Import SEG-2 .DAT & Update header data & Smooth invert cross-hole line MDW2011 v. 4.05 :

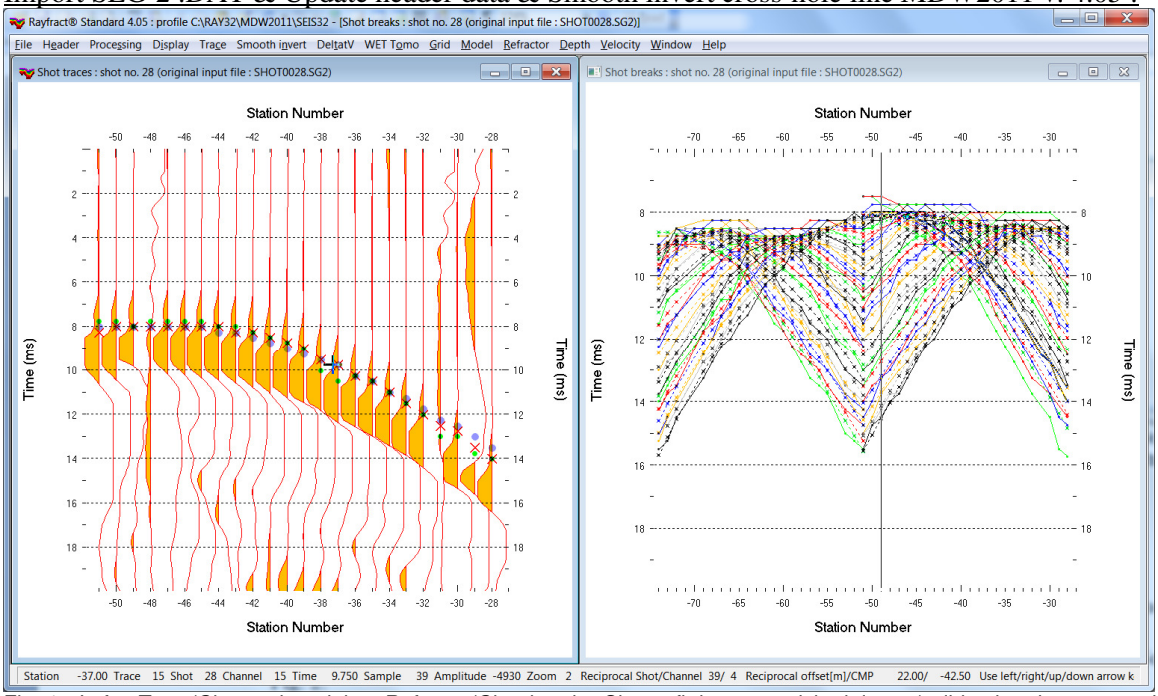

Fig. 1 : Left : *Trace|Shot gather*, right : *Refractor|Shot breaks*. Shows fit between picked times (solid colored curves, red crosses) and modeled times (dashed colored curves, blue dots). Green dots are your reciprocal picks.

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

- ***File|New Profile***…, set *File name* to **`MDW2011`** and click *Save button*
- in the prompt shown next (Fig. 4) click ***No*** button .
- in ***Header|Profile***… set *Line type* to **`Borehole spread/line`** . Set *Station spacing* to 2.0m. See Fig. 2.
- unzip archive **`https://rayfract.com/tutorials/MDW2011_23_INPUT.zip`** with **`SEG-2 .SG2`** shot files & files **`COORDS.COR & SHOTPTS.SHO & BREAKS.LST`** in directory **`C:\RAY32\MDW2011\INPUT`**
- select ***File|Import Data***… and set *Import data type* to **`SEG-2`**. See Fig. 3.
- click *Select button* and navigate into **`C:\RAY32\MDW2011\INPUT`**
- set *Files of type* to **`ABEM files (*.SG2)`** and select a file e.g. **`SHOT0001.SG2`** & click *Open*
- leave *Default spread type* at **`10: 360 channels`**
- click ***.HDR batch*** button. Select **`MDW2011.HDR`** file and click *Open* button.
- check box ***Batch import*** (Fig. 3). Click ***Import shots button*** . All **`.SG2`** files listed in **`MDW2011.HDR`** batch file are imported automatically.
- select *File|Update header data|Update Station Coordinate*s & **`COORDS.COR`**. Click *Import & Reset*.
- select *File|Update header data|Update Shotpoint coordinates* & **`SHOTPTS.SHO`** & click *Open*.
- select *File|Update header data|Update First Breaks*. Select file **`BREAKS.LST`** & click *Open*.
- select *Trace|Shot gather* and *Window|Tile* to obtain Fig. 1
- click on title bar of *Refractor|Shot breaks* window (Fig. 1 right) and press ALT+P. Edit *Maximum time* to 20 ms & press ENTER key to redisplay. Do the same for *Trace|Shot gather* window (Fig. 1 left).
- click on title bar of *Trace|Shot gather* window and press CTRL+F1 to zoom trace amplitude
- press CTRL+F3 to toggle trace wiggle display mode in *Trace|Shot gather* window.
- browse shots in *Trace|Shot gather* window with F7/F8 (Fig. 1 left).

To configure and run our default fail-safe *Smooth inversion* :

- check option *Grid|CS_CENTERED font for shot points and receivers* to fix Surfer display issues
- select option *Grid|Vertical plot title*.
- edit *Grid|Surfer plot Limits* as in Fig. 8.
- select ***Smooth invert|WET with constant-velocity initial model***
- wait for the constant-velocity starting model to show as in Fig. 5
- confirm prompt to continue with WET inversion to obtain WET output shown in Fig. 6 & 7

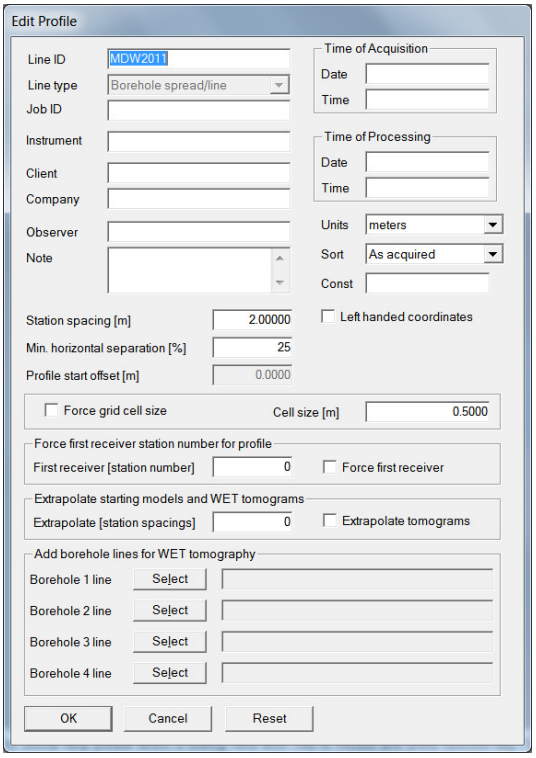

Fig. 2 : *Header|Profile*

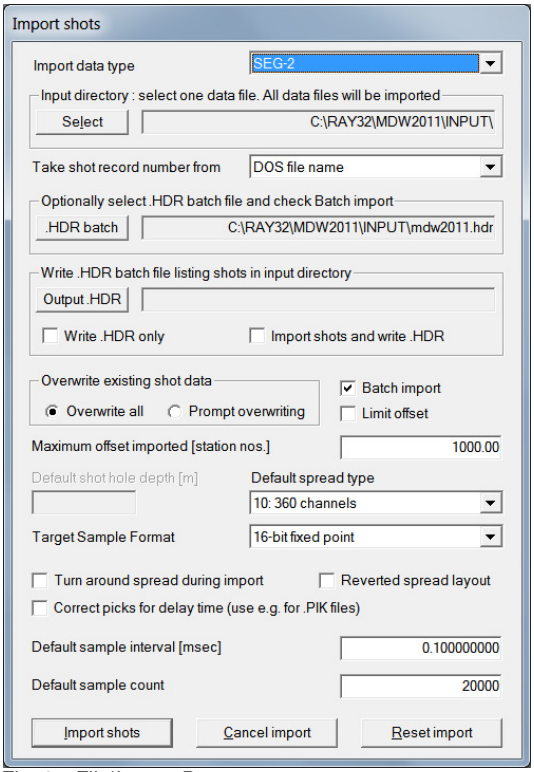

Fig. 3 : *File|Import Data*

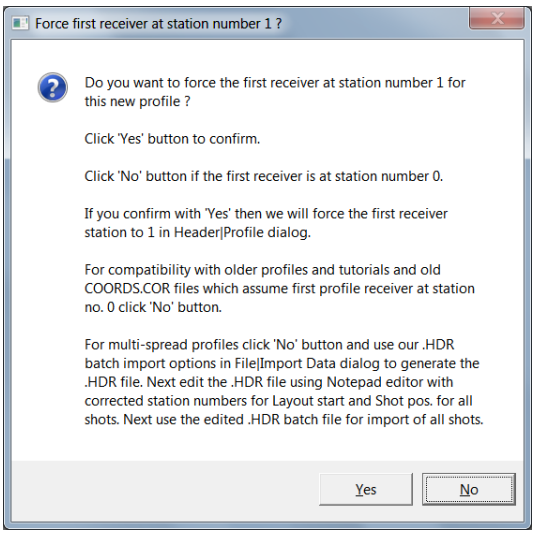

Fig. 4 : click *No* button.

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 multi-spread profiles click No button and use our .HDR batch import options in *File|Import Data* dialog to generate the .HDR file. Next edit the .HDR file using MS Notepad editor with corrected station numbers for *Layout start* and *Shot pos.* for all shots. Next use the edited .HDR batch file for import of all shots.

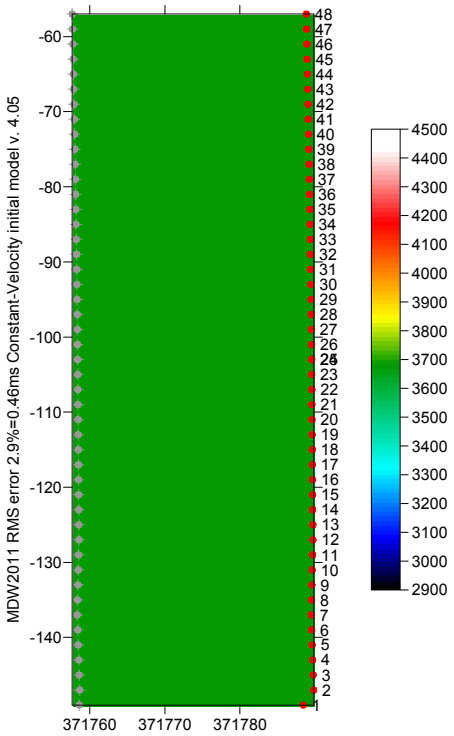

Fig. 5 : Smooth invert|WET with constant-velocity initial model.

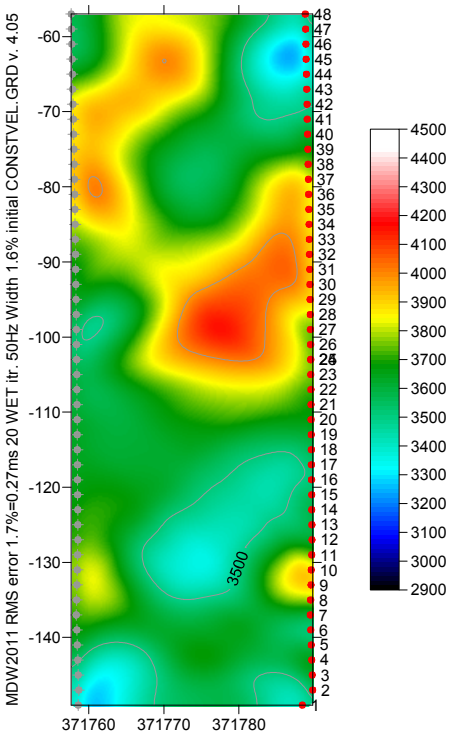

Fig. 6 : Smooth invert|WET with constant-velocity initial model. 20 Steepest-Descent WET iterations. Full WET smoothing. WDVS disabled.

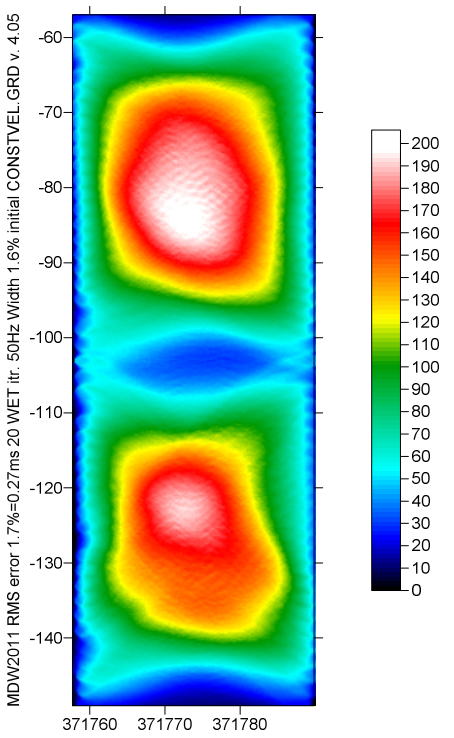

Fig. 7 : WET wavepath coverage plot obtained with Fig. 6. Unit is wavepaths per pixel.

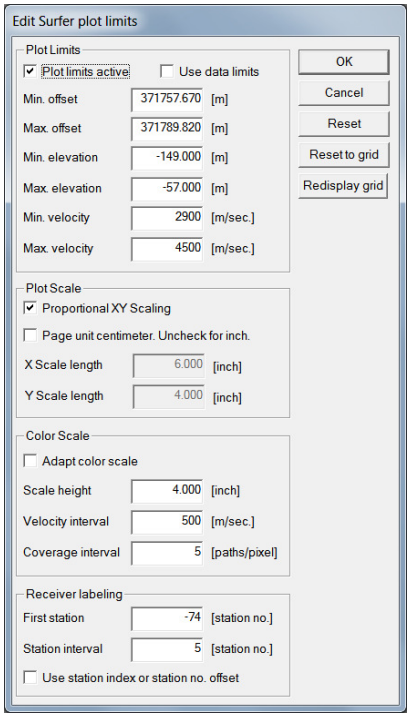

Fig. 8 : Grid|Surfer plot Limits

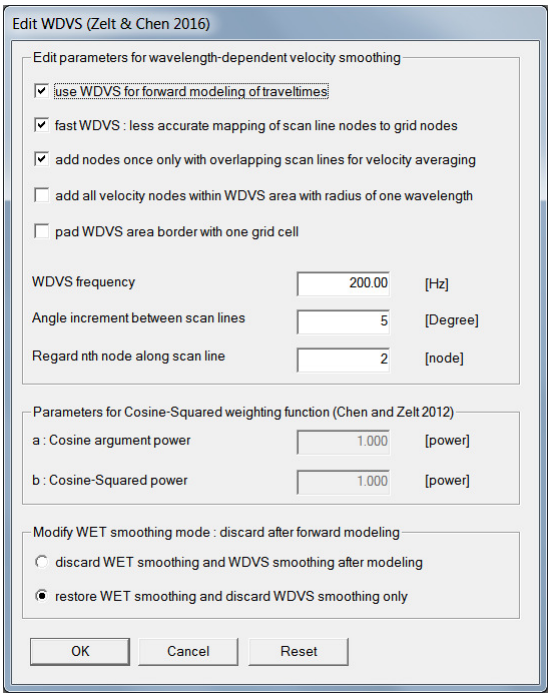

Fig. 9 : Model|WDVS Smoothing dialog .

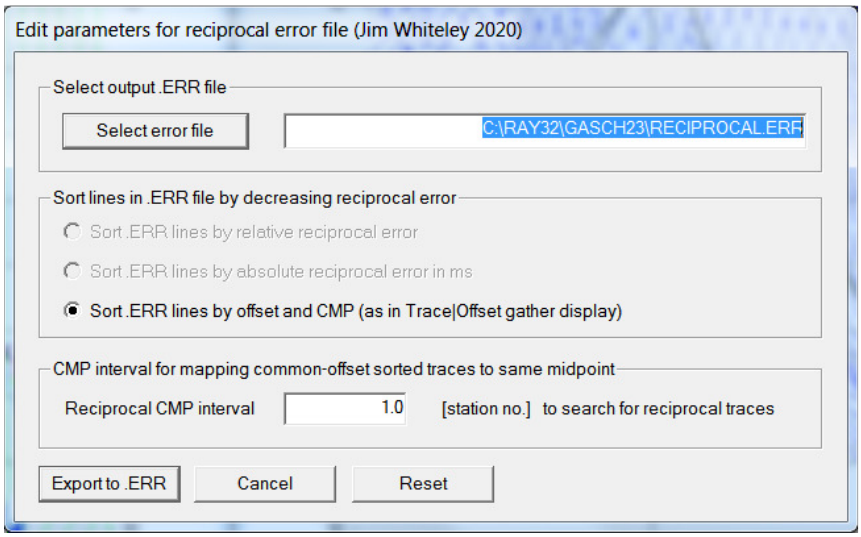

Fig. 10 : Trace|Export reciprocal errors and update database

<u>How to enable WDVS (Wavelength-Dependent Velocity Smoothing) and rerun Smooth inversion :</u>

- select *Model|WDVS Smoothing* (Fig. 9)
- check box *use WDVS for forward modeling of traveltimes*
- edit field *WDVS frequency* to 200Hz
- click button *OK*
- select ***WET Tomo|Automatic WET tomography***
- navigate into folder **`C:\RAY32\MDW2011\HOLETOMO`** and select starting model **`CONSTVEL.GRD`**
- click *Open* to rerun the Smooth inversion using your selected starting model grid to obtain Fig. 11&12

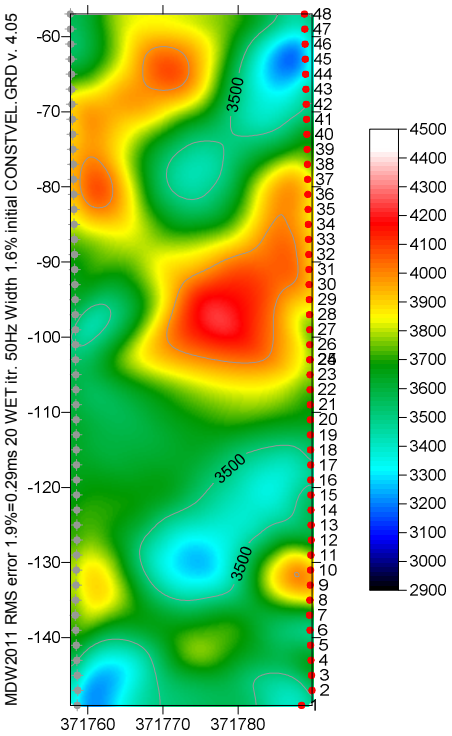

Fig. 11 : WET Tomo|Automatic WET with WDVS enabled @200Hz (Fig. 9). Starting model is Fig. 5.

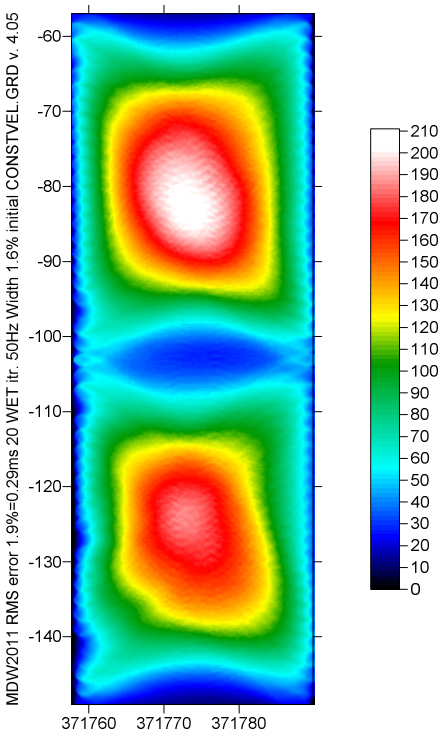

Fig. 12 : WET wavepath coverage plot obtained with Fig. 11. Unit is wavepaths per pixel.

How to plot your reciprocal traveltime picks on shot-sorted trace gathers :

Next we show how to plot your reciprocal traveltime picks on shot-sorted trace gathers. This lets you quality-control your first break picks and check the validity of your recording geometry specification (shot station numbers and receiver station numbers). See Whiteley J. et al. 2020 : Landslide monitoring using seismic refraction tomography – The importance of incorporating topographic variations :

- select ***Trace\|Export reciprocal traveltime picks and update database***
- click button *Select error file* and click *Save* button (Fig. 10)
- increase field *Reciprocal CMP interval* to 1.0 stations from default 0.5 stations to increase number of reciprocal trace pairs exported to .ERR file
- click button *Export to .ERR*
- select *Trace\|Shot gather* and *Window\|Tile* to obtain a window display as in our Fig. 1
- check new version 4.05 option ***Display\|Show reciprocal picks on Shot Gather***
- browse and zoom trace gathers with function keys F7/F8, F1/F2 etc. as usual
- navigate traces with arrow-left and arrow-right keys
- if a reciprocal pick was determined/matched to the current trace then this is plotted as a green dot on the trace
- also we show ***Reciprocal Shot/Channel*** and ***Reciprocal offset[m]/CMP*** in status bar at bottom of window (Fig. 1 left) if a reciprocal pick is available in the .ERR file
- after repicking traces in *Trace\|Shot gather* repeat above steps to update the reciprocal pick display

Here is the link to the .RAR archive with the MDW2011 profile folder for above Fig. 11 :

https://www.dropbox.com/scl/fi/lov8folnew8ctq1nf6ioa/MDW2011_Dec9_2023.rar?rlkey=cqome9rgi5536e4fhkxqy9gf1&dl=0

Select above link and copy with CTRL+C. Then paste the link into your web browser with CTRL+V and press RETURN key to download the .RAR archive.

Note how enabling WDVS (Wavelength-Dependent Velocity Smooothing; Zelt and Chen 2016) increases the contrast between low-velocity and high-velocity anomalies in the WET tomogram. Compare Fig. 11 with Fig. 6. The RMS error increases slightly (0.29ms vs. 0.27ms) when enabling WDVS at 200Hz.

We recommend restoring WET smoothing after forward modeling (Fig. 9) for cross-hole surveys.

See also our earlier tutorial from 2011 showing processing of the same data and available at

https://rayfract.com/tutorials/mdw2011.pdf

We thank Zivko Terzic formerly at GHD in Australia, for making available this consistent borehole data set in 2011 and for their permission to use this profile for a tutorial.

For an overview of our WDVS (Wavelength-Dependent Velocity Smoothing; Zelt and Chen 2016) see these publications :

Zelt, C. A. and J. Chen 2016. Frequency-dependent traveltime tomography for near-surface seismic refraction data, Geophys. J. Int., 207, 72-88, 2016. See https://dx.doi.org/10.1093/gji/ggw269 and https://www.researchgate.net/publication/305487180_Frequency-dependent_traveltime_tomography_for_near-surface_seismic_refraction_data .

Rohdewald S.R.C. 2021a. Improving the resolution of Fresnel volume tomography with wavelength-dependent velocity smoothing, Symposium on the Application of Geophysics to Engineering and Environmental Problems Proceedings : 305-308. https://doi.org/10.4133/sageep.33-169 . Slides at https://rayfract.com/pub/SAGEEP%202021%20slides.pdf

Rohdewald S.R.C. 2021b. Improved interpretation of SAGEEP 2011 blind refraction data using Frequency-Dependent Traveltime Tomography, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-4214, https://doi.org/10.5194/egusphere-egu21-4214

For an objective comparison of tomographic refraction analysis methods see these publications :

Zelt, C.A., Haines, S., Powers, M.H. et al. 2013. Blind Test of Methods for Obtaining 2-D Near-Surface Seismic Velocity Models from First-Arrival Traveltimes, JEEG, Volume 18(3), 183-194. https://scholarship.rice.edu/handle/1911/72113?show=full
https://www.researchgate.net/publication/267026965 .

Hiltunen, D. R., Hudyma, N., Quigley, T. P., & Samakur, C. 2007. Ground Proving Three Seismic Refraction Tomography Programs. Transportation Research Record, 2016(1), 110–120. https://doi.org/10.3141/2016-12 . https://www.researchgate.net/publication/242072938 .

Sheehan J.R., Doll W.E. and Mandell W.A. 2005a. An Evaluation of Methods and Available Software for Seismic Refraction Tomography. Journal of Environmental and Engineering Geophysics, volume 10, pp. 21-34. ISSN 1083-1363, Environmental and Engineering Geophysical Society. JEEG March 2005 issue. https://dx.doi.org/10.2113/JEEG10.1.21 . https://rayfract.com/srt_evaluation.pdf .
https://www.researchgate.net/publication/242159023 .

More references :

Whiteley J. et al. 2020. Landslide monitoring using seismic refraction tomography - The importance of incorporating topographic variations. Engineering Geology 2020.
https://www.researchgate.net/publication/339280163