Aaknes-1 Smooth inversion with 1D-gradient & Plus-Minus starting model vs. WDVS enabled WET using minimal WET smoothing & DeltatV inversion :

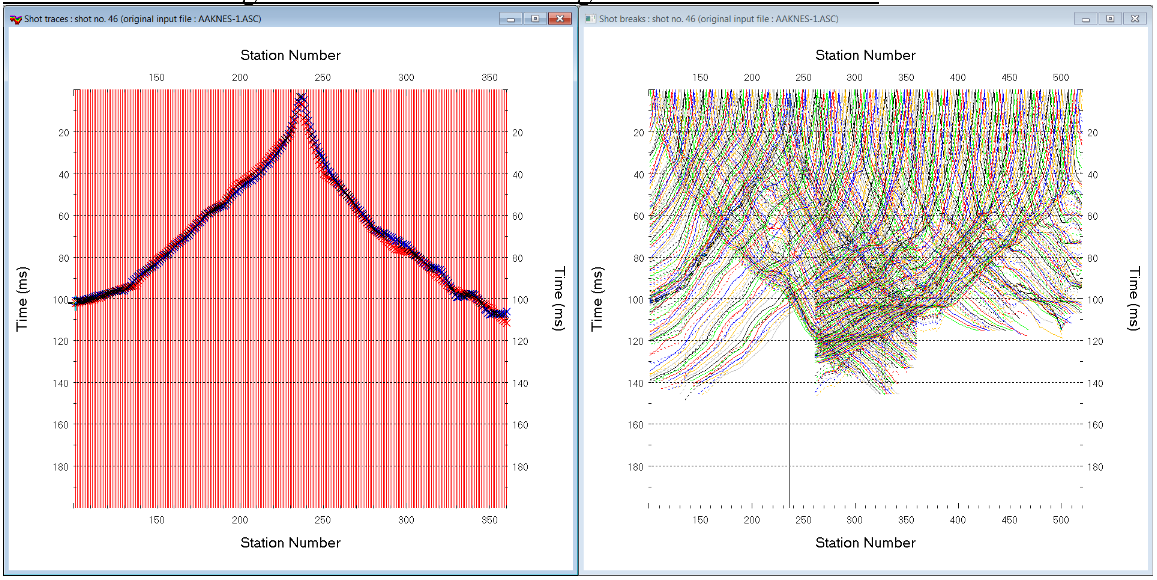


Fig. 1 : left : *Trace|Shot gather*, right : *Refractor|Shot breaks*. Shows fit between picked times (solid colored curves, red crosses) and modeled times (dashed colored curves, blue crosses) obtained after 20 WET iterations with 1D-gradient GRADIENT.GRD starting model (Fig. 6)

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

- ***File|New Profile***..., set *File name* to **`Aaknes-1`** and click *Save button*
- in ***Header|Profile***... set *Line type* to **`Refraction spread/line`** . Set *Station spacing* to 2.0 m.
- check *box Force grid cell size* and set *Cell size[m]* to 1.0m. See Fig. 2.
- unzip archive [**`AAKNES-1.zip`**]() with files **`ASCII.ASC`** & **`COORDS.COR`** & **`SHOTPTS.SHO`** in directory **`C:\RAY32\Aaknes-1\INPUT`**
- select ***File|Import Data***... and set *Import data type* to **`ASCII column format`**. See Fig. 3.
- click *Select button* and navigate into **`C:\RAY32\Aaknes-1\INPUT`**
- select file **`ASCII.ASC`** & click button *Open*
- leave *Default spread type* at **`10: 360 channels`**
- check box *Batch import* & click ***Import shots button*** . All shots listed in **`ASCII.ASC`** are imported.
- select *File|Update header data|Update Station Coordinates* & **`COORDS.COR`**. Click *Import & Reset*.
- *File|Update header data|Update Shotpoint coordinates* with **`SHOTPTS.SHO`**. Click *Open button*.
- select *Trace|Shot gather* and select *Window|Tile* to obtain Fig. 1
- click on title bar of *Trace|Shot gather* window and press F1 to zoom time axis (Fig. 1 left)
- browse shots in *Trace|Shot gather* window with F7/F8 (Fig. 1 left)
- click on title bar of *Refractor|Shot breaks* window (Fig. 1 right) and press ALT+P. Edit *Maximum time* to 200 ms & hit ENTER key to redisplay. Do the same for *Trace|Shot gather* window (Fig. 1 left).

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
- select *Grid|Receiver station ticks on top axis*
- uncheck *WET Tomo|WET tomography Settings|Blank|Blank below envelope after last iteration*
- check *WET Tomo|WET tomography Settings|Blank|Blank no coverage after last iteration*
- select ***Smooth invert|WET with 1D-gradient initial model***
- wait for the 1D-gradient starting model to display as in Fig. 5

- when prompted to continue with WET inversion click *No button*
- select *WET Tomo|Interactive WET tomography*
- click *Select button* and select **`C:\RAY32\Aknes-1\GRADTOMO\GRADIENT.GRD`**
- set ***Number of WET tomography iterations*** to 20
- increase ***Wavepath width [percent of one period]*** from default 6.5 percent to 12 percent and set ***Max. velocity*** to 6,500 m/s (Fig. 15)
- click button ***Start tomography processing*** to obtain WET output shown in Fig. 6 & 7

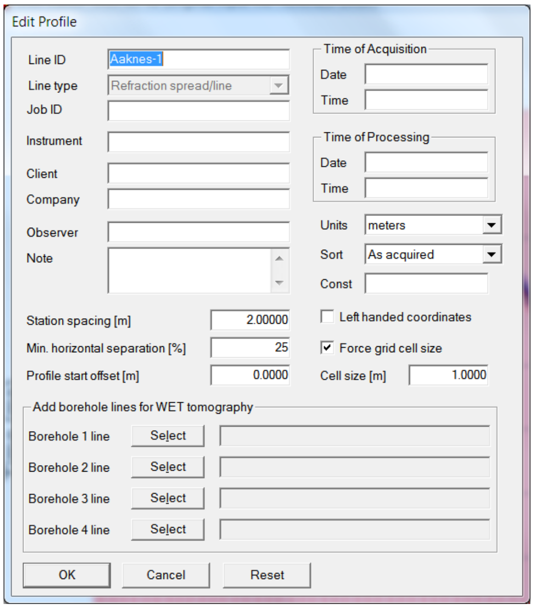


Fig. 2 : *Header|Profile*

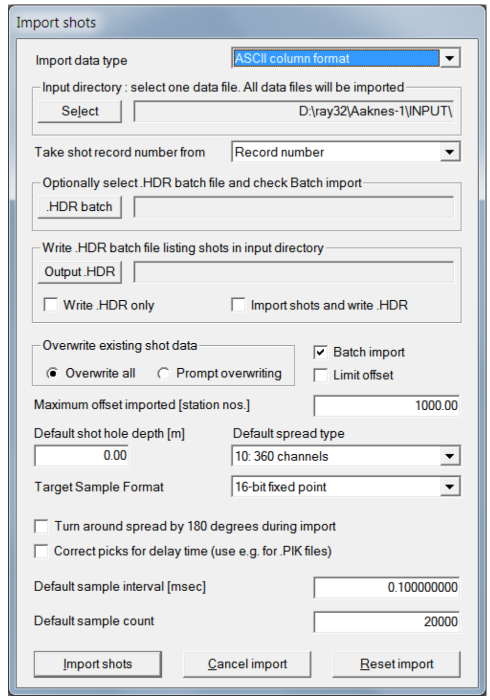


Fig. 3 : *File|Import Data*

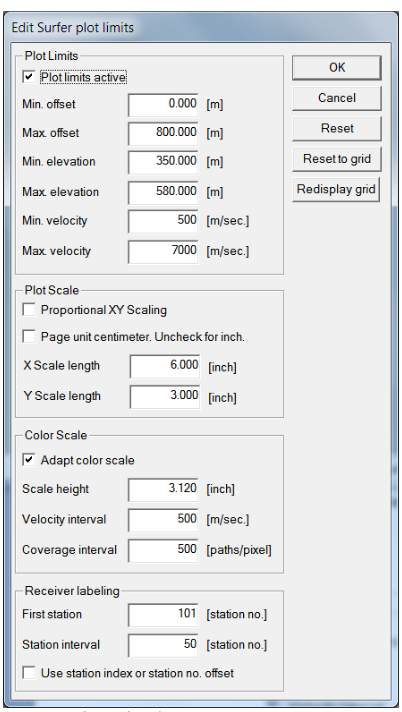


Fig. 4 : *Grid|Surfer plot Limits*

Surfer plot limits shown in Fig. 4 are used for WET inversion output (Fig. 6&7) only and not for the 1D-gradient starting model (Fig. 5). To display the starting model using these plot limits :

- select **`C:\RAY32\Aaknes-1\GRADTOMO\GRADIENT.GRD`** with *Grid|Turn around grid file*
- reimage **`C:\RAY32\Aaknes-1\GRADTOMO\GRADIENT.GRD`** with *Grid|Image and contour velocity and coverage grids*

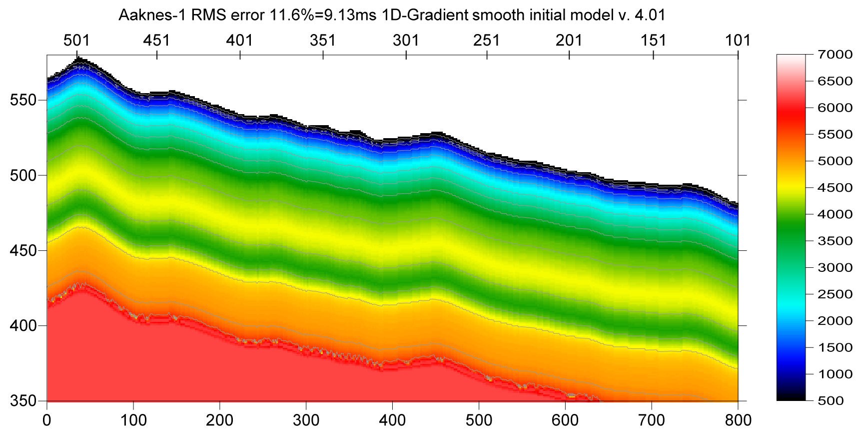


Fig. 5 : 1D-gradient starting model obtained with *Smooth invert|WET with 1D-gradient initial model*

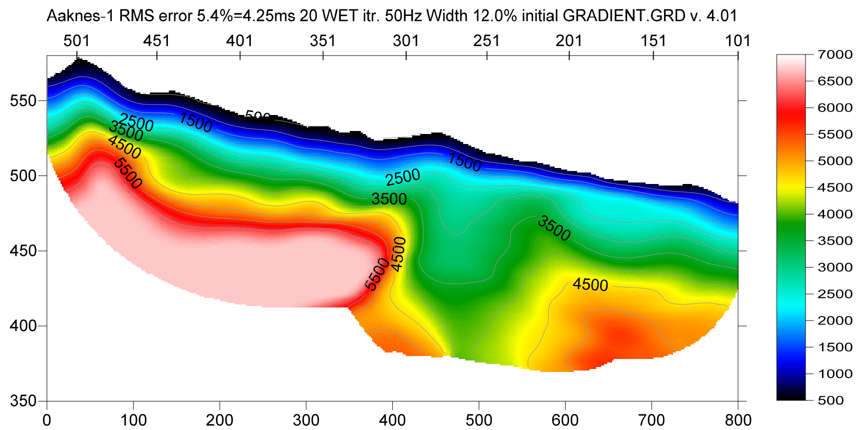


Fig. 6 : 2D WET output obtained with *Smooth invert|WET with 1D-gradient initial model* & starting model shown in Fig. 5. 20 WET iterations using Steepest Descent method & Gaussian update weighting & full WET smoothing.

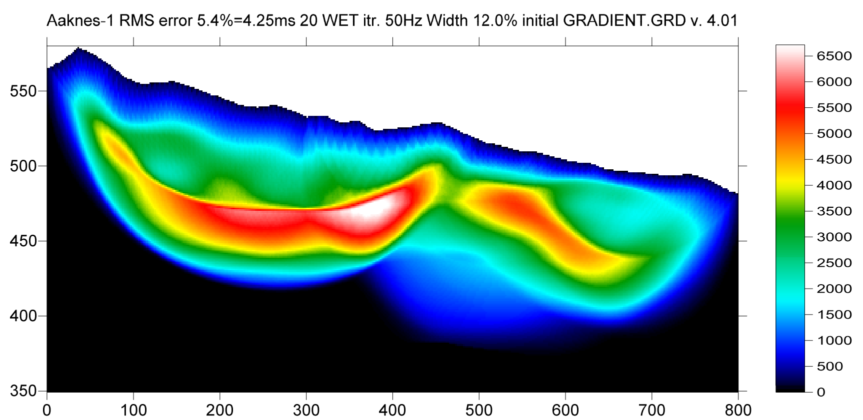


Fig. 7 : WET wavepath coverage plot obtained with Fig. 6. Unit is wavepaths per pixel

Next we try to increase the WET resolution by increasing the WET iteration count but keeping default Full WET smoothing :

- select *WET Tomo|Interactive WET tomography*
- set ***Number of WET tomography iterations*** to 50 (Fig. 15)
- click button ***Start tomography processing*** to obtain WET output shown in Fig. 8 :

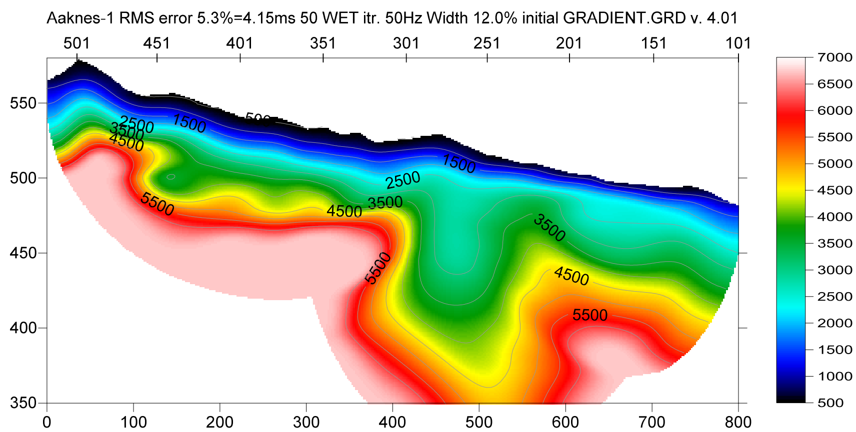


Fig. 8 : 2D WET output obtained with *WET Tomo|Interactive WET tomography* & 50 WET iterations & 1D-gradient starting model shown in Fig. 5

Fig. 8 shows more detail in relief and lateral variations at top of basement (yellow color) compared to Fig. 6 so increasing the WET iteration count apparently did improve the resolution a bit.

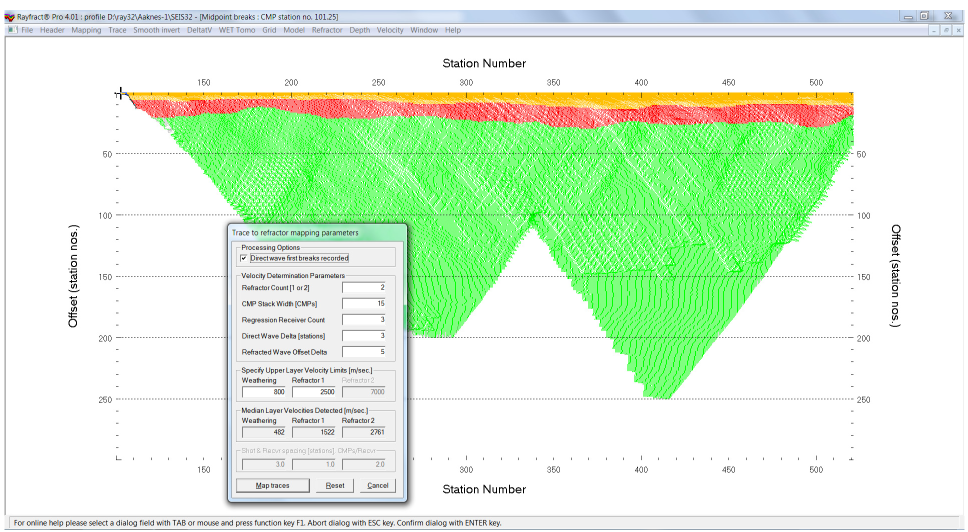


Fig. 9 : map traces to refractors in *Refractor|Midpoint breaks*. Press ALT+M to display mapping dialog. Edit as shown and click button *Map traces*.

Now we try Smooth inversion using Plus-Minus layered refraction starting model :

- map traces to refractors in *Refractor|Midpoint breaks* with **ALT+M** (Fig. 9)
- press ALT+G to laterally smooth crossover distance. Set both *Overburden filter [station nos.]* and *Basement filter* to 30 and click button *Accept*.
- select *Depth|Plus-Minus* to display Plus-Minus layered refraction starting model (Fig. 10). When prompted to continue with WET inversion click *No button*.

- ➢ click on title bar of *Plus-Minus Depth Section window*. Press ALT+M and set both *Overburden filter [station nos.]* and *Base filter width* to 20. Press ENTER to redo Plus-Minus method interpretation.
- ➢ when prompted to continue with WET inversion using default WET parameters click *Yes button*.
- ➢ select *WET Tomo|Interactive WET tomography* & set ***Number of WET tomography iterations*** to 50
- ➢ set ***Wavepath width [percent of one period]*** to 12 percent and set ***Max. velocity*** to 6,500 m/s
- ➢ click button ***Start tomography processing*** to obtain WET output shown in Fig. 11.
- ➢ Smooth WET inversion is somewhat dependent on the starting model after 50 WET iterations when using default full WET smoothing & Steepest Descent search method : Fig. 8 and Fig. 11 are similar.
- ➢ interactive WET inversion with 50 iterations (Fig. 8 and Fig. 11) takes about 16 minutes on 2017 iMac using 2.3 GHz Intel Core i5 processor with 2 hyper-threaded CPU cores running Windows 7 64-bit Pro in Parallels desktop.

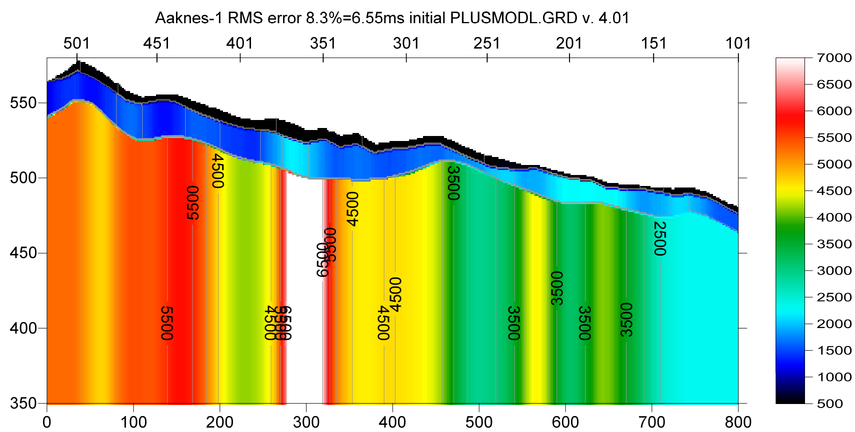


Fig. 10 : Plus-Minus method starting model

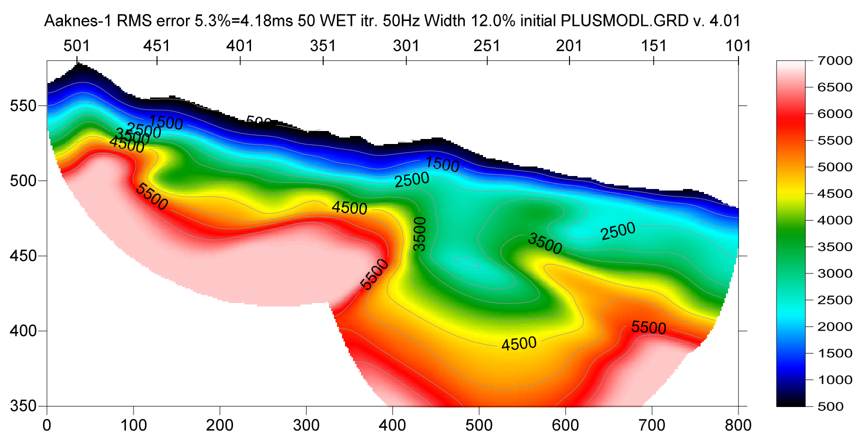


Fig. 11 : Smooth inversion using Plus-Minus method starting model (Fig. 10). 50 WET iterations using default Steepest Descent method & Gaussian update weighting & full WET smoothing. Compare with Fig. 8.

We thank NGU for making available the original input files with inconsistent first break picks and their smoothed and shifted version of the recording geometry.

Also we thank GeoExpert for making available SEGY files with improved first break picks (Fig. 16) and their version of the recording geometry. See Fig. 14 for Smooth inversion using GeoExpert topography and recording geometry. Note the significant differences between Fig. 14 topography and Fig. 8 and Fig. 13 using NGU smoothed and shifted topography. Also note noisy SEGY traces in Fig. 16.

As shown above we always recommend starting with our default Smooth inversion using Steepest Descent search method and full WET smoothing. In case of such uncertain first break picks and such uncertain recording geometry you may want to increase the default WET wavepath width as shown above.

It is not completely clear to us why NGU chose to ignore our default fail-safe Smooth inversion method (Sheehan 2005) and used our pseudo-2D DeltatV method with suboptimal settings instead.

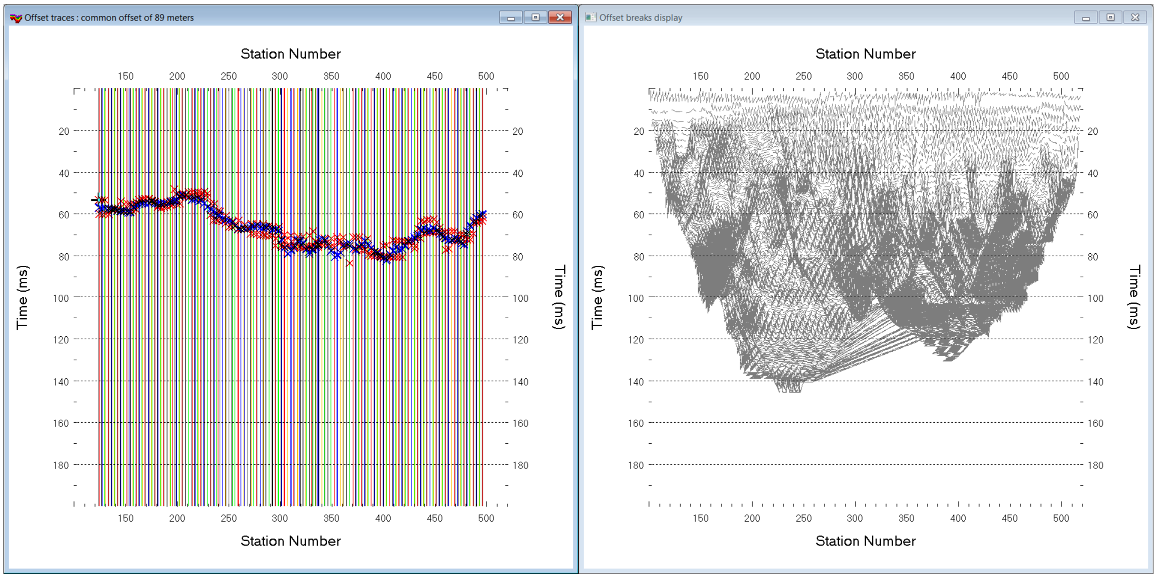


Fig. 12 : *Trace|Offset gather* for common offset = 89m (left). Red crosses are picked first breaks. Blue crosses are modeled first break times. Refractor|Offset breaks (right).

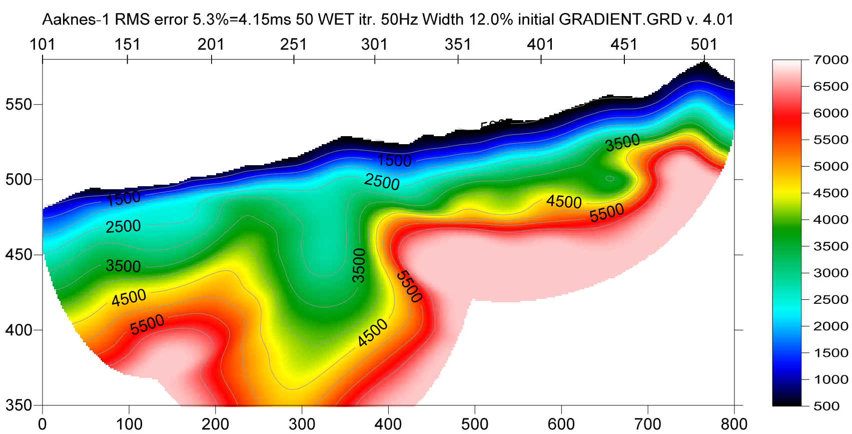


Fig. 13 : copied from Fig. 8. but un-flipped ...**\GRADTOMO\VELOIT50.GRD** with *Grid|Turn around grid file* and reimaged with *Grid|Image and contour velocity and coverage grids.* Note good correlation with Fig. 12 (right) : *Refractor|Offset breaks* display.

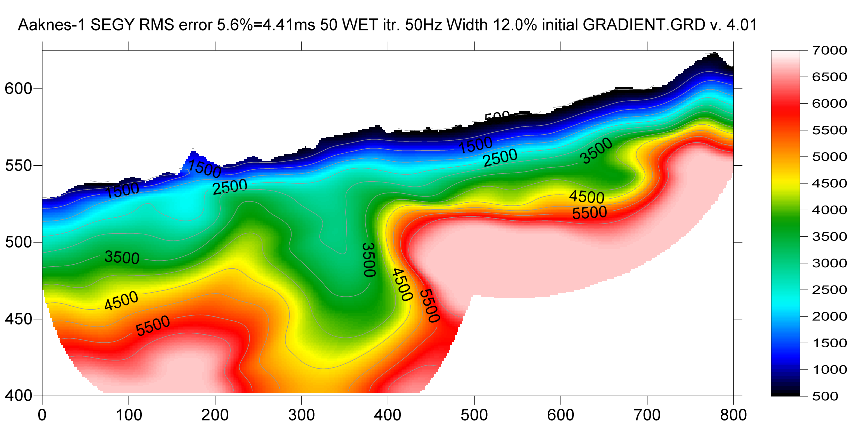


Fig. 14 : Same WET processing as Fig. 8 & Fig. 13 but with GeoExpert unsmoothed topography

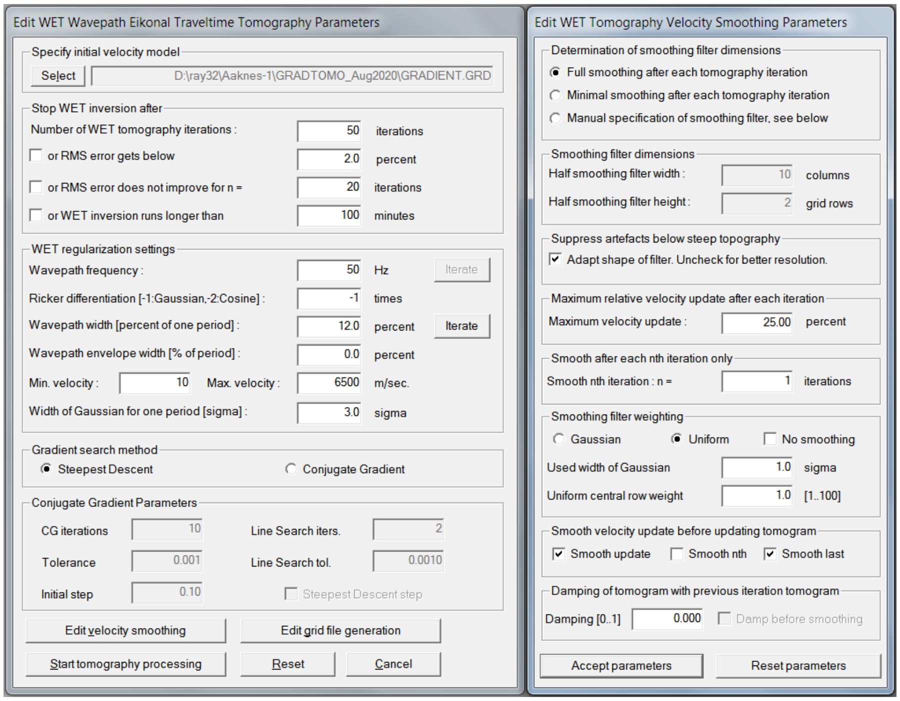


Fig. 15 : *WET Tomo|Interactive WET tomography* settings to obtain Fig. 8

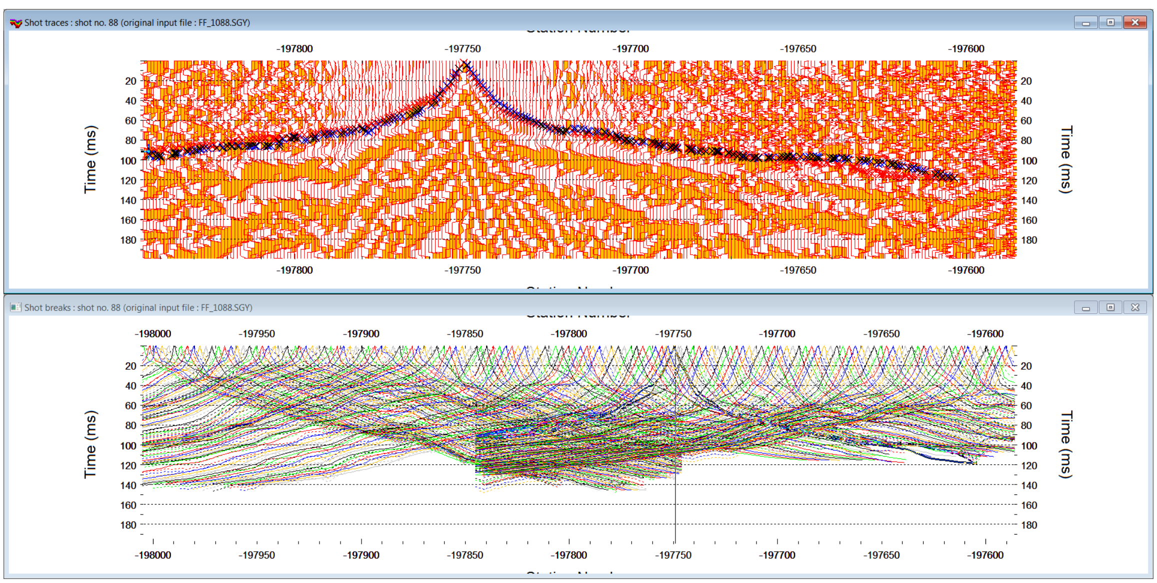


Fig. 16 : sample SEGY shot. Note the low signal-to-noise ratio (top).

Earlier processing of this line shown in 2019 NGU report was done using the original first break picks which are not consistent and show too large reciprocal traveltime errors in *Trace|Offset gather*. Even after repicking of the traces the reciprocal traveltime picking errors are still significant at large offsets (Fig. 12, Fig. 27). We recommend stacking shots in the seismograph to improve the signal-to-noise ratio, or using a more powerful seismic source. Also avoid over-interpretation of uncertain field data by decreasing the WET smoothing too much. Don't reuse inversion settings optimized for noise-free synthetic data when processing noisy field data with reciprocal traveltime picking errors and errors in specification of used recording geometry.

Our earlier tutorial Slope1 shows how to identify and improve inconsistent traveltime picks in *Trace|Offset* gather based on traveltime reciprocity principle.

Sheehan et al. 2005 objectively compare our fail-safe default Smooth inversion method using 1D-gradient starting model with other commercially available seismic refraction tomography software.

Here are the profile database files for line Aaknes-1. Here are Surfer .GRD & .PAR & .FIT files for Smooth inversion shown in Fig. 5 to Fig. 8 with WET settings as in Fig. 15. Here are Surfer .GRD files for layer-based inversion shown in Fig. 10 and Fig. 11.

As shown in our SAGEEP10 short course tutorials, our short manual and our help file we always recommend running our Smooth inversion as a first step during interpretation. Next you can try to improve the resolution by increasing the number of WET iterations and optionally decreasing WET smoothing for consistent data.

Copying minimized WET smoothing settings optimized for one profile to another profile is not recommended and not supported. Default full WET smoothing filter size and default wavepath width are determined automatically based on grid dimensions (grid cell size, number of columns & rows), velocity distribution in the starting model and maximum picked time. Since these parameters are specific to each profile and starting model you need to always start with our Smooth inversion. Next you can optionally try step-wise decreasing of WET smoothing, for consistently picked traveltimes and correctly specified recording geometry.

If you decrease WET smoothing too much then you effectively prevent WET inversion from improving on the starting model. This is true for any starting model : Plus-Minus, pseudo-2D DeltatV or 1D-gradient obtained with our *Smooth invert|WET with 1D-gradient initial model*.

Interactively adapt WET smoothing to your profile data (first breaks and recording geometry) or just use default full WET smoothing. Don't force some arbitrary smoothing copied from a completely different profile and assume that this should just work with your current data. This is not supported by us.

For multi-run WET inversion of synthetic data as shown in SAGEEP11_16 tutorial you can decrease ***WET smoothing*** more than for single-run WET inversion of field surveys as shown e.g. in our new P6 tutorial. For P6 we leave WET smoothing at default *Full smoothing* and increase the *WET iteration count* only, from default 20 to 100. But we keep using default *Ricker differentiation -1 [Gaussian]*, default *Steepest Descent search method* and default *Full smoothing*. Also we use Smooth inversion with default full WET smoothing in our TYLERLN1_2019 tutorial, CLUD1 tutorial, BROADEPI tutorial, EPIKINV tutorial, FIG9INV tutorial, TRA9002 tutorial and most other tutorials. Use *Conjugate-Gradient* search method for WET inversion instead of default *Steepest Descent* search method for consistently picked travel times and correctly specified source and receiver geometry used to record the data only.

Above NGU line Aaknes-1 and our P6 tutorial show fault zone imaging in Norway. Traveltime curves and results show gradual increase of velocity with depth below topography and deep weathering along fracture zone. This contrasts with the strictly Plus-Minus layered refraction assumption used by NGU for their modeling, with unrealistic abrupt velocity increase to over 4,000 m/s directly below thin weathering layer or topography. We have asked NGU to use more realistic models of weathered subsurface in future, with deep weathering. The modeled velocity should increase gradually with depth both in overburden and in basement. Of course the Plus-Minus method works best to interpret synthetic data obtained by forward modeling over such strongly layered models. We show this in our earlier tutorial NGUP1_1 .

The SAGEEP 11 blind refraction model (Zelt et al. 2013) uses more realistic velocity gradients and deep weathering including a dipping fault zone, all of which are better modeled with diving waves and seismic refraction tomography than with strictly critically refracted rays used with classical refraction methods.

In http://rayfract.com/samples/SAGEEP2011shootout.pdf Prof. Bob Whiteley compares the GRM interpretation (Stoyer, 2012) of above synthetic data with our published blind interpretation and the true model (Zelt et al. 2013).

(Hagedoorn 1959) already shows Fresnel volumes (seismic transmission volume) and gradual increase of velocity with depth both in basement and in overburden, resulting in curved rays and diving waves in Fig. 1 of his classical Plus-Minus refraction method paper.

Mattsson et al. compare WET interpretation with conventional refraction processing for imaging of granitic bedrock in Sweden with thin overburden and mapped deformation zones. Mattsson shows deep weathering and diving waves due to gradual increase of velocity with depth in overburden and below top-of-basement. These results are contrary to unrealistic NGU synthetic model 1_1D which shows no increase of velocity with depth inside basement and abrupt velocity increase to over 4,000 m/s below thin weathering layer or even directly below topography. These extremely sharp velocity increases at layer boundaries with no layer-internal velocity gradients prevent reliable interpretation with our DeltatV method. DeltatV assumes diving waves due to gradual increase of velocity with depth. This assumption is realistic for most field surveys we have ever seen in recorded traveltime curves. See our tutorials in archives TUTORIAL.ZIP and OLDTUTOR.ZIP for interpretation of client's field survey data. Corner cases for which a starting model method fails can be constructed for every such method : 1D-Gradient, DeltatV, Plus-Minus etc.

DeltatV apparent velocity pseudo-sections can be compared to ER apparent resistivity pseudo-sections. See e.g. https://pages.mtu.edu/~ctyoung/LOKENOTE.PDF chapter 2.3 on page 8. Quote : "The pseudosection is useful as a means to present the measured apparent resistivity values in a pictorial form, and as an initial guide for further quantitative interpretation. One common mistake made is to try to use the pseudosection as a final picture of the true subsurface resistivity."

When you run our DeltatV inversion via *DeltatV menu* items we prompt you about apparent velocity artefacts and recommend using our *Smooth inversion* method instead (Fig. 17).

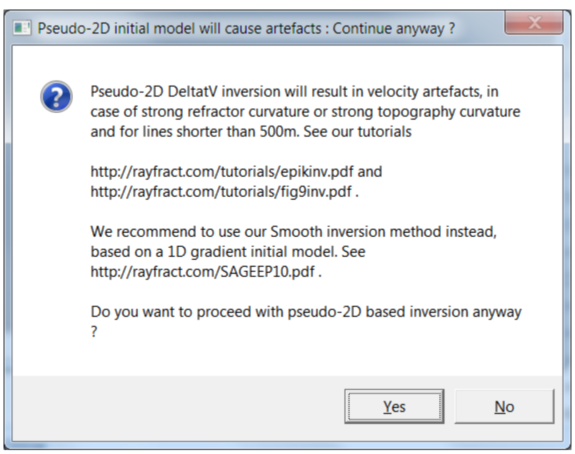


Fig. 17 : Artefact warning prompt shown when running DeltatV method inversion

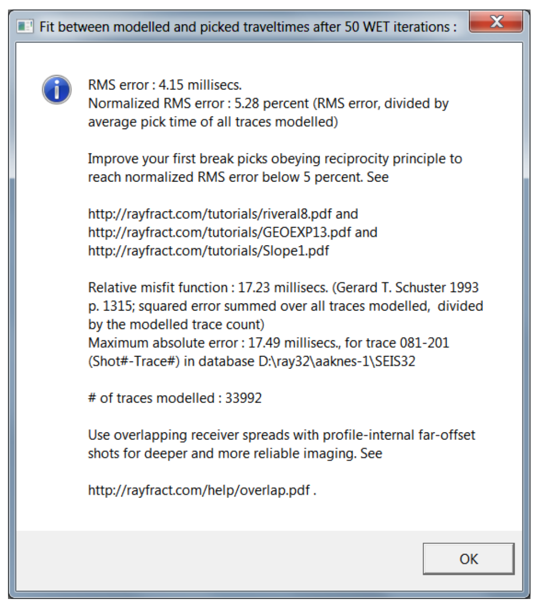


Fig. 18 : Traveltime misfit prompt shown after WET

Also when the normalized RMS error exceeds 5 percent we prompt after WET inversion to improve your traveltime picks regarding the traveltime reciprocity principle (Fig. 18).

Below we show reprocessing of this line with our version 4.01 software with WDVS (Zelt and Chen 2016) enabled, done in Dec 2020. WDVS Wavelength-Dependent Velocity Smoothing is described in

Zelt, C. A. and J. Chen, Frequency-dependent traveltime tomography for near-surface seismic refraction data, Geophys. J. Int., 207, 72-88, 2016

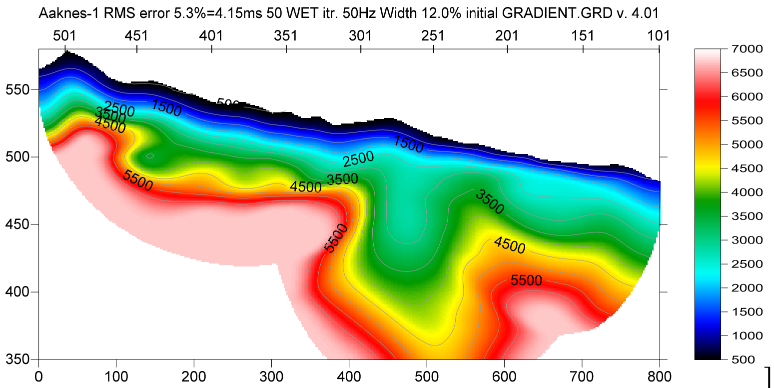


Fig. 19 : 2D WET tomogram obtained with *WET Tomo|Interactive WET tomography* & 50 Steepest-Descent WET iterations using 1D-gradient starting model shown in Fig. 5. Same as Fig. 8.

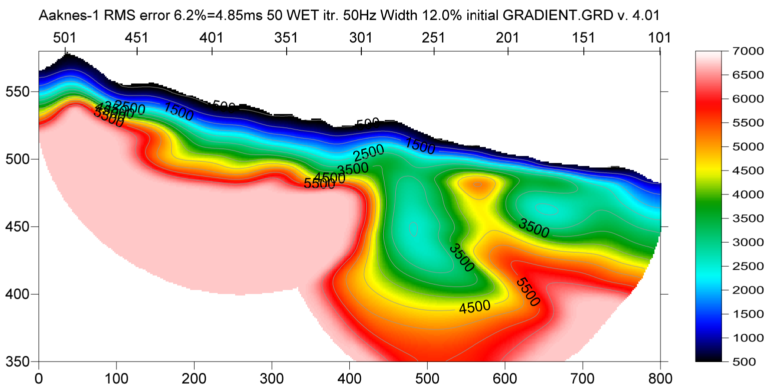


Fig. 20 : Same as Fig. 19 but with WDVS engaged (Zelt and Chen 2016; Fig. 24). Full WET smoothing.

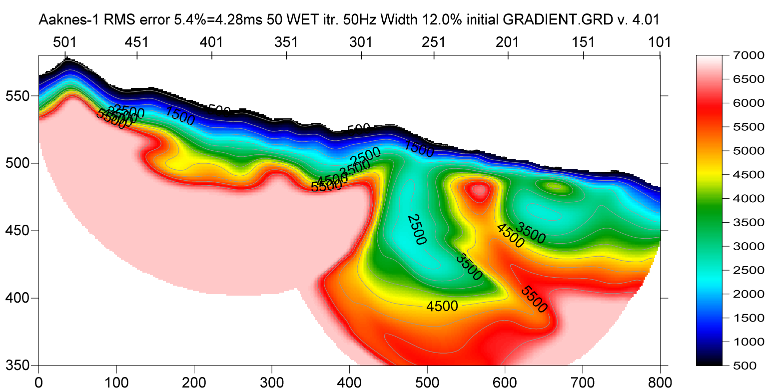


Fig. 21 : Same as Fig. 20 but with minimal WET smoothing. WDVS as in Fig. 24. WET as in Fig. 25.

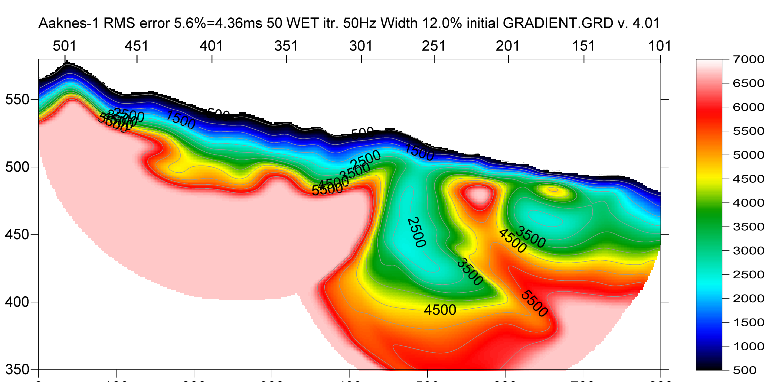


Fig. 22 : Same as Fig. 21 but WDVS *Regard nth node*=2 instead of 3 (Fig 24). *Fast WDVS Smoothing* unchecked.

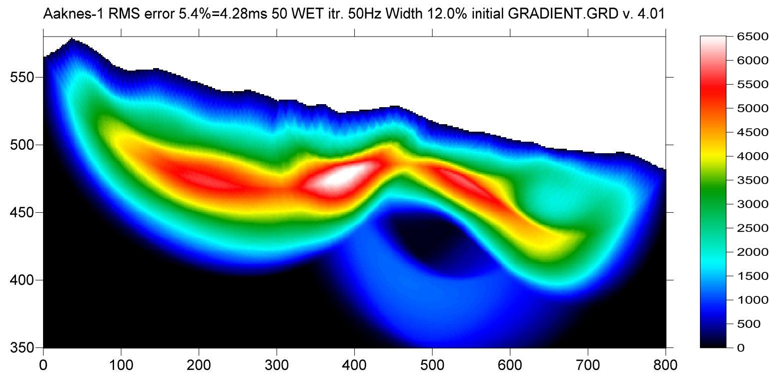


Fig. 23 : WET wavepath coverage plot obtained with Fig. 21. Unit is wavepaths per pixel.

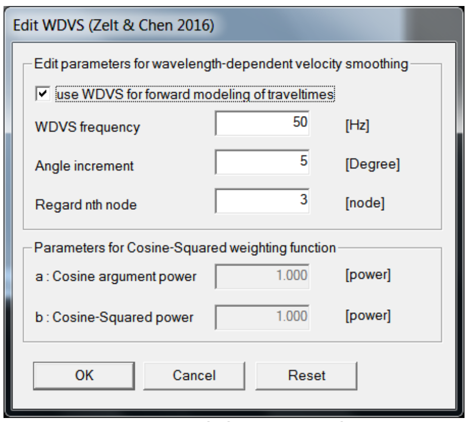


Fig. 24 : *Model|WDVS Smoothing*. Check *Model|Fast WDVS Smoothing*.

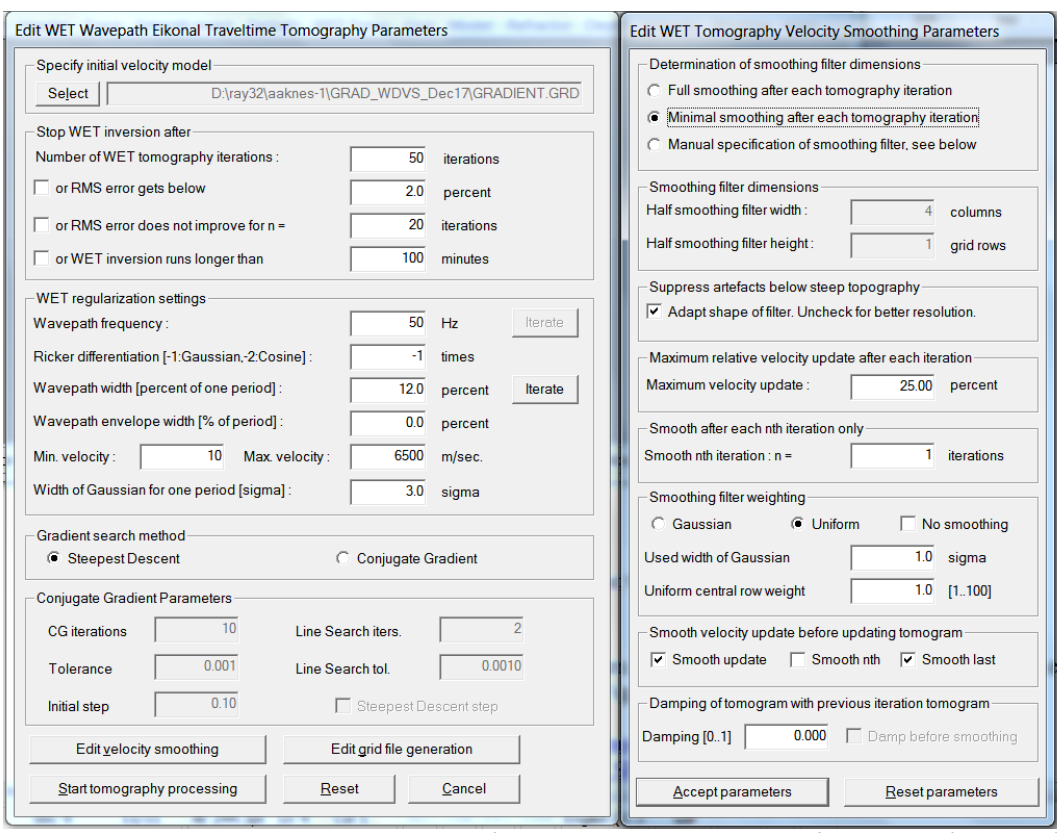


Fig. 25 : *WET Tomo|nteractive WET* main dialog (left). *Edit velocity smoothing* (right). Settings used for Fig. 21 & 22 & 23.

Note the apparently improved resolution in the overburden and sharper imaging of top-of-basement when engaging WDVS with minimal WET smoothing (Fig. 21 & Fig. 22). As shown in Fig. 13 & Fig. 14 the recording geometry and topography is highly uncertain and disputed for this line. Fig. 12 (left) shows reciprocal traveltime picking errors in *Trace|Offset gather*. These errors are caused by too low signal-to-noise ratio (Fig. 16) and errors in specification of used recording geometry. WET interpretation using WDVS shown in Fig. 20, Fig. 21 and Fig. 22 may ***over-fit these noisy first break data*** and Fig. 19 (Smooth inversion without WDVS) may be more reliable.

We found the shown and used *WDVS frequency* of 50Hz (Fig. 24) by iteratively decreasing from 400Hz/200Hz/100Hz/75Hz (Zelt and Chen 2016). Decrease WDVS parameters *Regard nth node* and *Angle increment* or *WDVS frequency* to obtain sharper imaging of velocity contrast and more shallow basement top. You need to tune these WDVS parameters for each individual line. If you decrease these WDVS parameters too much then high-velocity anomalies in overburden may show too much contrast (Fig. 22) and top-of-basement may be imaged too shallow and too fast.

Check option *WET Tomo|WET tomography Settings|Limit WET velocity to maximum velocity in initial model* to counter a bias towards too high velocities in basement when enabling WDVS. This bias gets stronger when you decrease the *WDVS frequency* or the two other WDVS parameters : *Angle increment* and *Regard nth node*. We limited *max. WET velocity* to 6,500 m/s in Fig. 25 with option *WET Tomo|WET tomography Settings|Edit maximum valid WET velocity* checked.

WDVS option *Model|Fast WDVS Smoothing* maps radial scan line nodes to velocity grid nodes less accurately during WDVS smoothing. See https://rayfract.com/help/release_notes.pdf bullets dated Nov 10 and Nov 12, 2020. See also our 2022 tutorial showing WDVS enabled interpretation of Line14 data.

(Zelt and Chen 2016) show the effect of varying the WDVS frequency.

Basically the optimum choice of the *WDVS frequency* is subjective. The lower the WDVS frequency the stronger the contrast of imaged velocity anomalies in overburden and the more shallow the top-of-basement is imaged. Same applies when decreasing WDVS parameters *Regard nth node* and *Angle increment*.

We give you meaningful parameters for WET inversion and *WDVS Smoothing* to explore the non-unique solution space of the misfit function (Schuster, 1993). It is your job to navigate this solution space using these parameters and appropriate heuristics to arrive at a satisfying solution showing small RMS error and good correlation with a priory knowledge from boreholes, outcrops, trenching and other geophysical methods such as resistivity etc.

See our updated help file for description of WDVS parameters in chapter ***Forward model traveltimes***. Press F1 function key in ***Model|WDVS Smoothing dialog*** (Fig. 24) to display popup help window for current control. Use TAB key to switch focus between controls. See our updated tutorials showing WDVS :

http://rayfract.com/tutorials/epikinv.pdf
http://rayfract.com/tutorials/sageep11_16.pdf
http://rayfract.com/tutorials/camp1.pdf
http://rayfract.com/tutorials/11REFR.pdf
http://rayfract.com/tutorials/jenny13.pdf
http://rayfract.com/tutorials/NORCAL14.pdf

Here is the archive with seis32.* profile database files for Fig. 21 and Fig. 23
Here is the archive with Surfer 11 .GRD and .SRF and .PAR files for Fig. 21 and Fig. 23

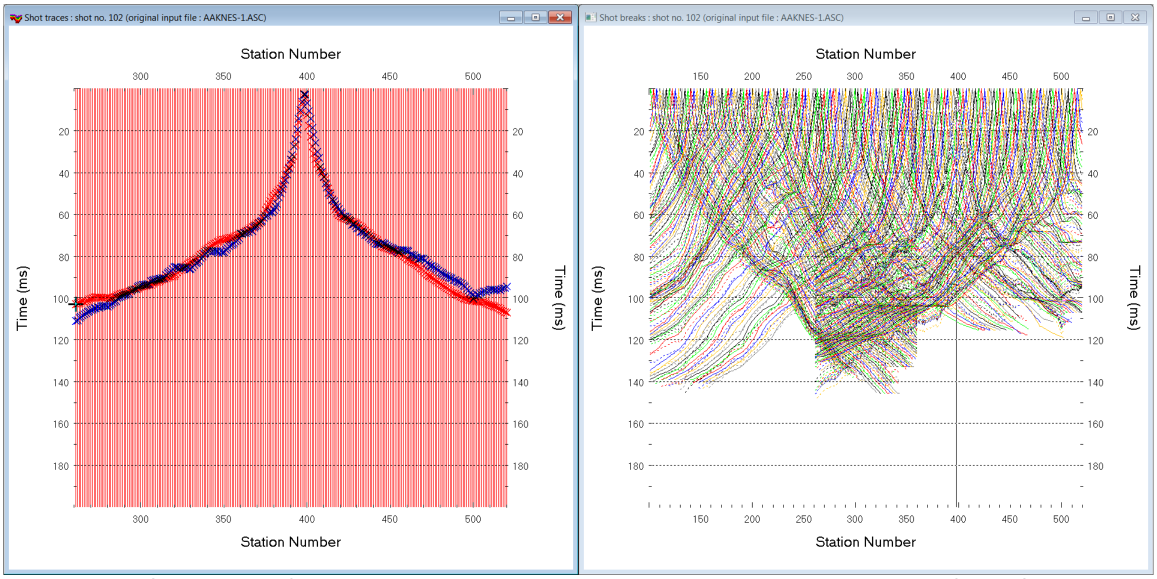


Fig. 26 : Trace|Shot gather (left). Red crosses are picked times. Blue crosses are modeled times. Refractor|Shot breaks (right). Solid curves are picked traveltime curves. Dashed curves are modeled traveltime curves.

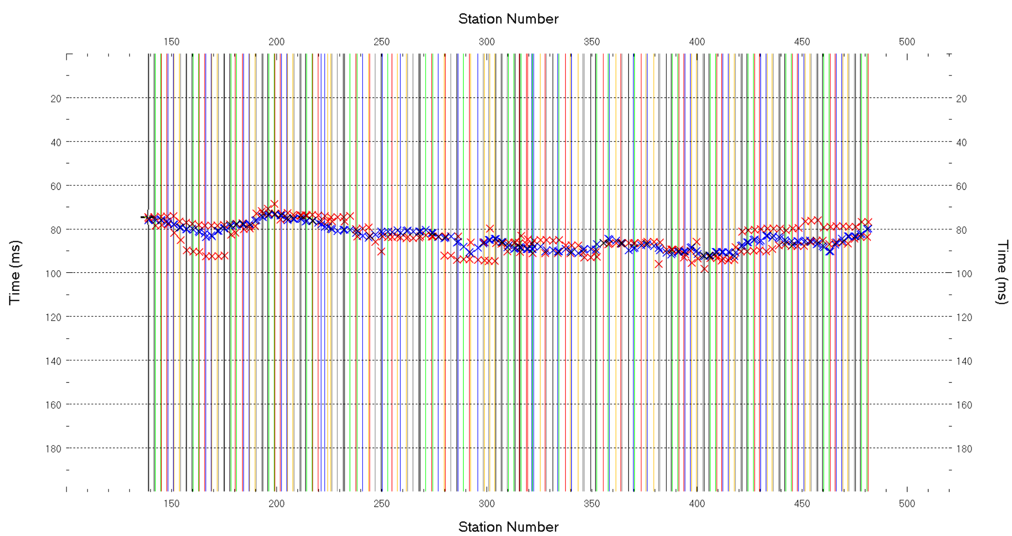


Fig. 27 : Trace|Offset gather. Common offset 149m. Red crosses are picked times. Blue crosses are modeled times.

Note the inconsistent first break picks in Fig. 26 and Fig. 27. Compare these displays with the consistently picked traveltimes in our OT0608 tutorial (Fig. 23 and Fig. 24 on last page).

On the next page we compare *Interactive DeltatV* inversion with suboptimal/pessimized *DeltatV parameters* used by NGU for their Fig. 4.1 in NGU report 2019_004 (our Fig. 28) with our *Automatic DeltatV* with *max. velocity exported* increased to 6,000 m/s (our Fig. 29).

In Fig. 28 we show *DeltatV|Interactive DeltatV* inversion with *DeltatV settings* and parameters copied from /reset to **DELTATV.PAR** made available by NGU for their Fig. 4.1 in NGU report 2019_004. In Fig. 29 we show *DeltatV|Automatic DeltatV* with same *DeltatV settings* (Fig. 33) and parameters as for Fig. 28, with *max. velocity exported* increased to 6,000 m/s (Fig. 32). In Fig. 31 we compare NGU **DELTATV.PAR** used for Fig. 28 with automatic default **DELTATV.PAR** parameters used for Fig. 29.

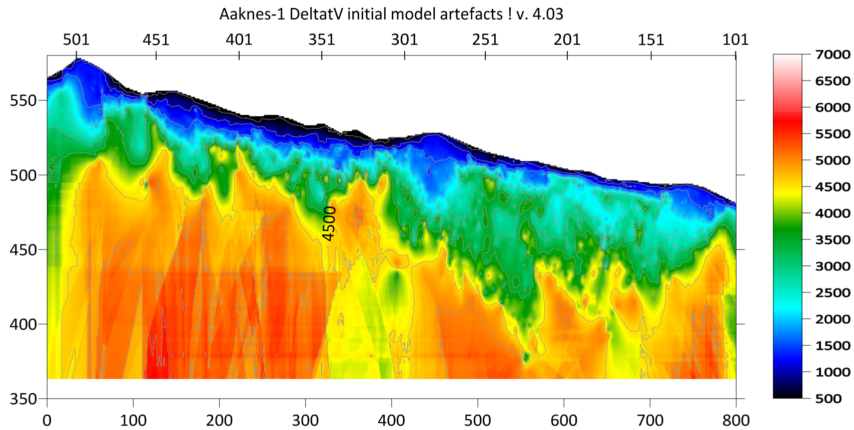


Fig. 28 : *DeltatV|Interactive DeltatV* with NGU DELTATV.PAR parameters used in [NGU report 2019_004] Fig. 4.1 (Fig. 33). Bad ***CMP curve stack width*** 15 CMP's. Bad ***Topography filter*** 100 stations. See Fig. 31 for differences in DeltatV parameters compared to automatic default parameters used for Fig. 29.

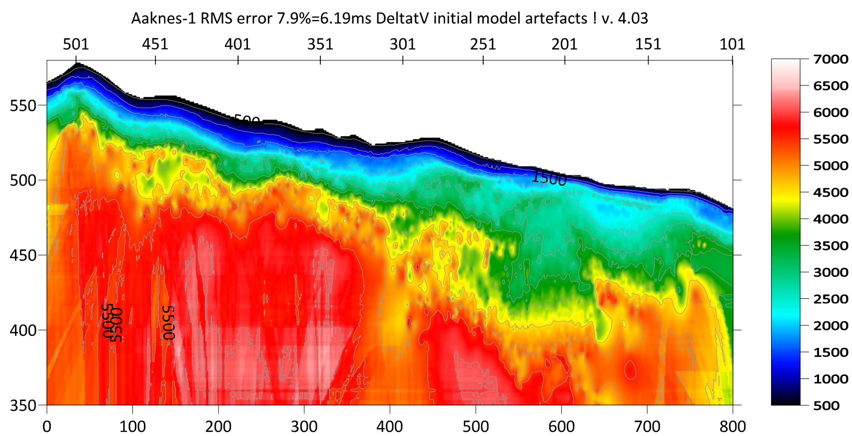


Fig. 29 : *Deltat|Automatic DeltatV*. *DeltatV settings* as for Fig. 28 (Fig. 33). *Max. velocity exported* 6,000m/s (Fig. 32). Default ***CMP curve stack width*** 84 CMP's. Default ***Topography filter*** 15 stations. See Fig. 31 for differences in DeltatV parameters compared to NGU bad parameters used for Fig. 28.

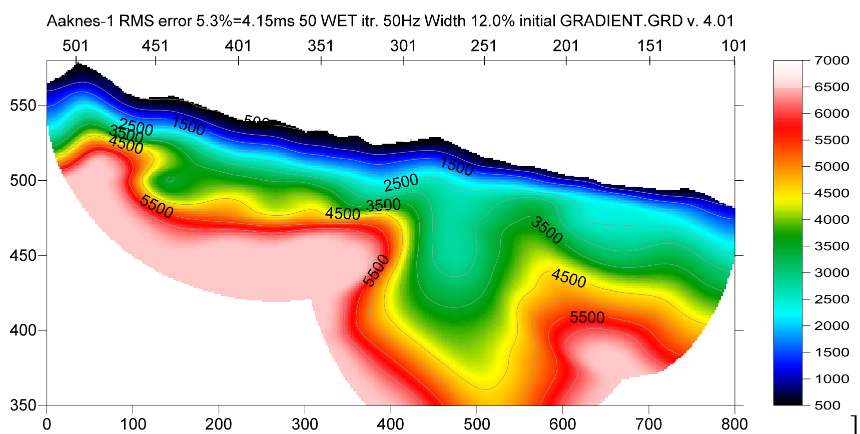


Fig. 30 : 2D WET tomogram obtained with *WET Tomo|Interactive WET tomography* & 50 Steepest-Descent WET iterations using 1D-gradient starting model shown in Fig. 5. Same as Fig. 8.

Note the too wide ***Topography smoothing filter*** 100 stations (Fig. 31 right) used by NGU & for Fig. 28 compared to default ***Topography smoothing filter*** 15 stations (Fig. 31 left) used to obtain Fig. 29.

Also note the too narrow ***DeltatV CMP curve stack width*** 15 CMP's (Fig. 31 right) used by NGU & for Fig. 28 compared to default ***DeltatV CMP curve stack width*** 84 CMP's (Fig. 31 left) used for Fig. 29. The *CMP curve stack width* is determined automatically based on your profile's length and station spacing.

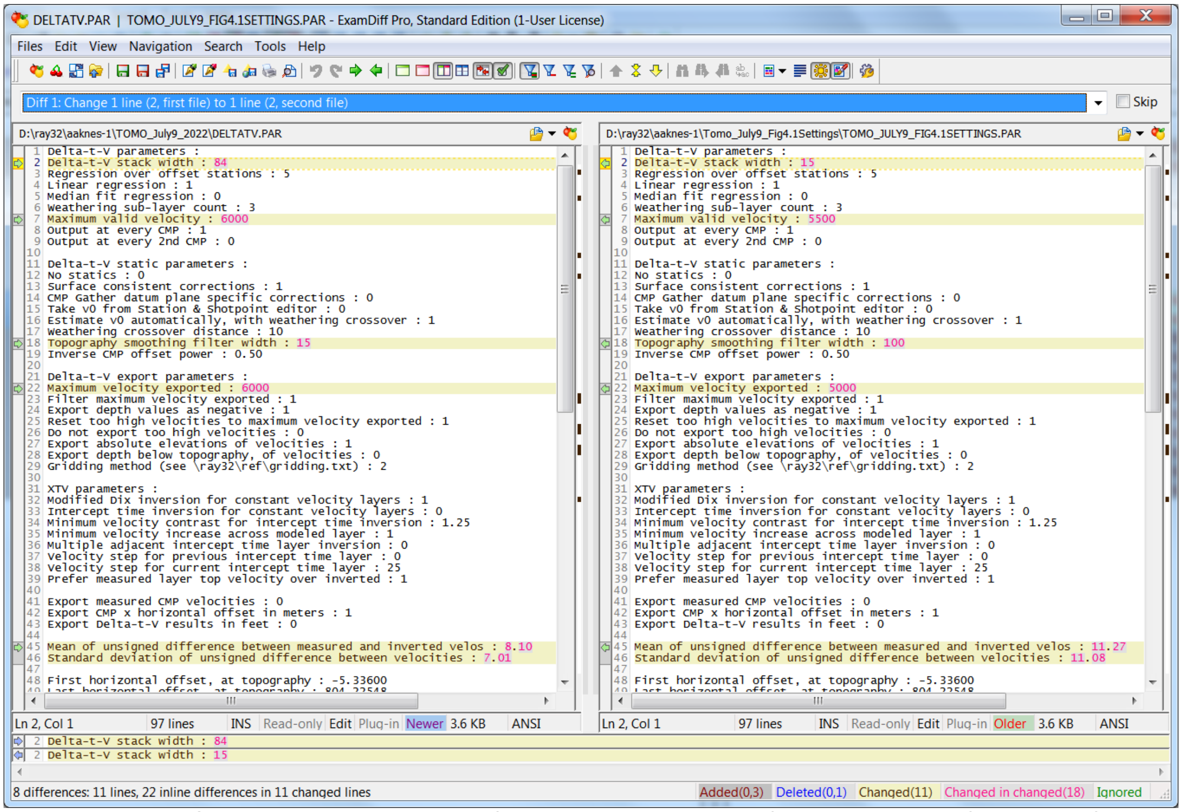
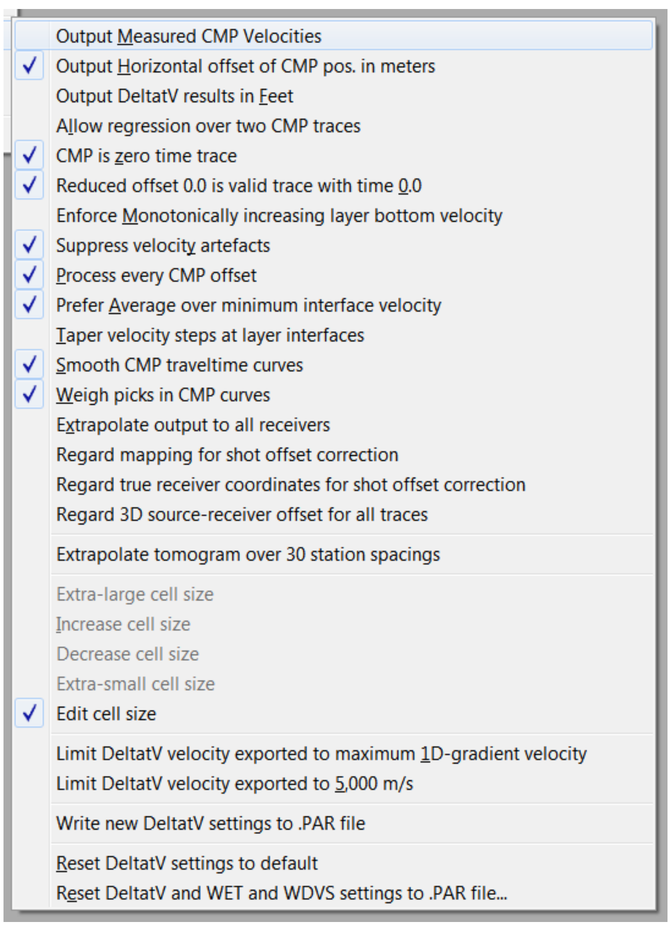


Fig. 31 : compare NGU DELTATV.PAR (right, used for Fig. 28) with automatic default DELTATV.PAR for Fig. 29 (left).



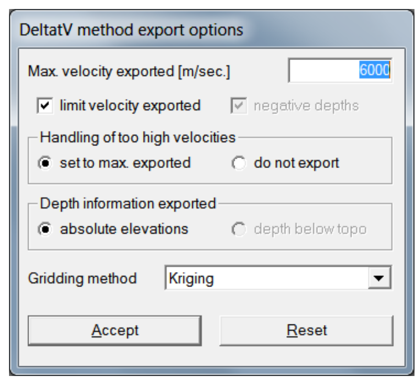


Fig. 32 (above) : *DeltatV|Interactive DeltatV|Export Options*. Increase *Max. velocity exported* to 6,000 m/s. Click *Accept* and *Cancel* buttons.

Fig. 33 (left) : *DeltatV|DeltatV Settings* used for Fig. 28 and Fig. 29.

To obtain Fig. 28 do these steps :

- create the profile database and import the .ASC and update header data with .COR and .SHO as on first page of this tutorial if not yet done so
- open Windows Explorer window
- create directory **C:\NGU_Fig4.1** in Windows Explorer
- download archive [Fig 4.1.zip] and copy into **C:\NGU_Fig4.1** folder in Windows Explorer and unzip
- select *DeltatV|DeltatV Settings|Reset DeltatV and WET and WDVS settings to .PAR file*
- select **C:\NGU_Fig4.1\DELTATV.GRD** and confirm prompt with *Yes* button
- select *DeltatV|Interactive DeltatV*. Confirm artefact prompt and click button *DeltatV Inversion*.
- click *Save* button to save file **DELTAT.TXT** into folder **C:\RAY32\AAKNES-1**
- wait for Surfer to complete the gridding and imaging of **C:\RAY32\AAKNES-1\DELTATV.GRD**
- select *Model|Forward model traveltimes* and **C:\RAY32\AAKNES-1\DELTATV.GRD**
- select *Grid|Turn around grid file by 180 degrees* and **C:\RAY32\AAKNES-1\DELTATV.GRD**
- select *Grid|Image and contour velocity* and **C:\RAY32\AAKNES-1\DELTATV.GRD**

Next obtain Fig. 29 with these additional steps :

- select *DeltatV|DeltatV Export options* or *DeltatV|Interactive DeltatV|Export options*
- increase *Max. velocity exported* to 6,000 m/s (Fig. 32). Click buttons *Accept* and *Cancel*.
- select *DeltatV|Automatic DeltatV* and confirm artefact warning prompt with *Yes* button
- select *Model|Forward model traveltimes* and **C:\RAY32\AAKNES-1\TOMO\DELTATV.GRD**
- select *Grid|Turn around grid file by 180 degrees* and **C:\RAY32\AAKNES-1\TOMO\DELTATV.GRD**
- select *Grid|Image and contour velocity* and **C:\RAY32\AAKNES-1\TOMO\DELTATV.GRD**

The too wide ***Topography smoothing filter*** 100 stations used by NGU (Fig. 31 right) causes over-correction of basement-refracted first breaks with too large static time corrections to too smooth floating datum obtained with this too wide *Topography smoothing filter* 100 stations (Fig. 28). Also due to the too narrow ***CMP curve stack width*** of 15 CMP's (Fig. 31 right) used by NGU the pseudo-2D DeltatV plot (Fig. 28) is not smoothed enough laterally/in horizontal direction with such strong topography. This constitutes not an optimization but rather a pessimization of default DeltatV parameter settings by NGU. Compare Fig. 28 with Fig. 4.1 (top right) in [NGU report 2019_004] to see similar artefacts caused by the same pessimized DeltatV settings.

The ***CMP curve stack width*** in *DeltatV|Interactive DeltatV* main dialog is automatically determined based on your profile's length and *Station spacing*. We strongly recommend leaving the *CMP curve stack width* at this already optimized default setting. Also we strongly recommend using *DeltatV|Automatic DeltatV* instead of *DeltatV|Interactive DeltatV* for more reliable DeltatV interpretation. DeltatV main dialog and DeltatV static corrections dialog are reset to safe default values with *Automatic DeltatV* inversion.

For recommended default settings for DeltatV static corrections dialog see our .pdf help https://rayfract.com/help/rayfract.pdf chapter ***DeltatV Static Corrections*** on page 208. For latest description see https://rayfract.com/help/DeltatV_Static_Corrections_July12_2022.jpg .

For recommended default settings in interactive DeltatV main dialog see our .pdf help https://rayfract.com/help/rayfract.pdf chapter ***Interactive DeltatV*** on page 206. For latest description see https://rayfract.com/help/DeltatV_Interactive_Main_Dialog_July12_2022.jpg .

For latest version of our help chapter on pseudo-2D DeltatV inversion see https://rayfract.com/help/DeltatV_Inversion.pdf .

For latest version of our help chapter on XTV inversion see https://rayfract.com/help/XTV_inversion_July_2022.pdf .

Here is the archive with Surfer 23 .GRD and .SRF and .PAR files for Fig. 28
Here is the archive with Surfer 23 .GRD and .SRF and .PAR files for Fig. 29
Here is the archive with seis32.* profile database files for Fig. 29
Here is the archive with NGU DELTATV.PAR for Fig. 28, made available by NGU on July 4, 2022

See also our NGU_G1 tutorial comparing pessimized DeltatV static correction settings used by NGU (Fig. 30) with our optimized DeltatV+XTV settings and default static correction settings (Fig. 25 and Fig. 32).

Conclusions

With significant errors in reciprocal traveltime picks (Fig. 27) of up to 15ms and strong and uncertain topography (Fig. 13 and 14) we strongly recommend using our default fail-safe *Smooth inversion* method (*Smooth invert|WET with 1D-gradient initial model*) which eliminates DeltatV artefacts by laterally averaging DeltatV velocities over the whole profile (Sheehan, 2005). Over-fitting such noisy data with our multirun WET inversion and too much minimized WET smoothing does not make sense. Low-resolution input gives low-resolution output. However WDVS (Zelt and Chen 2016) can help even with noisy picks (Fig. 21, Fig. 22).

Also we strongly recommend using *DeltatV|Automatic DeltatV* instead of *DeltatV|Interactive DeltatV* for more reliable DeltatV interpretation. DeltatV main dialog and DeltatV static corrections dialog are reset to safe default values with *Automatic DeltatV* inversion. Edit export options (Fig. 32) with new *DeltatV menu* item *DeltatV Export options* available in latest 4.03 build dated July 14, 2022. Edit XTV parameters with *DeltatV menu|XTV parameters* & check version 4.03 box *Use above XTV settings for Automatic DeltatV*.