

# Tutorial on Seismic Reflection CDP Data Processing in the *RadExPro Plus* software

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## Introduction

This tutorial is intended for the users, who begin to process seismic reflection CDP data in the **RadExPro Plus** program. All standard stages of basic CDP processing are discussed, from the introduction of geometry to stacking, that is the so-called minimal processing sequence. It is assumed that the user is already familiar with the theory of the CDP reflection method and with the fundamental technology of processing such data.

The processing is conducted on an example of the real data, which can be downloaded from our Web-site: <u>http://radexpro.ru/upload/file/tutors/CDP/inpdata.zip</u>

The archive contains initial data for the work: a fragment of an on-shore seismic profile, recorded in SEG-Y format (file *line\_l.sgy*), with the trace headers containing source point and receiver point numbers, and two ASCII files, *rec\_geom.txt* and *sou\_geom.txt*, containing coordinates of the receivers and sources, respectively.

Furthermore, you can load the final project, which is a result of executing all steps, described in the tutorial: <u>http://radexpro.ru/upload/File/tutors/CDP/MyProject.zip</u>

Note that the facilities of the software, of course, are not limited to the minimal processing sequence described here. We consciously did not consider more complicated tasks such as, for example, horizontal velocity analysis, migration, calculation and analysis of seismic attributes, etc. You can find the information about these and other procedures of data processing and analysis in the "User Manual" to the program.

## Data input, assigning geometry, binning

#### Creating a RadExPro Plus project

All reflection data processing in the **RadExPro Plus** is performed within the framework of *projects*. A project is a complex of initial data, intermediate and final processing results, processing flows, all organized into a common database used by the software. The projects are stored in separate folders on disk. When a project is created, the new folder for it is created automatically. A project can be transferred from one computer to another by simple copying of the folder (in case that all the data used are stored inside this folder).

Let us create a new processing project. Start-up the software. To do this select **RadExPro Plus Total 3.75** command in the Windows Start menu.



When the **RadExPro Plus** starts, the **Project Manager** dialog opens, containing the list of registered projects.

🎇 RadExPro Project Manager	
Registered projects	
Line_22_lam	
hhh WS test	New project
DEMO_QC_nomarine shallow_NSP	Select project
WS_2005_EAST BlackSea_vels BlackSea	Remove from list
seismic_tasks	
Project directory:	
OK Cance	

Click the button **New Project** and select a parental folder on the disk, where the subdirectory with the project will be created. After this, in the appearing window, enter the new project name.

New database			
Title My Project			
🔽 Create subfolder			
OK Cancel			

Make sure that the option **Create subfolder** is selected and click **Ok**. In the selected folder, the subdirectory with the project name will appear. Also the project will appear in the list of available (registered) projects.

🖀 RadExPro Project Manager	×		
Registered projects WS_2005_EAST BlackSea_vels BlackSea seismic_tasks DEM0_QC_nomarine LandDemo BUST_2007_calibr	New project Select project		
Practicum My Project			
Project directory: F:\Practicum\My Project\			
OK Cancel			

Select it and click Ok.

The main window of the **RadExPro** program, containing the project tree, will appear. By now this tree is empty.



#### Loading raw data into the project

Using Windows Explorer, enter the project folder:



In this folder, create a subdirectory **Data** and copy the initial data there.



Storing the data inside the folder of the project allows the software to use relative paths to the data files instead of the absolute ones. This makes the transfer of projects from one computer to another much easier.

Return to the main window of the **RadExPro** program. A **RadExPro** database has 3 structural levels. The upper level corresponds to a study *area*, the middle level - to a *line*, and the lower one - to a processing *flow*. Right-click with the mouse on the yellow circle (that is the root of the project tree), select option **Create new area** in the context menu, and enter a name of the area where the field work was conducted.



The following figure shows the window, where the name of the area should be entered :

New area name		×
My Area		
ок	Cancel	

T 💹 Ra	adExPro	+ 3.7 >>> My	Project
Help	Options	Database Too	ls Exit
•	— <mark>My A</mark>	View map Create line Rename Delete	

Similarly, right-click with the mouse on the yellow rectangle with the name of the area, select **Create line** command and create a new line. The name of the line is assigned the same way.

New line n	ame		
Line 1			_
	ок	Cancel	

The database allows storage of several areas within one project. Each area may contain several lines, each line may contain several processing flows that are applied to the data of this line.

The same way you created the area and the line, create a processing flow and name it 010 - data *load*. It is recommended to that you start the name of each flow with a number. The process of seismic data processing has several stages, carried out consecutively. Since the **RadExPro Plus** program sorts the structural elements of the database alphabetically, it is reasonable to number the flows so that they would be displayed in an accurate logical sequence.

🗱 RadExPro+ 3.7 >>> My Project		×
<u>H</u> elp <u>O</u> ptions <u>D</u> atabase Tools E <u>x</u> it		
<mark>│ My Area Line 1 010 - data load</mark>	_	^
	RENAME	
	TRASH	
MB1 DblClick - Default action; MB2 - Context menu; MB1 - Drag flow to line to copy	1	~

Double-click the left mouse button on the flow name to enter the flow editing mode. The window of the flow editor will open. On the left side of the window is the flow itself (it is empty so far), on the right side is the library of available processing routines (modules), divided into groups.

My Project/My Area/Line 1/010 data l	pad	
Help Options Database Tools Run Flow	mode <u>Ex</u> it	
		Data I/O
	Trace Input	Data Input
	Trace Output	Data Output
	SEG-D Input	Super Gather
	Lamb: Solid Layer - Solid modeling	SCS-3 Input
	SEG-B Input	SEG-Y Input
	SEG-Y Output	Text Output
		Signal Processing
	Amplitude Correction	Bandpass Filtering
	DC Removal	Hilbert Transform
	Resample	Trace Math Transforms
	Trace Math Transforms (1)	Wave field subtraction
		Stacking/Ensembles
	Ensemble Stack	Asymptotic CCP Binning
		Deconvolution
	Deconvolution	Predictive Deconvolution
	Surface-Consistent Deconvolution	Custom Impulse Trace Transforms
	Nonstationary predictive deconvolution	m
		Trace Editing
	Trace Math	X Interpolation
	Trace Length	Trace Editing
		Data Enhancement
	2D Spatial Filtering	F-K Filtering
	Radon Transforms	Radial Trace Transform
	2D Spatial Filtering (1)	
		Migration
	T-K Migration	STOLT3D
	Stolt F-K Migration	
		Interactive Tools
	Screen Display	Velocity Editor
	QC Analysis	Interactive Velocity Analysis
	3D Gazer	Stream Plotting
	Radar Screen	
		Connetry/Henders
MB1 - Drag module; Ctrl+MB1 - Copy module; MB	<ol> <li>DblClick - Module Parameters; MB2 - Toggle modi</li> </ol>	ule; Ctrl+MB2 DblClick - Delete

Create a flow, consisting of the modules **SEG-Y Input** and **Trace Output** (both are located in group **Data I/O**). This flow will read the data from a SEG-Y- file and record them into the project database a "dataset"-object of the database.

Modules are added to the flow one by one. To add a module into the flow just drag it over from the library on the right to the area of the flow on the left. At this moment, a parameter dialog of the module will be opened (later, when the module is already in the flow, the same routine parameter dialog can be called up by a double-click of the mouse on the module name in the flow). While already in the flow, the routines can be moved up and down relative to each other by simple drag-and-drop.

In **Data I/O** group find the **SEG-Y Input** module and add it into the flow. When adding the routine, assign the parameters of data reading in the opened dialog box. Click the **Add...** button and select our test data file *line\_1.sgy*. For training purposes, the information about source and receiver positions in this file is stored not in the standard SEG-Y trace header words, but in the reserved space of the trace headers. In order to read the traces header information recorded in non-standard positions within the SEG-Y trace headers, enter a remap of the header fields. For this, switch on the **Remap header value** option and enter the following text *RECNO*, *4I*, *181/ SOURCE*, *4I*, *185/*.

**Remap of header fields.** Some seismic data formats allow trace header remapping, that is storage in the trace headers of some values, not provided by the standard. Sometimes the values are recorded in a non-standard format of number representation or in a non-standard position within the header. As a rule, contemporary software packages provide a possibility to indicate explicitly from what byte from the beginning of a header and in what format to read the values saved this way. In the training file *line\_1.sgy*, the header fields containing the number (picket) of source and receiver position are recorded as integer 4-byte numbers in bytes 181-184 and 185-188 are saved this way. The remap string shown above will allow for reading them from there and saving into the RECNO and SOURCE header fields of the RadExPro Plus database.

*RadExPro header fields.* The RadExPro software uses its own set of header fields for storing auxiliary information about seismic traces. The values of header fields are associated with the trace and can be perceived an array of named variables linked to the trace.

When creating a new project, the default set of header fields generated is quite similar to the SEG-Y trace header. (See the correspondence of the RadExPro header fields and SEG-Y trace header in the description of module SEG-Y Output in the "User's manual"). However, further the header fields can be edited – you can add new fields, remove or re-name the existing ones.

A part of the header fields are standard and it is strongly not recommended to change their meaning (for example field DT must always store the value of the sample interval). Other fields can be used at your discretion. In the new (or existing, but not used) header fields different information can be recorded, for example the arival time of a wave as picked on this trace. You can perform mathematical operations with the values of the header fields, convert them into picks, etc.

After the **SEG-Y Input** module, add into the flow the module **Trace Output**, which will save the data from the flow into the database. Name the object, which will contain these data as "*line 1 – raw*" and place it at the second level of the database into the *Line 1* (as shown in the following

Select dataset	
Object <u>name</u> line 1 - raw	
<u>O</u> bjects	Location
	⊡- My Area ⊡- Line 1 010 - data load
Rename Delete	Ok Cancel

figure).

Besides, for the control, after module **Trace Output**, add into the flow the **Screen Display** module. The obtained flow must appear as follows:

📓 My Project/My Area/Line 1/010 - d	ata load		
Help Options Database Tools Run Flowmode Exit			
SEG-Y Input <- line_1.sgy Trace Output -> line 1 - raw Screen Display	Trace Input Trace Output VSP Data Modeling 3D Data Output 2D Finite Difference Modeling GSSI	Data Input Data Output 3D Data Input SEG-D Input Super Gather RAMAC/GPR	
	ЛОГИС SCS-3 Input SEG-Y Input Text Output	Lamb: Solid Layer - Solid modeling SEG-B Input SEG-Y Output Analogic Data Input	
	Amplitude Correction DC Removal Resample VSP SDC Wave field subtraction	Signal Processing Bandpass Filtering Hilbert Transform Trace Math Transforms Trace Math Transforms (1)	
	Ensemble Stack Deconvolution Surface-Consistent Deconvolution Nonstationary predictive deconvolutio	Asymptotic CCP Binning Deconvolution Predictive Deconvolution Custom Impulse Trace Transforms	
MB1 - Drag module; Ctrl+MB1 - Copy module; MB1 DblClick - Module Parameters; MB2 - Toggle module; Ctrl+MB2 DblClick - Delete			

For executing the flow select the **Run** menu command. As a result, the **Screen Display** window should open, showing the data being entered, while the data will be read from the disk file and recorded into the database. The window **Screen Display**, which should appear on the screen, is shown below.



*Important!:* When the volume of the data read from the file is great (comparable or exceeds the volume of RAM or just around 1 Gb or more), it is necessary to use Framed mode, which allows to read the data into the memory not as a whole, but by pieces (frames). To turn into this mode and to determine the size of the frames use the Framed mode... command available from the flows editor main menu.

*Note about the names.* A name of any object of the database (seismic dataset, processing flow, etc.) must reflect its essence, but not consist just of several letters. The name of a seismic dataset should consist of 2 parts –the identifier of initial data and the processing stage of the data. Thus, when entering the field data, the name *line 1 - raw* was selected here.

#### Geometry assigning and binning

Assigning geometry to seismic data means that for each trace a number of values are determined, which, then, are saved in the specified header fields of the dataset in the project database. The list of the necessary values and the header fields corresponding to them are given below:

- 1. Source point (also called 'shot point' or SP) number (header field SOURCE)
- 2. SP coordinate(SOU\_X)
- 3. Receiver point (RP) number (RECNO)
- 4. RP coordinate (REC\_X)
- 5. Distance between the source and the receiver (OFFSET) and the modulus of this value (AOFFSET)
- 6. Unique field record number (FFID)
- 7. Channel number (CHAN)

*Note*. The list given above corresponds to one-dimensional geometry. Generally speaking, the header fields SOU\_X, SOU\_Y and REC\_X, REC\_Y can be used for describing the coordinates of SP and PP. However, as the observations in the training file were carried out along one line only, it is proposed to use only one coordinate X, X axis is directed along the profile.

While the FFID, CHAN, SOURCE and RECNO header fields were filled when reading the data from the initial SEG- Y file, the coordinates of SP and RP should be imported from the test files, and the distances between SP and RP should be calculated.

In practice, absolutely any combination of the filled trace headers can be met. For example, the data can be transmitted into processing with empty headers. In this case they should be formed with the use of tools, available in the processing software package.

The situation, in which the initial seismic data contain the numbers of field records and channels, while the connection between the field record numbers and SPs, as well as between the channel numbers for each shot and the RPs is to be calculated is rather widespread. However, for simplification of geometry assigning for training purposes, the data already contain the numbers of pickets shot points and receiver points, and only the coordinates are to be imported.

#### Import of coordinates of source and receiver points from a text file

For manipulations with trace header field values, including import of the values from ASCII tables, in the **RadExPro** software the **Geometry Spreadsheet** tool is used.



#### Select the Database/Geometry Spreadsheet... entry in the menu.

Then, in the opened dialog, select the seismic dataset, geometry of which is to be edited.

Choose dataset	
Object <u>name</u> line 1 - raw	
<u>O</u> bjects	Location
line 1 - raw	⊡- My Area È- Line 1 010 - data load
Rename Delete	History Ok Cancel

The following figure shows the Geometry Spreadsheet window.



In order to display the required header fields (all header fields declared in the database already exist, but are not displayed) use the **Fields/Add fields...** option of the menu In the opened dialog box, keeping the Ctrl key pressed, select the following header fields: SOURCE, SOU\_X, RECNO, REC\_X

Add header fie	lds to view	X
Name	Tupe	Description
PICK2	Beal	Horizon pick
PREAMP	Real	Instrument gain constant
BLINE	Int32	Beceiver line number
	Integer	Receiver's cross line number
DEC DATUM	Deal	Datum elevation at receiver group
DEC DATOM	Deal	Datum elevation at receiver group
	neal Deal	Neceiver group elevation
	Heal	water depth at receiver group
REC_INE	Integer	Heceiver's inline number
REC_RESID	Heal8	Ben and the second second
REC_SLUC	Int32	Receiver station number within receiver line
REC_STAT	Heal	Receiver group static correction
REC_STAT1	Real8	
REC_STAT2	Real8	
REC_STAT3	Real8	
REC_UPHOLE	Real	Uphole time at receiver group
REC_X	Real	X receiver group coordinate
REC_Y	Real	Y receiver group coordinate
RECNO	Int32	Receiver station Number
S_LINE	Int32	Source line number
SCDP	Int32	Super gather CDP
SEQNO	Integer	Trace sequence number within CDP ensemble
SFPIND	Int8	Stack index
SOU CRL	Integer	Source's cross line number
SOU DATUM	Real	Datum elevation at source
SOUTELEV	Real	Surface elevation at source
SOU H2OD	Real	Water depth at source
SOUTINE	Integer	Source's inline number
SOLL BESID	Beal8	
SOUISLOC	Int32	Source station number within source line
SOU STAT	Beal	Source static correction
SOU STATI	Real8	
	RealS	
	Real8	
	Peal	Y source coordinate
	Real	X source coordinate
SOUPCE	Inear Inear	Course station number
	101.32	Source station number
SHF_SLOC	Int32	Number of certically summed transportiality this tran
	Ini.52 Real	Interventive time shifts
	Deel	Interactive time shifts
	neal Deal	End of earth lines
THULLS	Heal	End or mute time
TOT OTAT	Real	Start or mute time
TOT_STAT	Heal	I otal static applied
TR_FULD	Integer	Number of horizontally stacked traced yielding this tr
TRALENU	Integer	I race sequence number within line
TRC_TYPE	Integer	I race identification code
UPHULE	Heal	Uphole time at source
XLINE_NO	Integer	CDP Cross Line Number
<		
		Hold Ctrl to select several fileds.
ОК	Cancel	Load template selection Save template selection

As a result the header editor window shall look as following:

H	H line 1 - raw - Geometry Spreadsheet						
Eie	lds <u>E</u> dit <u>T</u> ools	E <u>×</u> it					
						~	
	TRACENO	SOURCE	sou_x	RECNO	REC_X	-	
	99	1	0.00000	98	0.00000		
	100	1	0.00000	99	0.00000		
	101	1	0.00000	100	0.00000		
	102	1	0.00000	101	0.00000		
	103	1	0.00000	102	0.00000		
	104	1	0.00000	103	0.00000		
	105	1	0.00000	104	0.00000		
	106	1	0.00000	105	0.00000		
	107	1	0.00000	106	0.00000	~	
					NUM		

Select the **Tools/Import** menu command. The dialog with the import parameters will open. Open the file *sou\_geom.txt* there and define the rules of filling header fields. For this add to the **Matching fields** list the field SOURCE (for that, click the appropriate **Add** button and select it from the list). To the **Assign Fields** list add the SOU\_X field. Then specify the columns of the text file from which the indicated fields should be read. They shall be set in the text lines under **Set column** buttons. (By the way, if you set the cursor into the appropriate column and click **Set column**, the number of the column will be automatically entered there). Finally, the range of the lines should be

indicated, from which the program will obtain the values. This shall be done in Lines field: set **From** and **To** values. The correct settings are shown on the figure below.

Import Headers		×
Matching fields           Matching fields         Add           Delete         Set column           1         1           Multiplier         1	Assign fields SDU X Add Delete Set column 2 Multiplier 1 Lines Trom To Text table type © Delimited © Fixed width	2 156
SOURCE 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	S0U_X -12[.50000 38.53920 88.54920 137.54919 187.54919 237.54919 288.54919 388.54919 388.54919 387.55942 437.56940 487.57941 587.58942 637.58942 637.58942 637.59943 737.59943 787.60938 837.61938	
OK Cancel	Load template	Save template File

When importing the values of the header fields from the text file, the program works as follows. For each line of the text file, all the matching fields as well as the assign fields are read from the specified columns. In the specified seismic dataset all the traces with the values of the matching header fields being *precisely* equal to the values from the read line are determined. Then, the values from the read line are entered into the assign fields of these traces.

*Important!:* Among other things, this means that the matching fields are better to be integer (this fact shall be taken into account when the files with the geometry are formed).

Click the **OK** button to assign the header fields. The result is shown below.

H	H line 1 - raw - Geometry Spreadsheet					
Eie	lds <u>E</u> dit <u>T</u> ools	E <u>x</u> it				
						^
	TRACENO	SOURCE	SOU_X	RECNO	REC_X	-
	99	1	-12.50000	98	0.00000	
	100	1	-12.50000	99	0.00000	
	101	1	-12.50000	100	0.00000	
	102	1	-12.50000	101	0.00000	
	103	1	-12.50000	102	0.00000	
	104	1	-12.50000	103	0.00000	
	105	1	-12.50000	104	0.00000	
	106	1	-12.50000	105	0.00000	
	107	1	-12.50000	106	0.00000	~
					NUM	

Import the coordinates of the receiver points from the rec\_geom.txt file in the same way.

H	H line 1 - raw - Geometry Spreadsheet 📃 🗖 🔀					
<u>F</u> ie	lds <u>E</u> dit <u>T</u> ools	E <u>×</u> it				
						~
	TRACENO	SOURCE	SOU_X	RECNO	REC_X	-
	99	1	-12.50000	98	2451.00000	
	100	1	-12.50000	99	2476.00000	
	101	1	-12.50000	100	2501.00000	
	102	1	-12.50000	101	2526.00000	
	103	1	-12.50000	102	2550.00000	
	104	1	-12.50000	103	2575.00000	
	105	1	-12.50000	104	2601.00000	
	106	1	-12.50000	105	2626.00000	
	107	1	-12.50000	106	2651.00000	
1					NUM	

## Calculation of the distances between the shot and receiver points, coordinates of CDP points, binning

Using the **Fields/Add fields** menu entry add to the spreadsheet the following fields: OFFSET (source- receiver distance), AOFFSET (the absolute value of the offset), CDP\_X (coordinate of the CDP), CDP (CDP point number).

H line 1 - raw - Geometry Spreadsheet										
<u>F</u> ielo	ds <u>E</u> dit <u>T</u> ools	E <u>×</u> it								
										^
	TRACENO	SOURCE	SOU_X	RECNO	REC_X	OFFSET	AOFFSET	CDP_X	CDP	
	99	1	-12.50000	98	2451.00000	2463.00000	2463.00000	0.00000	0	
	100	1	-12.50000	99	2476.00000	2488.00000	2488.00000	0.00000	0	
[	101	1	-12.50000	100	2501.00000	2512.00000	2512.00000	0.00000	0	
	102	1	-12.50000	101	2526.00000	2537.00000	2537.00000	0.00000	0	
	103	1	-12.50000	102	2550.00000	2562.00000	2562.00000	0.00000	0	
	104	1	-12.50000	103	2575.00000	2587.00000	2587.00000	0.00000	0	
	105	1	-12.50000	104	2601.00000	2612.00000	2612.00000	0.00000	0	
[	106	1	-12.50000	105	2626.00000	2638.00000	2638.00000	0.00000	0	
[	107	1	-12.50000	106	2651.00000	2663.00000	2663.00000	0.00000	0	
[	108	1	-12.50000	107	2676.00000	2688.00000	2688.00000	0.00000	0	
Ī	109	1	-12.50000	108	2701.00000	2713.00000	2713.00000	0.00000	0	
Ī	110	1	-12.50000	109	2726.00000	2738.00000	2738.00000	0.00000	0	
Ī	111	1	-12.50000	110	2751.00000	2763.00000	2763.00000	0.00000	0	
[	112	1	-12.50000	111	2776.00000	2788.0000	2788.00000	0.00000	0	_
				·						<u> </u>
									NUM	

For calculation of the specified values use the **Trace Header Math** tool, dedicated to mathematical operations with header field values. The **Trace Header Math** is available from the menu **Tools/Header Math**.

In the open dialog box enter the following expressions:

Trace Header Math	
cdp_x = ([rec_x] + [sou_x]) / 2 offset = [rec_x] - [sou_x] aoffset = abs([offset])	
OK Cancel	Load template Save template

and click the **OK** button.

The numbers of the CDP gathers will be calculated, on the basis of the CDP coordinate and desired size of a bin. As the distance between the receivers was  $\sim 25$  m, and the shot interval was  $\sim 50$  m, the bin size should be selected as 12.5 m. For calculation of the CDP numbers, in the same **Trace Header Math** window enter the following expression:



The resulting table should look like the following:

H	H line 1 - raw - Geometry Spreadsheet									
Eje	<u>Fields Edit T</u> ools E <u>x</u> it									
	TRACENO	SOURCE	SOU_X	RECNO	REC_X	OFFSET	AOFFSET	CDP_X	CDP	-
	99	1	-12.50000	98	2451.00000	2463.50000	2463.50000	1219.25000	97	
	100	1	-12.50000	99	2476.00000	2488.50000	2488.50000	1231.75000	98	
	101	1	-12.50000	100	2501.00000	2513.50000	2513.50000	1244.25000	99	
	102	1	-12.50000	101	2526.00000	2538.50000	2538.50000	1256.75000	100	
	103	1	-12.50000	102	2550.00000	2562.50000	2562.50000	1268.75000	101	
	104	1	-12.50000	103	2575.00000	2587.50000	2587.50000	1281.25000	102	
	105	1	-12.50000	104	2601.00000	2613.50000	2613.50000	1294.25000	103	
	106	1	-12.50000	105	2626.00000	2638.50000	2638.50000	1306.75000	104	
	107	1	-12.50000	106	2651.00000	2663.50000	2663.50000	1319.25000	105	
	108	1	-12.50000	107	2676.00000	2688.50000	2688.50000	1331.75000	106	
	109	1	-12.50000	108	2701.00000	2713.50000	2713.50000	1344.25000	107	
	110	1	-12.50000	109	2726.00000	2738.50000	2738.50000	1356.75000	108	
	111	1	-12.50000	110	2751.00000	2763.50000	2763.50000	1369.25000	109	
	112	1	-12.50000	111	2776.00000	2788.50000	2788.50000	1381.75000	110	
										<u> </u>
									NUM	

To save the changes in the database on exit from the **Geometry Spreadsheet** select **Yes**, or use the **Edit/Save changes** menu option.



### Sorting the data by CDP and control of the assigned geometry

To verify the correctness of geometry assigned, make the following.

Create a new flow, name it 020 - geometry check

RadExPro+ 3.7 >>> My Project	
Help Options Database Tools Exit	
My Area Line 1 010 - data load 020 - geometry check	
MB1 DblClick - Default action; MB2 - Context menu; MB1 - Drag flow to line to copy	// 💙

Construct a processing flow, consisting of the **Trace Input** and **Screen Display** modules.

📓 My Project/My Area/Line 1/	My Project/My Area/Line 1/020 - geometry check							
Help Options Database Tools Ri	<u>i</u> elp <u>O</u> ptions <u>D</u> atabase Tools Run Flow mode <mark>Exit</mark>							
Trace Input <- line 1 - raw	mare jieu sumacuon							
Screen Display	Ensemble Stack	Asymptotic CCP Binning						
	Deconvolution	Predictive Deconvolution						
	Surface-Consistent Deconv Nonstationary predictive de	olutiCustom Impulse Trace Transforms econvolution						
		Interactive Tools						
VSP Display Screen Display								
	3D View	3D Screen Display						
	Velocity Editor	QC Analysis						
MB1 - Drag module; Ctrl+MB1 - Copy m	odule; MB1_DblClick - Module Parame	ters; MB2 - Toggle module; Ctrl+MB2 DblClick - Delete 🏾 📈 😒						

The **Trace Input** should enter the data into the flow sorted by, primarily, CDP and, secondarily, OFFSET (hereinafter, we will use CDP:OFFSET notation to describe this sorting). For this, set the routine parameters as shown on the following figure.

Trace Input	X
Data Sets	Sort Fields CDP OFFSET CDP OFFSET CDP OFFSET
Add Delete	Add Delete  Selection  *.*
OK Cancel	Select from file     File       Database object     Choose       Get all     File

Due to this selection of the **Sort Fields**, the traces will be entered into the flow ordered by their CDP number. Within each ensemble with identical CDP number, the traces will be ordered by the OFFSET.

The text line specifying a trace selection mask for each of the sorting keys should be entered in the **Selection** field. Selection parameters for each of the keys are separated by a colon. In this case, \*:\* means that for each of the two sorting keys, all available traces will be entered into the flow sorted according to the sorting key values in ascending order.

In the Screen Display module assign the parameters as shown on the figure below.

Display parameters	X
From t= 0.0 to 2996.  t Scale 10 Number of traces 200  Additional scalar 0.3 Bias 0 % Finsemble boundaries Variable spacing field Space to maximum ensemble width Ensembles' gap 2	Display mode C WT/V C WT C VA G Gray C R/B C Custor Define Normalizing factor C None Entire screen C Individual
✓ Muliple panels 1 ✓ Use excursion 2.0 traces	Axis Header mark Plot headers Picks settings
Save Template Load Template	Ok Cancel

If the **Ensemble boundaries** parameter is switched on, the ensembles of traces will be separated on the screen by empty spaces. The ensemble in the **RadExPro** is defined by the first sorting key assigned in the **Trace Input**, that is, in this case, by the value of the CDP field.

Click the button Axis... and assign the following parameters of the axes:

Axis Parameters	
Primary lines	Traces CDP ○ Different dx Values C Interval 10.0 ▼ C Multiple
Secondary lines	OFFSET
Font size 10	Margins
Ok Cancel	Lett axis 20 mm Top axis 20 mm margin 20 mm margin 20 mm

Execute the flow using the **Run** command of the menu. The raw data sorted by CDP:OFFSET (CDP gathers) will be displayed on the screen.



To control geometry assigning display the theoretical travel times of reflected wave calculated from header field values. To do it use the **Tools/Approximate/Hyperbola (reflection)** entry of the **Screen Display** menu.



Use the default parameters of the travel-time hyperbola:



On the screen the travel time curve of a wave reflected from the boundary of a half-spaces is depicted by a blue line. Current parameters of the medium and the boundary are displayed in the upper left corner of the **Screen Display** window.

Using the arrows on the keyboard (right/left) change the velocity in the medium, until the approximate coincidence of the blue line and the observed first arrivals is achieved.



If it is possible to attain good matching of the observed direct wave by the theoretical travel times for all CDP gathers, then the distances between the SP and the RP were calculated correctly.

If the matching cannot be attained (for example, the observed travel times appear to be shifted relative to the theoretical positions), this indicates an error in the geometry of the traces. Then assign the geometry again or find and correct the error some other way.

## Data analysis and trace by trace processing

#### Sorting traces by CDP and analysis of the wave field

To preprocess the seismic data, create a new flow in the RadExPro project, as shown on the figure.

🔀 RadExPro+ 3.75 >>> My Project	
<u>H</u> elp <u>O</u> ptions <u>D</u> atabase Tools <mark>Exit</mark>	
My Area Line 1 010 - data load 020 - geometry check 030 - preproc	
MB1 DblClick - Default action; MB2 - Context menu; MB1 - Drag flow to line to copy	1. 💙

Put the **Trace Input** and **Screen Display** routines into the 030 - preproc flow. Enter the following parameters in the **Trace Input** dialog:

Trace Input	
Data Sets	Sort Fields OFFSET
Add Delete	Add Delete © Selection 0-10000(10):*
OK Cancel	<ul> <li>Select from file</li> <li>Database object</li> <li>Choose</li> <li>Get all</li> </ul>

The 0-10000(10):\* as a sorting rule means the following:

• From all CDP gathers, which fall into the range of 0-10000 (but these are all CDP gathers in

the dataset), only those with the numbers divisible by 10, will be taken;

• Within the CDP ensembles, the traces will be sorted by the values of OFFSET in ascending order.

This sorting is necessary now to decrease the amount of data (in 10 times) on the stage of testing of the processing parameters. Because of this sorting it will be possible to control the result of the processing not on a single ensemble but on a number of CDP gathers evenly selected along the line.

Assign the parameters of the **Screen Display** to have some 3-5 gathers on the screen. The flow will look as follows:

My Project/My Area/Line 1/030	preproc	
Help Options Database Tools Run Fl	/ow mode Exit	
Trace Input <- line 1 - raw Screen Display	Trace Input Trace Output VSP Data Modeling 3D Data Output 2D Finite Difference Modeling GSSI JOFHC SCS-3 Input SEG-Y Input Text Output	Data Input Data Output 3D Data Input SEG-D Input Super Gather RAMAC/GPR Lamb: Solid Layer - Solid modeling SEG-B Input SEG-Y Output
	Amplitude Correction DC Removal	Bandpass Filtering Hilbert Transform
MB1 - Drag module; Ctrl+MB1 - Copy module;	MB1_DblClick - Module Parameters; MB2 - Tog	igle module; Ctrl+MB2 DblClick - Delete

Execute the flow, the CDP gathers will appear on the screen.

Examine the gathers on the screen and try to identify the types of the observed waves. Find the direct wave, reflected waves, surface waves.

Estimate the velocity of the direct wave, the group velocity of the surface waves. For this, use the the **Screen Display** "Line"-tool allowing to fit theoretical travel times of the direct wave to the data. Since velocity is calculated as distance from the source divided by the arrival time, first it is necessary to indicate the header field, which will be used for calculation of the distance between the traces when calculating the apparent velocity. Use the point of menu **Tools/Approximate/Line Header word...** and select the field OFFSET.



For evaluating the apparent velocity use **Tools/Appoximate/Line**. In order to fit the line to the data assign the beginning of the approximated section on the screen by left click of the mouse, then the end of the section - by right click. The current value of the apparent velocity will be shown in the green line in the top left corner of the screen.





Record the obtained values of velocities into a text file. It can be made automatically. For that, while the Line-tool is active, select **Tools/Approximate/Save parameters** menu entry.



Additional window with an editable text field will open. Copy the current velocity there by pressing Ctrl+Q while the **Screen Display** window is in focus. You can copy as many values as you like.

Comments can be added to the copied values in the window, just type them manually. When you are finished with the velocities, save the file, selecting the command **File/Save** in the menu of additional window and then close the window.



Estimate the spectrum of different parts of the record. For this use the **Tools/Spectrum/Average** menu command.



#### Correction for amplitude attenuation

To compensate amplitude attenuation add the **Amplitude Correction** module into the flow. Place it between the modules **Trace Input** and **Screen Display**. Changing the parameters of the module and each time executing the flow, you can test different types of amplitude corrections. For purposes of the subsequent processing, spherical divergence correction is a good choice. In order to apply this correction, set the parameters of the module as shown on the figure below.

Amplitude Correction	×	
Action to apply :		
Spherical divergence correction (1/s)	1.000000	
Exponential correction (dB/s)	0.000000	
Automatical Gain Control. Operator length (ms)	100.000000	
Type of AGC scalar	MEAN	
Basis for scalar application	CENTERED	
Trace equalization. Basis for scaling :	MEAN	
Time gate start time (ms)	0.000000	
Time gate end time [ms]	512.000000	
Time Variant ScalingSpecify amplifying law along trace. (t - (ms))		
Example format : t1:k1,t2-t3:k2,,tN:kN		
OK Cancel		

Compare the appearance of the data before and after the spherical divergence correction. For this, run the flow two times - with the active and "commented" **Amplitude Correction** module. (to "comment" the module right-click it with the mouse). As a result, two **Screen Display** windows appear on the screen, one of which contains corrected data, the other one – initial data.

#### Spectrum spreading

After the correction for spherical divergence, add the module **Predictive Deconvolution** to the flow. When the purpose of the predictive deconvolution is spectrum spreading, it is reasonable to set prediction gap equal to one sample, to select the filter length close to the length of the wavelet and to assign the window for the calculation of the deconvolution operator in such a way that it contains the target reflections. Basing on these considerations, some initial parameters can be assigned as follows:

Predictive Deconvolution	×
Decon gate start time 2000.00	
Decon gate end time 4000.00	
Prediction gap 4.00	
Decon operator length 50.00	_
'White noise' level % 0.010	_
OK Cance	

Experiment with different parameters, research how the level of white noise influences the result. The following two figures demonstrate the data before and after the use of predicting deconvolution.



#### After the deconvolution:



#### **Bandpass filtering**

Bandpass filtering is to be used after the deconvolution, aimed to decrease the level of lowfrequency and high-frequency noise and to shape the spectrum of the trace to achieve a simple wavelet. Add the module **Bandpass Filtering** into the flow after the deconvolution routine. In the parameters of the module select Ormsby's filter with the following parameters: 5-10-40-80 Hz. Several CDP gathers after the bandpass filtering with these parameters are shown on the following figure.



#### Trace amplitude equalization

The amplitudes, recorded by each seismic receiver is influenced, among other things, by the conditions around the source and the receiver. When the data is not aimed for the dynamic interpretation (for example, for the purposes of AVO- analysis) it is not necessary to use the complex procedures of the surface-consistent amplitude corrections, instead you can try to reduce the differences between traces by the simple traces equalization. To do this add the module **Amplitude Correction** into the flow again with the following set of the parameters:

Amplitude Correction			
Action to apply :			
Spherical divergence correction (1/s)	1.000000		
Exponential correction (dB/s)	0.000000		
Automatical Gain Control. Operator length (ms)	100.000000		
Type of AGC scalar	MEAN		
Basis for scalar application	CENTERED		
Trace equalization. Basis for scaling :	MEAN		
Time gate start time (ms)	1700.000000		
Time gate end time [ms] 4000.000000			
Time Variant ScalingSpecify amplifying law along trace. (t - (ms))			
Example format : t1:k1,t2-t3:k2,,tN:kN			
OK Cancel			

Note, that the window we select here for estimation of the average amplitude of each trace contains the target reflections and does not contain trace sections before the first arrivals.

At the present moment the flow looks as follows:

My Project/My Area/Line 1/0	)30 - preproc	
<u>H</u> elp <u>O</u> ptions <u>D</u> atabase Tools Ru	ın Flow mode <mark>Exit</mark>	
Trace Input <- line 1 - raw Amplitude Correction Predictive Deconvolution Bandpass Filtering Amplitude Correction	3D View Velocity Editor Advanced VSP Dispaly 3D Gazer	3D Screen Display QC Analysis Interactive Velocity Analysis Stream Plotting
Screen Display	VSP Migration Curved Profile VSP Migration STOLT3D	T-K Migration Stolt F-K Migration
	Trace Math Trace Length	X Interpolation
	2D Spatial Filtering Antenna Ringdown Removal Radial Trace Transform	F-K Filtering Radon Transforms 2D Spatial Filtering (1)
	3C Orientation	3C Processing sym2ort
	Trace Header Math	Header Averager
MB1 - Drag module; Ctrl+MB1 - Copy module; MB1 DblClick - Module Parameters; MB2 - Toggle module; Ctrl+MB2 DblClick - Delete 🍡 🔽		

#### Assigning muting parameters

Since our processing is aimed to obtain a seismic section of reflected waves, in this case, direct wave is, obviously, shall be considered as noise. The most effective method of suppression of this noise is the top muting from the beginning of the trace to the time, equal to the direct wave arrival time, plus some time after it, containing the wavelet of the direct wave.

In order to assign this muting, re-sort the traces in the module **Trace Input** temporarily in the order OFFSET:CDP. To do it, change the parameters of the module Trace Input as follows:

Trace Input	
Data Sets	Sort Fields
line 1 - raw	OFFSET CDP
Add Delete	Add Delete  Selection  *:0-10000(10)
OK Cancel	C Select from file File C Database object Choose C Get all

Execute the flow; the traces, sorted out in ascending order of the OFFSET header field will be shown on the screen. Such a gather (called, common-offset gather) allows convenient assigning the muting time, which will be suitable for all CDP gathers.

To do it, create a new pick object (Tools/Pick/New Pick menu command of the Screen Display), then pick the time of muting approximately as shown on the figure (direct wave arrival time plus  $\sim$ 100-200 ms).



A pick in the **RadExPro** is the collection of the time values matched by two header fields, as it is considered that it is always possible to find two header fields that will unambiguously identify a trace (for example, number of CDP and offset, or shot point number and channel number). In this case, however, we want the time of the muting to be suitable for all CDP gathers and depend only on the offset. Therefore we must bind the pick to only one header field - OFFSET.

To do it, select the Tools/Pick/Pick Headers entry of the Screen Display menu



In both columns of the open window select OFFSET:OFFSET

Then click the OK button and save the pick with the **Tools/Pick/Save As...** command of the **Screen Display** menu. Indicate the name of the pick as *top\_mute*.

#### Top muting

In the flow 030 - *preproc* return to the initial sorting (CDP:OFFSET) changing respectively the **Trace Input** parameters.

Add the module **Trace Editing** to the end of the flow (before the **Screen Display** module) with the following parameters:

Trace Editing			
Muting Horizon			
<ul> <li>Top muting</li> <li>Bottom muting</li> <li>Trace killing</li> </ul>			
C Muting in window	10	ms	
Taper window length	10		
Save template	Load template	OK	Отмена

On the second tab specify the horizon that will define muting, as a database pick *top\_mute*, which was saved at the previous stage. The **Horizon** tab must look like this:

Trace Editing
Muting Horizon
Pick in database Select top_mute     Trace header Browse
C Specify
Save template Load template ОК Отмена

Now the flow looks like the following:

🛣 My Project/My Area/Line 1/030 - preproc 📃 🗖 🔀		
<u>H</u> elp <u>O</u> ptions <u>D</u> atabase Tools Ru	ın Flow mode Exit	
Trace Input <- line 1 - raw Amplitude Correction Prodictive Decenvelution	Advanced VSP Dispaly 3D Gazer	Interactive Velocity Analysis Stream Plotting
Bandpass Filtering Amplitude Correction Trace Editing	VSP Migration Curved Profile VSP Migration STOLT3D	T-K Migration Stolt F-K Migration
Screen Display		Trace Editing
	Trace Math	X Interpolation
	Trace Length	Trace Editing
		Data Enhancement
	2D Spatial Filtering	F-K Filtering
	Antenna Ringdown Removal	Radon Transforms
	Radial Trace Transform	2D Spatial Filtering (1)
	3C Orientation	3C Processing sym2ort
	Trace Header Math	Header Averager
	Shift Header	and an or ager
		Other
MB1 - Drag module; Ctrl+MB1 - Copy mo	ı odule; MB1_DblClick - Module Parameters;	MB2 - Toggle module; Ctrl+MB2 DblClick - Delete 🛛 🗸



#### Execution of the preprocessing flow

At this point you may consider that the parameters of preliminary data processing are selected and you can execute the flow with the complete dataset. To do it change the parameters of the **Trace Input** in such a way that now the data from all CDP points enter the flow:

Trace Input	N 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997
Data Sets	Sort Fields OFFSET
Add Delete	Add Delete   Selection  0-10000(1):*
OK Cancel	C Select from file File C Database object Choose C Get all

As the volume of data in the flow is rather large now, we have to execute it frame by frame. In the window of the flow editor select the **Flow mode** menu entry and assign the frame size so that the data of each frame were completely fit to the available RAM memory:

Flow Mode	×
Flow Data Processing Mode C All at once (all in memory) Framed Frame Selection Honor ensemble boundaries Frame width (traces) 1500	
OK Cancel	

Add the module **Trace Output** to the end of the flow in order to save the results of the preliminary data processing. In the parameter dialog of this routine create a new dataset with the name *line* 1 - preproc where the data from the flow will be saved to.

#### Comment the Screen Display.

Finally the processing flow appears as follow	Finally t	the process	sing flow	appears	as follows
---	-----------	-------------	-----------	---------	------------

🏙 My Project/My Area/Line 1/030 - prepro	с	
Help Options Database Tools Run Flow mode.	Exit	
Trace Input <- line 1 - raw Amplitude Correction Predictive Deconvolution Bandpass Filtering Amplitude Correction Trace Editing Trace Output -> line 1 - preproc ***Screen Display	Trace Input Trace Output VSP Data Modeling 3D Data Output 2D Finite Difference Modeling GSSI JOFHC SCS-3 Input SEG-Y Input Text Output	Data Input Data Output 3D Data Input SEG-D Input Super Gather RAMAC/GPR Lamb: Solid Layer - Solid modeling SEG-B Input SEG-Y Output
	Amplitude Correction DC Removal Resample VSP SDC Wave field subtraction Ensemble Stack	Signal Processing Bandpass Filtering Hilbert Transform Trace Math Transforms Trace Math Transforms (1) Stacking/Ensembles Asymptotic CCP Binning
MB1 - Drag module; Ctrl+MB1 - Copy module; MB1_DblC	lick - Module Parameters; MB2 - Toggle module; Ctrl	I+MB2 DblClick - Delete 🛛 📈 😒

Execute the flow.

## Velocity analysis and stacking

#### Preparation of the data for velocity analysis, super-gathering

As a rule, in order to increase the signal-to-noise ratio and obtain more coherent velocity spectra, velocity analysis is carried out on ensembles consisting of several adjacent CDP gathers (the so called super-gathers), rather than on separate single CDP gathers.

Another peculiarity of the data preparation to the velocity analysis is that the data must possess maximum signal-to-noise ratio, while the high vertical resolution of the record and the recovery of the dynamics are not important. Therefore, when preparing the data to the velocity analysis such procedures as automatic gain control in a relatively short window and bandpass filtering in a relatively narrow band (aimed to keep only the part of the spectrum with the the maximum signal-to-noise ratio) are often used.

Create the flow 040 – velocity analysis.

🗱 RadExPro+ 3.75 >>> My Project	
Help Options Database Tools Exit	
<u>My Area</u> <u>Line 1</u> <u>010 - data load</u> <u>020 - geometry check</u> <u>030 - preproc</u> <u>040 - velocity analysis</u>	
MB1 DblClick - Default action; MB2 - Context menu; MB1 - Drag flow to line to copy	//. 🕶

Place the Super Gather routine, which will form the super-gathers, in the beginning of the flow.

It is reasonable to select the **Super Gather** parameters approximately as shown on the following figure.

			×
Super gather			,
2D Gathe	X Start 0	×End 1	00000
	X Step 50	×Range 1	0
C 3D Gathe	Y Start	Y End	
	Y Step	Y Range	
🔲 Bin offsets	Off. Start	Off. End	1
	Off. Step	Off. Range	
Dataset	line 1 - preproc		
Save te	mplate Load template	OK	Отмена

That is, the velocity analysis will be carried out with an interval of 50 CDP points, each supergather will contain10 adjacent individual CDP gathers. The super-gathers are formed of the preprocessed dataset *line 1 - preproc* prepared at the previous stage.

If you add the module **Screen Display** into the flow after the **Super Gather** you will be able to see how the resulting super-gathers look like.

🏙 My Project/My Area/Line 1/040 - ve	locity analysis	
Help Options Database Tools Run Flow	mode E <u>x</u> it	
Super Gather	Resample	Trace Math Transforms
Screen Display	VSP SDC	Trace Math Transforms (1)
	Wave field subtraction	
	Ensemble Stack	Asymptotic CCP Binning
	Deconvolution	Predictive Deconvolution
	Surface-Consistent Deconvolution Nonstationary predictive deconvolutio	Custom Impulse Trace Transforms n
		Interactive Tools
	VSP Display	Screen Display
	3D View	3D Screen Display
	Velocity Editor	QC Analysis
	Advanced VSP Dispaly	Interactive Velocity Analysis
	3D Gazer	Stream Plotting
		Migration
	VSP Migration	T-K Migration
	Curved Profile VSP Migration	Stolt F-K Migration
	m 14.0	Trace Editing
MB1 - Drag module; Ctrl+MB1 - Copy module; MB1	L DblClick - Module Parameters; MB2 - Toggle modu	ule; Ctrl+MB2 DblClick - Delete 🛛 📈 🗸

The following figure shows the result of executing such a flow.



It is easy to see that, due to the use of a substantially larger volume of data, the phases of the reflected waves are outlined much more confidently than on single CDP gathers..

#### Velocity analysis

Comment the **Screen Display** module or remove it from the flow. For conducting the velocity analysis, add the **Interactive Velocity Analysis** routine to the end of the flow.

Let us discuss the assigning order and the reasonable values of the parameters of the module.

First, it is necessary to specify, where to save the resulting velocity pick. The output velocity field can be stored either in a text file or in a database "velocity-pick" object. We recommend that the output velocities are always saved as a database object. (Then all possible manipulations with them, such as export/import, can be made using the with the special tool **Database Manager**, available from the **Database/Database Manager** menu of the **RadExPro** main window). Therefore, in the module parameter dialog select the **Output Velocity** tab and make sure that the option **Database - picks** is selected.

Interactive Velocity Analysis
PS/PP velocities Semblance Display Gather Display FLP Display CVS Display Super gather Input velocity Output velocity Semblance
C Single velocity function
C Use file:
Browse
Database - picks vel0     Browse
C Database - grid Browse
Velocity domain Time C Depth RMS C Interval
Save template Load template ОК Отмена

Click the **Browse** button corresponding to this option and in the appeared dialog box specify the database object name, where the velocity pick is to be stored, as shown on the following figure.

Choose velocity picks	X
Object <u>n</u> ame vel0	
<u>O</u> bjects	Location
	<ul> <li>My Area</li> <li>Line 1</li> <li>010 - data load</li> <li>020 - geometry check</li> <li>030 - preproc</li> <li>040 - velocity analysis</li> </ul>
Rename Delete	Ok Cancel

It is reasonable to store the velocity picks at the second level of the database, corresponding to the line.

Now specify the same velocity pick as an input velocity function. It will be useful if you decide to return to the velocity analysis later and to continue the work with the pick. For this in the **Input Velocity** tab assign the same parameters as on the previous one.

Interactive Velocity Analysis		
PS/PP velocities         Semblance Display         Gather Display         FLP Display         CVS Display           Super gather         Input velocity         Output velocity         Semblance		
Single velocity function		
O Use file:		
Browse		
Database - picks vel0     Browse		
C Database - grid Browse		
Velocity domain Time O Depth RMS O Interval		
Save template Load template OK Отмена		

**Important**!: When assigning a new velocity pick, its name must be specified first on the **Output Velocity** tab and only then - on the **Input Velocity** tab. Otherwise the program reports an error message. Now select the tab **Super gather** and switch off the **Bin offsets** option. This option allows for summing up the traces with the close offsets before calculating the velocity spectrum. This would result in much faster calculation of the velocity spectrum, however its coherency somewhat deteriorates.

Interactive Velo	city Analysis	×
PS/PP velocities Super gather	Semblance Display   Gather Display   FLP Display   CVS Display   Input velocity   Output velocity   Semblance	۲ 
🖸 2D Gathe	× Start 0 × End 0	
	X Step 0 X Range 0	
C 3D Gathe	Y Start	
	Y Step 0 Y Range 0	
🔲 Bin offsets	Off. Start 0 Off. End 1000	
	Off. Step 100 Off. Range 100	
Dataset		
	Save template Load template OK Отмена	

Select the tab **Semblance** to assign the parameters of the velocity spectrum calculation: the start and end velocities, the velocity step and the time step. The velocity spectrum will be calculated as a normalized for the specified range of velocities.

Interactive Velocity Analysis
PS/PP velocities Semblance Display Gather Display FLP Display CVS Display Super gather Input velocity Output velocity Semblance
Start velocity 500 End velocity 5000
Velocity step 20 Time step 20
Number of CVS 11
Save template Load template ОК Отмена

The parameters by default for the considered data set are completely acceptable.

The remaining dialog tabs are responsible for display parameters of different elements of the velocity analysis window.

It is reasonable to keep the parameters by default on the **Semblance Display** tab responsible for the parameters of velocity spectrum display.

Interactive Velocity Analysis	×
Super gather       Input velocity       Out         PS/PP velocities       Semblance Display       Gather D         Display mode       Scaling       One         WT /VA       One       Individual         VA       Color       Individual         Palette       Bias       0	tput velocity Semblance isplay FLP Display CVS Display Maximur Mean RMS
Save template Load templa	ite OK Отмена

It is reasonable to display the traces of the current super-gather for which the velocity analysis is performed in color. Select any palette, in which the traces before and after the normal move-out (NMO) corrections will be conveniently observed (by default the gray-scale pallet is selected, here we are going to replace it by the black-white-orange pallet). For this, first select the **Color** option of the **Display mode** in the tab **Gather**.

Interactive Veloci	y Analysis		
Super gather PS/PP velocities S Display mode C WT /VA WT VA C VA Color Palette	Input velocity emblance Display Scaling None Entrire Scree Individual Additional scalar Bias	Output velocity Gather Display FLP Dis Normal typ Maxin Mean RMS	Semblance play CVS Display e num
	Save template Lo	ad template OK	Отмена

Then click the **Palette** button and in the appeared dialog box click on the **Load palette** button.

Custom Palette	
	ОК
	Cancel
Load palette Save palette	

A set of the predefined palettes is stored in the folder, where the RadExPro package is installed, in *PALETTES* subdirectory. Select the palette *blkwtord.pal*.

Открыть					? 🛛
Папка:	PALETTES		•	+ 🗈 💣 📰 •	
Недавние документы Рабочий стол Мои документы Мой компьютер	bikwtord,pal fas.pal prism1.pal rainb1.pal shade.pal velink.pal				
Сетевое	<u>И</u> мя файла:	blkwtord.pal		<b>.</b> [	<u>О</u> ткрыть
окружение	<u>Т</u> ип файлов:	Palette files		•	Отмена

The result should be as shown in the following figure.

Custom Palette	×
	ОК
	Cancel
Load palette Save palette	

The dynamic stack (**FLP Display**) and the panel of the constant velocity stacks (**CVS Display**) can be conveniently observed when the traces are displayed in wiggle trace/variable area (**WT/VA**) mode. Therefore the parameters for them can be kept as they are set by default.

Interactive Veloci	ty Analysis		
Super gather PS/PP velocities S Display mode (• WT/VA) (• WT (• VA (• Color Palette	Input velocity emblance Display 0 Scaling None Entrire Scree Individual Additional scalar Bias	Output velocity Gather Display FLP Dis Normal typ Maxim Mean RMS	Semblance play CVS Display e nurr
	Save template Loa	d template	Отмена

After assigning the parameters, execute the flow.

As a result, the interactive velocity analysis window will appear. It consists of 4 parts (from left to right): the semblance (velocities spectrum), the current super-gather, the dynamic stack and the constant velocity stack panels.

The dynamic stack consists of the traces, obtained as a result of stacking of the CDP gathers of the current super-gather corrected for NMO with with the current velocity pick. When the velocity pick changes, the stack is dynamically recalculated.

The constant velocity panels show a series of stacked traces for a series of constant velocities. Each stack fragment here is obtained from the CDP gathers of the current super-gather corrected for NMO with one or another constant velocity.



Velocity pick is made on the semblance panel. When picking, follow the maximums of the energy of the semblance. An example of a reasonable velocity pick for the above figure is shown below:



Additionally, the module **Interactive Velocity Analysis** allows accomplishing the following actions, useful for the QC of the velocity picking:

• The button **N** on the tool bar switches on the mode, when the current super-gather is dynamically corrected for NMO with the current velocity pick. At that, the travel time curves of the reflections ideally must become rectified (see the figure below).



• Clicking the **Dix** button of the tool bar you may display the interval velocities calculated for the current velocity pick according to the Dix's formula (light-blue blocked curve on the figure). By the way, switching this option on and changing insignificantly the stacking velocity (barely moving one of the points of the velocity pick), you can see how extremely unstable is the conversion of the RMS velocities (that is what we actually pick) into the interval velocities. You can see that even the slightest changes in the stacking velocity can lead to sometimes catastrophic changes in the interval velocities. This effect is the greater, the less is the analyzed interval.

After the velocity pick for this super-gather position is assigned, it is possible to pass to the next position, clicking the button with the right arrow on the tool bar. If you carry out the velocity analysis in the framed mode, you can move through the super-gathers to the right or left within the current frame, otherwise – within the entire dataset.

Carry out the velocity analysis for all super-gathers, then before exiting the module press the **Save** button on the tool bar in order to save the created velocity pick.

#### Stacking

Create the flow 050 - stack.



The flow must contain the following routines:

**Trace Input**, which enters the *line 1 - preproc* dataset into the flow in the CDP:OFFSET sorting order.

Trace Input	
Data Sets	Sort Fields CDP OFFSET
Add Delete	Add Delete
OK Cancel	C Select from file File C Database object Choose C Get all

The NMO/NMI module to correct the traces for the NMO. The parameters of the module should be

assigned as follows. Select the **NMO** mode in the **NMO** tab, set muting on the signal tension = 30 (i.e. those parts of the traces, which as a result of the NMO correction will be extended to more than 30%, will be reset to zero).

NM0/NMI	×
NMO Velocity	
NM0 Mute percent 30	
C NMI	
Lise coordinate internolation	
Save template Load template OK Отмен	Ha

In the **Velocity** tab select the velocity pick, which was obtained as a result of the velocity analysis performed before.

NMO/NMI	×
NMO Velocity	
C Single velocity function	
, ⊂ Use file:	
Browse	
Database - picks vel0 Browse	
C Database - grid Browse	
Velocity domain © Time C Depth © RMS C Interval	
Save template Load template OK Отмен	a

After the **NMO/NMI** module in the flow, place the **Ensemble Stack** routine. This module stacks horizontally all the traces within each ensemble in the flow. Since in this case in the **Trace Input** at the beginning of the flow the CDP header field was selected as the first sorting key, the CDP gathers will be considered as ensembles.

Assign the parameters of the **Ensemble Stack** module as shown on the following figure.

Enser	nble Stack			×
	Mode Mean Median Alpha trimmed Coherent stack Window (traces) Filter length (ms)	30  30 3 60	% %	
	✓ Treat zero as res	ult of muting		
	OK	Cancel		

Finally, the **Trace Output** module should be the last one in the flow, it will save the results to the *line* 1 - stack dataset, which is also reasonable to be created at the second structural level of the database.

Trace Output	X
File line 1 - stack ; My Area ✓ Store headers outside database OK Cancel	\Line 1 \line 1 - stack Output sample format
Select dataset         Object name [line 1 - stack]         Objects         [line 1 - raw line 1 - preproc         line 1 - stack	Location My Area My Area O10 - data load O20 - geometry check O30 - preproc O40 - velocity analysis O50 - stack
Rename Delete	Ok Cancel

The flow looks now as shown on the following figure:

	- staun	
Help Options Database Tools Run F	low mode E <u>x</u> it	
Trace Input <- line 1 - preproc NMO/NMI Ensemble Stack Trace Output -> line 1 - stack	Trace Input Trace Output VSP Data Modeling 3D Data Output 2D Finite Difference Modeling GSSI	Data I/O Data Input Data Output 3D Data Input SEG-D Input Super Gather RAMAC/GPR
	ЛОГИС SCS-3 Input SEG-Y Input Text Output	Lamb: Solid Layer - Solid modeling SEG-B Input SEG-Y Output Signal Processing
	Amplitude Correction DC Removal Resample VSP SDC Wave field subtraction	Bandpass Filtering Hilbert Transform Trace Math Transforms Trace Math Transforms (1)
	Ensemble Stack	Stacking/Ensembles Asymptotic CCP Binning Deconvolution
MB1 - Drag module: Ctrl+MB1 - Conv.module:	Deconvolution Surface-Consistent Deconvolution Nonstationary predictive deconvolu	Predictive Deconvolution Custom Impulse Trace Transforms ution
	VSP Display 3D View Velocity Editor MB1_DblClick - Module Parameters: MB2 - Too	Screen Display 3D Screen Display OC Analysis Inle module: Ctrl+MB2 DblClick - Delete

For executing this flow, switch on the framed mode. Set any reasonable frame width and make sure that the **Honor ensemble boundaries** option is on. This will ensure that each frame is completed until the last trace of the last ensemble in the frame.

Flow Mode 🛛 🔀		
Flow Data Processing Mode All at once (all in memory) Framed Frame Selection Honor ensemble boundaries Frame width (traces) 1500		
OK Cancel		

Execute the flow.

#### Display of the stack

Sw 000 - View Stack.	
RadExPro+ 3.75 >>> My Project	
<u>H</u> elp <u>O</u> ptions <u>D</u> atabase Tools E <u>x</u> it	
My Area Line 1 010 - data load 020 - geometry check 030 - preproc 040 - velocity analysis 050 - stack 060 - view stack	
MB1 DblClick - Default action; MB2 - Context menu; MB1 - Drag flow to line to	copy 🅢 🔽

Create the flow 060 – view stack.

The flow should consist of the modules **Trace Input** and **Screen Display**. The **Trace Input** should read the obtained stack (*line 1 - stack*) sorted by CDPs.

The result should look approximately as shown on the following figure.

