

Palmer 2010 Syncline Model construction and forward modeling, with Rayfract® 3.25 and Golden Software Surfer® 11

We show how to define the recording geometry by importing dummy shots into a Rayfract® profile database, without first break picks. Next we create a syncline model grid with Surfer, as in [Palmer 2010 Fig. 5](#). Then we generate synthetic shots with our [Eikonal Solver](#), by forward modeling wave propagation through this model grid. Finally we run our *2D Smooth inversion* and *1.5D layer-based Wavefront refraction* methods on these synthetic data. See also <http://rayfract.com/tutorials/fig9inv.pdf>.

Create a new Rayfract® profile database, import dummy shots

Download archive PALMFIG9.ZIP containing file ONESHOT.ASC from our web site :

<http://rayfract.com/tutorials/palmfig9.zip> .

Now create new profile database named PALMFIG9, as described in our manual available at <http://rayfract.com/help/manual.pdf> . Specify *station spacing* of 5m, in *Header|Profile*. Copy above file ONESHOT.ASC into directory \RAY32\PALMFIG9\INPUT. ONESHOT.ASC specifies 49 channels, with first breaks set to -1. You may edit such a dummy .ASC shot with any text editor e.g. Windows WordPad.

Now import file ONESHOT.ASC repeatedly, once for each shot position which we want to model, as in above manual.pdf . Specify *Import data type* ASCII column format. Leave *Default spread type* at default setting 10: 360 channels. Specify *Shot pos. [station no.]* 0, 6, 12, 18, 24, 30, 36, 42, 48 as in Palmer 2010 Fig. 8. Specify *Shot Number* 1 to 9 for these shots, during import. Leave *Layout start* at 0.0 .Once done with import, set topography elevation “z” to 0.0 in *Header|Station* for one station. Hit ENTER and confirm prompt, to extrapolate elevation 0.0 to all stations.

Build model grid file with Surfer 8

Start up Surfer 8. Select *File|New* and choose *Plot Document*, then click OK. Now select *Grid|Function...* and specify the parameters for generation of our overburden grid as in Fig. 1 :

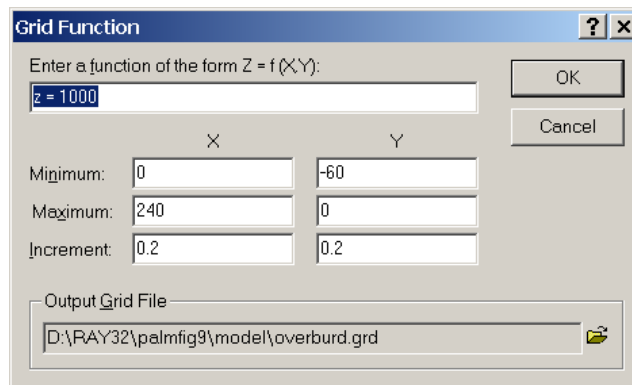


Fig. 1 : Generate overburden grid in Surfer

Click on OK to generate our constant-velocity overburden grid file. Select *Grid|Function...* again and set the “function” text field to “z = 2820”. Specify \RAY32\PALMFIG9\MODEL\BASEMENT.GRD for *Output Grid File*. Click on OK to generate the constant-velocity basement grid file.

Next we edit a *blanking file*, with any text editor. Select *Start|Run...*, enter the program name NOTEPAD.EXE and hit RETURN. Then enter content as in Fig. 2 :

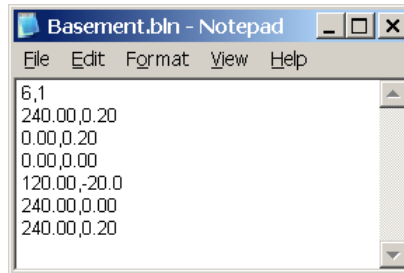


Fig. 2 : Edit basement blanking file in Notepad

Be sure to hit ENTER at end of last line 240.00, 0.20, to force an end-of-line character in the disk file. Select *File|Save As...* . Set *Save as type* to *All Files*. Set *File name* to BASEMENT.BLN. Click on *Save button*. This file is a *Golden Software Blanking File*; see your Surfer 8 manual Appendix C. Our blanking file describes the “syncline” triangular polygon which we want to cut out of above basement grid file. The lower side of the polygon is the “top of basement” topography i.e. relief.

Go back into Surfer, select *Grid|Blank...* and then the BASEMENT.GRD file as generated above. Then select our BASEMENT.BLN file. Specify \RAY32\PALMFIG9\MODEL\SYNCLINE.GRD as output file name and click on Save to generate our “basement with syncline” grid file.

Now we add our constant-velocity overburden to the syncline model. Select *Grid|Mosaic...* and then above OVERBURD.GRD file. Click on *Add...* and select above SYNCLINE.GRD file. Set *Overlap method* to *Maximum*. Click on the folder icon to the right of field *Output Grid File* and enter file name PALMFIG9.GRD. Our *Grid Mosaic dialog* should now look as in Fig. 3 :

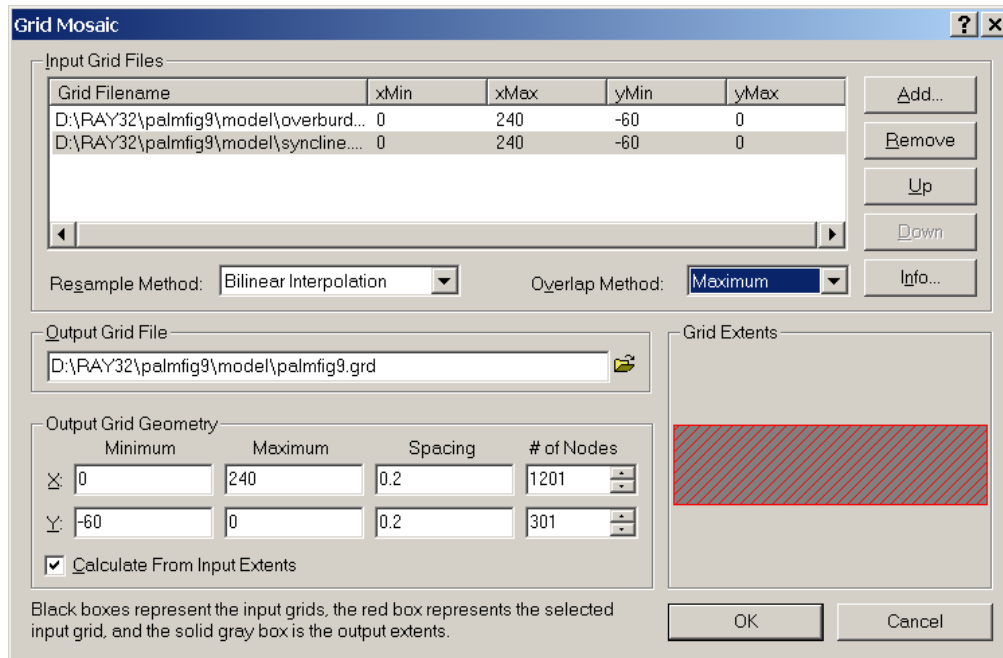


Fig. 3 : Combine overburden grid with blanked basement grid in Surfer

Click on OK to generate the final syncline model. Select *Map|Image Map...* and our PALMFIG9.GRD file. Double-click the resulting plot with left mouse key. Click on *Colors bar* in *General tab*, and load *Color scale* \RAY32\RAINBOW2.CLR. In frame *Data to Color Mapping*, set *Minimum* to 500, and *Maximum* to 5000. Adapt *Limits and Scale tabs* to obtain Fig. 4 :

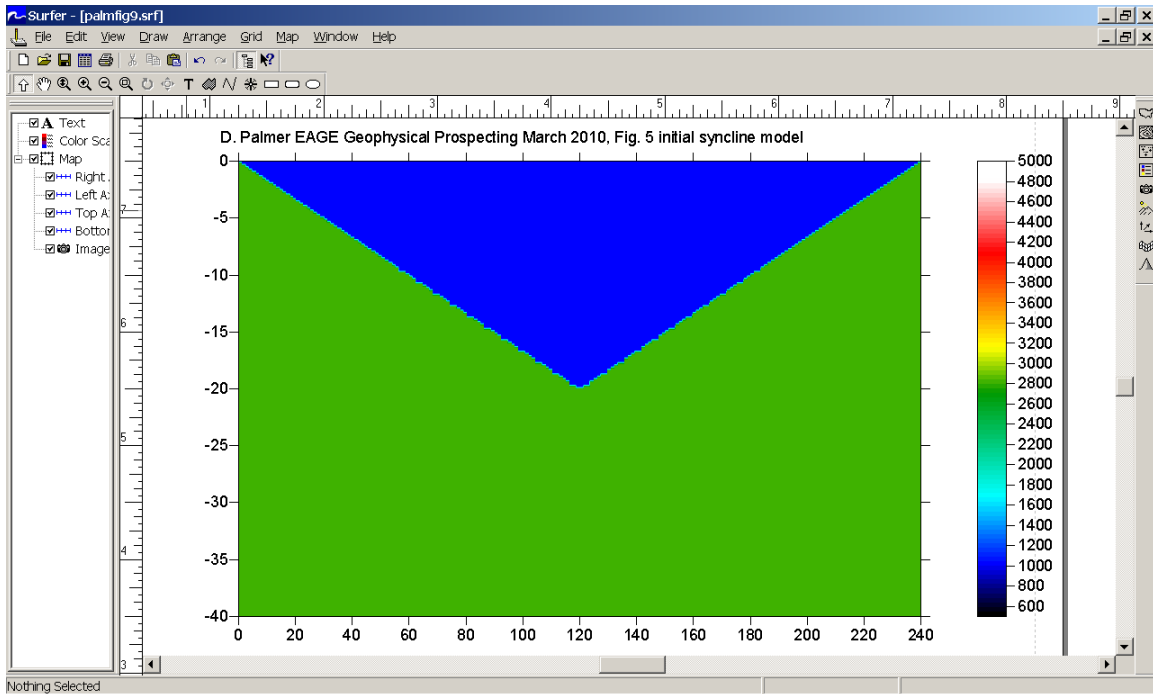


Fig. 4 : Image syncline model in Surfer

Forward model seismic body wave propagation through syncline model

Open profile database \RAY32\PALMFIG9 as created above, with Rayfract® *File|Open Profile...* Select *Model|Model synthetic shots...* and \RAY32\PALMFIG9\MODEL\PALMFIG9.GRD . Select *File|Export header data|Export First Breaks as ASCII...* . Save to file PALMFIG9.ASC. Select *Refractor|Shot breaks.* Now press ALT+P, set *Maximum time [msecs.]* to 90 and hit ENTER. Compare the traveltimes as shown in our Fig. 5 to Palmer 2010 Fig. 8; these data are identical.

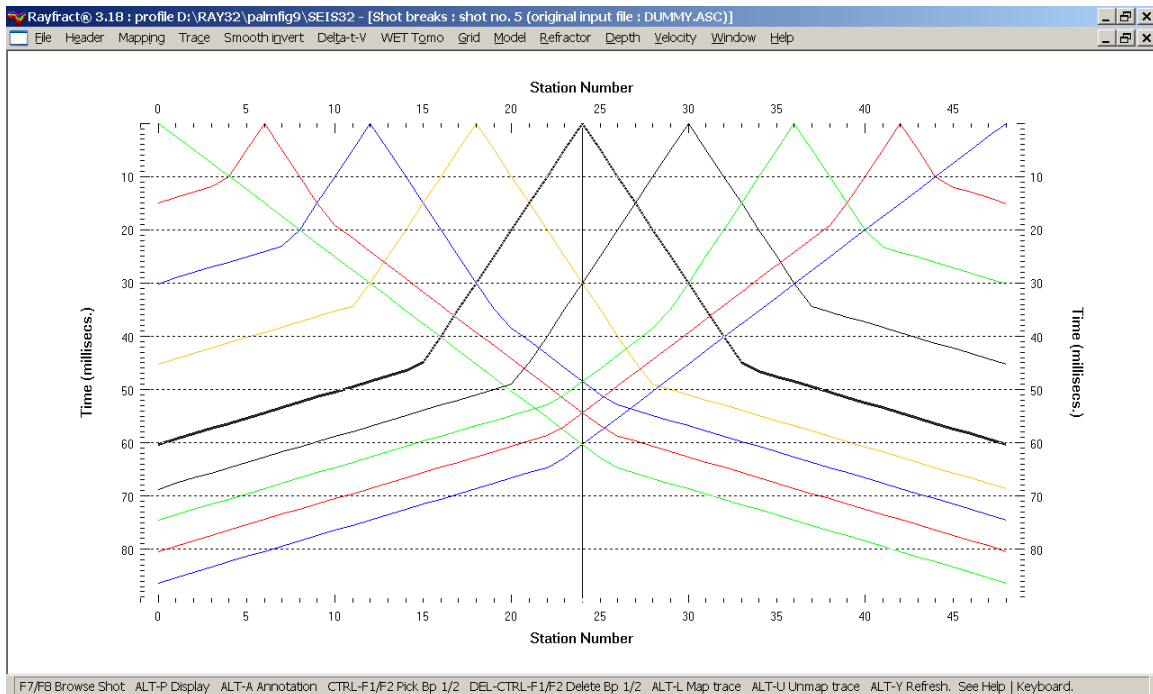
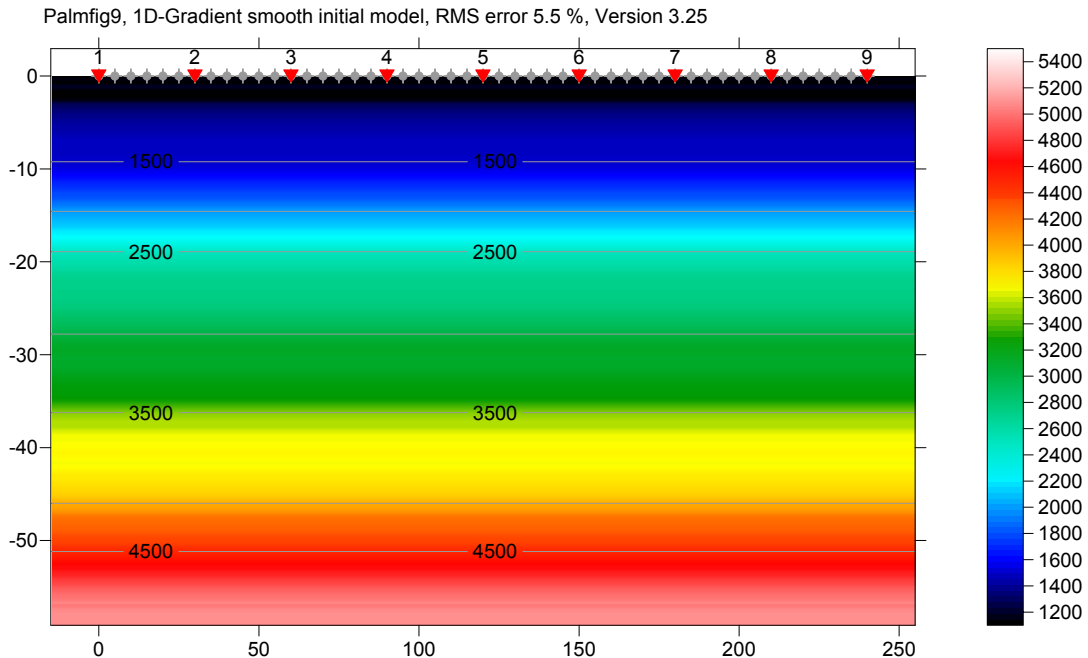


Fig. 5 : Refractor|Shot breaks, showing shot-sorted traveltimes curves

Next we show *Smooth inversion* of above synthetic first break data, shown in Fig. 5 :

- uncheck *WET Tomo|WET tomography Settings|Scale wavepath width*
- uncheck *WET Tomo|WET tomography Settings|Scale filter height*
- select *Smooth invert|WET with 1D-gradient initial model*, confirm prompts to obtain Fig. 6
- when you see the prompt “Continue with WET tomography ?” click *No button*
- select *WET Tomo|Interactive WET tomography...*
- click *Select button* and select `\RAY32\PALMFIG9\GRADTOMO\GRADIENT.GRD`
- click *button Accept parameters*
- set *Number of WET tomography iterations* to 100, and set *Wavepath width* to 10%
- set *Maximum valid velocity* to 3,000 m/s, and uncheck *or RMS error does not improve for n =*
- click *button Edit grid file generation*. Set *Store each nth iteration only : n =* to 20
- click buttons *Accept parameters* and *Start tomography processing* for Fig. 7 and 8



To obtain layer-based interpretation with our *Wavefront refraction* method :

- select *Refractor|Midpoint breaks*, press CTRL+F1 to zoom dip of *CMP traveltime curves*
- press ALT+M, edit fields as in Fig. 10, hit ENTER to map traces to refractors
- press ALT+G, hit ENTER to smooth *crossover distances*
- select *Depth|Wavefront*, press ALT+M, set *Base filter width* to 5 (Fig. 11), hit ENTER
- select *Velocity|Wavefront* and *Window|Tile* to obtain Fig. 9

To plot the basement refractor obtained in Fig. 9 on the 2D WET tomogram shown in Fig. 7 :

- click on *Window Wavefront Depth Section* (center) in Fig. 9
- select *File|Export header data|Export ASCII model of depth section...*
- click *Save button* to generate file WAVEMODL.CSV with refractor depths and velocities
- check *Grid|Plot refractors on tomogram*
- select *Grid|Select ASCII .CSV layer model for refractor plotting...* and your WAVEMODL.CSV
- select *Grid|Image and contour velocity and coverage grids...*
- select tomogram grid `\RAY32\STEP\GRADTOMO\VELOIT100.GRD` for Fig. 7

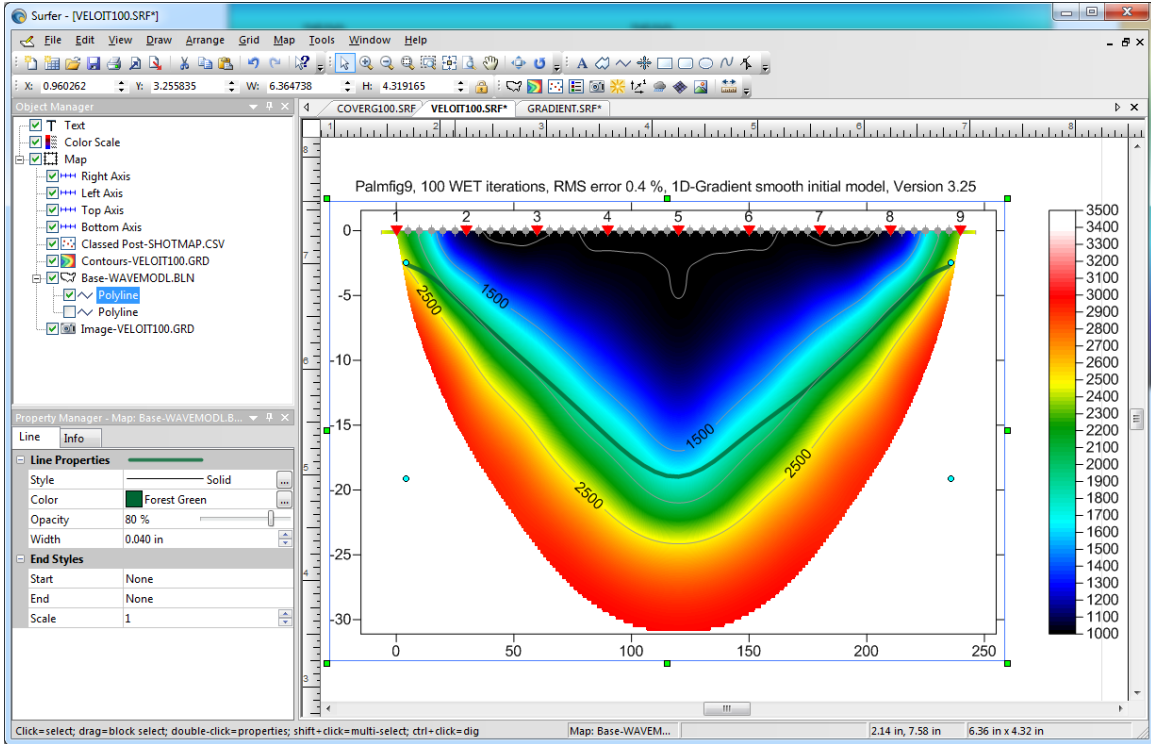


Fig. 7 : 2D WET tomogram obtained with Smooth inversion, 100 WET iterations, wavepath width 10%, maximum WET velocity limited to 3,000 m/s. No scaling of WET wavepath width and filter height. Basement refractor obtained with Wavefront refraction method (Fig. 9) is plotted as green line.

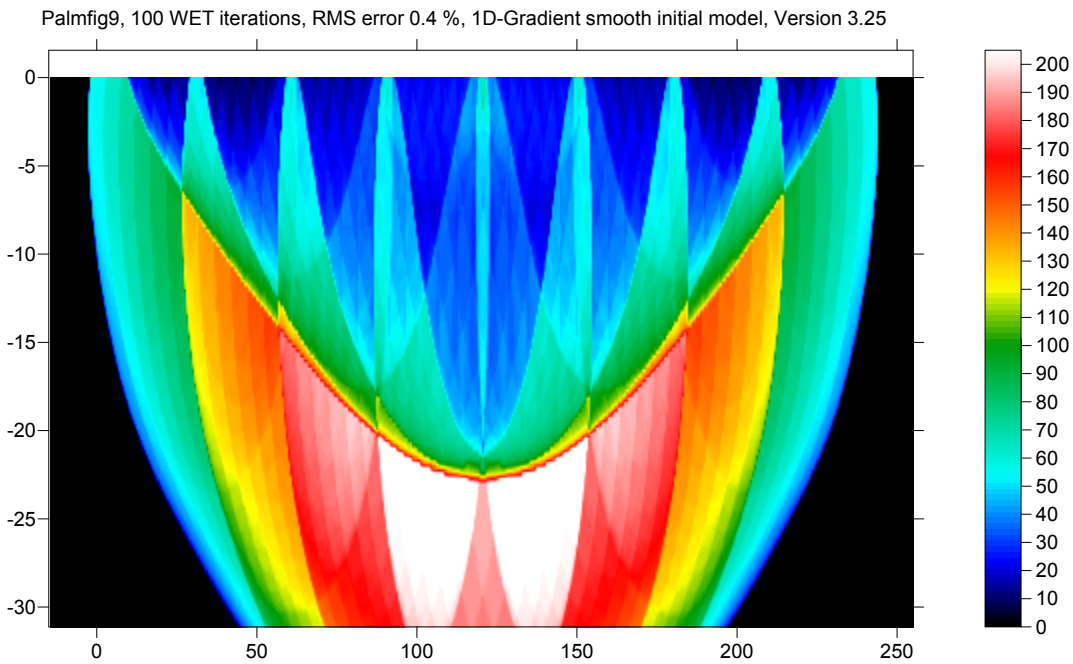


Fig. 8 : Wavepath coverage plot obtained with Fig. 7

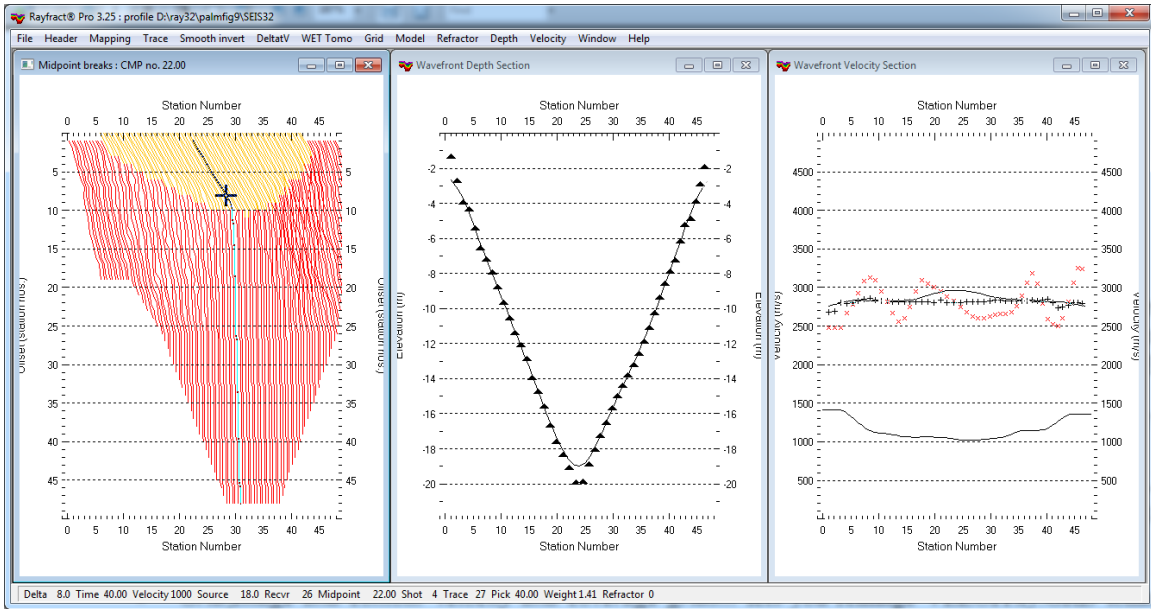


Fig. 9 : left : Refractor|Midpoint breaks, center : Depth|Wavefront, right : Velocity|Wavefront

Trace to refractor mapping parameters

Processing Options

Direct wave first breaks recorded

Velocity Determination Parameters

Refractor Count [1 or 2]

CMP Stack Width [CMPs]

Regression Receiver Count

Direct Wave Delta [stations]

Refracted Wave Offset Delta

Specify Upper Layer Velocity Limits [m/sec.]

Weathering	Refractor 1	Refractor 2
<input type="text" value="1200"/>	<input type="text" value="2500"/>	<input type="text" value="7000"/>

Median Layer Velocities Detected [m/sec.]

Weathering	Refractor 1	Refractor 2
<input type="text" value="1000"/>	<input type="text" value="1368"/>	<input type="text" value="0"/>

Shot & Recvr spacing [stations], CMPs/Recvr

<input type="text" value="6.0"/>	<input type="text" value="1.0"/>	<input type="text" value="2.0"/>
----------------------------------	----------------------------------	----------------------------------

Fig. 10 : Trace to refractor mapping

Wavefront Model Parameters

Regression parameters

Recompute traveltimes characteristics

Prefer CMP overburden refractor mapping

Prefer regressed traveltimes

Regression tolerance [msec.]

Smoothing parameters

Overburden filter [station nos.]

Base filter width [station nos.]

Surface consistency [0..100]

Fig. 11 : Wavefront parameters

For an explanation of *Refractor|Midpoint breaks* display of CMP sorted traveltime curves (Fig. 9 left) see our [DeltatV paper](#), Fig. 2. The steeper the local dip of a CMP sorted traveltime curve, the higher the local apparent velocity.

Obviously the layer-based *Wavefront refraction* method interpretation (Fig. 9) works better in this simple case. But as shown by [Sheehan et al.](#) in 2005, *Smooth inversion* including 2D WET inversion (Fig. 7) often works better than layer-based interpretation, in case of [strong lateral velocity variation](#), gradual increase of velocity with depth, laterally discontinuous layers, pinch outs, outcrops, [fault zones](#), [low-velocity layers](#) etc. Also, WET inversion does not depend on your always **subjective and non-unique mapping of traces to refractors**.

Also see our [earlier tutorial](#) showing the effect of limiting the maximum velocity for synthetic syncline traveltime data, when determining the starting model with [DeltatV inversion](#).