Import DMT SUMMIT .SEG2 & WET inversion for granitic basement imaging, version 4.02 :

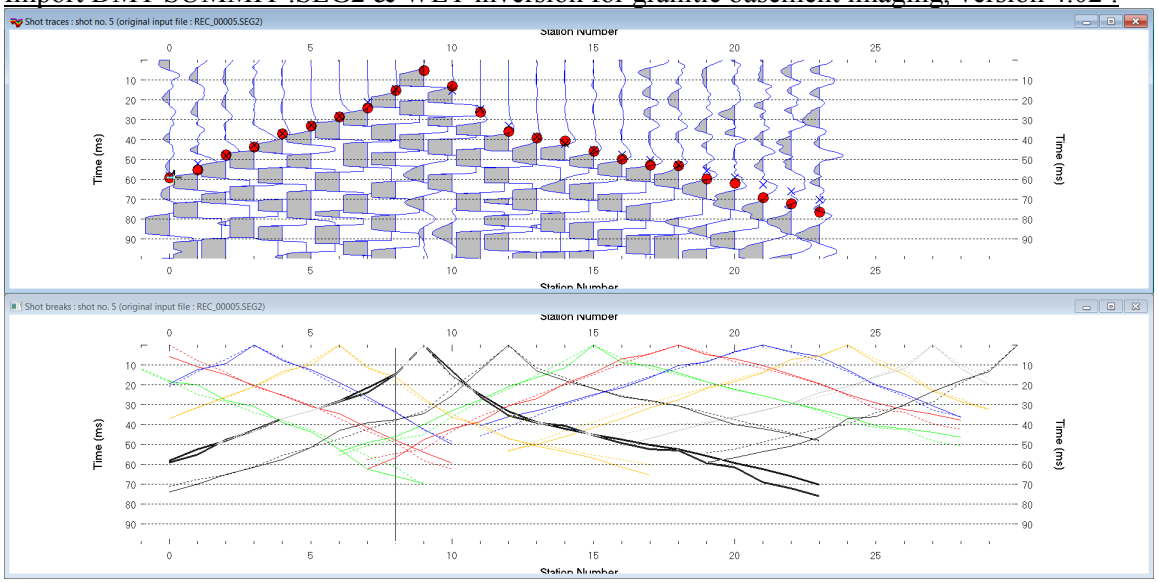


Fig. 1 : top : *Trace*|*Shot gather*, bottom : *Refractor*|*Shot breaks*. Shows fit between picked times (solid colored curves, red circles) and modeled times (dashed colored curves, blue crosses) obtained for Smooth invert output (Fig. 8)

To create the profile database, import the data and browse the imported shots do these steps :

- ***File*|*New Profile***..., set *File name* to **`Test21`** and click *Save button*
- in the prompt (Fig. 23) click ***No*** button to leave ***Profile start*** and first receiver at station no. 0.
- in ***Header*|*Profile***... set *Line type* to **`Refraction spread/line`** . Set *Station spacing* to 5.0 m.
- check *box Force grid cell size* and set *Cell size[m]* to 0.5m. See Fig. 2. With free trial check option ***Smooth invert*|*Smooth inversion Settings*|*Extra-large cell size*** instead.
- unzip archive **`Test21.zip`** with **`SEG-2 .SEG2`** shot files **`&`** first breaks file **`BREAKS.LST`** in directory **`C:\RAY32\TEST21\INPUT`**
- select ***File*|*SEG-2 import settings* |*Receiver Coordinates specified in SEG-2 trace headers***
- select ***File*|*SEG-2 import settings*|*Ignore SEG-2 station numbers in trace headers***
- select ***File*|*Import Data***... and set *Import data type* to **`SEG-2`**. See Fig. 3.
- click *Select button* and navigate into **`C:\RAY32\TEST21\INPUT`**
- set *Files of type* to **`DMT (*.SEG2)`**. Select any file e.g. **`Rec_00001.seg2`** & click button *Open* (Fig. 22).
- leave *Default spread type* at **`10: 360 channels`**
- click ***Import shots button*** . Click ***Read button*** for each shot displayed.
- select *File*|*Update header data*|*Update First Breaks*. Select file **`BREAKS.LST`** & click *Open button*
- select *Trace*|*Shot gather* and select *Window*|*Tile horizontal* to obtain Fig. 1
- click on title bar of *Trace*|*Shot gather* window and press F1 to zoom time axis (Fig. 1 top)
- click on title bar of *Trace*|*Shot gather* window and press CTRL+F1 to zoom trace amplitude
- browse shots in *Trace*|*Shot gather* window with F7/F8 (Fig. 1 top)
- click on title bar of *Refractor*|*Shot breaks* window (Fig. 1 bottom) and press ALT+P. Edit *Maximum time* to 100 ms & hit ENTER key to redisplay. Do the same for *Trace*|*Shot gather* window (Fig. 1 top).

To configure and run *Smooth inversion* :

- select *Grid*|*Surfer plot Limits*. Edit fields as in Fig. 4. Click *OK button*.
- check *Grid*|*GS CENTERED font for receivers* to work around Surfer 11 issues with receiver display
- check *Grid*|*Receiver station ticks on top axis* to show stations on top and inline offset (m) at bottom
- uncheck *WET Tomo*|*WET tomography Settings*|*Blank below envelope after last iteration*
- select ***Model*|*WDVS Smoothing.*** Edit dialog as in Fig. 16. Click radio button ***discard WET smoothing***.

- select ***Smooth invert|WET with 1D-gradient initial model***
- wait for the 1D-gradient starting model to display as in Fig. 6
- confirm prompt to continue with WET inversion to obtain WET output shown in Fig. 7

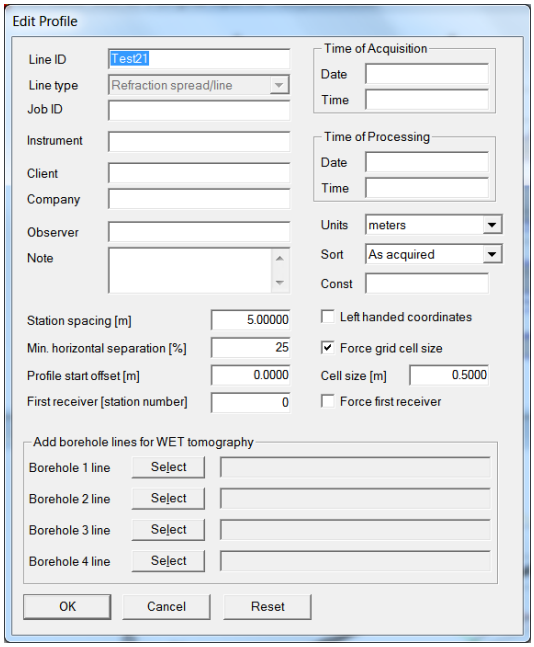


Fig. 2 : *Header|Profile*

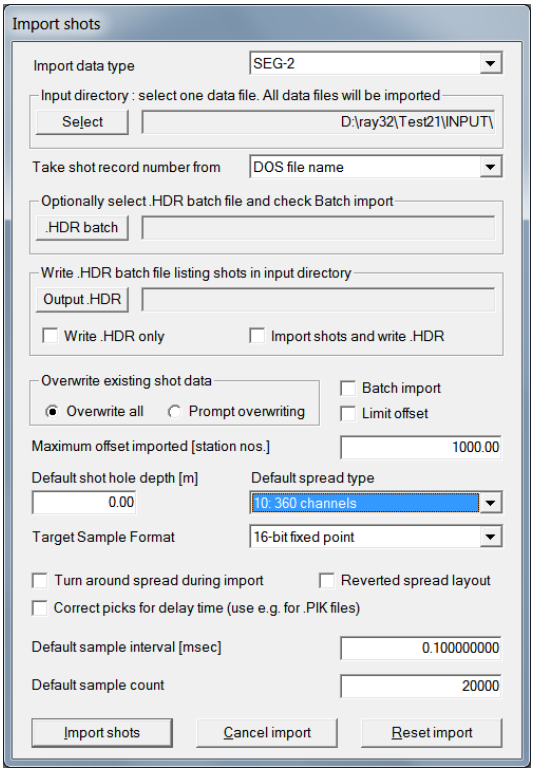
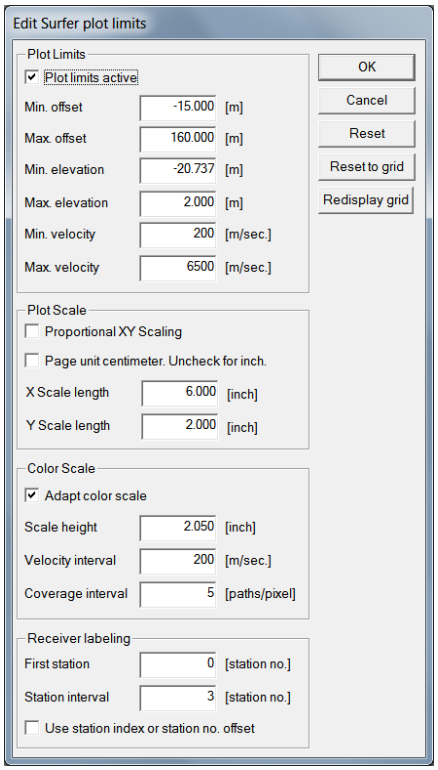


Fig. 3 : *File|Import Data*



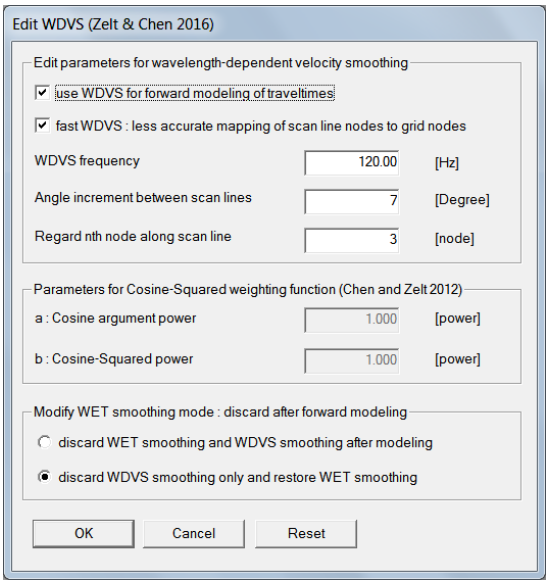


Fig. 5 : *Model|WDVS Smoothing* for Fig. 9 and 10. Check radio button ***discard WDVS smoothing only*** .

Fig. 4 : *Grid|Surfer plot Limits*

To display the 1D-gradient starting model in Fig. 6 using plot limits edit in Fig. 4 :

- select ***Grid|Image and contour velocity and coverage grids***
- navigate into directory **`C:\RAY32\TEST21\GRADTOMO`**
- select file **`GRADIENT.GRD`**

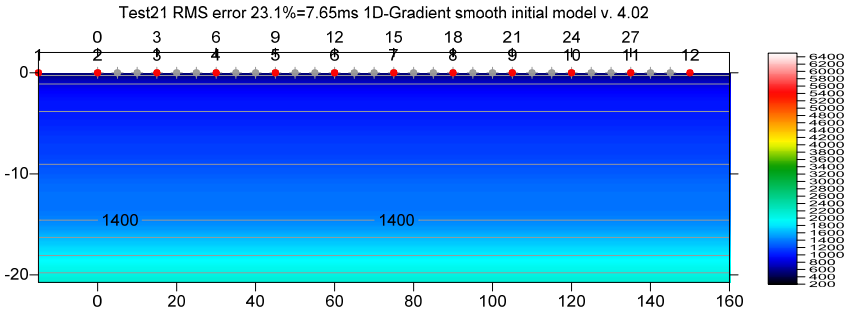


Fig. 6 : 1D-gradient starting model obtained with *Smooth invert|WET with 1D-gradient initial model*

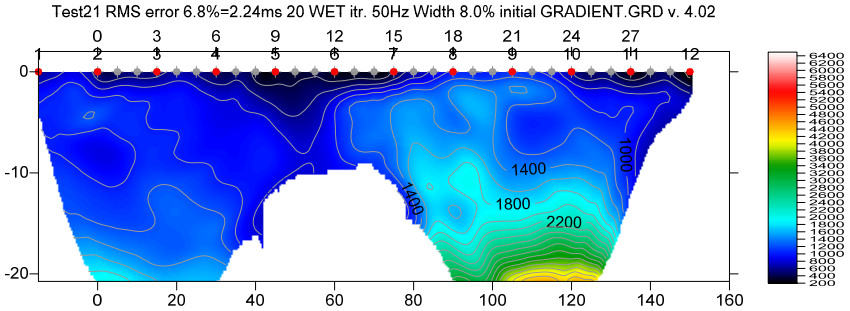


Fig. 7 : *Smooth invert|WET with 1D-gradient initial model* & starting model shown in Fig. 6. 20 WET iterations@50Hz using Steepest Descent method & Gaussian update weighting & full WET smoothing. WDVS@120Hz as in Fig. 16. Discard WET smoothing and WDVS smoothing after forward modeling. Compare with Fig. 18.

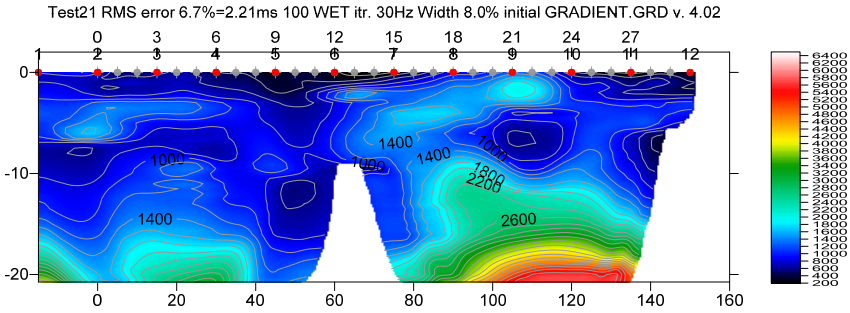


Fig. 8 : obtained with *WET Tomo|Interactive WET tomography* (Fig. 12 left) : 100 WET iterations@30Hz & 1D-gradient starting model shown in Fig. 6. Wavepath frequency set to 30Hz. Minimal WET smoothing (Fig. 12 right). WDVS@120Hz as in Fig. 5. Discard WDVS smoothing only and restore WET smoothing. Compare with Fig. 7 and 19.

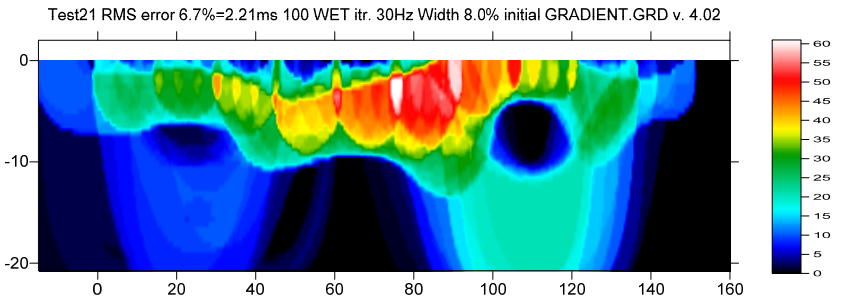


Fig. 9 : WET wavepath coverage plot obtained with Fig. 8. Unit is wavepaths per pixel.

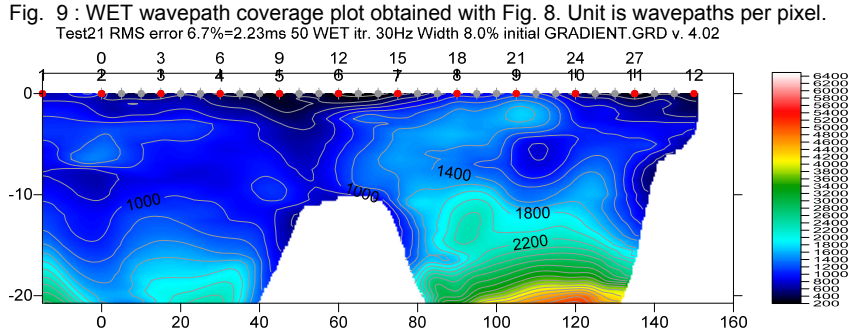


Fig. 10 : same as Fig. 8 but setting ***WET Tomo|Interactive WET|Number of WET tomography iterations*** (Fig. 12 left) to 50 WET iterations only instead of 100 WET iterations used for Fig. 8.

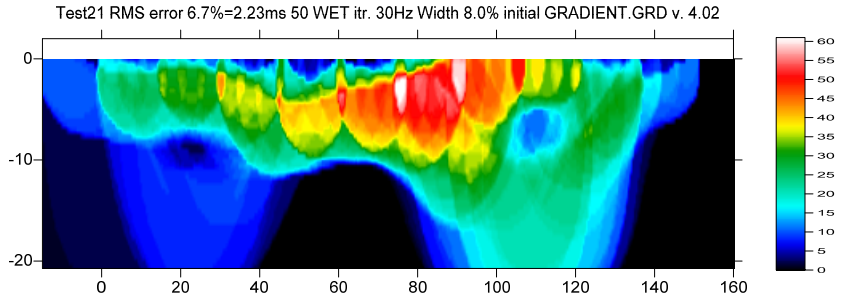


Fig. 11 : WET wavepath coverage plot obtained with Fig. 10. Unit is wavepaths per pixel.

Now we try increasing the WET resolution by increasing the iteration count and tuning the smoothing :

- select ***Model|WDVS Smoothing***. Edit as in Fig. 5. Click radio button ***Discard WDVS smoothing only***.
- select *WET Tomo|Interactive WET tomography*
- increase ***Number of WET tomography iterations*** to 100 from default 20 iterations. See Fig. 12 (left).
- decrease ***Wavepath frequency*** to 30Hz from default 50Hz for deeper imaging
- set ***Max. velocity*** to 5,500m/s
- click button ***Edit velocity smoothing***. Edit as in Fig. 12 (right). Click *Accept parameters*.
- click button ***Start tomography processing*** to obtain WET output shown in Fig. 8 and Fig. 9

Above we show WET+WDVS imaging of a strongly weathered granitic basement in Australia with local velocity inversions in overburden.

The RMS error of 6.7% shown on top of Fig. 8 and Fig. 10 is almost as high as 6.8% shown for Fig. 7. However Fig. 8 and Fig. 10 seem to show more details after 50 and 100 WET iterations with ***minimal WET smoothing*** and ***Adapt shape of filter*** unchecked instead of default 20 WET iterations and default full WET smoothing used for Fig. 7.

For instructions on tuning the ***WDVS frequency*** see our ***Help menu***, Contents, Forward model traveltimes. Scroll down to section ***WDVS velocity smoothing***. We recommend first leaving WDVS parameters in ***Model|WDVS smoothing*** at their default settings with WDVS frequency at 200Hz. Then increase/decrease *WDVS frequency* using these heuristics :

- for a short line (100m or 200 long) with shallow high-velocity basement increase ***WDVS frequency*** to 400Hz or higher. See our Broad Epikarst tutorial.
- for a short line with thick and low-velocity overburden as above decrease ***WDVS frequency*** to 100Hz or 150Hz
- for a long line up to 1km or 2km long : decrease WDVS frequency to 50Hz or 60Hz. See our Aaknes-1 tutorial.
- if you lower the *WDVS frequency* too much then the top-of-basement is imaged too shallow and overburden velocity anomalies show too strong magnitude. Compare Fig. 8 and Fig. 10 with Fig. 7.

- also the ***RMS error*** shown on top of WET tomograms increases too much with too low *WDVS frequency*.

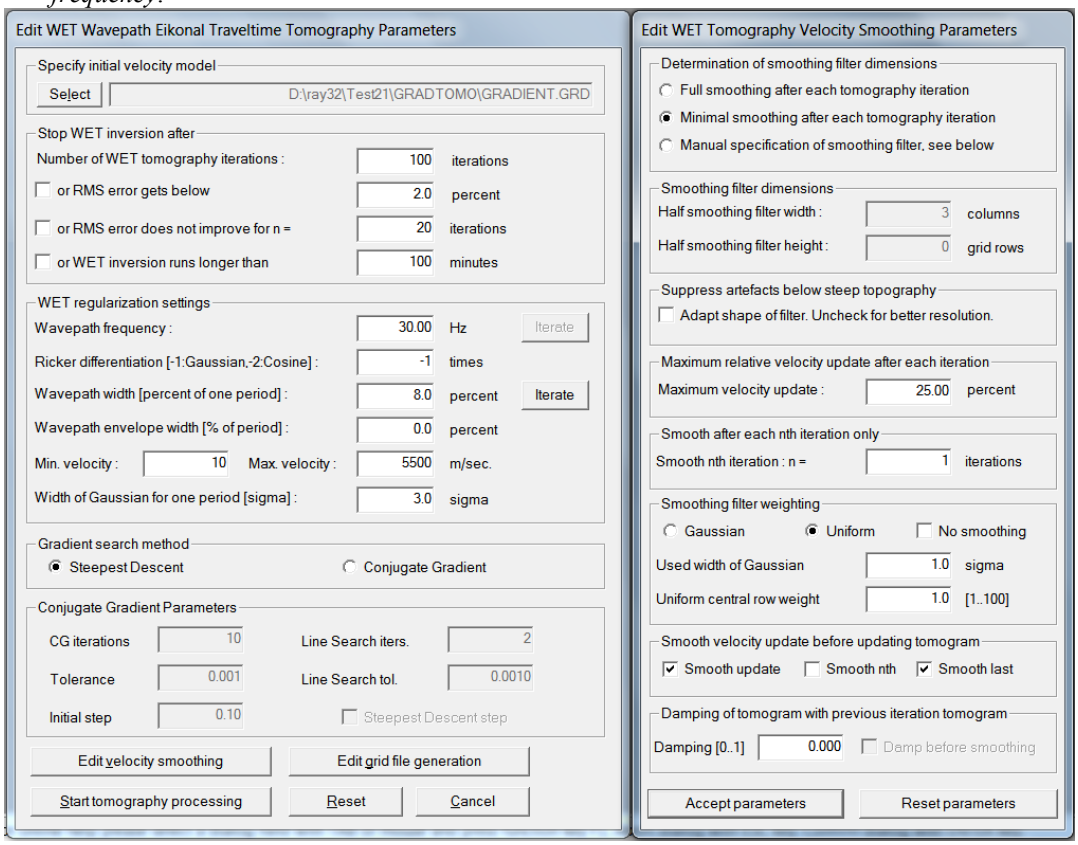


Fig. 12 : *WET Tomo|Interactive WET* main dialog (left). *Edit velocity smoothing* dialog (right).

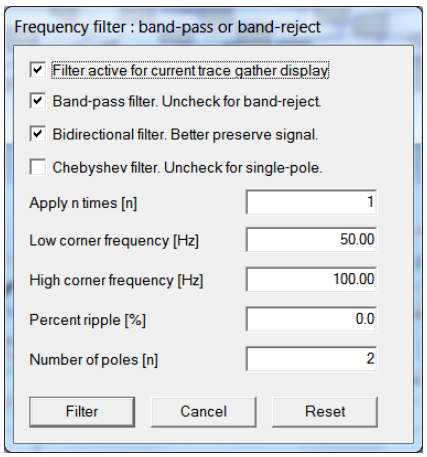


Fig. 13 : *Trace|Shot gather* SHIFT+Q Bandpass

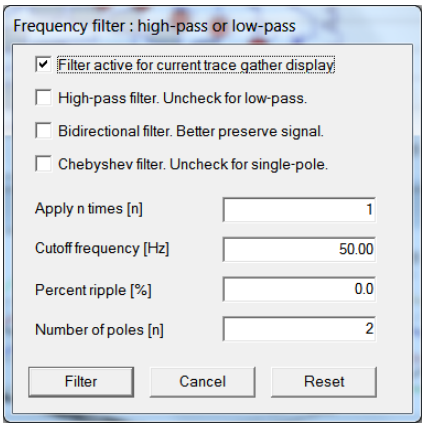


Fig. 14 : *Trace|Shot gather* ALT+Q Lowpass

To optimize frequency filtering in ***Trace|Shot gather*** display (Fig. 1 top) or in *Trace|Offset gather* :

- select ***Trace|Shot gather***. Press SHIFT+Q keyboard shortcut and edit bandpass as in Fig. 13
- press ALT+Q and edit low-pass filter as in Fig. 14

Bandpass filtering and low-pass filtering are done in sequence for trace display in *Trace|Shot gather* or *Trace|Offset gather*.

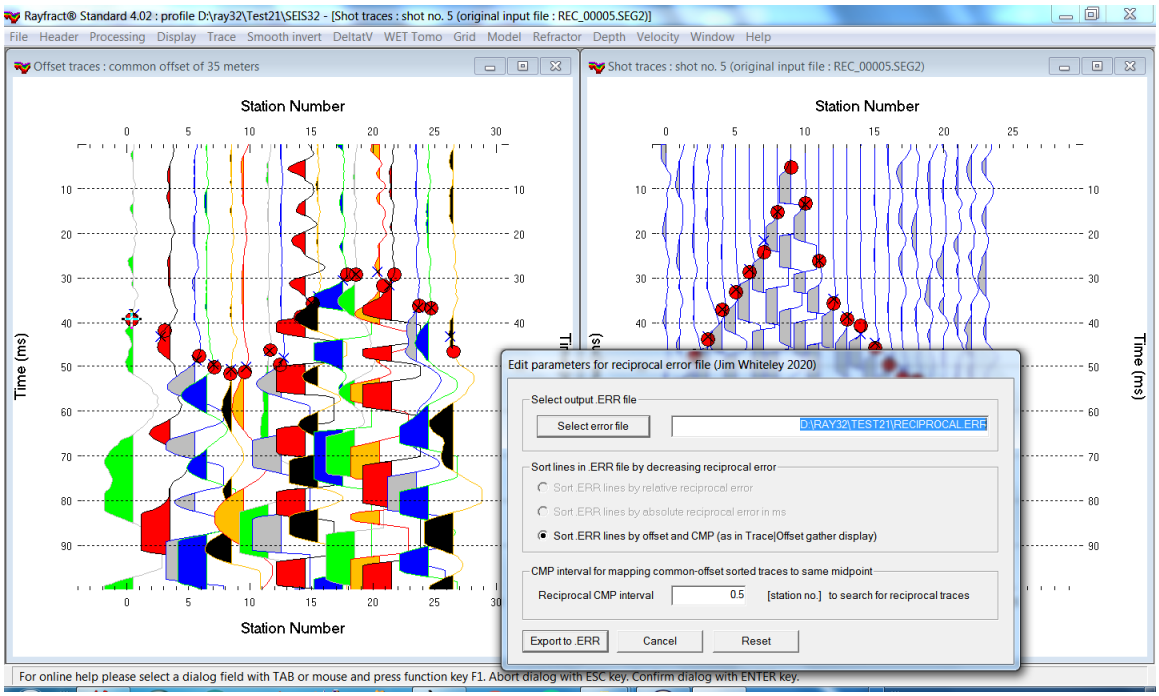


Fig. 15 : check reciprocal picking errors in *Trace*|*Offset gather* (left). Browse shots in *Trace*|*Shot gather* (right). Display reciprocal picking error export dialog with *Trace*|*Export reciprocal errors*.

We recommend checking reciprocal picking errors in ***Trace*|*Offset gather*** (Fig. 15) as in our Slope1 tutorial. Export reciprocal picking errors to file **`RECIPROCAL.ERR`** in ***Trace*|*Export reciprocal errors***.

Import **`RECIPROCAL.ERR`** into Microsoft Excel spreadsheet and sort by column **`reciprocal_error(%)`** or **`absolute_error(ms)`** to identify trace pairs in *Trace*|*Offset gather* display that need to be repicked.

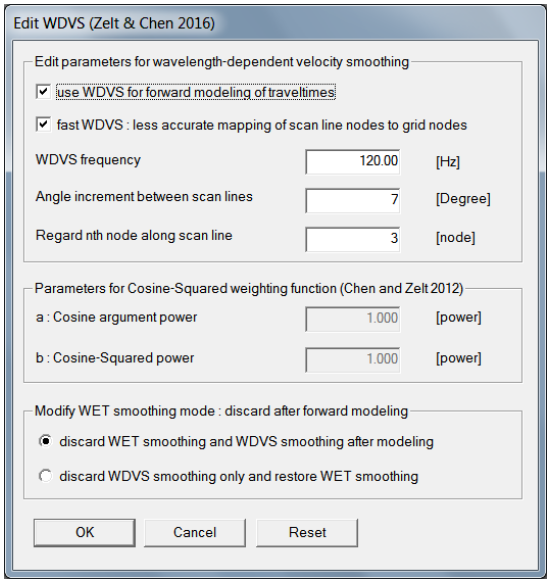


Fig. 16 : *Model*|*WDVS Smoothing* used for Fig. 7. Check radio button ***discard WET smoothing and WDVS smoothing after modeling***.

Next we show using our pseudo-2D DeltatV starting model instead of the laterally averaged 1D-gradient starting model (Sheehan 2005).

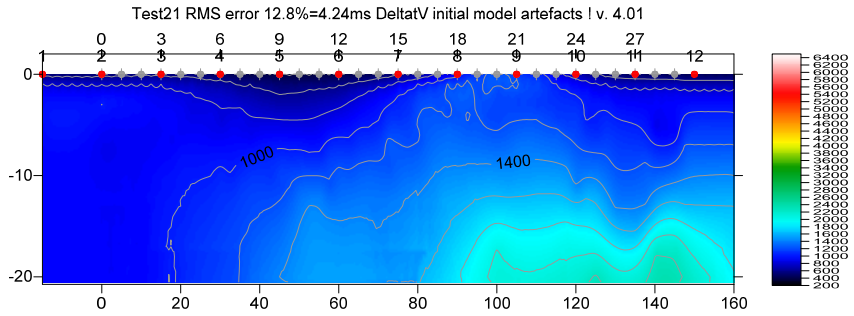


Fig. 17 : pseudo-2D DeltatV starting model obtained with *DeltatV|Automatic DeltatV and WET inversion*

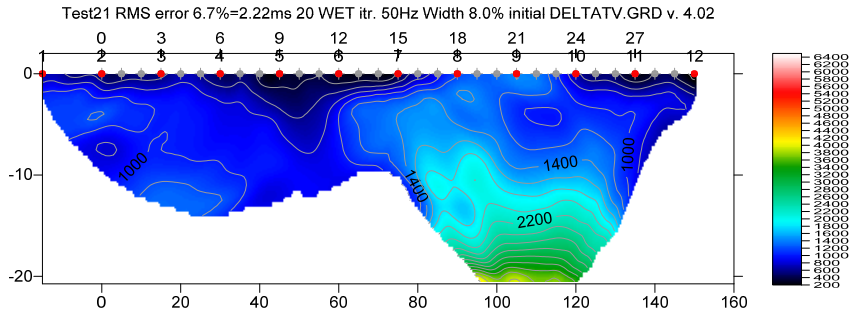


Fig. 18 : *DeltatV|Automatic DeltatV and WET inversion* & starting model shown in Fig. 17. 20 WET iterations@50Hz using Steepest Descent method & Gaussian update weighting & full WET smoothing. WDVS@120Hz as in Fig. 16. Discard WET smoothing and WDVS smoothing after forward modeling. Compare with Fig. 7.

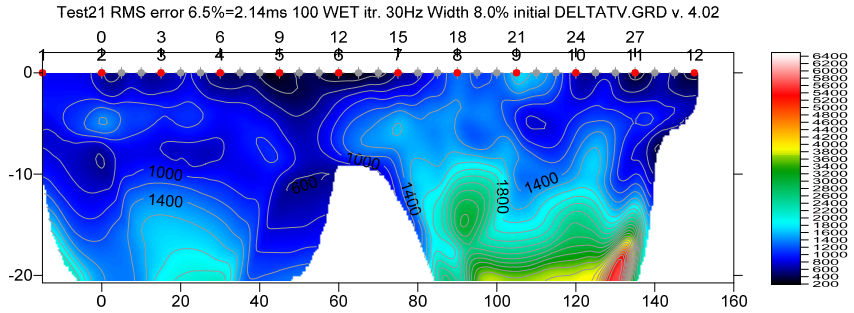


Fig. 19 : obtained with *WET Tomo|Interactive WET tomography* (Fig. 21 left) : 100 WET iterations@30Hz & 1D-gradient starting model shown in Fig. 17. Wavepath frequency set to 30Hz. Minimal WET smoothing (Fig. 21 right). WDVS@120Hz as in Fig. 5. Discard WDVS smoothing only and restore WET smoothing. Compare with Fig. 8 and 10.

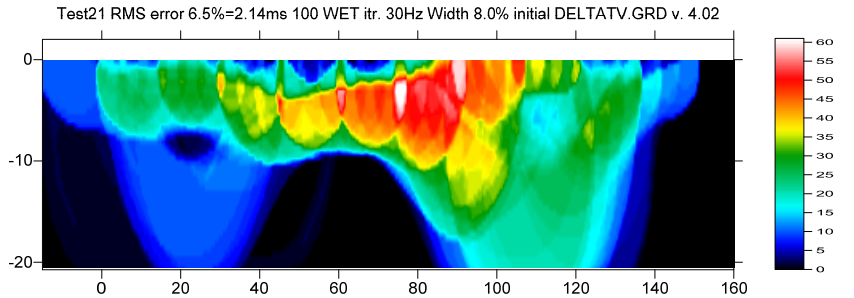


Fig. 20 : WET wavepath coverage plot obtained with Fig. 20. Unit is wavepaths per pixel.

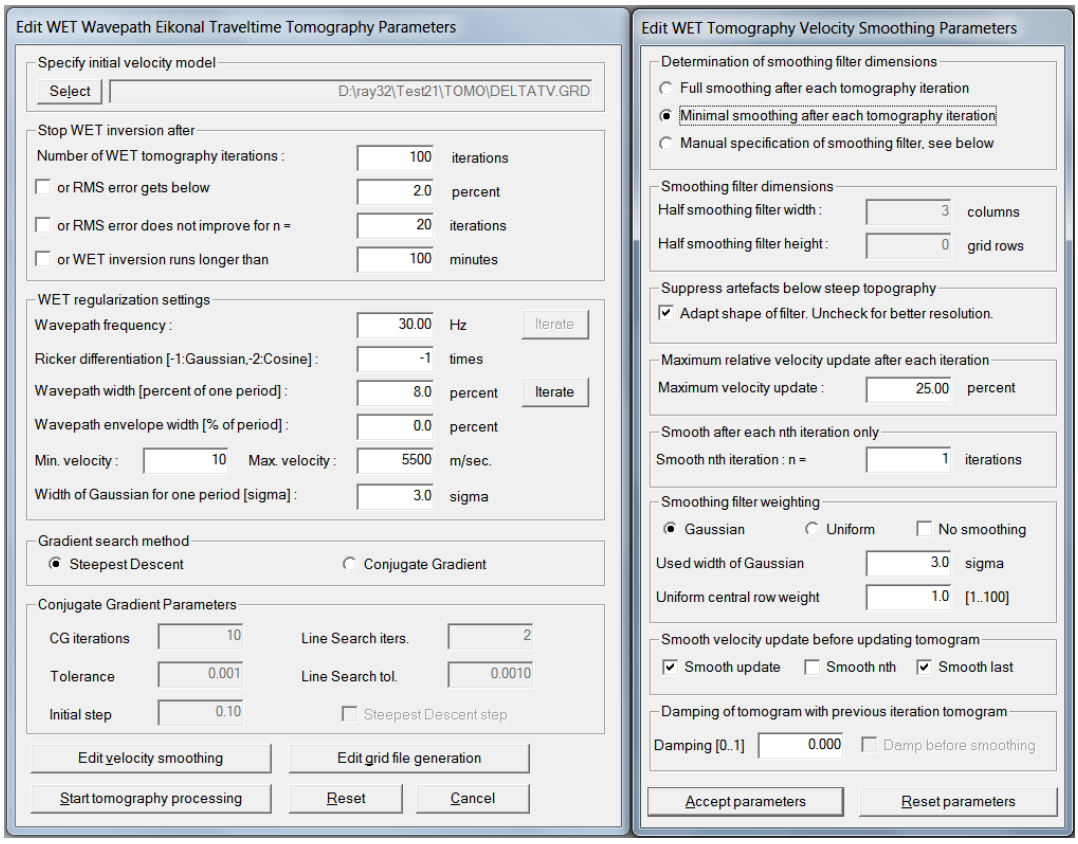


Fig. 21 : *WET Tomo*|*Interactive WET* main dialog (left). *Edit velocity smoothing* dialog (right).

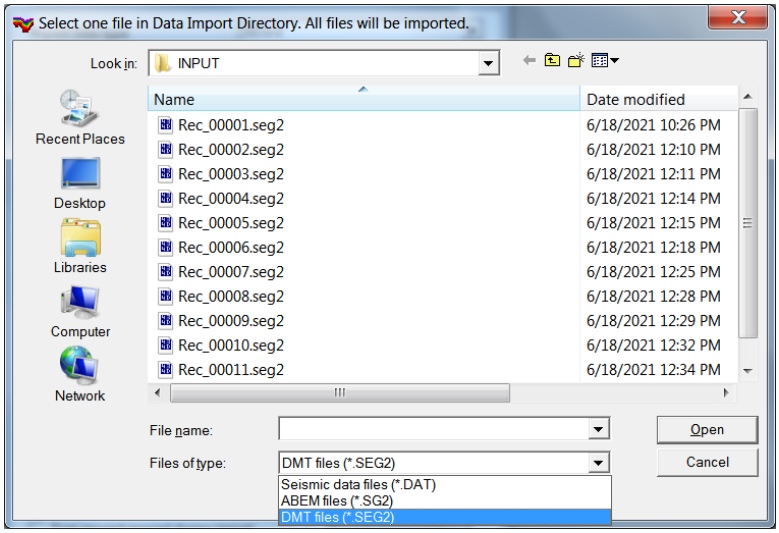


Fig. 22 : in *File*|*Import Data* set *Import data type* to **`SEG-2`**. Click *Select* button. Click on down arrow in *Files of type* drop-down field and select entry **`DMT files (*.SEG2)`**. Select any .SEG2 file e.g. **`Rec_00001.seg2`** and click *Open*.

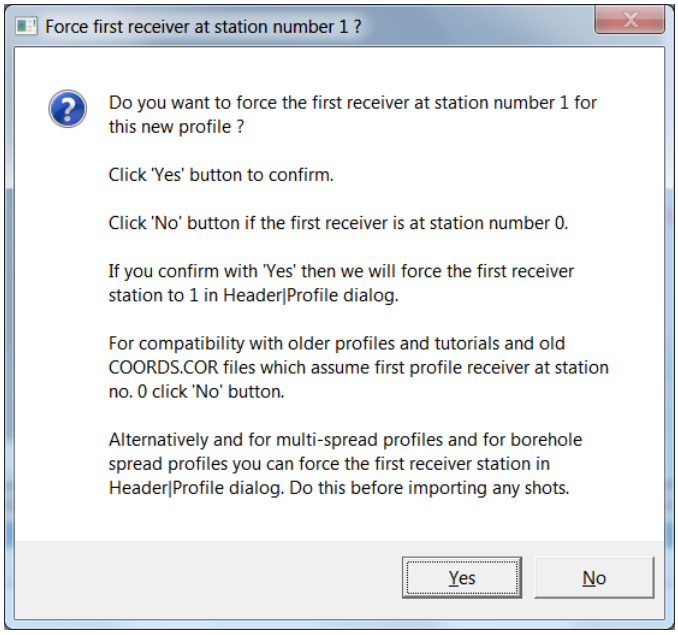


Fig. 23 : click No button to leave ***Profile start and first receiver station*** at station no. 0.

For compatibility with older profiles and tutorials and old COORDS.COR files which assume first profile receiver at station no. 0 click No button.

For more recommendations on optimal application of WDVS and tuning of WDVS frequency see our SAGEEP 2021 expanded abstract and slides, and our EGU 2021 online abstract.

Optimal tuning of *WDVS frequency*, *WET wavepath frequency*, WET smoothing and number of WET iterations is subjective and should be based on a-priori knowledge of the imaged subsurface section, obtained from boreholes, trenching etc. The WDVS frequency should be about two to four times the predominant frequency in the first break waveforms or WET wavepath frequency or higher. Lowering the WET wavepath frequency corresponds to increasing the *WET wavepath width*.

As shown above in Fig. 5 and Fig. 16 we recommend enabling option ***discard WET smoothing and WDVS smoothing*** in ***Model|WDVS Smoothing*** dialog for our *Smooth inversion* or *Automatic WET inversion* only. When using our *WET Tomo|Interactive WET inversion* and minimizing the *WET smoothing* (Fig. 12) we strongly recommend checking option ***restore WET smoothing and discard WDVS smoothing only*** instead to prevent high-velocity artefacts below the shot points in the resulting WET tomogram.

The theory for ***WDVS Wavelength-Dependent Velocity Smoothing*** is described in (Zelt and Chen 2016).

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