

Release notes Rayfract® versions 2.61 to 3.22 :

Version 3.22 released in May 2012 :

- **support non-standard SEGY .SGY import**, with *File/Import Data...* .Test this with updated free trial [RAYTRIAL.EXE](#) . This now allows import of **Ambrogeo Echo 12/24** non-standard .SGY files. Enable the following three new SEGY settings for this to work :
- *File/SEGY import settings/Non-standard byte ordering : low byte stored first (NOT big-endian)* allows import of .SGY disk files with words store in reversed byte order (little-endian).
- *File/SEGY import settings/One shot per .SGY file : disregard original field record number in trace header* assumes that all traces in one .SGY file belong to one shot record, when importing.
- *File/SEGY import settings/No receiver coordinates specified in .SGY file* assumes that .SGY does not contain valid receiver coordinates. Our SEGY import routine determines *receiver position* for each .SGY channel via *channel number, default spread type* and *edited layout start*.
- *Smooth invert/Smooth inversion Settings/Wide smoothing filter for 1D initial velocity profile* is now enabled per default, when opening/creating a profile database, or when resetting settings to defaults.

Version 3.21 released in April 2012 :

- **SEGY .SGY import**, in *File/Import Data...* .Test this with updated free trial [RAYTRIAL.EXE](#) .
- support importing multiple shots stored in same SEGY .SGY file.
- display of SEGY trace header fields *FieldRecordNo* and *EnergySourcePointNo* in *Header/Shot* .
- *Shot pos.* and *Layout start* are determined by dividing .SGY *source/group x/y/z coords.* by *Station spacing* as specified in *Header/Profile*. You can edit these station numbers in *Import Shot dialog*.
- check *File/Import Data Settings\ Keep same Layout start for consecutive shot files* and *File/Import Data Settings/Default layout start is 1.0* to assign station number 1 to leftmost profile/spread receiver during following import, with *File/Import Data...* . This works again for SEG-2 import as well.
- **Batch import of shot files**. You can *specify shot file name, sequential shot number in input file, shot number in database, layout start, shot pos.* etc. in a .HDR import batch file. Tested SEG-2 and SEG-Y import, with one or multiple shots per SEG-Y file. See [2lamb15.hdr](#) for a sample .hdr batch import file, specifying import of shots from two .sgy files.
- updated [mdw2011.zip](#) with mdw2011.hdr batch file, for tutorial [mdw2011.pdf](#) .
- *WET Tomo/Coverage plot setup...* allows thinning of the WET coverage plot. Specify *every nth shot and receiver* for which wavepaths are plotted. **Easier visualizing of wavepaths**, with dense plots.
- *WET Tomo/WET tomography Settings/Export modeled WET times to .LST* writes VELOITXY.LST files with picked and modeled times, for tomogram VELOITXY.GRD and during WET inversion.
- *Model/Forward model traveltimes...* now forward models first break times with our *Eikonal solver* for both sources and receivers, and determines an improved synthetic time by taking the average of forward time (from source) and reverse time (from receiver), for the same ray and trace.
- wider *station number range*, now from -1,000,000 to 1,000,000. Previously was -10,000 to 10,000 .
- improved Wavefront and Plus-Minus refraction methods for long sections. We allow larger values for **smoothing parameters** (*overburden filter, basement filter*). See our updated tutorials [ot0608.pdf](#) and [GEOXMERC.pdf](#) .
- wider text fields showing selected .GRD and .PAR files of selected initial model, in *WET Tomo/Interactive WET tomography...* .
- write new *Smooth inversion* and WET settings to .PAR files.
- *Grid/Reset DeltatV and WET settings to .PAR file...* **restores inversion parameter settings from .PAR** file, associated with selected DeltatV, Gradient or WET velocity .GRD file. Available with our Rayfract® Pro annual subscription license only.
- improved robustness of memory management during *DeltatV* method inversion, for large data sets.
- *Trace/...gather/Processing/Edit offset range* allows editing of station number range with ALT+P, used for displaying trace gathers with *Trace menu*. This disables horizontal zooming with SHIFT+F1.
- *Trace/...gather/Processing/Edit time window* allows editing of time window with ALT+P, used for displaying trace gathers with *Trace menu*. This disables vertical time zooming with F1.
- *GeoTomCG .3DD* and *Geometrics Plotrefa .VS* import routine sequentially increases shot number when importing multiple .3DD or .VS files, stored in same *input directory*. Previously, the shot number was reset to 1 for first shot of each file.
- more accurate determination of *shot position*, during import of shots, editing in *Header/Shot* , updating *shot points* with SHOTPTS.SHO and when forward modeling traveltimes with Eikonal solver. Helps with strong topography and lateral offsets. Now stores 3 digits after decimal point instead of 2 digits.

- *Smooth inversion Settings/Increase grid cell size* now gives .GRD Surfer grids with at least 400 columns, instead of at least 600 columns, and at least 100 rows. This further increases cell size.
- *Smooth invert/Smooth inversion Settings/Wide smoothing filter for 1D initial velocity profile* sets vertical smoothing filter width to 20% of depth range of *1D-gradient initial model*, instead of 10%.
- increased minimum required *WET wavepath width* in *WET Tomo/Interactive WET tomography...*, to 20% of unscaled default value, to prevent the publication of artefacts. Too narrow wavepath width and *Fresnel volume width* is physically impossible and meaningless. See Fig. 1 in [Hagedoorn 1959](#).
- see [SAGEEP10.pdf](#) for help on *WET wavepath width* and other WET and DeltatV settings.
- fixed scaling bug in *Refractor/Midpoint breaks display*, for long seismic traces ([riveral8.pdf](#)).
- fixed a few corner cases when mapping traces to refractors in *Refractor/Midpoint breaks display*.
- allow importing non-standard **Micromed SoilSpy Rosina SEG-2 files**.
- allow import of non-standard **DMT SUMMIT SEG-2** trace files.
- *File/SEG-2 import settings submenu*, for more control over **determination of SEG-2 trace data start**.
- recommend to improve first break picks if *normalized RMS error* larger than 3%. Refer to [riveral8.pdf](#).
- updated Windows Help file [rayfract.hlp](#). Install via [rayhlpup.exe](#) installer. Updated topic **Crosshole survey interpretation**, and new topic **Downhole VSP interpretation**.
- to open **Windows help files under Windows 7**, you need to download and install Microsoft [WinHlp32.exe](#). This component is not included out-of-the-box any longer.
- regenerated [rayfract.pdf](#) from latest version of help file, now with graphics.
- updated [function_keys.pdf](#), listing new keyboard shortcuts ALT+Z and SHIFT+Z.
- [ot0608.pdf](#) tutorial shows interpretation of a large and dense data set, with Smooth inversion, XTV inversion and Wavefront refraction. These methods show good agreement with each other.
- updated tutorial [clud1.pdf](#). Uncheck *WET tomography Settings/Disable wavepath scaling for short profile*, to get more resolution directly below topography. Weathering layer looks more realistic.
- set *WET Tomo/Interactive WET tomography... /Degree of differentiation of Ricker wavelet* to 1, to obtain sharper/less smooth WET output, e.g. for [SAGEEP11 refraction data set](#). Watch for artefacts.
- [Benjumea et al. 2011](#) compare ERT with SRT (WET tomography) and Nakamura H/V method.
- [Lamb et al. 2011](#) show geothermal fault imaging with ERT, SRT and SP, on an AGU 2011 poster.
- [Doug Crice](#) describes how to record and process borehole shear-wave surveys including VSP
- pick S-wave first breaks in our *Trace/Shotpoint gather* display, for pairs of shots with reversed trace polarity, recorded at common shot points.
- use Matlab code [fn_writeseg2.m](#) to convert SEG-Y files to SEG-2. We provide this code as is without support, and you need to adapt it to your situation (number of channels, number of samples per trace). Also, you need to load the [SegyMAT module](#), on which this code depends. We thank Andrew Lamb at Boise State University for making this code available.
- install and run Rayfract® under **Parallels Desktop on an Apple iMac or MacBook Air portable**, e.g. in a Windows 7 virtual machine. We tested Parallels 6 with Mac OS X 10.6 Snow Leopard on iMac, and Parallels 7 with Mac OS X 10.7 Lion on MacBook Air. Adapt the Apple keyboard mapping :
 - in Apple menu under Mac OS X, select System Preferences... and Keyboard. Check **Use all F1, F2, etc. keys as standard function keys**, for easy usage of **function keys in Windows**.
 - map Windows style right-click to Ctrl+Click, in Parallels Desktop|Preferences...|Keyboard.
 - disable Mac OS X system shortcuts in Parallels Desktop|Preferences...|Keyboard.

Version 3.20 released in October 2011 :

- *WET Tomo/WET tomography Settings/Enable AWE physical memory page caching* uses RAM memory above 4GB, up to 64 GB, for travelttime grid caching during WET inversion, with Microsoft® [Address Windowing Extension](#). Also see [Mark Russinovich's description of AWE](#). This setting is enabled with our **Rayfract® Pro annual subscription license** only. Ask for our pricing. Normally 32-bit Windows® applications can only use maximally 2 or 3 GB of RAM. This option speeds up WET inversion by up to 5 times for large data sets, by avoiding disk access and virtual memory paging/swapping to disk. We recommend running our Annual Pro license under Windows 7 64-bit.
- **more WET regularization/smoothing, for low-velocity sections**. Based on average velocity of the initial model, we now automatically increase default *WET wavepath width* and *smoothing filter size*, for low-velocity sections e.g. shear-wave surveys or areas with thick non-consolidated, loose overburden.
- *Processing/Frequency filter...* allows **frequency filtering with single-pole filter or Chebyshev-Butterworth**, in *Trace/Shot gather display*. High-pass or low-pass filter. Edit *cutoff frequency*, and

number of times the filter is cascaded. Edit *percent ripple* and *number of poles* (relevant for Chebyshev-Butterworth only).

- each filter stage is in turn convolved with the (filtered) trace signal, for better numerical stability.
- we optionally do **bidirectional filtering**. This can help to better preserve the wave form of the recorded signal and first break pulse.
- *Processing/Bandpass filter...* shows **Band-pass/Band-reject dialog**, in *Trace/Shot gather*. Uses single-pole filter or Chebyshev-Butterworth twice, in sequence for band-pass and in parallel for band-reject.
- per default, we use single-pole filter, for above high-pass/low-pass and band-pass/band-reject filters, instead of Chebyshev-Butterworth. This reduces overshoot and ringing in trace display, but has more gradual roll-off in frequency domain.
- for more information on these digital filters, see <http://www.dspguide.com/>, chapters 19 and 20.
- four most recent profile databases are listed at bottom of *File menu*. Select any of these to quickly reopen the database, containing trace data, header data, recording geometry and inversion parameters.
- when you reopen any profile database, trace gather displays shown with *menu Trace* are restored to same settings (coloring, zooming, filtering, processing) as when you worked with these the last time.
- trace processing and display settings in *menu Processing* are stored separately for each trace gather type, as selected with *Trace menu*. These settings are also restored, when you reopen a profile database.
- *Velocity display/Show maximum velocity at bottom* option. Plot velocity graph with inverted velocity axis, with velocity increasing towards bottom. Better correlation with depth section display.
- *Smooth invert/Smooth inversion Settings/Increase grid cell size* increases default cell size for the initial model grid. This allows longer initial models, regarding constant maximum grid node count of 640,000. Use to avoid **Degenerated grid message**, for **long, shallow initial models and marine surveys**. For both short and long profiles, grid row count decreases, to at least 100 grid rows instead of at least 200 rows. This speeds up *WET inversion*. With this option enabled, *WET inversion* may become instable, in case of velocity inversion. *WET RMS error* will slightly increase.
- our Rayfract® Pro annual subscription license allows larger grids with up to 1,280,000 nodes.
- *WET Tomo/WET tomography Settings/Disable traveltime grid caching* results in all *traveltime grids* being written to disk, instead of cached in RAM. May reduce disk swapping, in case of low RAM.
- *File/Update header data menu* items *Update First Breaks...*, *Update from Gremix .GRM files ...* and *Update from OYO .ODT files...* don't reset the trigger delay of updated shots any longer.
- our *Interpex Gremix .GRM import routine* now accepts a *station interval* (specified on first line of .GRM file) smaller than 1.0. Previously, the *station spacing* was reset to 1.0m in this case.
- fixed determination of *source/receiver elevation* during SEG-2 import into *borehole spread/line*, based on *Station spacing*, *Default spread type*, *Layout start* and *Shot pos.* specified during import.
- fixed first break picking in *Trace/Shot gather* if *Refractor/Shot breaks* is open. This was broken in early version of 3.20. Just close *Refractor/Shot breaks window*, so picking in shot gather works fine again.
- we do not support running our software under Microsoft® Windows 2000 any longer. When starting version 3.20 under Windows 2000, it recommends using Windows XP, and shuts down again.
- if Rayfract® can't open a profile database under Windows 7 64-bit, shutting down with an error message instead, right-click the Rayfract® *desktop icon* and select *Run as administrator*. Retry open.
- before backing up a profile database (files SEIS32.*), always first exit via *File/Exit*, to close the database. Otherwise the profile database is still opened and being updated by Rayfract®. **Backing up an opened database results in missing database files, or in a corrupted snapshot of the database.**
- if you change *Surfer Preferences/Drawing/Page Units* to *Centimeters* from default *Inches*, tomograms plotted with Rayfract® will be too small. Just revert this *Surfer* setting to *Inches*, to fix this issue.
- to update your rayfract.hlp help file and Rayfract® help menu, download our new installer <http://rayfract.com/help/rayhlpup.exe> and run on the PC holding your current Rayfract® installation.
- updated [thrust tutorial](#), showing building of a thrust zone model grid with Golden Software Surfer. Now shows easier forward modeling of dummy shots over this grid, to obtain synthetic shots. Following *Smooth inversion* shows that our *WET inversion* is capable of **imaging lateral velocity variation**.
- tutorial [rival8.pdf](#) shows *WET inversion* of 6 shots into 12 receivers, imaging a sapprolite setting. Also, we show our new band-pass frequency filtering, and how to **quality-check first breaks and picks in Trace/Offset gather, according to traveltime reciprocity principle**.
- tutorial [mdw2011.pdf](#) shows SEG-2 borehole shot import, header data update and *Smooth inversion*.
- tutorial [lnc17.pdf](#) shows how to image two adjacent cross-hole surveys (3 boreholes) in one tomogram. You can import SEG-2 shots into *borehole spread* profiles instead of .3DD shots. Just select the *import data type* in our *Import shots dialog*. See above [mdw2011.pdf](#).
- updated [tutorial camp1](#) shows how to build a custom layer-based initial model and use this for *WET inversion*. We recommend to always use our default 1D initial model, with *Smooth inversion* method.

- for surveys with homogeneous overburden, including marine streamer surveys, pseudo-2D DeltatV can work well, even without running WET inversion. See [GEOXMERC.pdf](#) and [ot0608.pdf](#) . The longer the overlapping receiver spreads and the resulting seismic line, recorded with roll-along technique customary in reflection seismics, and the denser the receiver and shot spacing, the better DeltatV will work. DeltatV and XTV parameters need to be tuned; see above two .pdf tutorials.
- [Falgàs et al.](#) show mapping of a deltaic subsurface system near Barcelona, with audiomagnetotellurics, reflection and refraction seismics interpretation (WET tomography), combined with borehole logs.
- [Boiero and Socco](#) compare surface wave analysis with WET tomography, using both synthetic model-generated and field-recorded data. These two methods show good agreement with each other.
- [Benjumea et al. 2008](#) show combining seismic and CSAMT methods in a sinkhole site study.
- [Robert Whiteley](#) comments on Mt. Bulga refraction data interpretation published by Dr. Palmer. Regarding [Dr. Palmer's response](#), our WET inversion is capable of **imaging lateral velocity variation**, see our [thrust.pdf](#) tutorial and tutorials [epikinv.pdf](#), [broadepti.pdf](#), [fig9inv.pdf](#) and [SAGEEP11.pdf](#), showing inversion of synthetic data generated from known models. These tutorials come with links to the synthetic data and model files. So anybody can verify our imaging, or test their own inversion method. We continue to recommend running [at least 50 or 100 WET iterations](#). This enables our WET inversion to **remove artefacts of the initial model**. This removal of artefacts is shown in our tutorials [thrust.pdf](#), [epikinv.pdf](#), [broadepti.pdf](#), [fig9inv.pdf](#) and [SAGEEP11.pdf](#) .
- [Thesis Stefan Jansen, Niels Bohr Institute, University of Copenhagen 2010](#) evaluates WET with synthetic data for models of faults and small velocity anomalies, in Appendix C. Using 50 WET iterations as recommended, helped to **remove horizontal layering artefacts of the 1D initial model**.
- for theoretical determination of resolution limit of WET inversion see [Sheng and Schuster 2003](#).

Version 3.19 released in June 2011 :

- **select and configure Printer in File/Print Setup...** under Microsoft Windows® Vista and Windows 7. Once done, click on *Print button*, then select *File/Print* to print the currently selected window. For version 3.18, left-click *Windows 7 Start button* and select default printer in *Devices and Printers*.
- *Window/Display annotations in Arial* uses Arial font, for axis annotation. Uncheck for Sans Serif font.
- *Window/Large annotations* uses large font, for display of axis title and labels. Uncheck for small font.
- *Window/Print wide sections with large annotations* for **report-style .PDF graphics, when printing to Adobe Acrobat or CutePDF Writer**. Specify horizontal scale and vertical scale with ALT+P in corresponding section window. Uncheck this when printing high sections, to prevent too large font.
- *Window/Print with display colors* uses orange color for printing of travelttime curve segments mapped to weathering layer (refractor 0), in *Refractor/Shot breaks* or *Refractor/Midpoint breaks* . Uncheck this to print with light blue color instead.
- **delete all first break picks for current shot** in *Trace/Shot gather*, with SHIFT+Z keyboard shortcut.
- **delete all branch points for current shot** in *Refractor/Shot breaks*, with SHIFT+Z keyboard shortcut.
- easier shortcuts for deleting branch points in *Refractor/Shot breaks*, now with ALT+F1, ALT+F2 .
- new ALT+Z shortcut for deleting first break pick of current trace, in *Trace menu gather displays* .
- always draw travelttime curves with solid pen in *Refractor/Shot breaks* for *Line type Borehole spread/line*, independent of *Station spacing* and actual *receiver spacing*.
- improved **AGC Automatic Gain Control** in *Trace/Shot gather*, ALT+M. *AGC window length* can vary between 0 and length of trace. All samples at trace start/end are gained, independent of window length.
- *Smooth inversion* and *WET processing* now are enabled once you **import at least 3 shots into your profile database**, for *line type Refraction spread/line*. Also, these methods refuse to run if your *shot spacing* is too wide, compared to the *receiver spacing*.
- *Smooth invert/Smooth inversion Settings/Extrapolate tomogram over five station spacings* lets you use shotpoints offset maximally 5 station intervals from first/last profile receiver, for *DeltatV* and *WET* . May cause velocity artefacts in tomogram, due to missing receivers. Use if absolutely necessary only.
- fixed endless loop in *Wavefront method* for short profiles, if forward/reverse refractor segments do not overlap sufficiently, with *Depth/Depth conversion Settings/Link travelttime curves* checked.
- faster back-projection of residuals along wavepaths, with SIRT-like algorithm, during WET inversion. **Up to 25% faster overall WET inversion**, for large and dense data sets. Small data sets 5% faster.
- database utilities for creating a new profile, checking a profile database, importing and exporting spread types, and Scripiter are now called directly instead of via .BAT batch file. This should help to avoid **issues with too stringent security checks for .BAT files**, e.g. under Windows XP SP3.

- improved error handling logic when calling external commands such as database utilities. Easier to understand error messages. For DBREV.EXE database revision utility, exit codes are translated to text.
- when running 3.19 under Windows Vista, select *File/Call batch via PIF file*, before running our *Smooth inversion* etc. Otherwise Rayfract® cannot call into Golden Software Scripiter and Surfer version 8.
- if **Golden Software Scripiter utility hangs and/or shows ActiveX errors**, please upgrade to Surfer version 10. The free demo version is available at <http://goldensoftware.com> . First startup Surfer via *desktop icon* and click on *Splash screen*, to avoid delay or Scripiter errors. Next image tomograms with Rayfract® using *Smooth invert*, *WET Tomo* and *Grid menus*, as usual. If Scripiter still hangs, right-click *Surfer desktop icon* and select *Run as administrator*. Surfer 10 also offers corrected **Grid blanking** with *Grid/Blank...* , for large .GRD grid files.
- you can have multiple Surfer versions installed at the same time. Just start the desired version with its *desktop icon*, before running Rayfract®.
- updated [rayfract.hlp](#) help. Run [raywn318.exe](#) to install this. With more information, easier instructions and lots of screen shots of dialogs and menus.
- updated uphole tutorial [coffey04.pdf](#) . We reprocessed this with version 3.19, and updated instructions.
- to suppress horizontal layering artefacts in the 1D initial model, **limit the maximum exported DeltaV velocity to e.g. 3,000 m/s instead of default 5,000 m/s**. See [palmfig3.pdf](#) and [SAGEEP10.pdf](#), page 25 of 44. This will speed up convergence, together with increased *WET iteration count* of e.g. 200.
- for high-quality seismograph traces with good signal-to-noise ratio, we recommend to **stack 10 or 12 shots at the same shot point. This enables accurate first-break picking**, a prerequisite for SRT .
- for exact shot timing try [GISCO piezoelectric trigger switches](#) . Timing is essential for shot stacking.
- try **disabling AGC on your seismograph when stacking shots**. Otherwise pre-first break noise may not cancel out while adding shots to the stack. Verify this on your seismograph trace display.
- aim for an **RMS error below 2%** (as shown on top of WET tomograms). For higher RMS errors, check and fix first break picks, in *Trace gather* and *Refractor/Shot breaks* displays. See [GEOXMERC.pdf](#) .
- for noisy traces, uncertain first break picks and *Smooth inversion RMS error* above 2%, **increase the WET wavepath width**, e.g. multiply by two. This gives smoother WET output, avoiding artefacts.
- also increase *WET wavepath width* if subsurface velocity is slower than normal, e.g. in case of S-wave surveys and low-velocity, unconsolidated overburden sediments. Otherwise the too thin wavepaths may cause **black uncovered regions in the wavepath coverage plot**, with too wide shot spacing. This may prevent a robust convergence towards meaningful interpretation, with increasing *WET iteration count*.
- SRT Seismic Refraction Tomography and seismic refraction methods in general will not work reliably or at all in **strong velocity-inversion situations**, with a high-velocity layer (paved road) above a lower-velocity sediment layer. You may have a chance to image this by orientating the line perpendicular to the road, and planting shots and receivers both on and besides the road, at sufficient offsets to reach the higher-velocity basement. See http://rayfract.com/samples/street_crossing.pdf .
- to increase lateral resolution when inverting first breaks with WET :
 - run *Smooth invert/WET with 1D-gradient initial model* as usual
 - select *WET Tomo/Interactive WET Tomography...*
 - click *button Edit velocity smoothing*
 - select *Manual specification of smoothing filter*
 - divide *Half smoothing filter width* by 2. E.g. change from 7 to 3.
 - click *Accept Parameters button*
 - click *Start tomography processing button* to redo WET inversion
- [tutorial camp1](#) shows how to build a custom layer-based initial model and use this for WET inversion. We still recommend to always use our default 1D initial model, with Smooth inversion method.
- for a new tutorial showing how to sort borehole traces by common receiver see [a13r1dm.pdf](#) .
- review [Detecting perched water bodies using surface-seismic time-lapse traveltime tomography](#) (Gaines et al, SEG 2010). Includes WET velocity error analysis with checkerboard method.
- [Thesis Stefan Jansen, Niels Bohr Institute, University of Copenhagen 2010](#) evaluates our Smooth inversion method with synthetic data for models of faults and small velocity anomalies, in Appendix C. Wavepath width used in Appendix E is too narrow for reliable interpretation with our software. Please use the default WET wavepath width, or even increase this, for the WET inversion to have a chance to robustly converge towards a meaningful interpretation, especially in case of bad picks.
- for a comparison between Wavefront refraction, Plus-Minus and GRM methods, see (Ali Ak, 1990). Traveltime data for one of the models used (irregular refractor) is available in your sample profile \RAY32\PALMFIG4. Invert this with our conventional Wavefront and Plus-Minus methods. See <http://rayfract.com/help/manual.pdf> , chapter 1.10 .

- ([Riddle, Hickey and Schmitt, SAGEEP 2010](#)) show subsurface tunnel detection with ERT and SRT .
- see ([Hickey, Ekimov and Hansen, SAGEEP 2009](#)) for imaging of a collapsing dam .
- ([Hickey, Schmitt and Sabatier, SAGEEP 2009](#)) detect underground high-contrast voids with SRT .
- ([Ali Ak, 1990](#)) used Dr. Palmer's synthetic models to compare the Wavefront Refraction method (WR) with Plus-Minus and GRM. WR can image irregular refractor surfaces and detects sudden lateral change in velocity. WR depth calculations are independent of the refractor velocity.
- for frequency filtering, shot stacking, resampling, conversion between SEG-2 and SEG-Y etc. try the free [Geogiga Front End](#) . Write the processed shots to SEG-2 files and import into our software.

Version 3.18 released in December 2010 :

- **check first break picks for reciprocal errors in Trace/Offset gather**, after *Smooth inversion*. See our tutorial <http://rayfract.com/samples/GEOXMERC.pdf> . Repick bad traces and redo *Smooth inversion*.
- **WET inversion (back projection routine) now uses multiple CPU cores**. Eikonal Solver used for forward modeling during WET still uses one core only. Overall WET runs up to 25% faster, for large datasets e.g. <http://rayfract.com/samples/GEOXMERC.pdf> and with **Intel Core i3 processor**, on Sony Vaio with 4 GB of RAM. No noticeable speedup for small datasets, e.g. LINE14 on Intel Core 2 Duo .
- **Model/Model synthetic shots... forward models traveltimes over your custom-built Surfer .GRD file, without preexisting seismic survey and without .PAR file**. Picked times are reset to these modeled traveltimes. Import ASCII.ASC or GeomTomCG .3DD dummy shots without picked times (all traces set to time -1), and then directly convert these dummy shots into synthetic shots modeled for your custom grid model. See <http://rayfract.com/tutorials/palmfig9.pdf> .
- **File/Export header data/Export Modeled Times to GeoTomCG .3DD...** allows export of synthetic picks to .3DD. Allows generation of .3DD with all traces set to -1, after above synthetic shot modeling, and with **File/Export Data Settings/Export dead traces to GeoTomCG.3DD** checked.
- **Window/Export ASCII Model of depth section** now regards **File/Export Data Settings/Export coordinates in feet**, when generating .CSV file for currently selected **depth section window**.
- **DeltaV/Delta-t-V Settings/Extrapolate output to all receivers** option extrapolates *Delta-t-V inversion* output to all receivers, beyond first/last CMP stations. This new option is disabled per default.
- **SHIFT-L command** (reverse polarity of current trace) now works in all *Trace menu gather displays*, not just in *Trace/Shot gather*. Select the *current trace* with *arrow-left* and *arrow-right* keys.
- **ALT-L command** (reverse polarity for all traces of currently displayed gather) works for all *gather displays* as well.
- **File/Import Data Settings/Round shot station to nearest whole station number** is unchecked per default for *File/New Profile...*, since version 3.17. If you specify **y coordinates different from zero** in *Header/Station*, you need to check this option for 3.17 and earlier versions. This ensures valid **correction of traveltimes for lateral shotpoint offsets**, during *Smooth inversion* and *WET*. You can leave this setting unchecked for version 3.18 . Be sure to reimport your shots after toggling this setting.
- **.GRD grid file and .CSV file selection** now works with newer matching **.PAR file**, without requiring you to update the **.GRD or .CSV time stamp** with TOUCH.EXE utility.
- *Smooth inversion* now always runs 20 WET iterations per default, even for low-coverage profiles with average shot spacing of more than 3 receiver spacings.
- **WET Tomo/WET tomography Settings/Scale wavepath width** may help to improve weathering layer resolution (less smoothing) for consistent first break picks. Uncheck **WET Tomo/WET tomography Settings/Disable wavepath scaling for short profile**, to enable adjustment. This wavepath width **scaling with picked time is preferred over minimal WET smoothing** (**WET Tomo/Interactive WET tomography/Edit velocity smoothing/Minimal smoothing**), to prevent artefacts. See <http://rayfract.com/SAGEEP10.pdf> for up-to-date description of WET options and parameters.
- import of ASCII.ASC now regards the last line even if this is not terminated with a <carriage return> character (generated with ENTER key while editing).
- **Refractor/Midpoint breaks** , mapping traces to refractors with ALT-M : we now check if *Upper Layer Velocity Limits* increase with layer number. If not, we show an error message and ask to correct this.
- **Refractor/Midpoint breaks** , mapping traces to refractors with ALT-M : now works for large and dense data sets, with high *Weathering Velocity Limit*.
- all Rayfract® dialogs are now displayed in MS Sans Serif 8 pts, a bit smaller than previously.
- files **SHOTPTS.SHO, COORDS.COR and BREAKS.LST** are stored into **BACKUP** subdirectory of your profile, each time you select *File/Import Data...* . Generate these files manually via *File/Export header data* at appropriate times, to make sure they contain up-to-date information. Export these files into your own subdirectory e.g. MyBackup to ensure they are not overwritten.

- to ensure unique numbering for shots imported from multiple *Geometrics SeisImager/PlotRefa* .VS files, into the same Rayfract® profile database, we recommend pasting together all .VS files into one .VS file e.g. with Windows® WordPad or NotePad apps, and then import just this one .VS file.
- we now support importing with a *spread type* specifying fewer channels than actually contained in SEG-2 data files. E.g. specify *default spread type* “01: 24 channels” instead of “02: 48 channels” in *File/Import Data...*, to import only the first 24 channels from 48-channel SEG-2 files. **Do not try this with earlier versions of our software**, or you will corrupt the profile database and will need to reimport all the shots and geometry information and first break picks into a new profile database !
- use SEG2_EDIT utility <http://pubs.usgs.gov/of/2003/ofr-03-141/> to rewrite SEG-2 files, with arbitrary trace ranges selectively removed. Use or define a matching *receiver spread type* with our software.
- default *WET wavepath width* is now always limited to 100%, even with bad/too late first break picks.
- we now support **import and inversion of ASCII.ASC with first break picks up to two seconds**. We increased the maximum allowed value for the following parameters :
 - *WET wavepath width* : maximum increased from 50% to 100%
 - maximum *sample count* imported per trace : 20,000 instead of 10,000
 - *trace gather displays* : trace amplitude, vertical time axis, horizontal station number axis can now be zoomed up to seven times, instead of six times
 - *DeltatV/Interactive Delta-t-V/CMP curve stack width* : max. 240 instead of 120
 - *Refractor/Midpoint breaks/ALT-M/CMP stack width* : new max. 240, old max. 120
- *DeltatV/Interactive Delta-t-V/Static Corrections/Inverse CMP offset power* helps to **filter out DeltatV artefacts for long/deep and high-coverage profiles**. Default value is 0.5. Decrease to 0.2 and increase *CMP curve stack width* to 120 or 240. Enable *DeltatV/Delta-t-V Settings/Weigh picks in CMP curves*. See <http://rayfract.com/samples/GEOXMERC.pdf> (data made available by GeoExpert ag). This tutorial also shows **how to identify bad picks, in Trace/Offset gather and Trace/Shot gather displays**.
- *Smooth invert/Smooth inversion Settings/Wide CMP stack for 1D-gradient initial model* lets you toggle *DeltatV parameter CMP curve stack width* between default value 120 and wide setting 240.
- assert failure with **expression `deltatv_v0 > 0.0`** can happen e.g. with marine streamer surveys, when using a small station spacing of 0.1m and spread type “36: 360 every 20”. This allows for **arbitrary shifting of the receiver spread** during ”roll-along” recording. With this assert failure, please
 - select *Delta-t-V/Interactive Delta-t-V* and click *Static Corrections button*
 - increase *Weathering crossover* to e.g. 50 and *Topography filter* to e.g. 500 stations
 - click *Accept button*, and run *Smooth inversion* or *Automatic Delta-t-V and WET inversion* as usual
- if Rayfract® 3.18 fails to start, with message mentioning VCOMP.DLL or error 0xc0000034 or “This application has failed to start because the application configuration is incorrect” or “Impossibile avviare l’applicazione specificata”, install the **Microsoft Visual C++ 2005 SP1 Redistributable Package** from <http://tiny.cc/b494e> . This installs VCOMP.DLL into subdirectory of C:\WINDOWS\WinSxS . The updated <http://rayfract.com/common/raywn318.exe> installs VCOMP.DLL automatically.
- if Rayfract® does not accept your grey CmStick/CodeMeter dongle e.g. on Windows 7 64-bit and after reassigning disk partitions to drive letters, please
 - select Start button|Control Panel
 - type “Disk management” into field *Search Control Panel* , hit Enter key
 - left-click blue text **Create and format hard disk partitions**
 - plug in CmStick into any USB port
 - search for disk with blank Volume name, 39 MB Capacity and 0% Free
 - right-click disk symbol for this blank volume
 - right-click **menu item Change Drive Letter and Paths...**
 - click **Add... button**, select **drive letter** in drop-down box, click OK button
- <http://rayfract.com/tutorials/palmfig9.pdf> shows how to build the syncline model and forward model synthetic shots, as described in [Palmer 2010](#) .
- <http://rayfract.com/tutorials/fig9inv.pdf> shows how using a closer *shot spacing* decreases the degree of non-uniqueness. E.g. shoot at every 2nd receiver instead of just at every 6th receiver. Increasing the *WET iteration count* from its default value of 10 or 20 iterations to 50 or 100 improves the resolution also. And we recommend using our 1D-gradient initial model, instead of pseudo-2D Delta-t-V initial model.
- <http://rayfract.com/tutorials/epikin.pdf> shows interpretation of the “Broad Epikarst” model described by Jacob Sheehan in his JEEG March 2005 Seismic Refraction Tomography evaluation.

- resolution of WET and seismic refraction tomography in general decreases with increasing imaged depth. See e.g. <http://rayfract.com/tutorials/thrust.pdf> , [D.J. White 1989 Two-Dimensional Seismic Refraction Tomography](#) and [J.G. Hagedoorn 1959 The Plus-Minus method of interpreting Seismic Refraction Sections Fig. 1](#) .
- for a recent comparison between our WET tomography and Dr. Palmer's GRM see http://www.univie.ac.at/ajes/archive/volume_102_2/marschallinger_et_al_ajes_v102_2.pdf
- Dr. Palmer assumes in his GRM method that the optimum XY spacing is constant for the whole profile. This is generally not true. See e.g. [Hamdy H. Seisa 2007](#) , Fig. 1 & 2 (dipping refractor case).
- our Wavefront method automatically determines a laterally varying XY receiver separation. See [Jones and Jovanovich \(1985\)](#), [Brueckl \(1987\)](#) and [Ali Ak \(1990\)](#). Wavefront considers local emerging wavefront angles. A critically refracted ray is represented by first break and emergence angle at a receiver. Each reverse ray is combined with a matching forward ray, such that both rays surface from an approximated common refractor location.
- for our interpretation of the Palmer Mt. Bulga data set see <http://rayfract.com/tutorials/mtbulga.pdf> . The original traveltimes data is available at <http://rayfract.com/tutorials/mtbulga.zip> . Process this with our free trial available at <http://rayfract.com> . Set *Station spacing* to 5m in *Header/Profile*. Next *File/Import Data...* with *Import data type* Interpex Gremix .GRM. Now *Smooth invert/WET with 1D gradient initial model*. Apparently Dr. Palmer used a non-default Delta-t-V initial model and changed WET smoothing to *minimal smoothing* instead of leaving it at default *full smoothing*, in Fig. 2 of his [EAGE Geophysical Prospecting January 2010](#) online paper. Also, he seems to have decreased *WET wavepath width* from its default setting, and only run a few WET iterations. With such poor settings, our WET inversion is effectively crippled, and WET output will be very similar to the starting model. As automatically proposed by our software, using a closer *shot spacing* would decrease the degree of non-uniqueness. E.g. shoot at every 2nd receiver instead of just at every 12th receiver. Increasing the *WET iteration count* from its default value of 20 iterations to 50 or 100 usually improves the resolution.
- updated <http://rayfract.com/tutorials/mtbulga.pdf> with link to <http://rayfract.com/tutorials/thrust.pdf> . We did this thrust fault modeling specifically for Mt. Bulga data set. Also, we now recommend shooting at every 3rd, optimally at every 2nd receiver instead of every 6th receiver.
- to **batch-edit multiple SEG-2 files**, e.g. changing file descriptor field UNITS from FEET to METERS, and adding file descriptor field NOTE, please :
 - download SEG2_EDIT.ZIP archive from <http://pubs.usgs.gov/of/2003/ofr-03-141/>
 - unzip e.g. into local directory C:\SEG2_EDIT
 - download SEGBATCH.ZIP from <http://rayfract.com/tools/segbatch.zip>
 - unzip e.g. into local directory C:\TEMP, and open command prompt, with Start|Run... CMD.EXE
 - copy your SEG-2 files *.SG2 into C:\TEMP, with COPY command
 - create subdirectory C:\TEMP\BATCHOUT, with MD command
 - edit SET_METERS.TXT response file for SEG2_EDIT, e.g. changing COMPANY and NOTE entries
 - edit SETUNITS.BAT if necessary, to point to directory containing SEG2_EDIT.EXE executable
 - run SETALL.BAT, to batch-edit all of your .SG2 files and write them to BATCHOUT subdirectory
- to **visualize an individual wavepath between one source and one receiver**, please :
 - run our Smooth inversion with *menu Smooth invert*, e.g. for sample profile C:\RAY32\LINE14
 - select *WET Tomo/Interactive WET tomography...*
 - click *Select button* and specify last iteration e.g. VELOIT20.GRD
 - set *Number of WET iterations* to 1
 - click on *button Edit grid file generation*
 - set *Write wavepaths to disk for shot no.* e.g. to value 3 for shot no. 3
 - click on *button Accept parameters* and then *Start tomography processing*
 - start up Surfer® and select *File/New...* . Specify form type "Plot document".
 - select Surfer menu item *Map/Image Map...*
 - select e.g. grid file C:\RAY32\LINE14\GRADTOMO\W003-024.GRD (shot no. 3, trace no. 24)
 - double click on the generated black-and-white plot
 - left-click on *Colors scale* and *Load button*
 - select file Rainbow2.CLR in C:\RAY32 or your Golden Software Surfer Samples directory
 - click on *button Open* and confirm with *OK*
 - check *Interpolate Pixels* and *Show color scale*. Set *Missing Data* to white color and click *OK*
 - select Surfer menu item *View/Fit to Window*

- you will then obtain a color plot of wavepath from shot no. 3 to receiver no. 24. The wavepath is centered on (black) time value of 0 milliseconds.
- save Surfer® plot with *File/Save As...* , as file C:\RAY32\LINE14\GRADTOMO\W003-024.SRF

- to **identify and fix bad shot positions**, please :
 - select *Refractor/Shot breaks*
 - uncheck *Mapping/Display raytraced traveltimes*
 - uncheck *Mapping/Display synthesized traveltimes curves*
 - optionally check *Mapping/Gray picked traveltimes curves*
 - optionally check *Mapping/Dark Gray traveltimes curves*
 - use F7/F8 to browse picked traveltimes curves
 - the *vertical pick bar* indicates the *shot position* you specified during import
 - so a *bad shot position* shows as a horizontal offset between traveltimes curve minimum and pick bar
 - use SHIFT+O keyboard shortcut for *Mapping/Check shot positions*, for automatic checking
 - use *Smooth invert/Smooth inversion Settings/Strict shot position checking* for more accurate checking with above SHIFT+O command, in *Refractor/Shot breaks display*.
 - export picked first breaks to .LST with *File/Export header data/Export First Breaks...*
 - reimport identified bad shot(s) with correct *shot position* (specified in station numbers)
 - import saved first breaks from .LST with *File/Update header data/Update First Breaks...*

- to manually **install the WibuKey driver 6.00a under Windows 7 32-bit or 64-bit**, please :
 - logout from your current Windows 7 session, and unplug your green WibuKey dongle
 - restart your PC, running Windows 7
 - login as Administrator
 - keep WibuKey dongle unplugged
 - download http://www.wibu.us/files/user/wk6_00b/WkRuntime.exe
 - run this WkRuntime.exe installer, confirming any prompts
 - finally plug in your WibuKey dongle again
 - wait for any balloon type messages to complete

Version 3.17 released in June 2010 :

- tested under **Microsoft Windows 7 64-bit on Intel Core i3 processor**. This works fine. Install our software as usual. Now go to <http://wibu.com>, download and install the **WibuKey Win 32 / Win 64 driver 6.00a** sized at 19 MB. Rayfract® versions earlier than 3.16 will not work with driver 6.00a.
- <http://rayfract.com/common/raywn316.exe> base installer prompts you to download WkRuntime.exe when run under Windows 7 64-bit. Confirm download with *Save button*, and run WkRuntime.exe, to install WibuKey 6.00a driver for 64-bit. Next run the latest rayup316.exe or rayup317.exe as supplied.
- once you run *Smooth inversion* at least once for a profile, and check *Smooth invert/Smooth inversion Settings/Allow unsafe pseudo-2D Delta-t-V inversion*, our *Delta-t-V menu* is reenabled again.
- for high-coverage profiles with at least 2,500 picked traces, you can enable *Delta-t-V* without first running *Smooth inversion*.
- all Surfer tomogram plots showing *Delta-t-V initial model* or *WET output based on Delta-t-V* will show a warning in the plot title saying **Delta-t-V initial model artefacts !!!**
- we strongly recommend using our *ID-gradient initial model* instead, via *Smooth invert/WET with ID-gradient initial model*. *Delta-t-V initial model* may work better in some complicated cases of subsurface structure, such as a **thrust fault with fault zone** (see <http://rayfract.com/tutorials/thrust.pdf>) or with extreme topography, e.g. when imaging a dike. But in most situations of strong refractor curvature our *ID-gradient initial model* results in less artefacts. See <http://rayfract.com/tutorials/broadepi.pdf> .
- when using our *Delta-t-V initial model*, **test limiting the maximum exported Delta-t-V velocity to e.g. 3,000 or 4,000 m/s, to suppress artefacts**. See <http://rayfract.com/tutorials/palmfig3.pdf> .
- for **pseudo-3D fence diagrams** we recommend Golden Software's Voxler software. This lets you import 2D WET tomograms which are formatted as Surfer .GRD files, as generated with our software. See sample <http://rayfract.com/samples/9.bmp>, made available by our client Terra Geosciences.
- *Delta-t-V method* and *Midpoint breaks display* now support common-midpoint *CMP station numbers* smaller than -8,000 and larger than 8,000. Previously these were cached incorrectly, resulting in invalid CMP sorted trace gathers. The minimum/maximum station number range still is -10,000/10,000.

- *File/New Spread Type...* now allows defining custom spread types with **minimum receiver separation of up to 20 station numbers**. For underwater seismic refraction USR profiling, you may want to define a new spread type “36: 360 every 20”, with 360 receivers and receiver separations “359*20”. Then specify *station spacing* as e.g. 0.1m in *Header/Profile* instead of 2.0m. This allows for **arbitrary shifting of the receiver spread** during “roll-along” recording.
- *Delta-t-V/Interactive Delta-t-V.../Static Corrections* now allows *Weathering crossover* of max. 200 stations, and *Topography filter* of up to 2,000 stations. Also, these two parameters are not reset to default values any longer, during *Smooth inversion*.
- copy any *trace gather/refractor display/depth or velocity section* to Windows® clipboard. Select the section window with mouse left-click on its title bar, and press CTRL+C shortcut, to **copy window content as bitmap to clipboard**. Use CTRL+V shortcut in Golden Software Surfer, Microsoft Word, Microsoft Paint (MSPAIN.T.EXE) etc. to paste clipboard contents to current document.
- copy **bitmap of all opened section windows** to clipboard with CTRL+A shortcut.
- *Window/Export ASCII Model of depth section* lets you **write topography, refractor elevations and velocities to a comma-separated value .CSV file**. You may import this into Microsoft Excel etc. .CSV column 1 lists receiver station number, column 2 shows horizontal inline offset in meters.
- uncheck *Depth conversion/Display Wavefront positions* when viewing *Depth/Wavefront... section*, to **suppress display of estimated basement positions** with black triangles.
- we now explicitly pass the complete *grid line geometry* (min/max x/y coordinates, # of Lines) when calling into Golden Software Surfer® via Scriptor. This ensures that you will never have to manually regrid the .CSV, when running our *Delta-t-V method*.
- when displaying traces with *Trace/Shot gather*, check option *Processing/Refresh shot breaks when picking traces* to enforce automatic refresh of *Refractor/Shot breaks display*, with updated traveltimes curves. Leave this option unchecked for large data sets, and refresh manually with ALT-Y.
- for **stacking of SEG-2 trace files**, we recommend *seg2_edit* utility offered by Karl J. Ellefsen. See <http://pubs.usgs.gov/of/2003/ofr-03-141/> and **section 3.3.4 Stack Traces, of the referenced report**. Create an auxiliary Rayfract® profile database, and import original unstacked shots plus stacked shots. Number stacked shots differently from original shots. Display shots in *Trace/Shot gather* as usual, and use F7/F8 to compare stacked with unstacked shots.
- **conversion of shot point position to station numbers and back to coordinates** is not trivial, especially in case of strong topography and varying receiver separation. To **ensure shot point x/y/z coordinates are specified correctly in the profile database**, import shots and update station and shotpoint coordinates as usual. Next

- select *File/Export header data/Export Shot Point Coordinates...*
- left-click *Create New Folder icon* on top right of *Export shotpoint coordinates dialog*
- name this new folder e.g. export
- navigate into this new export folder, and store SHOTPTS.SHO into this folder with *Save button*
- open SHOTPTS.SHO e.g. with *Windows WordPad text editor*
- ensure for all shotNr values (column 1) that shotX, shotY and shotZ are correct (columns 2 to 4)
- fix shotX, shotY and shotZ in this editor session if required
- save the fixed SHOTPTS.SHO to disk from within your editor, e.g. with *File/Save command*
- *File/Update header data/Update Shotpoint coordinates...* and select fixed SHOTPTS.SHO file

Our **WET tomography** requires **exact source and receiver positions**. A coordinate error of even just one centimeter may change the output visibly, especially at the bottom of the WET tomogram.

- uncheck *File/Import Data Settings/Round shot station to nearest whole station number* **before importing your data files**, to minimize above conversion error between shot station number and shot point coordinates. With this unchecked, shot stations are rounded to .5, e.g. to values 0.5, 1.0 or 1.5 . Version 3.17 of our software will uncheck this option automatically during *File/New Profile...* .
- improved *GeoTomCG .3DD* import routine now handles **duplicate traces** (same source and receiver coordinates) and empty lines. Empty lines are skipped. At the 2nd trace of two adjacent traces with same source and receiver coordinates, our import starts a new shot.
- once you edited *Trigger delay* in *Header/Shot* for one or more shots, be sure to export station coordinates via *File/Export header data/Export Station Coordinates...* to COORDS.COR and shot point coordinates including time terms to SHOTPTS.SHO via *File/Export header data/Export Shot Point Coordinates...* Save these files e.g. into a subdirectory named backup.
- if you then update first breaks via *File/Update header data/Update First Breaks...* , *Trigger delay* will be reset to 0 for all shots. Use *File/Update header data/Update Shot Point Coordinates...* with above SHOTPTS.SHO to **reapply your saved trigger delay values**.

- if your PC crashes with a Rayfract® profile opened, Rayfract® under rare circumstances may not allow you to create a new or open any existing profile database, showing messages saying **Raima Object Manager Error -905, -30** or similar. Please exit Rayfract® via *File/Exit* and
 - open *Windows Explorer window* with Windows key + E shortcut or via *Start/Run...* Explorer.exe
 - navigate into directory C:\RAY32\DAT
 - delete files rdm.taf, vista.taf, and user1.log
 - restart Rayfract® with *desktop icon*, and retry *File/Open Profile...* or *File/New Profile...*
- *temporary traveltimes grid files* for negative receiver station numbers named R-????.GRD are now deleted during *File/Open Profile...* .
- for our SAGEEP10 short course tutorial see <http://rayfract.com/SAGEEP10.pdf> . This includes introductory **slides describing Smooth inversion and relevant WET and Delta-t-V parameters**.
- http://rayfract.com/help/function_keys.pdf replicates the table shown in Rayfract® help menu
- updated tutorials <http://rayfract.com/tutorials/line2.pdf> and <http://rayfract.com/tutorials/sapri12.pdf> , both now using *station spacing* 5m and *Default spread type* 10: 360 channels .
- updated tutorial <http://rayfract.com/tutorials/thrust.pdf> explains how to build your own model grid with Golden Software Surfer® and then generate synthetic traveltimes by forward modeling propagation of synthetic shots with the Rayfract® Eikonal solver.
- review [Determining depth of blast induced damage in a mine wall \(J.A. Singer et al. 2009\)](#) and [Enhanced coastal geotechnics with integrated marine seismic reflection and multi-source, extended array refraction \(Robert Whiteley, Matthieu Bardout and Simon Stewart 2010; includes synthetic model with velocity inversion\)](#)

Version 3.16 released in March 2010 :

- **we do not support running our software under Windows 98 and Windows NT any longer**. When started up under Windows 98 or Windows NT, Rayfract® 3.16 will display an error message recommending using Windows XP and will then shut down again.
- support import of **Micromed SoilSpy .SG2 SEG-2 files**
- **disabled pseudo-2D Delta-t-V inversion with Delta-t-V menu, to suppress Delta-t-V artefacts**. It is not possible to decide if an imaged velocity anomaly is for real or a Delta-t-V artefact. So to be safe we now just completely block Delta-t-V, in our latest version 3.16. See also http://rayfract.com/srt_evaluation.pdf , Fig. 1, <http://rayfract.com/tutorials/depress.pdf> , and <http://rayfract.com/tutorials/palmfig3.pdf> .
- you still can edit *Delta-t-V parameters and options* used by our *Smooth inversion* method, for determination of the *1D-gradient initial model* required by subsequent *2D WET Wavepath Eikonal Traveltimes inversion*.
- support **zero-offset VSP Vertical Seismic Profiling** surveys. See <http://rayfract.com/tutorials/vsp.pdf>
- default *WET smoothing filter height* for *borehole spread/line profiles* is now limited to maximally twice the filter width, in grid cells. This gives better vertical resolution, of VSP surveys.
- when you invert your first break picks with *Smooth invert*, *WET Tomo* and *Delta-t-V menu commands*, we now always first **match shot positions to picked traveltimes curves**. If these don't match we show an error message and prompt you to adjust picks in *Trace/Shot gather*, adjust the *shot position* in *Header/Shot*, or reimport the shot (with corrected shot position) if required.
- in *Header/Shot*, *shot inline offset* may be set to maximally plus/minus one *station spacing* as defined in *Header/Profile*. If you need to change the *inline offset* to a larger amount, please reimport the shot with corrected *shot position* (in *station numbers*).
- new *SHIFT-O command* (Check shot positions) in *Refractor/Shot breaks* interactively pages through all shot-sorted traveltimes curves and matches *shot positions* to picked *traveltimes curves*, see above.
- *ALT-L command* (Remap all traces to refractors) in *Refractor/Shot breaks* and *Refractor/Midpoint breaks* now also matches *shots positions* to picked *traveltimes curves*.
- new *SHIFT-S command* (Export first breaks to .LST) in *Trace menu* and *Refractor menu displays*. The current *trace gather display* or *refractor display* will stay open. This allows you to quickly save different picking versions to .LST .
- new *SHIFT-L command* (reverse polarity of current trace) in *Trace/Shot gather*. Select the *current trace* with *arrow-left* and *arrow-right keys*.
- we show the *trace amplitude zoom* in *trace gather displays* opened with *Trace menu*. The zoom is displayed on the *status bar* at the bottom of the screen, when navigating traces with *arrow keys*.
- *File/Export Data Settings/Export coordinates in feet* option. Check this and **export .COR, .SHO and .3DD files in feet instead of meters**. The unit is written to the first header line of these files. So you can e.g. export receiver coordinates in feet with *File/Export header data/Export Station Coordinates*, to

a .COR file. Now update the .COR file with e.g. Windows Notepad editor, with receiver elevations in feet. Then reimport the .COR file with *File/Update header data/Update Station Coordinates*.

- adapted *import routine for GeoTomCG .3DD* files, to check for unit feet or meters in the .3DD . Feet values are always converted to meters, during import.
- our *Optim LLC SeisOpt and GeoTomCG .3DD import routines compute and initialize shot depths, based on source and receiver coordinates. We interpolate line topography between all receivers. Source z coordinate* in these input files specifies *elevation of shot hole bottom*. We determine *shot depth* as difference between interpolated topography (at source x coordinate) and shot hole bottom (source z coordinate). Source y and receiver y (see *Header/Station*) are always set to 0.0, during Optim LLC SeisOpt and GeoTomCG .3DD import. *Shot point elevation* shown in our SHOTPTS.SHO file is the interpolated topography, at source x coordinate. Our tomography routine determines the actual *source elevation* by subtracting the shot hole depth from this shot point elevation. You can check the *source elevation* in *Header/Shot*.
- *shot hole depths* are initialized according to Geometrics PickWin/PlotRefa .VS files, during *File/Import Data...*
- when importing *Geometrics PickWin/PlotRefa .VS files*, *x coordinate of first receiver* now can have any value and is not restricted any longer to 0.0 .
- fixed *shot depth* determination when importing multiple *.3DD files* from same *input directory*.
- fixed *shot position* determination when importing *uphole shots* from *GeoTomCG .3DD files* into *refraction spread/line* profiles. For earlier versions you need to correct the *shot position* during import.
- *Shot inline offset* in *Import shot(s) dialog* is regarded again, when importing shots into *refraction spread/line profiles*. This was broken in early 3.16, but works fine in version 3.15.
- improved matching of .GRM trace positions to profile database station numbers, during *File/Update header data/Update from Gremix .GRM files...*
- *File/Import Data Settings/Round shot station to nearest whole station number* option. This option is enabled per default. Source *inline offset* (in meters) in *Header/Shot* is set to the difference between true and rounded shot location (in meters). If you uncheck this option before importing your data with *File/Import Data...* , imported shot stations are rounded to the nearest half-station number. E.g. to 0.5, 1.0, 1.5, 2.0 etc. As a consequence our *Trace/Offset gather display* is more useful for traces with short source-receiver offset and sources between receivers, at station numbers 0.5, 1.5 etc. **Reciprocal traveltimes errors now are easier to identify, even for small common-offset values**. These errors can then be corrected for with *Header/Shot Trigger delay field*.
- when you invoke our *File/Import data... dialog*, station coordinates, shot point geometry and picked first breaks are exported and thus backed up automatically, to files COORDS.COR, SHOTPTS.SHO and BREAKS.LST. These files are stored in your profile subdirectory.
- *WET Tomo/WET tomography Settings submenu* now contains *WET options* formerly contained directly in *WET Tomo menu*.
- *Traveltimes misfit* determined during WET forward modeling is now displayed as **RMS error (in milliseconds) and normalized RMS error (in percent, of maximum picked time over all traces modeled)**. We determine **RMS error and normalized RMS error** (NRMSE) as described at http://en.wikipedia.org/wiki/Root_mean_square_deviation .*Mean unsigned errors* and *signed errors* are not shown any longer. These *RMS errors* are also stored in *.FIT misfit files*, e.g. VELOIT10.FIT for tomogram VELOIT10.GRD , in GRADTOMO or HOLETOMO profile subdirectories.
- *Line ID* specified in *Header/Profile*, *WET iteration* number or description of initial model, *RMS error* (in percent) and software version are now automatically shown on all Surfer-generated *velocity tomograms* and *wavepath coverage* plots.
- *negative shot hole depths* are not regarded any longer, when determining the *shot location* on a .GRD velocity grid during WET tomography.
- temporary *shot and receiver traveltimes grids* (files S*.GRD and R*.GRD) located in profile subdirectories GRADTOMO, TOMO and HOLETOMO as well as in the *WET initial model directory* are always automatically deleted. **Earlier versions of our software do not delete these grid files if you abort Rayfract® via the Windows task manager**. Version 3.16 deletes these files the next time you open the profile you worked on when aborting. 3.16 keeps these grids if *WET Tomo/Interactive WET tomography... |Edit grid file generation/Delete traveltimes grid files for last WET iteration* is unchecked.
- *WET Tomo/WET tomography Settings/Disable wavepath adjustment for short profile* option will automatically disable WET options *Adjust wavepath width and Scale WET filter height*, for short profiles with 48 or less receiver stations. This will **prevent WET artefacts due to bad first break picks**. Also, WET output will be smoother and more reliable, for short profiles. If your picks are good and you need to image detailed subsurface structure, you may uncheck *WET Tomo/WET tomography Settings/Disable wavepath adjustment for short profile*, as done implicitly for version 3.15 and earlier.

- option *Smooth invert/Smooth inversion Settings/Lower velocity of 1D-gradient layers*. Use this to set the *gradient-layer bottom velocity* to $(\text{top velocity} + \text{bottom velocity})/2$, for each layer in the initial model. This option is disabled per default. Enable to **lower the velocity of the overburden layers**.
- option *Smooth invert/Smooth inversion Settings/Interpolate velocity for 1D-gradient initial model*. Enable to linearly interpolate the *averaged 1D-velocity profile* to determine the 1D-gradient initial model (as in previous versions). Disable for **constant-velocity initial overburden layers**, with the *layer-top velocity* assumed for the whole layer except the bottom-most 0.1m. This option is enabled per default, since *WET tomography* works most reliably with a smooth minimum-structure initial model.
- fixed correction of traveltimes for *lateral shotpoint offset*, when shot positioned exactly on last *receiver station* of profile.
- select *Depth/Depth conversion Settings/Link traveltimes curves for Wavefront* to algorithmically shift and link traveltimes curves for *Wavefront method*, instead of *Brueckl traveltimes field regression*.
- select *Depth/Depth conversion Settings/Link traveltimes curves for Plus-Minus* to algorithmically shift and link traveltimes curves for *Plus-Minus method*, instead of *Brueckl traveltimes field regression*.
- use *Depth/Depth conversion Settings/Skip reciprocal traveltimes check* to suppress resetting of *regressed traveltimes* if local *reciprocal time estimate* deviates from mean reciprocal time for regressed or algorithmically shifted and linked traveltimes, for *Wavefront* and *Plus-Minus* methods.
- if your Golden Software **Surfer 9 Demo Scripter component does not start up under Windows Vista**, please uninstall Surfer 9 Demo and all other Surfer versions, download the latest version from goldensoftware.com, backup to USB flash and reinstall.
- if **Scripter fails to automatically open Golden Software Surfer under Windows 7**, please open Surfer interactively first and then retry e.g. *Smooth invert* with our software.
- when double-clicking our *desktop icon* multiple times, our software may try to start up multiple times. The first instance should succeed, but other instances will fail to start up, showing “**Internal error (40) An exclusive access conflicts with another exclusive access**” message. Click *Cancel button* to dismiss these and shut down these multiple instances.
- under rare circumstances our software may hang during *File/Open Profile...* . Open the *Windows Task Manager* with ALT-CTRL-DEL key combination. Now select *Image Name Rayfract32.exe* on *Processes tab* and click on *End Process button*. Restart Rayfract© via desktop icon, and retry the open.
- for a new paper by Laura V. Socco et al. comparing resistivity tomography with WET tomography and surface-wave analysis see <http://www.citeulike.org/article/6511101> .
- for a new tutorial showing **interpretation of 5 shots into 12 channels** see <http://rayfract.com/tutorials/EJEMPL3.pdf> . Use our free trial to work through this. **We recommend using at least 24 channels for reliable WET interpretations**. Also, we recommend stacking of shots.

Version 3.15 released in May 2009 :

- more accurate determination of *layout start* and *shot position* (in station numbers), when importing Optim LLC SeisOpt or GeoTomCG .3DD files into *refraction spread/line* profiles, in case of strongly undulating topography.
- in *Trace menu gather displays*, the currently selected trace (with pick cursor) is kept selected, when zooming or unzooming the display. This allows for easier first break picking and correction. When opening a *trace display window* via *Trace menu*, the first (leftmost) trace and first break is selected automatically.
- higher zooming of trace amplitude, in *Trace menu gather displays*.
- corrected variable area trace display, with high zoom of trace time.
- better match of sample time at pick cursor (as displayed at bottom of screen), with trace time axis ticks, for high zoom of time.
- our installers RAYINSTL.EXE and RAYWN315.EXE correctly call the WIBU-KEY dongle driver installer, when run under Windows Vista. To invoke the driver installer manually, just run \RAY32\WIBUKEY\SETUP.EXE .
- improved matching of interpolated topography to source and receiver elevations. All sources and receivers with picked traces will be regarded during WET tomography, and will be displayed on the resulting velocity tomogram.
- updated tutorial <http://rayfract.com/tutorials/sapri12.pdf> . Answer prompt “Update profile station spacing ?” (shown during import of .VS file) with no, to preserve our custom *station spacing* of 2.5m .
- updated tutorial <http://rayfract.com/tutorials/poisson.pdf> . Specify elevation of 0.0 for all stations in *Header/Station*. Just fill in *z coordinate* for one station, and hit ENTER to extrapolate to all stations.
- supports calling both Surfer 8 and Surfer 9 free demo, available at <http://goldensoftware.com> .

- traces in *Trace menu displays* are shifted by *delay time* and *trigger delay*, as specified in *Header/Shot* . This lets you **interactively correct shots for reciprocal errors caused by trigger delays**, visible in our *Trace/Offset gather display* .
 - new *Trace Processing menu* option *Show picks on time axis*, without amplitude offset.
 - new *File/Import Data Settings/Match .LST traces by station number* option. If this option is unchecked (by default), .LST traces are matched to database traces by channel number. If checked, .LST traces are matched to database traces by station number, during *File/Update header data/Update First Breaks* .
 - to reimport **shots with changed shot position or layout start and keep current first break picks**, first store picks to .LST with *File/Export header data/Export First Breaks...* . Now reimport the shots. Next select *File/Update header data/Update First Breaks...* and specify the .LST just generated.
 - to **suppress artefacts along tomogram edges (lateral smearing of velocity anomalies)**, WET sometimes works better with pre-3.05 settings :
- uncheck *WET Tomo/Adjust wavepath width*
 - set *Degree of differentiation of Ricker wavelet* to 1 in *WET Tomo/Interactive WET tomography...*
 - adjust *wavepath width* : multiply by two for increased smoothing, divide by two for less smoothing

- for our expanded tutorial as presented at our SAGEEP 2009 short course see <http://rayfract.com/SAGEEP09.pdf>
- make sure that picked **travelttime curves for adjacent shots are at least somewhat similar** to each other, when reviewing them in our *Refractor/Shot breaks display*. See our tutorials at <http://rayfract.com/tutorials/TUTORIAL.ZIP> for typical travelttime curve sections.

Refraction tomography is based on the **assumption that subsurface physical properties (related to propagation speed of seismic waves) have a quasi-continuous nature and do not vary randomly** on a small scale. Since first break energy incited at adjacent shot points propagates through the subsurface along similar wave paths and rays, the measured and picked travelttime curves for these shots should be similar.

Version 3.14 released in January 2009 :

- supports **import of SEG-2 formatted trace data files, into borehole spread/line profiles**.
- we assume that channel no. 1 was recorded for the deepest borehole receiver, of the current spread or chain. If not so please check import option *Turn around spread by 180 degrees* after selecting *File/Import Data...* .
- *Layout start* and *Shot pos.* station numbers are determined by dividing SEG-2 trace header fields RECEIVER_LOCATION and SOURCE_LOCATION for the first channel, with *Header/Profile* value *Station spacing*. We recommend using **negative station numbers and source/receiver z coordinates to indicate depth below topography**, as usual for borehole surveys.
- select *File/Import Data Settings/Import horizontal borehole survey or .3DD refraction survey*, before importing SEG-2 or .3DD data files for a horizontal borehole spread/line, with *File/Import Data...* .
- color traces shown in *Trace menu* gather displays, with new options in menu *Processing*. You may vary the color both of the variable area filling and of the signal outline. You may color shot traces by *source type*, as selected in *Header/Shot*.
- move the *picking cursor* (“plus” symbol) along the currently selected trace outline with up-arrow and down-arrow keys. Move the cursor to next left/right trace with left-arrow and right-arrow keys.
- **hit the space bar key to pick the first break for the current trace**, at the current sample (as indicated at bottom of display). Pick with the left mouse key to first select current trace and sample and then pick the first break at that position, in one operation.
- delete the first break pick for the current trace, with ALT-DEL. Use Shift-left mouse key to first select the trace and then delete the pick for that trace, in one operation.
- **sort traces by common shot-point station**, with our new *Trace/Shot point gather* display. This allows for **easy picking of shear-wave shots (recorded at the same shot point)**, if the sign-inverted waveforms are colored appropriately with above options. Alternatively, you may pick traces in our *Trace/Offset gather* display.
- our redesigned install scripts are now based on Inno Setup. The resulting **installable archives will run under Windows 64-bit versions**. After installing our software on a Windows 64-bit version with RAYWN314.EXE, you will be prompted to download and install the 64-bit WIBU-KEY driver software for Win64, from <http://wibu.com/download.php> . Click “English” at top of page, and then click “Software” and “User”. Now scroll down to section with green WibuKey headline.

- after running the new RAYWN314.EXE installable archive, you will also be prompted to import your custom spread types (file \RAY32\REF\MYSPREAD.SPR), into the reinstalled reference database.
- updated tutorial <http://rayfract.com/tutorials/line2.pdf> . Check *File/Import Data Settings/Keep same Layout start for consecutive shot files* before importing the data, for compatibility with the included .LST / .SHO / .COR files. These assume that the first receiver is assigned to station number 1, and not 0.
- updated tutorial <http://rayfract.com/tutorials/clud1.pdf> . Uncheck *File/Import Data Settings/Default distance unit is meter*, to specify distance unit feet before importing the Optim LLC SeisOpt data. This file format does not specify the distance unit, so you must specify this explicitly with our *File menu*.
- *WET Tomo/Blank low coverage after each iteration* is now unchecked, when opening an existing or creating a new profile database. You may uncheck this manually for version 3.12, to prevent excessive blanking at the bottom of the tomogram.
- if after importing data our software shows geometry errors, with the inline offset between stations either not increasing or increasing by twice the *station spacing* specified in *Header/Profile*, check *File/Import Data Settings/Keep same Layout start for consecutive shot files* and redo the import. This should help to correctly determine *layout start* and *shot position* in station numbers, for each shot being imported.
- for a new tutorial showing data import and *Smooth inversion* of our TRA9002 data set (Val de Travers, made available by GeoExpert ag), see <http://rayfract.com/tutorials/TRA9002.PPT>. For the input data see <http://rayfract.com/samples/TRA9002.ZIP> .

Version 3.12 released in November 2008 :

- *File/Export header data/Export Traces to GeoTomCG .3DD...* lets you generate Tweeton GeoTomCG .3DD files. Use *File/Export Data Settings* options to configure :
- *File/Export Data Settings/Export dead traces to GeoTomCG .3DD*
- *File/Export Data Settings/Gather traces by common-receiver station* as primary key. This option lets you reverse walkaway VSP surveys into uphole shot surveys and vice-versa. To be able to import these reversed uphole shots into a refraction spread/line profile, please make sure that the shot points for the original walkaway VSP survey are positioned at whole station numbers, of the refraction spread. If this setting is unchecked (as per default), traces are sorted by common shot number (primary key) and receiver station (secondary key), when exporting to GeoTomCG .3DD format.
- *File/Export Data Settings/Secondary trace key is shot point elevation*, for common-receiver primary key and borehole spread/line. For refraction spread/line type profiles, the secondary sort key for common-receiver primary key is always shot x for refraction shots, and shot z for uphole shots. So make sure to correctly mark uphole shots in *Header/Shot*.
- you may **constrain the refraction tomographic inversion of one surface based refraction spread/line profile, with uphole shot surveys recorded for multiple in-line boreholes**. An uphole shot survey may optionally be obtained by reversing a walkaway VSP survey, as described below (steps 5. to 10.). This will further increase the degree of angular coverage of the subsurface with rays and wave paths, and make the tomographic inversion even more robust. Be sure to reverse each walkaway VSP survey with a separate borehole spread/line profile.
- test .3DD export and import with our <http://rayfract.com/tutorials/coffey04.pdf> tutorial and data set :
 0. create new refraction spread/line profile COFFEY04 with *File/New Profile...*, *station spacing* 2.5m
 1. download input files from <http://rayfract.com/tutorials/coffey04.zip> . Copy COFFEY04.ZIP into \RAY32\COFFEY04\INPUT, unzip to obtain ASCII.ASC, COORDS.COR and SHOTPTS.SHO .
 2. *Start/Run...* WORDPAD.EXE text editor, and delete shots 1 to 13 so the ASCII.ASC contains uphole shots 14 to 37 only.
 3. import ASCII.ASC into profile COFFEY04. Update with COORDS.COR and SHOTPTS.SHO.
 4. export uphole shot traces as .3DD, sorted by common-receiver station
 5. create new borehole spread/line profile with *File/New Profile...* and *station spacing* of 1m
 6. import above .3DD reversed uphole shots, resulting in walkaway VSP shots
 7. export VSP shot traces as .3DD, sorted by common-receiver station
 8. create new refraction spread/line with *station spacing* 2.5m
 9. enable *File/Import Data Settings/Import horizontal borehole survey or .3DD refraction survey*
 10. import above .3DD reversed VSP shots, resulting in uphole shots
 11. export these regenerated uphole shots as .3DD, sorted by common shot
 12. export uphole shot traces from profile created in step 0., as .3DD and sorted by common shot
 13. compare .3DD files generated in steps 11. and 12. with file comparison utility. These should be identical.

- *Smooth invert/WET with constant-velocity initial borehole model* now writes Surfer .GRD files to \RAY32\Smooth invert/WET with 1D gradient initial model output.
- no more blanking at the bottom of WET tomogram after last iteration for horizontal borehole surveys, in areas not covered by wave paths (regarding WET parameter *Envelope wavepath width*).
- when you select *File/Import Data Settings/Import horizontal borehole survey or .3DD refraction survey*, and then import a .3DD refraction survey into a refraction spread/line type profile database, our .3DD import routine now updates shot hole depths correctly. Edit shot hole depths manually in *Header/Shot*, for versions 3.10 and 3.11 of our software, after import of .3DD surface refraction survey.
- during *File/Exit* without having opened any SEIS32.DBD profile, an early version 3.12 of our software displays an error message “Raima Object Manager Error: -6018 / database swap failed”. You can safely ignore this message. Also, this issue has been fixed for the final version 3.12.
- **if Smooth inversion imprints wavepaths on the velocity tomogram and the tomogram is too noisy**, especially when processing a short (one spread with 48 or less receivers) and low-coverage refraction spread/line (shot spacing of 5 or more average receiver spacings), you may want to uncheck *Smooth invert/Scale WET filter height*, and uncheck *WET Tomo/Adjust wavepath width*. Then redo the Smooth inversion, with *Smooth invert/WET with 1D gradient initial model*. This will give smoother inversion output, especially if the refraction spread/line is steeply inclined (more than 30 degrees) and for low-velocity weathering layers.
- *WET Tomo/Blank low coverage after each iteration* blanks low coverage areas at tomogram bottom after each iteration, except the last one. Low coverage means less than 10 percent of maximum grid coverage. This blanking option is enabled per default.
- *WET Tomo/Blank low coverage after last iteration* blanks low coverage areas at tomogram bottom after the last iteration. This option is disabled per default.
- *WET Tomo/Blank below envelope after each iteration* blanks the tomogram below envelope of all wavepaths, after each iteration except the last. Regards WET parameter *Envelope wavepath width*. This is disabled per default, when creating a new profile or opening an existing profile database. Also, we recommend to leave this blanking option disabled, since it blanks excessively and may suppress meaningful output.
- *WET Tomo/Blank below envelope after last iteration* blanks the tomogram below envelope of all wavepaths, after the last WET iteration. Regards WET parameter *Envelope wavepath width*. This is enabled per default.
- above four new WET blanking options help to suppress the imaging of high-velocity and low-velocity artefacts at the bottom of tomograms, as described e.g. by Jacob Sheehan et al. in http://pubs.usgs.gov/sir/2005/5160/PDF/Part1_2.pdf, Fig. 3a.
- see <http://nsg.eage.org/details.php?pubid=10557> for “Seismic characterization of an Alpine site” by L.V. Socco et al., published in EAGE Near Surface Geophysics August 2008 issue. Correlates WET tomography with reflection seismic, surface wave and pseudo-2D shear wave interpretation plus downhole measurement.
- to fix geometry errors in SEG-2 trace data files we recommend the free XVI32 hex. editor. See <http://www.chmaas.handshake.de/delphi/freeware/xvi32/xvi32.htm>. Be sure to always edit SEG-2 files in overwrite mode and NOT insert mode. Otherwise you damage the file structure (pre-computed offsets to next field). To correct the shot position, update SEG-2 field SOURCE_STATION_NUMBER or SOURCE_LOCATION for the first channel (CHANNEL_NUMBER 1) of the problem shot. To fix the layout start, edit SEG-2 field RECEIVER_STATION_NUMBER or RECEIVER_LOCATION of the first channel.
- to correct the SEG-2 UNITS field from FEET to METER, overwrite “FEET” with “METE”, without the trailing ‘R’, using above XVI32 hex. editor. Otherwise you damage the SEG-2 file structure.
- some PC’s have a “non-standard” LPT port implementation and/or do not supply enough power to the dongle. If the WIBU-KEY driver software does not recognize your LPT parallel port WIBU-KEY dongle (e.g. after (re)installation), please proceed as described in <http://rayfract.com/help/rayfract.pdf>, bottom of page 90 and top of page 91, to adjust the LPT port address used by the WIBU-KEY driver. **Make sure to always uncheck box System default on the Setup tab of the WIBU-KEY control panel applet, and always specify the Port address explicitly** (even if MSINFO32.EXE shows default value of 0378 Hex). Leave *Bus type* as ISA and *Bus index* as 0.
- if the above does not help with your LPT port WIBU-KEY communication, please try connecting a printer with a parallel port printer cable plugged into the LPT WIBU-KEY or unplug such a cable.

- if the LPT dongle is still not recognized by the WIBU-KEY driver, you may introduce a delay factor to prevent a timeout, in case of too low power supply to the dongle. See also <http://support.wibu.com/en/faq/faq.html#Delay> . Please

- download the .ZIP archive <http://rayfract.com/dongle/diaglpt.zip> from our web site.
- *Start/Run* "explorer.exe" (without enclosing ""), to open Windows Explorer .
- create a directory \ray32\wibukey\diaglpt on your laptop's hard disk, with Windows Explorer.
- copy diaglpt.zip file into this directory, and unzip it e.g. with WINRAR utility.

Now slow down the communication speed between the LPT port and the WIBU-KEY dongle :

- open a DOS command prompt via *Start/Run* "cmd.exe" (without the enclosing "").
- change the current directory of that prompt with command line "cd \RAY32\WIBUKEY\DIAGLPT".
- navigate with Windows Explorer to your \ray32\wibukey\diaglpt directory, as created above.
- click on w2k_delay4.reg, and confirm the two prompts.
- switch to the DOS prompt as opened above
- enter command line "WKU32 RESET ALL"
- then try to start up Rayfract® again.

If this does not help, please repeat the above last four steps for all other .reg files in your DIAGLPT directory. ...delay12.reg will slow down the communication speed the most.

If your LPT WIBU-KEY dongle is still not recognized by the WIBU-KEY driver, please contact us for an USB key license upgrade offer.

Version 3.11 released in July 2008 :

- new refractor mapping option in *menu Mapping : Blue direct wave first breaks* to color direct wave travelttime curve segments in blue instead of the default orange. This may help with certain display devices (depending on lighting) and when printing sections.
- new *Depth conversion menu* option *Blue weathering bottom*, to plot refractor 1 elevation and velocity in solid blue color instead of the default black. Refresh displayed depth and velocity sections with ALT-Y.
- improved matching of trace positions in Interpex Gremix .GRM and BREAK.LST files, to receiver stations in the currently opened profile database. Input file positions are now always matched to the closest database receiver station, when updating header data with *File/Update header data menu* items.
- *branch point pick bar* is now always displayed and updated correctly in *Refractor/Shot breaks*, without a second bar ghost showing at a previous position.
- uphole shot traces are not mapped to a refractor any longer, in *Refractor/Midpoint breaks display*.
- corrected tutorial <http://rayfract.com/tutorials/coffey04.pdf> for imaging of an uphole refraction survey. Uphole shots (inverted walkaway VSP downhole shots) are combined with surface refraction shots.
- fixed an assertion failure during computation of the initial model, for uphole refraction surveys. If you encounter this problem with an early version 3.11 of our software, please download and install your corrected RAYUP311.EXE installable archive. See our e-mail instructions.
- combination of walkaway VSP with surface refraction requires resorting VSP traces by common borehole receiver, to create synthetic (inverted) uphole shots. See above for version 3.12 release notes, describing automated conversion of walkaway VSP surveys to uphole shot surveys and vice versa..
- you may want to combine walkaway VSP (shots at topography, receiver string in borehole) with crosshole shots, recorded with the same borehole receiver string. We support such a geometry in the same GeoTomCG .3DD survey file, with one or more overlapping borehole receiver spreads (in same borehole) and arbitrary shot positions. These shots may be positioned on the topography or in any number of other boreholes or tunnels.

Version 3.10 released in June 2008 :

- we now support import of Tweeton GeoTomCG .3DD files for horizontal borehole surveys and surface refraction surveys. Just select *File/Import Data Settings/Import horizontal borehole survey or .3DD refraction survey*, before importing the data with *File/Import Data...* .
- our import routine automatically **detects the averaged minimum distance between receiver stations for the current input file, and lets you update the station spacing to this new value.**

- import of Optim LLC SeisOpt, Geometrics SeisImager PickWin/PlotRefa .VS, Daryl Tweeton GeoTomCG .3DD and Interpex Gremix .GRM files has been improved, with missing dead/unpicked traces and strongly undulating topography. Missing traces are matched by inline offset, to spread receiver channels and line topography as specified in the input file, for other shots and traces.
- import of Geometrics SeisImager PlotRefa .VS now works with irregular receiver spacing.
- geometry error messages shown during data import will not swamp you any longer. Adjusting *Header/Shot field station spacing* by a few percent may help. Also, you may want to toggle *File/Import Data Settings/Allow missing traces* and *File/Import Data Settings/X coordinate is corrected for topography already*, if appropriate. Uncheck this option for Geometrics SeisImager .VS and Interpex Gremix .GRM, and check it for Optim LLC SeisOpt and Tweeton GeoTomCG .3DD files.
- new *File/Import Data Settings/Swap borehole x with z* option. Enable this to swap coordinates during import of .3DD files, and during export of SHOTPTS.SHO and COORDS.COR files.
- our *Refractor display parameter dialog* (invoke with ALT-P, in *Refractor/Shot breaks*) now allows entering a *Minimum station number* value in range -10000 to +10000. Also, we now allow adjusting the *Minimum time* to a value larger than 0, for borehole spread profiles.
- two new **conventional method refractor mapping** options in *menu Mapping : Undercorrect picks for shot point offset* will not fully correct first break picks for shot point offset (from nearest integer station), during Wavefront and Plus-Minus interpretation. This allows for diving waves, even at near-shot point receivers. Use this option to obtain less distorted corrected traveltimes, in case of a thin low-velocity overburden.
- *Regard mapping for shot offset correction* uses our earlier first break pick correction method if enabled, based on trace-to-refractor mapping and resulting refractor velocities. If unchecked, picks are corrected based on source-receiver geometry only, not regarding the trace-to-refractor mapping. Picked traveltimes are corrected for *shot point offsets* from nearest receiver station. Thus our traveltimes field regression method (preliminary step of our *Wavefront and Plus-Minus conventional methods*) can reliably reduce recorded traveltimes to one pair of forward/reverse curves, for one or multiple sections of the whole profile database.
- during *WET inversion* and forward modeling, first breaks are always corrected for lateral shotpoint offsets, based on source-receiver geometry only and disregarding any earlier trace-to-refractor mapping. *Inline shot point offsets* (from *shot station*) and *shot depth* are not corrected for, during *WET inversion*.
- for accurate shot timing, we recommend GISCO piezoelectric trigger switches. See <http://www.giscogeo.com/pages/seixptr.html> .
- for our new tutorial showing sub-bottom river imaging between two boreholes, see <http://rayfract.com/tutorials/b8b9.pdf> .

Version 3.09 released in May 2008 :

- WET options are now correctly initialized, when creating a new borehole spread/line profile database. To ensure correct settings for 3.08, create profile with *File/New....* Now reopen with *File/Open....* .
- we now support traveltimes tomography of first breaks recorded for **Walkaway VSP surveys, with a constant-velocity initial model**. See <http://rayfract.com/tutorials/walkaway.pdf>
- improved support for **combination of uphole shots with surface refraction shots**, both recorded with surface refraction receiver spreads. See <http://rayfract.com/tutorials/coffey04.pdf> . You may generate uphole shots from multi-offset VSP downhole shots as follows :
 - import VSP shots (Tweeton GeoTomCG .3DD format) into Rayfract® borehole spread profile. See above WALKAWAY.PDF tutorial .
 - export traces as ASCII.ASC with *File/Export header data/Export First Breaks as ASCII...* .
 - resort traces by common borehole receiver station, e.g. with Microsoft Excel spreadsheet software .
 - correct order of columns : swap column “Shot station #” with column “Receiver station #” .
 - reset column “Shot number” to same value, for all traces recorded by a common borehole receiver.
 - export updated column data from Microsoft Excel, to generate ASCII.ASC with uphole shots.
 - now import the surface refraction shots into a new Rayfract® refraction spread profile .
 - finally import the .ASC uphole shots into this same refraction spread profile .
 - invert the data with our Smooth inversion method as shown in above COFFEY04.PDF tutorial .
- our Smooth inversion routine will now automatically depth-extend the 1D gradient initial model (generated from surface based refraction shots) to elevation level of deepest uphole shot.

- when marking shots as uphole shots in *Header/Shot* by selecting *Shot Type* “Uphole shot”, field *Uphole time correction term* is now set to the new default value of 0.01 msec. instead of 10 msec.
- when changing back *Header/Shot* field *Shot Type* to “Refraction shot”, shot traces are now correctly marked as refraction shot traces in the profile database. *Uphole time correction term* is reset to 0.
- we now support **Smooth inversion of uphole refraction surveys with a constant-velocity initial model**. See <http://rayfract.com/tutorials/coffey04.pdf> .
- *Delta-t-V/Delta-t-V Settings/Regard Uphole picks for Delta-t-V inversion* is not supported any longer, since correct interactive estimation of *Header/Shot* field *Uphole time correction term* is too difficult.
- please uncheck *Delta-t-V/Delta-t-V Settings/Regard Uphole picks for Delta-t-V inversion* before processing uphole refraction surveys with older versions of our software.
- the WET continuation prompt as shown after display of initial model now allows aborting the inversion.
- our *Refractor display parameter dialog* (invoke with ALT-P, in *Refractor/Shot breaks*) now allows entering a negative *Maximum station number*.
- *Refractor/Shot breaks* does not link traveltimes curves to shot station any longer, for borehole spreads.

Version 3.08 released in April 2008 :

- uncheck *File/Import Data Settings/Keep same Layout start for consecutive shot files*, to determine layout start and shot position station numbers by division of positions specified in Geometrics SeisImager .VS, Interpex Gremix .GRM, Optim LLC SeisOpt and Tweeton GeoTomCG .3DD files, with the *station spacing* as specified in *Header/Profile* . This import option is unchecked per default when creating new profiles.
 - WET continuation prompt is displayed on top of all other windows, and cannot get "lost" any longer.
 - *Smooth invert/Scale WET filter height* is now supported for crosshole surveys, but is unchecked per default. Option *WET Tomo/Adjust wavepath width* is not allowed for crosshole surveys any longer.
 - Both of these options are activated when you create a new refraction spread profile.
 - updated PDF help topics available at <http://rayfract.com/help/rayfract.pdf>
 - You may rerun our Smooth inversion with a slightly different 1D gradient initial model :
- shut down Rayfract® and Golden Software Surfer® applications with *File/Exit* .
 - Rename directory \RAY32\<profile name>\GRADTOMO to ... \DFLTGRAD, in Windows Explorer
 - restart Rayfract, reopen profile database with *File/Open* .
 - check *Delta-t-V/Delta-t-V Settings/Process every CMP offset*, for sharper layer boundaries
 - select *Smooth invert/WET with 1D gradient initial model*
 - proceed as in chapter 1.4 of our manual at <http://rayfract.com/help/manual.pdf>
 - once WET inversion finishes, open both VELOIT10.SRF or VELOIT20.SRF (as stored in subdirectories ... \DFLTGRAD and ... \GRADTOMO) in Surfer and tab through them.

Version 3.07 released in March 2008 :

- shows Root Mean Square RMS error (standard deviation) of misfit between modeled and picked times. Both mean and RMS error of signed and unsigned misfit are displayed after WET inversion or forward modeling, and written to VELOITXX.FIT files (VELOIT10.FIT for VELOIT10.GRD).
- correctly imports topography from Geometrics PlotRefa .VS files if unpicked traces missing from .VS , or if .VS contains shots recorded with not just one spread but multiple overlapping receiver spreads .
- when importing uphole shots, the traveltimes curve minimum position may deviate from the hole position, by up to the depth of the shot. Specify shot depth in ASCII.ASC column or during import.
- topography now is always imaged correctly (no blank pixels below topography) on WET tomograms, even with widely spaced shots and receivers.
- *Grid menu* transformations “Convert grid file between feet and meters” and “Turn around grid file by 180 degrees” now correctly transform both the velocity tomogram VELOITXX.GRD and the corresponding coverage grid COVERGXX.GRD .
- *File/Import Data Settings/Keep same Layout start for consecutive shot trace files* is now disabled (unchecked) per default. With this option disabled, our import routine determines layout start and shot position directly from the SEG-2 trace headers. See below, notes for version 2.65 . SEG-2 trace header fields SOURCE_STATION_NUMBER and RECEIVER_STATION_NUMBER override fields SOURCE_LOCATION and RECEIVER_LOCATION.

- *Trace menu* items *Shot gather*, *Midpoint gather* and *Offset gather* now show trace cursor attributes at bottom of display, when moving the pick cursor with left/right/up/down arrow keys. We show station, trace, shot, channel, sample, time and amplitude attributes .

Version 3.06 released in February 2008 :

- **scales WET smoothing filter height, with depth below topography.** This ensures better resolution of weathering layer, and fewer artefacts at bottom of WET tomograms. Also, the misfit between modeled and picked first breaks decreases faster during WET inversion (with fewer iterations).
- startup diagnostics allow for date change across time zones when validating database schema \RAY32\REF\PROTO32.DBD .
- all recently added Smooth inversion and WET settings are appended to .PAR files.
- Shot point symbols (inverted red triangles) are now plotted on top of receiver symbols (grey diamonds), on WET tomograms. See Grid menu options.
- *File/Update header data/Update from Gremix .GRM files...* correctly matches .GRM shot and receiver positions with profile database station numbers.
- for Smooth inversion 3.06 of an Optim LLC SeisOpt® data set made available by FUGRO WEST see <http://rayfract.com/tutorials/clud1.pdf> .
- for imaging of a reactivated landslide in Austria see <http://rayfract.com/tutorials/gso801.pdf> .

Version 3.05 released in January 2008 :

- automatic adjustment of *WET wavepath width* for each trace, based on the picked time. For low coverage surveys (wide shot spacing), you may want to disable this new option in menu “WET Tomo”.
- WET parameter *Degree of differentiation of Ricker wavelet* has been changed to the new default value 0 (former default value 1). Also, the Ricker wavelet weighted wavepath modeling has been corrected, for value 0.
- these improvements lead to more robust WET output, even with difficult data sets showing e.g. velocity inversions in overburden and at a high WET iteration number. Also, the weathering layer is better resolved, and basement velocity is imaged more reliably.
- to restore **pre-3.05 WET default parameters** :
 - uncheck *WET Tomo/Adjust wavepath width*
 - select *WET Tomo/Interactive WET tomography...*
 - for a new profile, click on *button Reset* to reset the *WET wavepath width*
 - reset *Degree of differentiation of Ricker wavelet* to 1
 - Adapt other WET parameters such as *WET iteration count* and *velocity smoothing*
 - click on *button Start tomography processing* and continue as usual
- pre-3.05 WET default parameters may work better for some special applications, such as cavity imaging and with a wide shot spacing (higher than 6 average receiver separations).
- we now correct first breaks for lateral shotpoint offsets, during WET inversion and forward modeling over Surfer .GRD files.
- two new *Refractor mapping menu* options, for coloring of shot sorted traveltime curves. You may display all curves in gray, or color each shot curve by source type, as selected in *Header/Shot*.
- to adjust minimum/maximum velocities used for Surfer® color coding of velocities :
 - start up Surfer e.g. via desktop icon
 - select Surfer menu item *File/Open...*
 - select WET tomogram e.g. VELOIT20.SRF file, located in \RAY32*<your profile>* subdirectories :
 - GRADTOMO (Smooth inversion) or
 - BOREHOLE (Crosshole survey) or
 - TOMO (Pseudo-2D Delta-t-V initial model based inversion).
 - select Surfer menu item *View/Object Manager*
 - double-click on *Image Map* label shown at left of Surfer® VELOIT20.SRF plot
 - click on *Colors* color bar
 - Set *Minimum* to e.g. 500 m/s, *Maximum* to e.g. 5000 m/s and click on OK twice

- select Surfer menu item *File/Save* to store edited VELOIT20.SRF tomogram
- our new tutorial <http://rayfract.com/tutorials/sapri12.pdf> shows interpretation of a Geometrics SeisImager™ PickWin .VS file, with version 3.05 Smooth inversion.
- when creating new spread types with *File/New Spread type...*, MYSREAD.SPR is written to \RAY32\REF again instead of \RAY32\BIN
- resets interactive WET *wavepath width* to default value, when importing new data or when running our Smooth inversion.

Version 3.04 released in December 2007 :

- More robust routines for database creation and automated revision of old profiles
- Improved automatic determination of default wavepath width, for very shallow refraction surveys with a short receiver spacing / for closely spaced boreholes.
- For S-wave surveys and slow P-wave surveys with max. time picked for inline shots exceeding 200 msec. you may need to decrease WET wavepath width interactively by 35%. Otherwise WET output may show wavepaths following a high-speed “skeleton” with slow background velocity “cells” in overburden, especially with a high number of WET iterations. Also, decreasing the WET wavepath width may result in a better match between picked and modelled times.
- Improved startup diagnostics. If the RAYFRACT32.EXE is started up in the wrong directory, or the prototype database schema \RAY32\REF\PROTO32.DBD is invalid, the software will display an according error message. Once you dismiss this message, the software will shut down again.
- *Menu Smooth invert* contains new borehole survey option *Beydoun weighting for borehole WET* to enable/disable Beydoun weighting.
- *Menu Smooth invert* offers new borehole survey option *Coverage grid shows unweighted hit count*. If unchecked, the coverage grid shows the hit count of each grid cell, scaled by Beydoun weighting.
- To generate Daryl Tweeton GeoTomCG .3DD input files required by our new crosshole tomography routine, we recommend using **TomTime picking software**, available from GeoTom LLC. Contact Daryl Tweeton at tweetond@tc.umn.edu or at dtweeton@giscogeo.com . TomTime reads all common seismograph formats, and offers versatile frequency filtering and display options. See

<http://giscogeo.com/pages/seixgott.html>

for more information. TomTime also allows easy picking of shear-wave first breaks. Alternatively you may want to upgrade to our latest version 3.14 which now supports import and picking of SEG-2 borehole spread/line traces, and shear-wave picking.

Version 3.03 released in November 2007 :

- Profile creation and database update now work again correctly, on non-English language Microsoft Windows installations
- When running our software under Microsoft Windows® 2000, be sure to always uncheck *File menu* item *Call batch from PIF file*, immediately after starting up Rayfract®. Otherwise database revision and spread type import/export routines will fail to complete.
- For instructions showing processing of a crosshole data set see <http://rayfract.com/tutorials/igta13.pdf> .
- To disable dynamic Beydoun weighting during WET inversion of borehole surveys, check *Smooth invert menu* option *Precompute static Beydoun weight matrix*. Static weighting assumes that each pixel is affected by all wave paths. Dynamic weighting does not make this assumption. Static weighting is more conservative, and a compromise between dynamic weighting and no weighting at all.
- To specify elevations for all profile shot and receiver stations in a surface based refraction survey :
 - select *Header/Station*
 - browse station records with F7/F8 . If x/y/z are correct already exit with ESC key.
 - otherwise click on *button Reset coordinates and v0*
 - leave x/y coordinates empty for all stations
 - enter elevation z for a few non-adjacent stations
 - you do not need to enter z elevation for all stations
 - now click on *button Interpolate coordinates and v0*

- Next you may reopen the station editor with *Header/Station*. Now browse station records with F7/F8 to check the interpolated elevations. Also, x/y coordinates have been generated automatically.
- To specify a known/fixed elevation at more stations before interpolation, you need to first click on *button Reset coordinates and v0*. Then reenter the elevation at all relevant stations, and click again on *button Interpolate coordinates and v0*.
- Alternatively, generate COORDS.COR file with *File/Export header data/Export Station Coordinates...*
- edit the COORDS.COR e.g. with Wordpad or Notepad text editors
- reimport the edited COORDS.COR with *File/Update header data/Update Station Coordinates...*
- To display Daryl Tweeton GeoTomCG .3DD files in a readable way, please proceed as follows :
 - select *Start/Run*
 - enter "Wordpad.exe" without the enclosing "" and click OK
 - select *File/Open* in Wordpad program
 - navigate to your \RAY32\DOC directory and select e.g. IGTA13.3DD
- To enable or disable posting and labeling of shot points and/or receivers on WET tomograms, check or uncheck the corresponding menu item in *menu Grid* before starting our Smooth inversion.
- You don't have to redo the Smooth inversion to redisplay WET tomograms with/without posting and labeling of shot points and/or receivers. Proceed as follows instead :
 - check or uncheck corresponding items at bottom of *menu Grid*
 - select *Grid/Image* and contour velocity and coverage grids...
 - select desired WET tomogram grid file e.g. VELOIT20.GRD (output after 20 WET iterations), stored in profile subdirectories GRADTOMO (Smooth inversion),
 - BOREHOLE (crosshole survey) or
 - TOMO (pseudo-2D Delta-t-V initial model).
- To generate a desktop shortcut for easy Rayfract® startup :
 - Left-click *Start menu*, All Programs, Rayfract32
 - right-click menu item Rayfract32 and select "Copy" command
 - minimize all windows
 - right-click on Desktop and select *Paste Shortcut command*

Version 3.02 released in October 2007 :

- Implements improved weighting/preconditioning for Smooth inversion of crosshole surveys. Velocity artefacts/anomalies at grid corners and at grid edges/directly adjacent to boreholes are suppressed. See Beydoun and Mendes 1989 "Elastic Ray-Born L_2 -Migration/Inversion" with abstract at <http://www.blackwell-synergy.com/doi/abs/10.1111/j.1365-246X.1989.tb00490.x> . See also Luo and Schuster 1991 "Wave-equation Traveltime Inversion" Appendix B, with abstract at <http://link.aip.org/link/?GPY/56/645/1> . Luo and Schuster describe this weighting as "... Another modification is to use a preconditioned gradient (search) direction (formula). This preconditioning compensates for geometrical expansion (Beydoun and Mendes, 1989)".
- The high sensitivity of WET to velocity variations directly at source/receiver is welcome for surface refraction surveys, since receivers are located close to the shot point in this case. For borehole surveys, the closest receiver is in the other hole. So velocity variation at source/receiver cannot be measured reliably in this case, and needs to be suppressed during tomography processing. More weight is given to the central portion of the subsurface section, located between the two boreholes. The fundamental assumption is that for borehole surveys, there are no "large" velocity variations, i.e. minimum velocity smaller than e.g. 50% of maximum velocity. For surface refraction surveys, minimum velocity (directly below topography) may be as small as 10% or less of maximum subsurface section velocity (in basement).
- Further optimized WET based inversion of surface refraction surveys. Smooth inversion of our LINE14 sample profile runs another 10% faster under Windows XP SP2 on an Intel Core 2 Duo processor.
- *Channel numbers* and *station positions* in *Header/Receiver* now always correspond to ASCII.ASC input file values, even when limiting the offset during import.
- Import option *Turn around spread* now works for all input file formats. Also, shot positions are inverted correctly, relative to the receiver spread.

- Import options *Turn around spread* and *Limit offset* may not be selected both at the same time.
- WET *smoothing filter* size now is determined based on average receiver spacing instead of the profile station spacing.

Version 3.01 released in September 2007 :

- We now support crosshole traveltimes tomography, based on a constant velocity initial model which is iteratively refined with WET Wavepath Eikonal Traveltime tomography processing.
- We have tested our new crosshole tomography routine with sample survey files made available by our Spanish client I.G.T. International Geophysical Technology. These files are formatted as Daryl Tweeton GeoTomCG .3DD files. See <http://rayfract.com/samples/borehole.zip>
- For instructions on crosshole data interpretation, see file BOREHOLE.TXT included in borehole.zip .
- We currently regard X and Z coordinates only for crosshole surveys. Y coordinates as specified in GeoTomCG input files are not regarded and are assumed to be all zero.
- If you want us to support your crosshole data format and samples, you are welcome to send us these files, as long as you have a current support contract.
- Also, we now support posting and labeling of both sources and receivers on WET velocity plots. See new items at bottom of Grid menu.
- We offer a new routine *File|Update header data|Import synthetic breaks from .LST*
- For IGTA13 crosshole data set (see above BOREHOLE.ZIP and BOREHOLE.TXT) a synthetic model is available at <http://rayfract.com/samples/swiss.zip> . This allows determination of vertical and lateral velocity resolution in WET output.

Version 2.75 released in August 2007 :

- Supports importing Geometrics SeisImager™ .VS files generated with Plotrefa and Pickwin modules. Specify distance unit feet by unchecking File|Import Data Settings|Default distance unit is meter.
- Import routine supports trace gaps with more than three adjacent missing traces
- Improved robustness of Wavefront method when processing low-coverage data sets
- WET tomography will regard a receiver station if traces have been picked for that station only
- File|Update header data|Update from Gremix .GRM allows for missing traces in .GRM files
- File|Update header data|Update First Breaks from .LST now matches .LST traces to profile database traces by station number instead of trace number. So you can
 - import e.g. SEG-2 shots (always all traces imported) into one profile
 - import e.g. SeisOpt files with missing traces into another profile
 - select File|Export header data|Export First Breaks to generate .LST file with SeisOpt picks
 - update first profile with File|Update header data|Update First Breaks.. and the .LST just generated.

Version 2.74 released in July 2007 :

- Improved compatibility with Microsoft Windows® Vista™. Axis ticks are now always labeled correctly, in time/depth/velocity sections.
- Comes with latest version 5.20b of WIBU-KEY dongle driver software.
- To activate Setup, Context and Update tabs in the WIBU-KEY control panel applet 5.20, left-click on the small icon to the left of the dialog title bar and select "Advanced Mode".
- We now display the current WET iteration number, at left bottom of Rayfract® main window.
- WET Tomo menu options are now enabled before starting with first Smooth inversion or pseudo-2D Delta-t-V and WET inversion.
- The receiver spread layout start is now always rounded correctly to the nearest whole integer station number, when importing shots into a profile database.
- When importing multiple e.g. Interpex Gremix .GRM files in one session, the layout start for each shot in each .GRM file is now determined correctly, based on receiver locations specified in the .GRM files.
- When updating from version 2.72 or 2.73 to version 2.74, your custom receiver spread types are now imported automatically during installation of 2.74, from file \RAY32\REF\MYSPREAD.SPR .

- Every time you open a profile database and spread types referenced have been validated, these are exported automatically to file MYSPPREAD.SPR in your profile directory. Also, MYSPPREAD.SPR is updated whenever you import one or more additional shots into the same profile database.
- Version 2.74 has been recompiled with Microsoft Visual C++ 2005. Smooth inversion for our sample profile LINE14 runs about 10% faster as a consequence.
- Also, 2.74 comes with updated versions of Birdstep RDM database utilities, for initializing, checking, revising, import into and export from profile databases.
- Use our Trace|Offset Gather display to check your first breaks for consistency regarding reciprocal traveltimes. For the same offset and midpoint (station number), first breaks picked (red crosses) should collapse onto a single pick. If these are displayed on the same trace but vertically offset from each other, such picks violate the traveltime reciprocity principle which states that traveltime is invariant to exchanging source and receiver between two constant measuring stations. Browse offsets with F7/F8 in Trace|Offset Gather. Browse individual traces with left arrow/right arrow keys. Disregard reciprocal errors at small offsets, regard reciprocal errors at large offsets.
- For a short description of the mathematical theory behind our Delta-t-V and XTV inversions, see http://rayfract.com/xtv_inversion.pdf
- A recent Karst study done at University of Florida compares Rayfract® Smooth inversion with Geometrics SeisImager™, Optim LLC SeisOpt® Pro and core data. See <http://rayfract.com/07-2353.pdf>
- For a recent USGS publication comparing GeoTomo LLC GeoCT-II with Rayfract® see <http://pubs.usgs.gov/sir/2006/5166/>

Version 2.73 released in May 2007 :

- Supports Microsoft Windows® Vista™, Windows XP, Windows 2000, Windows 98 SE. Follow Vista instructions on how to download and install WINHLP32.EXE, to enable Rayfract® help file display.
- Allows import of Optim LLC SeisOpt files. You may generate SeisOpt data files e.g. with W_GeoSoft WinSism 10. For Rayfract® import of SeisOpt files, disable File|Import Data Settings item "Default distance unit is meter" to specify distance unit feet. Disable setting "Default time unit is seconds", to specify time unit milliseconds.
- If there are dead traces missing from SeisOpt or Interpex Gremix input data files, these missing traces are regenerated during import automatically for the active part of the receiver spread type specified.
- You now can browse/add/import/export receiver spread types in menu File without opening a database.
- If during import of data files with File|Import Data... Rayfract® shows an error message and you switch to another application, the cursor may display as an hour glass when you try to reactivate Rayfract®. Be sure to click once or twice on the Rayfract™ icon shown in the task bar at the bottom of your display, to reset the cursor to the normal arrow and to unlock our software. This issue has been fixed for version 2.73.
- We recommend to refine Smooth inversion WET output by increasing the WET iteration count to e.g. 100 or 200 iterations. See our tutorials <http://rayfract.com/tutorials/line01pt.pdf> <http://rayfract.com/tutorials/line2.pdf>
- For a recent survey imaging subsurface velocity below a street using Rayfract® pseudo-2D Delta-t-V and Smooth inversion, see http://rayfract.com/samples/street_crossing.pdf
- For a recent study comparing a published Palmer GRM interpretation with Rayfract® Smooth inversion, see <http://rayfract.com/papers/eg374whiteleyditchcheck.pdf> . This paper also includes interpretation of a low coverage synthetic data set, with four different methods.

Version 2.72 released in January 2007 :

- We have implemented "File" menu functions for export/import of receiver spread types. Please note that you need to open any profile e.g. LINE14 first, to enable this. Also, whenever you define a new spread type, all spread types are exported to file \RAY32\REF\MYSPPREAD.SPR. Spread types are stored in the reference database (directory \RAY32\REF, files SEISRF32.*), and not in the individual profile databases. So any custom spread type defined or imported is available for all profile databases.
- We offer a new Header|Profile field "Min. horizontal separation [%]". This field defines the minimum horizontal station offset applied during coordinate interpolation, in percent of the inline station offset. You may want to leave this field at its default value of 25%, for most recording geometry situations.

- Also, we now support posting and labeling of shot points. See new options at bottom of Grid menu.
- Our software supports again reading of .PAR parameter files generated with version 2.64 and earlier versions.

Version 2.71 released in December 06 :

- This updated version features a new XTV parameters dialog, in menu Delta-t-V. You may enable modeling of constant velocity layers with a modified Dix inversion, and/or with Intercept time layer inversion. The XTV method also supports modeling of constant velocity gradient layers (with our existing Delta-t-V method), and has been described by Roland A. Winkelmann in his 1998 thesis, as done with Professor Helmut Gebrande in Munich. We recommend enabling XTV inversion for high coverage profiles only.
- Once you have specified your preferred XTV parameters in above dialog, you may then carry out a pseudo-2D inversion, with our existing Delta-t-V menu item "Interactive Delta-t-V". This inversion algorithm has been generalized and now supports the XTV method.
- The XTV parameters are now correctly loaded from the profile database, when displaying the XTV dialog. Also, the valid range of the three numeric parameters has been changed. The minimum velocity ratio required for application of the Intercept time layer inversion now ranges from 1.01 to 2.5. And the sum of the two velocity step parameters may not exceed 100 percent.
- XTV parameters chosen are now written to the .PAR file, during Delta-t-V inversion. And the inversion type used for each layer is written to the last column of the .CSV file.
- We have improved our automated database revision routine. The revision log is now written to file SEIS32.REP in the profile database directory.

Version 2.70 released in November 06 :

- We have adapted our WET imaging such that the topography is now imaged correctly, for receivers beyond the first/last shot position. Please note that imaged velocity shown below such receivers is not very meaningful, since the all-important weathering velocity and thickness can't be determined below these receivers. Since there are no shot points positioned close to these receivers.
- This version features a first try at our implementation of the XTV inversion as described by Roland A. Winkelmann in his 1998 thesis. See Delta-t-V settings submenu. Use for high coverage surveys and at your own risk only.
- The SEIS32.BLN blanking file generated during Delta-t-V inversion will now be corrected for a non-zero "Profile start offset" as specified in Header|Profile.
- Also, our Rayfract(tm) software now correctly imports extrapolated shot branches generated during conventional Wavefront and Plus-Minus interpretation of profiles with a minimum receiver separation of two or more station numbers.

Version 2.66 released in November 06:

- We offer a new Grid menu command "Convert elevation to Depth below topography..." for conversion of elevation section grids to depth sections grids.
- Also, the station header V0 (weathering velocity) is now updated automatically, when remapping traces to refractors in Refractor|Shot breaks, and when smoothing crossover distances in Refractor|Midpoint breaks. If consecutive Wavefront or Plus-Minus interpretation fails saying "Bad travelttime field" after 10,000 regression iterations, please proceed as follows :
 - select Refractor|Shot breaks or Refractor|Midpoint breaks
 - disable Trace mapping|Automated updating of v0
 - proceed as described in above manual.pdf, chapters 1.8 & 1.9 (Shot breaks) or chapters 1.12 and 1.13 (Midpoint breaks)
- In menu WET Tomo|WET tomography Settings, we offer a new option "Update imaged grid depth". This option is enabled by default. If enabled, the grid depth will be updated after each tomography iteration. Otherwise, the imaged grid depth will stay the same as for the initial model.
- Wavefront and Plus-Minus modeling parameters "Overburden filter" and "Base filter width" can now be set to maximally 20 and 30 station numbers, respectively.

Version 2.65 released in September 06 :

- The "original input file" name is shown correctly again, in Refractor|Shot breaks.
- Forward modeling of traveltimes with our optimized Eikonal Solver runs about 15% faster.
- Our SEG-2 binary trace data import routine now should correctly import most trace data files, even if the trace data start is not rounded up to the next a 32-bit (double word) block boundary, as prescribed by the SEG-2 standard.
- We offer a new "Image and contour velocity and coverage grids..." function, in menu "Grid". Use this function for imaging of Surfer(tm) grid files as generated during previous inversions.
- Interactive Delta-t-V export settings dialog offers a new option "Gridding method". Select one of "Natural Neighbor", "Nearest Neighbor", "Delaunay Triangulation" and "Minimum Curvature".
- Menu "Grid" offers another new function "Grid and image Delta-t-V .CSV file...". This function regards the current setting of Delta-t-V export option "Gridding method". So you may grid the same .CSV with alternative methods, without having to redo the Delta-t-V inversion.
- If you disable the new setting "File|Import Data Settings|Keep same layout start for consecutive shot trace files", layout start and shot position are determined directly from SEG-2 trace header fields SOURCE_LOCATION and RECEIVER_LOCATION. The layout start is rounded to an integer station number, and the shot position is shifted by the resulting offset (less than half a station spacing).
- We recommend the latest version 3.22 of the INTERPEX IXSEG2SEGY utility, for frequency filtering and picking of traces. This version now correctly preserves SEG-2 trace header fields SOURCE_STATION_NUMBER and RECEIVER_STATION_NUMBER. See <http://www.interpex.com>. These fields override fields SOURCE_LOCATION and RECEIVER_LOCATION.
- We have deprecated our pseudo-2D Delta-t-V inversion, and now recommend to always at least trying our Smooth inversion method, based on a 1D gradient initial model. See e.g.

<http://rayfract.com/help/manual.pdf>

<http://rayfract.com/tutorials/palmfig3.pdf>

<http://rayfract.com/tutorials/depress.pdf>

<http://rayfract.com/tutorials/broadepi.pdf>

Version 2.64 released in May 2006 :

- Delta-t-V inversion once again works fine with parameter "Regression over offset stations" set to values higher than 7. This was broken in version 2.62.
- Displaying and picking shot traces with up to 10,000 samples now works correctly. Previously, this did not always work, with more than 5,000 samples per trace.
- Data import routine supports merging of binary trace data files with ASCII first break picks as supplied in GEOMETRICS .BPK pick files, even if columns 5 and 6 of the .BPK are not separated by white space characters. Column 5 is assumed to contain "0.0" (without the enclosing "").
- "Import shots" dialog offers new option "Detect shifted 32-bit floating point sample data start". This option was implicitly enabled up to now, but did not always work. Use this option if imported binary shots don't show any coherent signal, in Trace|Shot gather.
- SEG-2 import routine supports DMT SUMMIT 32-bit floating point traces.
- Improved support for import option "Limit offset". Use for improved imaging of shallow subsurface (e.g. weathering layer), if the data was recorded with too long receiver spreads and too many channels.
- New function "Reverse polarity" in menu "Trace processing".
- When opening or moving any other window on top of trace gather window, mouse cursor is not reset any longer when the underlying trace gather is repainted.
- The "original input file" displayed in the title bar of the Trace|Shot gather window is out of sync with the actual shot no. displayed. This is shown correctly in Refractor|Shot breaks. Rest assured that this display bug does not affect geometry handling and inversion of your data in any way.
- The Surfer(tm) Kriging gridding method sometimes generates artefacts, such as false high velocity anomalies directly below the topography. If you want to experiment with different algorithms than the default Kriging method, please download archive <http://rayfract.com/common/scripts.zip> to a temporary directory e.g. C:\TEMP. Now unzip the archive in C:\TEMP and proceed as described in the included README.TXT. We offer scripts for gridding methods "Natural Neighbor", "Nearest Neighbor", "Delaunay Triangulation" and "Minimum Curvature".
- For optimum coverage of the subsurface with seismic energy, we recommend to employ overlapping receiver spreads. See <http://rayfract.com/help/overlap.pdf> and <http://rayfract.com/help/overlap.txt>.

- To suppress velocity artefacts, we strongly recommend using our Smooth inversion method. See http://rayfract.com/pub/srt_evaluation.pdf and <http://rayfract.com/tutorials/broadepi.pdf> .
- Wavefront and Plus-Minus inversion may abort with a message saying "Refractor coverage may be too low or too short". Please record more (far offset) shots for this profile, and use a shorter receiver spacing. Also, use longer receiver spreads, with more channels. Our Plus-Minus and Wavefront inversions include a preliminary processing step called "traveltime field regression" which reduces basement refractor first breaks to a single set of forward and reverse traveltime curves (Brückl 1987). This data reduction step requires a certain data density. If too few shots were recorded, or the receiver spacing was too wide and/or receiver spreads were too short, this reduction algorithm may not be able to reduce the data set.
- The traveltime field regression algorithm works best if all sources and receivers are positioned at whole station numbers. So you may want to reimport your shots into a new profile, with a more appropriate "Receiver spread type", e.g. "13: 48 every2nd".
- Also, overburden refractor first breaks are interpreted with the conventional intercept time method, for adjacent reversed shot pairs. This step requires a certain data density as well. Please note that such low coverage problems do not arise with our Smooth inversion and Delta-t-V and WET inversion, since these methods do not require you to map traces to refractors at all.
- When importing first breaks from Interpex Gremix .GRM files or ASCII.ASC files, these files need to specify first break pick times for all receivers specified in the spread type used. If a trace cannot be picked (data is too noisy or the trace is dead), please specify a time of -1, meaning "not picked".
- Import of ASCII.ASC shots may show an error message "'Shot position of shot nr. ... is not at traveltime curve minimum !" The import routine detects for inline shots the two channels with the smallest first break picks. If the shot is not positioned between these two channels, above message is shown and the shot is not imported. You may want to repick traces or edit the .ASC such that the shot position is located between the two smallest first break times. You may need to introduce "artificial" picks for near-shot traces which you did not pick previously.
- To update the Windows help file topics shown in menu "Help", please proceed as follows :
 - Download <http://rayfract.com/help/rayfract.hlp> to a directory on your PC, e.g. C:\TEMP.
 - Open a Windows Explorer window via Start|Run..., enter "Explorer" and hit RETURN.
 - Navigate to your C:\TEMP directory. Select file RAYFRACT.HLP with left mouse key.
 - Press CTRL-C or select Edit|Copy .
 - Navigate to your \RAY32\HELP directory, e.g. C:\RAY32\HELP.
 - Press CTRL-V or select Edit|Paste . Confirm the "Confirm File Replace" prompt.

Context sensitive popup help (in dialogs) will work for a recently updated Rayfract™ installation only.

- If the word feet or meter is contained in a header line of a .PRN, .SHO or .COR file, the shot and receiver positions and coordinates in that file are assumed to be specified in that distance unit. See <http://rayfract.com/help/ln14feet.zip> for sample files, specified in feet.
- You may want to limit the maximum Delta-t-V velocity to a value lower than the default 5,000 m/s. Use "Export Option" parameter "Max. velocity exported", in Delta-t-V|Interactive Delta-t-V. This parameter is regarded by both pseudo-2D inversion and Smooth inversion.

Version 2.63 released in December 2005 :

- WET grid caching algorithm correctly decides whether to cache all receiver grids in RAM, or whether to write all grids to disk, depending on the amount of free RAM available.
- Integrated optimized memory manager (MicroQuill SmartHeap version 8), for improved data processing performance.
- Inversion will recognize if a profile is too long, and will recommend splitting the profile into two parts. This may happen e.g. in case of many short overlapping receiver spreads, and short maximum offset between shot point and receiver.
- New edit field "Profile start offset" in Header|Profile. Use this field to specify a horizontal inline offset different from 0.0, for the first profile receiver. This start offset value will be used by subsequent Delta-t-V and WET imaging, and is shown on the horizontal X axis.
- New WET setting "Write grids for every iteration".
- The maximum imaged depth has been extended to 70 km, and there is not any longer a limit on the maximum first break pick time.
- The "Annotation parameters" dialog allows selection of X/Y axis Line type "Dashed line"/"Dotted line"/"No line" and ticks type "Major & Minor"/"Major ticks"/"No ticks".

Version 2.62 released in August 2005 :

- Significantly improved Delta-t-V internal static corrections. During a second pass of statics computation, ray emergence angles are now regarded.
- Additional Delta-t-V setting “Suppress velocity anomalies”. Use for medium to high coverage profiles, to suppress noise and processing artifacts.
- New Delta-t-V setting “Process every CMP offset”. Use for medium to high coverage profiles, high S/N ratio and flat subsurface layering, for increased vertical resolution.
- SEG-2 import routine now supports importing 32-bit floating point traces generated with Interpex IXSEG2SEGY utility.
- Numeric field entry always allows adding more digits without first having to delete the whole entry.
- When toggling Delta-t-V static correction methods “surface consistent” and “CMP gather specific”, just one subsequent run of the Delta-t-V inversion is required, for stable output.
- A few minor bugs have been fixed.

Version 2.61 released in March 2005 :

- Improved robustness of WET tomography implementation.
- Maximum number of WET iterations increased to 999.
- Updated and optimized database subsystem.
- Correctly regard “off end” shots during WET inversion, located at a distance of up to two station spacings, from first/last profile receiver.
- Mapping of traces to refractors in Midpoint breaks display (Refractor|Midpoint breaks) now works as advertised in our manual, with spread type “13: 48 every 2nd” and a station spacing of half the true receiver separation. See <http://rayfract.com/tutorials/line2.pdf> .

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