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



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

GEOEXP13, 20 WET iterations, RMS error 2.1 %, 1D-Gradient smooth initial model, Version 3.24



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

GEOEXP13, 20 WET iterations, RMS error 2.1 %, 1D-Gradient smooth initial model, Version 3.24





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

Edit Profile	
Line ID         GEOEXP13           Line type         Refraction spread/line            Job ID         test tutorial	Time of Acquisition Date Time Time
Instrument unknown Client Company Observer Note	Time of Processing       Date       Time       Units       meters       ✓       Sort       As acquired       ✓
Station spacing [m]         0.5000           Min. horizontal separation [%]         25           Profile start offset [m]         0.0000           Select borehole lines for WET tomography         Borehole 1 line           Borehole 1 line         Select           Borehole 2 line         Select	Left handed coordinates

Fig. 10 : Header Profile, edit profile header data

Import shots		
Import data type	ASCII column format	
Input directory : select one data file. All data files will be imported		
Select	D:\ray32\GEOEXP13\INPUT\	
Take shot record number from	Record number	
Optionally select .HDR batch file and check Batch import		
Select		
Overwrite existing shot data		
Limit offset		
Maximum offset imported [station nos.] 1000.00		
Default shot hole depth [m]	Default spread type	
0.00	10: 360 channels 🔹	
Target Sample Format	16-bit fixed point	
Tum around spread by 180 degrees during import		
Correct picks for delay time (use e.g. for .PIK files)		
Import shots	<u>C</u> ancel import	
in 11 · Eilellum aut Data immart als ata		

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

Edit WET Wavepath Eikonal Traveltime Tomography Parameters	Parameters for DeltatV method
Specify initial velocity model	
Select D:\RAY32\GEOEXP13\GRADTOMO\GRADIENT.GRD	CMP curve stack width [CMPs] 120
Stop WET inversion after	Regression over offset stations 5
Number of WET tomography iterations : 100 iterations	Linear regression method
or RMS error gets below 2.0 percent	least squares     C least deviations
or RMS error does not improve for n = 10 iterations	
or WET inversion runs longer than 100 minutes	Weathering sub-layer count 3
WET regularization settings	Maximum valid velocity [m/sec.] 6000
Wavepath frequency : 50 Hz	Process all CMP curves
Ricker differentiation [-1 is Gaussian bell] : 0 times	process all CMP     Skip every 2nd
Wavepath width [percent of one period] : 40.0 percent	
Wavepath envelope width [% of period] : 39.0 percent	Shot & Recvr spacing [Stations], LMPs/Recvr
Maximum valid velocity [m/sec.] : 6000 m/sec.	6.0 1.0 2.0
	Static Corrections Evport Options
Edit velocity smoothing Edit grid file generation	
Start tomography processing Reset Cancel	DeltatV Inversion Reset Cancel
Fig. 12 : WET TomolInteractive WET tomography	Fig. 13 : DeltatVIInteractive DeltatV

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 shaff", 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 <u>bulgatrl</u> 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 <u>broadepi</u>, <u>epikinv</u> and <u>fig9inv</u>.

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 <u>GEOXMERC</u> and <u>OT0608</u>.

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