

# GEOEXPLORER DOWNHOLE

Version 2.2.1

## USER MANUAL

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*Warning! Some software features may be different compared to this manual  
but the basics remain the same.  
If you are in trouble understanding the software's operations  
feel free to ask for help to our engineers.*

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*This software is produced for professional and research purposes. The use of the software for the purpose of recording geophysical data and / or assessment of risks and mechanical characteristics of soils is reserved for qualified and specialized personnel such as doctors of engineering, architecture, physics and geology, having also followed specialization courses in geophysics and structural calculation. All certifications regarding this material are the responsibility of the end user.*

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## 1 Introduction

The **Downhole** module was developed with the aim of being able to verify the quality of the data through the management of the spy geophone, to be able to process acquisitions with regular and irregular geometries, without limitations, using different processing methods, returning the seismic-stratigraphic profile with the speeds and the geophysical parameters that can be calculated.

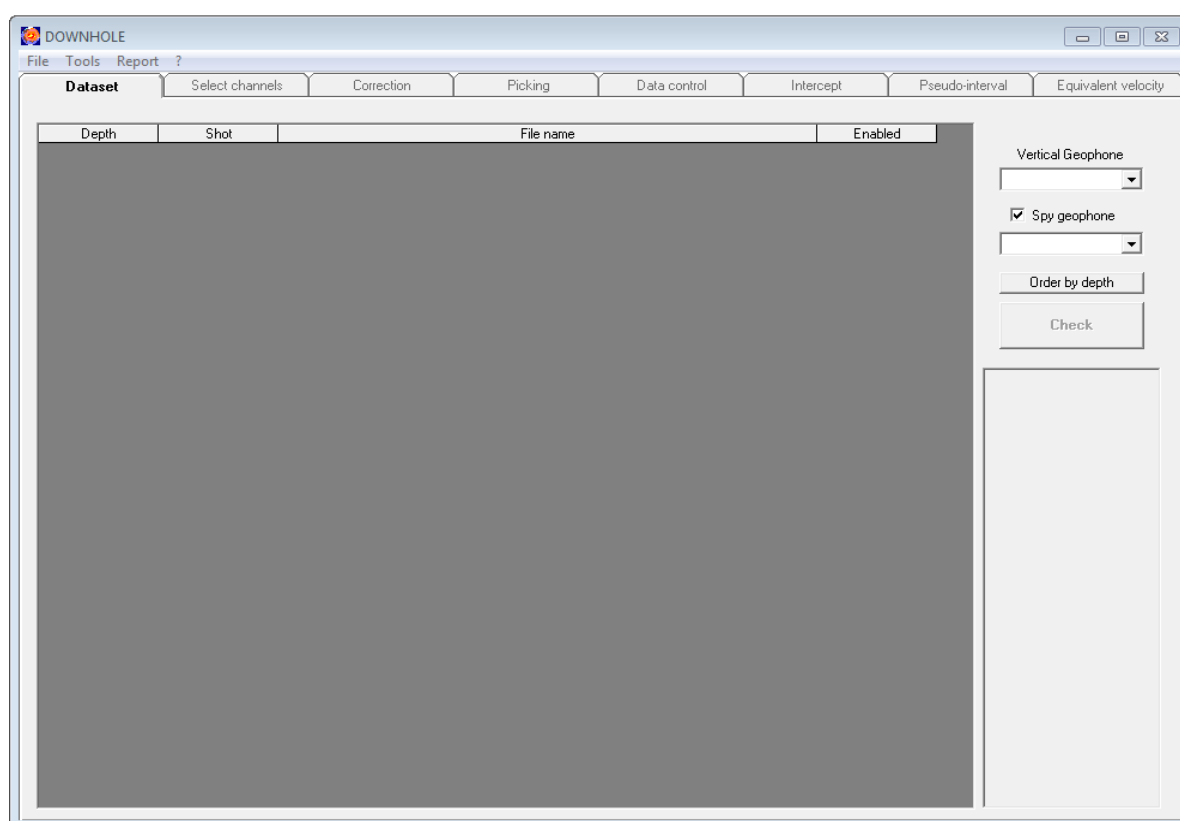
## 2 Downhole

To use the module is mandatory to plug the **USB license** dongle to the PC and to start the program from the **GEOEXPLORER** suite.

*Please note: it is recommended to run the software as administrator.*



*Illustration 2-1*



*Illustration 2-2*

The main page of the software is the *Dataset* tab where is possible to load in different ways the dataset recorded in the field or directly the seismograms ready for the picking.

## 2.1 Menu bar

From the File menu is possible to load the data in different ways:

1. *New elaboration*: Resets the program and makes it available for new processing
2. *Import files*: This option allows to load data massively, even if the dataset has been recorded with a third part seismograph.

*Please note: it is possible to load SEG 2 files. However the geometry and others information must to be applied manually (See chapter 2.2.1 Dataset page 12). The software will automatically convert the data in .drm.*

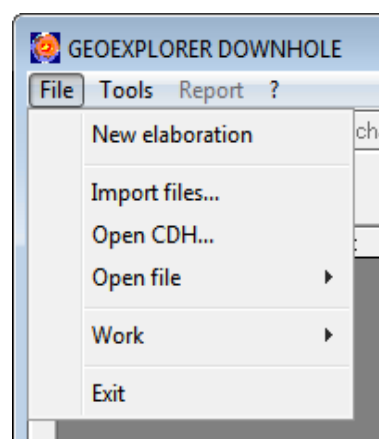


Illustration 2.1-1

3. *Open CDH*: It is possible to load directly the dataset recorded by the **Downhole** module of **GEOEXPLORER DoReMi**. (please see the **GEOEXPLORER DoReMi** manual)
4. *Open file – P*: It is possible to load directly the P seismogram for picking
5. *Open file – S*: It is possible to load directly the S seismogram for picking. It is possible to load the Overlap seismogram or the invert & sum seismogram.

*Please note: for points 4 and 5, if the geometry is missing, the software will open a pop up for the geometry setting. It is also possible to manually set the geometry (see chapter 2.2.4 Picking page 21)*

***Please note: it is recommended to always make a backup copy of the file.***

6. *Work*: This menu allows to save, search, load works and see the last saved works history.

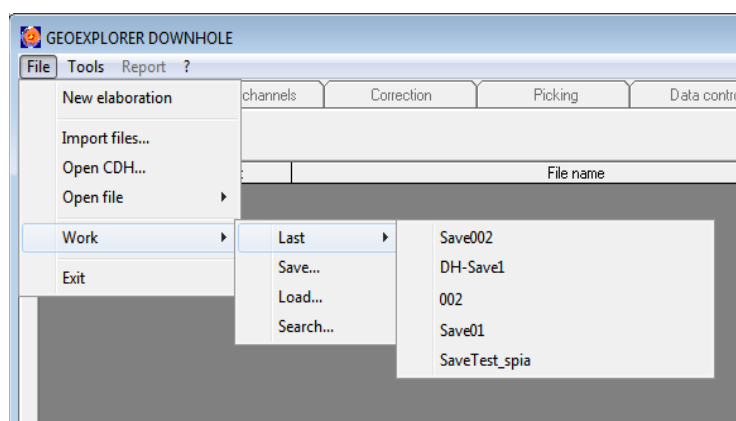
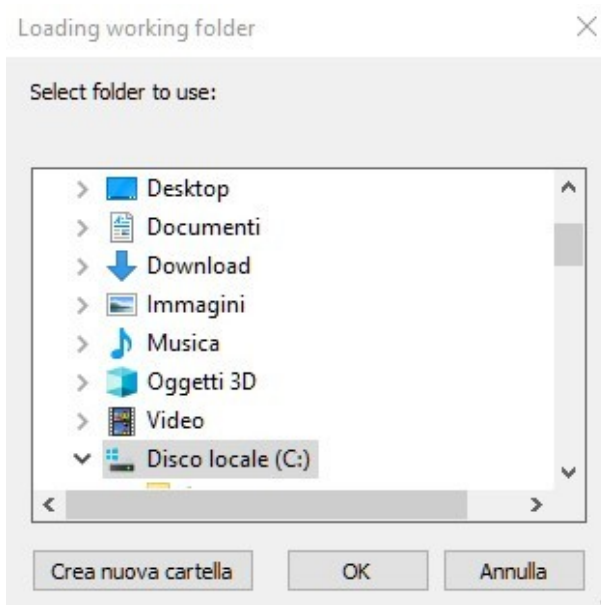


Illustration 2.1-2

## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

The *Load work* option allows to select a previously saved folder. This folder contains a previously processed dataset.



*Illustration 2.1-3*

The *Search work* window allows to look for a work in the device and in the time interval selected.

If the dates selected are both the current day the search will be done on the whole device without restriction.

*Illustration 2.1-4*



## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

This software generate a temporary copy of the uploaded files on which it works. When you proceed with saving the *work*, the program generates a folder with the selected name in the desired position. The folder contains the original files, the support files and the processing information, thus creating an image relating to the status of the processing process at the time of saving.

*Please note: in addition to making a backup copy of the original files, it is advisable to proceed with periodic backups in different folders, in order to preserve the various processing steps. The software also provides the overwriting function in the same save folder, but we **DO NOT RECOMMEND** this procedure*

*Please note: Manually modifying the contents of the save folders can lead to anomalous behavior of the software and/or to the loss of processed information. **WE STRONGLY NOT RECOMMEND** modifying save folders.*

The *Tools* menu allows to:

1. *Recalculate layers*: It recalculates the values from the Intercept tab and also highlights the invalid values in red.
2. *Recalculate pseudo and equivalent*: It recalculates the values from the Pseudo-interval and Equivalent velocity tab and also highlights the invalid values in red.
3. *Settings*: A screen opens in which it is possible to set limit values for the evaluation of velocities and Poisson. The default values are those displayed in Illustration 2.1-6. It is possible to change these values within certain limits of consistency. For Vp the largest settable value is 14000m/s, while for Vs 8000 m/s. The minimum is instead 1 m/s, both for Vp and Vs. For Poisson values, the largest settable value is 0.5, the smallest is 0.

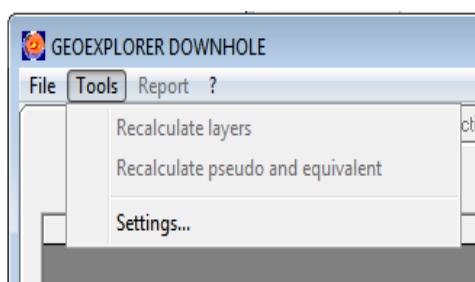


Illustration 2.1-6

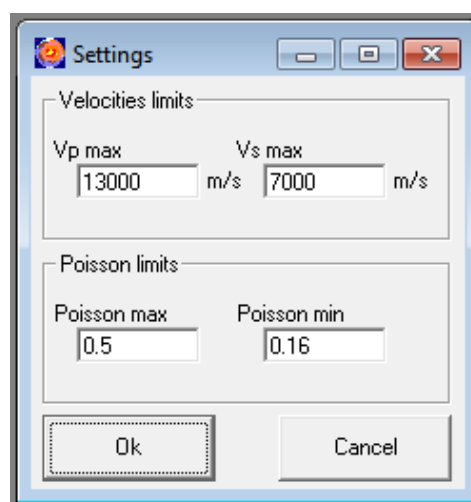


Illustration 2.1-5

## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

The *Report* menu, allows to set all the work specific information for printing the pdf, as well as the photos the elaborations

### Generate report

**Info report**

Date: 11/08/2022  
User: SARA electronic instruments  
Client: Cliente  
Place: Cantiere n°20  
Address: Via delle vie n°20  
Latitude: 43.156 Longitude: 12.16615  
Elevation [m]: 250 Datum: WGS84  
SPS: 10000 Length [s]: 0.4  
Depth [m]: 29 Shot distance [m]: P 3 S 3  
Weather: Sereno  
Note: Apunti vari

**Images**

Image path: photo\_2022-08-11\_16-57-40.jpg  
Note:   
Add Delete

**Acquisitor details:**  
Company: SARA electronic instruments  
Model: SSBH-5C Sensor: 10 Hz

Select image to export: Select all Disable all

☒ Waveforms ☒ Intercept ☒ Pseudo-Interval ☒ Equivalent velocity

☒ P ☒ P ☒ Poisson ☒ Poisson  
☒ Invert - Sum ☒ S ☒ G. density ☒ G. density  
☒ Overlap ☒ Stratigraphy ☒ Bulk ☒ Young  
☒ Picking data ☒ Bulk ☒ Shear

☒ Show report after generation **Scrivi report** Esci

Illustration 2.1-7

The ? menu gives the software information like version and contacts.

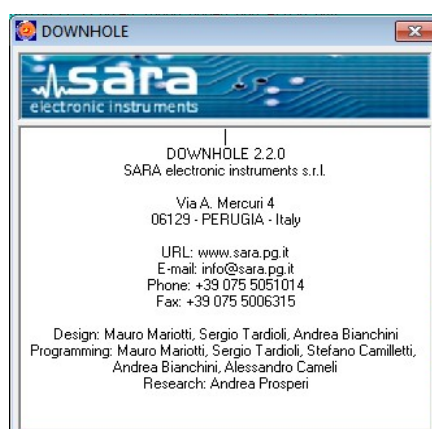


Illustration 2.1-8

## **2.2 Tabs**

The software is structured in tabs which will guide the user through the whole the elaboration process:

**1. 2.2.1 Dataset**

In this tab is possible to load a dataset and set the geometry

**2. 2.2.2 Channel selection**

In this tab is possible to select the horizontal channel for each horizontal shot

**3. 2.2.3 Correction**

In tab is possible to evaluate the spy geophone correction and apply it

**4. 2.2.4 Picking**

In this tab is possible to pick the first break

**5. 2.2.5 Data control**

In this tab is possible to revise the picking and see a resume of it

**6. 2.2.6 Intercept**

In this tab is possible to use the intercept method

**7. 2.2.7 Pseudo-interval**

In this tab is possible to use the Pseudo-interval method

**8. 2.2.8 Equivalent velocity**

In this tab is possible to use the Equivalent method

## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

### 2.2.1 Dataset

As explained before, on this tab is possible to load a dataset. Selecting one of the files, it is possible to see a preview in the box on the right.

DOWNHOLE - DOWNHOLE05\_05\_2022 16\_37\_34.dhs

File Tools Report ?

**Dataset** Select channels Correction Picking Data control Intercept Pseudo-interval Equivalent velocity

Depth	Shot	File name	Enabled
1	P	2020-08-11_11-07-32_10000_00040_006_Acq v2.drm	<input type="checkbox"/>
1	P	2020-08-11_11-07-32_10000_00040_006_Acq v2_Stack5m.drm	<input checked="" type="checkbox"/>
1	P	2020-08-11_11-05-08_10000_00040_006_Acq v2.drm	<input type="checkbox"/>
1	R	2020-08-11_11-08-16_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
1	L	2020-08-11_11-08-40_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
2	P	2020-08-11_11-09-58_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
2	R	2020-08-11_11-10-22_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
2	L	2020-08-11_11-10-47_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
3	P	2020-08-11_11-12-32_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
3	R	2020-08-11_11-12-56_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
3	L	2020-08-11_11-13-17_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
4	P	2020-08-11_11-14-16_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
4	R	2020-08-11_11-14-37_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
4	L	2020-08-11_11-15-01_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
5	P	2020-08-11_11-16-31_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
5	R	2020-08-11_11-17-07_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
5	L	2020-08-11_11-17-48_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
6	P	2020-08-11_11-18-54_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
6	R	2020-08-11_11-19-43_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
6	L	2020-08-11_11-20-13_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
7	P	2020-08-11_11-21-31_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
7	R	2020-08-11_11-22-01_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
7	L	2020-08-11_11-22-36_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
8	P	2020-08-11_11-25-58_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
8	R	2020-08-11_11-26-22_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
8	L	2020-08-11_11-26-49_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
9	P	2020-08-11_11-27-38_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
9	R	2020-08-11_11-28-00_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
9	L	2020-08-11_11-28-23_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
10	P	2020-08-11_11-29-55_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
10	R	2020-08-11_11-30-17_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
10	L	2020-08-11_11-30-38_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
11	P	2020-08-11_11-31-30_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
11	R	2020-08-11_11-31-51_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
11	L	2020-08-11_11-32-15_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>
12	P	2020-08-11_11-33-26_10000_00040_006_Acq v2.drm	<input checked="" type="checkbox"/>

Vertical Geophone  
Channel 1  
☒ Spy geophone  
Channel 6  
Order by depth  
Check

Preview of seismic waveforms.

Illustration 2.2-1

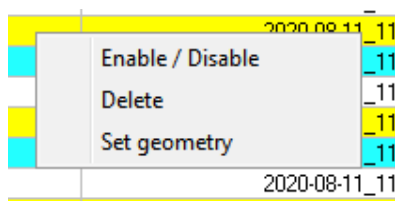


Illustration 2.2-2:

By right-clicking on the desired row it is possible to enable or disable it (*Enable/Disable*) or *delete the row*.

With *Set geometry* is possible to set the geometry for the massive SEG import. The SEG import will not have geometry information.

Start (m): it is possible to set the start depth.

Step (m): it is possible to set the step value between the acquisitions.

Shot type: It is possible to set the type of the shot.

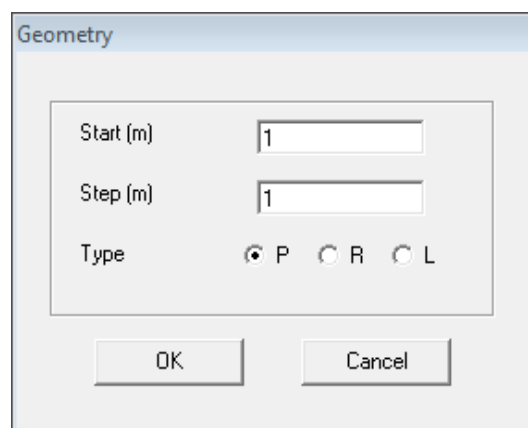


Illustration 2.2-3:

*Please note: the Set geometry allows to set the geometry and shot information massively. To do this, select the desired files for editing. (Drag and drop with the mouse or Shift+click). It is recommended to load the data as shot type dataset and edit them before load the second shot type dataset.*

To modify single information just double click on the desired cell. It is possible to change *Depth*, *Shot*, and enable/disable the file using the checkbox.

*Please note: double clicking on Shot will change automatically following this pattern P, R, L... Clicking on the Enable cell is possible to switch the habitation from YES to No and vice-versa*

It is possible to browse the table using the arrow keys, and modify the values with the space bar.

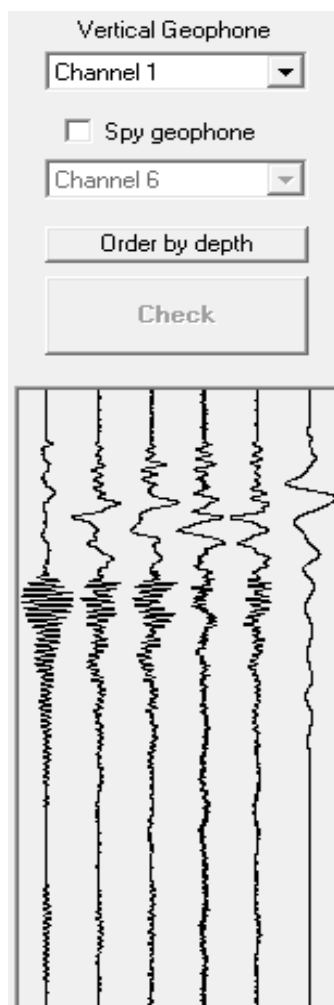
## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

On this tab is possible to, in order from top to bottom, to select the P channel, enable the *Spy geophone* option, select the channel of the spy geophone.

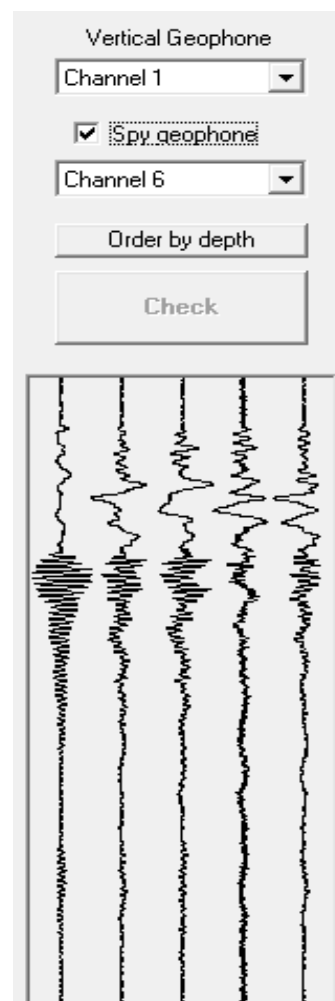
The selected P channel will be used to process P waves

Enabling the Spy geophone option, the channel selected as spy geophone or the geophone on the surface for the quality check of the data will be removed from the display.

The channels selected as P and as spy geophone will be deleted from the channel selection in the *Channel selection* tab.



*Illustration 2.2-4*



*Illustration 2.2-5*

*Please note: it is not allowed to select the same channel both for P and the spy geophone. In that case, an error message will be shown and it will not be possible to continue with processing.*

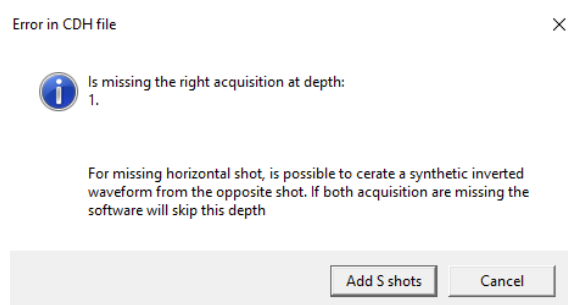
Once completed the dataset configuration, click on *Order by depth*. The dataset will be rearranged according to depths and the *Check* button will be enabled. By clicking on it, checks will be carried out on the dataset and, if successful, the next tab will be displayed.

If there are more shot enabled with the same properties the software will automatically stack the seismograms. If there are no enabled seismograms, or if data have not been acquired at a

specific depth, the software will skip the depth.

*Please note: if there is only one measure between the right and the left for the S measures, the program will allow the choice between the following possibilities:*

*Automatically generate a synthetic seismogram resulting from the inversion of the present data; Modify the dataset to skip the quota, disabling the present one; Enable the disabled file; Upload the missing file.*



*Illustration 2.2-6*

### 2.2.2 Channel selection

On this tab is possible to select the desired left and right shot and to create the best overlap and invert & sum that are possible to see on the preview. This selection can be done manually, or automatically.

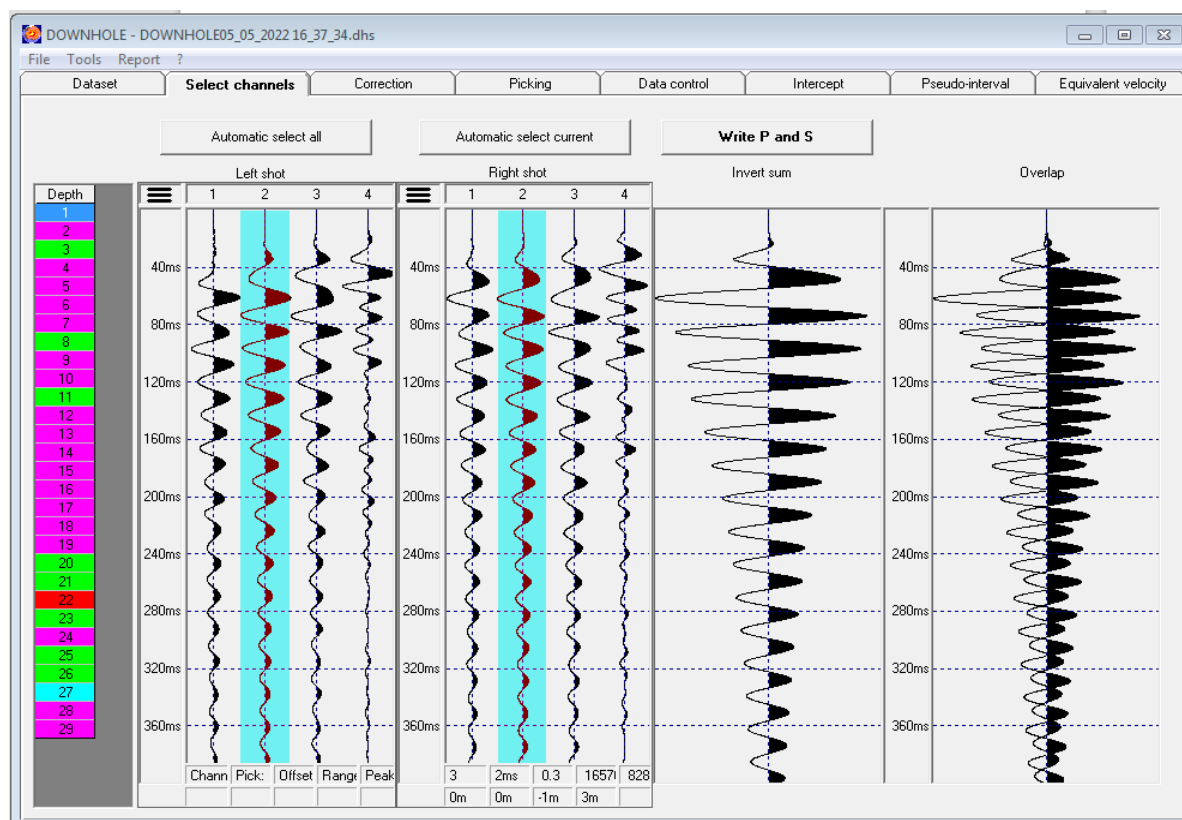


Illustration 2.2-7

The buttons over the seismograms:

- *Automatic select all*
- *Automatic select current*

allow respectively to automatically select the left and right channels for all depths or for the current depth.

*Please note: the software perform the automatic selection analyzing the amplitude of the channel. This selection does not mean is the best solution; we recommend to check manually every depth.*

The button *Write P and S* create the P and S files that, if the *Spy geophone* option has been selected, will be loaded in the *Correction* tab, otherwise they will be used to create the final seismograms that will be opened on the *Picking* tab.

The seismogram windows have the same viewing functions of the **GEOEXPLORER DoReMi**, so we refer to the **GEOEXPLORER DoReMi** manual for further explanation.

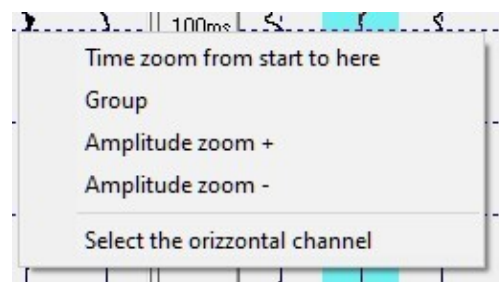


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Right click on both left and right seismograms to open the context menu where is possible to manual select the desired channel with *Select the horizontal channel*.

Depth
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

*Illustration  
2.2-9*



*Illustration 2.2-8*

On the left is possible to see the selection progress:

- **Blue:** highlight the selected file
- **Green:** the selection has not changed from the default
- **White:** the seismograms has not visualized
- **Light blue:** it has been done the automatic or manual selection of the right shot
- **Purple:** it has been done the automatic or manual selection of the left shot
- **Red:** it has been done the automatic or manual selection of both shots

*Please note: the default selection is done by the Downhole module in the GEOEXPLORER DoReMi for a .cdh file. For a dataset from a third part seismograph the GEOEXPLORER DOWNHOLE select the last channel.*

### 2.2.3 Correction

In this view it is possible to correct the seismograms of the P, left S and right S waves, shown in the right graph, by means of the respective seismograms of the spies, shown in the graph on the left.

*Verify* button allows to check which channels needs to be corrected according to the selected configuration. Those channels will be highlighted in yellow.

*Process* button, applies the correction to the seismograms according to the chosen method, generates the final corrected files and loads them in the *Picking* tab.

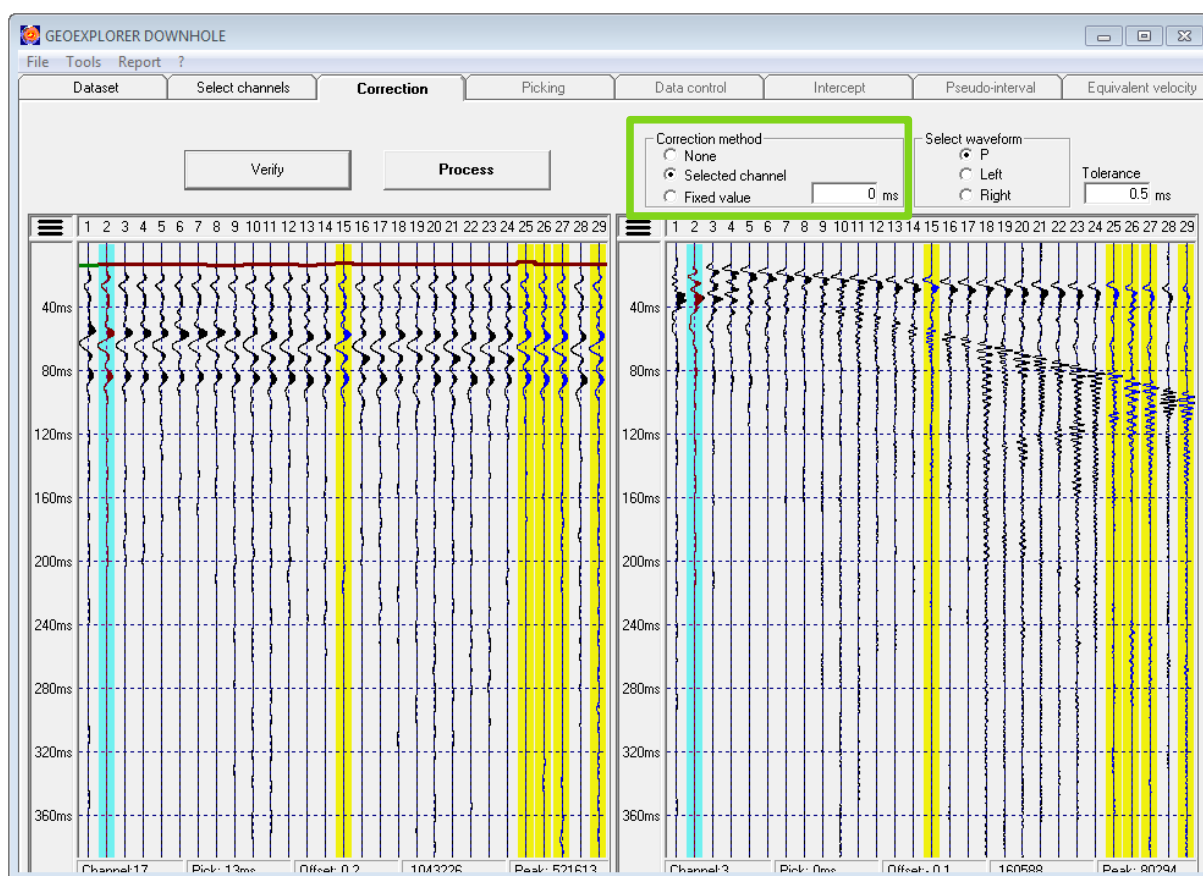


Illustration 2.2-10

To perform the correction it is necessary to pick on each of the left seismograms.

It is possible, *inside the Select seismogram*, to select what seismogram to visualize for the picking. The seismogram window has the same function of the **GEOEXPLORER DoReMi** seismogram window.

In order to carry out the picking just hold **SHIFT** key and To perform the picking hold the **SHIFT** key and click with the left mouse button on the point of the first arrival. Holding the left mouse button and the **SHIFT** key, it is possible to pick the other channels by dragging the cursor along the seismogram.

It is possible to browse the seismogram using the keyboard. By *Left* and *Right* arrows the channels will be selected. (the currently selected channel is highlighted by a different line color). *Up* and *Down* arrows move the picking up or down 1 sample at a time. *Pag Up* and *Pag Down* keys move the picking up or down 1 millisecond at a time. *Home* and *End* keys move the picking at the beginning or at the end of the window.

There are 3 correction methods (green box):

1. **None:** No correction needed. *Process* button will be enabled. It allows to proceed to Picking without any correction. In that case it is not needed to pick the seismograms of the spies.
2. **Selected Channel:** The correction is made on the basis of the picking carried out on the reference channel (by default the first). A different reference channel can be selected for each of the seismograms.
3. **Fixed Value:** The correction is made on the basis of a user defined value. In the checkbox on the side a different value can be selected for each of the seismogram. If the value has not been set for a seismogram, it will be automatically set as the average of the picking values of all the channels of the same.

The correction tolerance is set with the *Tolerance* field. This is the minimum value for which the channel picking must deviate from the reference value to make a correction necessary.

The context menu that is shown by right-clicking on the seismogram, has some additional functions in addition to display functions.

The *Pick* function allows to perform the picking on the channel. The *Select as Reference* function allows the user to select the desired channel as the reference channel for the correction mode: *Selected Channel*.

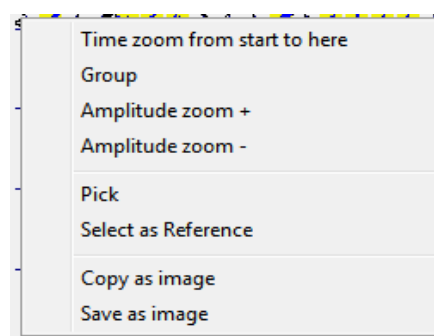


Illustration 2.2-11

These functions work separately on each channel.

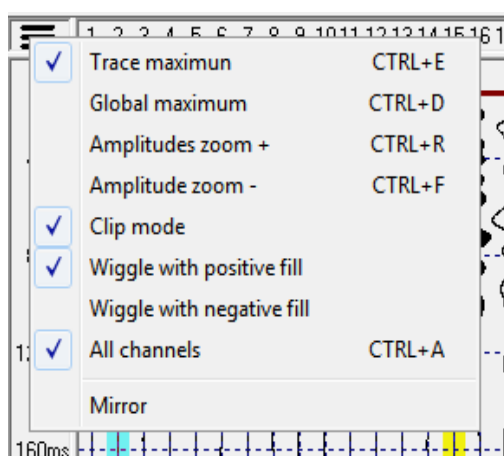


Illustration 2.2-12

Other functions are in the generic seismogram menu. These functions allows the user to better manage the processing.

In addition to display functions there is the mirror tool, which, allows the user to mirror an acquisition. It is useful when the acquisition has been recorded down-top.

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*Please note: the program treats each acquisition as top-down, then assuming that the first channel is the most superficial acquisition.*

Once the correction tab is set, and the picking has been completed, using the *Verify* button the dataset will be analyzed in search of the channels that need to be corrected. These channels will be highlighted in yellow. At this point it is possible to repeat the operation until the desired result is obtained or press the *Process* button, which it will apply corrections to the dataset and will enable the *Picking* tab.

The program checks the difference in ms of each picking of the spy geophone with respect to the selected method and translates the corresponding channels in the P and Sh seismograms by a value equal to the ms of difference between the picking value of the indicator and the value used as a reference (dependent from the selected methodology) if it exceeds the selected tolerance.

### 2.2.4 Picking

In this tab is possible to perform the first break picking on the various seismograms. These seismograms can be opened directly (see chapter 2.1 Menu bar pag 7) or generated by the process explained on the previous chapters.

P pickings are represented in red, S pickings are represented in blue. Furthermore, if enabled the option *Show Pickings* → *Both P And S*, on the seismogram of the P the picking of the S is shown and vice versa, so as to be able to visually compare the two pickings.

The table on the right shows the speed values on which the picking has been carried out for each channel. You can manually change these values by double clicking on the desired cell.

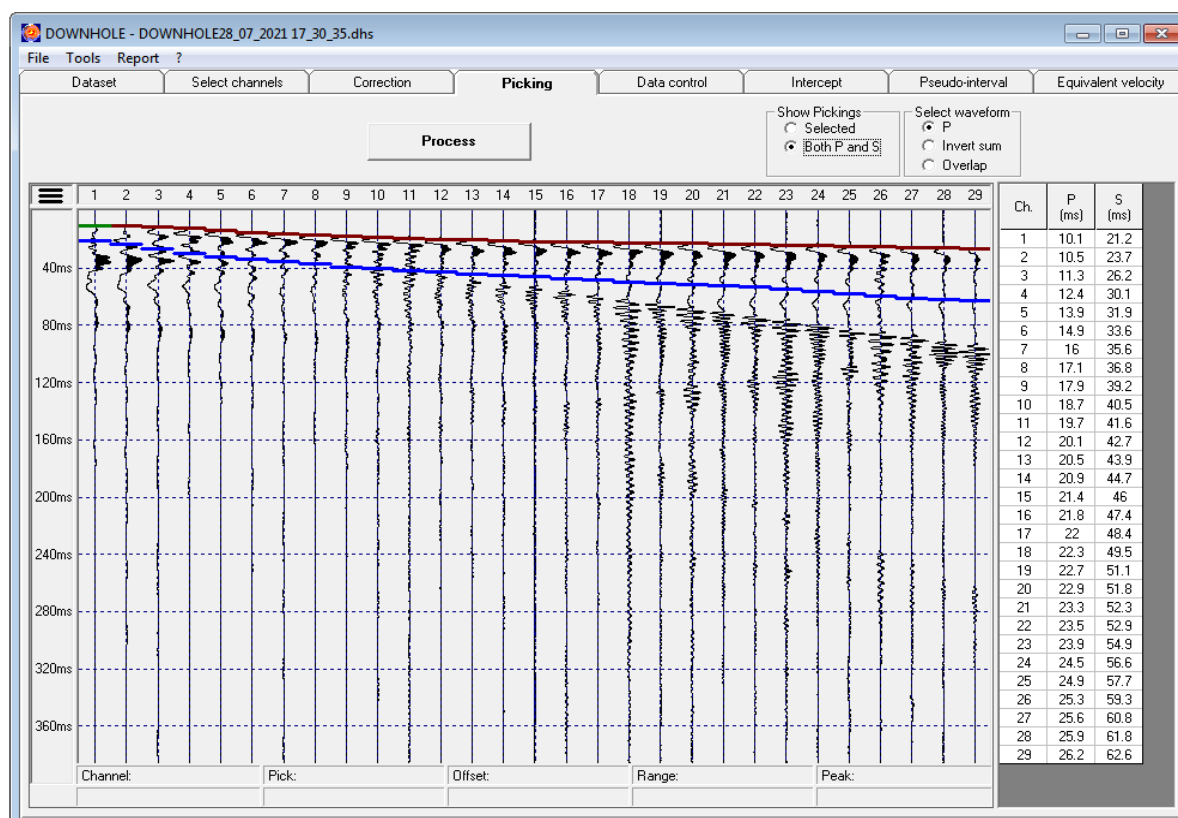


Illustration 2.2-13

*Please note: is not mandatory to load the invert & sum and the overlap for the S shot seismogram.*

It is possible, inside the *Select seismogram*, to select what seismogram to visualize for the picking. The seismogram window has the same function of the **GEOEXPLORER DoReMi** seismogram window. To be able to perform the picking just follow the same instruction given for the *Correction* tab.

*Please note: the picking performed on the seismograms S (Invert Sum and Overlap) is simultaneous. This means is possible to perform the picking only on one of them.*

Whit the right click on the seismogram is possible to open the menu where there are new features with the visualization options.

The *Pick* function allows the user to perform the picking. It is also possible to set the depth of the channel in case of irregular acquisition, by *Adjust channel depth*.

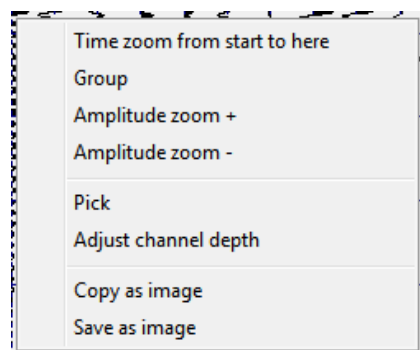


Illustration 2.2-14

These functions work separately on each channel.

On the generic seismogram menu are present other geometrical setting function:

1. *Set geometry*
2. *Mirror*

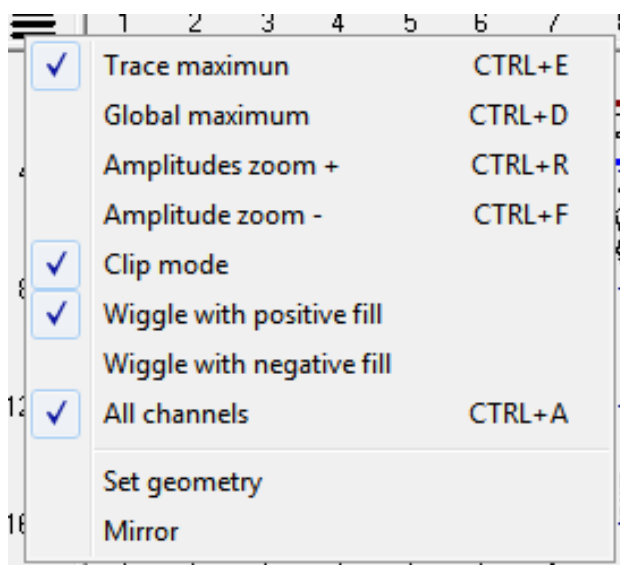


Illustration 2.2-15

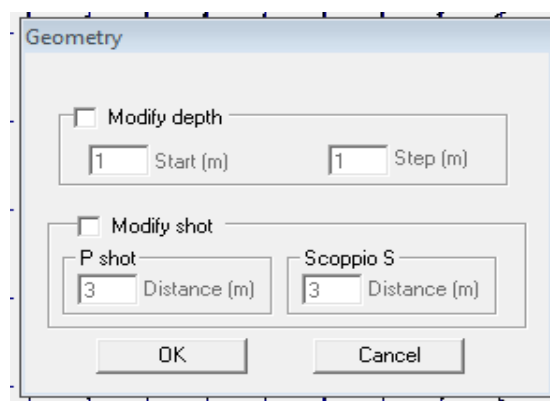


Illustration 2.2-16

*Set geometry* allows to quickly manage the geometry of the acquisition by being able to change the position of the shots separately and the depth progression, as well as the height of the most superficial measurement.

The *Mirror* function allows to flip the acquisition. This function is useful in the case the dataset is recorded as down-top.

## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

*Please note: the GEOEXPLORER DOWNHOLE assumes the acquisition is performed as top-down.*

Once the picking is done, the button *Process* allows to elaborate the acquisition on the other Tabs.

*Please note: the software check if the picking has been done. If it find more then 3 consecutive channel with the same picking it will ask to do the picking assuming has not been done. Is the geometry is not set the geometry window will open.*

*Please note: if the geometry of the shots and / or the position of the channels on the vertical is absent, the program automatically opens the Set geometry window indicating which information to insert.*

### 2.2.5 Data control

On this Tab is possible to see the resume of the acquisition and picking. On the table are shown the picking and the relative geometrical correction.

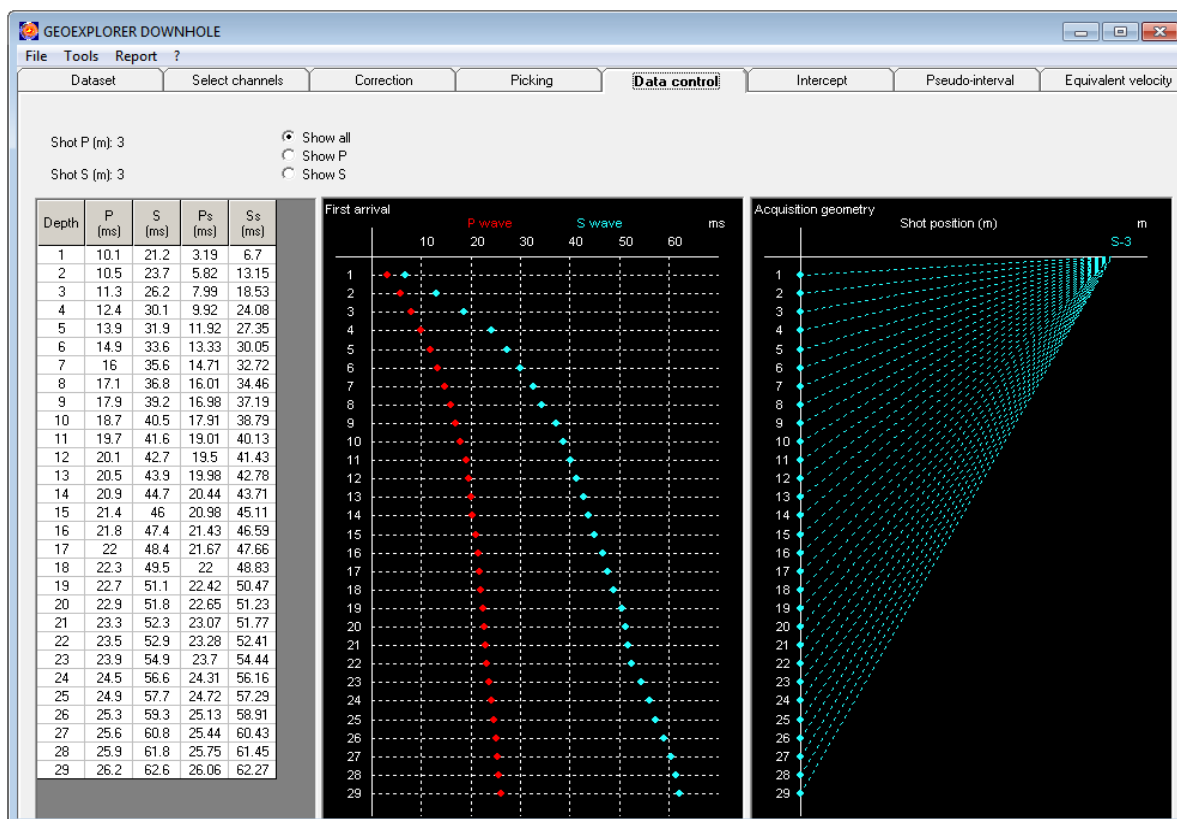


Illustration 2.2-17

On the table is possible to edit the single picking value; by double click on the desired cell and is possible to edit the picking value and with the enter button on the keyboard is possible to apply this modification for the new geometrical correction computation.

With the right click you can open the menu where is possible to:

- *Disable cell*: disable the selected cell
- *Enable cell*: enable the selected cell
- *Enable all cells*: enable all the cells
- *Export table*: Export the selected table to .csv

Depth	P (ms)	S (ms)	Ps (ms)	Ss (ms)
1	10.1	21.2	3.19	6.7
2	10.5	23.7	5.82	13.15
3	11.3	26.2	7.99	18.53
4	12.4	30.1	9.92	24.08
5	13.9	31.9	11.92	27.35
6	14.9	33.6	13.33	30.05
7	16	35.6	14.71	32.72
8	17.1	36.8	16.01	34.46
9	17.9	39.2	16.98	37.19
10	18.7	40.5	17.91	38.79
11	19.7	41.6	19.01	40.13
12	20.1	42.7	19.5	41.43

Illustration 2.2-18



## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

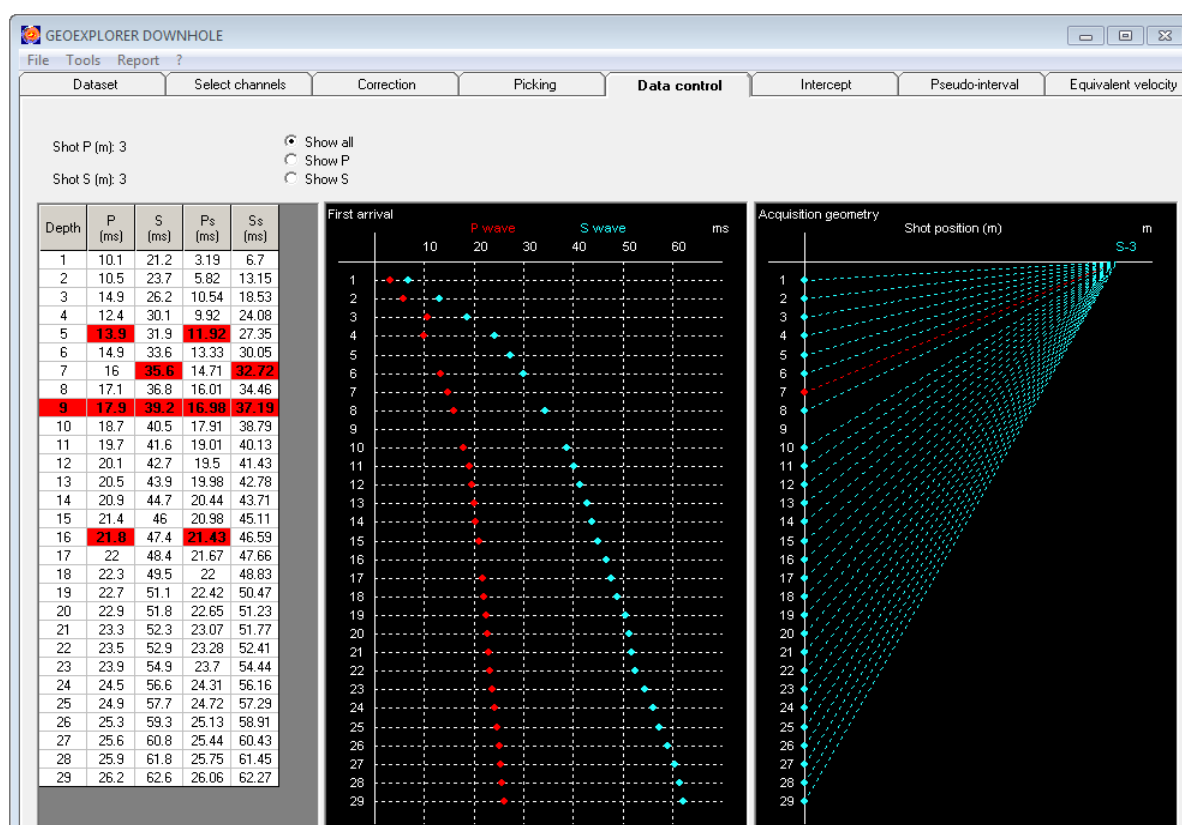


Illustration 2.2-19

The dataset is automatically updated based on the enabled cells

*Please note: the disabled cells are not used for the computation on the other tabs.*

In each of the visualization windows it is possible by right-clicking the mouse, to copy the image to the clipboard or save it to file.

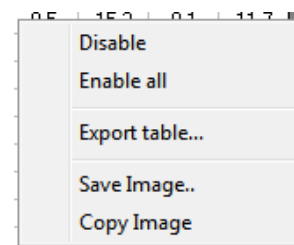


Illustration 2.2-20

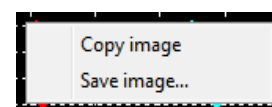


Illustration 2.2-21

### 2.2.6 Intercept

In this tab is possible to do the intercept interpretation. The software will plot the enabled geometrical corrected pick on the *Data Control* tab, allowing to draw the segment for P arrival and S arrival interdependently.

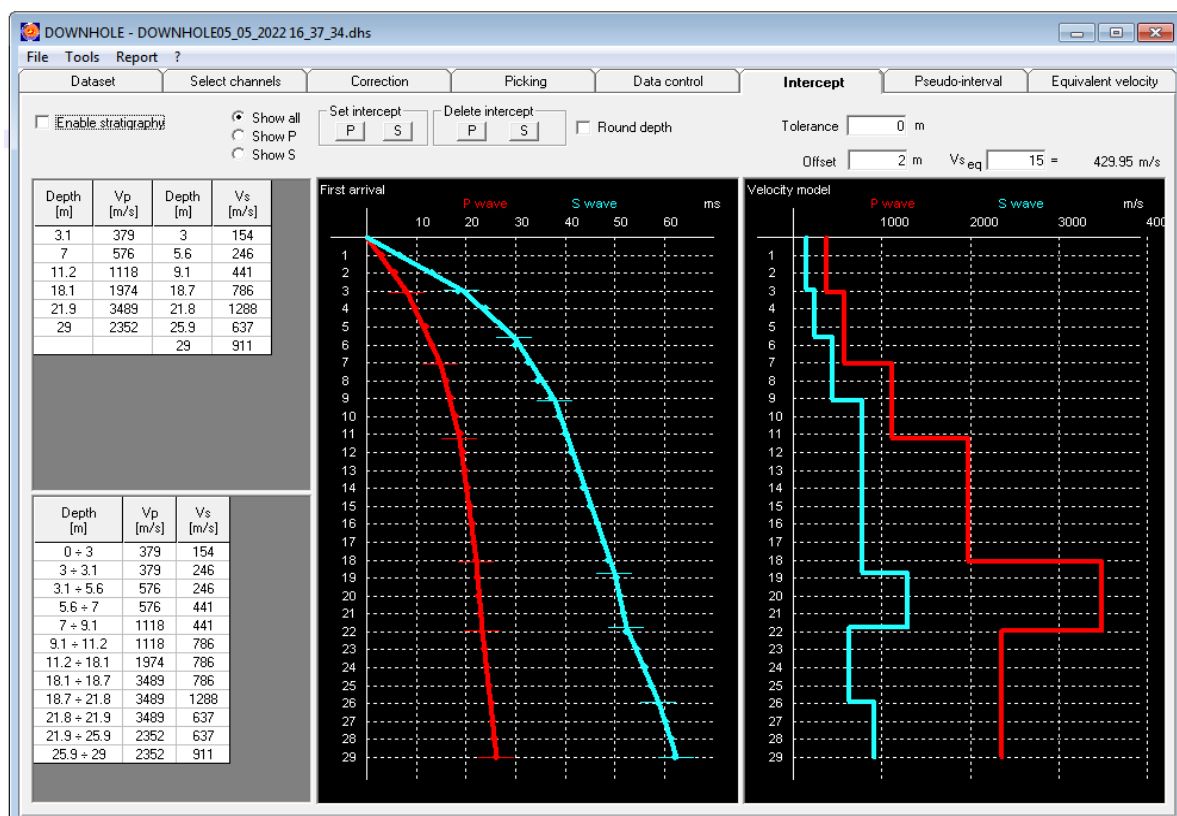


Illustration 2.2-22

With the options *Set intercept* it is possible to pick the relative P arrival segment or S arrival segment.

Once selected the wave, the software will move the mouse on the axis origin and from there will be possible to see the preview of the segment. To set the segment it is need only the left click on the desired position. From this second point the software will plot the preview of the second segment.

On every moment with the right click of the mouse it is possible to stop the picking process and selecting again the option is possible to start from the last point picked.

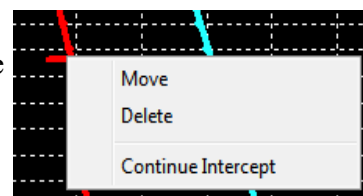
To end the picking is mandatory to pick a point below the last represented depth.

Placing the mouse over one knee of the intercept, it will be highlighted. Shift + Click on one knee of the intercept to reposition the knee in another point of the graph.

## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

Right clicking on a vertex of the intercept line will show a context menu with the following options (Illustration 2.2-23)

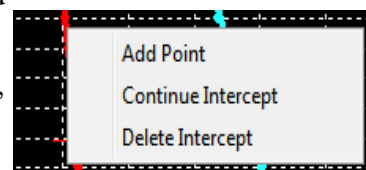
- *Move*: It allows the user to reposition the vertex on the graph by clicking on another point on the graph
- *Delete*: Removes the selected point
- *Continue Intercept*: It allows the picking of intercepts to be resumed from the last point positioned



*Illustration 2.2-23*

Right clicking along the intercept line will show a context menu with the following options (Illustration 2.2-24)

- *Add Point*: Allows the user to position a new point, breaking the segment that was clicked.
- *Continue Intercept*: It allows picking to be resumed from the last point entered
- *Delete Intercept*: Deletes the selected intercept



*Illustration 2.2-24*

By enabling the *Round depth* option, at the time of the picking the depth value is rounded to the nearest unit.

The software will fill the top left table with the depth and velocity information of every picked segment for the P and S waves. Picking P and S the software will populate the bottom left table with the layer interval computed with the combination of P and s stratigraphy.

With the options *Delete intercepts* it will be possible to delete the desired profile.

*Please note: is not possible to pick a value above the previous in time and depth. For example if you pick 8,1ms is no possible to pick 7ms and if you pick a 7m is no possible to pick a 6m.*

## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

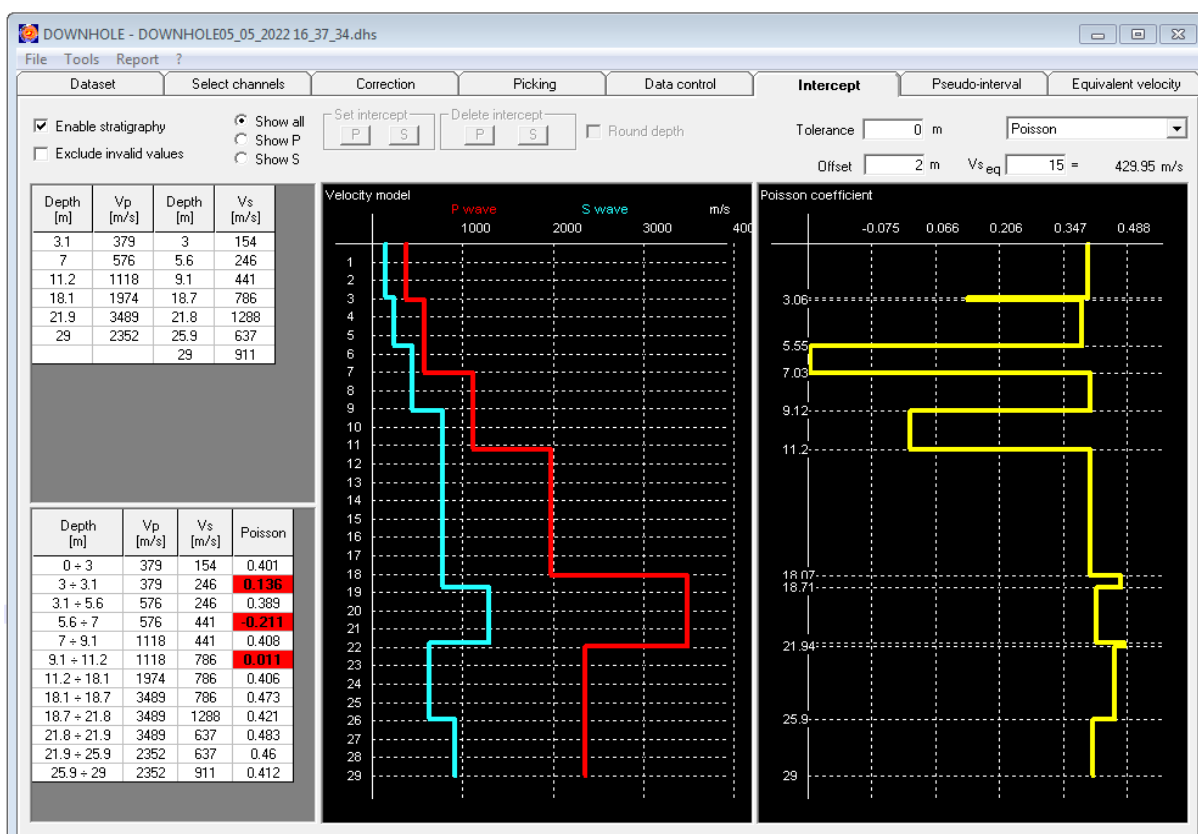


Illustration 2.2-25

Using the text boxes *Offset* and *Vs eq*. It is possible to set the software for the calculation of the equivalent Vs. In the offset field it is possible to indicate from what depth to start the calculation, while in the Vs eq field the depth at which to calculate the Vs eq is defined in meters. The result of the calculation is shown on the right in m/s.

With the option *Enable layer* the software will show the stratigraphy and relative modules i (see formulas in the chapter 5.4):

- *Poisson*
- *Density (RHO)*
- *Gamma*
- *Young*
- *Shear*

The option *Exclude invalid value* allows to do not plot out of range Poisson values. (Illustration 2.2-26) The default values are 0,16 the minimum limit, and 0,5 the maximum. These values can be changed in the Tools → Settings menu. (see Chapter 2.1 )

## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

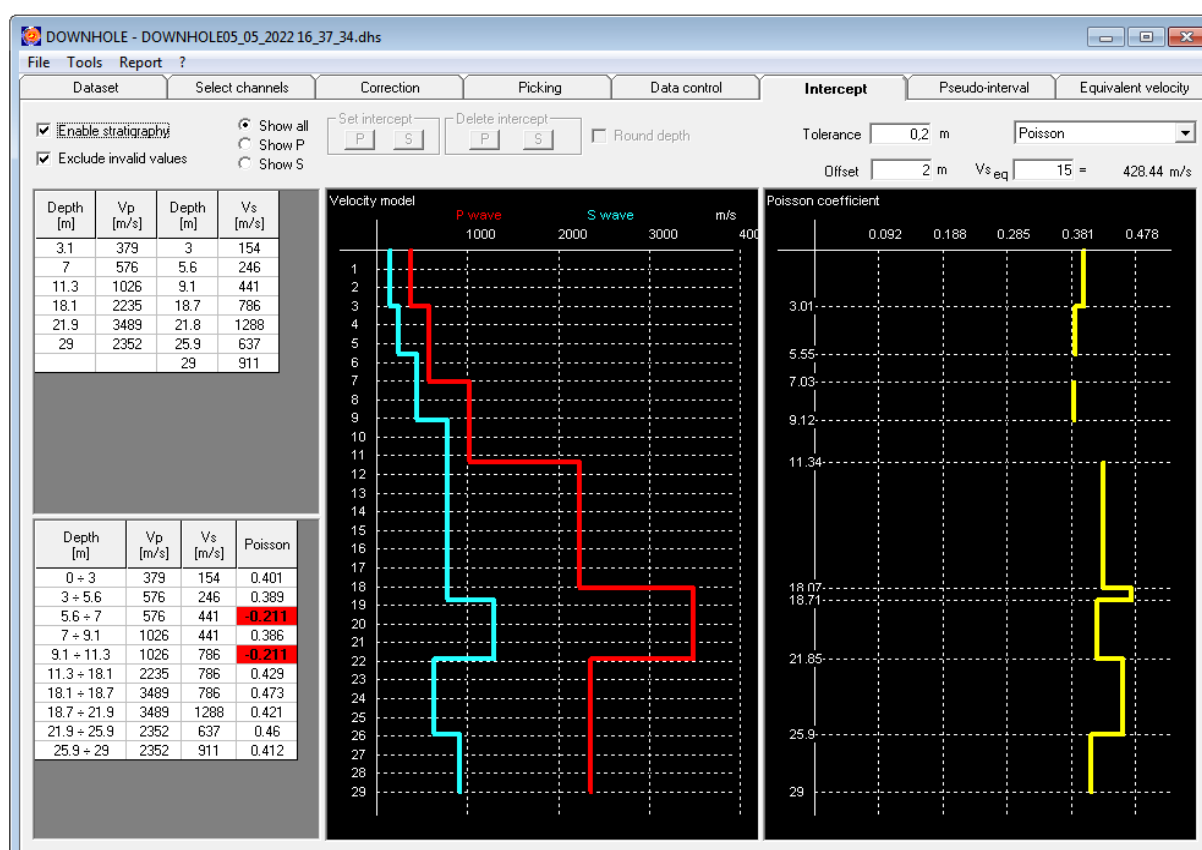


Illustration 2.2-26

The *Tolerance* parameter allows the user to define a tolerance value for the layers, if a tolerance value greater than 0 is assigned, all the layers with thickness less than the tolerance value are ignored as they are not significant. The maximum tolerance value that can be set is 1m.

### 2.2.7 Pseudo-interval

This tab elaborate the dataset as it has been recorded with 2 sensor in the well (true interval). The software will compute the time difference between two consecutive measurement to evaluate the interval velocity.

*Please note: if the acquisition has been done with a 1m spacing, and for some reason is missing a depth, or it has been disabled in the Data control tab, the software will compute the interval velocity analysis with the closer measurement, in this case the step will be 2m.*

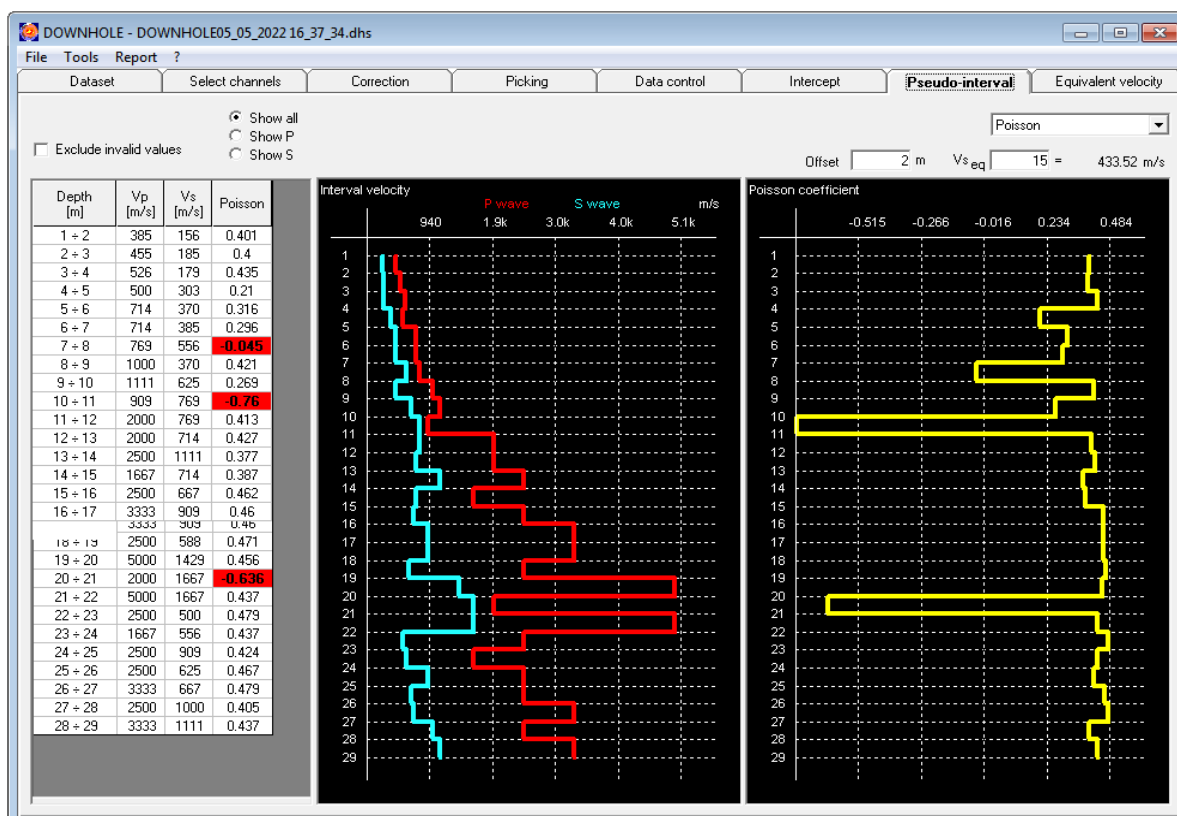


Illustration 2.2-27

As for the intercepts it is possible to calculate the  $V_s eq$  on the basis of the layers and the velocities calculated using the *Pseudo-Interval* method. The calculation takes place using the same methods and with the same *Offset* and  $V_s eq$  values, which are synchronized between the two views.

With the *Exclude invalid values* option the software will eliminate from the graphical representation the values that, according to the verification of the calculations, return outliers.

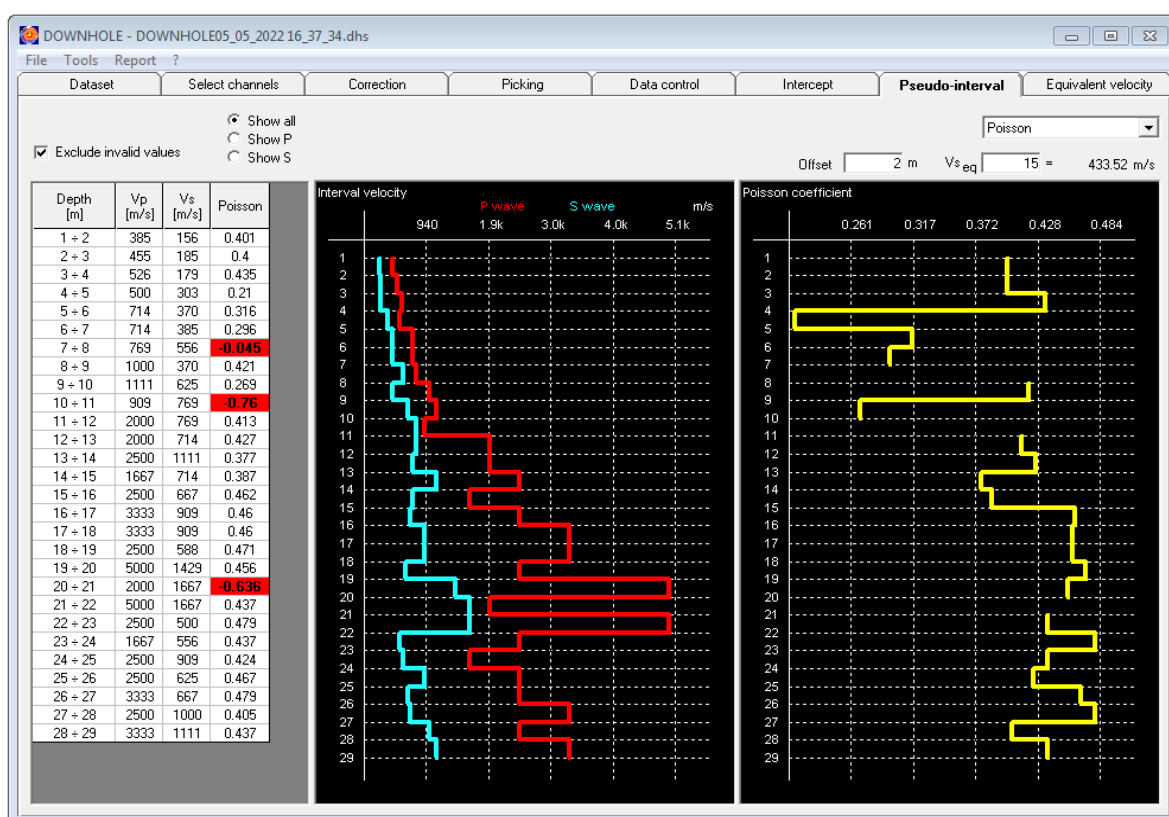


Illustration 2.2-28

On the table is possible to see the result of the velocity analysis (Vp and Vs) and relative selected module. From the drop-down menu is possible to select the module.

With the right click of the mouse on the table is possible to enable/disable cells, row and column and copy the data as text or image.

*Please note: the software will execute some data control:*

1. Checks if there are negative velocities
2. Checks if the Vs is bigger or equal to Vp
3. Checks if there are Poisson values out of range. The default values are 0,16 the minimum limit, and 0,5 the maximum. These values can be changed in the Tools → Settings menu.(see chapter 2.1).

*If one of the three check is wrong, the software will disable automatically the cells with wrong values. Is possible to visualize or not these values on the various representation enabling or disabling the option Exclude invalid values.*

### 2.2.8 Equivalent velocity

This tab works as the *Pseudo-interval* tab, computing the velocities and the modules between the first acquisition and the various depths.

Even in this tab the data control are done, as on the previous tab.

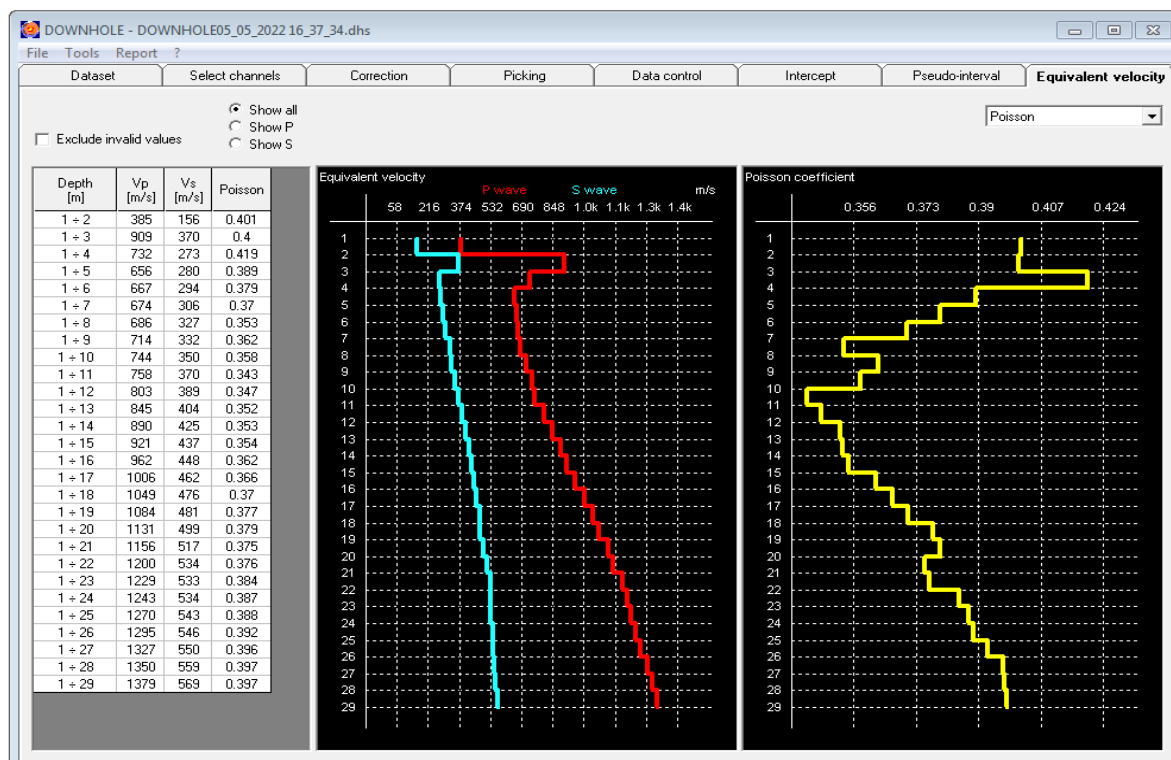


Illustration 2.2-29

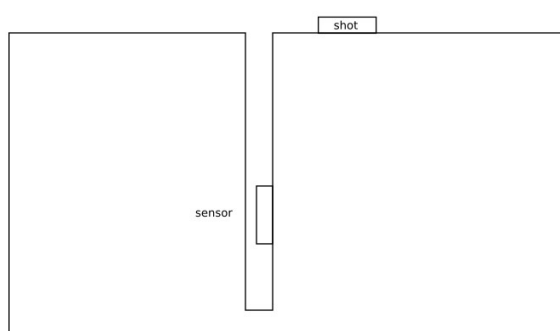


### 3 Introduction to data acquisition

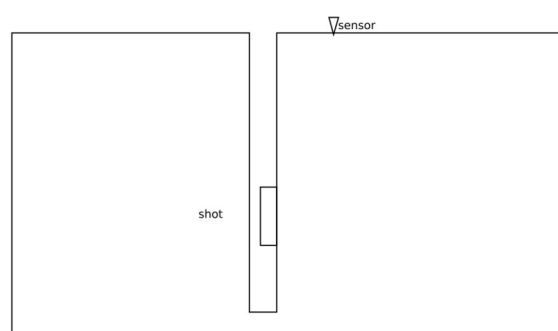
The in hole microseismic investigation is the main technique for the direct determination of the elasto-mechanical properties of the subsoil; the prospecting is carried out in a specifically equipped hole and allows to determine the propagation speed of the compression or longitudinal P waves, and the shear or transverse S waves. This is done by measuring the travel time of a wave train from the position of a specific source to the sensor (or sensors) prepared and made integral with the ground or in the hole.

Three alternative methods are available for in hole seismic measurements:

- a) Surface energization and in hole reception, and vice versa.

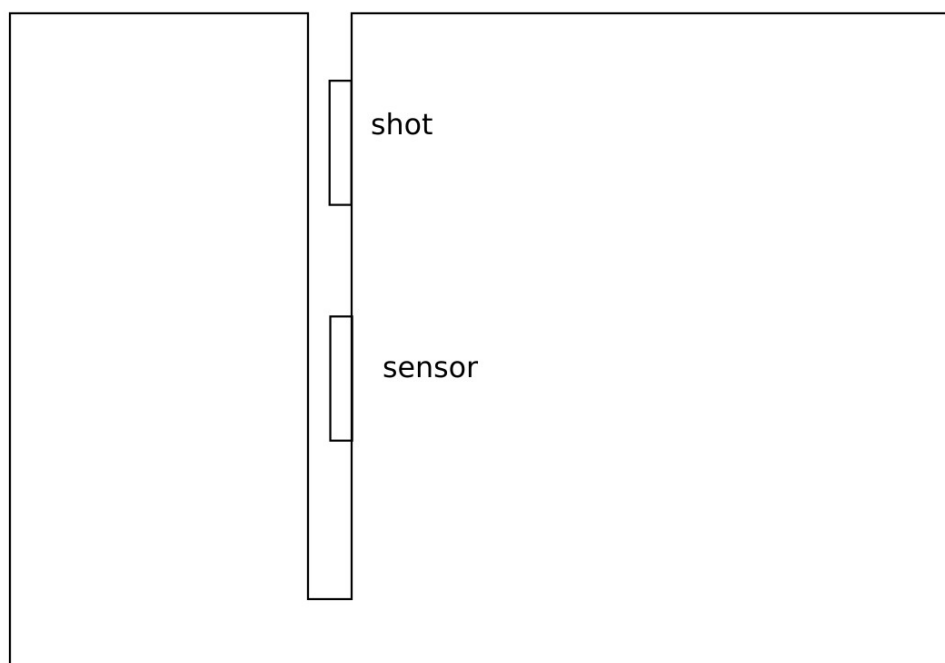


*Illustration 3-1*



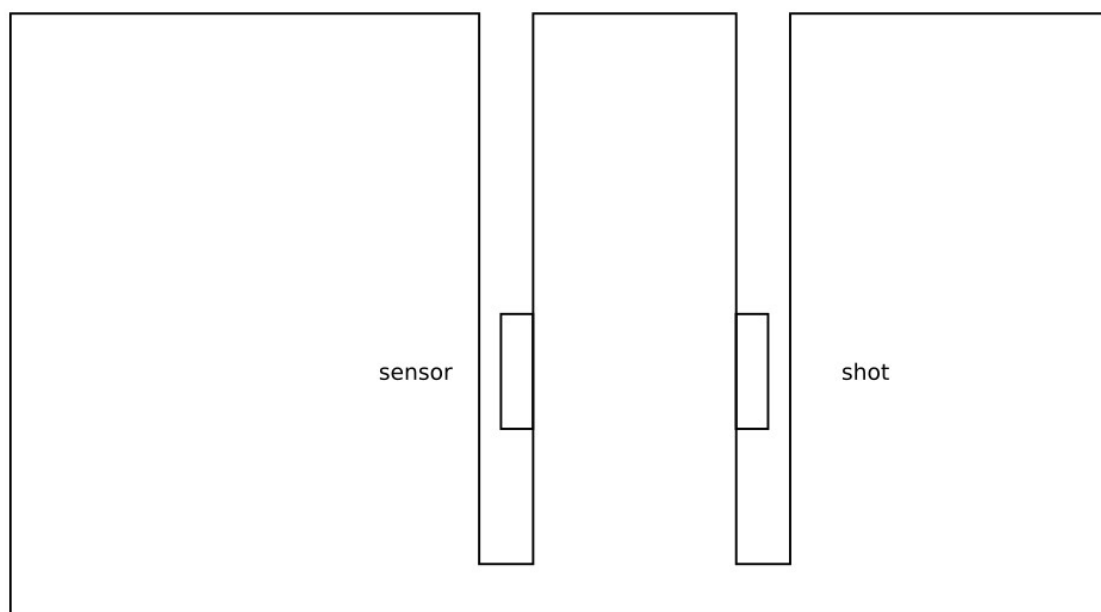
*Illustration 3-2*

- b) Energization and reception in the same equipped hole.



*Illustration 3-3*

- c) Energizing in a hole and receiving in one or more adjacent holes.



*Illustration 3-4*

The most used microseismic techniques include the following detection techniques:

- a) *Down-Hole (DH)*: the energization station is located on the surface and the sensor body are located at a specific depth in the hole.
- b) *Up-Hole (UH)*: the energization station is located in the hole and the sensors are placed on the surface, generally at a different distance from the equipped vertical.
- c) *Cross-Hole (CH)*: the energizations are produced in the hole, on a specific vertical while the sensors are arranged on a different equipped vertical, at a specific distance from the first.

The *Down-Hole* and *Up-Hole* investigation techniques are the best known and most widespread, while the *Cross-Hole* technique is less used, as it presents higher costs for setting up the test station.

The *Down-Hole* and *Up-Hole* techniques allow to determine the elastic behavior of soils along the direction normal to the ground (P and SH waves), while the *Cross-Hole* technique characterizes the behavior of the subsoil with regard to the propagation of the seismic input on the conjugate direction.

This quickstart explains the correct acquisition method for the *Down-Hole* technique and the processing method.

## 4 Data Acquisition

The investigation technique is based on the determination of the time it takes the wave train to travel the known distance from the energization point to each of the receiver positions.

To determine the time taken by the wave train it is necessary to have:

- a) accurate precision in determining the energization instant (trigger) and a control of possible “delays” at the trigger (spy geophone), for the identification of the energization instant.
- b) high resolution of the signal, through a high signal / noise ratio, which allows the recognition of the instant of first arrival of the wave train at the sensor.
- c) adequate sampling frequency, which allows the instant of first arrival of the wave train to be determined with the greatest possible accuracy.
- d) length of the recording signal that allows you to sample the wave train at least for a duration that appreciates an attenuation of the amplitude of the recorded signal of at least 1/3 of that on first arrival.

### 4.1 *Techniques of preparing the test vertical: characteristics and controls*

The vertical test consists of a geognostic survey conducted with continuous or destruction coring, with a diameter between 100mm and 140mm, completed with PVC or ABS DN80 piping, suitably cemented to be made integral with the surrounding ground.

The pipeline can also be stabilized by filling with fine sand, in particular geological conditions; exceptionally and only in particular lithostratigraphic conditions it is possible to proceed in non-equipped holes.

The survey can also be carried out in piezometric verticals or holes equipped for inclinometric measurements, also completed with aluminum, fiberglass or plastic pipes, where it is possible to make the recording / energization apparatus adhere and make integral (with pistons or homologous systems) in the hole with the pipe.

It is considered particularly useful to know the stratigraphic succession involved up to the expected depth of survey.

**Before carrying out the survey, it is necessary to wait for the withdrawal of the cement mortar: a waiting period of about 20 days must be foreseen, where mortars with specific aging accelerating additives have not been used.**

Checking the practicability of the hole and the integrity of the completion pipeline is the preliminary phase to the prospecting procedure.

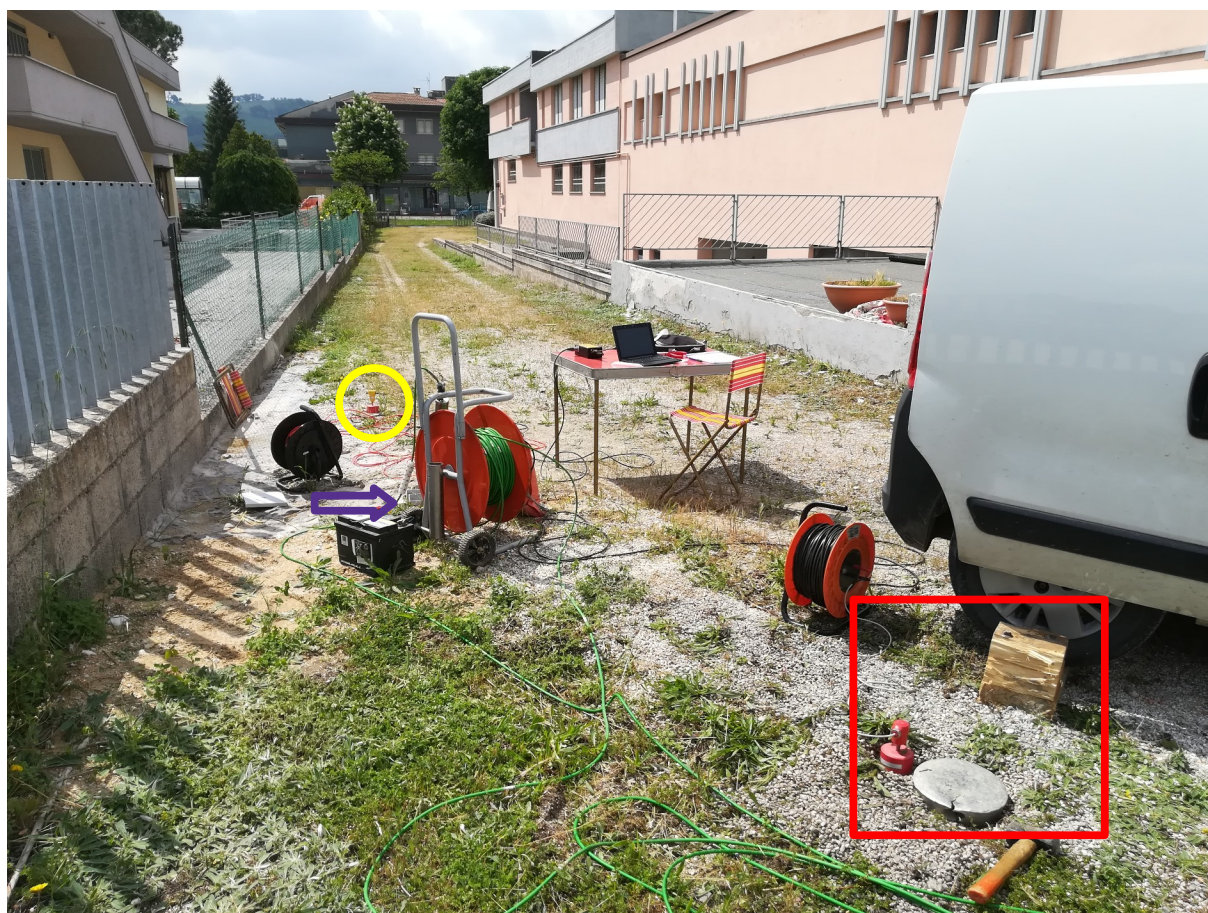
The maximum depth in which detection by *Down-Hole* or *Up-Hole* techniques is reliable does not exceed 50-60m.

If you do not have certain data on how to complete the equipped forum, it is mandatory to carry out an investigation with a "witness" (it is a good idea to proceed with this procedure even if you have this data), which does not involve the possible loss instrumental in case it is not recoverable the control tool.

## **4.2 Preparation of the detection station**

The test plant is set up around the equipped hole, placing the following components in appropriate positions

- a) The seismograph and the PC must be positioned in such a way as to be able to: view the recordings, note peculiarities of the signal, assess the need to proceed with multiple energizations, perform stacking operations (summation) or whatever is necessary to obtain signals of adequate readability.
- b) The energization station, for the P and SH waves, must be placed contiguously at a distance between m 2 and m 5 from the vertical of the hole (in order to minimize the refractive effects of the seismic ray and avoid channeling effects of the wave train along the vertical hole). It is necessary to appropriately ballast the sleeper to be used for energizing in shear waves and verify the feasibility of operating a reverse polarization of the waves (as shown in the red box).
- c) Spy geophone to be used to check for any delays introduced in the recording from the moment of energization, due to incorrect operations (as shown in the yellow circle).



*Illustration 4.2-1*

Red box P and SH sources, violet arrow head hole, yellow circle spy geophone.



## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

The site must be set up in such a way as to be able to carry out and supervise each measurement operation, to verify the height of the sensor in the hole, to verify the energization procedures and for a quality check in the field.

The construction site must provide for protection to the instrumentation and operators, in the expected climatic conditions, and the foreclosure of the detection area to the uncontrolled transit of people and vehicles, for the entire duration of the survey.

The use of a pulley arranged in axis with the hole allows you to avoid breakages and damage to the data cable and the safety cable of the system due to the edge of the hole at the wellhead.



*Illustration 4.2-2*

### 4.3 Seismic sources

The seismic sources to be used during the test must have adequate energy capacity, in relation to the maximum depth that is expected to be used in the test. They must also produce elastic waves with a wide range in frequency and have low noise.

	sorgenti di superficie	sorgenti in foro
onde P	esplosivo, mazza, massa cadente, ecc.	esplosivo cannone ad aria, sparker, martello, ecc.
onde SH	martello su tavola, cannone per SH, vibratore orizzontale, ecc.	martello ad azione orizzontale vibratore
onde SV	mazza massa cadente	esplosivo, cannone ad aria, sparker, martello, vibratore, ecc.

*Illustration 4.3-1*

The energization station must be equipped with a strike plate for energizing in P waves, and a sleeper, suitably ballasted, for energizing in SH waves.

Each strike station must be equipped with a "trigger" for recording the moment of energization; any operational errors that lead to incorrect assessments on the moment of energization must be corrected by evaluating the signal with the spy geophone, appropriately prepared for this purpose.

The energization station for P and transverse waves must be placed at a distance usually between 2m and 5m from the measurement vertical.

The sleeper for energizing for shear waves must be suitably ballasted to ensure adherence to the ground during energization, for efficient transmission of the signal to the ground.

The sleeper is placed on the ground previously leveled with an orthogonal direction to the source-hole joining; the stress produced is carried out at both ends with the same axis orientation.

The energization at the two ends of the sleeper is necessary to allow the polarization in opposition of the shear waves and facilitate their recognition during data processing.

The sleeper must not have metal fittings, bolts or anchors that may produce unwanted "noise" at the time of energization.

The position of the energization points must be maintained and must not be changed throughout the test run.

#### **4.4 Sensor**

The forum registration system consists of:

- a) Vertical and horizontal velocimeter (s) or accelerometer (s) with 3 or 5 channels.  
they are made integral to a specific height along the measurement vertical or arranged in a chain, at a predetermined mutual distance, in the previously chosen recording depth.



*Illustration 4.4-1:*

The receivers must be made integral with the walls of the hole, except for measurements in holes filled with water, where suspension receivers can be used.

The characteristics of the sensors must be adequate for the sensitivity and resolving capacity of the signal to be interpreted; ordinary instrumentation provides for the use of velometric sensors with a frequency of its own between 8 and 14 Hz with a flat response for frequencies above 10 Hz.

If only one recording group is used, there is 1 vertical sensor and 2 or more horizontal sensors, arranged on a horizontal plane at variable angles of 90 ° (2 sensors), 60 ° (3 sensors) or 45 ° ( 4 sensors).

An additional receiver must be set up in the measurement area to check for any "delays" on the moment of energization recorded by the dedicated trigger.

This receiver generally consists of a vertical velocity sensor, kept at a predetermined distance by the energization system, which allows you to introduce any corrections on the wave arrival times to the different receivers, during subsequent measurements; for this sensor there is no need for particular technical specifications.

#### ***4.5 Campaign data acquisition and setup***

The acquisition unit is connected to the recording system, to the control sensor and to the trigger connected to the energization system.

It must be set up with a sampling frequency, a recording duration and, possibly, with gains appropriate to the survey, in relation to the seismic source used in the prospecting, the nature of the subsoil soils, the "environmental noise" and the maximum depth that occurs. plans to reach into prospecting.

The sampling required is greater than 5000 Hz; we indicate the use of an SPS of 8000-10000 Hz and with a recording length of 250-350 ms, for investigations on verticals of about 30 meters depth equipped in loose soils of medium tenacity / consistency.

Campaign registrations do not involve the use of pre-filtering, stacking, summation or other functions on the first acquisition data. The operations of analysis and pre-processing of the field recordings must foresee the conservation of the original acquisition data.

The field data must be prepared in such a way as to allow the identification, for each recording, of the type of receiver, of the height of the housing in the equipped hole, of the energization methods at the source and of the distance of the seismic source from the detection vertical, as well as that of the acquisition specifications in terms of frequency, duration and gain of the signal, also by means of an explanatory report associated with the data.



#### **4.6 Execution procedure of detection – Down-Hole acquisition technique**

Micro-seismic detection with Down-Hole techniques of the elastic characteristics of the soils in the subsoil, through the use of a specifically equipped hole, involves the following steps:

- a) positioning of the recording system consisting of the oriented sensors, at a predefined depth
- b) locking of the sensors at the defined depth, through hydraulic, pneumatic or mechanical systems
- c) energization of compression or longitudinal waves and recording of the resulting signal to the sensors housed in the hole and to the surface control sensor, for the predefined time from the instant indicated by the trigger

The distance between the energization station and the vertical measurement, indicated as the offset value, is usually between m 2 and m 5. This is the appropriate value to minimize the refractive effects of the seismic ray in the subsoil and exclude channeling effects of the wave train along the vertical of the hole.

Energization in the context of each measurement, must be carried out in the same location for all subsequent acquisitions on the vertical, in order to exclude that areal variations of the elastic characteristics in the immediate subsoil do not allow a correct interpretation of the data

- d) energization of shear or transverse waves, for the normal and conjugate impulse. Recording of the resulting signal to the sensors housed in the hole and to the surface control sensor, for the predefined time starting from the instant indicated by the trigger.

Normal and conjugate energization, by applying the stress at the two ends of the sleeper in the direction of axis orientation, produces polarized waves with opposing phase that allows easier recognition, during the data processing phase.

- e) unlocking of the sensors and repositioning at a different depth

The procedure is therefore repeated with the same operational phases along the survey vertical.

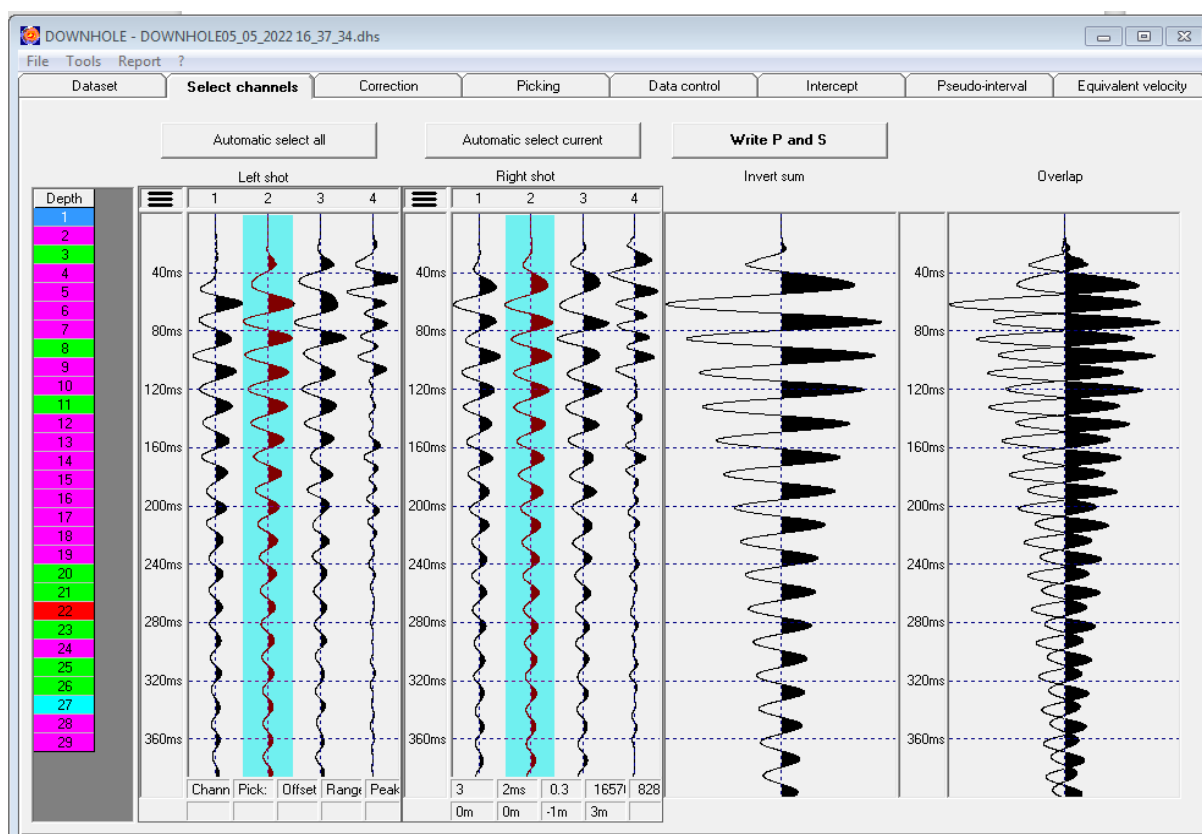
The distance between the measurements corresponds to the repositioning interval of the receiver (or the spacing between the geophones of a system of multiple receivers in the hole); the interval is chosen according to the accuracy and efficiency required for speed measurements and is generally between 0.5 m and 5 m (in general the measurements are carried out every m 1).

The survey can be conducted by proceeding towards the maximum depth of investigation (from top to bottom) or from the maximum depth to the top of the equipped hole (from bottom to top).

## 5 Processing

Processing can be carried out with different methodological approaches. In **GEOEXPLORER DH** module it has been made possible to use the graphic method of the intercepts and the interval method in the resulting Pseudo-interval and Equivalent.

In the first instance, the data is loaded, the geometric settings are checked for correctness and the horizontal channels are selected. After that, the spy geophone is checked and, if necessary, corrections are applied to the channels that have triggering problems, which can be caused by badly positioned blows, local variations at the strike point (compaction, displacement of the plate from the trigger, etc.).



*Illustration 5-1*

It is necessary to pick up the first arrivals on the seismograms of the spy geophone, thanks to which the software will check the triggering of the various channels. Once the correction method has been chosen and applied, the picking files will be generated.

## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

Example of trigger error and correction applied through the use of the spy geophone, which allows you to evaluate how much to correct the burst x with respect to a reference value chosen by the operator:

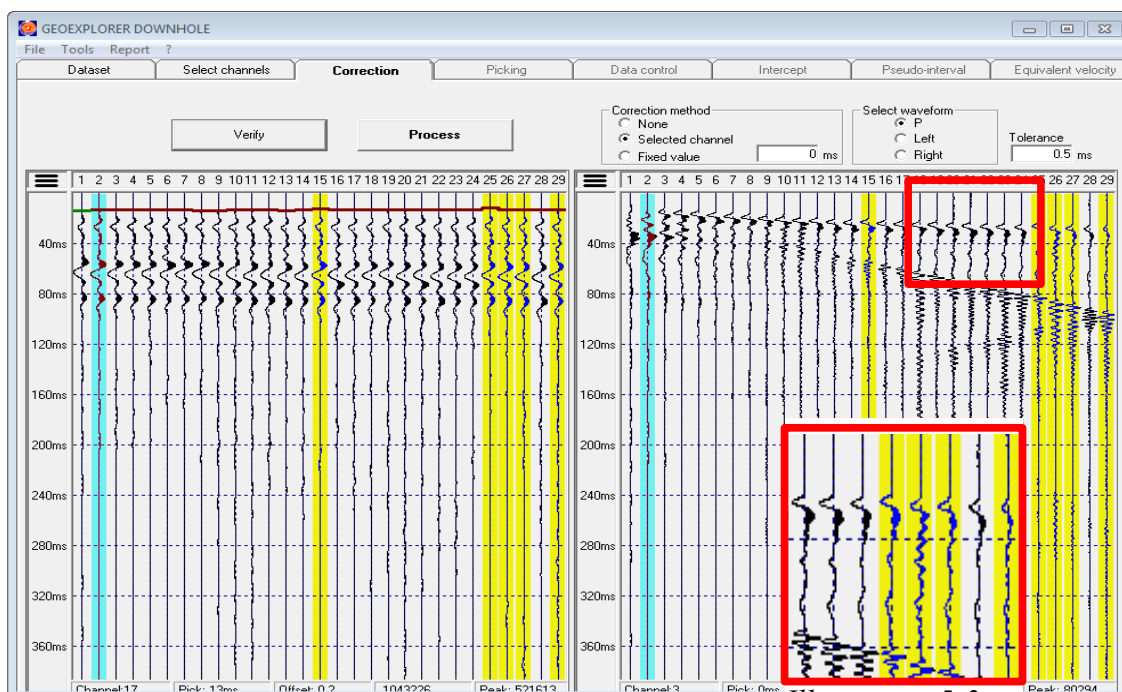


Illustration 5-2

Illustration 5-3

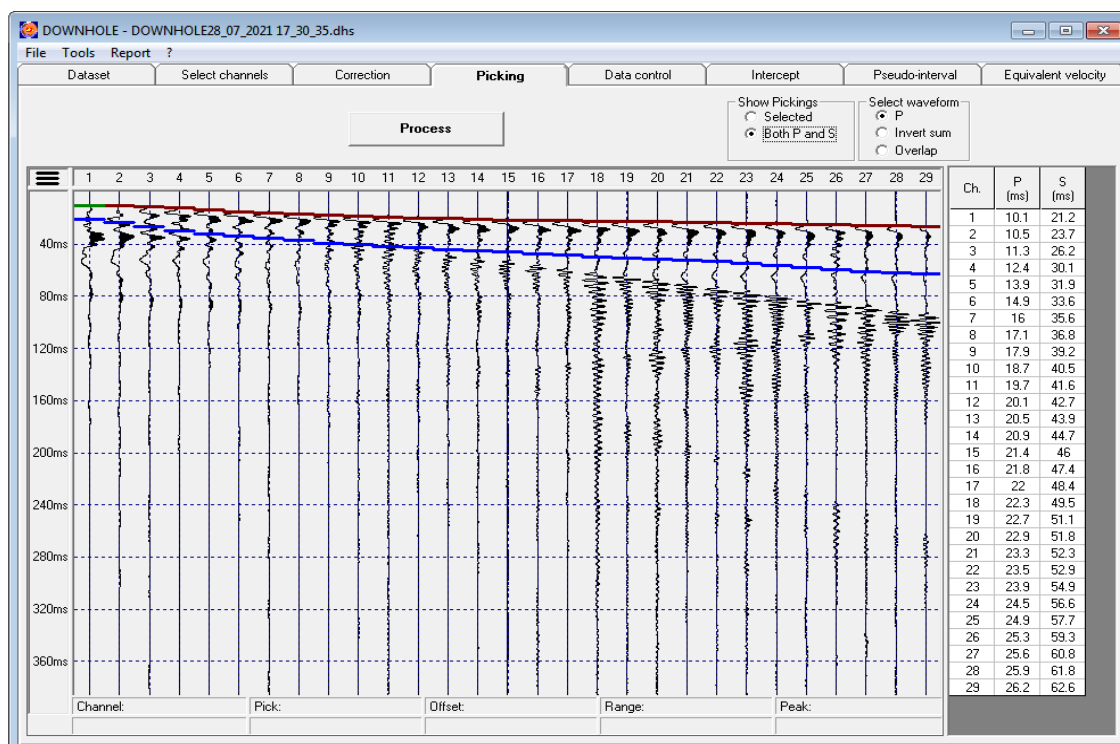
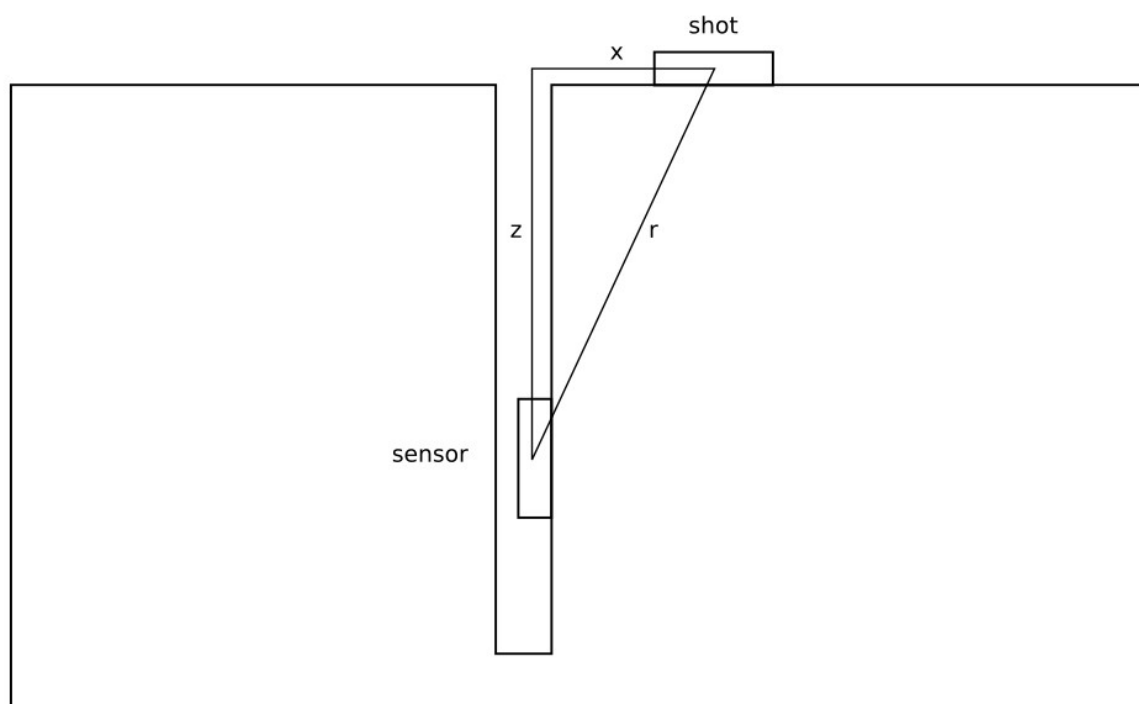


Illustration 5-4

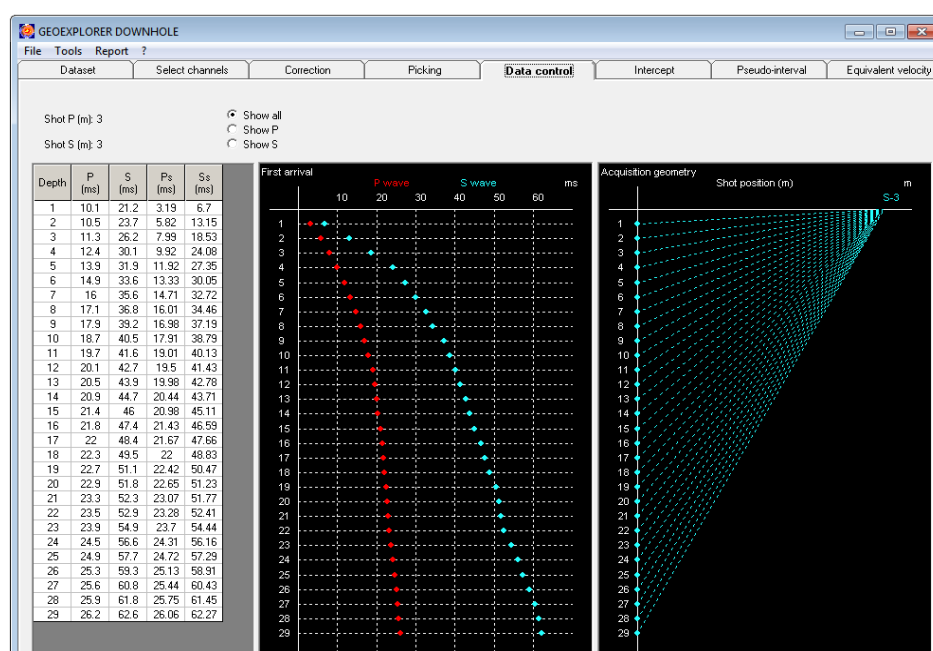
## GEOEXPLORER DOWNHOLE – 2.2.1 – USER MANUAL

The program automatically calculates the geometric correction for each single burst by applying the law:

$$T_{corr} = \frac{z}{r} \times T \text{ dove } r = \sqrt{z^2 + x^2}$$



*Illustration 5-5*



*Illustration 5-6*

## 5.1 Intercept

The graphical method consists in selecting the segment that includes the points that line up indicating a constant speed of propagation. By analyzing the inverse of the angular coefficient of this segment, it is possible to evaluate the speeds of the layer.

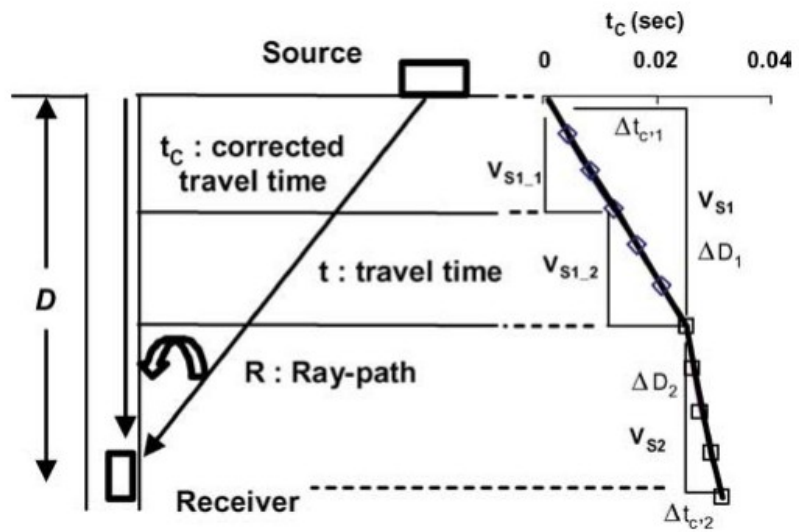


FIG. 2—Illustration of the Direct Method.

Illustration 5.1-1

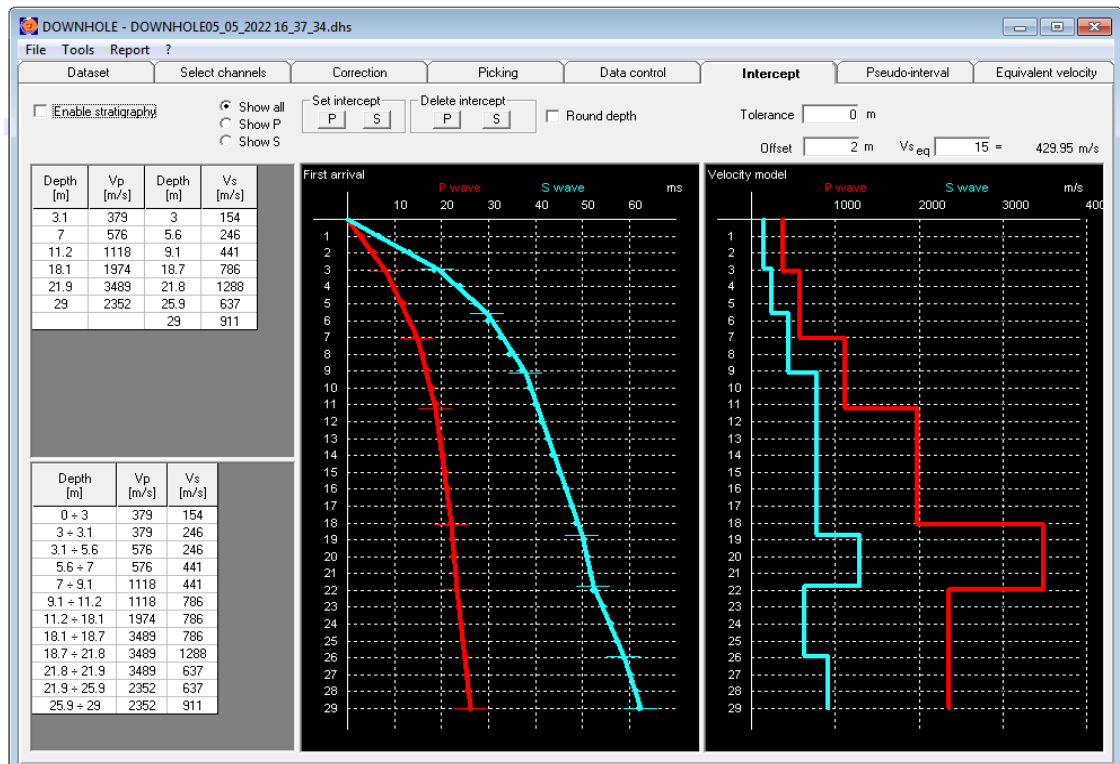


Illustration 5.1-2

## 5.2 Pseudo-interval

The interval technique is based on the fact that the acquisition is performed with the use of two sensors, placed at a constant distance in the hole. the two sensors move along the hole with a constant displacement distance.

The pseudo-interval technique allows to analyze the data acquired with a single sensor, as if they had been acquired as described above.

Obviously this leads to an error which is mitigated by the use of the spy geophone.

The software calculates the interval speed following this law:

$$V = \frac{Z_n - Z_{n-1}}{T_{corr_n} - T_{corr_{n-1}}}$$

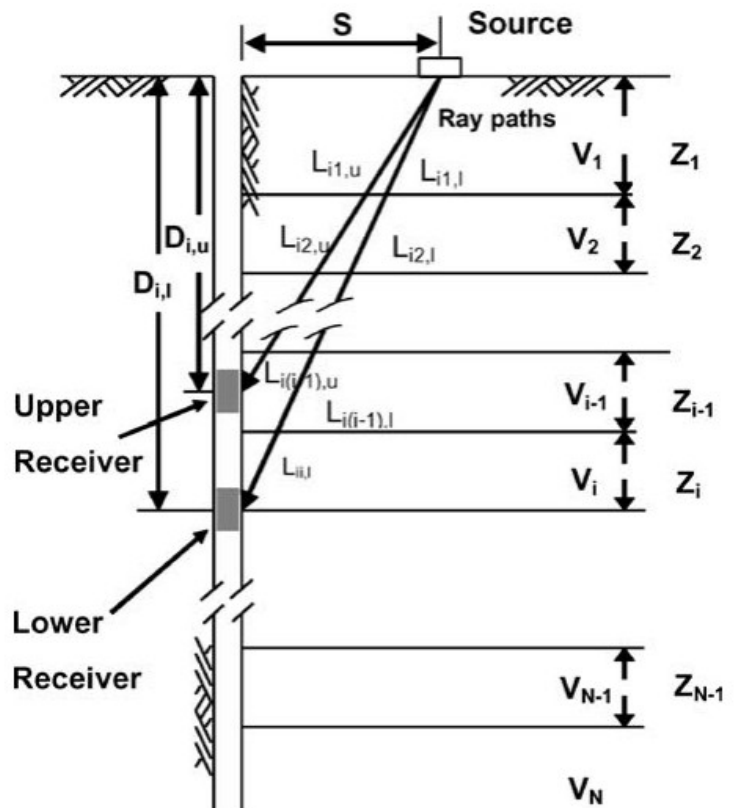


Illustration 5.2-1

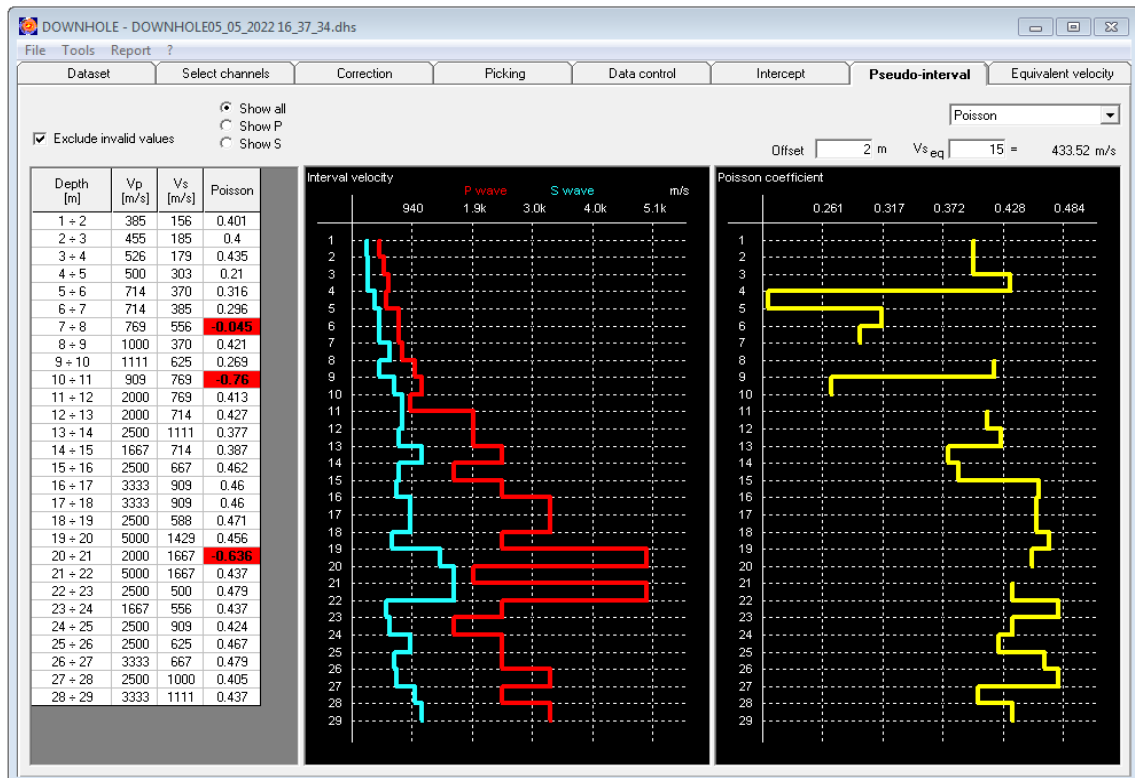


Illustration 5.2-2

### 5.3 Equivalent velocity

This processing method uses the same assumptions described in the previous technique, keeping the surface sensor at a fixed height, in this case the most superficial depth.

The software calculates the equivalent speed following this law:

$$V = \frac{Z_n - Z_1}{T_{corr_n} - T_{corr_1}}$$

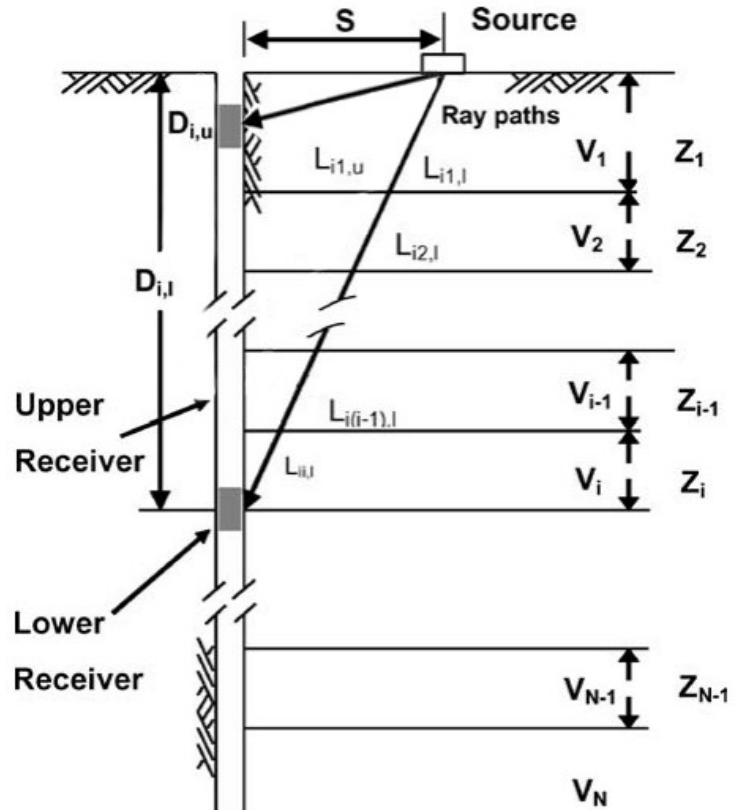


Illustration 5.3-1

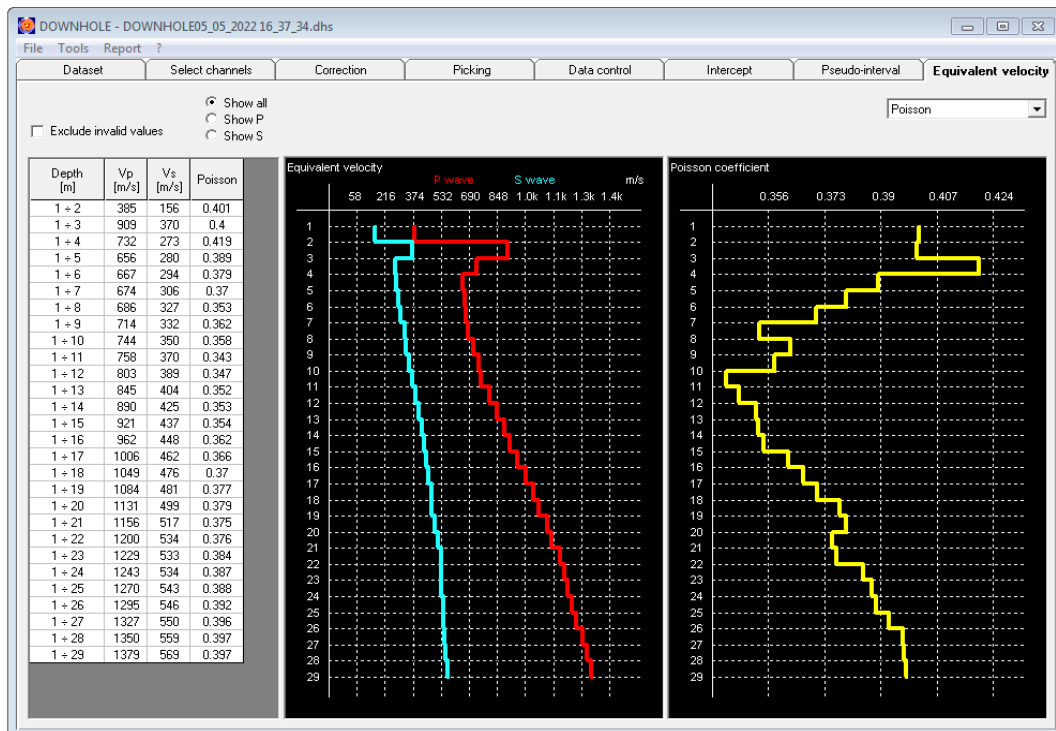


Illustration 5.3-2

## 5.4 Formulas

The formulas used in the software are as follows:

Calculation of correct times:

- Correct Times

$$T_{corr} = \frac{z}{r} \times T \text{ dove } r = \sqrt{z^2 + x^2}$$

- Poisson

$$\frac{((VP/VS)^2 - 2)}{2((VP/VS)^2 - 1)}$$

Valid if:  $|VP/VS| \neq 1$  and Poisson  $> 0.16$  and Poisson  $< 0.5$

- Density ( $T/m^3$ )

$$0.51(VP^{0.19})$$

- Bulk (MPa)

$$\frac{(Density(VP^2 - (\frac{4}{3})VS^2))}{1000}$$

- Young (MPa)

$$(\frac{(VS^2) * Density * (3VP^2 - 4VS^2)}{(VP^2 - VS^2)}) / 1000$$

- Shear (MPa)

$$\frac{(Density(VS^2))}{1000}$$



## **5.5 Bibliography**

- M.Corrao, G.Coco – *Geofisica applicata* - <http://flaccovio.geoexpo.it/DF8784.pdf>
- [https://wiki.seg.org/images/c/c5/Ch02\\_tab2-2a.png](https://wiki.seg.org/images/c/c5/Ch02_tab2-2a.png)