VSPseisded -- Seismic data editor

1 Function

The program is intended for seismic file visualization alone or with hodographs, first break or first maximum hodograph determination, hodograph calculation and transformation, manual editing operations over seismic traces and hodographs. It's possible to display spectrum of selected seismic traces.

The target seismic for the program is VSP data, but surface seismic files may be processed as well by selecting special coordinate and time axis orientation on the stage of loading data.

Hodographs are visualized from trace header words (H_FIRSTBREAK and H_VSP_FIRST_PSCK) or from given database object. It's possible to work with up to 12 hodographs simultaneously (two from trace headers and ten from database).

To calculate hodograph from 1D velocity model it should be loaded from database at appropriate moment.

The program can be called from GeoEast main console to visualize selected VSP seismic file. In this case the file will be open with default pre-loading options (see paragraph 3.4 for details).

1.1 Visualization

The program visualizes seismic in wiggle mode and has next options:

- Different submodes of wiggle mode (special drawing for positive and negative samples).
- Gain and normalization control (automatic gain, visual gain, global and ensemble normalization, samples top cutting).
- Color support (monochrome, different color for positive and negative samples, special color for zero samples)
- Drawing multiple traces with the same coordinate as an ensemble.
- Show spectrum of pointed trace in separate window.

It's possible to display several seismic components in several neighbor areas, VSP or surface seismic oriented. Default coordinate is H_GRPDEPTH (cable depth) but user may select among several other header words when opens seismic file.

1.2 Operations

Seismic file may be modified by next operations:

- Mute along hodograph (from the left or right of it).
- Mute polygon shaped region.
- Revert polarity of the trace.
- Shift the trace.
- Edit the shape of the trace manually.
- Mark the trace as a dead or as a normal one (see H_TRACE_TYPE header word meaning).

Hodograph modification operations are listed below:

- Edit manually.
- First break/first maximum automatic determination.
- Calculation of hodograph for direct, converted and/or reflected wave from 1D velocity model.
- Transformation to track reflected or converted waves.
- Shift the whole hodograph.
- Copy one hodograph to another.

User may undo any modification operation and redo it. The depth of undo/redo buffer is not limited.

Changed data (seismic and hodographs) may be stored in database at the same or at the another name.

2 Input and Output Data Descriptions

2.1 Input Data

2.1.1 Seismic data

The program requires seismic file as the input. By default the input file will be interpreted as VSP (cable depth as a coordinate is oriented vertically) but surface seismic may be loaded as well.

Next header words may be used as coordinate: H_GRPDEPTH, H_FIELD_FILE, H_CHANNEL_NUM, H_COMPID, H_SHOT_LINE, H_SRCPTNO, H_SHOT_NUMBER, H_SHOT_DEPTH, H_RECEIVER_LINE, H_RECEIVER_STICK_NO, H_CMP_LINE, H_CMP_TRACE, H_AZIMUTH, H_OFFSET. Seismic traces may be sorted and selected by any of listed header word.

In addition «Receiver vertical depth» may be used as coordinate for sorting.

This is depth of receiver directed vertically downward and calculated from well mouth as an origin.

It's possible to draw seismic traces in different areas. In this case traces may be separated by next header words: H_COMPID, H_FIELD_FILE, H_CHANNEL_NUM, H_RECEIVER_LINE, H_RECEIVER_STICK_NO.

2.1.2 Hodographs

The program operates over two kinds of hodographs:

- First break and VSP first break hodographs are taken from trace header words H_FIRSTBREAK and H_VSP_FIRST_PSCK accordingly. This is so called *resident hodographs*. They accompany the seismic file and are loaded automatically with it. User may load hodograph from database in resident hodograph.
- Custom hodograph may be loaded from database. Loaded hodograph is linear interpolated on coordinates of traces of currently loaded seismic file. If depth range of the loaded hodograph is not intersected with the coordinate range of seismic file, the result of loading will be empty.

2.1.3 1D Velocity model

The database object with 1D velocity model (parallel layers of the same dip given by the topmost layer) is loaded at time of hodograph calculation.

2.2 Output Data

2.2.1 Seismic data

The program allows to store seismic file with the same name or with another one. The file will contain changed built-in hodographs. All attributes of the saved seismic file (volume header content and trace headers) will be the same as in original file except for H_TRACE_TYPE value which can be changed the way described in paragraph 3.15.

2.2.2 Hodographs

Built-in hodographs are saved in the seismic file in the trace headers. In addition, user may save built-in hodograph in database separately.

Custom hodograph may be saved in database at the same or at the another name. The saved hodograph will have time marks on the depths the same as in seismic file. Depths, shot and receiver coordinates will be from the seismic file too.

3 Windows Descriptions

3.1 Main window

The main window includes menu bar, tool bar, status bar and work area. The main window is represented on figure 1.

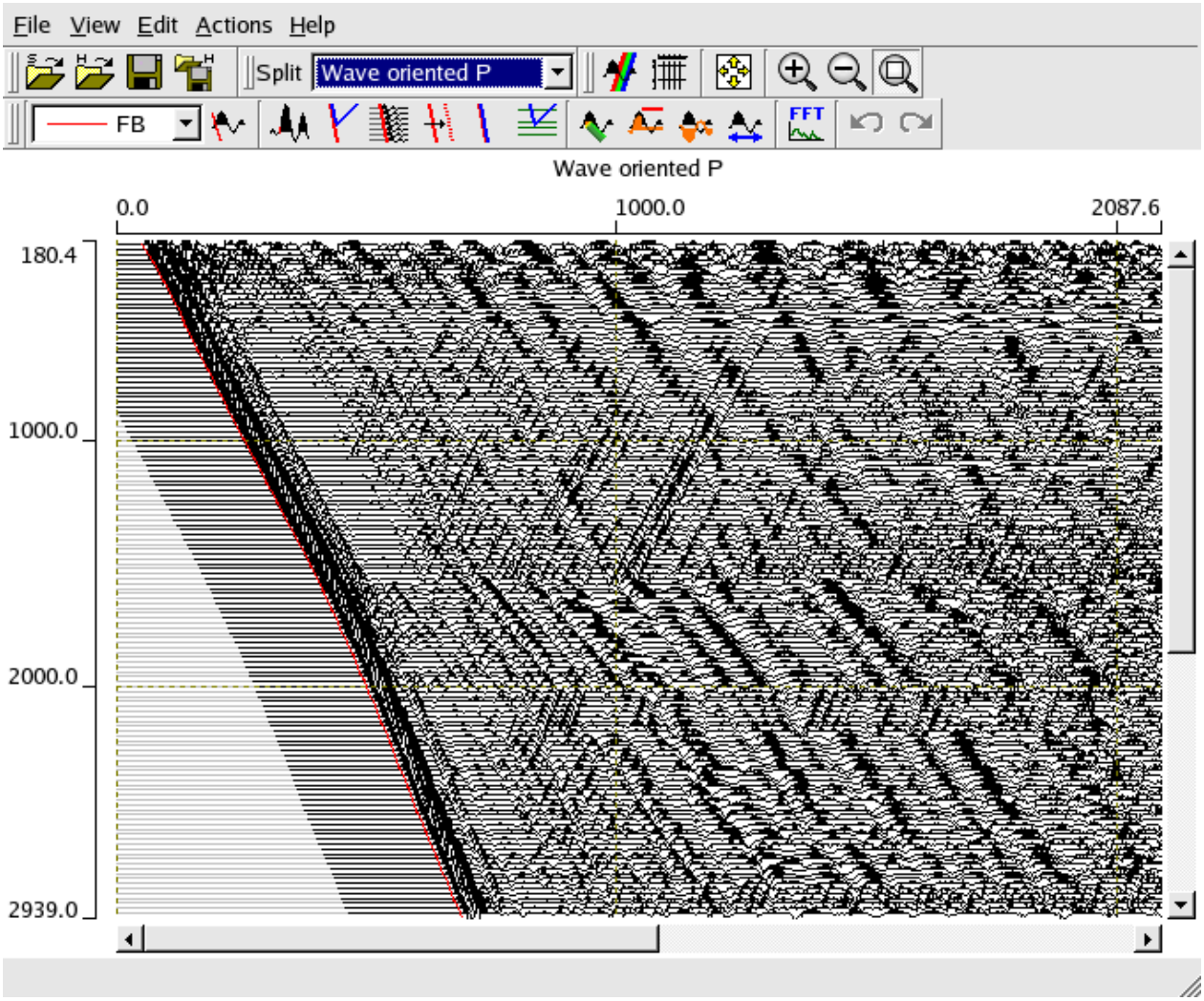


Figure 1

Mouse operations are performed in work area. Most of them consider actions on seismic traces area. Only one operation is active at one time. Active operation is displayed as toggled toolbar button.

The operation of changing trace type (normal/dead) is performed on narrow area between seismic trace area and coordinate axis. Red mark in this are means dead trace.

3.1.1 Menu bar

3.1.1.1 File

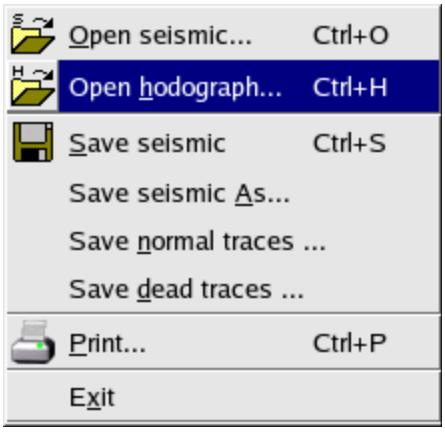


Figure 2

- *Open seismic* – open seismic file instead of current one. A dialog window for seismic file selection is displayed (figure 3). If check box *Pre-load options* is tuned on, then before loading one more dialog window will appear with pre-load options (see paragraph 3.4 for details). These options are responsible for custom selection of header word used for coordinate (H_GRPDEPTH by default), split and select header words, VSP or surface seismic axis orientation and other minor parameters.

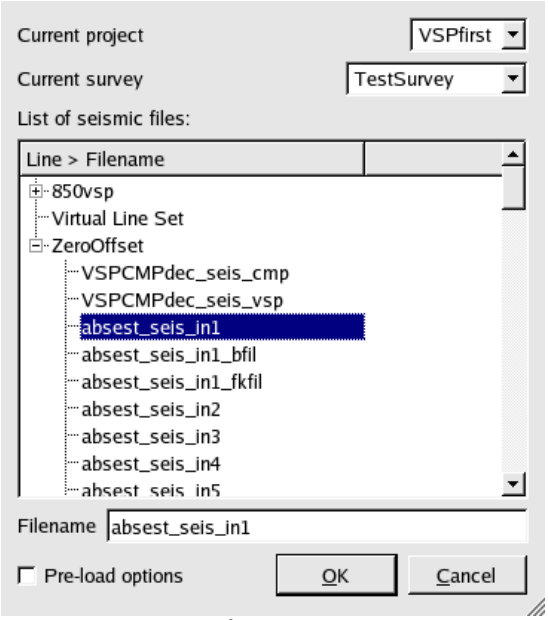


Figure 3

- *Open hodograph* – load hodograph from database. The loaded hodograph is interpolated in the current seismic file coordinate. If the coordinate is not cable depth the result of loading is unpredictable. Hodograph open dialog is represented on figure 4.

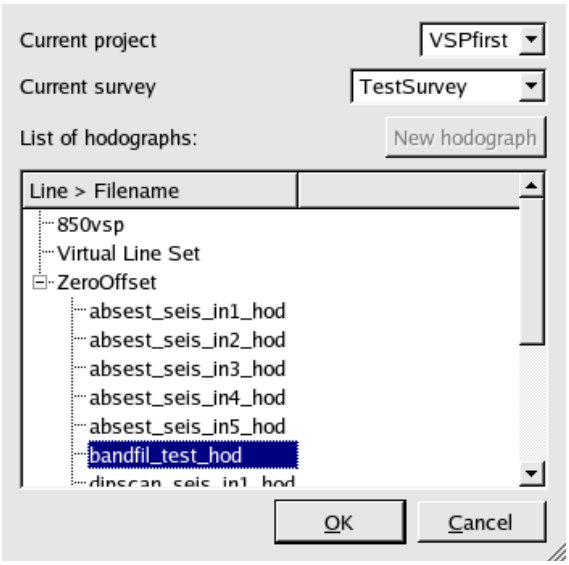


Figure 4

- *Save seismic* – save actual state of the current seismic file to database. In addition to seismic two resident hodographs are stored (in H_FIRSTBREAK and H_VSP_FIRST_PSCK header words).
- *Save seismic as* – save actual state of current seismic file and two resident hodographs to database with custom name. A dialog window is displayed

to select existent name or enter new one (see figure 5).

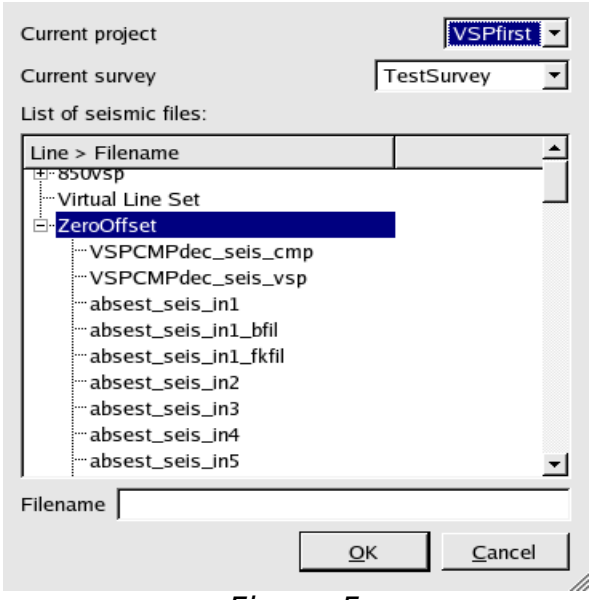


Figure 5

- *Save normal traces* – save all traces which are not marked as dead ones (red dots from the left side of seismic traces). The dialog window appeared is the same as in *Save seismic as* (see Figure 5).
- *Save dead traces* – save all traces which are marked as dead ones making them normal in created seismic file. This operation allows to copy several selected traces to separate seismic file for special processing procedures. The dialog window appeared is the same as in *Save seismic as* (see Figure 5).
- *Print* – store current seismic view to CGM file. The first, print settings dialog windows appears (figure 6).

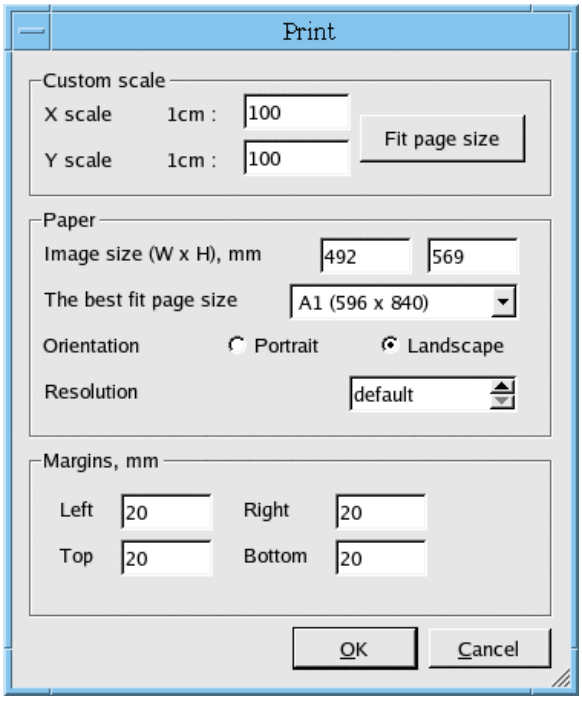


Figure 6

In this window user is allowed to set next parameters of target picture:

- Scale of the X and Y axis (ratio to the 1cm should be entered). In this case image and paper size is calculated automatically according to scale, orientation and margins.
- Size of the target paper page. In this case user user should select one of standard page sizes and push *Fit page size* button. Both scales will be recalculated to appropriate values.
- Margins around main view allow to position the target picture on the page.

After entering print settings user is asked about target filename with default **.cgm** extension. On entrering filename the program prepares the picture. The process can take several minutes depending the size and complexity of the visualized data.

- *Exit* – finish the working session. If some changes were made during the session a warning dialog window will be displayed to confirm exit. If no changes were made then the program exists immediately.

3.1.1.2 View

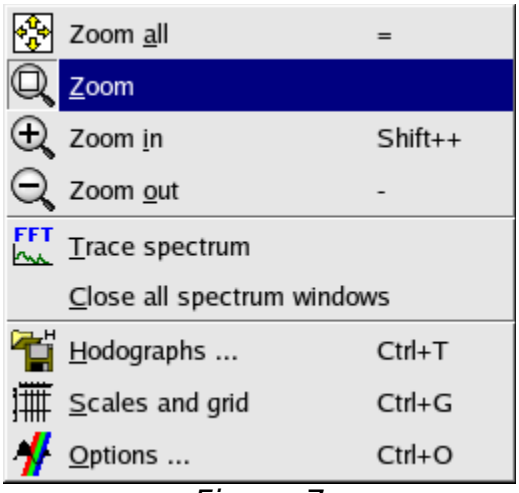


Figure 7

- *Zoom all* – displays the seismic in the whole available range of times and coordinates. Button [=] can be used as a keyboard accelerator.
- *Zoom* – provides interactive zoom in custom rectangle with rubber edges. This is mouse mode among other exclusive modes (when one mode is on all other are off). Pressing left button the first corner became fixed, then one need to drag mouse holding the button pressed to choose the rectangle to zoom. Release the left button to apply chosen operation. Press the right button to cancel it.
- *Zoom In* – single close-up of the whole area based on predefined scale factor. [Shift]+[+] can be used as a keyboard accelerator.
- *Zoom Out* – single zooming out of the whole area based on predefined scale factor. Button [-] can be used as a keyboard accelerator.
- *Trace spectrum* – mode for trace spectrum visualization in separate windows. On every click on seismic field new window with selected trace spectrum will appear. See the detailed description of this feature in paragraph 3.13.
- *Close all spectrum windows* – close all windows with trace spectrum.
- *Hodographs* – display dialog window with hodograph input/output and view/hide/clear options. See the description in paragraph 3.12.
- *Scales and grid* – display dialog window with tuning options for grid and scales steps and manual zoom mode (coordinate and time range setting). See the description in paragraph 3.6.
- *Options* – display dialog window visualization options for seismic data.

See the description in paragraph 3.5.

3.1.1.3 Edit

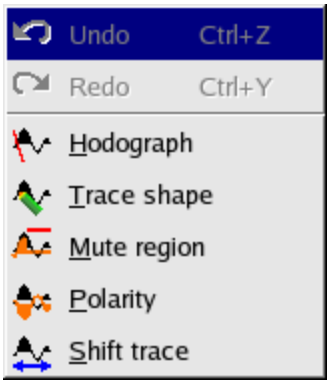


Figure 8

Orders:

- *Undo* – undo the last modification operation. The short description of the operation to undo is displayed nearby in the label. The undone action can be redone with redo. The depth of undo buffer is limited only by computer resources.
- *Redo* – redo the last undone operation. The short description of the operation to redo is displayed nearby in the label.

Mouse modes (only one is on at one time):

- *Hodograph* – manual change of the currently selected hodograph. The hodograph selection box is present on toolbar. There are two modes of hodograph manual modification: click the new point and drawing new line. The second mode is performed by rubber line dragged from the first point where user pressed left mouse button until the point where user release left button.
- *Trace shape* – edit trace samples by mouse. The first one need to click the target trace by left mouse button. The trace shape will be drawn by special color. Then user may click left button to set new sample amplitudes. To apply changes press middle mouse button. To cancel changes press right button. **Attention!** If automatic gain control mode is turned on then changing samples will lead to visual changes of neighbor samples in the range of gap width. Actual value of neighbor samples will rest the same!
- *Mute region* – assign zero to all samples inside marked polygon. To mark corners of custom polygon one needs to click several times in preferred points on the seismic view. The sequence of polygon segments will be drawn as polyline. To forget previous entered point one need to press

right button. To close the polygon and apply muting procedure the middle mouse button should be clicked.

- *Polarity* – click a trace by left mouse button to revert its polarity.
- *Shift trace* – mouse driven drag-and-drop procedure to shift the trace. Left mouse button is used for dragging.

3.1.1.4 Actions

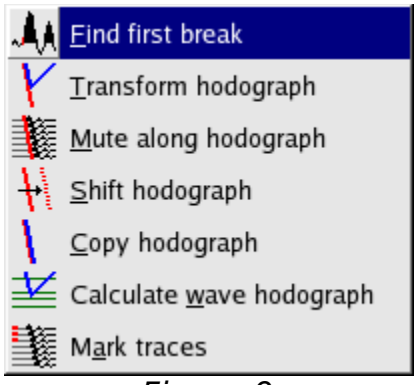


Figure 9

- *Find first break* – open dialog window with first break determination parameters. See the detailed description in paragraph 3.7.
- *Transform hodograph* – open dialog window with hodograph transformation parameters. See paragraph 3.8 for detailed description.
- *Mute along hodograph* – open dialog window with muting parameters. See paragraph 3.11 for detailed description.
- *Shift hodograph* – open dialog window with shift parameters. See paragraph 3.10 for detailed description.
- *Copy hodograph* – open dialog window with source and destination hodograph selectors. See paragraph 3.9 for detailed description.
- *Calculate wave hodograph* – open dialog window with wave specification. See paragraph 3.14 for detailed description.
- *Mark traces* – open dialog window with custom selection condition to mark traces as dead or normal ones. See paragraph 3.15 for more details.

3.2 Tool bar

Tool bar consists of several floating panels. Each panel may be attached to another one or placed in free manner inside the main window or even outside it. Standard composition of tool bar is represented on figure 10. The function of buttons in the tool bar are similar with menu items

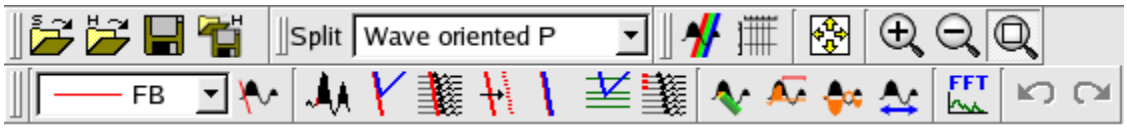


Figure 10

3.2.1 Input and output actions panel

Figure 11

The panel groups operations with database: open, save, save as and includes hodograph control dialog window (see paragraph 3.12 for details).

3.2.2 Split combo box panel

Figure 12

The panel allows to display traces, separated from all input traces by split header word selection (see paragraph 3.4 for details). If on pre-loading stage user solved to display all splitted traces in different areas in main window, then this tool bar panel will not present.

3.2.3 Select combo box panel

Figure 13

The panel allows to display traces, separated by given value of selected header word. Values to be selected should be set in pre-loading dialog window (see paragraph 3.4 for detailed description). If select header word is not set (by default, for example), this panel will not present in toolbar.

3.2.4 Visualization panel

Figure 14

The panel combines all facilities needed for visualization tuning. Visualization and grid options are grouped with zoom tools.

3.2.5 Modification operations panel

Figure 15

The panel contains all tools for editing data: seismic and hodographs. Undo and redo tools are represented on the panel too. Hodograph selection combo box allows to point the hodograph to change by mouse.

3.3 Status bar

The status bar displays transient information about events, tools, brief help messages and so on.

3.4 Pre-load options dialog window

The dialog (see figure 16) allows to arrange several important parameters for seismic visualization which are can't be changed later during the session. To access this dialog user should set check box in the seismic file open dialog window and press OK.

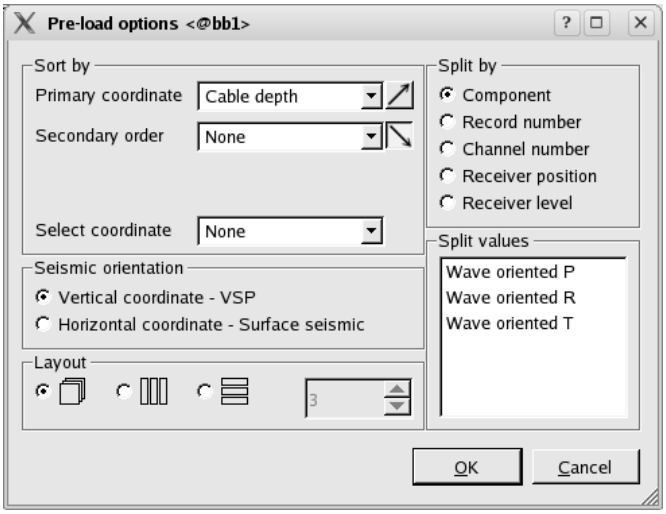


Figure 16

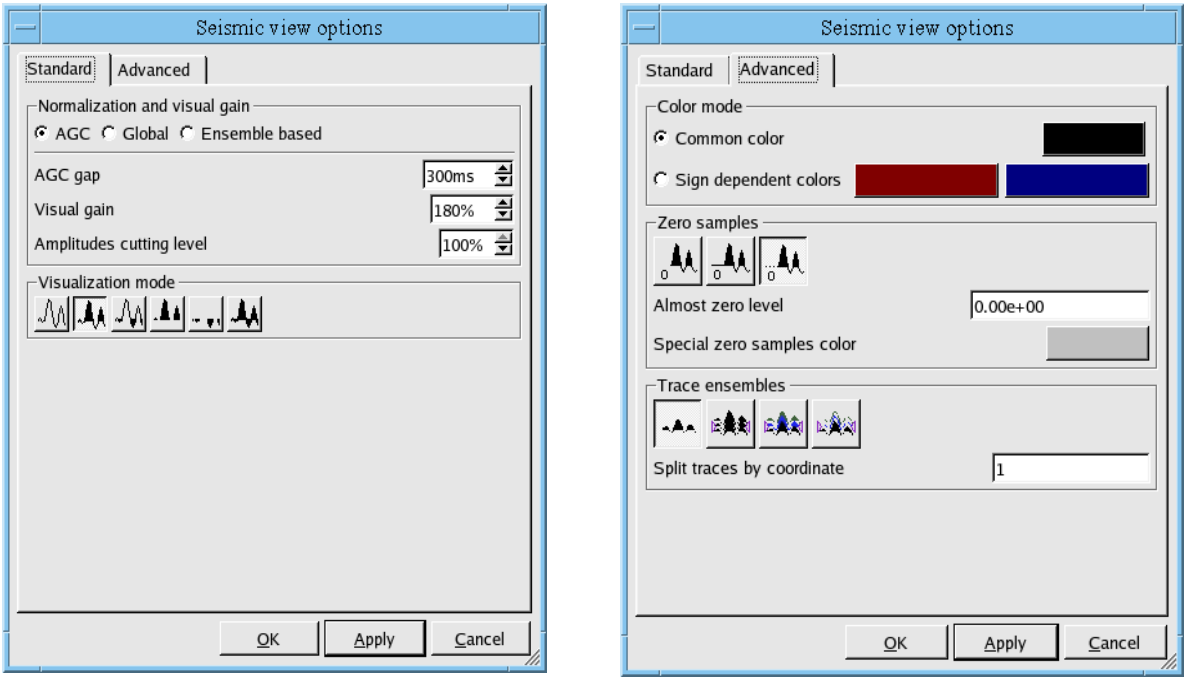
Next pre-loaded options can be changed:

- *Seismic orientation* – allows to select VSP or surface seismic usual coordinate axis orientation. Which coordinate will be used as primary is defined in *Sort by* options.
- *Sort by* – allows to manage which header words are used to sort seismic traces and which one is used as a selector. Secondary coordinate are useful only if user is going to draw seismic traces with the same primary coordinate – so called ensembles (see paragraph 3.6 for details).
- *Split by* – allows to manage multicomponent seismic traces or separate visualized traces by other header words. List of split values is displayed nearby. An user may select values to be shown (rest will be hidden).
- *Split layout* – it's possible to draw several seismic areas (splitted by defined criteria) in the same window. If several seismic areas drawing is selected here (horizontal or vertical split) then split combo box panel in tool bar will be absent.
- *Select coordinate* – allows to display seismic subsets with custom header word value. For example, for 2D/3D VSP data it's reasonable to use Record number. Optionally user may display several subsets in the same screen by activating splitting and entering number of subsets displayed

simultaneously (3 on Figure 16).

3.5 Seismic visualization options window

The dialog allows to control how seismic traces are drawn on the screen. Options are grouped on two tabs: standard features, used frequently (figure 17a) and advanced features for rare use (figure 17b).



a) b)

Figure 17

To apply changes one needs to press OK or Apply button.

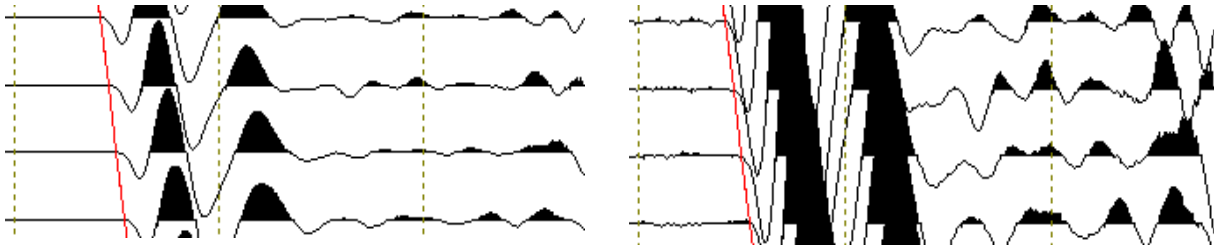
3.5.1 Standard drawing options

- *Visualization mode* – kind of wiggle trace drawing.
- *Normalization and visual gain* – provides ways to manage visual amplitudes magnification:
  - *AGC* – automatic gain control with floating time gap. Shorter gap eliminates ampltude fading along trace. In this mode amplitudes are normalized to the maximum one on the trace. This is default mode used for most purposes.
  - *Global* – all drawn amplitudes have true visual size relative to maximum amplitude in the seismic file. This mode allows to estimate time and depth fading and general energy distribution.

- *Ensemble* – all traces drawn in ensemble (see Advanced options) have amplitudes with true size relative to maximum amplitude in the whole ensemble. This mode allows to compare energy of traces with the same primary coordinate.

Numeric parameters:

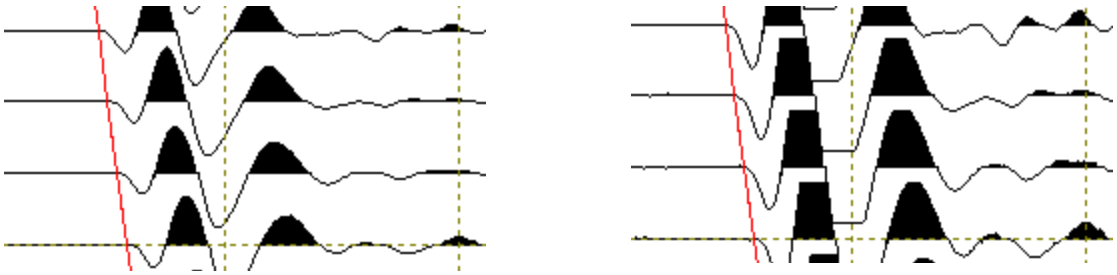
- *AGC gap* – width of the sliding gap used for automatic gain control. The value which is equal or greater trace length allows to turn off AGC amplification and it is equivalent to normalization to the trace maximum.
- *Visual gain* – percentage of visual amplification after normalization. The more visual gain is the greater will be visual trace overlap. 100% usually (for constant coordinate step among traces) means that every trace does not overlap with neighbor traces. See figure 18.



a) Visual gain = 100% b) Visual gain = 180%

Figure 18

- *Amplitudes cutting level* – percentage of maximum amplitude to cut heads while trace drawing. See figure 19 (visual gain was 90%).



a) Amplitudes cutting level = 100% b) Amplitudes cutting level = 50%

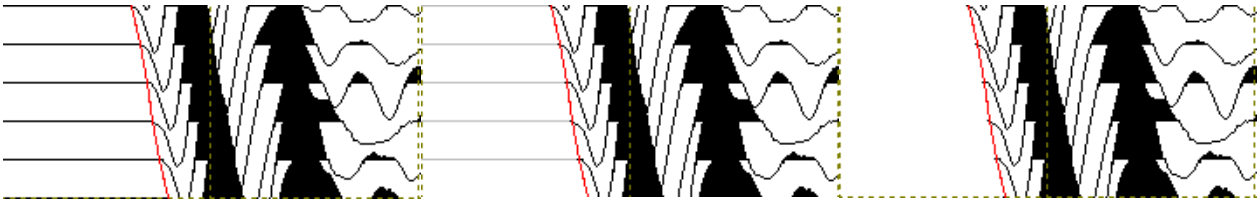
Figure 19

3.5.2 Advanced drawing options

- *Color mode* – includes definition of common color for traces drawing and

special colors used for positive and negative amplitudes drawing. By default, common color mode is turned on.

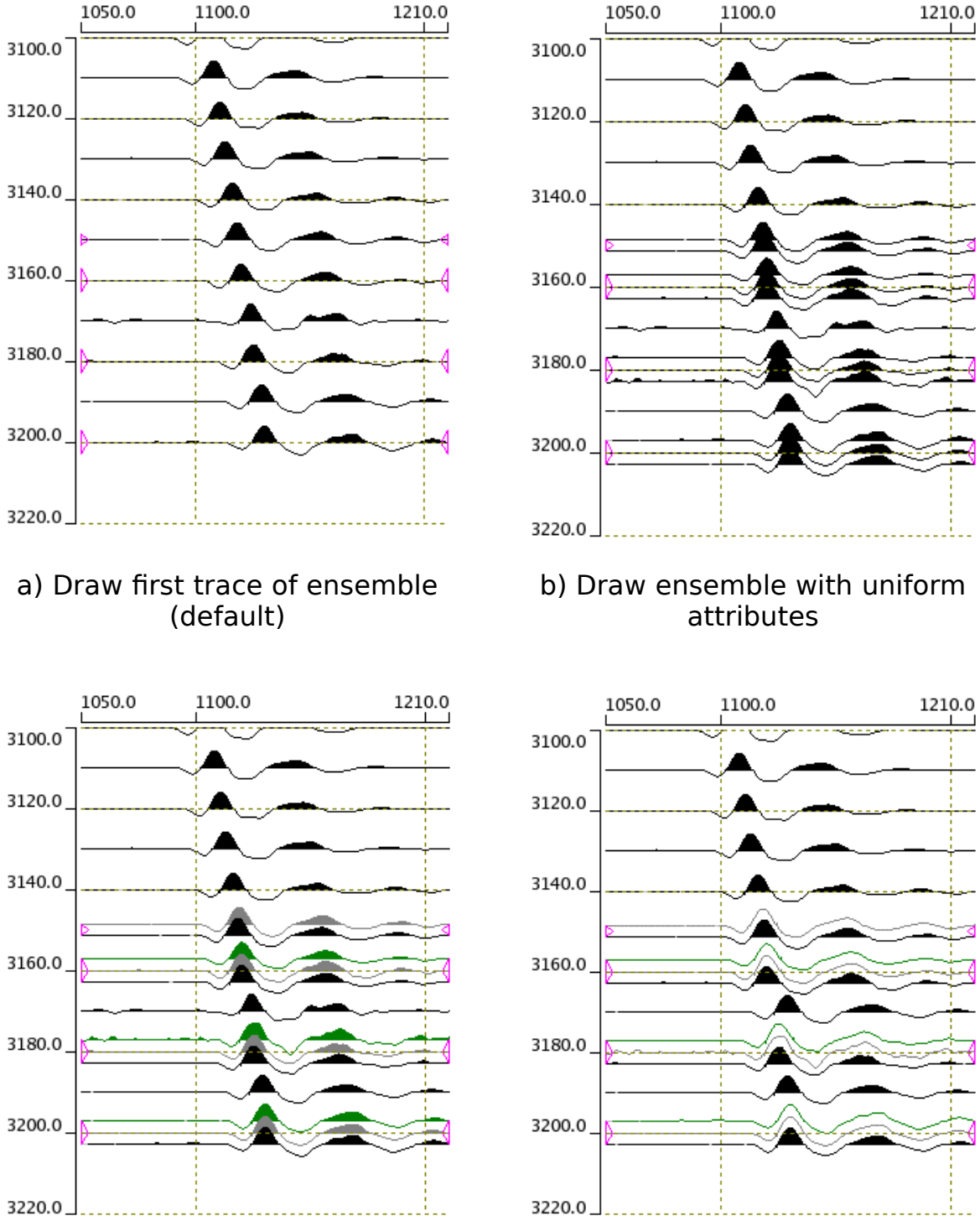
- *Zero samples* – they can be treated as usual samples (figure 20a), drawn with special color (figure 20b, the default mode) or not drawn at all (figure 20c). In addition, small samples (less than given value) can be treated as zero samples.



a) Zero samples as usual b) Special color of zero c) Don't draw zero samples

Figure 20

- *Trace ensembles* – the group of traces with the same coordinate is called *ensemble*. By default, only the first trace of the ensemble is drawn (figure 21a). Usually every trace has unique coordinate. But sometimes, due to complicated observation conditions, seismic import mistakes or custom needs (caused by special primary coordinate selection in Pre-load options dialog window; see paragraph 3.4), several traces have the coordinate and should be managed. Next features are provided for better ensemble visualization:
  - *Split traces by coordinate* – numeric parameter with allows to assign unique pseudo coordinate to each trace of ensemble. This is a step of traces, visualized in ensemble.
  - Magenta brackets allows to estimate number of traces in ensembles.
  - Different visualization methods for ensemble drawing (see figure 21).



a) Draw first trace of ensemble (default)

b) Draw ensemble with uniform attributes

c) Draw ensemble with different colors

d) Draw background traces with thin lines

Figure 21

3.6 Scale and grid options dialog window

The dialog allows to see and change visual ranges and grid steps for coordinate and time axis (see figure 22). Data bounds are provided just for information and can't be changed. Coordinate data bounds are slightly wider than actual data range because the first and the last trace should have more space for own visualization.

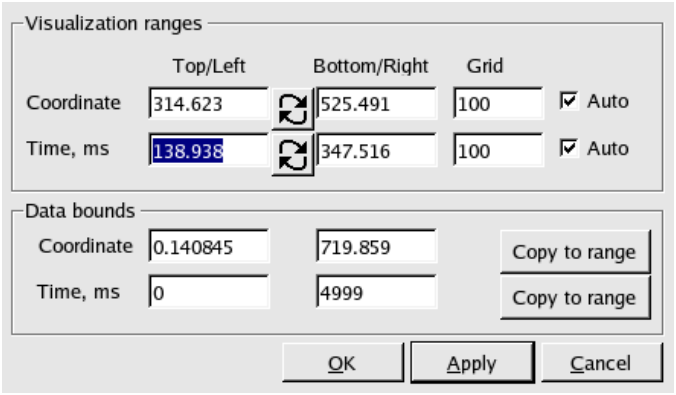


Figure 22

Next capabilities are provided in the dialog window:

- Numeric setting of visualization ranges for coordinate and time axis separately.
- Numeric setting of grid step for each axis or using automatic optimal step calculation.
- Reverting axis direction.
- Copying data bounds to visualization range.

To force the changes one needs to press OK or Apply button.

3.7 First break determination dialog window

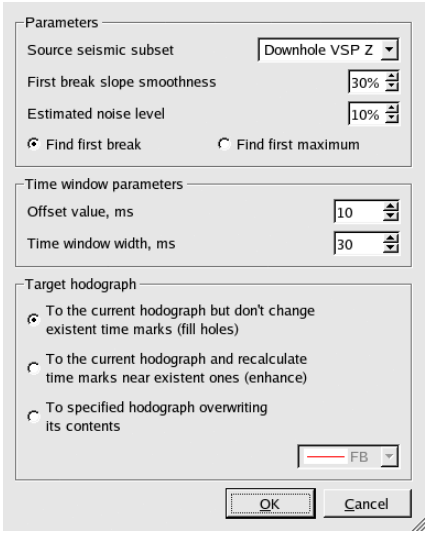


Figure 23

The dialog window provides first break determination algorithm for given subset of VSP seismic data (*Source seismic subset*). First maximum can be determined as well (see *Find first break* and *Find first maximum* radio buttons). Next parameters are considering while automatic determination process goes on:

- *First break slope smoothness* – the coefficient to control first break mark distance from left slope of first break wave. The more the coefficient is the far the first break will be from the wave to the left. In case of finding first maximum the parameter doesn't effect the resulting time.
- *Estimated noise level* – the coefficient to control level of noise in seismic signal. This parameter defines the level of amplitudes to find first break wave relatively to the global maximum on the trace. Higher value means higher noise level.
- *Time window parameters*: *Offset value* and *Time window width* – two values mark the window around existent hodograph time to find first break there (enhance mode).
- Target hodograph – where to put first break time. Next choices are allowed:
  - *Fill holes* mode – to the current hodograph (see selector on toolbar) but don't change parts of existent hodograph.
  - Enhance mode – to the current hodograph but enhance hodograph time in given time window. This case is adviced in case of high noise level.
  - To pointed hodograph overwriting its previous contents.

To run first break hodograph determination process one needs to press OK after entering values of all parameters.

3.8 Transform hodograph dialog window

The dialog window (see figure 24) allows to produce hodograph of reflected and converted waves in simple approach of one event medium (one reflection/conversion depth is specified). This features does not pretend to be kinematic modelling. It's just for hodograph editing.

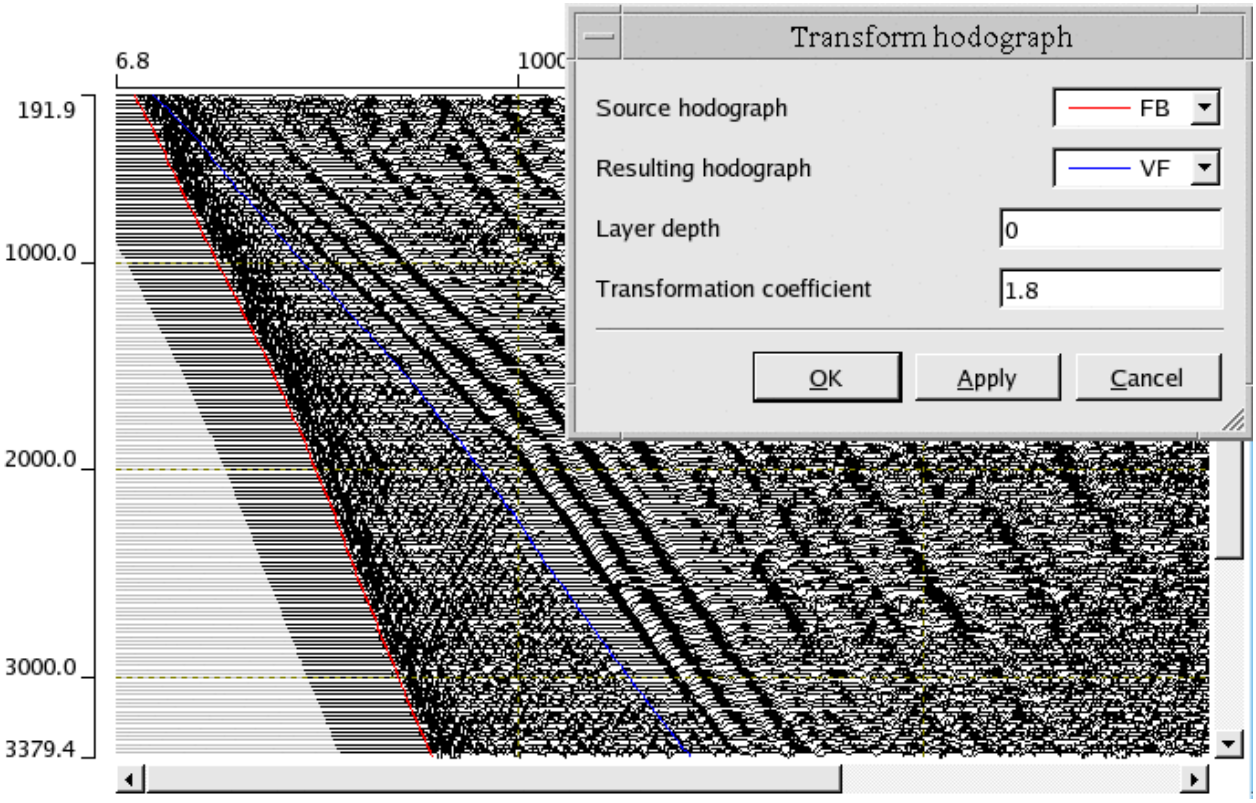


Figure 24

One should select source hodograph which will be transformed by given coefficient, target hodograph which will store results, layer depth at reflection/conversion event will be calculated and transformation coefficient *K*. Its meaning is described below:

$K > 1$	Resulting hodograph will have slower velocity than orignal one from given layer depth and lower (conversion P waves to S waves)
$0 < K \leq 1$	Resulting hodograph will have the same or higher velocity than orignal one from given layer depth and lower.
$K = 0$	The copy of original hodograph will be made.
$-1 \leq K < 0$	Resulting hodograph will be reflected at given depth with

the same or higher velocity than original one.

$K < -1$	Resulting hodograph will be reflected at given depth with slower velocity than original one (reflection with P to S conversion).

3.9 Copy hodograph dialog window

The dialog window (see figure 25) allows to copy one hodograph to another. In the window source and destination hodographs should be selected.

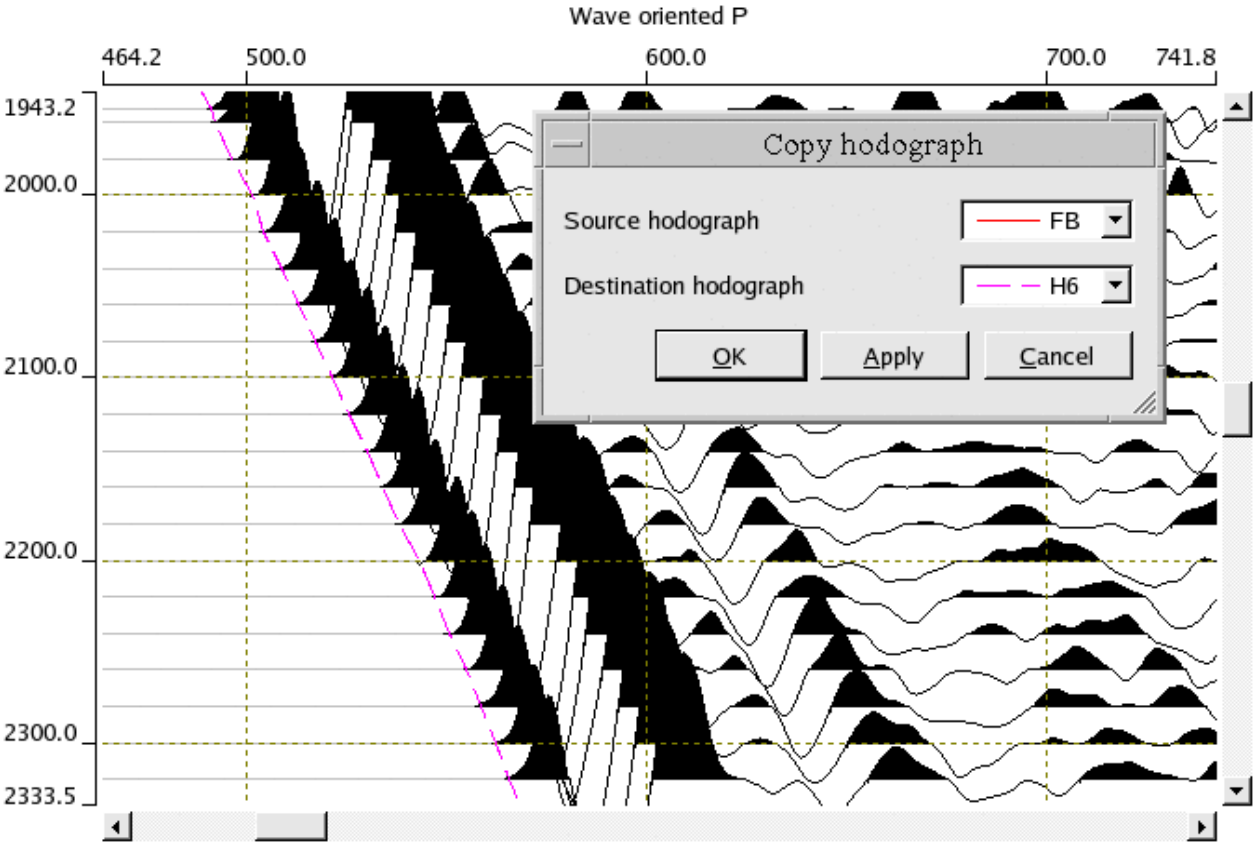


Figure 25

3.10 Shift hodograph dialog window

The dialog window (see figure 26) allows to shift the whole hodograph to the left (negative value of shift) or to the right (positive value of shift). User may select arbitrary hodograph to shift. To recalculate the hodograph OK or Apply should be pressed.

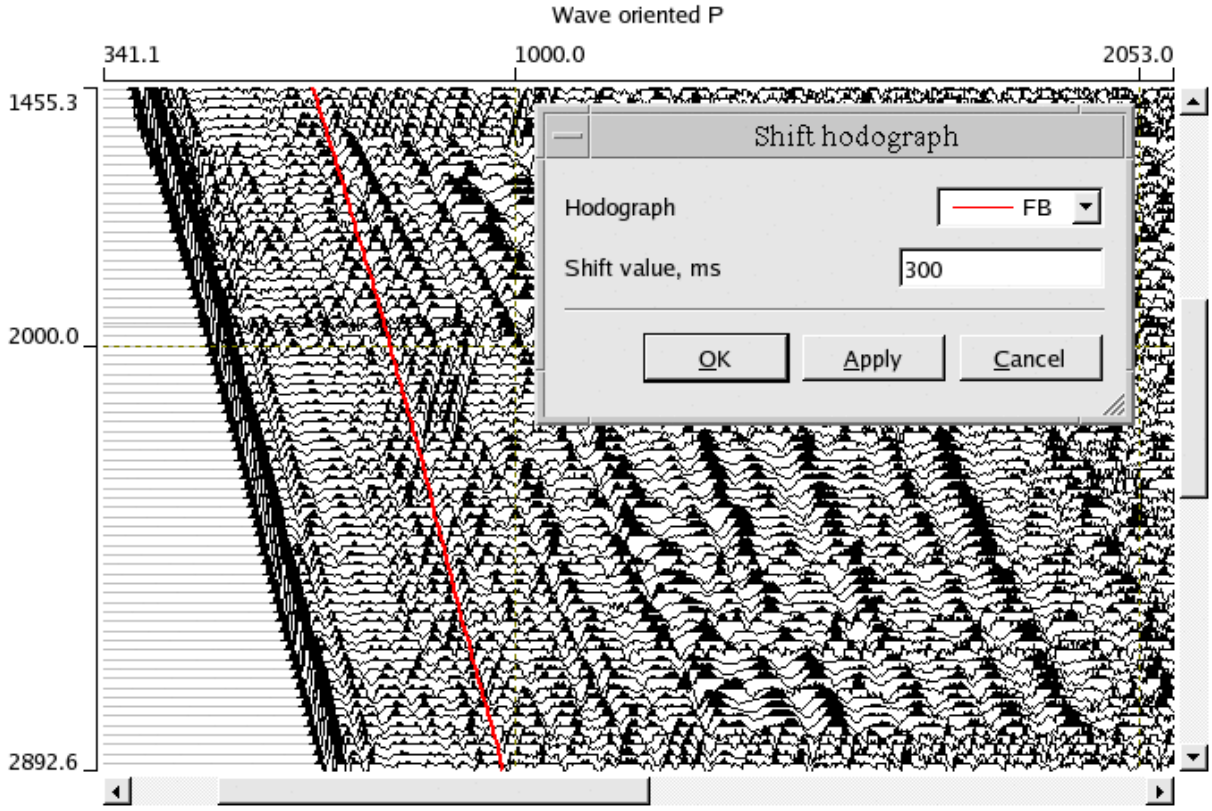


Figure 26

Attention! If user press Apply (dialog window will be not closed) and then press OK (dialog window will be closed), the shift will be applied twice! One can use Edit|Undo if extra shift was applied for mistake.

3.11 Mute along hodograph dialog window

The dialog window (see figure 27) allows to make all samples to be zero from the left or from the right side of given hodograph.

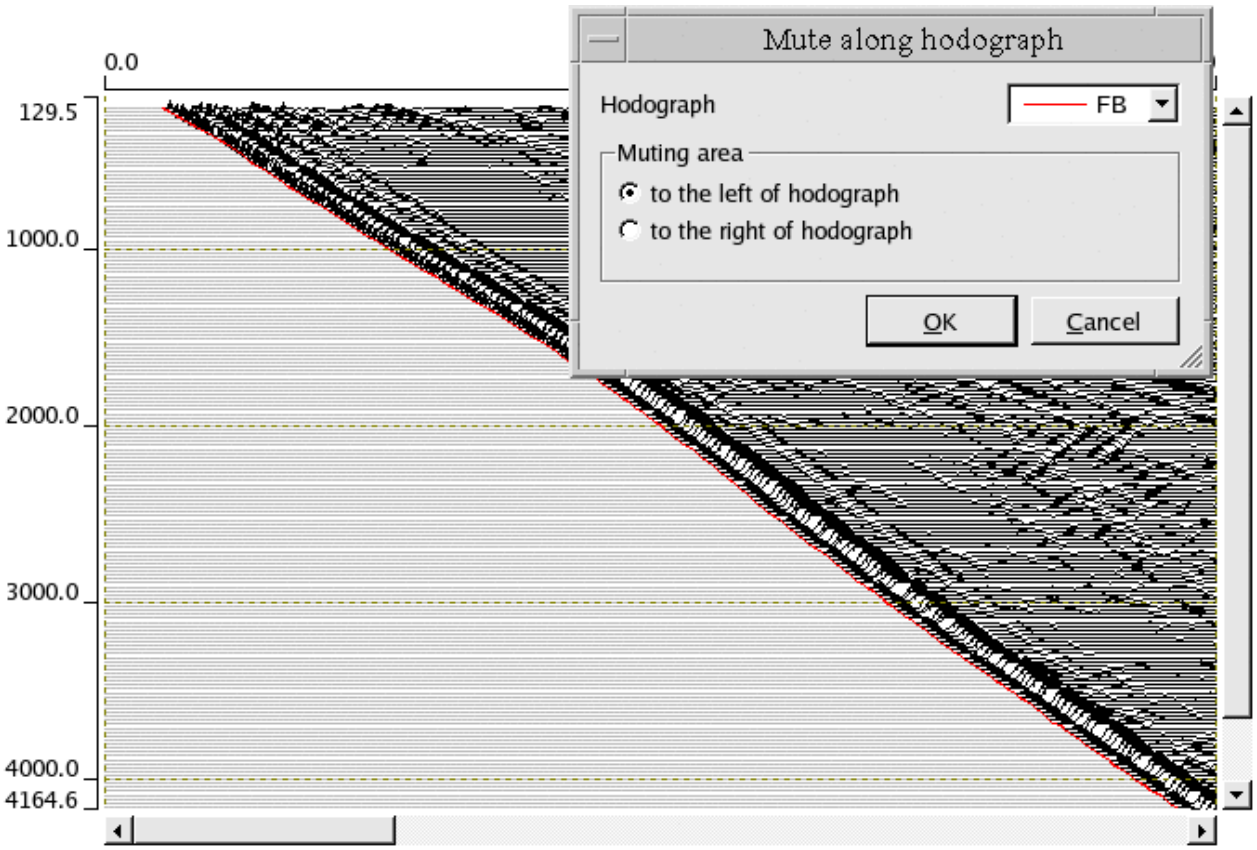


Figure 27

3.12 Hodograph input/output and options

The dialog window (see figure 28) composes all operations related to hodographs:

- Input/output operations with hodographs stored in database
- Clear the hodograph
- Enable/disable hodograph drawing

The window consists of two rows with resident hodographs (H_FIRSTBREAK and H_VSP_FIRST_PSCK), stored in seismic file and ten rows of transient (database stored) hodographs, each of them having name.

Next tools are provided in each row (from left to right order):

- Check box to enable/disable visibility of the hodograph.
- Small image with hodograph drawing method (solid line or dash line of some color).
- Database address (name,lineset,survey,project) for transient hodographs.
- Load/Merge button – if the hodograph is empty then pressing the button causes loading hodograph. Its database address will be displayed. If the hodograph is not empty then selected hodograph will be merged with existent one. Merging means filling holes in existent hodograph curve.
- *Save/Save as* button – if the database address is empty then *Save as* function is called and hodograph name selection dialog is displayed, otherwise *Save* is called.
- *Clear name/Erase* – if the database address is empty then it is cleared, so next press *Save/Save as* button will cause Save as function activation. If the database address is empty then the hodograph is erased and becomes invisible.

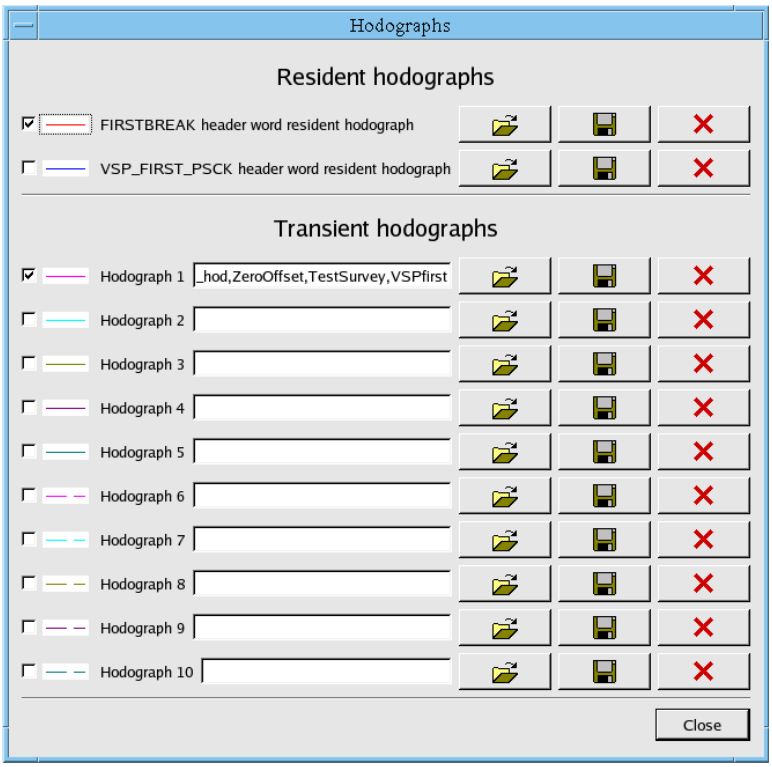


Figure 28

3.13 Trace spectrum windows

In *Trace spectrum* view mode every mouse click on seismic trace causes appearance of new window with trace spectrum displayed (see figure 29).

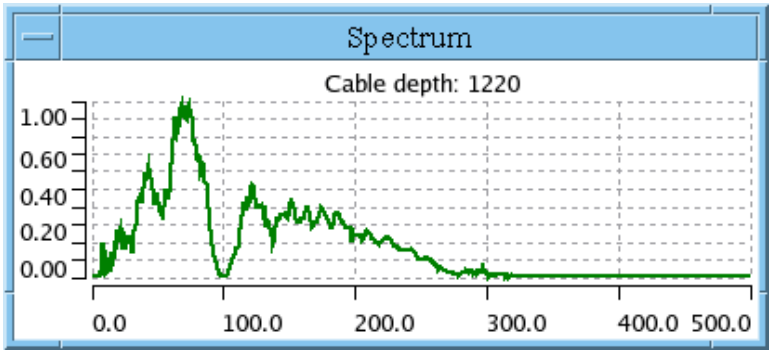


Figure 29

All appeared windows have common frequency axis, so then user zooms in the spectrum view on one window all windows are zoomed too. To return to the whole spectrum view an user should double click by middle mouse button.

Any spectrum window can be closed as usual window by system close

button. All windows can be closed by **View|Close all spectrum windows**.

3.14 Wave hodograph calculation dialog window

The dialog window (see figure 30) allows to calculate hodograph of given wave which goes from/through given point.

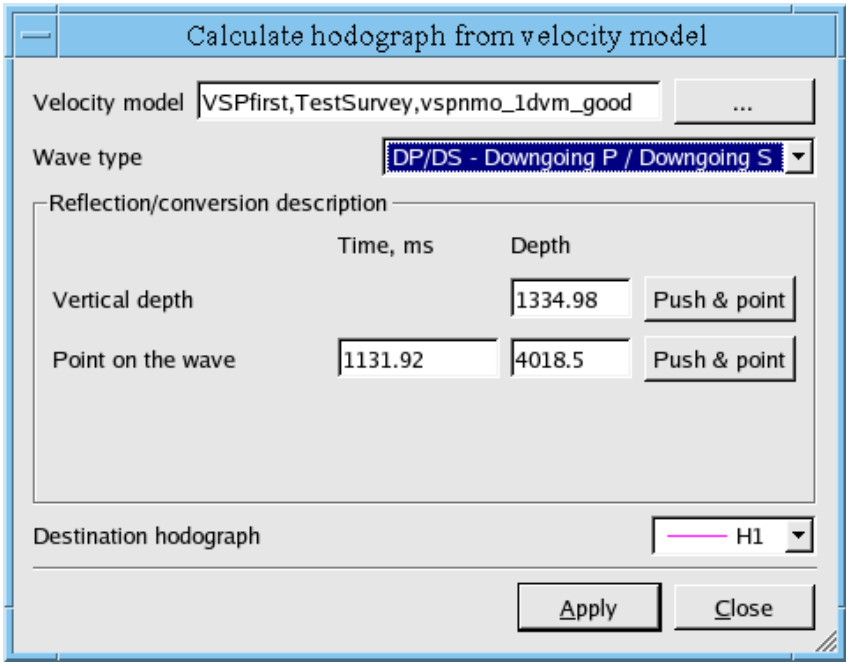


Figure 30

Next wave types are supported:

- Direct downgoing wave of P or S type (DP, DS).
- Downgoing converted wave of P-S or S-P type (DP-DS, DS-DP).
- Upgoing monotype (DP-UP, DS-US) and converted waves (DP-US, DS-UP).

To calculate wave hodograph 1D velocity model should be specified. Destination hodograph should be specified as well. Calculation starts when user press Apply button.

Direct downgoing wave can be calculated without any additional parameters.

To calculate reflected and/or converted wave hodograph one need to setup vertical depth of the conversion/reflection event. This depth may be specified in next ways:

- Enter the vertical depth manually.
- Push the button from the right of vertical depth numeric field and then point target depth on seismic area by mouse (left button should be clicked).
- Point the wave on seismic area by mouse (left button should be clicked)

after pushing appropriate button in the dialog window. Then coordinates of the point will be displayed and supposed target vertical depth of conversion/reflection will be set.

In the last case user may set point which can't belong to the selected wave type due to physical limitations of signal propagation in loaded velocity model. The program informs about such circumstances by next messages:

- “Entered point is before first break”
- “Conversion depth is over the surface”

Attention! In the dialog window vertical depth is used instead of cable depth (stored in H_GRPDEPTH). For not vertical well path cable depth differs from vertical one.

3.15 Mark traces

The dialog window (see figure 31) allows to select traces using custom condition based on some header word values selection. It's possible to select header word, range of it's values and scope of selection: current view or all traces. It's possible to mark traces as dead ones or normal.

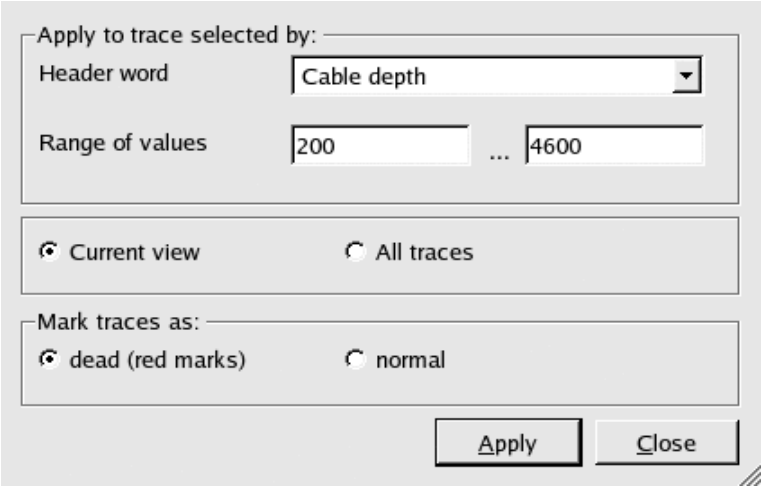


Figure 31

Another way to mark traces is to do this interactively by mouse. Dead trace marks are of red color and they are drawn along the coordinate axis. Clicking on this area an user may change dead/normal state of each trace. See figure 32.

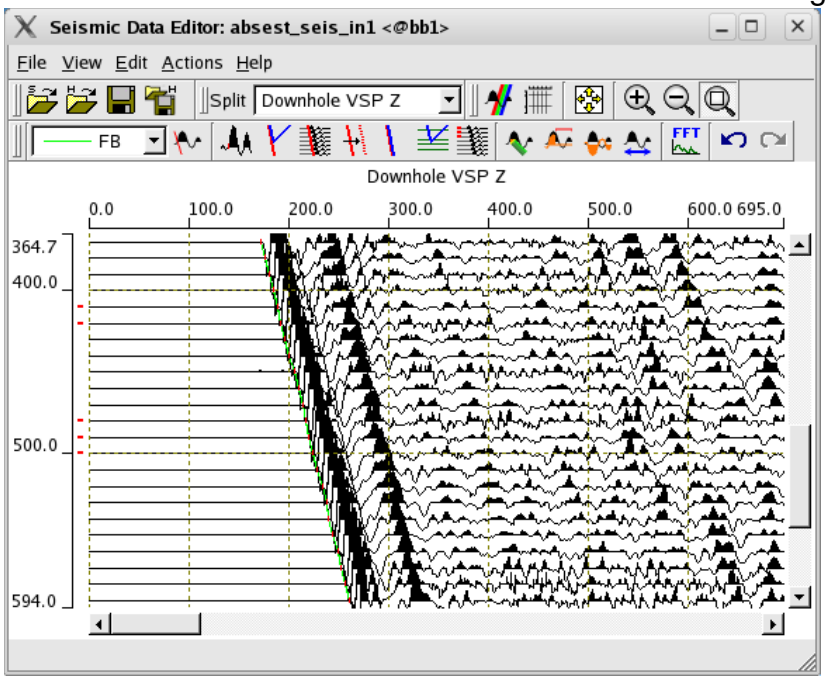


Figure 32

4 Using Examples

In this part several examples of seismic data visualization in not default mode are observed.

4.1 Split by channel number

Sometimes seismic channel produce invalid traces due to malfunctioning geophone, or cable. To check this case one can split seismic data by channel and draw traces of different channels in different regions (see figure 33). Then difference of channels can be estimated visually (see figure 34).

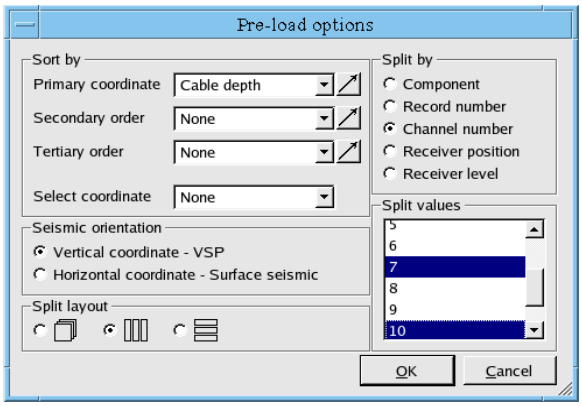


Figure 33

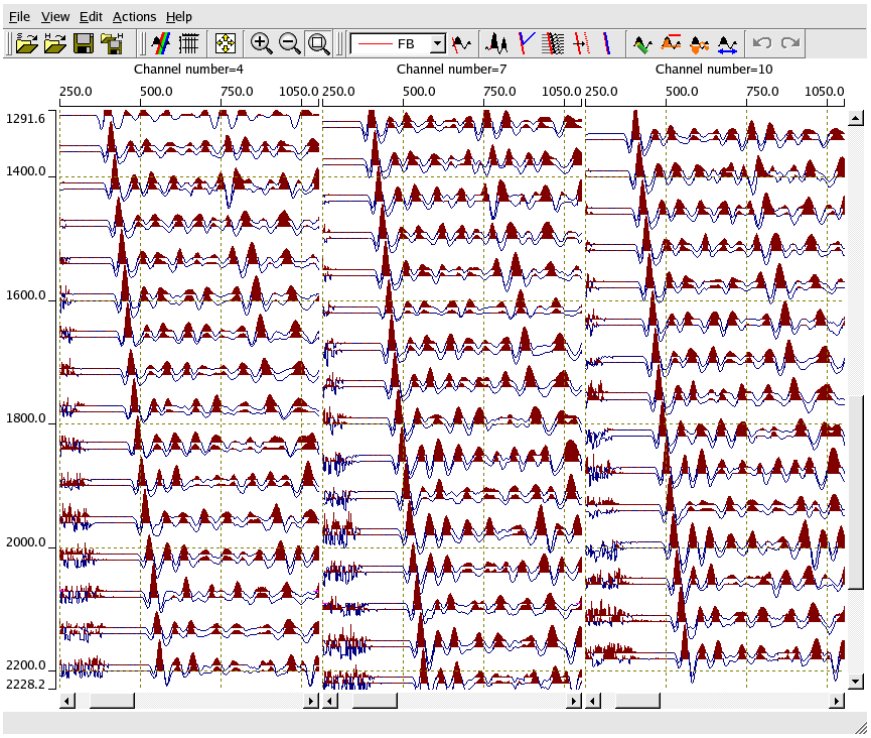


Figure 34

4.2 Surface seismic visualization

It's possible to use the program for surface seismic visualization. In this case one should call dialog window with pre-load options (see paragraph 3.4) and select appropriate primary coordinate. Then seismic orientation should be selected for time axis directed down. See figures 35 and 36 with example.

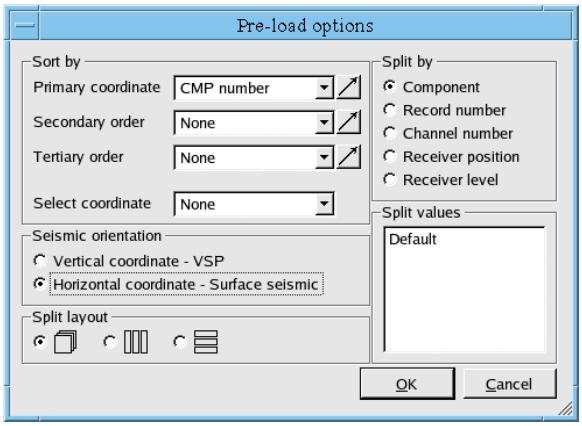


Figure 35

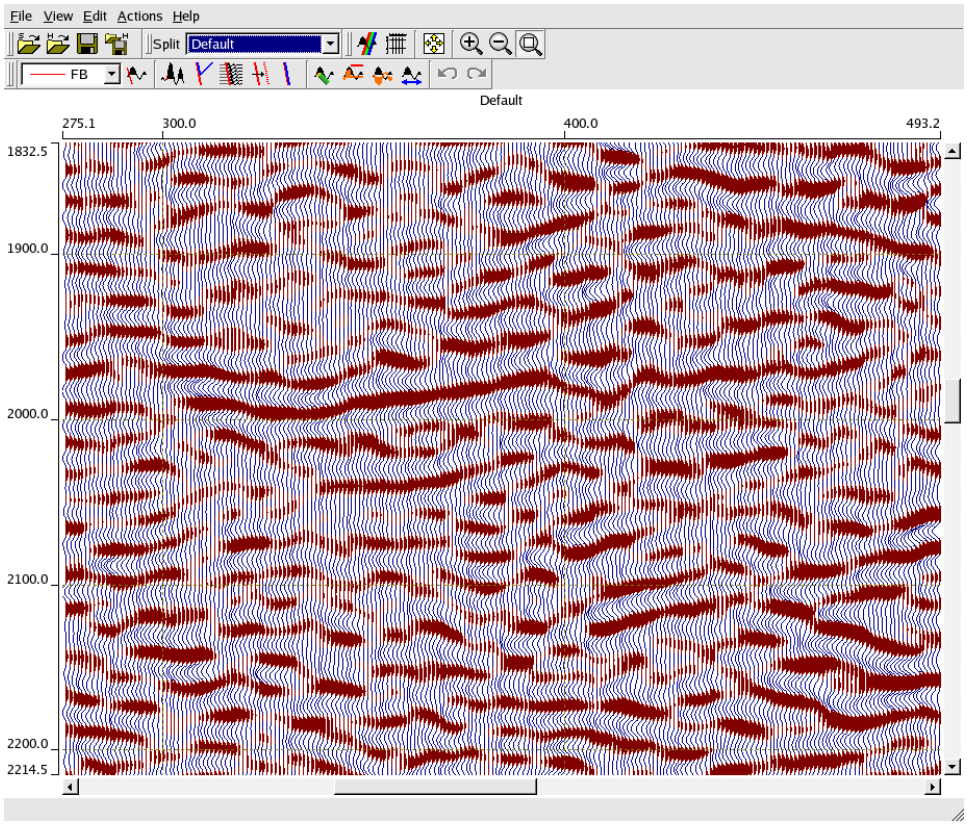


Figure 36