REFLEXW

for Windows9?/2000/NT/XP

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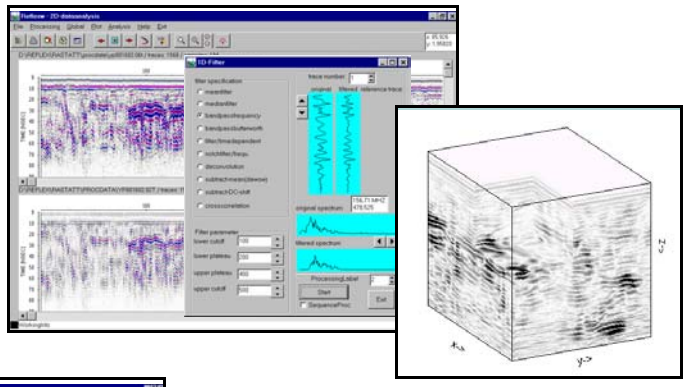
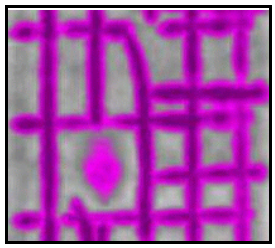
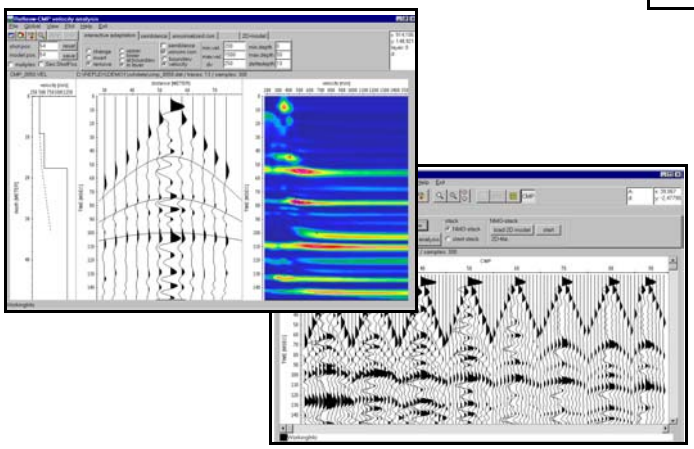
REFLEXW - the 2D processing and 2D/3D interpretation software for

" GPR



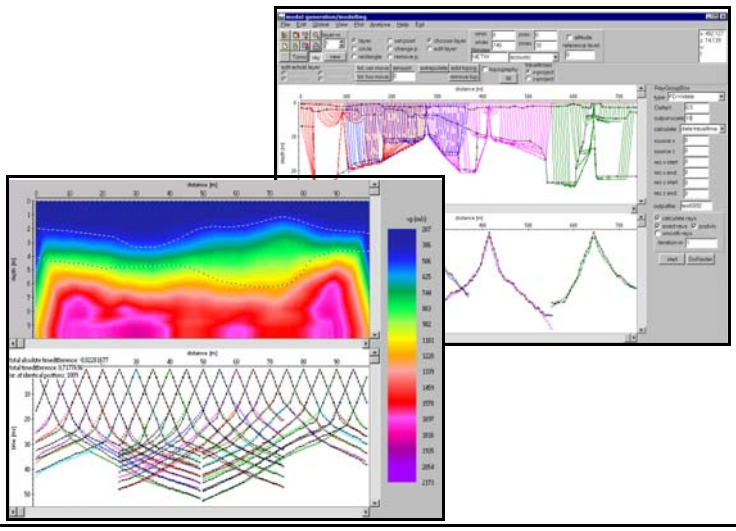
New Scan-3D





" reflection seismics

" refraction seismics



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REFLEXW

for Windows9?/2000/NT/XP

One software package for nearly all wave data like GPR, reflection seismics, refraction seismics

REFLEXW is the new WindowsNT/9?/2000/XP software generation of REFLEX for the **2- and 3-dimensional** processing and interpretation of reflection, refraction and transmission data with a wide range of applications:

- GPR (Ground penetrating radar)
- reflection seismics
- refraction seismics
- borehole-borehole wave data

Apart from the complete range of the standard filter- and CMP-processing steps many elements especially designed for various applications are incorporated:

- 3D-datainterpretation incl. calculation of timeslices
- picking of first arrivals or horizons
- wavefront-inversion of first arrival traveltimes
- raytracing using a Finite Difference approximation of the eikonal equation
- tomographic interpretation using SIRT
- Simulation of the wave propagation using a Finite Difference (FD) approximation of the elastic or electromagnetic wave equation

The following modules of **REFLEXW** are available:

* module **2D data-analysis** for GPR, reflection seismics, refraction seismics, borehole-borehole data
  Many different processing possibilities - interactive processing of single files or by generating a batch-file, one- and multi-channel filters, editing, static correction, deconvolution, migration and much more. All processing steps are documented.
  Easy Import of data of many different formats (e.g. SEGY, SEG2, most of the GPR- and seismic systems (for example: GSSI, RAMAC, PULSE-EKKO, ABEM, OYO, Summit and so on), integration of other non-standard formats.
  conversion of single sections and of a profile sequence (automatic assembling and storing of the sections under one single datafile or automatic generation of datafiles for parallel and inline-sections).
  Velocity analysis of zero offset or shot data using an interactive hyperbola or line adaptation or an intercepttime method
  Picking of arrivals - manual, automatic or semi-automatic, ASCII-conversion of the picks

* module **CMP-processing and 1D-velocity analysis** for GPR, reflection seismics and refraction seismics
  single-shot data processing (sorting, display, processing, NMO-analysis, stacking)
  interactive analysis of CMP- or shot-data using a semblance analysis or an interactive adaptation method calculating either the reflection hyperbolas (reflection seismics) or the complete traveltime branch including diving waves (refraction seismics).

* module **3D data-interpretation** for GPR and reflection seismics
  Display of x-,y- or z-slices. The slices are either displayed in manually scalable windows or by moving through the 3D-cube using a track bar.
  Picking of arrivals

* module **refraction traveltime analysis** for refraction seismics.
  Interpretation of refraction seismic first arrivals. The module includes various sorting and combining possibilities for the picked traveltimes. These combined traveltimes are the bases for a FD based wavefront-inversion. Different raytracing methods are available for the evaluation of synthetic traveltimes. An interactive 1D-velocity analysis tool allows the adaptation of the complete traveltime branch including diving waves.

* module **forward modelling/tomography** for simulating the electromagnetic and seismic wave propagation in a 2-dimensional medium using a Finite Difference scheme. A **tomographic** approach based on SIRT is incorporated for the inversion of the traveltimes. Straight and curved rays are supported.

2D data-analysis

The module **2D data-analysis** allows the complete 2-dimensional processing of single shots, zero offset lines or multi-shot gathers. The module is useful for the following applications:

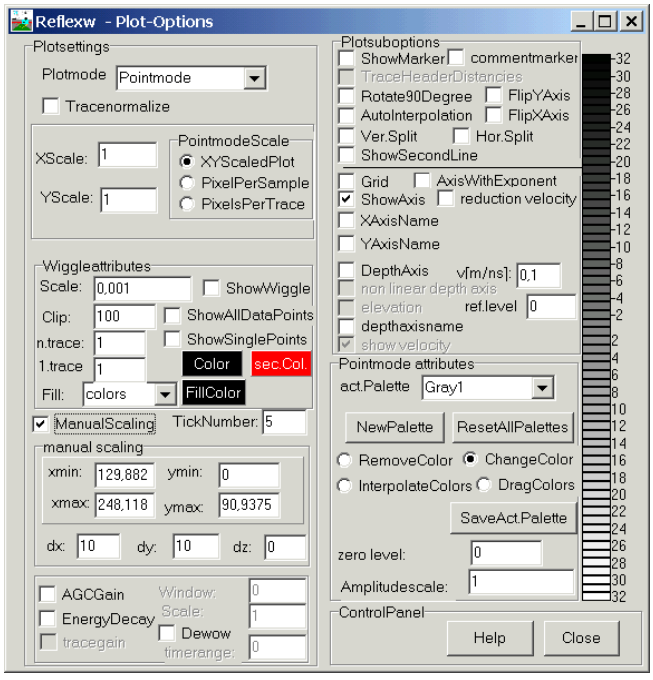
— GPR (Ground penetrating radar)
— reflection seismics
— refraction seismics
— borehole-borehole wave data

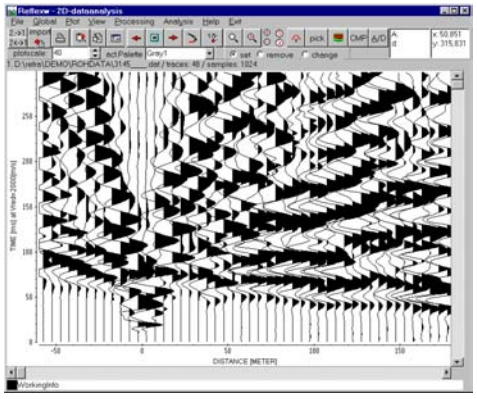
Import data

An **import** option allows the loading of the data for almost all existing GPR and seismic data formats (e.g. GSSI, PULSEEKKO, RAMAC, SEGY,SEG2). Single sections as well as a profile sequence (automatic assembling and storing of the sections under one single datafile or automatic generation of datafiles for parallel and inline-sections) may be imported.

The data **display** and **printing** possibilities

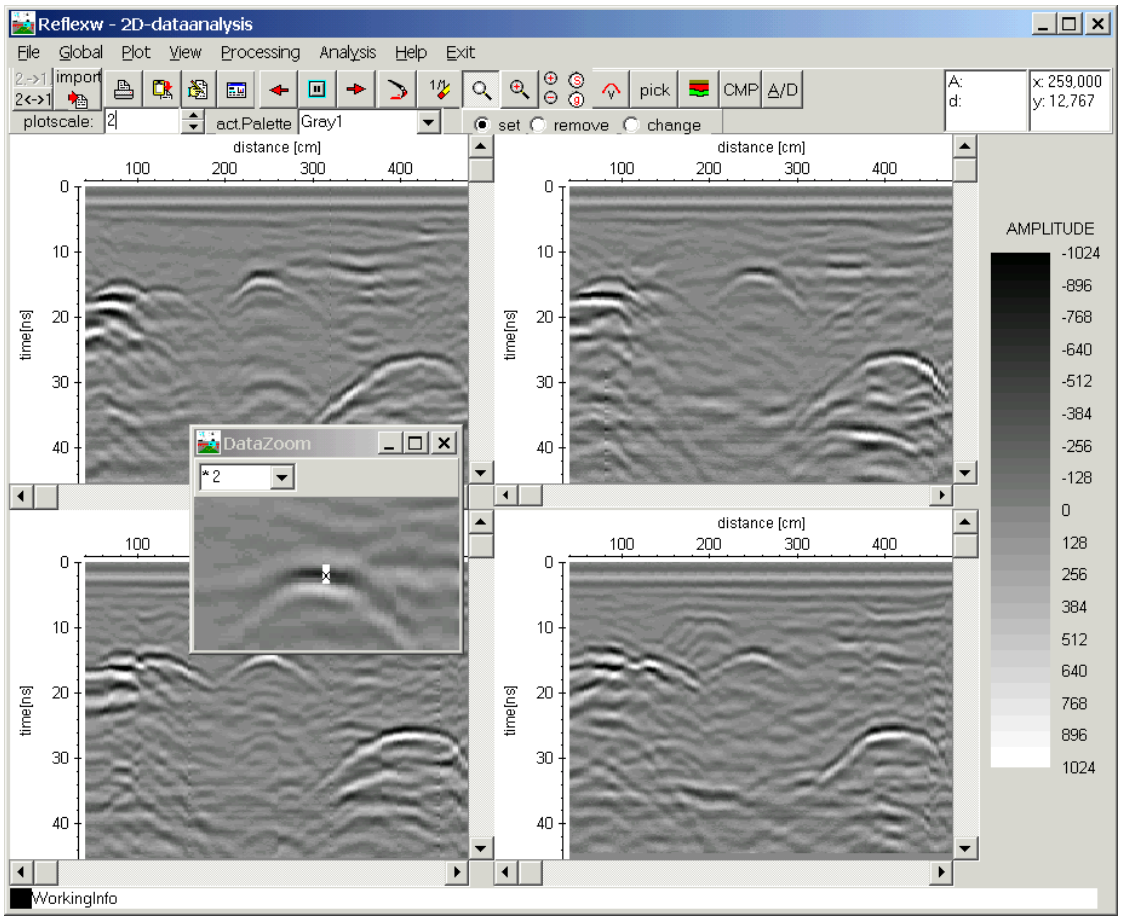
- display of the data either in **wiggle** or filled area **point mode**
- "normal" reflection (time axis from top to bottom) or refraction (time axis from bottom to top) display
- continuous display of the current mouse position parameters including time, distance, amplitude and depth
- the user may switch between two different scale modes:
  1. the data are completely plotted into the actual window with subsequent free zooming and moving possibilities
  2. trace based scale: the user chooses the pixel size for each trace. If the line is not completely plotted into the window moving possibilities are available.
- **zoom**- and **autoscroll** possibilities
- loading of a secondary profile, horizontal or vertical split-mode or overlapping of the profiles
- loading of up to 4 different files with single or multi axisscaling, horizontal and/or vertical split-mode
- interactive **magnifying glass** option (see figure on the next page) with choosable zoom factor - a freely choosable data part is continuously magnified when moving the mouse
- interactive **color amplitude assignment** for point mode
- display of the profiles in the point and wiggle mode
- many different **plot options**, e.g. rotated display, combination of wiggle and point mode, free choosable axis and so on
- easy transfer of the data to the **clipboard**
- **printing** out the data with freely choosable scale either in cm or scale like 1:1000; support of banner output (continuous printing on printers which support banner output, e.g. HP Deskjet 1120 C), possibility of freely placed **annotations** (see print preview).
- **stack printing** of a complete set of 2D-lines using the same printing parameters
- **Print preview** menu - allows to preview the size and shape of the print output and to define a print header consisting of up to 30 different header comment boxes containing up to 6 different comments.
- **oscilloscope-function** - wiggle plot of the actual trace with the indication of the actual amplitude, time and frequency
- comprehensive context sensitive **online help**



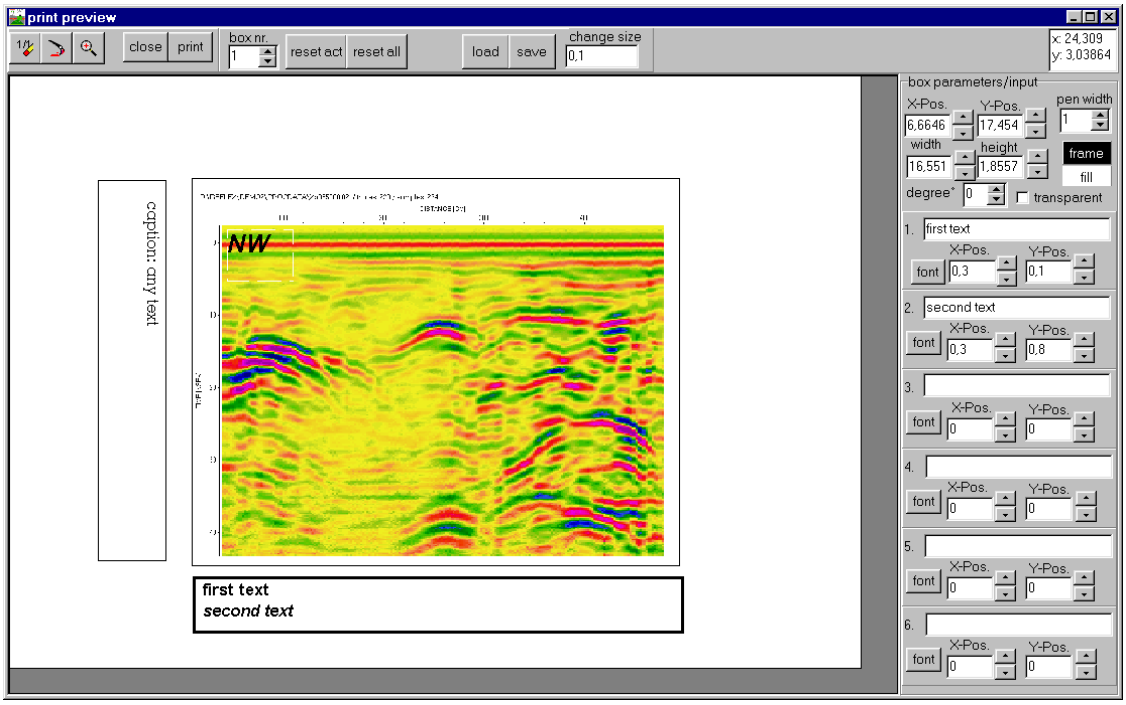


Example of the wigglemode display of a seismic refraction section

2D data-analysis



Example of the pointmode display of 4 different GPR-lines with activated magnifying glass



Print preview window with the possibility of defining freely placed boxes each containing up to 6 different comments

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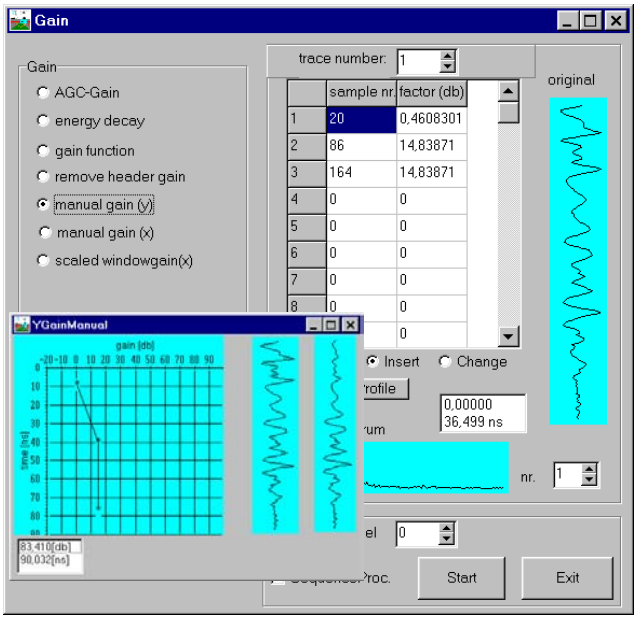
2D data-analysis

The **dataprocessing** possibilities

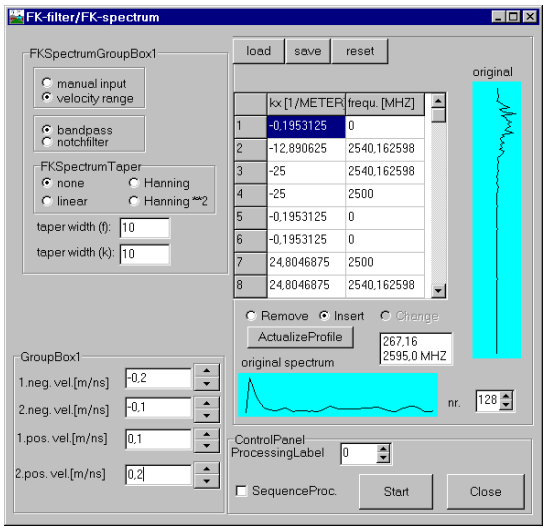
A single radargram or seismogram section can be **interactively processed**. Primary and secondary profile are displayed simultaneously.
The **batch mode** allows the automatic processing for a choosable number of lines. A sequence of processing steps will be applied on an arbitrary number of profiles. The batch mode runs totally automatically. Primary and secondary profile will be displayed, whereby a direct control of the result is given.
All processing steps are stored for each profile and can be edited at any time.

- The dataprocessing is completely interactive. The effect of the filter is online controlled when changing the filter parameters by showing both the original and filtered trace. All edit inputs may be entered either interactively in the original profile or using the table input.



An overview of the different **processing functions**:

- <u>editing functions</u> (like removing, extracting of single traces/trace ranges, muting, stacking, subtracting or adding of profiles and much more)
- <u>Horizontal scaling</u> of the data, automatically or manually or by a combination of both
- <u>flipping</u> the profile in x-direction or y-direction
- <u>static correction</u> (interactive input of the correction values, slant stack correction and so on)
- <u>gain-functions</u> in horizontal und vertical direction, AGC (AutomaticGainControl), automatic trace balancing, linear and exponential gain function, automatic gain based on mean amplitude decay curve

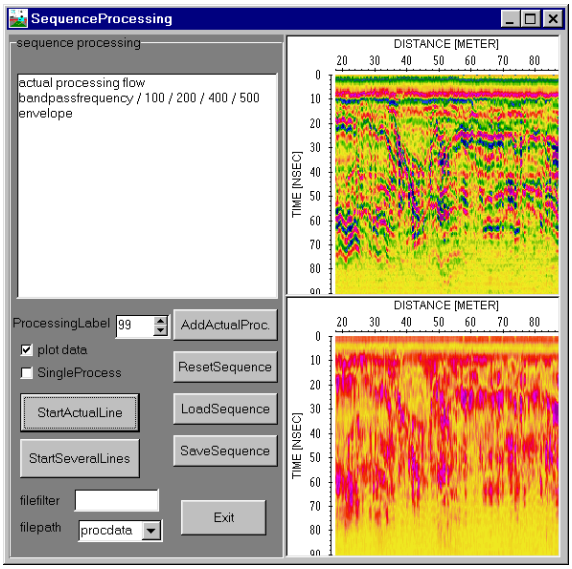


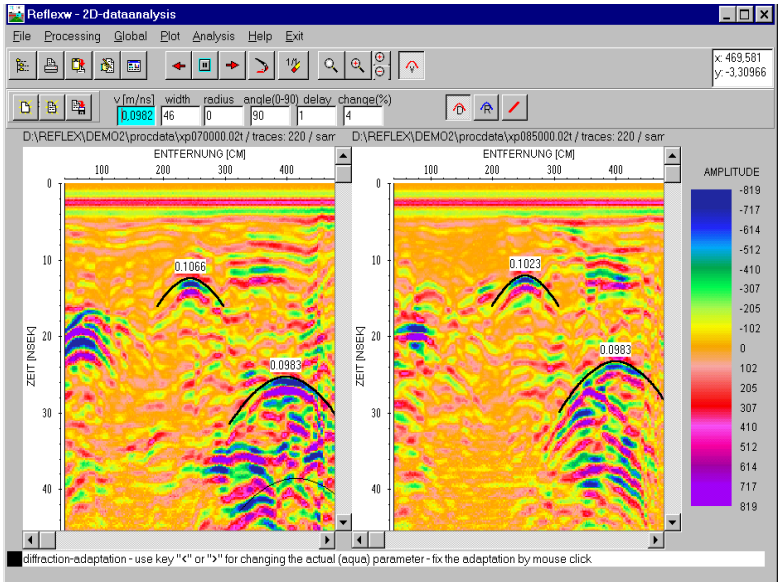
- a great variety of <u>1D-Filters</u> like bandpass, notch-filter, timedependent bandpass, crosscorrelation, arithmetic function, averaging, median-filter, deconvolution, complex trace analysis (instantaneous frequency, phase, envelope), time-depth conversion, background removal, declipping and so on.
- <u>Spectral analysis</u> - single spectra, moving-window-analysis
- <u>migration</u> - 2D Kirchhoff, 2D fk-migration, 2D Finite Difference migration with lateral varying velocities, 3D Kirchhoff
- some other <u>2D-filters</u> like subtracting average, running average, compress and expand and so on.
- <u>fk-filter</u> (see figure on the left) with the possibility of manually input the filter range within the fk-spectrum or by defining a velocity fan. Different tapers and taper width are available.
- and much more possibilities
- All processing steps are stored in the header of each profile and can be asked for at any time.

2D data-analysis

batch-processing

The batch-processing facilitates a completely automatic sequence of processing steps for a choosable number of profiles. Primary and secondary section are displayed simultaneously, whereby a direct control of the result is given. You may choose between the so called sequence mode and the single processing mode with the possibility of applying the processing steps individually on the primary profile.





Use of the diffraction adaptation for 2 different GPR-lines

velocity analysis

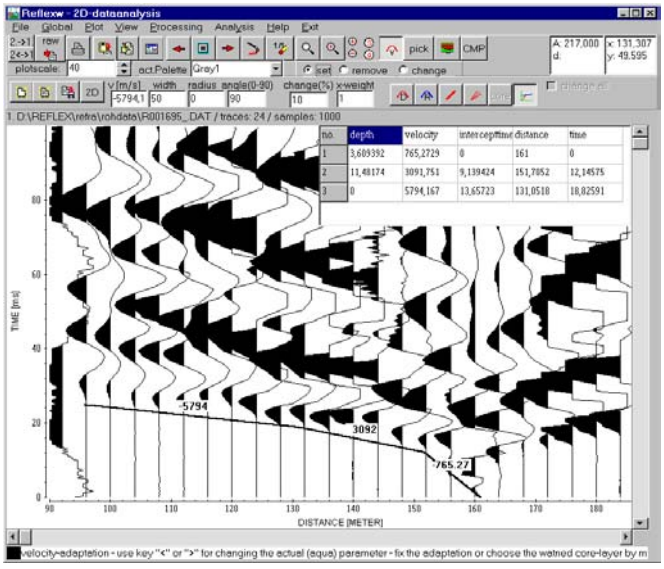
An interactive hyperbola-adaption for a simple determination of the average velocity from a zero-offset or CMP profile (see figure on the left) is integrated. It is possible to adapt **diffractions, reflections and straight lines**. You may change the velocity, the radius of the target, the angle between the line and the target and the width of the calculated diffraction or reflection hyperbola.

There is also the possibility of fitting **linear features** either by changing interactively a line or by setting two points.

The option **core** allows to vary interactively the velocities of the single layers of the individual cores stored within an ASCII-file.

In addition an interactive use of the **intercept time method** for seismic refraction data is included. The option enables to get a first 1D-model very quickly.

The velocities may be stored on file and may be reloaded at any time. The velocities are combined into a **2D-model** by using a special interpolation. Such a 2D-velocity distribution may be used in a subsequent step for the migration or the time-depth conversion.



Use of the intercepttime method for refraction data

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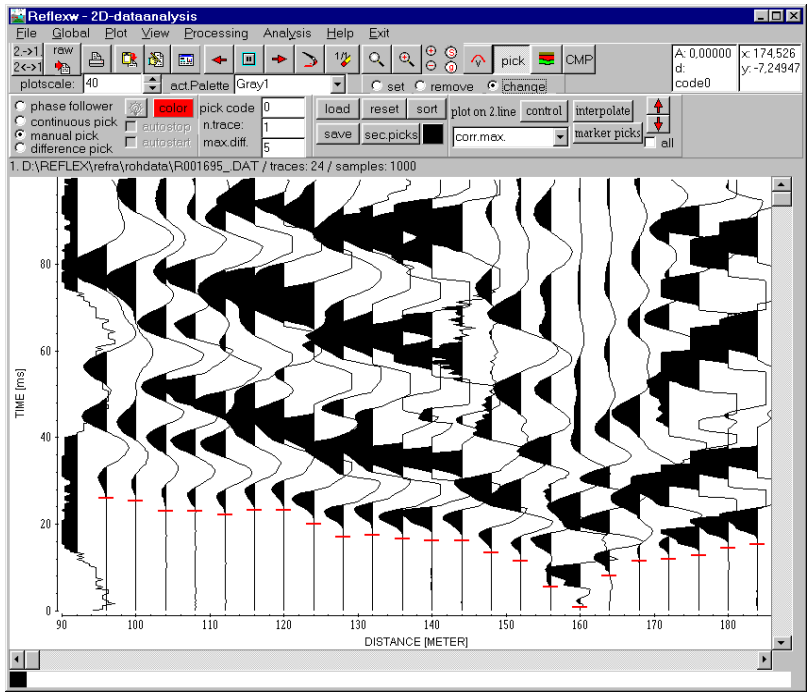
2D data-analysis

Picking the onsets/first arrivals



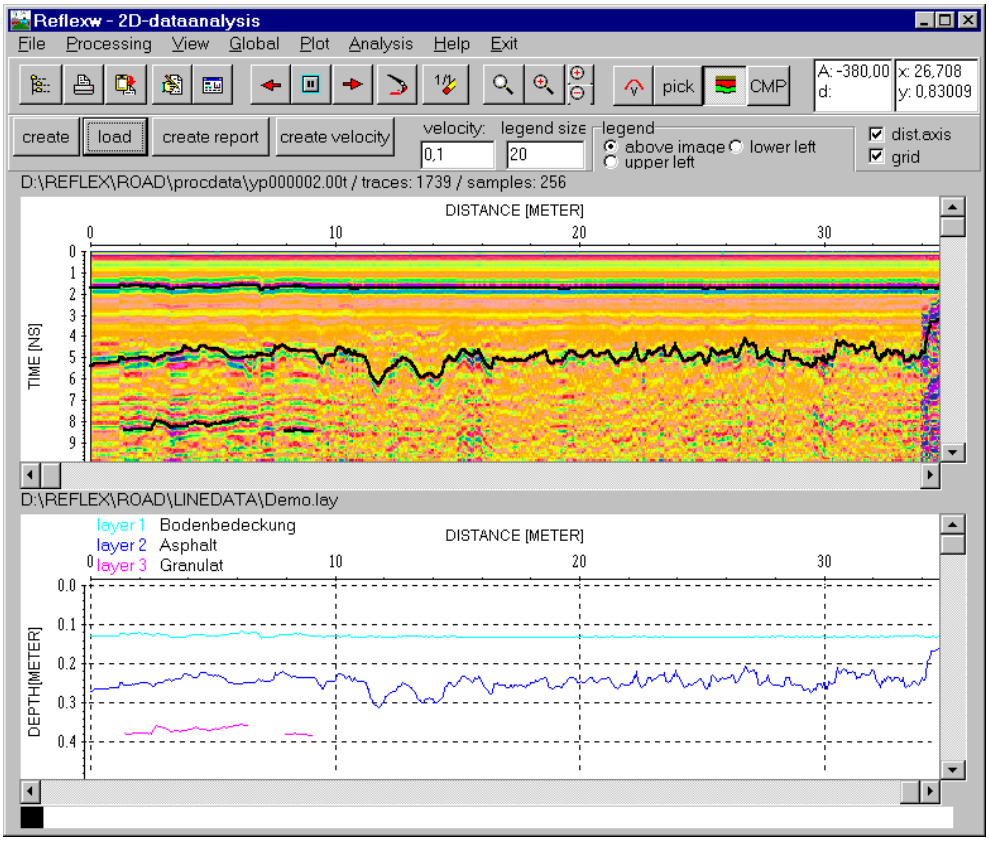
The picking option allows to pick the traveltime and the amplitude of different onsets like reflectors or hyperbola or the first arrivals.

You have the choice between manual picking, continuous picking and a semi-automatic picking using a phase follower (manual editing is always possible).

The picked values may be corrected to the extrema or the zero-crossing. In addition a time/distance correction to the maximum value within a given window is available. This allows you for example to pick the hyperbola cusps very quickly.

It is possible to export the picks into an ASCII-format together with the 3 space coordinates for a subsequent inter-pretation.

The so called **layer-show** offers the possibility to combine individual pick files, to plot them together with the wiggle-files and to output them in report form on printer or file containing the depths, velocities and amplitudes of the individual layers. The time-depth conversion of the picks is either based on a constant velocity for each layer or on a 2-dimensional velocity distribution allowing to take into account vertical and lateral velocity changes.



2D data-analysis

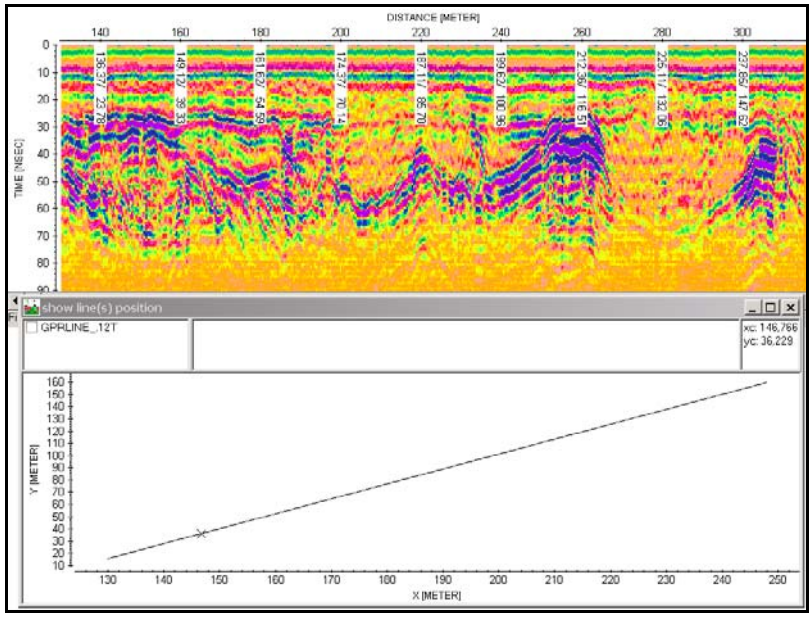
Handle the traceheader(GPS)-coordinates

REFLEXW allows to handle so called traceheader coordinates which are stored within the header of each trace. Several ASCII-formats for the GPS-data are supported in order combine the traceheaders with the GPS-coordinates. Therefore it is possible to use GPS-coordinates for special analysis.

The GPS coordinates can be used for **exporting picked data** to an ASCII-file.

In addition there exist two different **viewing options** of the GPS coordinates (see figure on the right).
First the profile location based on the traceheader coordinates can be shown in an additional window (any curvature of the line coordinates is displayed). When moving the mouse cursor within the data window the actual xy-position of the mouse cursor is also shown.
Second the xy-receiver traceheader-coordinates may be displayed along the distance axis.

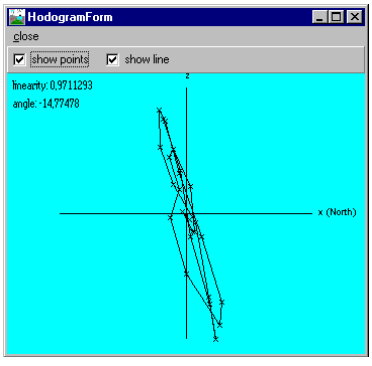
The GPS z-coordinates can be used for a static correction either as a plotoption or as a processing step.

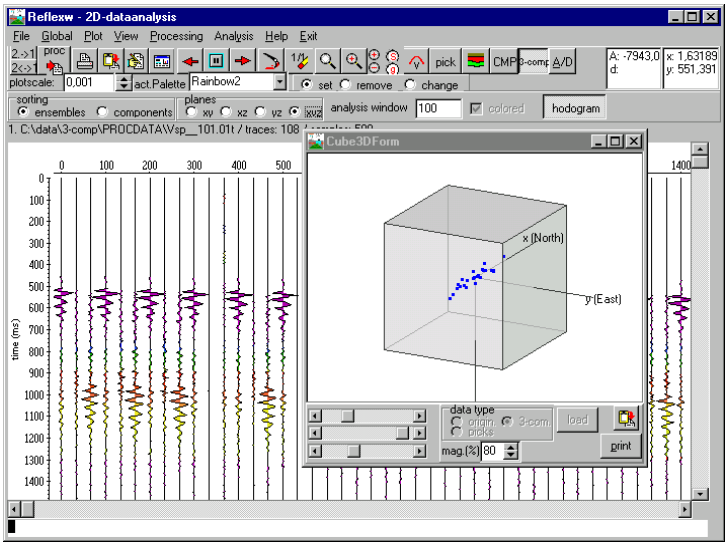


3-component analysis

The option allows the interpretation of 3 component data. The final REFLEXW 3-component datafile will be constructed from several original datafiles containing multicomponent data. Each original datafile must contain one single multicomponent dataset.

The data may be sorted after ensembles with each ensemble containing the 3 component traces (see figure on the right). It is also possible to display the into 3 different windows with each window containing all traces of one single component.
The **particle motion** and the **actual polarization** angle can be displayed.
The option **colored** allows to color the wiggles based on the actual polarization angle. The analysis window determines the lenght of the traveltime window for the polarization analysis. The option **hodogram** allows you to continuously display the particle motion within the chosen plane when moving the mouse cursor in the data. The linearity factor (1 - completely linear, 0 - circular) and the dominant angle are also determined and displayed when you have chosen one of the 2-dimensional planes (see figute on the left). If the plane xyz has been chosen, a 3D-cube display of the particle motion is shown.



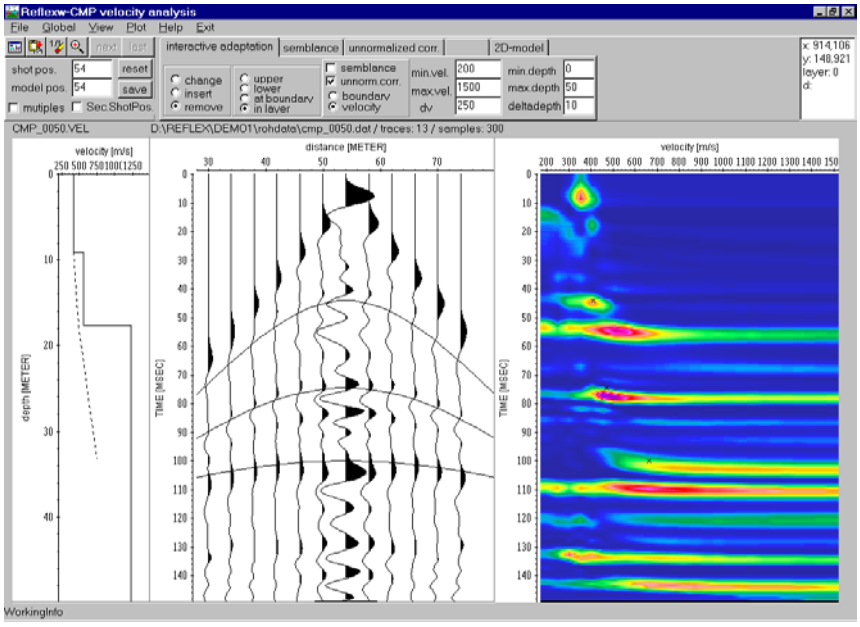


CMP-analysis

The **CMP-analysis** module consists of two parts (the CMP velocity analysis and the CMP-processing):
The module is useful for the following applications:

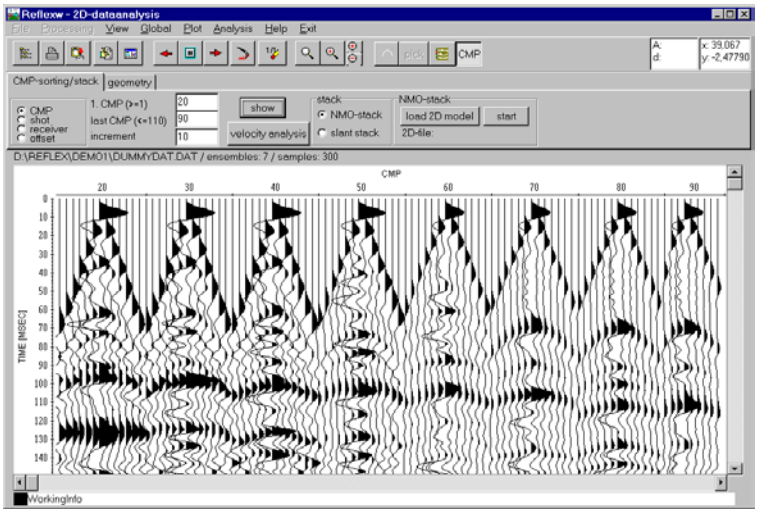
— reflection seismics
— GPR (Ground penetrating radar)

CMP-velocity-analysis



The **CMP-velocity-analysis** allows the calculation of a one-dimensional velocity-depth-distribution from CMP- or moveout-data based on different analysis techniques.
The module offers the following possibilities:

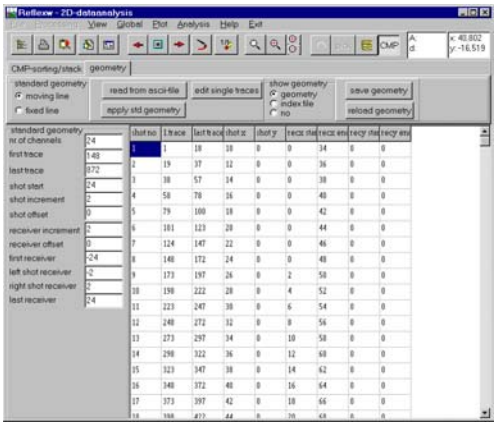
- interactive generation and change of a velocity-model for a CMP- or a moveout-section with continuous indication of the actual reflections
- **semblance analysis** for a given velocity-interval, interactive choice of a vrms-depth-distribution from the semblance analysis or from the interactive adaptation panel
- loading of a second CMP-section for a parallel adaptation of the reflections
- loading of a zero-offset section with true distance information for a calibration of the corresponding reflections
- generation of a 2-dimensional velocity-model based on the resulting 1D-velocity-depth distributions. This 2D-model represents the base for the stacking.



There are different possibilities of entering or changing the **geometry**:
Two different standard geometries are implemented: moving line and fixed line.
Activating moving line allows you to define the geometry for a geophone line moving with the shots.
Activating fixed line allows you to define the geometry for a fixed geophone line for different shot points.
In addition the geometry of each trace may be edited individually and the geometry may also be loaded from an ASCII-file**.**

CMP-processing

The **CMP-processing** allows the sorting of raw data to CMP, Common Shot, Common Receiver and Common Offset. It is very easy to change interactively between the given sorting possibilities.
Stacking or simple **NMO-correctio**n of CMP-Gather, Common Shot-Gather or Common Receiver-Gather is possible based on a 2-dimensional velocity-distribution (see velocity analysis) or using a slant stack algorithm (only stacking).
Optionally an automatic correction of the **residual statics** is applied.



REFLEXW

Refraction traveltime analysis

The **refraction traveltime analysis** module allows to analyse and interpret picked first arrivals. The module is useful for the following applications:

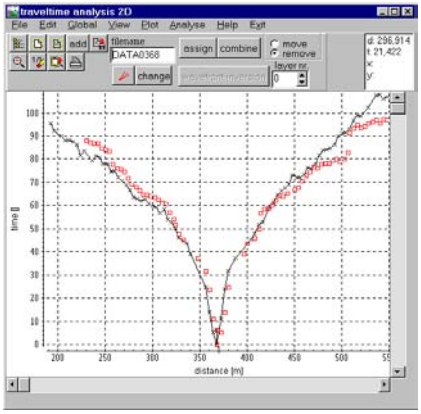
— refraction seismics

The module consists of two different parts:

The first part (**traveltime processing**) contains the possibility to put together the picked traveltimes from several shots and to assign the picks to special layers.
The second part (**traveltime interpretation**) contains the interpretation tools like wavefront-inversion, forward raytracing, interactive 1-dimensional adaptation and refraction tomography.

Traveltime processing

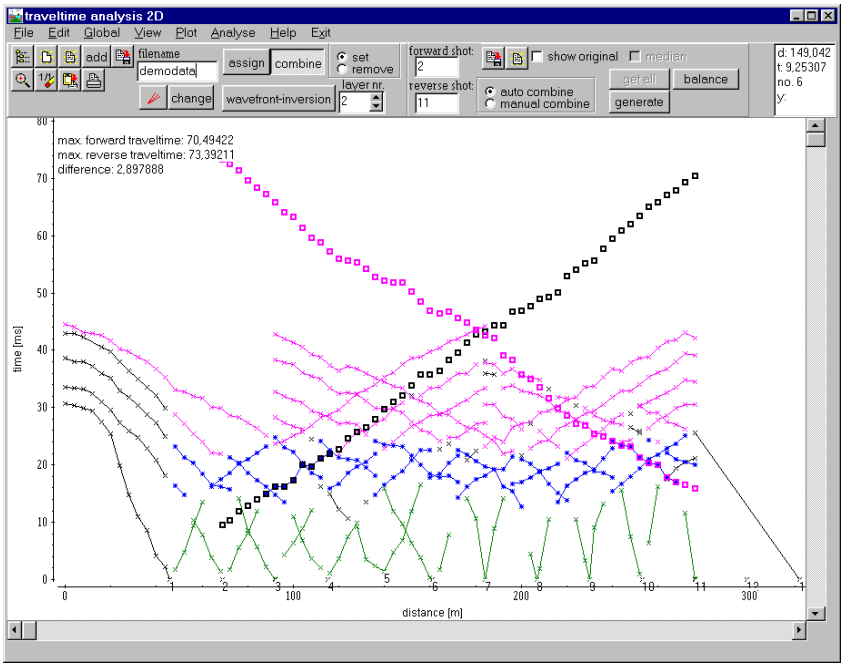
Within this menu it is possible to analyse and interpret picked first arrivals (refraction seismics). Precondition is that all chosen data are located along one line within one acquisition plane. You may put together the traveltimes from several shots and assign the traveltimes to special layers. Those traveltimes stemming from several shots and belonging to one layer may be combined together to one forward and reverse traveltime curve. These combined traveltimes are the basis for a subsequent 2D wavefront-inversion which allows to invert both the structure of the layer and the smoothed refractor velocity.



Comparison of a single shot traveltimecurve and the corresponding CMP-sorted traveltime branch

The traveltime processing part offers comprehensive tools for

* sorting of the traveltime data
* interactive editing (moving a set of traveltimes, cancelling of single traveltimes, combining different branches, ...)
* comparison of traveltime data (e.g. real and synthetic data); calculation of the discrepancies
* CMP-sorting (e.g. for 1-D-modelling)
* interactive assignment of arrival times to layers
* manual or automatic phantoming
* reverse traveltime control - output on screen or file



Traveltime data put together and assigned to 3 different layers - for layer 2 one complete forward and reverse traveltime curve has been automatically generated which is the basis for a subsequent wavefront inversion

REFLEXW

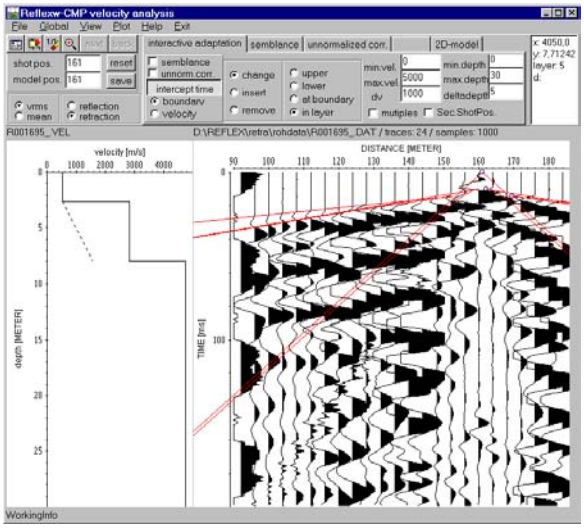
Refraction traveltime analysis

Traveltime interpretation

The first arrivals may be interpreted in the following different ways:

" interactive 1-dimensional traveltime adaptation
" 2-dimensional wavefront inversion of the complete forward and reverse traveltime curves
" 2-dimensional forward raytracing and comparison of the real and the calculated traveltime data
" refraction tomography

1-dimensional traveltime adaptation



The 1-dimension traveltime adaptation allows the interactive calculation of a one-dimensional velocity-depth-distribution from refraction shot or CMP-data.
The intercepttime option allows to calculate a first starting model which may be refined interactively (depth and velocities). The resultant diving waves, reflections (incl. overcritical) and surface multiples are displayed in real time. A comparison can be done with either real traveltime data or the complete data set (in this case picking is not necessary).

wavefront inversion:

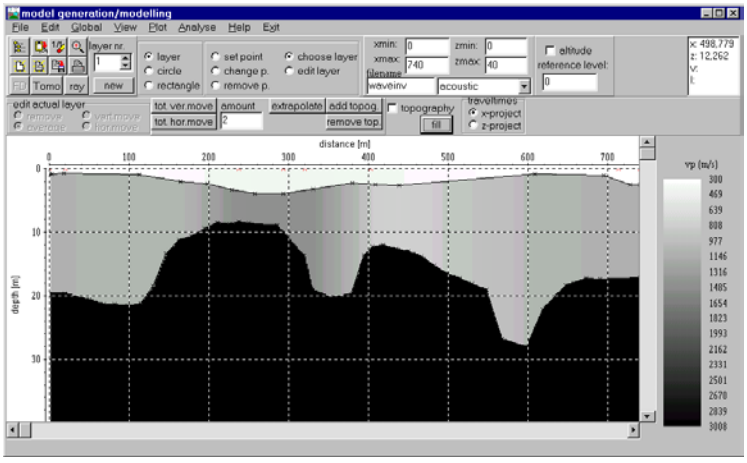
The wavefront inversion allows to migrate the combined forward and reverse traveltimes into depth using a Finite Difference approximation of the eikonal equation. The following traveltime processing steps must have been performed before:
X put the different traveltime curves together
X assignment to the actual layer
X combination to one single forward and reverse traveltime curve (see figure on the previous page).

The method allows:

- interactive back propagation of the wavefronts using finite differences approximation of the eikonal equation; the backpropagation is exact, even for very complicated overburdens.
- no parameter adjustments are necessary
- inversion of layer interfaces and layer velocities
- the topography can directly be included in the inversion process (no static correction is necessary)

The complete forward and reverse wavefronts are continued downward based on the given overburden model. The new refractor is automatically constructed at those points where the sum of the downward traveltimes is equal to the reciprocal traveltime. The refractor velocity is determined from the mean of the slopes of the forward and reverse wavefronts at the new calculated refractor points.

The method is iterative. This means that each layer must be inverted separately and that the overburden must be existent. It may contain any 2-dimensional structure.
The results (interfaces of the layers and layer velocities) can easily be manipulated (e.g. smoothed). A priori information can easily be incorporated to the overburden prior to the inversion of the next interface. This guarantees that all available information contributes to the inversion result.



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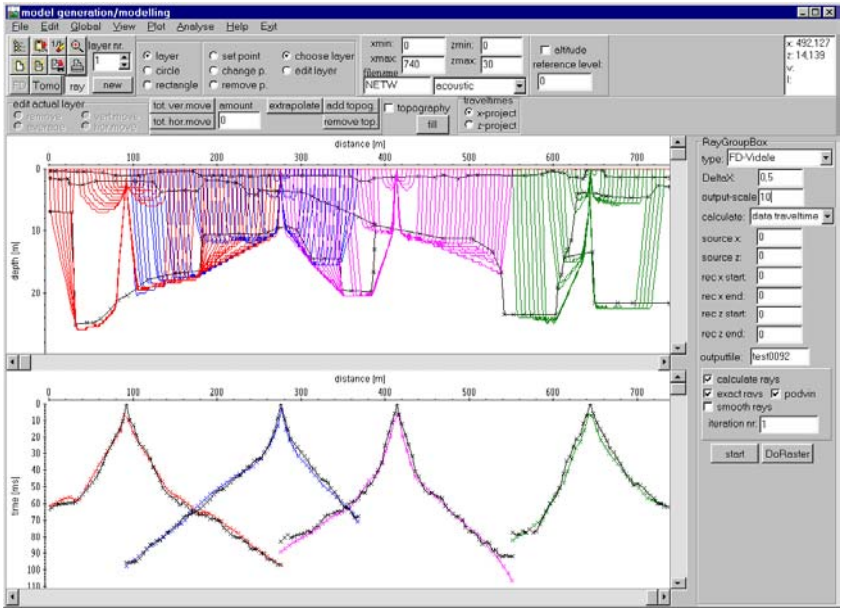
Refraction traveltime analysis

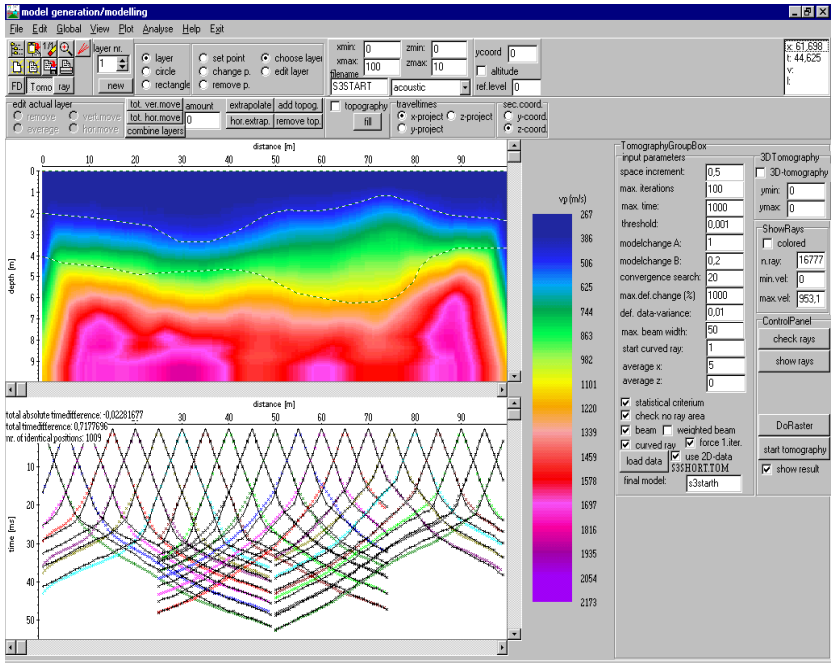
forward raytracing:

A fast and reliable traveltime calculation for arbitrarily complicated 2D-models is possible. The method is based on a finite difference approximation of the eikonal equation for calculating first arrivals. It takes into the account the existence of different propagation waves like transmitted, diffracted or head waves. Therefore no practical limitation concerning the complexity of the medium is given. The method is very suitable for near surface investigations, because there is no need for approximations concerning the complexity of the models. The wavefronts and therefore the raypaths can be stored and displayed.
The information about the geometry (shot and receiver positions) can automatically be adopted from the shot records or from the traveltime files. Editing, if necessary, is easily possible. The number of shots (e.g. a complete refraction seismic line) is not limited.



refraction tomography:

The **refraction tomography** allows an automatic inversion of the combined traveltimes. The data coverage must be high enough but no assignment to layers is necessary. The inversion is based on a two-dimensional **tomographic approach** based on **SIRT** (simultaneous iterative reconstruction technique). The curved rays are calculated using a finite difference approximation of the eikonal equation (see forward raytracing). A start model must be defined. The resulting velocity model is a rasterfile stored in REFLEX-format whereby all possibilites of REFLEX are available for a further display.

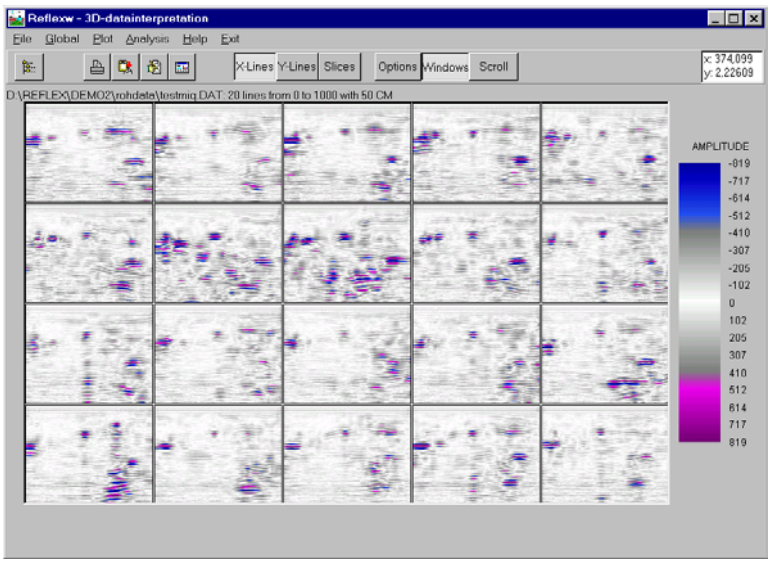


Example of a refraction tomographic inversion - the original data are calculated from a 3-layer model with v1=300 m/s, v2=800 m/s and v3=1500 m/s. The result of the tomography is shown in the upper panel - the original layerboundaries are overlaid. The lower panel shows the original traveltimes in comparison to the calculated traveltimes based on the tomograhic result.

3D data-interpretation

The module **3D data-interpretation** allows the interpretation of 3-dimensional data by displaying x-, y- or z-slices. The module is useful for the following applications:

— GPR (Ground penetrating radar)
— reflection seismics

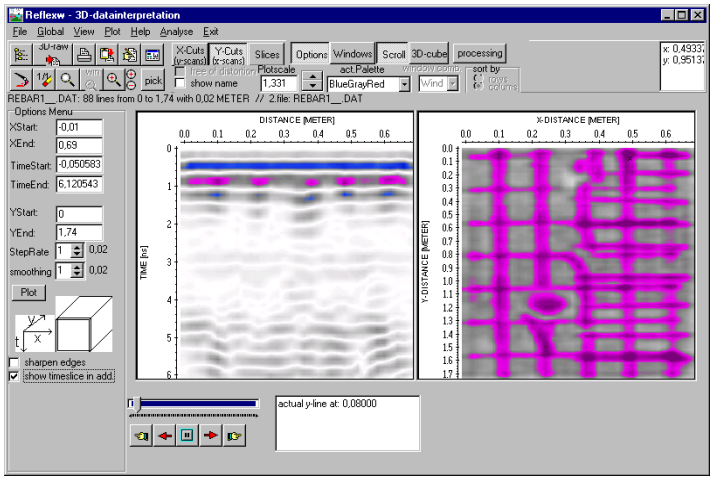


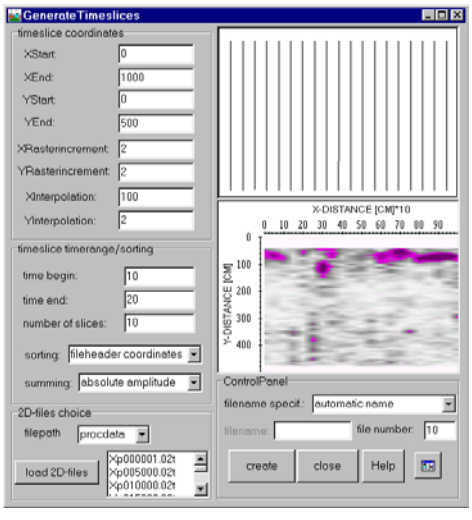
The **3D-data** may be easily constructed from equidistant or non-equidistant 2D-lines either during the import or in a later stage.
Equidistant: only the distance between each line must be entered. An interpolation filter allows a resampling of the data in the direction of each line if the number of traces differ in each 2D-line. The new **Scan3D** tool allows to automatically analyse parallel and crossing lines (see overnext page).
Nonequidistant: The lines may be arbitrarily orientated. The spatial interpolation ranges can be determined freely.
The data are completely loaded into the RAM of the computer whereby a fast visualization of the data is possible.
A **second 3D-data** file can be viewed in addition for a direct comparison.
The module also allows to load **several (up to 25) different 2D-files** in order to display them within the different modes. The scale of the different 2D-files can vary.

Two different display options are available.

Using the option **"windows"** (see figure on the top) the slices are displayed in manually scalable windows. The step and smoothing rate may be freely chosen.

Using the option **"scroll"** (see figure on the right) you may continuously move through the 3D-cube either in x-, y- or z-direction using the track bar. Again the step and smoothing rate is freely choosable. Optionally the actual timeslice (based on the envelope data) depending on the mouse position is shown in a second window. The actual cursor position is marked by a cross within the timeslice.





A **MPEG moviefile** for the later use with a MPEG-player may be easily constructed for the scroll and the 3DCube (see next page) mode.

In addition you may construct **single timeslices (C-scans)** from different 2D-lines originating all from one acquisition plane. The profiles can be arbitrarily orientated. Alternatively, data with different geometries sorted after midpoint-coordinates may be also used for the calculation of the timeslices. The spatial interpolation ranges can be freely determined. The timeslice is considered as a simple section - all processing and display possibilities can be applied on.

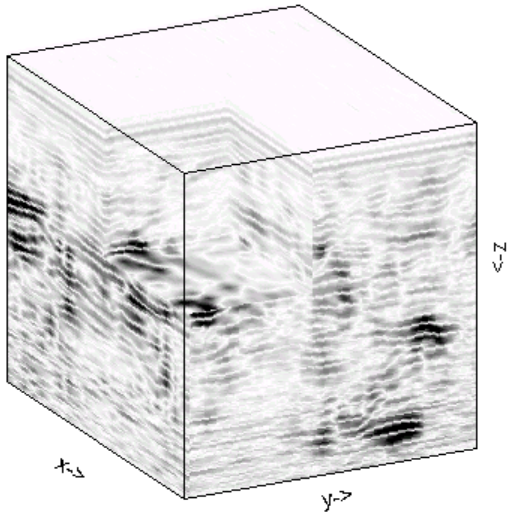
3D-picking

3D-Picking may be done within the individual 2D-cuts (scroll or windows mode) or within the 3D-datacube display. You have the choice between manual picking and continuous pick.
The 3D-pick surfaces may also be included within the 3D-cube (see next page).

3D data-interpretation

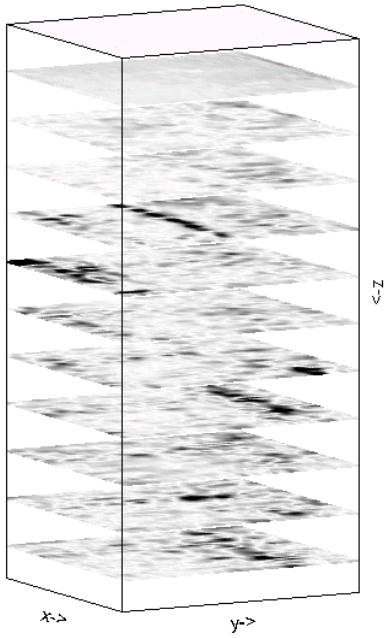
3D cube-display

The 3D-data can also be displayed within a 3D-cube. The program supports an interactive rotation of the 3D cube. The data can be viewed from any direction and can be zoomed. The 3 axis may be freely labelled.
You may select if only the front or back planes of the datacube are displayed or the full 3D-data volume. In addition you only may select single cuts and scroll through the cube in one distinct direction.



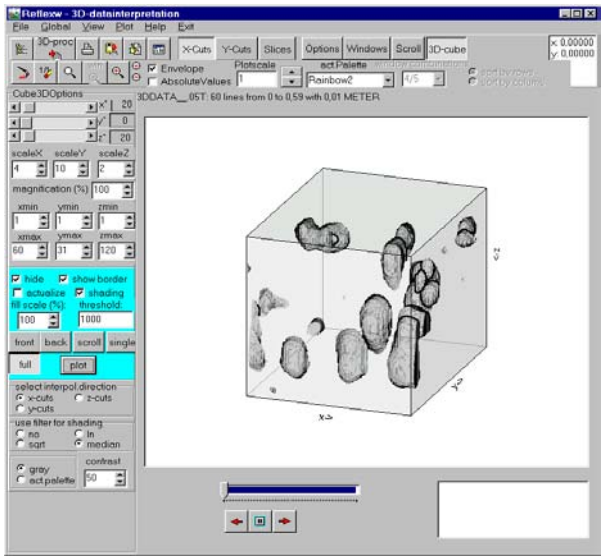
With the options **front** or **back** activated only the front or back planes of the datacube are displayed. In addition you may select a distinct **cornerpoint** which serves as the starting point for a cutting out of the cube (see picture on the left).

With the option **single** activated you may select any combination of x-, y- and z-cuts (see picture on the right).

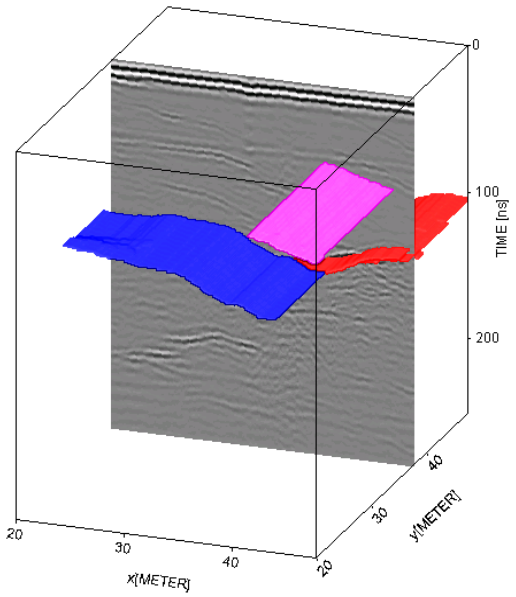


With the option **scroll** activated it is possible to continuously move through the 3D-cube either in x-, y- or z-direction using the track bar. The **step** rate is freely choosable. It is possible to plot a “background” consisting of any combination of x-, y- and z-cuts in addition.

With the option **full** activated all data of the 3D-cube are displayed. Shading and hiding are supported.Not visible parts of profiles are covered. However there is the possibility to "look through” certain parts of the 3D-data volume, whose amplitude values are smaller than the given **threshold** value.



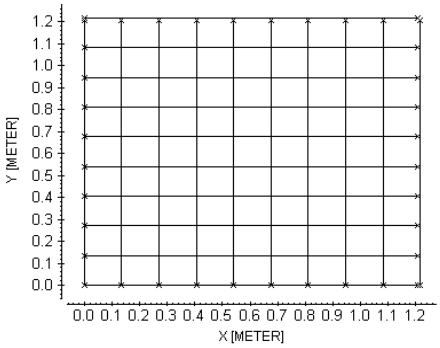
With the option **shading** activated a special shading algorithm is used in addition (see picture on the left).



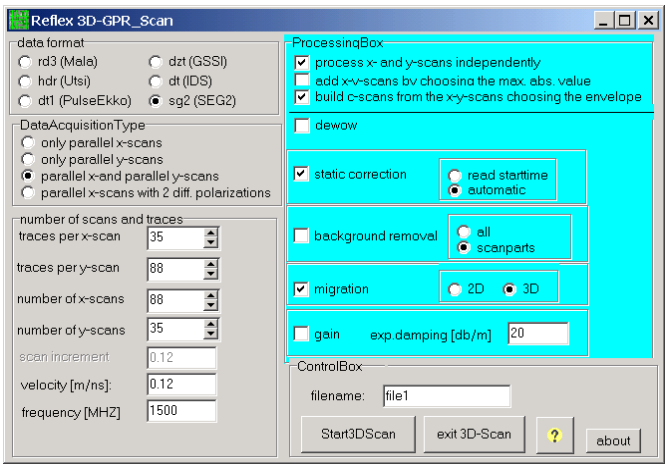
The **picked** surfaces may also be included within the 3D-datacube (see figure on the right).

3D-scan

The program Reflex **3D-Scan** (included within the 3D-datainterpretation module and also available as a standalone program) allows to import and to analyse automatically rectangular 3-dimensional GPR-data which have been acquired along 2D-parallel lines in one or two perpendicular directions.



Precondition is that the data have been acquired along equidistant parallel 2D-lines on a regular rectangular grid. This means that the traceincrement in one direction (x or y), the number of traces into this direction, the start- and endpositions of the 2D-lines and the scan increment between the 2D-lines must be equal. In addition if the data have been acquired in two perpendicular directions (see right picture) the increment between the parallel lines (scan increment) must equal the traceincrement.
If these preconditions are satisfied the 3D-scan program allows a very fast interpretation of your 3D-data.

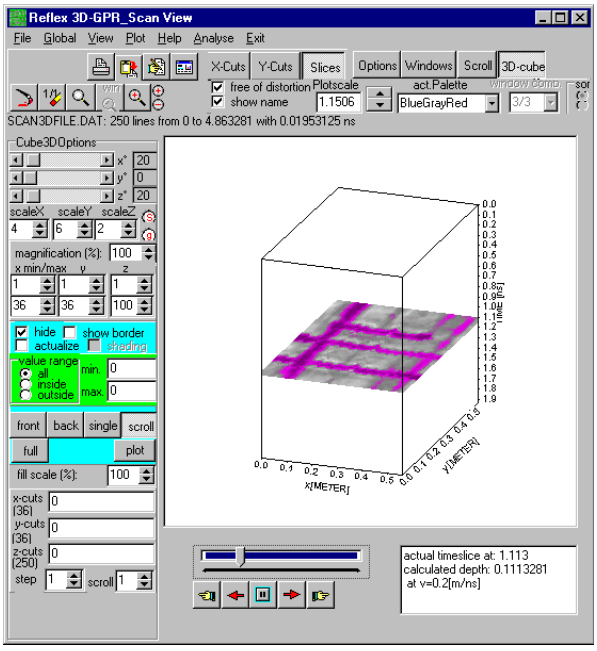


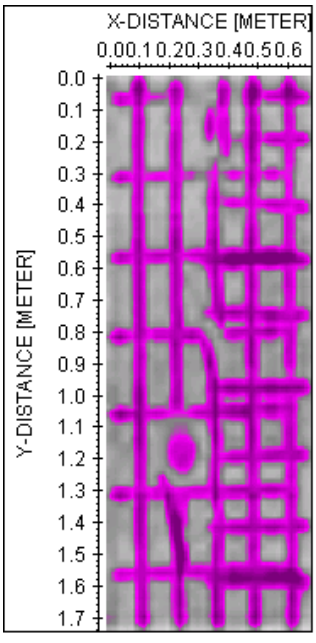
Different **dataformats** are supported (see picture on the left). The original data may be stored on individual 2D-files or on one 3D-file with the 2D-lines sequentially stored. With 2D-files acquired an automatic interpolation filter allows a resampling of the data in the direction of each line if the number of traces slightly differ in each 2D-line.

Optionally some **filter** steps are automatically performed. They are: dewow, static correction, background removal, migration (2D and 3D) and gain in timedirection.
The processing of the x- and y-scans may be done independently and the c-scans also may be built independently choosing the envelope of the original data.

Within the **3D-GPR ScanView** menu which opens after all sorting and processing steps have been finished all display options of the 3D-datinterpretation are available (option **windows**, option **scroll** and option **3D-cube**).

A **MPEG moviefile** for the later use with a MPEG-player may be easily constructed for the scroll and the 3DCube mode.



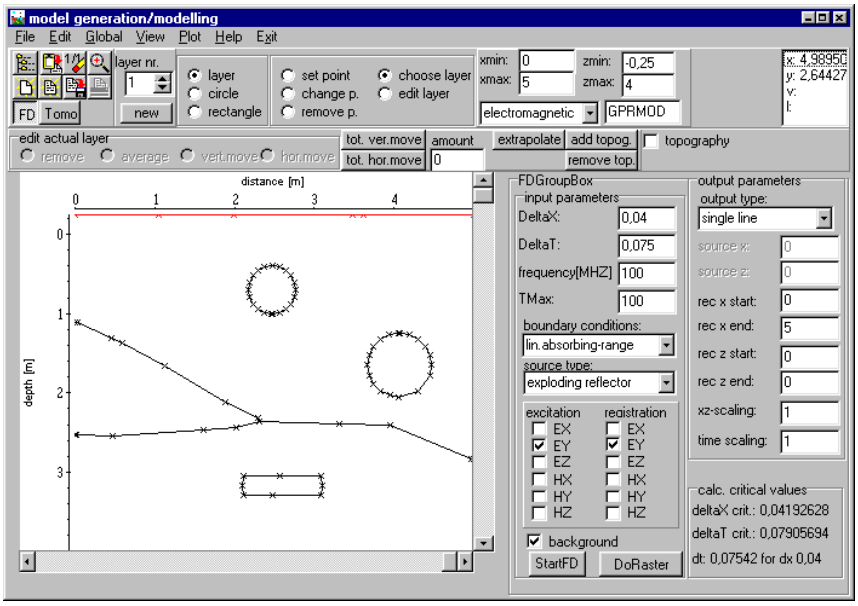


forward modelling / tomography

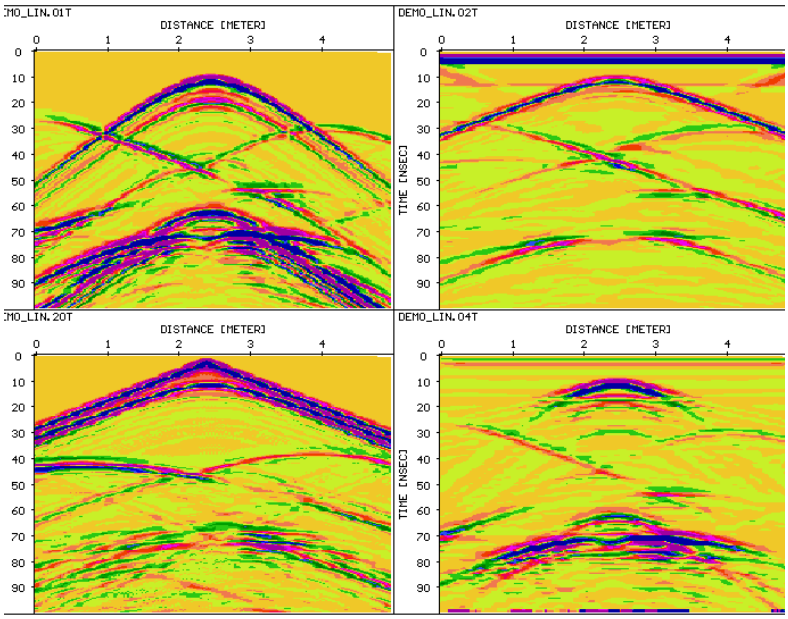
The module **forward modelling/tomography** allows the calculation of the complete electromagnetic or seismic wavefield for a 2-dimensional subsurface model. In addition a 2- and 3-dimensional **tomographic approach** based on **SIRT** (simultaneous iterative reconstruction technique) is integrated for the inversion of transmission traveltime data. The module is useful for the following applications:

— GPR (Ground penetrating radar)
— reflection seismics
— refraction seismics
— borehole/borehole transmission

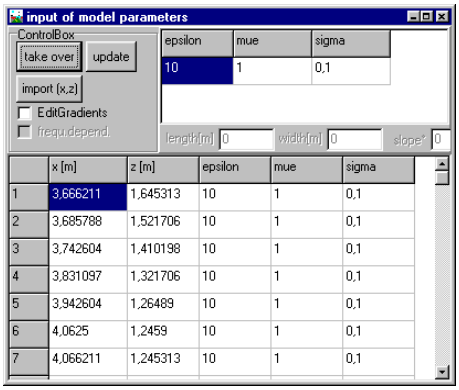
forward modelling



The module **forward modelling** allows the calculation of the complete electromagnetic or seismic wavefield for a 2-dimensional subsurface model. You may interactively edit any layer boundary and some predefined elements (e.g. circle or rectangle). The physical parameters may vary along the boundary whereby lateral changes are easily defined. The parameters are entered within a table which also may be used for entering the boundary values (see right figure below).
The forward modelling is done using a **Finite Difference** scheme solving the Maxwell equations (elastic wave equation, respectively). 3 different sources are implemented: point-source, plane wave and exploding



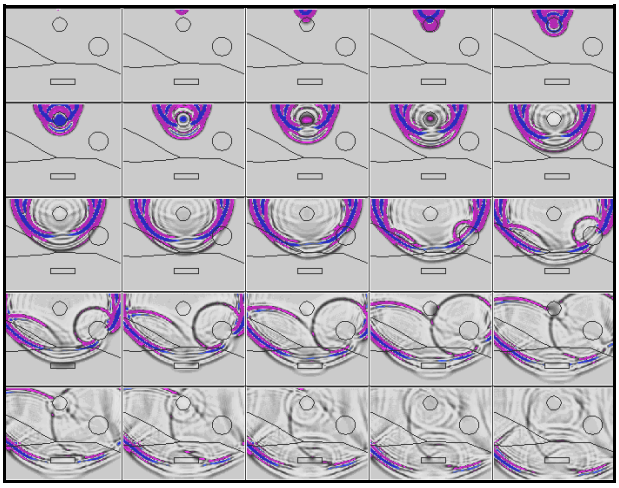
Synthetic radargrams for different source types. Upper panel left: Exploding Reflector Model, upper panel right: plane wave, lower panel left: point-source (gain-function in time-direction applied), lower panel right: Exploding Reflector Model with transmitter and receiver in the air



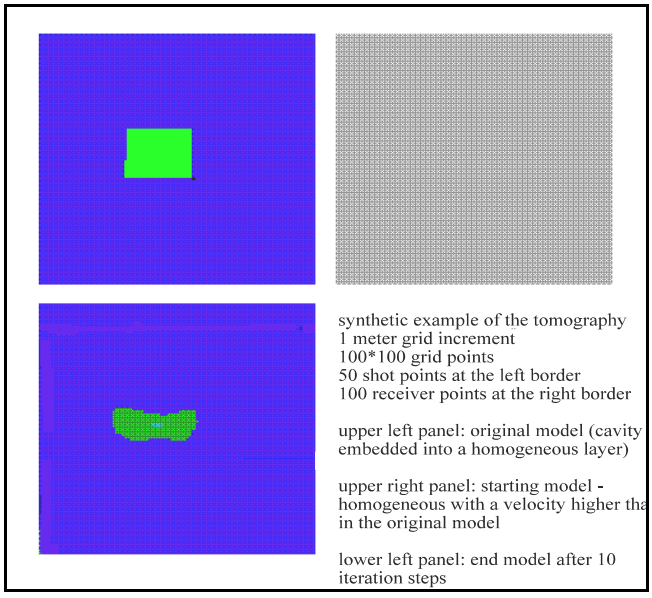
reflector model. Using the point source you may model the wave propagation from any point in the model (e.g. a transmitter at the surface). The exploding reflector model allows the modelling of a complete zero offset section in only one step. The complete wavefield or a single line is stored. The complete wavefield may be interpreted within the 3D-datainterpretation, the single line may be processed and interpreted like any 2D-data line.

REFLEXW

forward modelling / tomography



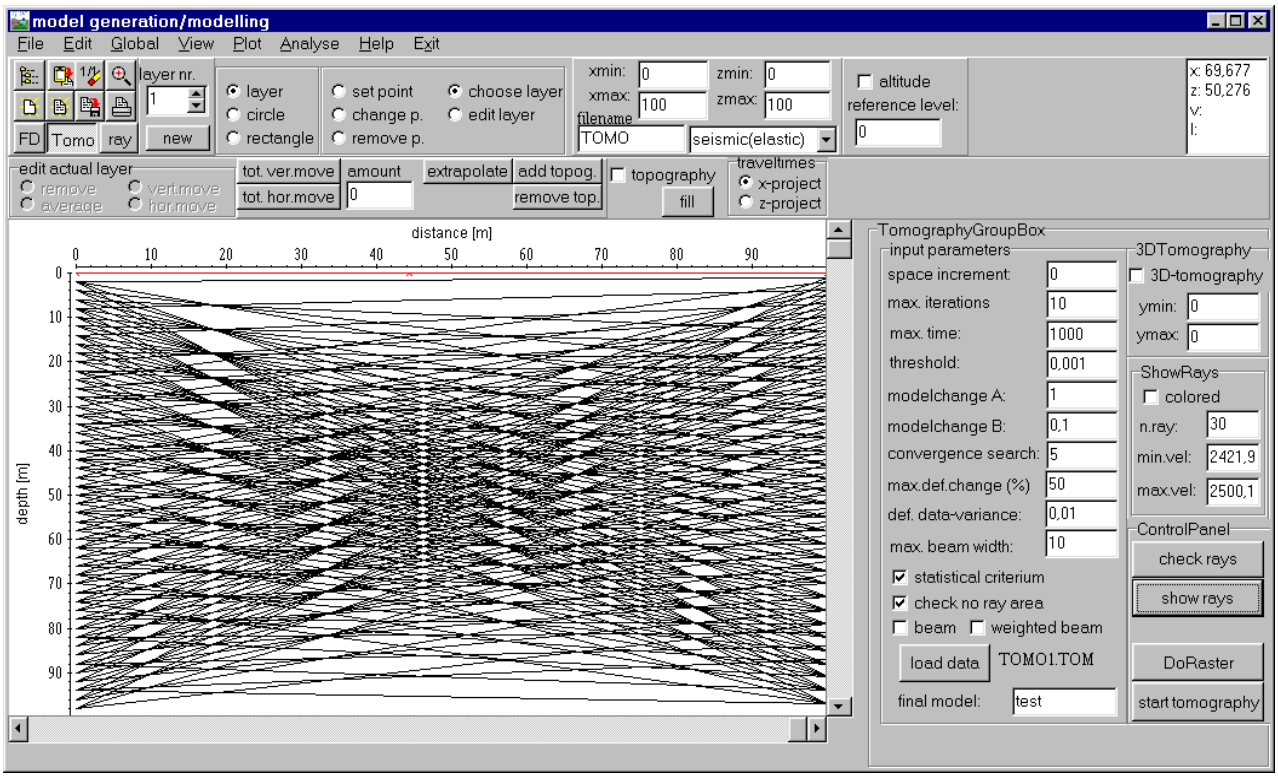
snapshot sequence for a point source - 25 snapshots between 0 and 50 nsec are shown



example for the 2-dimensional tomography

tomography

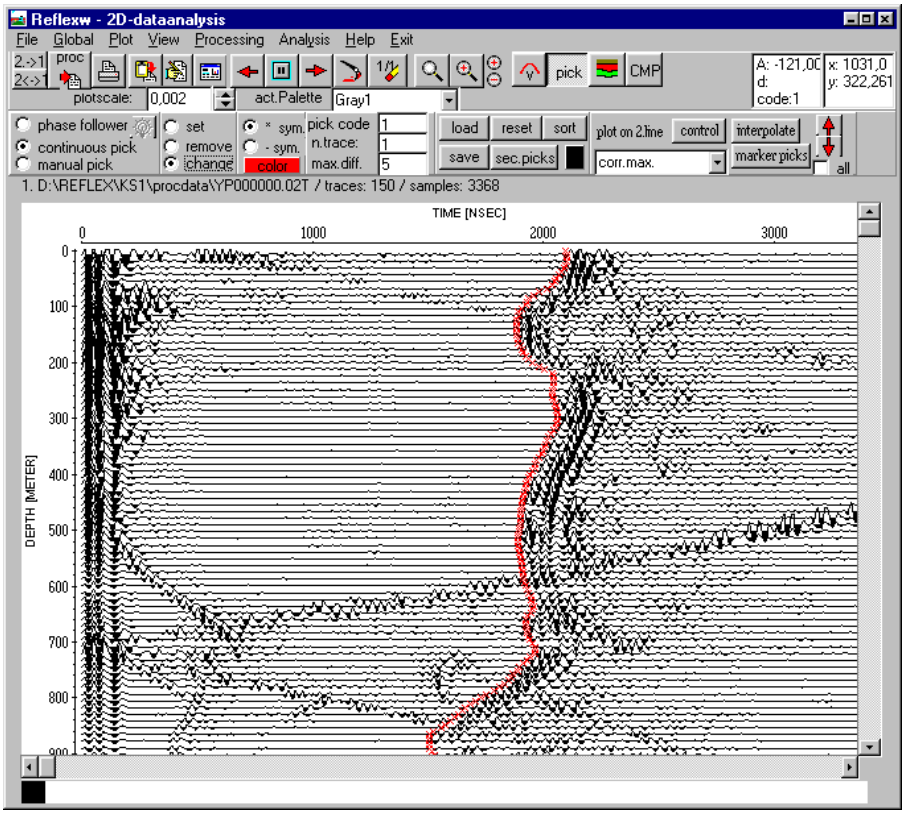
A 2- and 3-dimensional **tomographic approach** based on **SIRT** (simultaneous iterative reconstruction technique) may be used for the inversion of transmission traveltime data. The geometries of the individual sources and receivers are arbitrarily.
The figure at the upper right corner shows a synthetic example.
The starting model is interactively constructed and may contain any kind of inhomogeneities. The geometry of the rays may be loaded into the starting model (see figure below). Either **straight rays** or **curved rays** are used for the ray-tracing contained in the SIRT-algorithm. For the curved rays a finite difference approximation of the eikonal equation is used (see also refraction traveltime analysis). The 3D-tomography is restricted to straight rays.



REFLEXW

borehole data processing and interpretation

REFLEXW allows to display and process GPR-or seismic **borehole** transmission and reflection data but there does not exist a special module for these data. The figure at the right shows an example of a borehole GPR-reflection measurement (data from Kali+Salz, Kassel, Germany). There are many different kinds of displaying the equidistant or non equidistant profiles in the point and wiggle mode with zoom- and moving possibilities, manual and automatic scaling. All the features available in the modules data-analysis and data-interpretation may be used for the processing and the interpretation of the borehole data. Distinct elements may be picked, processed and compared to other borehole data. It is possible to extract all available signal informations like traveltime, amplitude, energy or nominal frequency.



A 2-dimensional **tomographic approach** based on **SIRT** (simultaneous iterative reconstruction technique) may be used for the inversion of transmission traveltime data (see also forward modelling/tomography).

examples of applications

The program REFLEXW has a modular character, whereby you may concentrate on those modules which are relevant for your application. In the following we give you a short overview of some possible modular assembles for different applications.

GROUND PENETRATING RADAR (GPR)

analysis of 2D-lines: 2D data-analysis
analysis and interpretation of 3D-data: 2D data-analysis, 3D data-interpretation, forward modelling
borehole data: 2D data-analysis, tomography

REFLECTION SEISMICS

analysis of 2D-lines: 2D data-analysis, CMP-dataprocessing
analysis and interpretation of 3D-data: 2D data-analysis, CMP-dataprocessing, 3D data-interpretation
borehole data: 2D data-analysis, tomography

REFRACTION SEISMICS

analysis of 2D-shots: 2D data-analysis, refraction traveltime analysis