

## WET inversion of reverse VSP survey, with Rayfract® 3.25

Start up Rayfract® Standard 3.25 via desktop icon. Select *File|New Profile...* . Set *File name* to ZIVKO13 and click *Save button*. Specify *Station spacing* of 5 m in *Header|Profile* (Fig. 1). Set *Line type* to Borehole spread/line.

Unzip archive [zivko13.zip](#) in directory \RAY32\ZIVKO13\INPUT.

Check *File|Import data Settings|Keep same Layout start for consecutive shot files* and check *Import horizontal borehole survey or .3DD refraction survey* (Fig. 2).

Select *File|Import Data...* (Fig. 3) and specify *Import data type* SEG-2. Click upper *Select button*, set *Files of type* to ABEM files (\*.SG2) and select Shot0001.SG2 in \RAY32\ZIVKO13\INPUT.

Click lower *Select* and .HDR batch file \RAY32\ZIVKO13\INPUT\ZIVKO13.HDF. Check *box Batch import*. Set *Default spread type* to 01: 24 channels. Click *button Import shots*, to import all 48 shots specified in ZIVKO13.HDR.

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

Fig. 2 : *File|Import Data Settings* submenu

Uncheck blanking options *WET Tomo|WET tomography Settings|Blank|Blank outside borehole tomogram* and *Blank below envelope after last iteration*.

Select *Refractor|Shot breaks*. Press ALT+P. Set *Maximum time* to 70 ms. Hit ENTER key to redisplay travelttime curves. Select *Mapping|Color picked travelttime curves*.

Select *Trace|Shot gather*. Press ALT+P. Set *Maximum time* to 70 ms. Hit ENTER. Select *Window|Tile*. Browse shots with F7/F8 (Fig. 4b).

Fig. 3 : *File|Import Data...*

Select *Smooth invert|WET with constant-velocity initial borehole model* and confirm prompt for Fig. 5. When you see the prompt “Continue with WET tomography ?” click *No button*.

Select *WET Tomo|Interactive WET tomography* and configure as in Fig. 4a. Click *button Edit grid file generation*. Set *Store each nth iteration only : n =* to 100. Click buttons *Accept parameters* and *Start tomography processing* for Fig. 6 and 7.

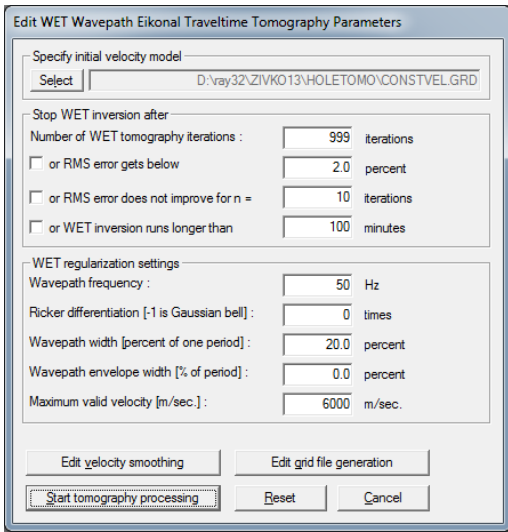


Fig. 4a : WET Tomo|Interactive WET tomography...

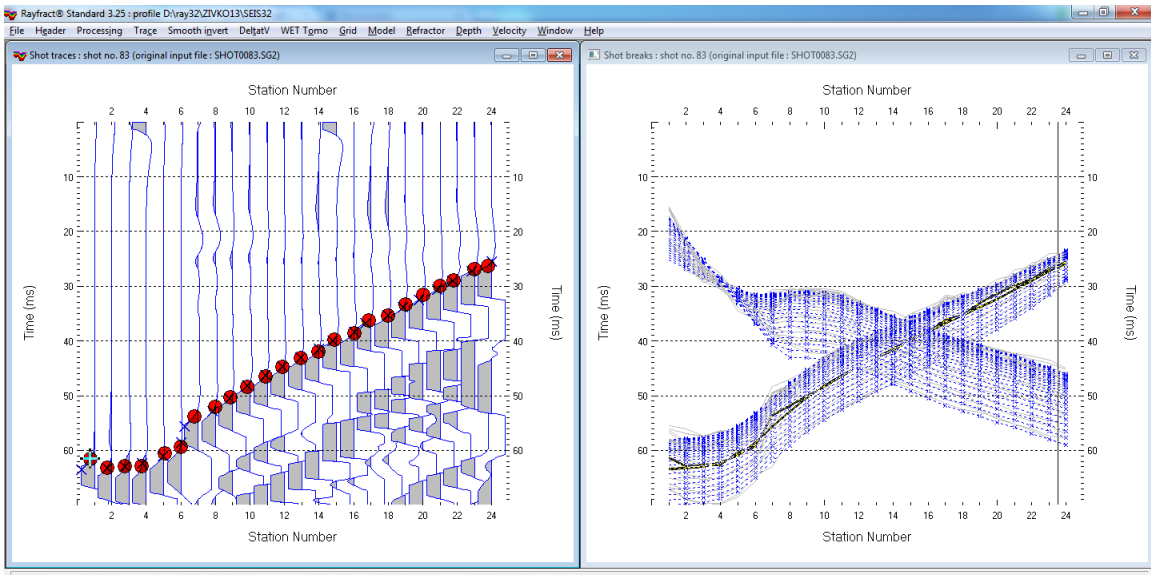


Fig. 4b : Left : Trace|Shot gather. Red circles are first break picks, blue crosses are modeled times.  
Right : Refractor|Shot breaks. Picked traveltime curves in grey, modeled times and curves in blue.

ZIVKO13, Constant-Velocity initial model, RMS error 9.5 %, Version 3.25

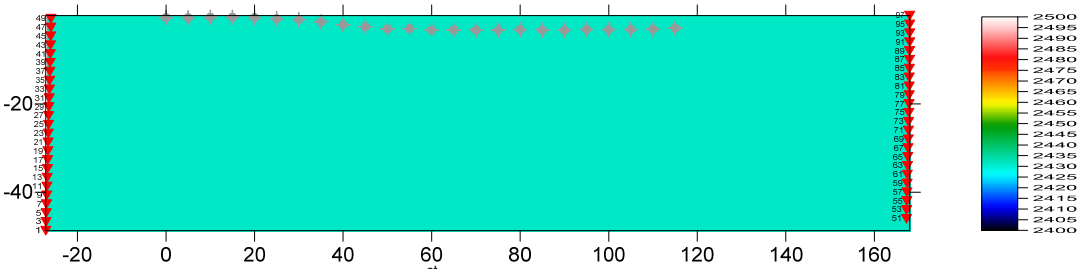


Fig. 5 : Constant-velocity starting model for 1<sup>st</sup> WET run

ZIVKO13, 999 WET iterations, RMS error 1.4 %, Constant-Velocity initial model, wavepath width 20%, Version 3.25

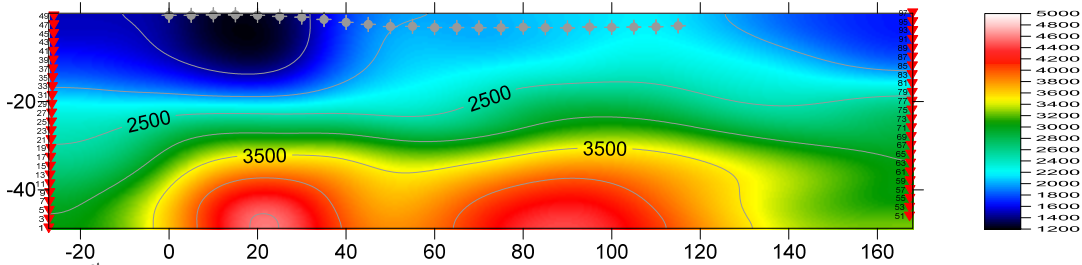


Fig. 6 : 1<sup>st</sup> WET run, 999 WET iterations, wavepath width 20%, Fig. 5 as starting model

ZIVKO13, 999 WET iterations, RMS error 1.4 %, Constant-Velocity initial model, wavepath width 20%, Version 3.25

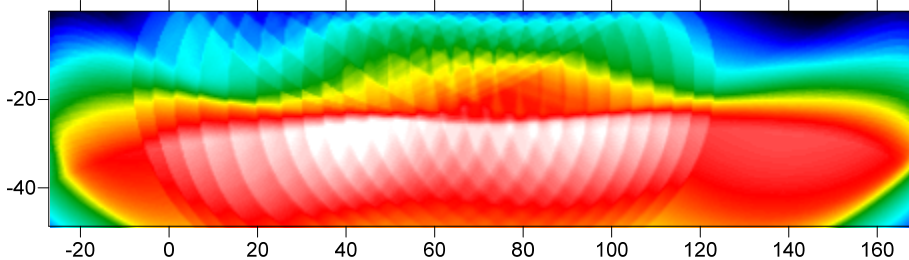


Fig. 7 : WET wavepath coverage plot obtained with Fig. 6

- start Windows Explorer and create new subdirectory \RAY32\ZIVKO13\2NDRUN4%
- copy \RAY32\ZIVKO13\HOLETOMO\VELOIT999.GRD into \RAY32\ZIVKO13\2NDRUN4%\ and rename to 1STRUNIT999.GRD
- copy \RAY32\ZIVKO13\HOLETOMO\VELOIT999.PAR into \RAY32\ZIVKO13\2NDRUN4%\ and rename to 1STRUNIT999.PAR
- select *WET Tomo|Interactive WET tomography* and configure as in Fig. 8
- click *button Edit grid file generation*. Set *Store each nth iteration only : n =* to 100
- click buttons *Accept parameters* and *Start tomography processing* for Fig. 10 and 11

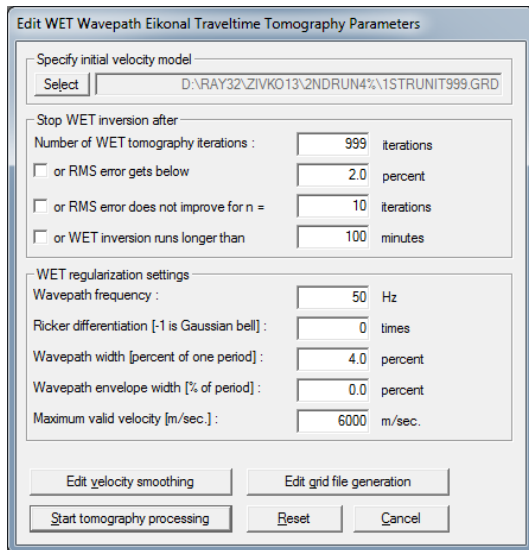


Fig. 8 : WET settings for 2<sup>nd</sup> run

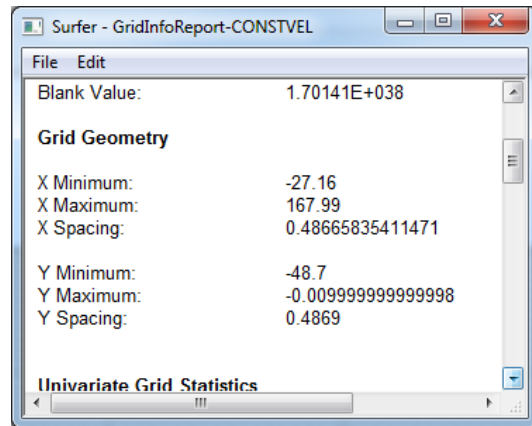


Fig. 9 : Surfer *Options|Grid Info...* for CONSTVEL.GRD

ZIVKO13, 999 WET iterations, RMS error 1.3 %, 2nd run, wavpath width 4%, Version 3.25

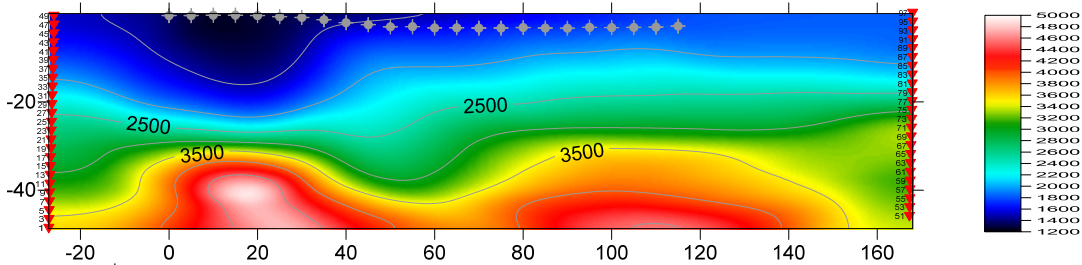


Fig. 10 : 2<sup>nd</sup> WET run, 999 iterations, wavpath width 4%, Fig. 6 as starting model

ZIVKO13, 999 WET iterations, RMS error 1.3 %, 2nd run, wavpath width 4%, Version 3.25

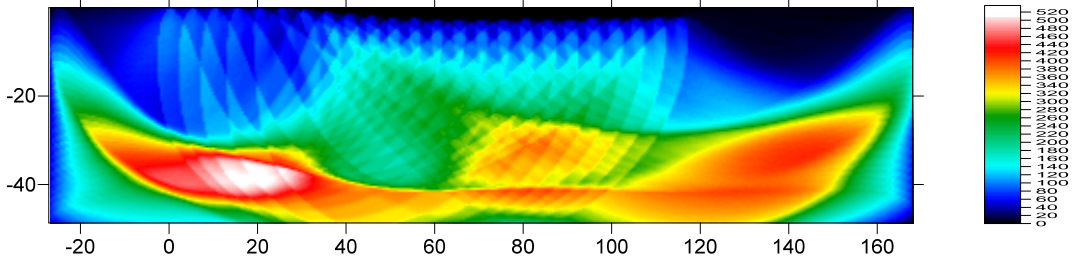


Fig. 11 : WET wavpath coverage plot obtained with Fig. 9

The RMS error decreases only slightly from 1.4% (Fig. 6) to 1.3% (Fig. 10). But the “top of basement” looks more plausible in Fig. 10, and velocities at the receivers are closer to 1,500 m/s .

Next we build a 1D-gradient starting model with Surfer. We can't use our DeltatV method for this, since there are no surface shots recorded, between the receivers. Then we rerun WET inversion with Fig. 14 as starting model, and limit the max. velocity to 4,500 m/s :

- create new directory \RAY32\ZIVKO13\GRADIENTMODEL, in Windows Explorer
- open \RAY32\ZIVKO13\HOLETOMO\CONSTVEL.GRD with Surfer
- select *Options|Grid Info...* in Surfer, to obtain Fig. 9
- select *File|New|Plot* in Surfer. Select *Grid|Function...* and edit as Fig. 12. Click *button OK*.
- using Windows Explorer, copy file \RAY32\ZIVKO13\HOLETOMO\CONSTVEL.PAR into directory \RAY32\ZIVKO13\GRADIENTMODEL and rename CONSTVEL.PAR to GRADIENT.PAR
- in Rayfract® 3.25, select *Model|Forward model traveltimes...* and your new GRADIENT.GRD
- select *Grid|Image and contour velocity and coverage grids...* and your GRADIENT.GRD for Fig. 14

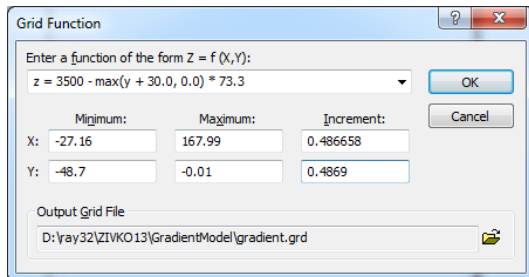


Fig. 12 : Surfer *Grid|Function...* settings

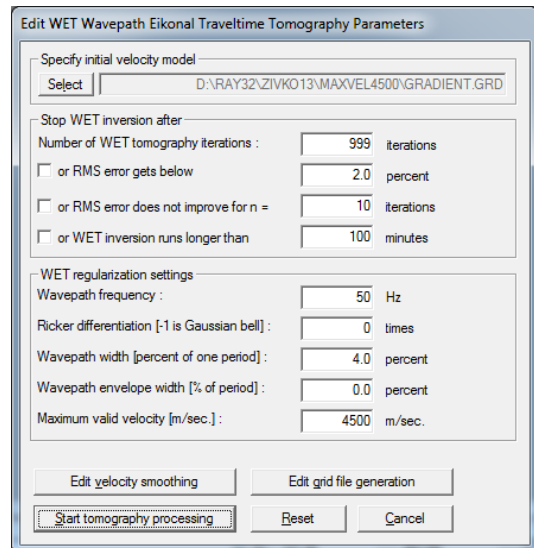


Fig. 13 : WET settings for 1D-gradient starting model

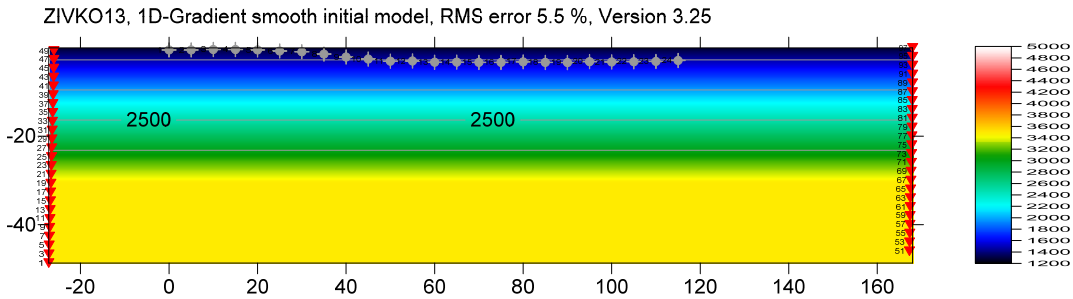


Fig. 14 : our 1D-gradient starting model, built with Surfer *Grid|Funtion...*, see Fig. 12

- in Windows Explorer, create new directory \RAY32\ZIVKO13\MAXVEL4500
- copy files GRADIENT.GRD, GRADIENT.PAR from directory ...\GRADIENTMODEL to ...\MAXVEL4500
- select *WET Tomo|Interactive WET tomography...* and edit as Fig. 13, click button *Start tomography processing...*
- confirm prompts to obtain Fig. 15 and Fig. 16

ZIVKO13, 999 WET iterations, RMS error 1.3 %, 1D-Gradient initial model, max. velocity 4,500 m/s, Version 3.25

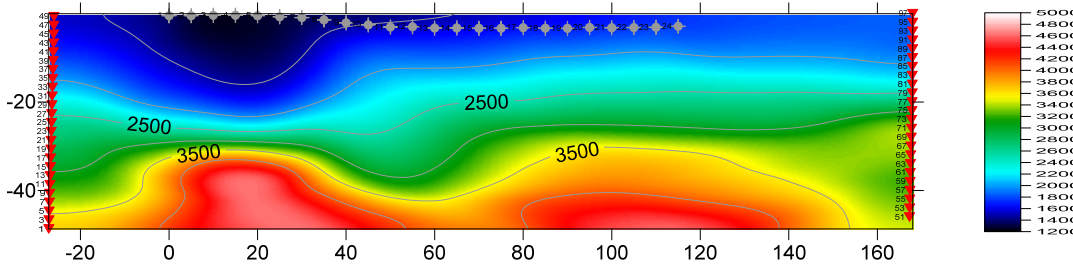


Fig. 15 : WET with 1D-gradient starting model (Fig. 14), 999 iterations, wavewidth 4% (Fig. 13)

ZIVKO13, 999 WET iterations, RMS error 1.3 %, 1D-Gradient smooth initial model, max. velocity 4,500 m/s, Version 3.25

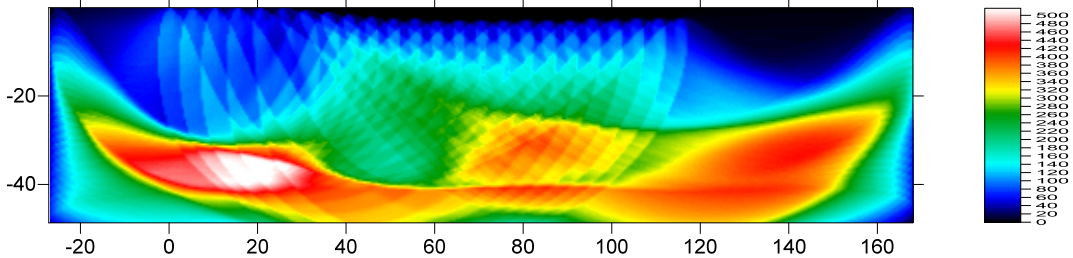


Fig. 16 : WET wavepath coverage plot, obtained with Fig. 15

Fig. 15 with 1D-gradient starting model is not significantly different from Fig. 10, based on Fig. 6 and constant-velocity starting model. So our 1D-gradient starting model did speed up the convergence, but the final WET velocity tomogram (Fig. 15) is not significantly improved from Fig. 10. WET inversion is not dependent on the starting model, at least in this case.

WET inversion as shown in Fig. 13, 15 & 16 took 23 minutes (999 WET iterations, 49 shots into 24 receivers) on MacBook Air with 1.8 GHz Intel Core i7 processor, using two hyper-threaded CPU cores.

Shoot from more than two boreholes to increase angular coverage and robustness of the 2D WET Wavepath Eikonal Traveltime tomographic inversion ([Schuster 1993](#)).

We thank our client GHD and Zivko Terzic for making available above data.