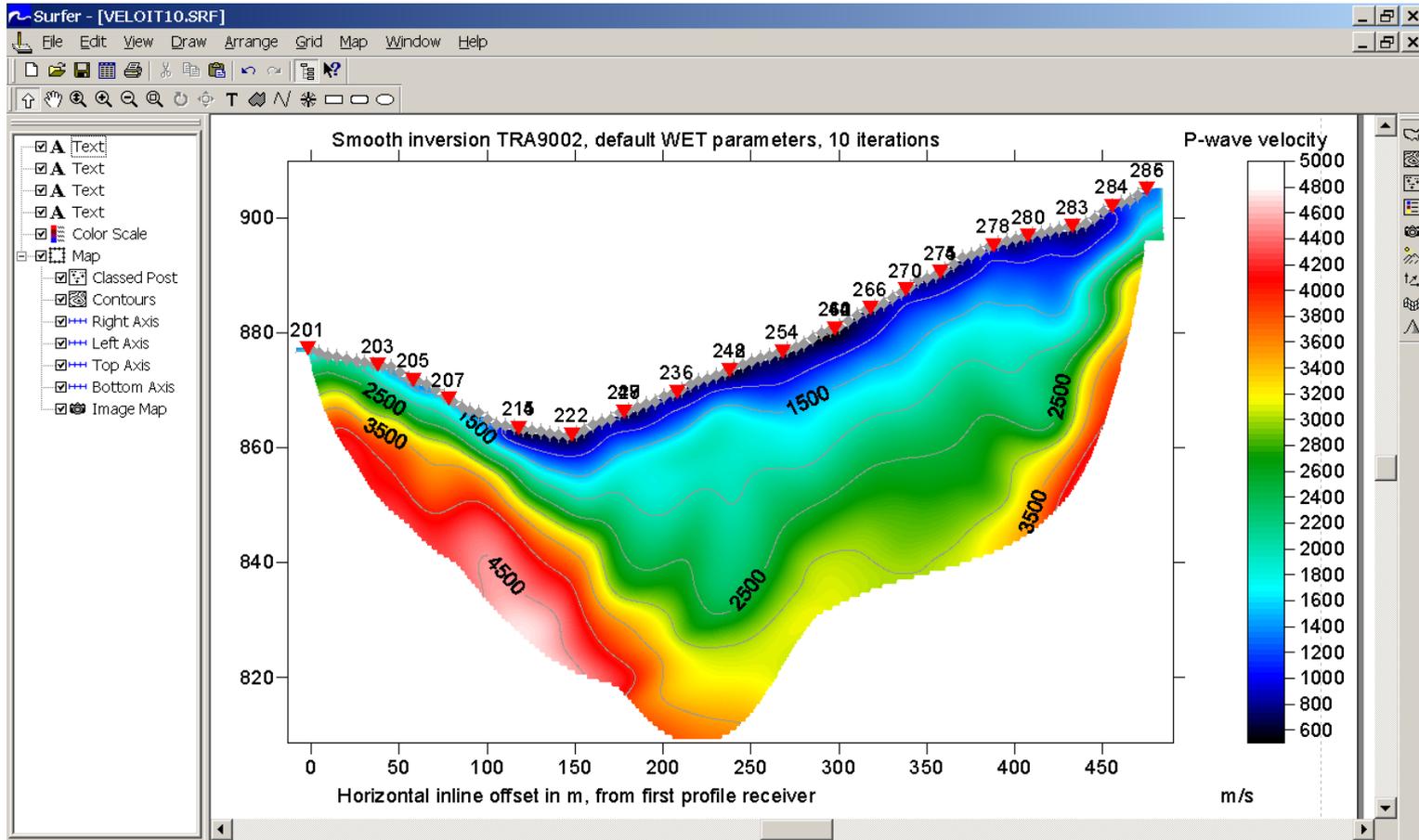
- 1 Select *File|Update header data|Update Station Coordinates...*
- 2 Click on *Select* and `\RAY32\TRA9002\INPUT\TRA9002.COR`
- 3 Click on *Open, Import File* and confirm the prompt
- 4 Select *File|Update header data|Update First Breaks* and `\RAY32\TRA9002\INPUT\TRA9002.LST` and click *Open*

# View and repick traces, display travelttime curves



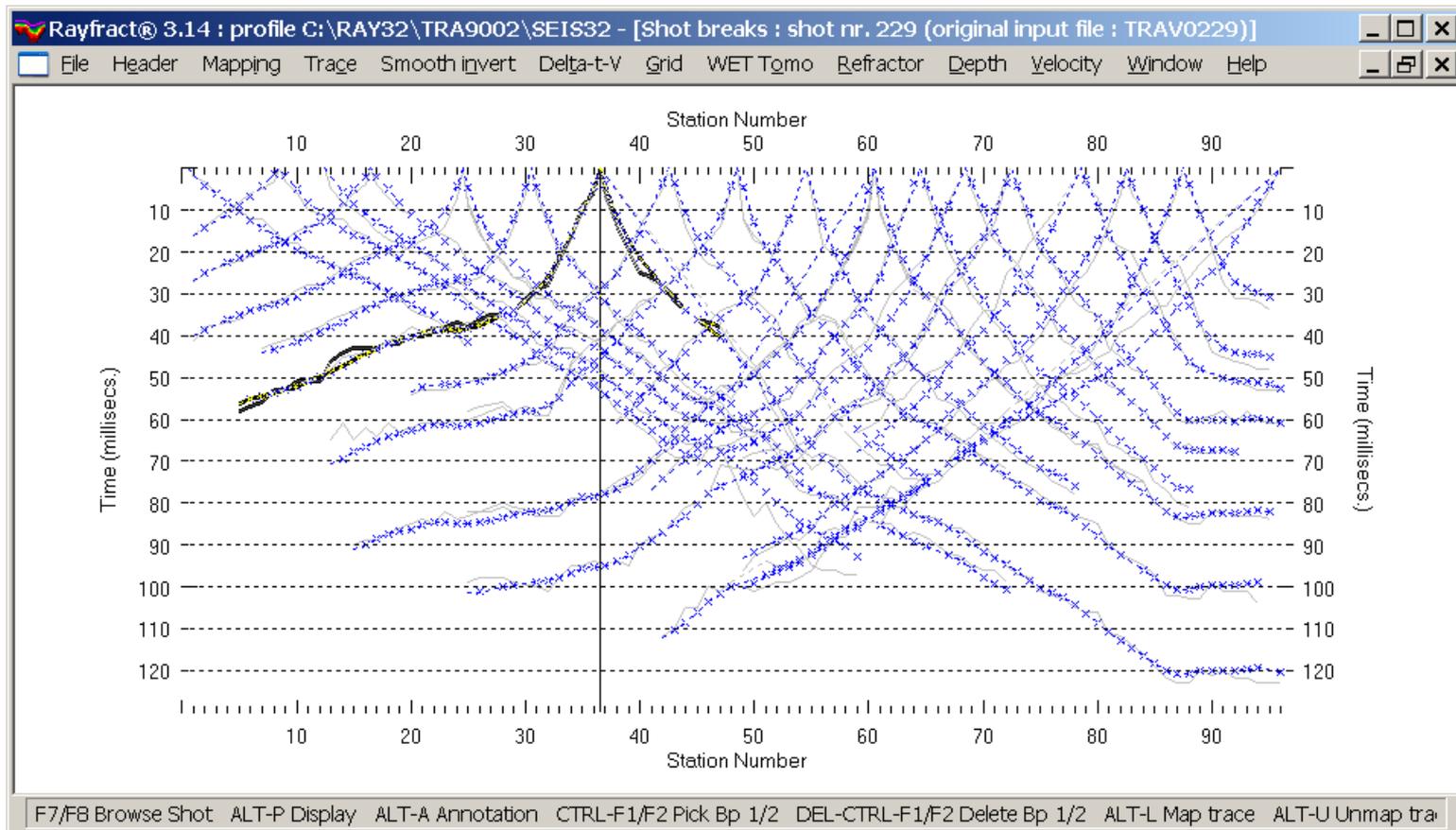
- 1 Select *Trace/Shot gather* and *Window/Tile*. Browse shots with F7/F8
- 2 Click on *Shot breaks window* and press ALT-P
- 3 Set *Maximum time* to 130 msec. and hit ENTER
- 4 Click on *Shot traces window* and press F1 twice to zoom time
- 5 CTRL-F1 twice to zoom amplitude, CTRL-F3 twice to toggle 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



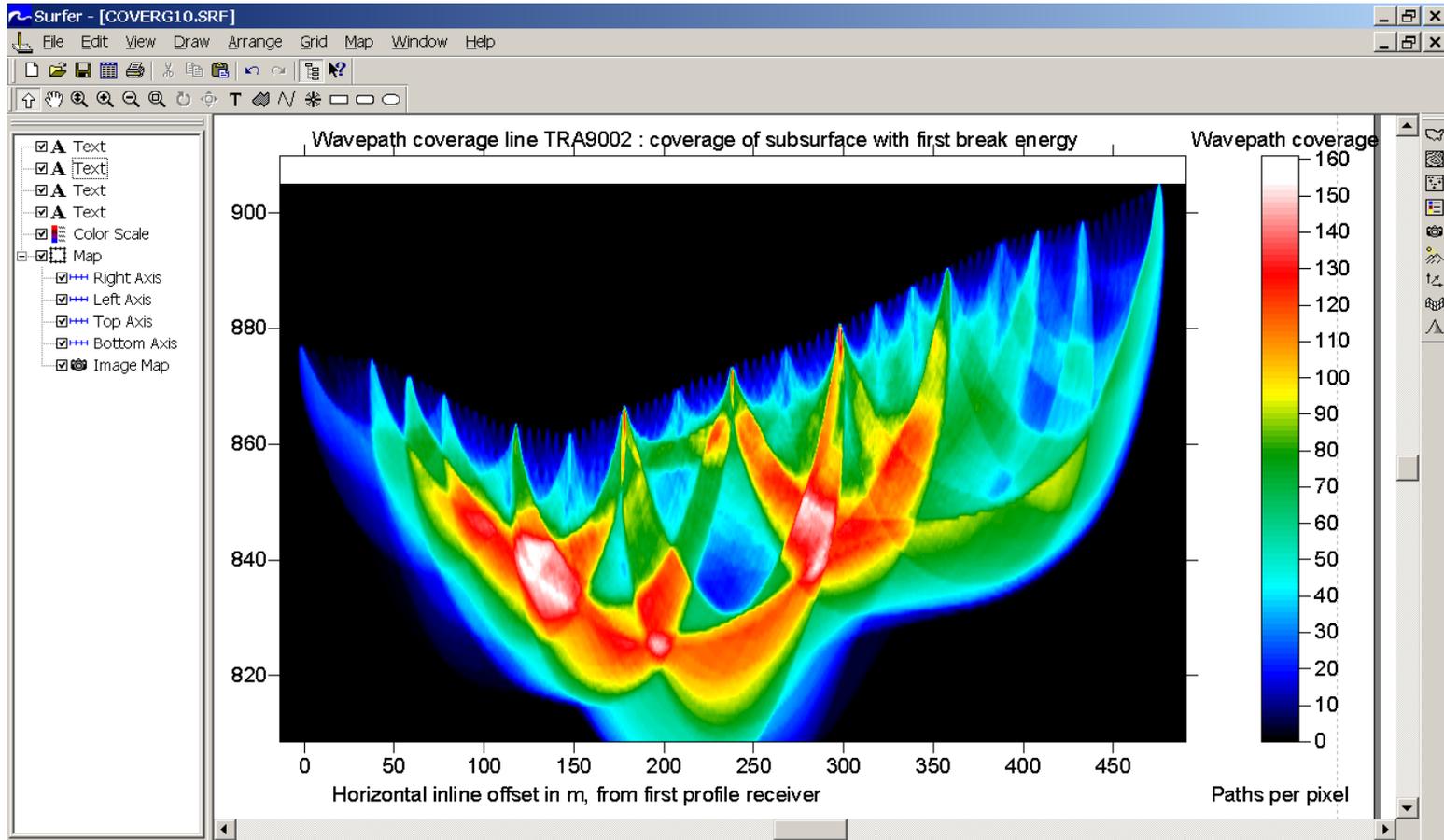
- 1 Select *Smooth invert|WET with 1D gradient initial model*
- 2 Once the 1D gradient model is shown in Surfer™, click on *Rayfract icon* at bottom of screen, to continue. Confirm following prompts
- 3 Click on *Surfer icon* and add text legends with Surfer *Draw|Text*

# Display modeled picks and traveltime curves



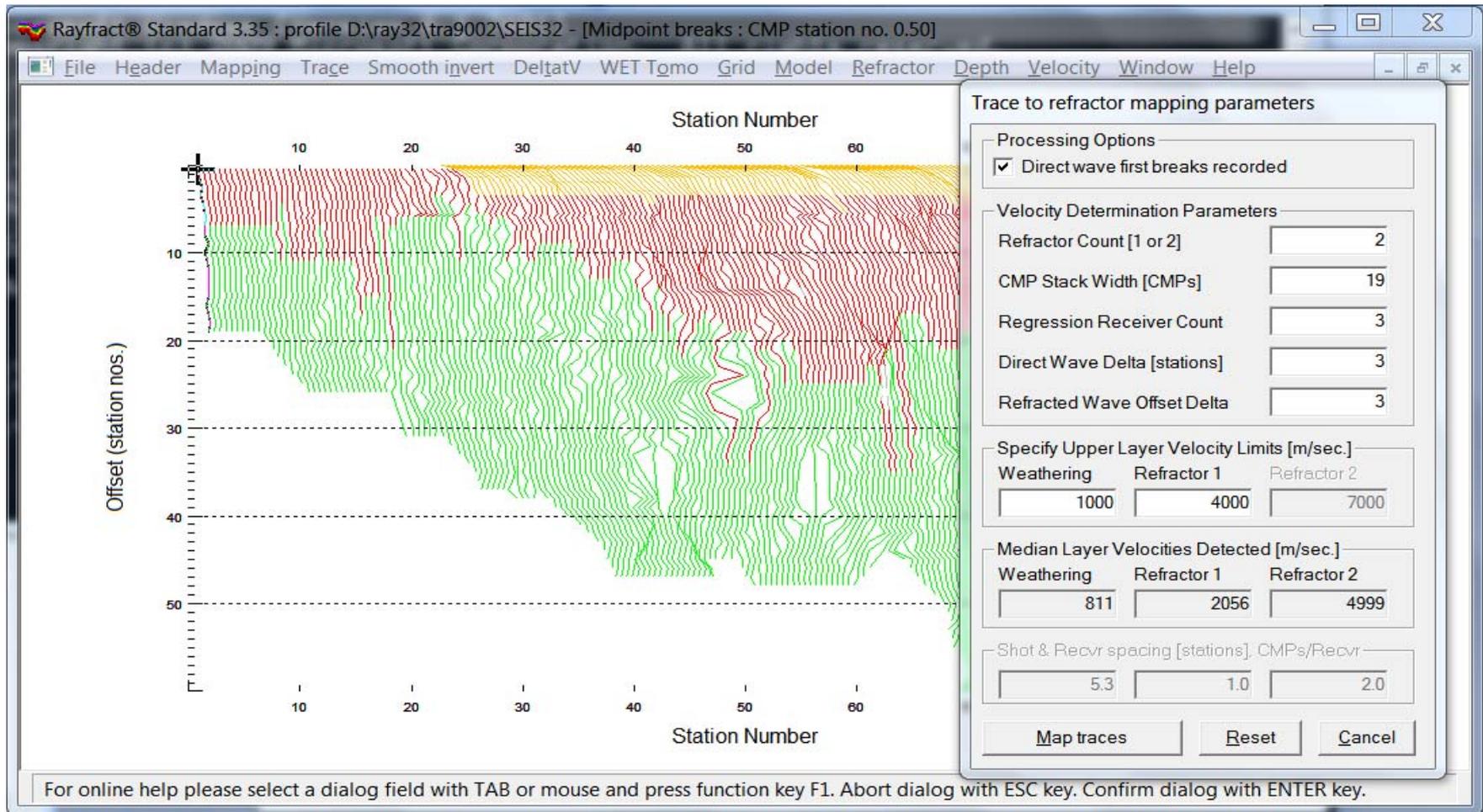
- 1 Click on *Rayfract icon* at bottom of screen
- 2 Select *Refractor|Shot breaks* to view picked and modeled (blue) times
- 3 Press F7/F8 keys to browse through shot-sorted traveltime curve
- 4 Use *Mapping|Gray picked traveltime curves* to toggle curve pen style

# Display WET wavepath coverage



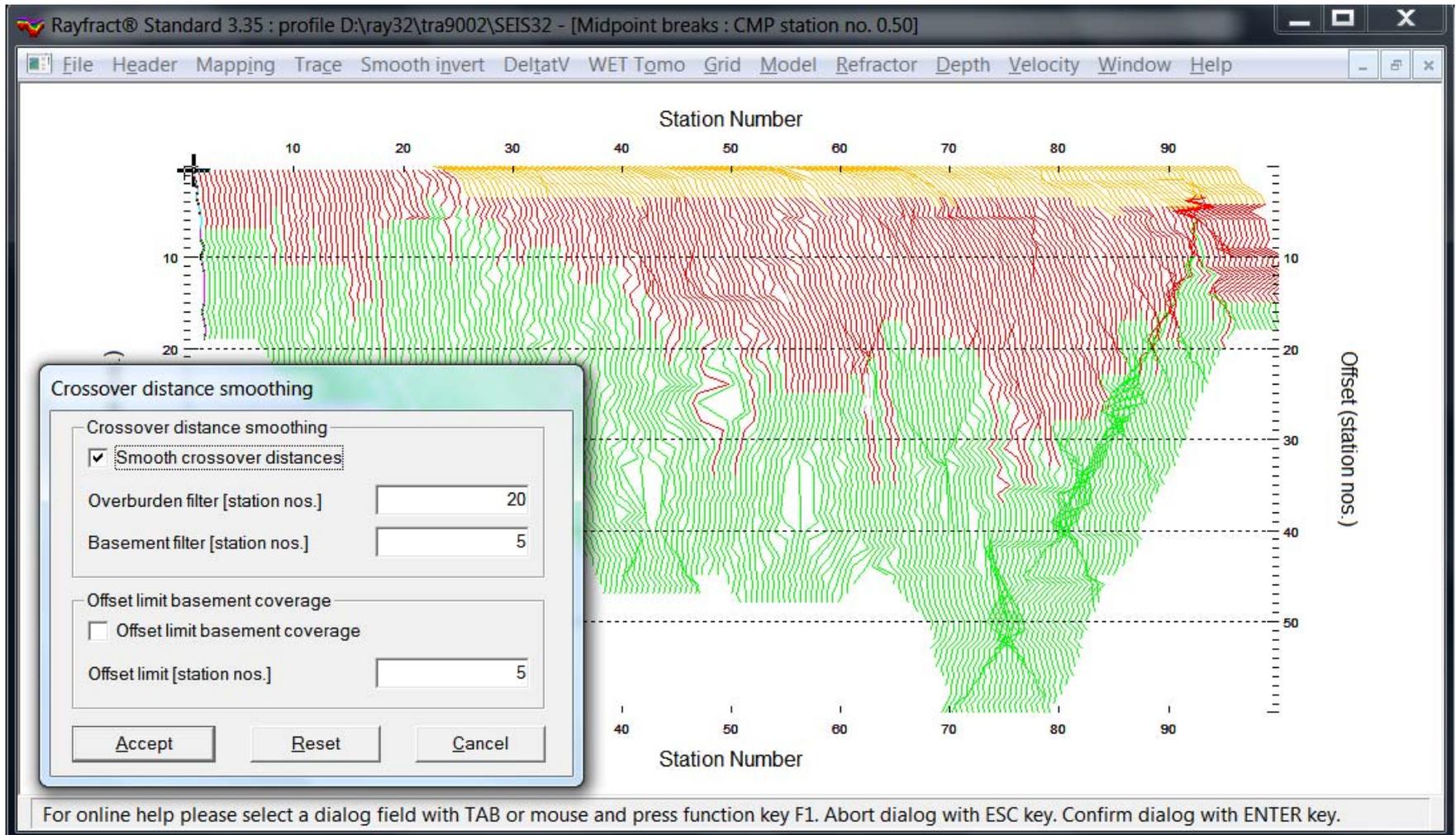
- 1 Click on *Surfer icon* at bottom of screen
- 2 Use CTRL-TAB to cycle between WET tomogram, wavepath coverage plot and 1D gradient initial model
- 3 Add text legends as shown above, with Surfer *Draw/Text* command

# Map traces to refractors in Midpoint breaks



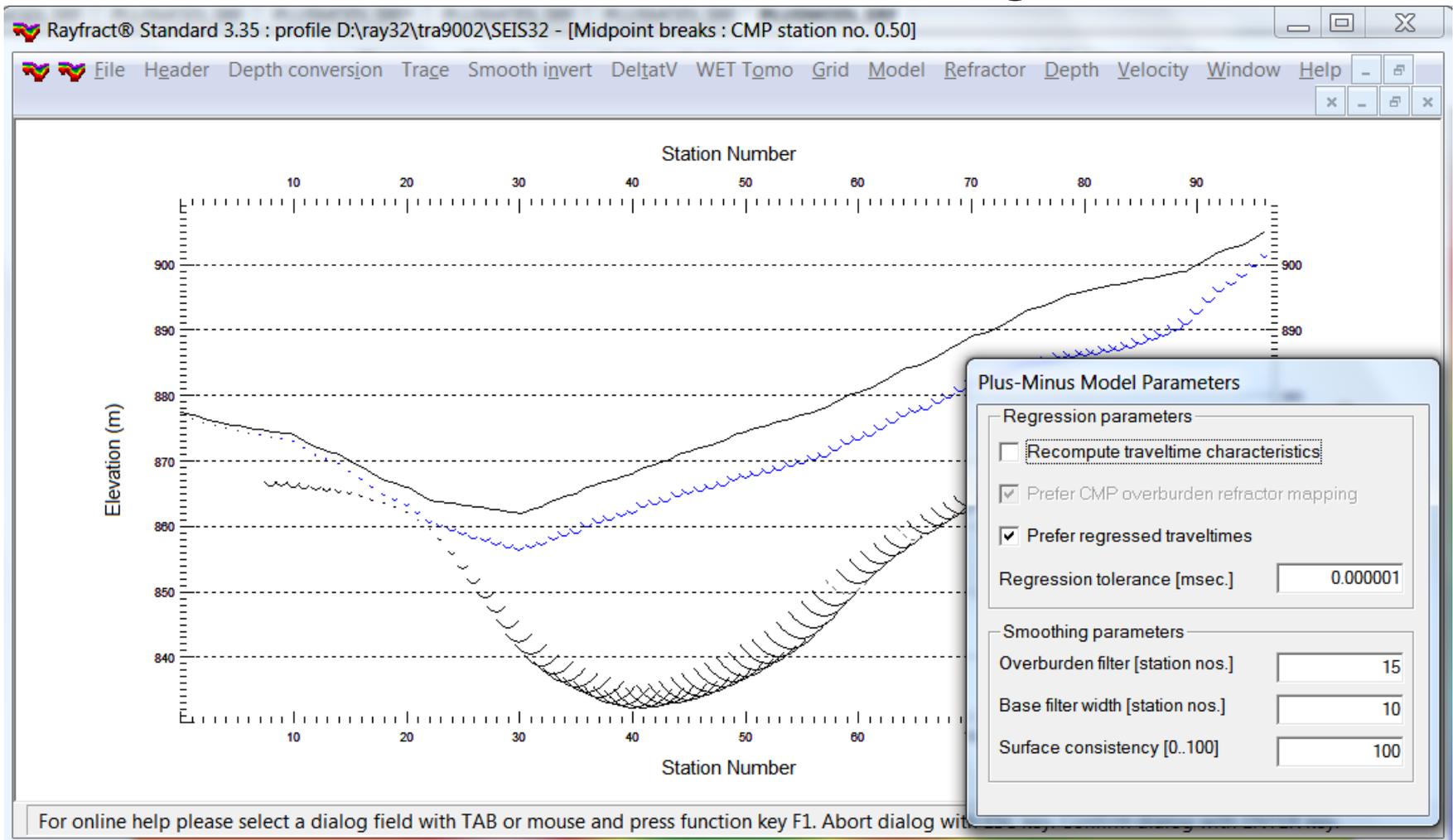
- 1 Select *Refractor/Midpoint breaks*. Zoom/Unzoom dip : CTRL+F1/CTRL+F2
- 2 Press ALT+M for mapping dialog. Edit as above. Click *Map traces button*.

# 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*.

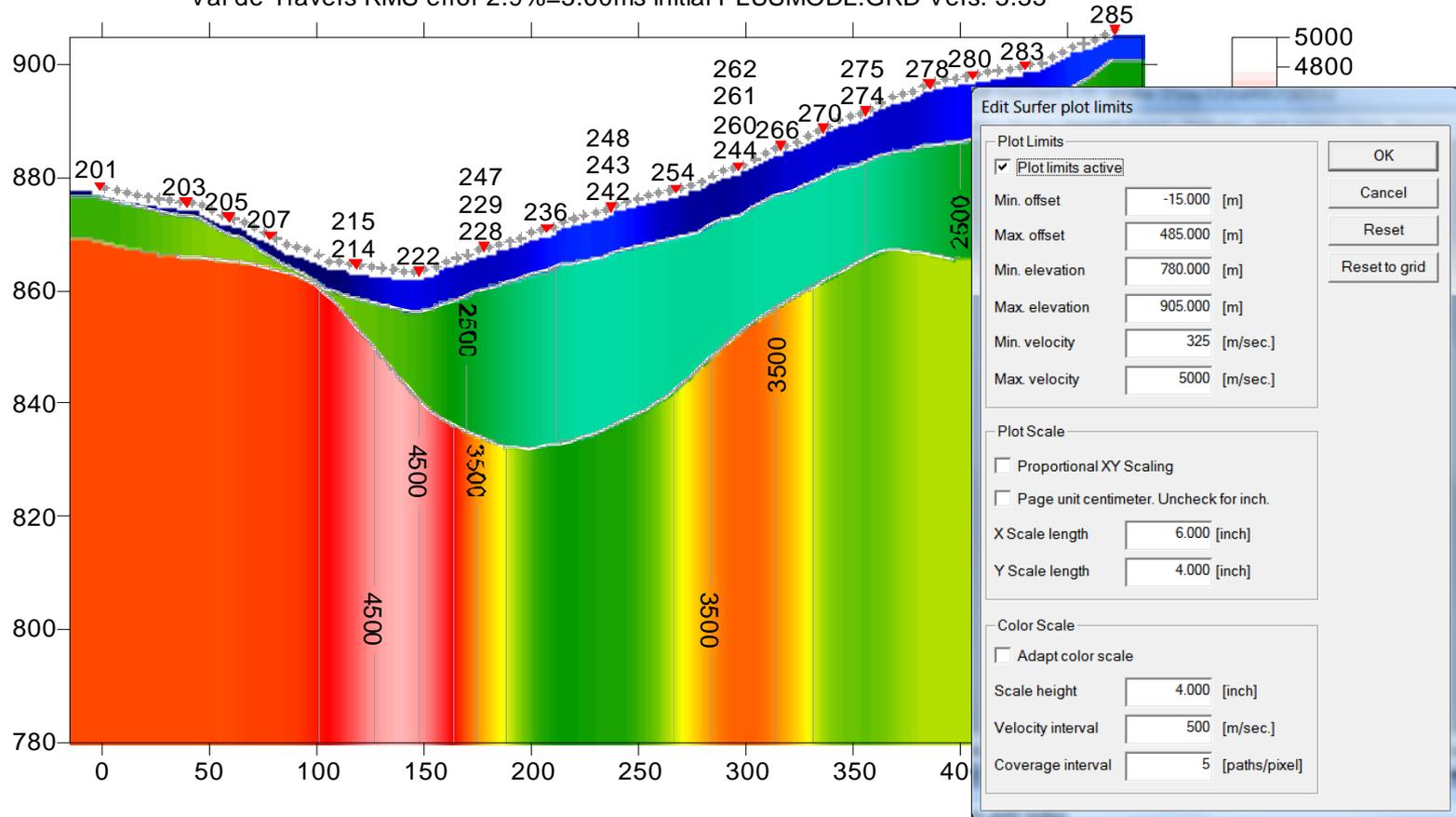
# Create Plus-Minus starting model



- 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

Val de Travers RMS error 2.9%=3.60ms initial PLUSMODL.GRD Vers. 3.35



- 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]

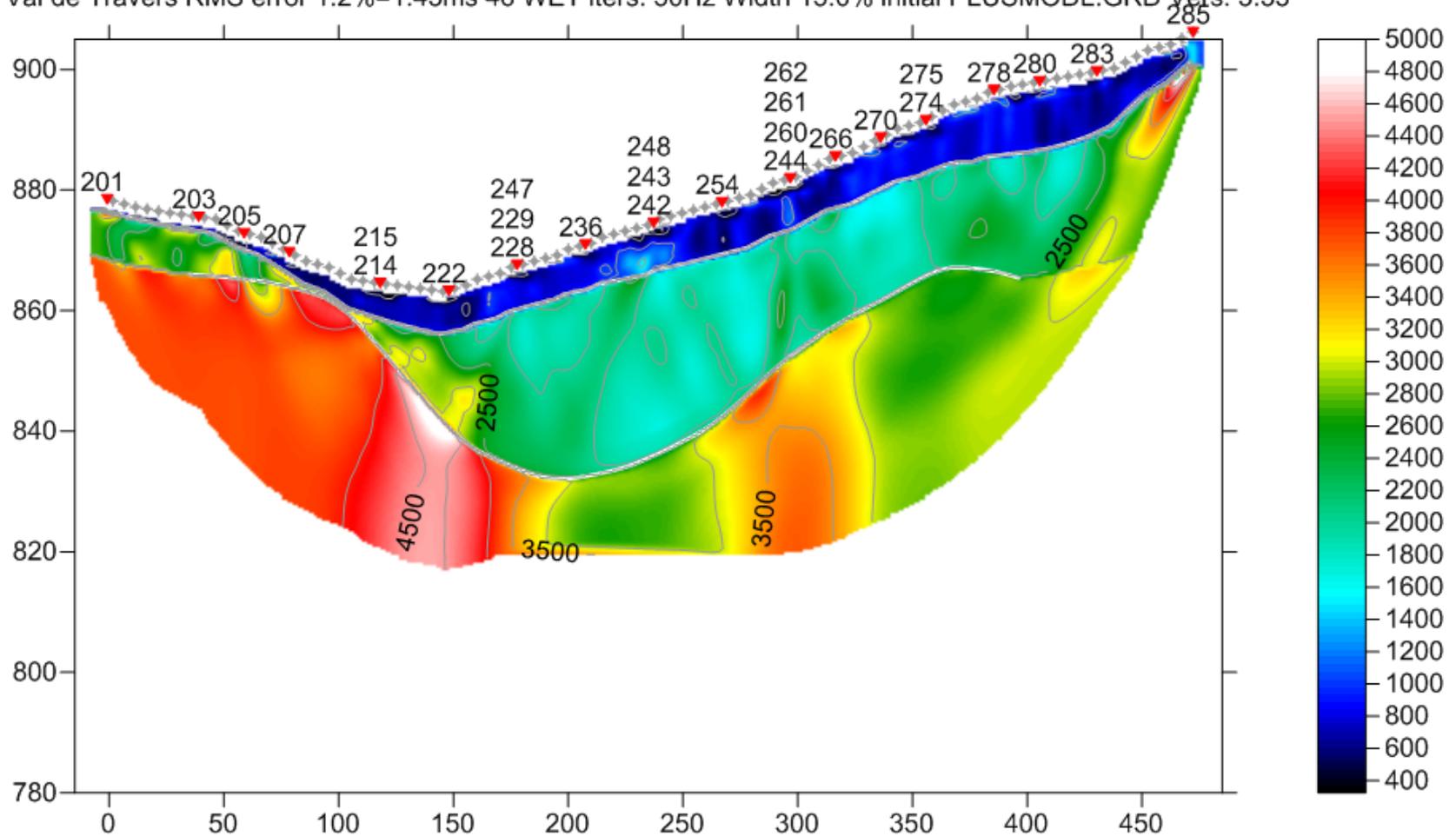
Smooth velocity update before updating tomogram  
 Smooth velocity update  Smooth last iteration

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

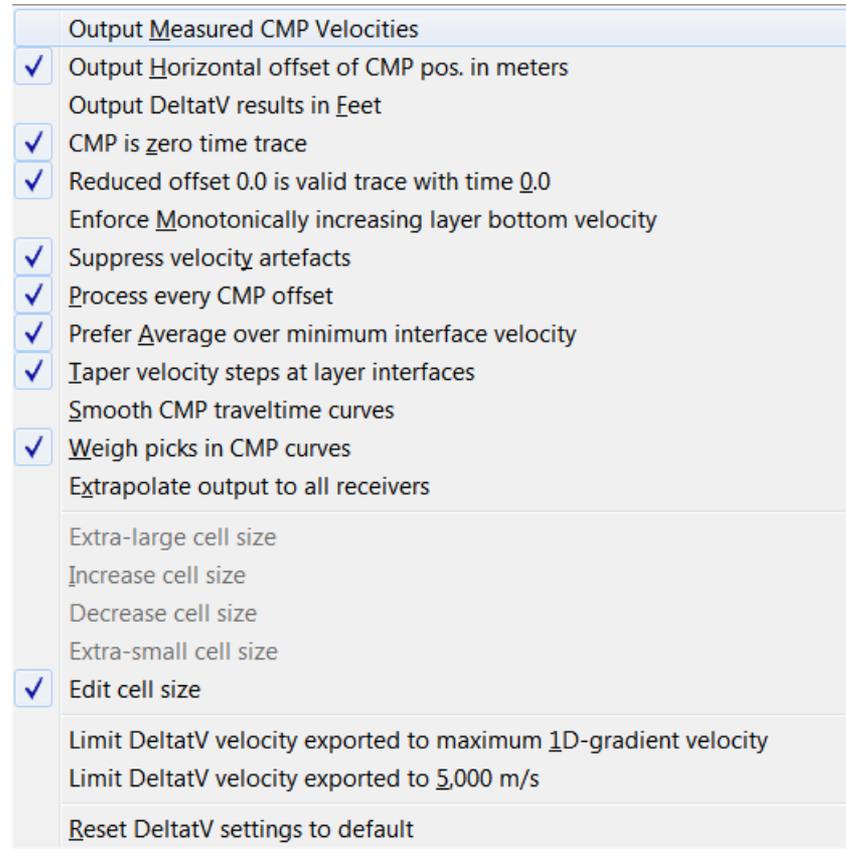
- 1 Check *WET Tomo|WET tomography Settings|Blank|Blank after last iteration*
- 2 Uncheck all other blanking flags in *WET Tomo|WET tomography Settings|Blank*
- 3 Select *WET Tomo|Interactive WET tomography*. Select ... \PLUSMODL.GRD.
- 4 Fill in as above. Click button *Edit velocity smoothing*. Fill 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



- 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 with two main panels. The left panel is titled "Parameters for DeltatV method" and contains several input fields and radio button options. The right panel is titled "Static first break corrections" and contains radio button options and input fields for weathering and topography parameters.

**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

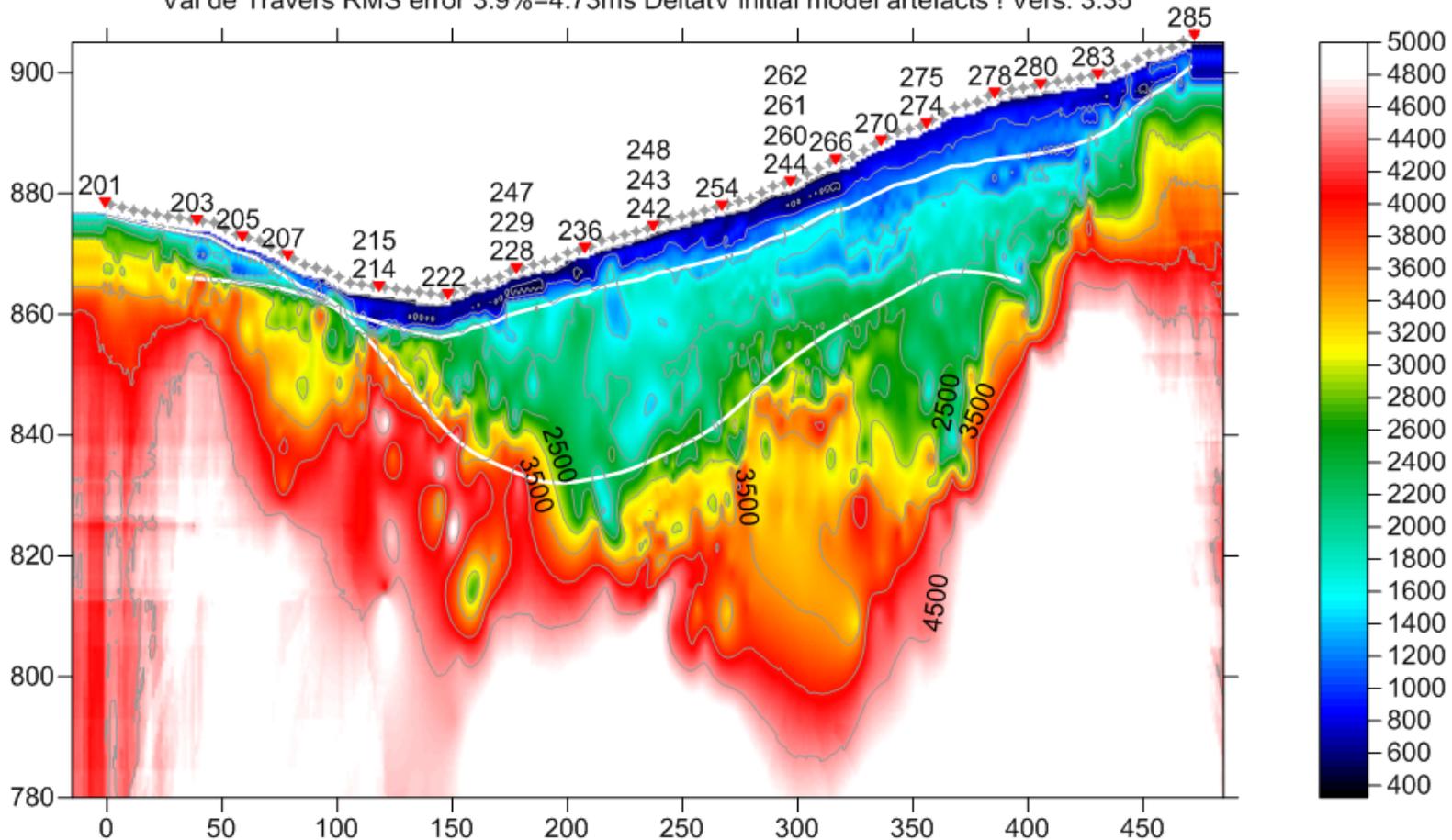
**Static first break corrections**

- 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

- 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.

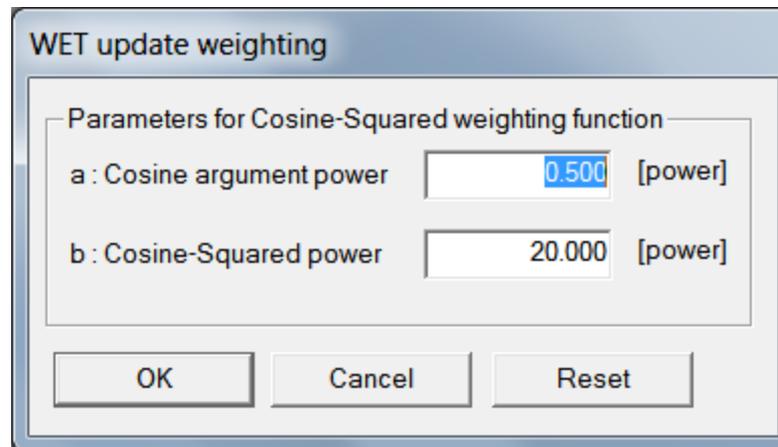
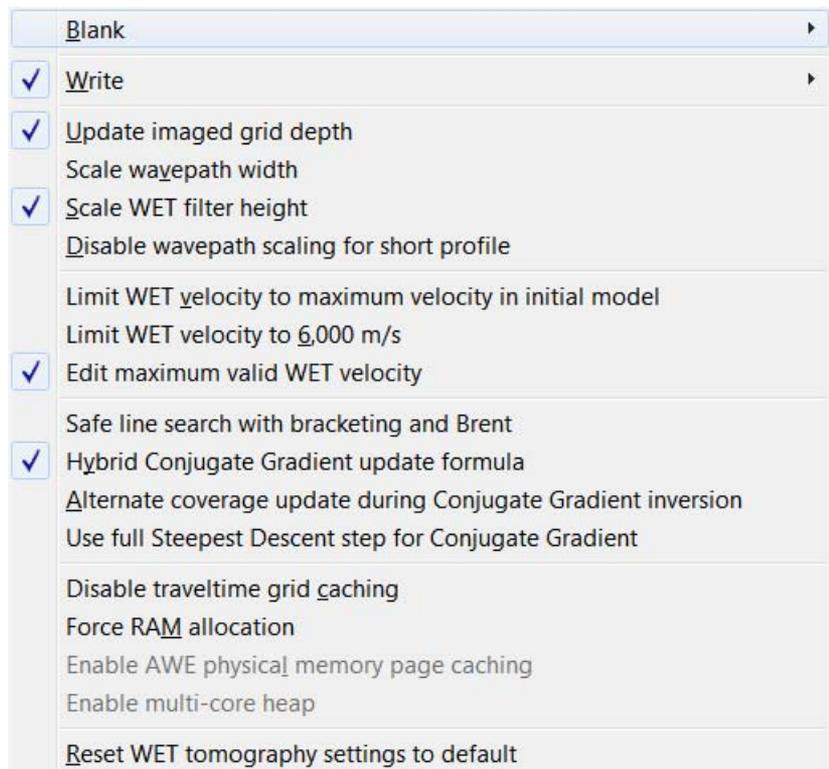
# View DeltatV starting model in Surfer

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

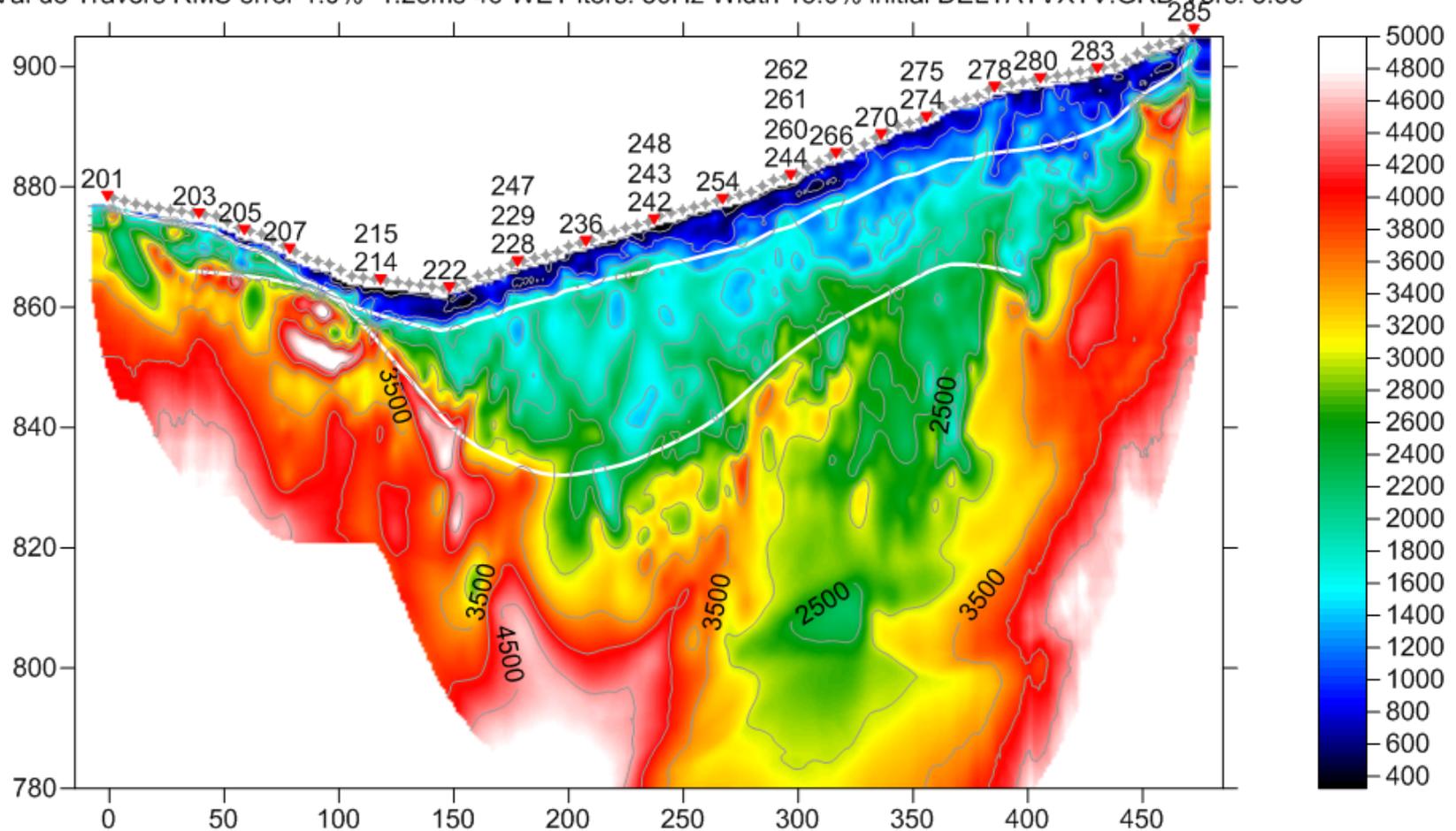
Damping of tomogram with previous iteration tomogram

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

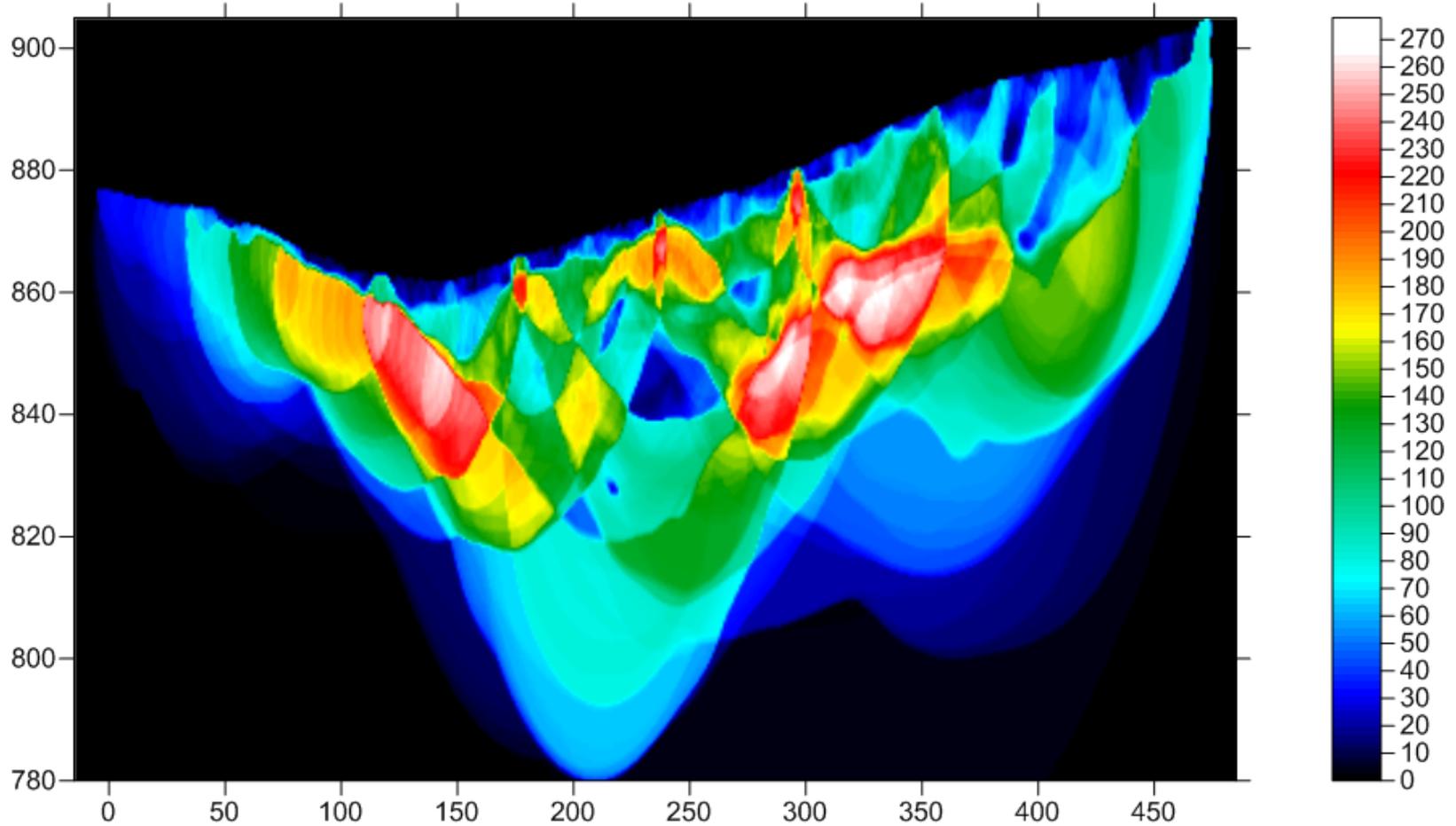
# View WET with DeltatV starting model

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



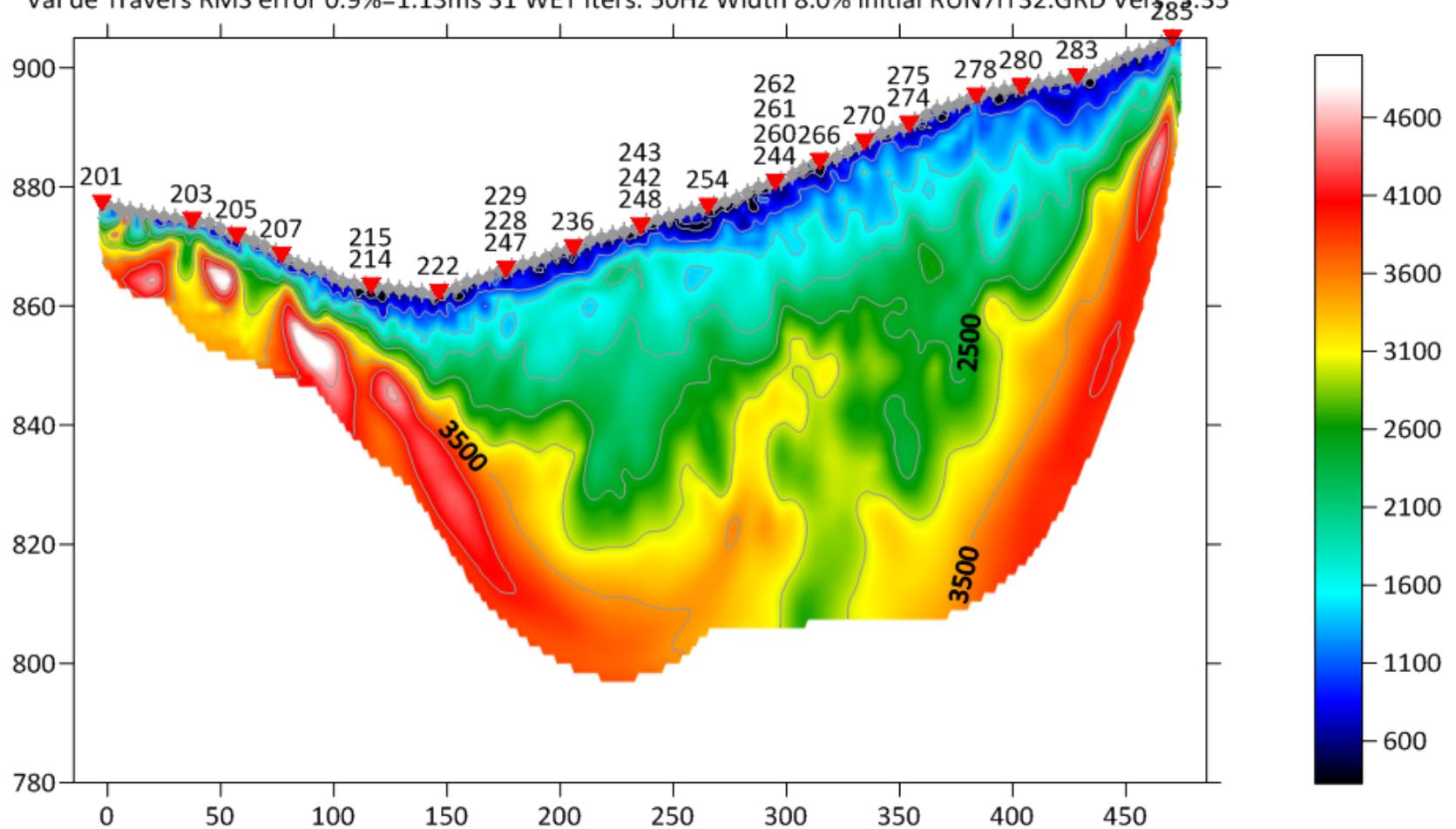
# View WET with DeltatV coverage plot

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

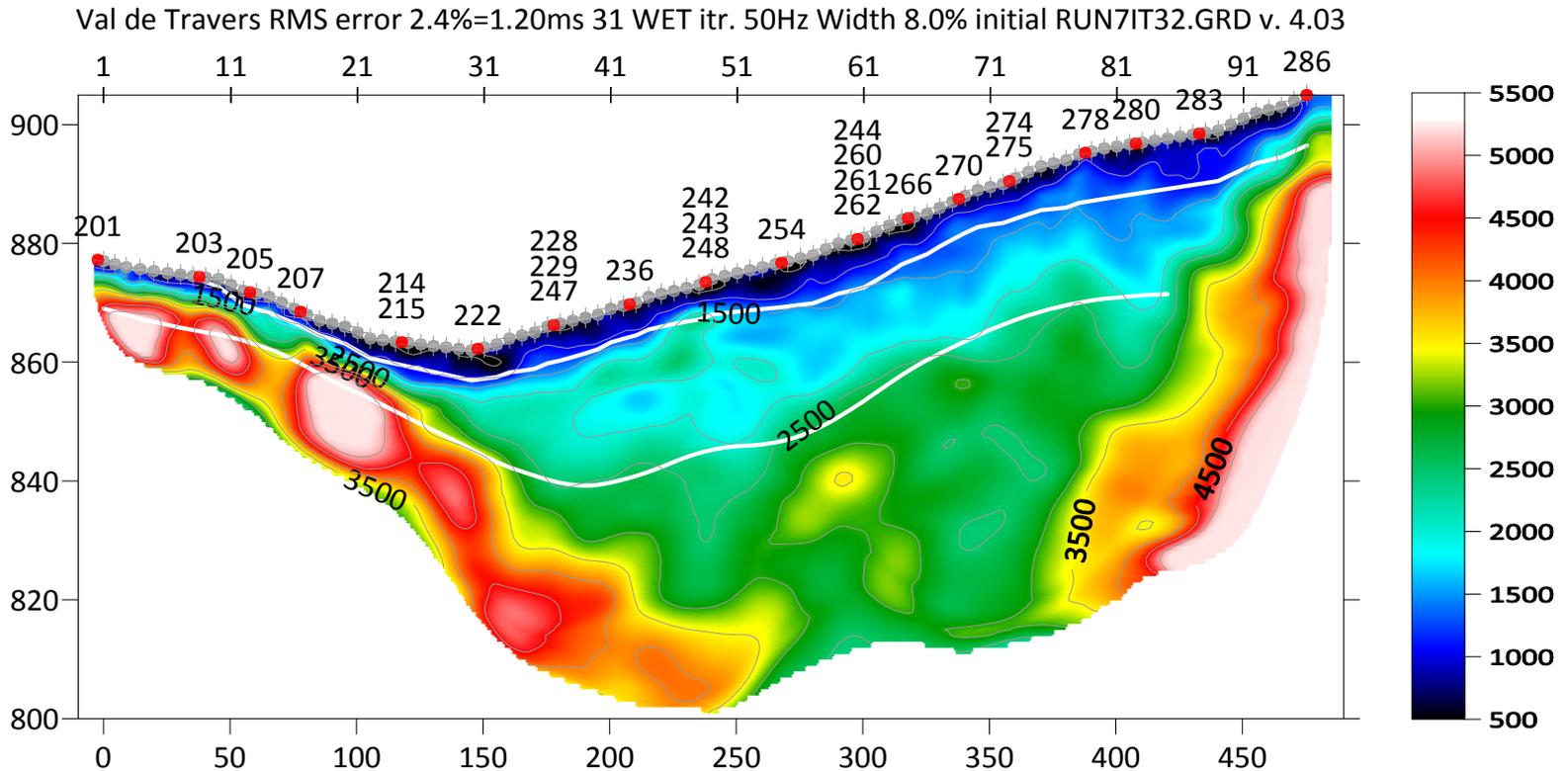


# Multirun Conjugate-Gradient WET with DeltatV starting model

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 10<sup>th</sup> 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](#)