Smooth inversion of Mt. Bulga data, with Rayfract® free trial version 3.22 :

Download our free trial and install it under Windows XP/Windows 2000/Windows Vista or Windows 7.

Start up Rayfract® trial 3.22 via desktop icon. Select *File|New Profile…* . Set *File name* to `BULGATRL` and click *Save button*. Specify *Station spacing* of 5 m in *Header|Profile* (Fig. 1).

Unzip archive mtbulga.zip in directory \RAY32\BULGATRL\INPUT.

Select *File|Import Data…* (Fig. 2) and specify *Import data type* `Interpex GREMIX .GRM`. Click *button Select* and select file MTBULGA.GRM in \RAY32\BULGATRL\INPUT.

Click *button Import shots*. Click *button Read* 9 times to import all 9 shots specified in MTBULGA.GRM. Do not edit any header fields.

Select *Refractor|Shot breaks*. Press ALT+P. Set *Maximum time* to 150 msecs. Hit ENTER key to redisplay traveltime curves. Select *Mapping|Color picked traveltime curves*. Browse curves with F7/F8 (Fig. 4).

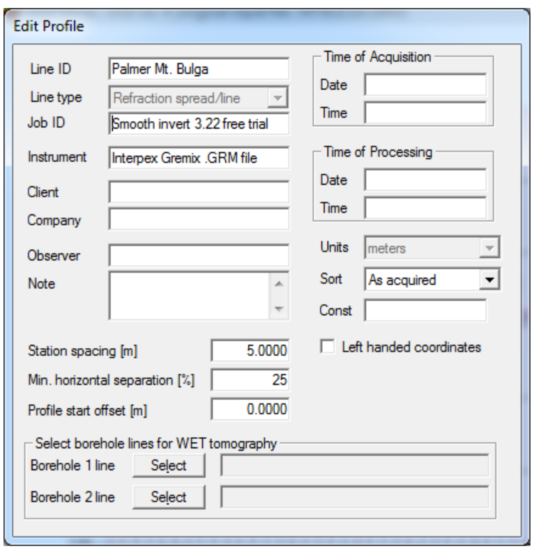

Fig. 1 : *Header|Profile*, edit profile header data

To invert the synthetic traveltime data with our *Smooth inversion* method :

- check *Smooth invert|Smooth inversion Settings|Wide smoothing filter for 1D initial velocity profile*
- run *Smooth invert|WET with 1D-gradient initial model*
- read *Shot point spacing is too wide warning prompt* (Fig. 3), recommending to position a shot at every 6th receiver instead of every 12th . Click *Yes button* to continue with Smooth inversion.
- confirm prompts to obtain Fig. 5, 6 and 7.

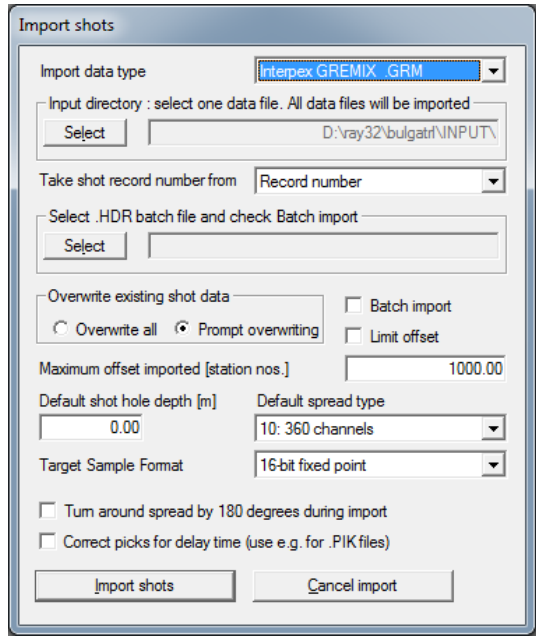

Fig. 2 : *File|Import Data…* dialog

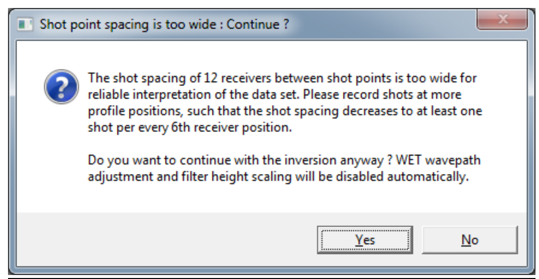

Fig. 3 : *Shot point spacing is too wide* warning prompt. Continue at your own risk.

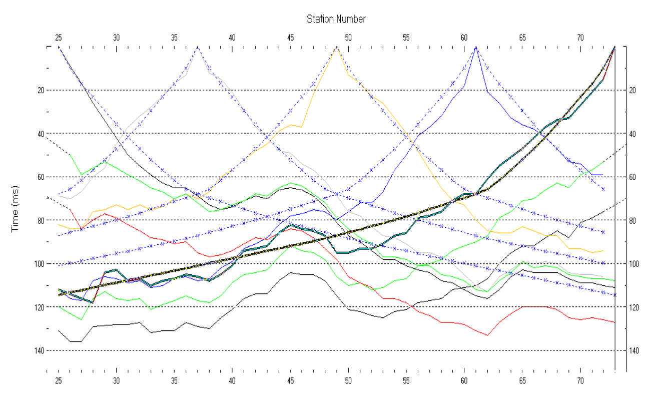

Fig. 4 : *Refractor|Shot breaks* display. Browse traveltime curves with F7/F8. Solid colored curves are picked times, dashed blue curves are modeled times, for starting model shown in Fig. 5 . RMS error is 7.1%.

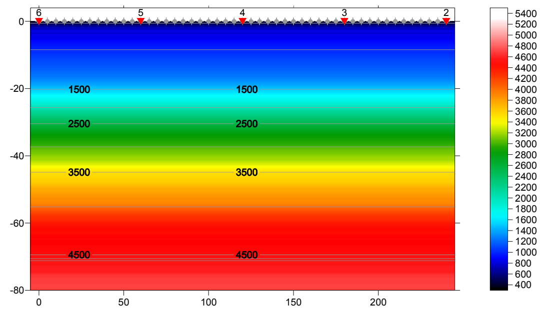

Fig. 5 : 1D starting model obtained with Smooth inversion, with default settings. RMS error is 7.1%. Horizontal/vertical axis in meters, color coding shows velocity in m/s.

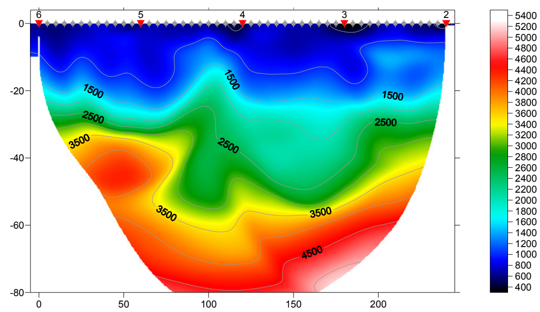

Fig. 6 : Velocity tomogram with Smooth inversion, 20 WET iterations, default settings, wavepath width 5.5%. RMS error is 2%. Starting model is Fig. 5.

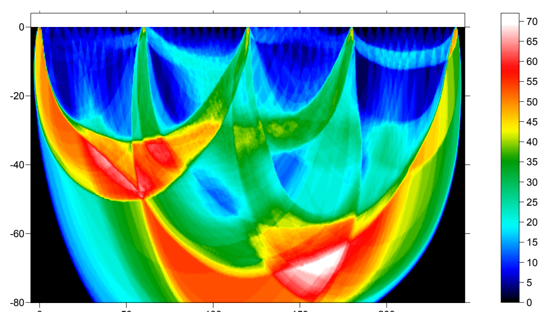

Fig. 7 : WET wavepath coverage obtained with Fig. 6. Color coding shows number of wavepaths per pixel / coverage of subsurface with first break energy.

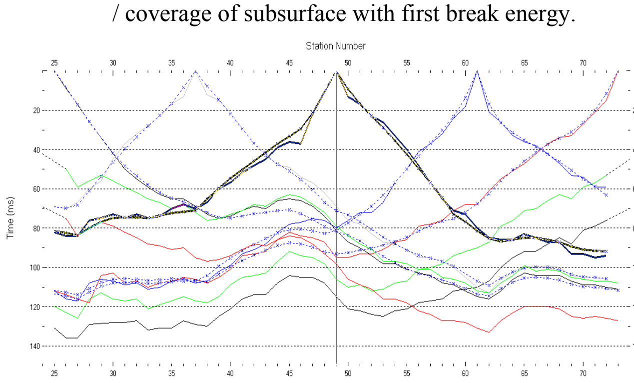

Fig. 8 : *Refractor|Shot breaks*, fit between picked (colored solid curves) and modeled (dashed blue curves) after 20 WET iterations. RMS error is 2%.

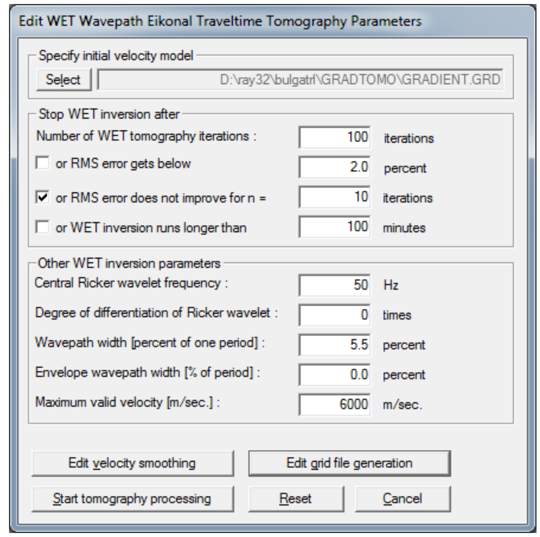

Fig. 9 : *WET Tomo|Interactive WET tomography…*

The following steps are not possible with the trial :

- select *WET Tomo|Interactive WET tomography*
- make sure *initial velocity model* is set to `\RAY32\BULGATRL\GRADTOMO\GRADIENT.GRD`
- change *Number of WET tomography iterations* from default 20 to new 100 (Fig. 9)
- edit other settings in *Stop WET inversion after frame* as shown in Fig. 9
- click *Edit grid file generation button*, and change *Store each nth iteration only* to 20
- click buttons *Accept parameters* and *Start tomography processing*. Obtain Fig. 10 and 11.

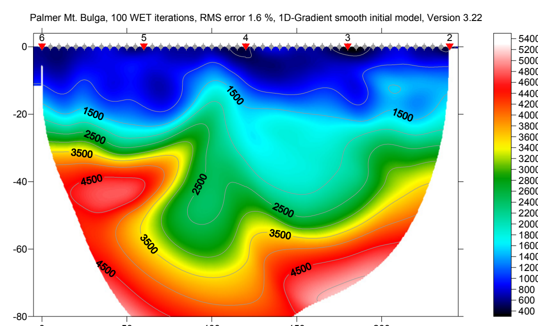

Fig. 10 : 100 WET iterations, wavepath width 5.5%. RMS error is 1.6%, starting model is Fig. 5.

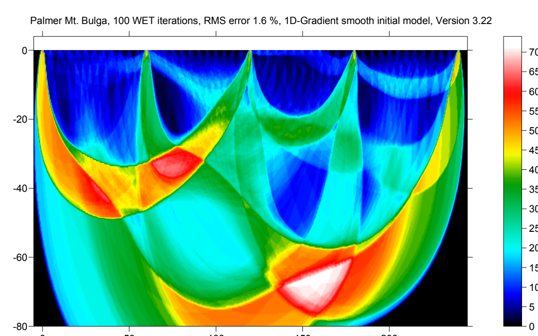

Fig. 11 : WET wavepath coverage shown with Fig. 10.

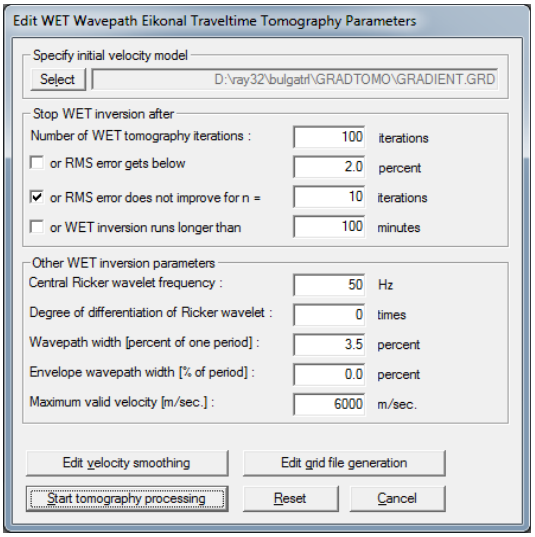

Fig. 12 : *WET Tomo|Interactive WET tomography…* , decrease *wavepath width* from default 5.5% to 3.5%

Next we decrease WET wavepath width (Fig 12) :

- select *WET Tomo|Interactive WET tomography*
- change *Wavepath width* from default 5.5% to new 3.5%
- click buttons *Accept parameters* and *Start tomography processing*. Obtain Fig. 13 and 14.

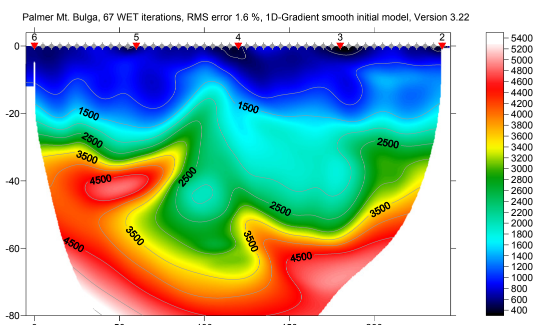

Fig. 13 : 67 WET iterations, wavepath width 3.5%. RMS error is 1.6%, starting model is Fig. 5.

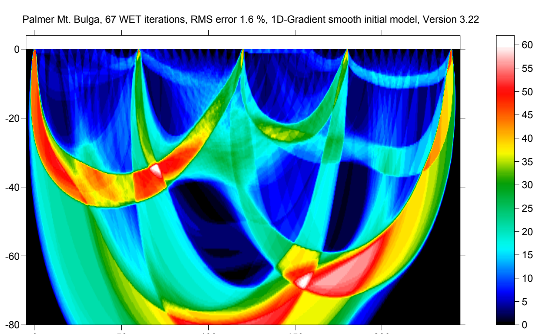

Fig. 14 : WET wavepath coverage shown with Fig. 13.

Next we increase WET wavepath width (Fig 15) :

- select *WET Tomo|Interactive WET tomography*

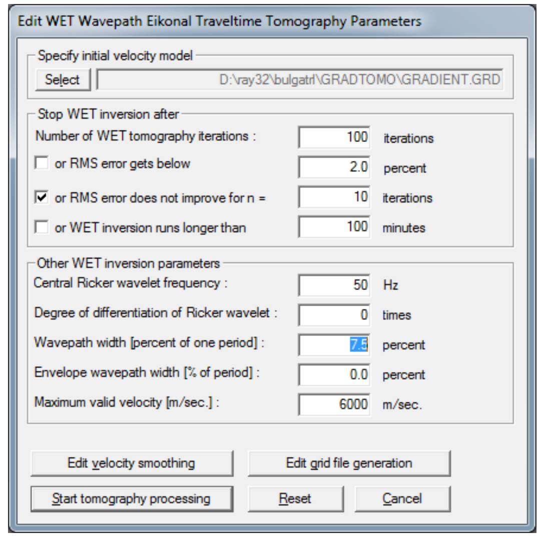

Fig. 15 : *WET Tomo|Interactive WET tomography…* , increase *wavepath width* from default 5.5% to 7.5%

- change *Wavepath width* from 3.5% to new 7.5%
- click buttons *Accept parameters* and *Start tomography processing*. Obtain Fig. 16 and 17.

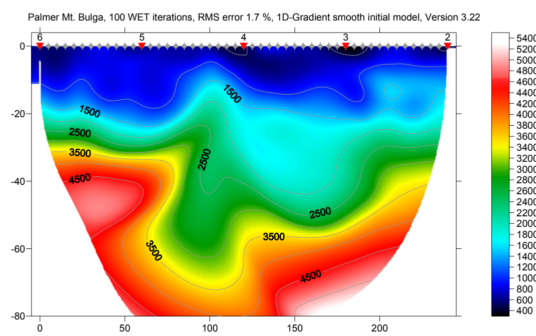

Fig. 16 : 100 WET iterations, wavepath width 7.5%. RMS error is 1.7%, starting model is Fig. 5.

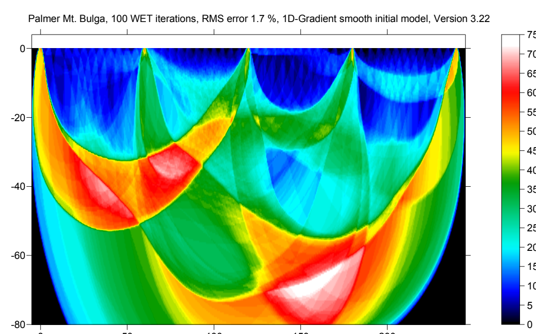

Fig. 17 : WET wavepath coverage shown with Fig. 16.

Next increase WET wavepath width to 15% (Fig. 18) :

- select *WET Tomo|Interactive WET tomography*
- change *Wavepath width* from 7.5% to new 15%
- click buttons *Accept parameters* and *Start tomography processing*. Obtain Fig. 19 and 20.

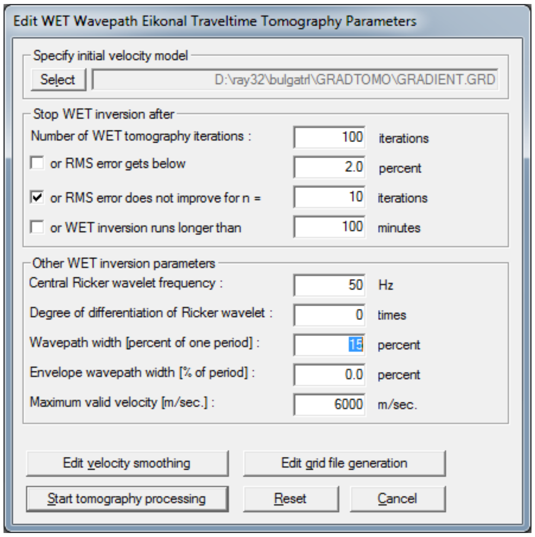

Fig. 18 : *WET Tomo|Interactive WET tomography…* , increase *wavepath width* from default 5.5% to 15%

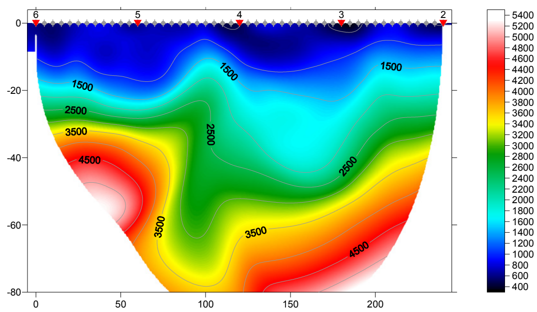

Fig. 19 : 100 WET iterations, wavepath width 15%. RMS error is 2%, starting model is Fig. 5.

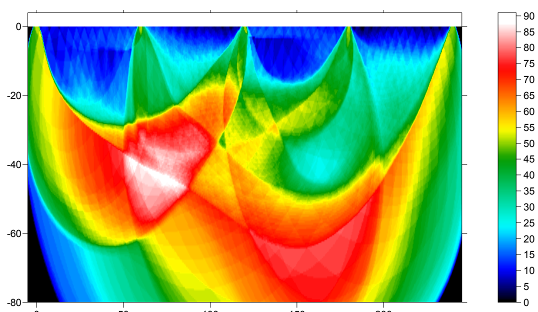

Fig. 20 : WET wavepath coverage shown with Fig. 19.

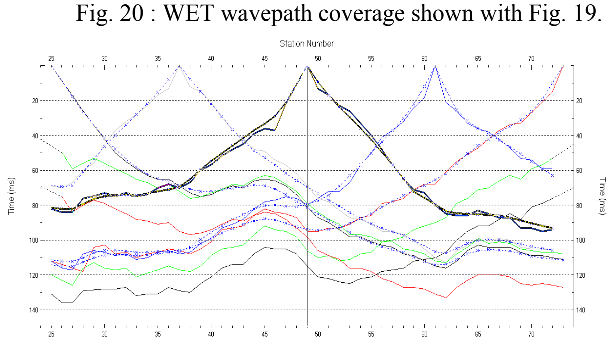

Fig. 21 : *Refractor|Shot breaks*, misfit after 100 WET iterations, wavepath width 15%. Compare Fig. 8.

Next we show WET output with same settings as in Fig. 18 and starting model Fig. 5, but with WET wavepath width increased to 30%, 50% and 100%.

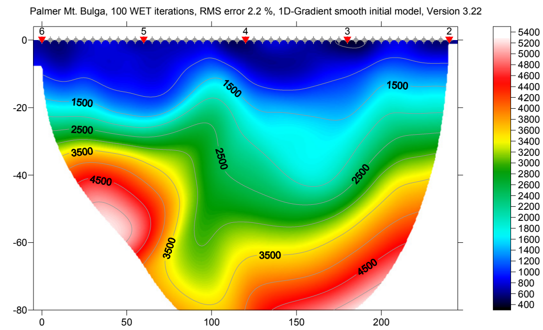

Fig. 22 : 100 WET iterations, wavepath width 30%. RMS error is 2.2%, starting model is Fig. 5.

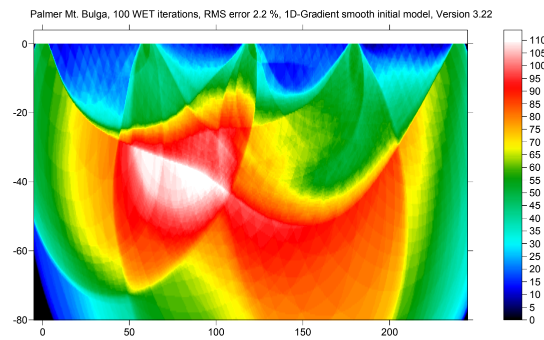

Fig. 23 : WET wavepath coverage shown with Fig. 22.

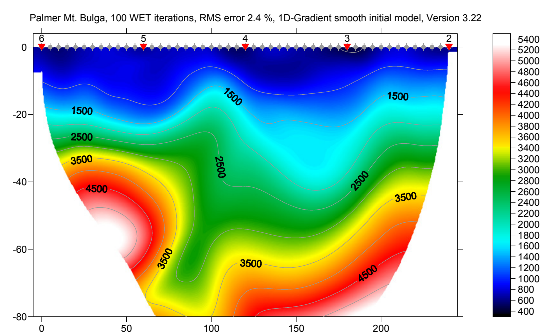

Fig. 24 : 100 WET iterations, wavepath width 50%. RMS error is 2.4%, starting model is Fig. 5.

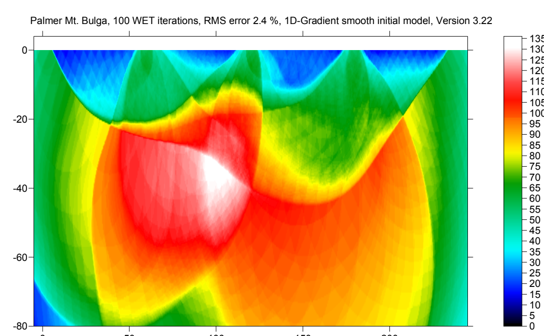

Fig. 25 : WET wavepath coverage shown with Fig. 24.

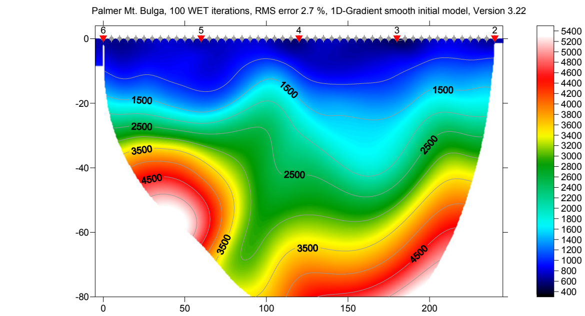

Fig. 26 : 100 WET iterations, wavepath width 100%. RMS error is 2.7%, starting model is Fig. 5.

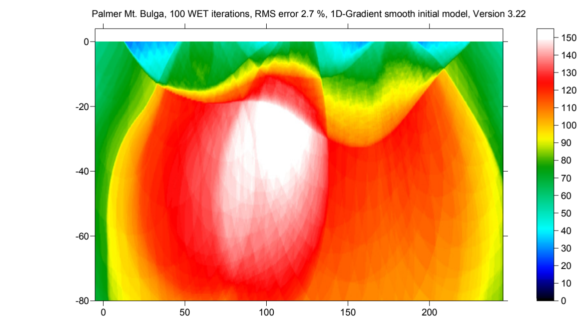

Fig. 27 : WET wavepath coverage shown with Fig. 26.

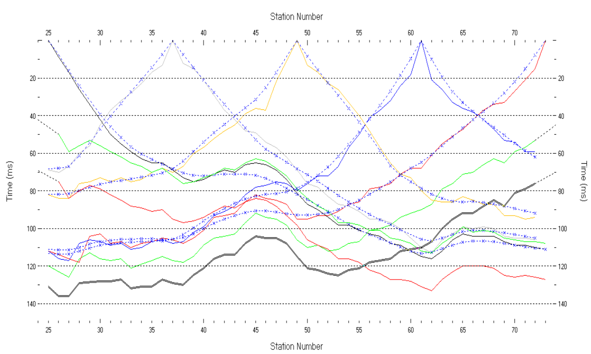

Fig. 28 : *Refractor|Shot breaks*, misfit after 100 WET iterations, wavepath width 100%. Compare Fig. 21.

We have shown how to explore the non-uniqueness of the model space, by varying WET wavepath width. Wider wavepath width results in less imaging artefacts, and smoother tomograms. This also decreases risk of unstable inversion and over-fitting to noisy or inconsistent (reciprocity, 2D assumption) traveltime data with bad picks.

The sub-vertical low-velocity fault zone remains visible throughout above tomogram series, while increasing wavepath width up to maximum possible value of 100%. So this fault zone is most certainly not an artefact of the processing, and is required to explain the traveltime data, even under minimum-structure assumption.

See our earlier interpretation mtbulga.pdf , showing layer-based Wavefront method and Smooth inversion with 999 iterations, using default wavepath width 5.5%. 100 iterations should be enough.

Run WET with 100 iterations and wide *wavepath width* of 50%. Then select tomogram grid \RAY32\BULGATRL\GRADTOMO\VELOIT100.GRD as starting model in Fig. 18, with *Select button*. Set *wavepath width* to smaller value e.g. 10% and do another 100 WET iterations. This gives a good image at bottom of tomogram due to wide wavepath width during 1st WET run, and also a good traveltime fit at near-offset channels due to more narrow width during 2nd WET run.

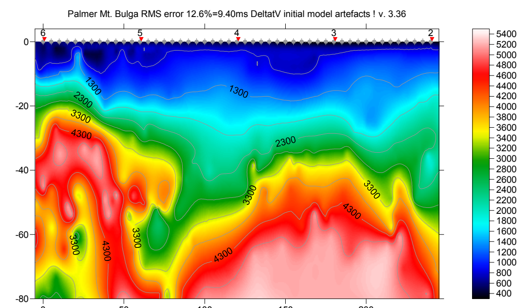

Fig. 29 : DeltatV starting model. CMP stack width 30, Regression over offset stations 6, Inverse CMP offset power 0.1, Smooth CMP curves.

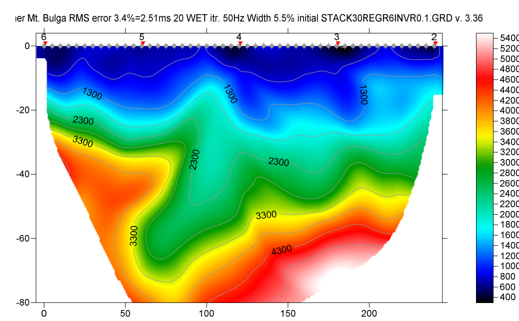

Fig. 30 : Automatic WET inversion with Fig. 29 DeltatV starting model. Wavepath width 5.5%. Wavepath frequency 50Hz. 20 WET iterations.

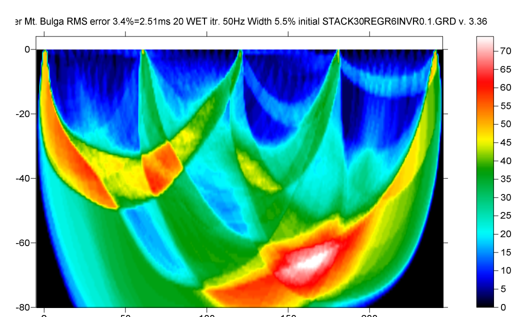

Fig. 31 : WET wavepath coverage obtained with Fig. 30. Unit is wavepaths per pixel.

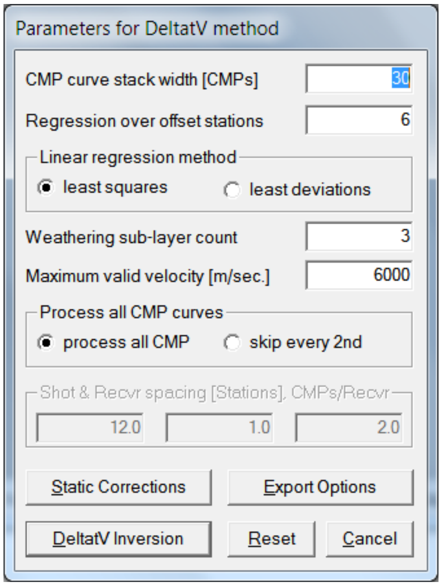

Fig. 32 : DeltatV|Interactive DeltatV settings used to obtain Fig. 29.

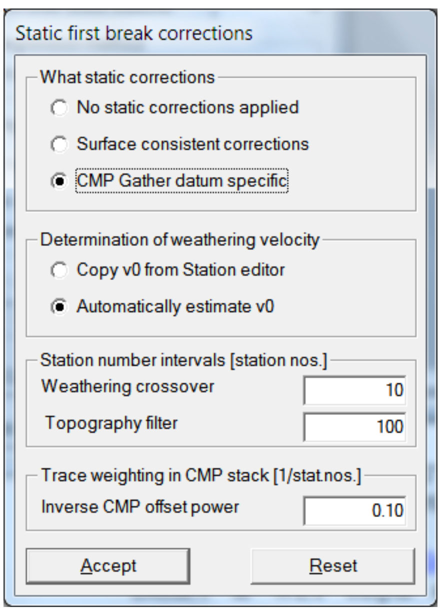

Fig. 33 : Interactive DeltatV|Static Corrections settings used to obtain Fig. 29.

In Fig. 29 we show DeltatV starting model obtained with *DeltatV|Interactive DeltatV* settings as shown in Fig. 32. & Fig. 33.

In Fig. 30 we show *WET Tomo|Automatic WET tomography* with Fig. 29 starting model.

Here are the SEIS32.* profile database files for Fig. 29&30. Here is DeltatV & WET output shown in Fig. 29&30 including .GRD & .PAR & Surfer 11 .SRF files.

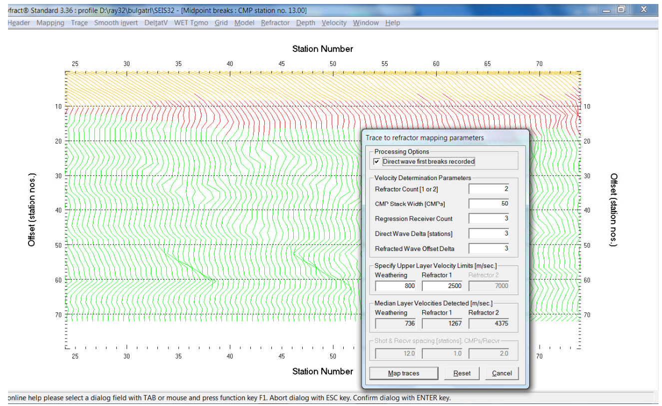

Fig. 34 : map traces to refractors with ALT+M in Refractor|Midpoint breaks. Next press ALT+G & click Accept button to smooth Crossover distances.

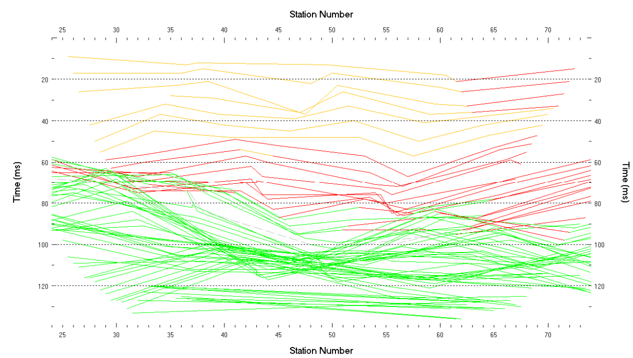

Fig. 35 : Refractor|Offset breaks display showing raw traveltime data sorted by Common Offset before running any inversion. Shows fault zone dipping to left imaged in Fig. 29&30. Traces mapped to refractors in Refractor|Midpoint breaks (Fig. 34).

In Fig. 34 and Fig. 35 we show how to visualize dipping fault zones in plots of raw traveltime data sorted by Common Mid-Point (CMP; Fig. 34) and Common Offset (Fig. 35).

In Fig. 34 fault zones show in green basement refractor as propagating "wavelet" zones.

In Fig. 35 fault zones show via propagating dip in traveltime curves sorted by common offset.

For inversion of synthetic traveltime data sets generated for known models, see tutorials thrust12, thrust, jenny10, epikinv, broadepi, fig9inv , SAGEEP11.pdf and SAGEEP11_16.pdf .

For more information on and instructions regarding our Smooth inversion method, see our short course notes SAGEEP10.pdf and our .pdf reference.

The best method to mitigate non-uniqueness of traveltime data interpretation is to **space shot points closely enough, at every 3rd receiver**. See SAGEEP10.pdf slide **Survey Design Requirements and Suggestions** on page 19 of 61**.** Also **pick traveltimes physically consistently**, regarding the reciprocity principle, to control non-uniqueness.

Our modeling in thrust and thrust12 tutorials shows that Smooth inversion and DeltatV inversion can detect dipping fault zones if these zones are wide enough. For an objective comparison of tomographic refraction analysis methods see Zelt et al. 2013 (JEEG, September 2013, Volume 18, Issue 3, pp. 183–194).

Copyright© 1996-2020 Intelligent Resources Inc. All rights reserved.