

Release notes Rayfract® versions 2.61 to 3.16 :

Version 3.16 released in February 2010 :

- **disallowed pseudo-2D Delta-t-V inversion with Delta-t-V menu, to suppress Delta-t-V artefacts.** See 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 used by our *Smooth inversion* method, for determination of the *ID-gradient initial model* required by subsequent *2D WET Wavepath Eikonal Traveltime 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 traveltime 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 traveltime curves and matches *shot positions* to picked *traveltime 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 *traveltime 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*.
- **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.
- **3.16 seems to work fine under Windows 7 32-bit.** To run it under Windows 7 64-bit, 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. Please note that earlier 3.16 versions may not work with driver 6.00a.
- *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*. Next 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.**

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://golden.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 "WКУ32 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 traveltime 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 traveltime curves, 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 curves 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. Also, inline shot point offsets 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 travelttime 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/g0801.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 traveltimes 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 RAYFRAC32.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 visualize individual wavepaths between one receiver and one source, please :
 - run our Smooth inversion with *menu Smooth invert*, e.g. for sample profile C:\RAY32\LINE14
 - select *WET Tomo\Interactive WET tomography...*
 - click on *button Edit grid generation*
 - set *Write wavepaths to disk for shot nr.* e.g. to value of 2 for shot no. 2
 - click on *buttons 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\W002-024.GRD (shot no. 2, trace no. 24)
 - double click on the generated black-and-white plot
 - left-click on *Colors scale* and *Load button*
 - select C:\RAY32\Rainbow2.CLR color scale
 - 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. 2 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\W002-024.SRF
- 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 traveltime 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 MYSPREAD.SPR in your profile directory. Also, MYSPREAD.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 travelttime reciprocity principle which states that travelttime 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 few comments on the Univ. of New South Wales thesis of Ramin Nikrouz, see <http://rayfract.com/tutorials/nikrouz.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/eg374whiteleyeditcheck.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\MYSPREAD.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 Rayfrac(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 traveltimes 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 traveltimes 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 traveltimes 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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