Interpretation of GEOXP13 with WET tomography, using smooth 1D starting model and pseudo-2D XTV starting model : imaging of velocity inversion over complex basement :

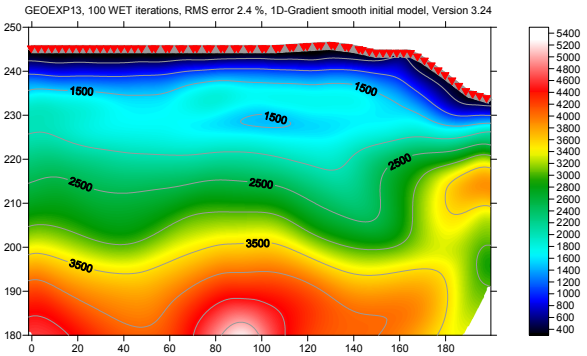

Fig. 1 : Smooth inversion, 100 iterations, 1D gradient initial model see Fig. 3. Wavepath width 40%, envelope width 39%.

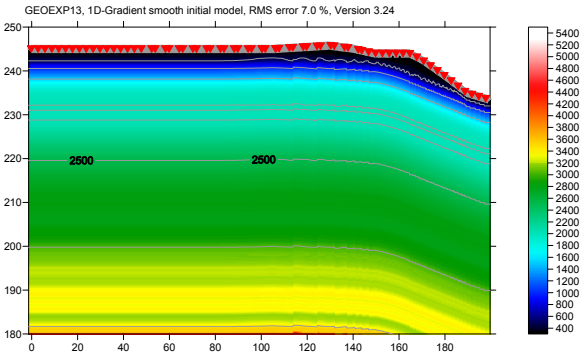

Fig. 3 : Smooth XTV starting model used for Fig. 1. Version 3.24 Smooth inversion defaults.

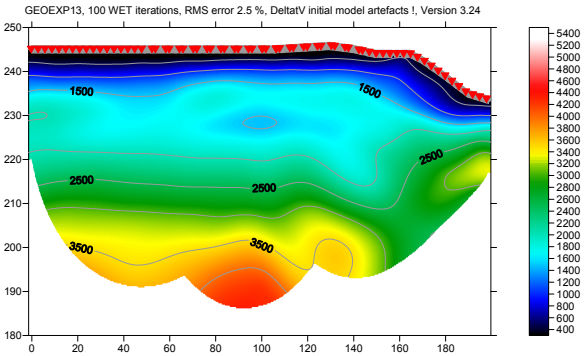

Fig. 2 : 100 WET iterations, pseudo-2D XTV starting model see Fig. 4. WET wavepath width 40%, envelope width 10%.

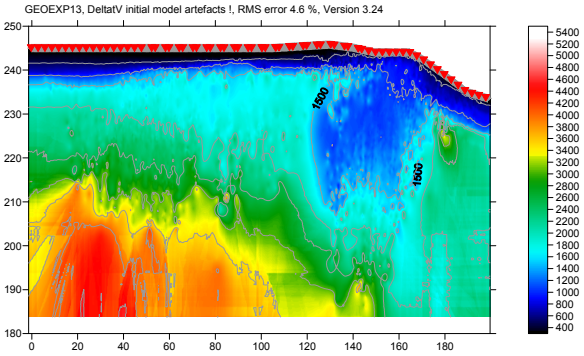

Fig. 4 : Pseudo-2D XTV starting model used for Fig. 2. Low-velocity artefact below anticline at horizontal offset 160m, as shown in tutorial broadepi

Runtime for Smooth inversion (Fig. 1) with 100 WET iterations over 13,256 traces was about 40 minutes on an Apple MacBook Air running Windows 7 Pro under Parallels Desktop 7, using 4 virtual CPU's on 1.8 GHz Intel Core i7 with two hyper-threaded physical cores.

The good match between Fig. 1 and Fig. 2 confirms these two interpretations, obtained with quite different starting models. Fig. 3 is starting model for Fig. 1 and Fig. 4 is starting model for Fig. 2.

First, import the data and review shot-sorted traveltime curves :

- Start up Rayfract® via desktop icon. Select *File|New Profile…*
- Set *File name* to GEOEXP13 and click *Save button*
- Specify *Station spacing* of 0.5 m in *Header|Profile*, see Fig. 10
- Unzip archive GEOEXP13.ZIP in directory \RAY32\GEOEXP13\INPUT
- Select *File|Import Data…* and specify *Import data type* ASCII column format, see Fig. 11
- Click *button Select* and select file GEOEXP13.ASC in directory \RAY32\GEOEXP13\INPUT
- Check box *Batch import*
- Leave *Default spread type* at *10: 360 channels*
- Click *button Import shots*, and confirm prompt
- *File|Update header data|Update Station Coordinates...* with \RAY32\GEOEXP13\INPUT\GEOEXP13.COR
- Select *Refractor|Shot breaks* to display traveltime curves, see Fig. 7

Now run Smooth inversion, with default parameters :

- Uncheck *Grid|Label shot points on tomogram*
- Select *Smooth invert|WET with 1D-gradient initial model*, and obtain 1D initial model, see Fig. 3
- if you see a prompt **Assertion failed! File: CMPPRCSR.CPP Expression: gradient_traceCount_ok**, safely dismiss this with *Ignore button.* These prompts do not show with latest version 3.24, for GEOEXP13 .

- Confirm prompts, for default WET output after 20 iterations (Fig. 5 and 6)

Redo Smooth inversion with **increased WET wavepath width 40%**, see Fig. 12 :

- Select *WET Tomo|Interactive WET tomography…*, set *Number of WET tomography iterations* to 100
- Uncheck *or RMS error does not improve for n =*, set *Wavepath width* to 40%, *envelope width* to 39%
- Click *button Edit grid file generation*, set *Store each nth iteration only* to 20, click *Accept parameters*
- Click *button Start tomography processing*. Confirm prompts, obtain Fig. 1 and 8.
- Note **deeper imaging in Fig. 1** compared to Fig. 5, due to deeper wavepath coverage, see Fig. 8 vs. Fig. 6.

Run pseudo-2D XTV inversion, see Fig. 13 :

- Check *Smooth invert|Smooth inversion settings|Allow unsafe pseudo-2D DeltatV inversion*
- Check *DeltatV|DeltatV Settings|Suppress velocity artefacts*
- Check *DeltatV|DeltatV Settings|Process every CMP offset*
- Check *DeltatV|DeltatV Settings|Smooth CMP traveltime curves*
- Select *DeltatV|XTV parameters for constant-velocity layers*, click *buttons Layer model* and *Accept*
- Select *DeltatV|Interactive DeltatV* and confirm prompt, set *CMP curve stack width* to 120, see Fig. 13
- Click *button Static corrections* and change *Inverse CMP offset power* to 0.2, from default value 0.5
- Click *button Accept* and *button DeltatV Inversion*
- Confirm prompts, and save output into new subdirectory XTVDeltatV, to file XTVDeltatV.CSV
- Obtain Surfer plot as in Fig. 4

Run WET tomography with Fig. 4 as starting model :

- Select *WET Tomo|Interactive WET tomography…*
- Click *button Select* and select file \RAY32\GEOEXP13\XTVDELTATV\XTVDELTATV.GRD
- Set *Number of WET tomography iterations* to 100, uncheck *or RMS error does not improve for n =*
- Set *Wavepath width* to 40%, set *Wavepath envelope width* to 10%
- Click *button Edit grid file generation*, set *Store each nth iteration only* to 20, click *Accept parameters*
- Click *button Start tomography processing*
- Confirm prompts to obtain WET output with 100 iterations as in Fig. 2, with starting model Fig. 4

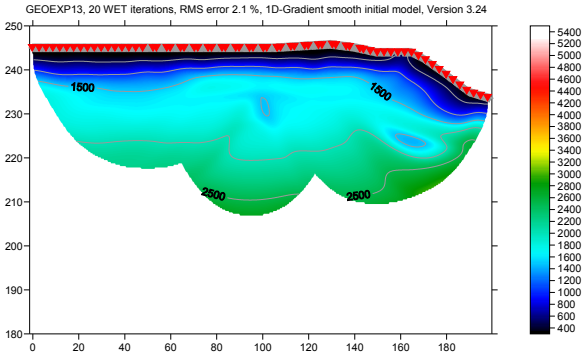

Fig. 5 : Smooth inversion 3.24 default settings, 20 WET iterations. Wavepath width 4.50, wavepath envelope width 0% .

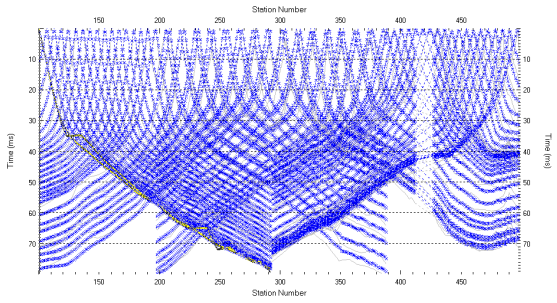

Fig. 7 : *Refractor|Shot breaks* . Grey curves are picked traveltimes, blue curves are modeled traveltimes, after 100 WET iterations, see Fig. 1.

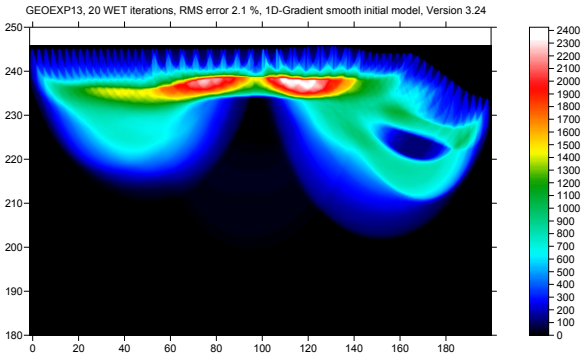

Fig. 6 : wavepath coverage plot obtained with Fig. 5.

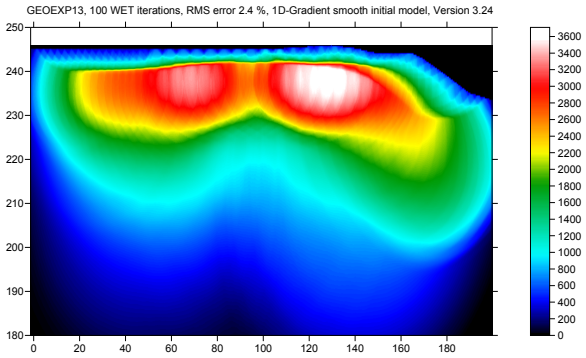

Fig. 8 : wavepath coverage plot obtained with Fig. 1

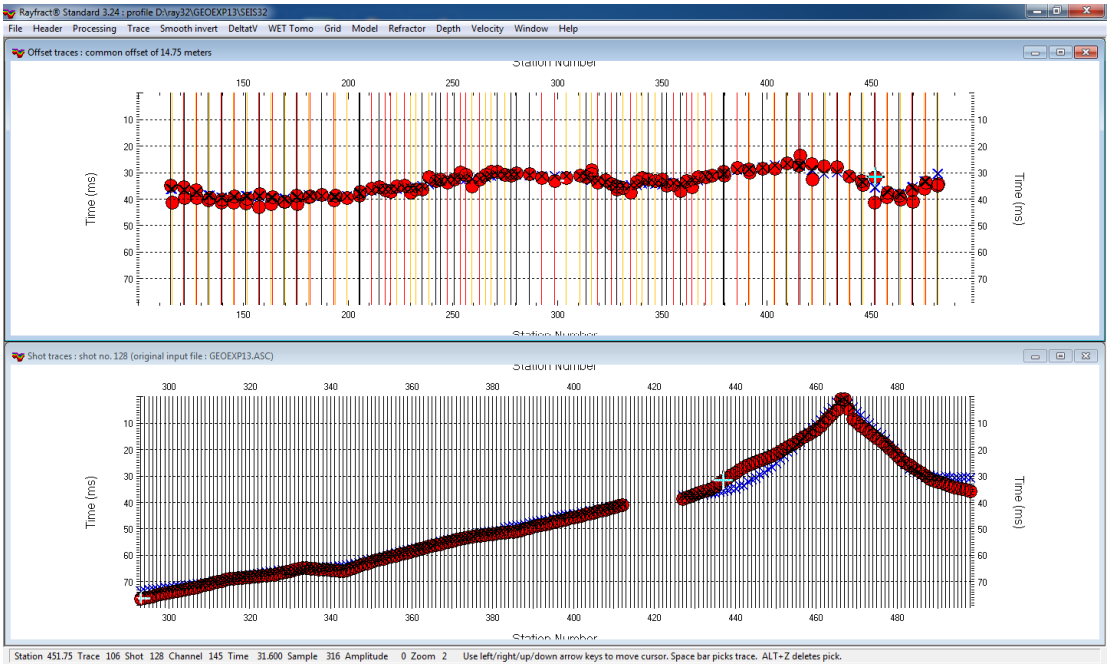

Fig. 9 : Top : *Trace|Offset gather*, for common offset 14.75m. Bottom : *Trace|Shot gather* for shot 128. Note reciprocity error of 10 ms at midpoint station number 451.75, shown on top. Channel 145 of shot 128 (highlighted with inverted cross picking cursor at top and bottom) is picked 10 ms earlier than channel 174 of shot 118. See riveral8 Fig. 11.

To **quality-check your first breaks with the traveltime reciprocity principle**, use *Trace|Offset gather* (Fig. 9). Browse common-offset sorted trace gathers with F7/F8. Browse traces and picks (red circles) in one gather with arrow left/right keys. The common offset is displayed in the title bar, in meters. Blue crosses are modeled picks.

According to the reciprocity principle, **seismic first break times, rays and wave paths are identical when swapping source and receiver positions, for each recorded trace**. So in Fig. 9, traces with same common offset and common midpoint (station number) should have the same first break pick time, according to the laws of physics. In other words, all first break picks (red circles) at same station number should vertically collapse onto each other. This would correspond to reciprocity error of 0 ms. The maximum reciprocity error in Fig. 9 is 10 ms at midpoint station number 451.75, see caption.

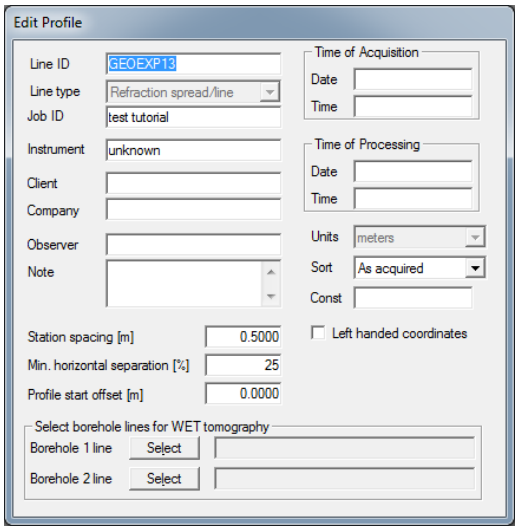

Fig. 10 : *Header|Profile*, edit profile header data

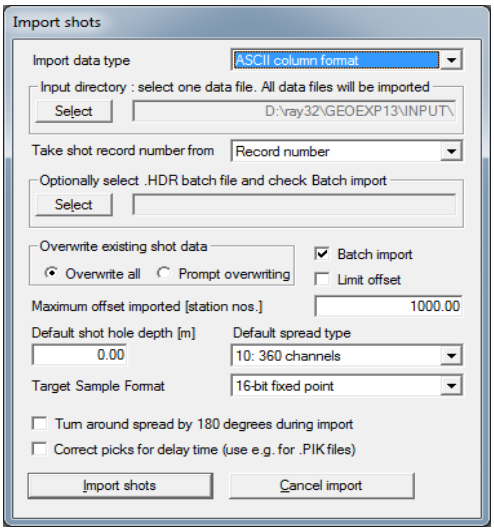

Fig. 11 : *File|Import Data...* , import shots

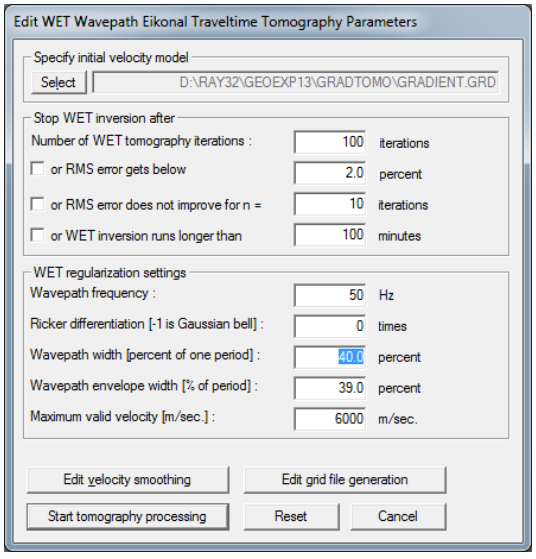

Fig. 12 : *WET Tomo|Interactive WET tomography…*, edit WET inversion parameters for Fig. 1 and 8.

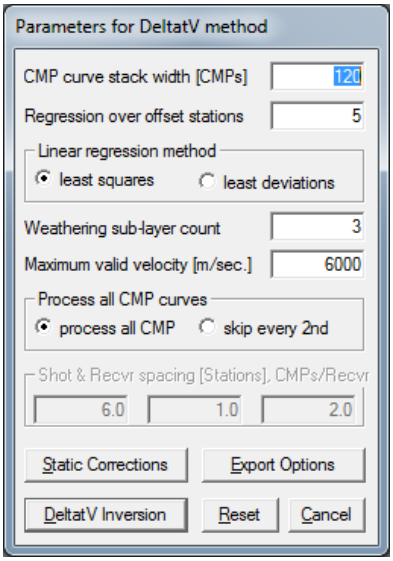

Fig. 13 : *DeltatV|Interactive DeltatV…*, edit DeltatV inversion parameters for Fig. 4.

The near-surface velocity inversion (low-velocity layer) in Fig. 1 and Fig. 2 "is in agreement with an abandoned mining shaft", according to Walter Frei of GeoExpert AG.

We have shown that increasing the WET wavepath width and envelope width results in deeper imaging, while keeping a good resolution in overburden (velocity inversion).

The low-velocity layer at elevation 230m and horizontal offset 100m is visible both with default wavepath width 4.5% in Fig. 5 and 40% in Fig. 1 and 2. So this anomaly is required to explain the traveltime data.

But the low-velocity anomaly at elevation 225m and horizontal offset 160m in Fig. 5 is not visible in Fig. 1 and 2. So this anomaly may be an artefact of the WET tomography, caused by too narrow WET wavepath width.

See our bulgatrl tutorial, showing systematic variation of WET wavepath width to explore non-uniqueness of the solution space.

The **low-velocity artefact** centered below the topography anticline at horizontal offset 160m in the pseudo-2D XTV starting model (Fig. 4) can be explained with ray geometry when sorting traces by Common MidPoint CMP. See our pdf reference chapter **Strong refractor curvature** and tutorials broadepi , epikinv and fig9inv .

We thank GeoExpert AG for this high-coverage and physically consistent data set, and for their permission to show processing of the data in this tutorial. For data sets with even lower RMS error see GEOXMERC and OT0608.