GeoLogik Software's

GeoLogik TRT

User manual

Thermal Response Test Analysis Software

05/2011

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Content

Part I

1 First Steps

1.1 Installation

System Requirements

- Windows XP, Vista or higher
- At least 50 MB free hard disk space
- Mouse or other pointing device

Installing GeoLogik TRT

Installing GeoLogik TRT on a Local Drive from CD:

- Insert the CD-ROM in the CD-ROM drive. Navigate to the folder TRT on the CD and run SETUP.EXE

Installing GeoLogik TRT on a Local Drive Using a Downloaded EXE:

- Navigate to the folder containing the downloaded file.
- Double-click the downloaded file to begin the installation process.

The installation file is digitally signed to protect it from unauthorized modifications.

The installation program guides you through the installation process.

Installing GeoLogik TRT requires that you be logged into an account that has Administrator rights.

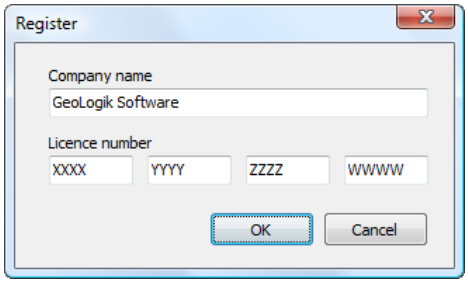
Registration

Registration is required to use the software as full version.

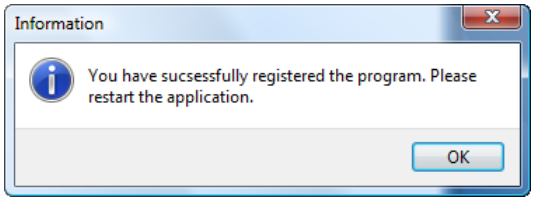
Under Windows Vista / Windows 7 GeoLogik TRT must be started with Administrator rights to successfully complete the registration process. To do this right click on the GeoLogik TRT program icon and select **Run as administrator** from the popup menu. If prompted by UAC, then click on **Yes** to apply permission to allow the program to run with full permission as an administrator.

Click on **Help** | **About** and afterwards on the link **Register**.

Enter your **Company name** and **Licence number**. The licence number has 4 blocks with 4 characters each:



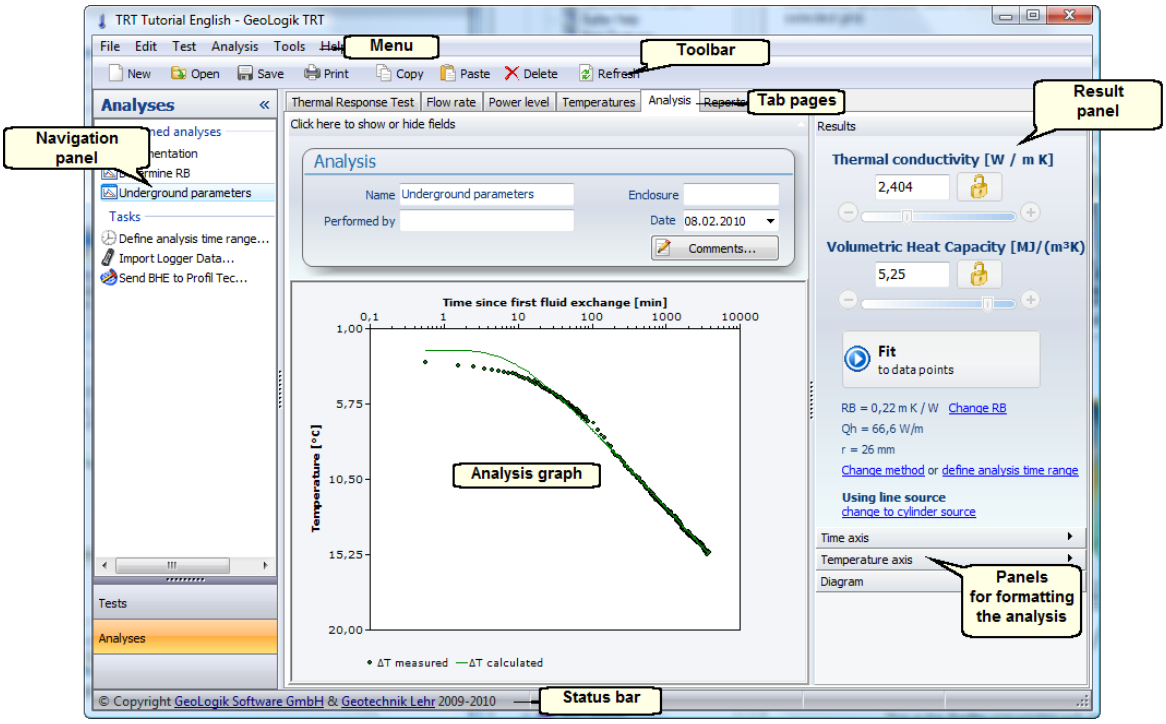
Close the Register dialog with OK and you should see a message that the registration was successful::



Click on **OK** in the message box and click once more in the About window to close it. You must restart GeoLogik TRT to use it as full version.

1.2 Introduction

GeoLogik TRT User interface:



Navigation panel: In this panel you can see all performed analyses and common tasks; at the bottom by clicking on Tests the view changes allowing to select a different TRT.

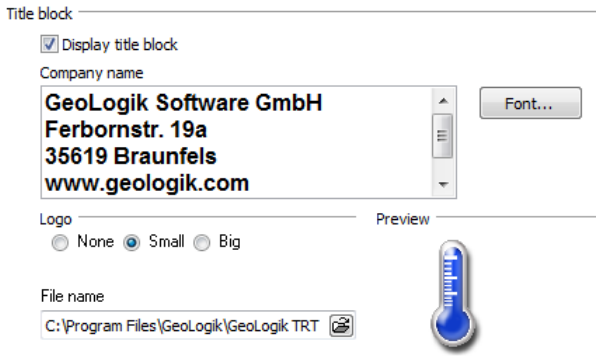
Tab pages: The program has 6 tab pages. It is a good idea to work through them from left to right. Depending on the active page different elements appear on that page. The picture above shows the page **Analysis**. On that page you can see the Analysis graph, the Results panel and additional panels for formatting the diagram.

Data structure

GeoLogik TRT is a file based application, similar to a word processing or spreadsheet software. A single file, i.e. a project, can contain several TRTs and boreholes (BHE). There is no need to create a new file for every TRT, you can simply select **Test** | **New TRT** to add a TRT to the project. If you create a new TRT the program automatically adds a new BHE. Click on **Select BHE** on the page **Thermal Response Test** to open a dialog for managing the BHEs.

1.3 Customizing the title block

After the installation name and logo of GeoLogik Software appear in the title block. To set your own company name and logo select **Tools** | **Options** from the menu, go to the tab **Reports** and look for the panel **Title block**:



In the text box **Company name** you can enter your own company name. Click on **Font** to change font style and size.

In the Logo panel you can select a graphic file. We recommend a Windows Bitmap (BMP) with a resolution of at least 300 dpi. If **Small Logo** is selected the graphic will show up as a square on the left side of the company name. Your graphic should also be square, otherwise it will be stretched.

If **Big Logo** is selected the entries under company name will not be displayed. Instead the full space is occupied by the graphic. The aspect ratio depends on the settings for the page margins. The title block always has a height of 2.5 cm, the width of the graphic is half of the page width minus the page margins. Example calculation: The paper size is A4 (21 cm width), left margin is 2 cm and right margin is 1 cm. Therefore the width of the graphic is 9 cm ((21 cm - 2 cm - 1 cm) / 2). The aspect ratio (width : height) of the graphic should be 9 : 2.5, e.g. 1080 x 300 pixel.

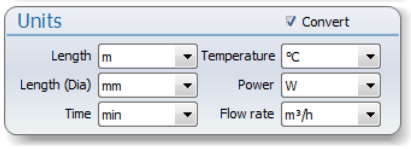
The settings for the title block are program settings and will not be saved along with the TRT file.

Part II

2 Reference

2.1 Data entry

All data use the units from the tab **Thermal Response Test**.



Setting units

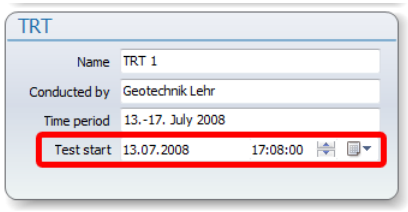
If you realize during data entry that a wrong unit was selected, uncheck the **Convert** box and change to the correct unit. Keep in mind that the units apply to all data in the active TRT.

The default units (which are used if you create new files or TRTs) can be set on the tab **Environment** under **Tools** | **Options**.

There are three pages to enter the measurements: Flow rate, Power level and Temperatures. They all have the same layout with a data table and a diagram. The diagram serves as a visual control for the data. Click on a data point in the diagram to jump to the corresponding data entry in the table.

GeoLogik TRT uses the decimal separator set up in Windows. With the Enter-key the cursor moves to the next cell in the table. There is no need to enter the data in chronological sequence, because the program sorts the data by time. Duplicated points of time are not allowed. If duplicated time values occur only the first will be taken and the others will be ignored.

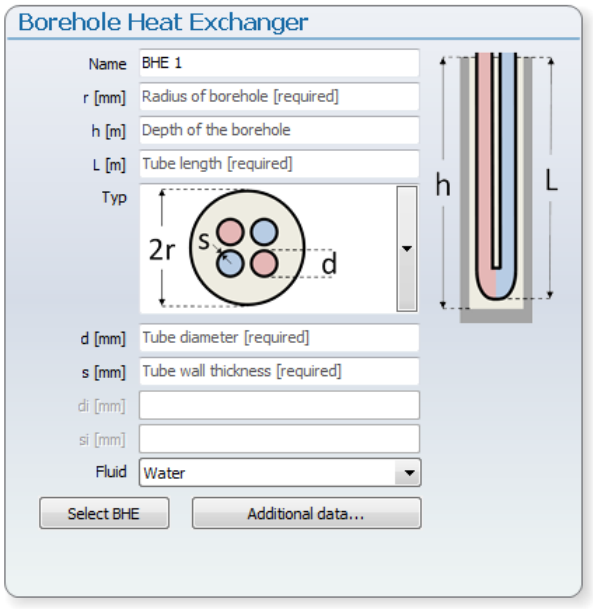
All time values are time since the Test Start. The Test Start is defined as the beginning of recording measurements and must be before the heat power is switched on. This point of time must be entered on the page **Thermal Response Test:**.



Test start

2.1.1 Entering BHE data

The panel **Borehole Heat Exchanger** (BHE) is located on the tab page **Thermal Response Test** and is used to enter construction details.



Panel Borehole Heat Exchanger

The following parameters are used in the calculation of results:

r: Radius of borehole

L: Tube length

d: Outer diameter of tube

s: Tube wall thickness

Fluid

Type of BHE

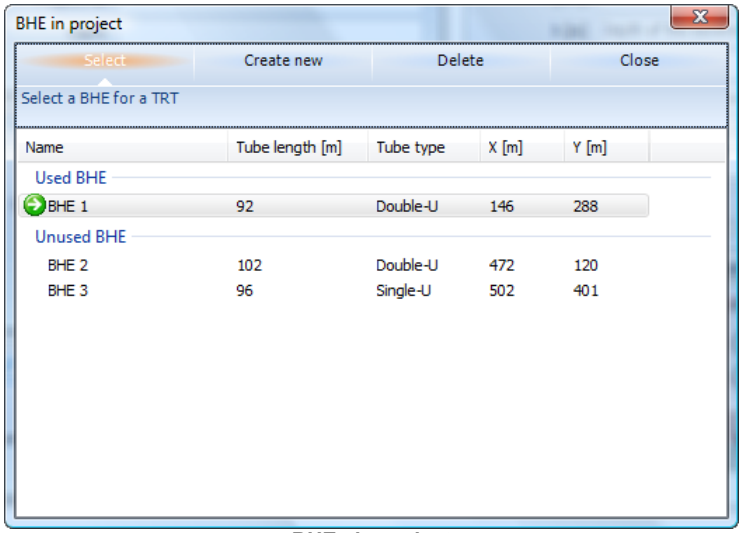
In case of a coaxial BHE also the inner tube diameter di and the inner wall thickness si are required.

Entering additional data for the BHE

Click on Additional data to enter location information (x, y, altitude) and grout material.

Selecting an existing BHE

Click on Select BHE to show all BHEs in the project.

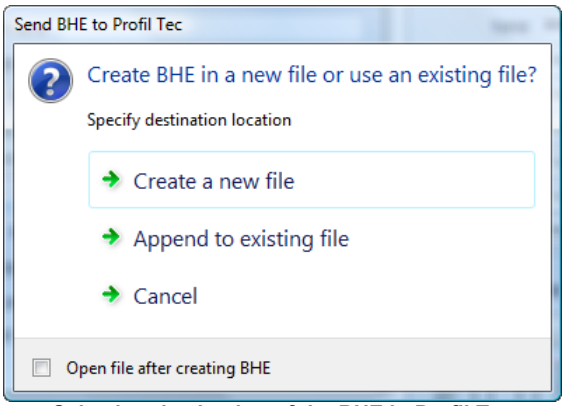


BHEs in project

The currently selected BHE is marked with a green icon. To select another BHE double click it or select it with the mouse and click on **Select** in the menu. This window is also used to create a new BHE or to delete an existing BHE.

2.1.1.1 Send BHE to Profil Tec

A BHE can be transferred to the borehole logging software Profil Tec. If you select **Tools** | **Send BHE to Profil Tec** a dialog will prompt you for the target location:



Selecting destination of the BHE in Profil Tec

Either a new Profil Tec file is created or the borehole is appended to an existing Profil Tec file. In any case the program prompts you to specify a file name. If the option **Open file after create** is checked Profil Tec will open after the process is finished and display the selected file.

The following data will be transferred:

- Name and location of BHE
- Depth and diameter of borehole
- Grout material
- Tube
- if you have selected Create new file the project details (project name, project number, client) will be transferred too.

The scale of the borehole will be set in a way that it fits on a A4 sized page.

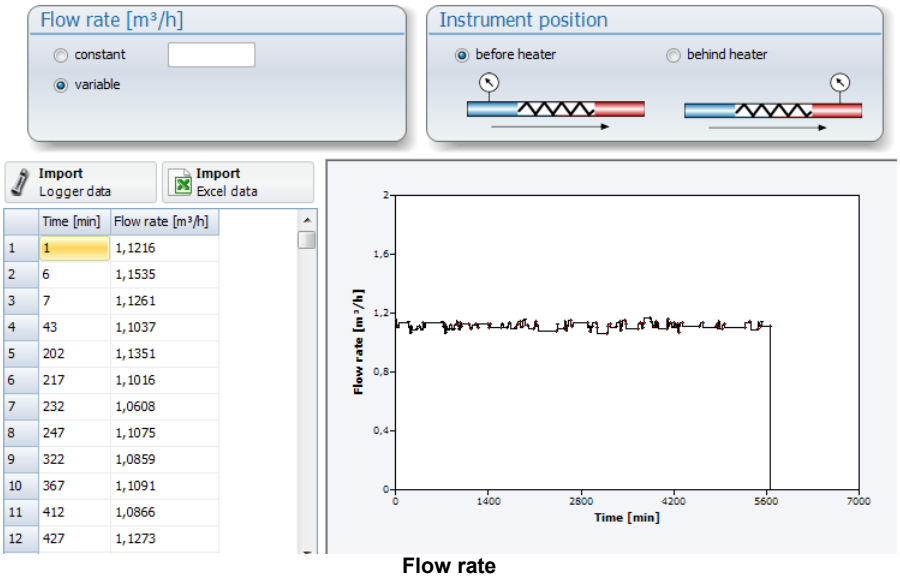
Optimizing the well completion diagram in Profil Tec:
- if the labels for grout material and borehole overlap click on **Align labels** (wizard icon).
- if the label for the grout material reads *Zementation*. Click on it an uncheck **Default Labeling** in

the panel **Appearance**.

This function required a licensed version of Profil Tec 6.3 or higher.

2.1.2 Entering Flow rate

The flow rates are entered on the page **Flow rate**:



Flow rate

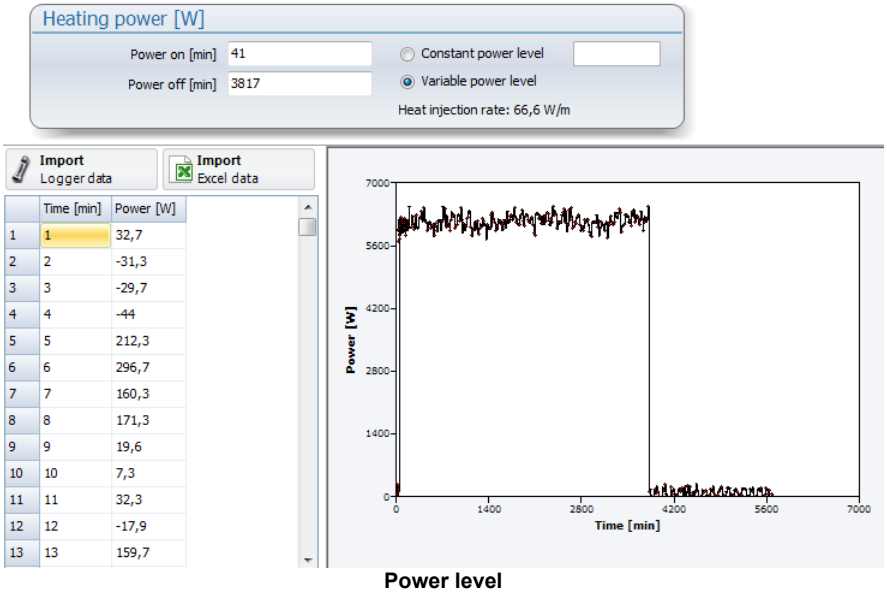
For a simple case select **constant** and enter the flow rate in the text box next to it.

The data table becomes active if you select **variable**.

The instrument position of the flow meter is used by the program when calculating the power level from difference in temperatures. This is because both density and specific heat capacity are functions of temperature, and depending on the instrument position the values will be calculated using either inlet or outlet temperatures.

2.1.3 Entering Heat power

The Heat power is entered on the page **Power level**:



Power level

For a simple case select **Constant power level** and enter the value next to it. If **Variable power**

level is selected the table becomes active.

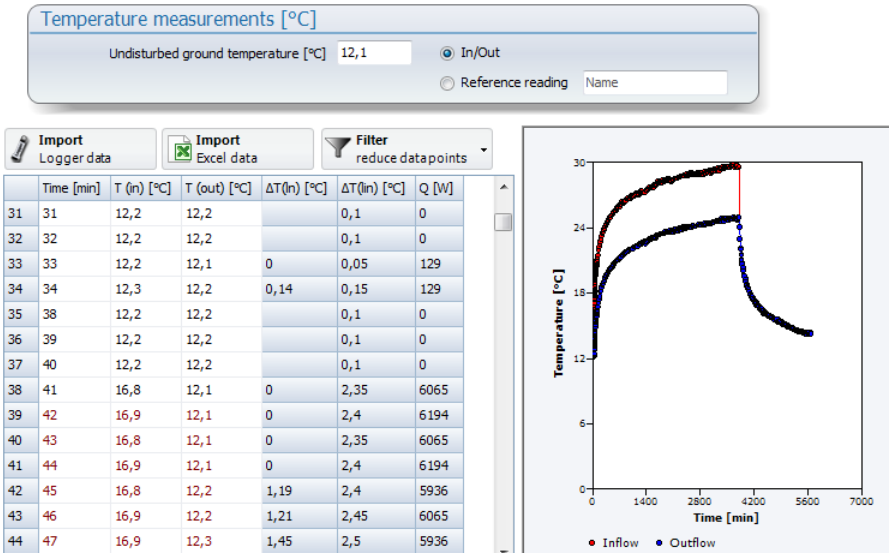
If you do the analysis later on you can select if the power level is taken from the measurements entered here of if it is calculated by using the differences in temperatures.

Enter the times for **Power on** and **Power off** because they are required. Time values must be given in **Time since Test start**.

In case of variable power level it is required that a data point with t ≥ Power off is given in the table.

2.1.4 Entering Temperatures

Temperatures are entered on the page Temperatures.



	Time [min]	T (in) [°C]	T (out) [°C]	ΔT(ln) [°C]	ΔT(lin) [°C]	Q [W]
31	31	12,2	12,2		0,1	0
32	32	12,2	12,2		0,1	0
33	33	12,2	12,1	0	0,05	129
34	34	12,3	12,2	0,14	0,15	129
35	38	12,2	12,2		0,1	0
36	39	12,2	12,2		0,1	0
37	40	12,2	12,2		0,1	0
38	41	16,8	12,1	0	2,35	6065
39	42	16,9	12,1	0	2,4	6194
40	43	16,8	12,1	0	2,35	6065
41	44	16,9	12,1	0	2,4	6194
42	45	16,8	12,2	1,19	2,4	5936
43	46	16,9	12,2	1,21	2,45	6065
44	47	16,9	12,3	1,45	2,5	5936

Temperatures

A required input is the **Undisturbed ground temperature**.

If **In/Out** is selected the table contains data triples, i.e. measurements containing time, inflow and outflow temperatures. If the data for a point of time is incomplete (if either inflow or outflow is missing) the data will no be accepted by the program and are deleted on the next refresh of the table.

T (in) means inflow, i.e. the fluid entering the BHE. **T (out)** means outflow, i.e. the fluid leaving the BHE.

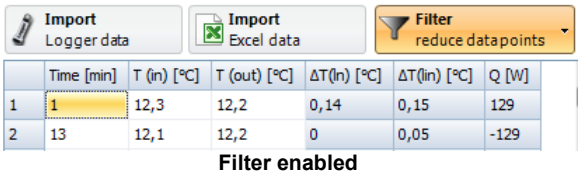
The data is automatically sorted by time, regardless of the input sequence. If duplicated time values the program informs you about it and deletes the duplicates.

The columns **ΔT(ln)** and **ΔT(lin)** display the logarithmic and linear temperature difference to the underground. The column **Q** contains the power level, which is calculated using the T(in) and T (out) values, assuming a averaged flow rate.

If **Reference reading** is selected the table contains time - temperature values. This can be used to document other relevant parameters, e.g. the outside air temperature.

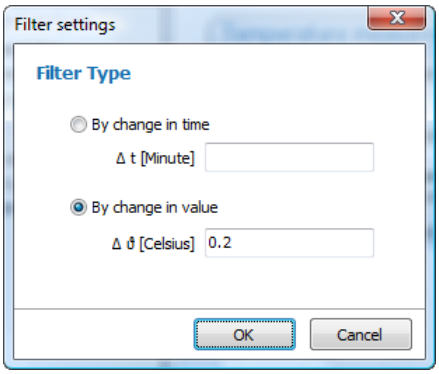
2.1.4.1 Filtering data points

The button **Filter** is located above the table. It is used to enable or disable filtering of the data points. If the filter is enabled the color of the button changes to inform the user that not all the data points are visible.



Filter enabled

If you click on the small triangle on the right side of the button the command Filter settings becomes visible. If you select it the following dialog appears:

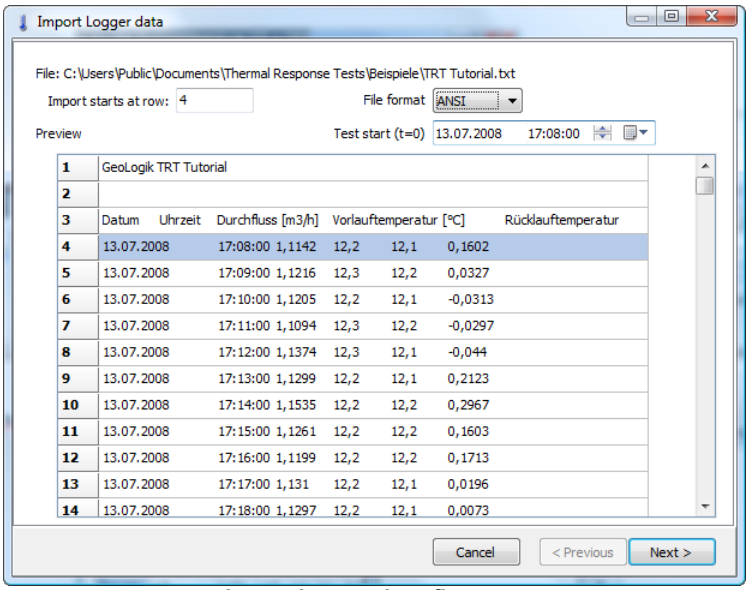


Now you can select the **Filter type**, which can be **By change in time** or **By change in value**. Enter a applicable Δ in the text box next to it.

2.1.5 Importing logger data

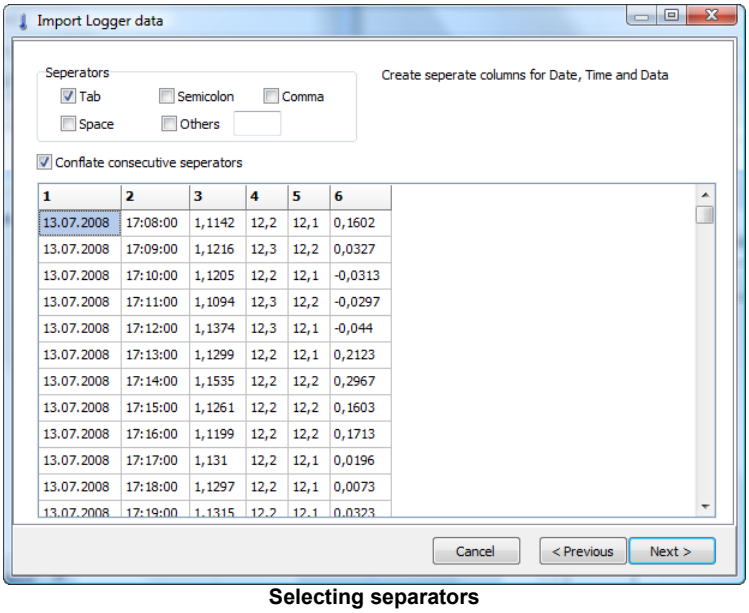
A logger data file contains the measurements in the format of Date, Time and Measured Data. The data must be in chronological sequence, starting with the earliest time. Click on **Import Logger data** above the table or in the task panel to start the process. After you have selected the file the **Import Logger data** wizard appears.

Die Messungen müssen in chronologischer Reihenfolge vorliegen. Um diese zu importieren klicken Sie auf **Logger-Daten importieren** im Aufgaben-Panel oder auf eine die Schaltfläche **Importieren von Logger-Daten** oberhalb der Eingabetabellen. Es öffnet sich dann der Dialog zur Auswahl der Logger-Datei und danach der Import-Assistent.



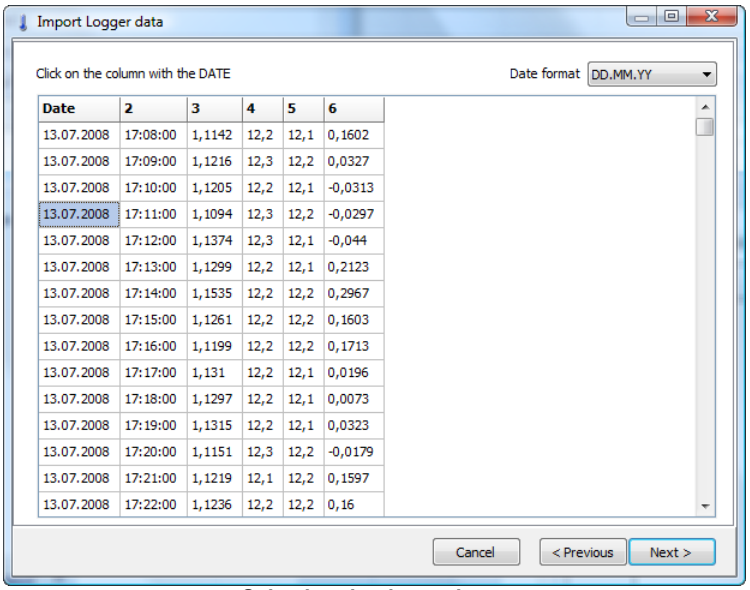
Import Logger data, first step

In the first step you specify the beginning of the data using the **Import starts at row** text box. To do this you can also simply click on a row in the table. Also the **Test start** is displayed and you can modify that value if is is not correct. Click on **Next** to continue.



Selecting separators

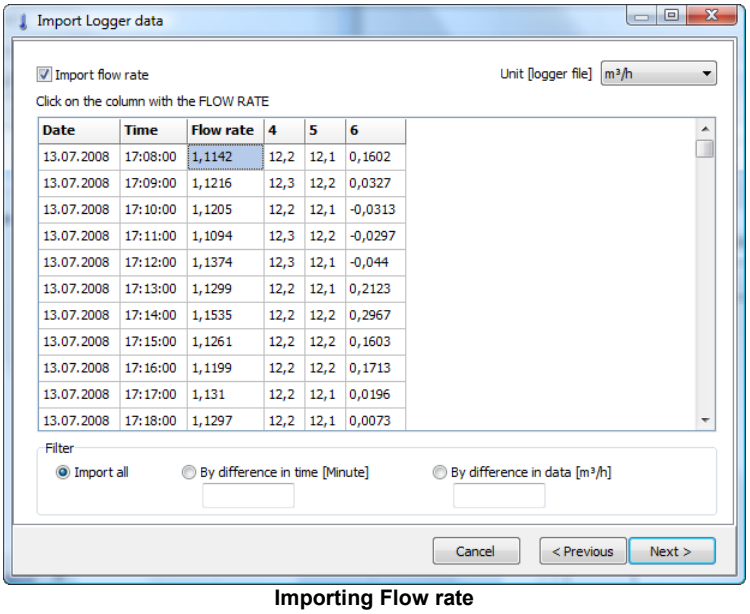
During the next step separators used to split the data into separate columns are selected. Date and time must be in separate columns.Click on **Next** to continue.



Date	2	3	4	5	6
13.07.2008	17:08:00	1,1142	12,2	12,1	0,1602
13.07.2008	17:09:00	1,1216	12,3	12,2	0,0327
13.07.2008	17:10:00	1,1205	12,2	12,1	-0,0313
13.07.2008	17:11:00	1,1094	12,3	12,2	-0,0297
13.07.2008	17:12:00	1,1374	12,3	12,1	-0,044
13.07.2008	17:13:00	1,1299	12,2	12,1	0,2123
13.07.2008	17:14:00	1,1535	12,2	12,2	0,2967
13.07.2008	17:15:00	1,1261	12,2	12,2	0,1603
13.07.2008	17:16:00	1,1199	12,2	12,2	0,1713
13.07.2008	17:17:00	1,131	12,2	12,1	0,0196
13.07.2008	17:18:00	1,1297	12,2	12,1	0,0073
13.07.2008	17:19:00	1,1315	12,2	12,1	0,0323
13.07.2008	17:20:00	1,1151	12,3	12,2	-0,0179
13.07.2008	17:21:00	1,1219	12,1	12,2	0,1597
13.07.2008	17:22:00	1,1236	12,2	12,2	0,16

Selecting the date column

Now click on the column containing the date information. The Date format can be set in the combo box in top right corner if it is different from the date format set in Windows. D means day, M means month and Y means year. Click on **Next** to continue to select the applicable column for the Time. Like the date column simply click on the column containing the Time information.Click on **Next** to continue.



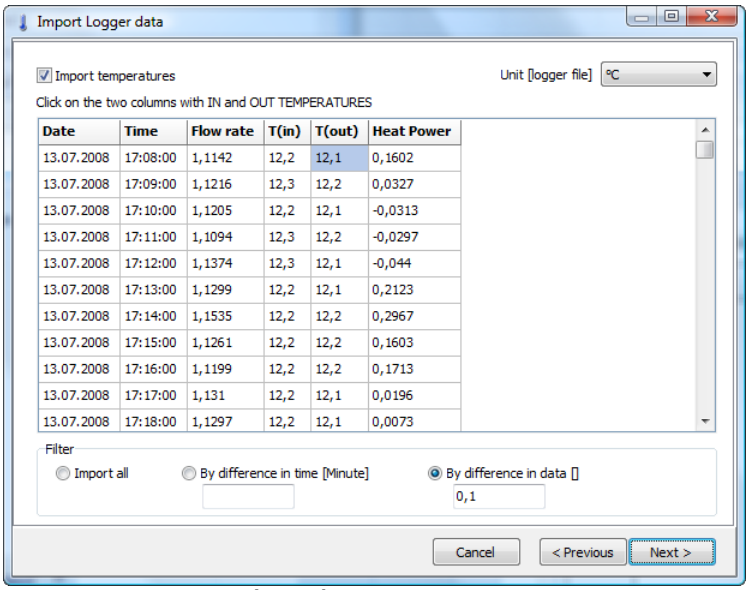
Date	Time	Flow rate	4	5	6
13.07.2008	17:08:00	1,1142	12,2	12,1	0,1602
13.07.2008	17:09:00	1,1216	12,3	12,2	0,0327
13.07.2008	17:10:00	1,1205	12,2	12,1	-0,0313
13.07.2008	17:11:00	1,1094	12,3	12,2	-0,0297
13.07.2008	17:12:00	1,1374	12,3	12,1	-0,044
13.07.2008	17:13:00	1,1299	12,2	12,1	0,2123
13.07.2008	17:14:00	1,1535	12,2	12,2	0,2967
13.07.2008	17:15:00	1,1261	12,2	12,2	0,1603
13.07.2008	17:16:00	1,1199	12,2	12,2	0,1713
13.07.2008	17:17:00	1,131	12,2	12,1	0,0196
13.07.2008	17:18:00	1,1297	12,2	12,1	0,0073

Importing Flow rate

To import flow rate data select the **Import flow rate** checkbox. Ensure that the correct **unit** is selected in the combo box in the top right corner. Then click on the column containing the flow rate information.

Below the table you can see the panel Filter. The meaning of Import all should be clear. If you select **By difference in time** or **By difference in value** and enter a difference the program will import data points only if the difference from the previously imported data point is reached. Typically this will reduce the number of data points imported, often making the analysis clearer.

Click on **Next** to continue to importing Heat power data. This screen works exactly like the one before: Check the box if you want to import, set the correct unit, click on the column with the data. Click on **Next** to continue with importing temperatures.

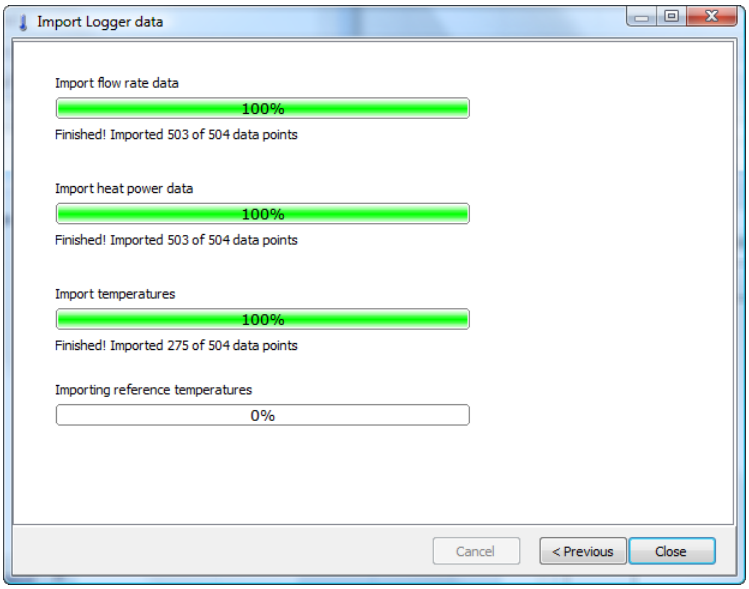


Importing temperatures

Now you have to click twice, because the first click will select the Temperature (in) and the second the Temperature (out). If you have selected the wrong column, simply click a third time to select Temperature (in) again, and a forth time for the Temperature (out), and so on.

Click on **Next** to continue with importing reference reading (e.g. the outside air temperature). That screen works like the screens before.

Click on **Next** to start the importing process. The process indicator keep you informed about the import and show the number of imported data points:



Completion of import

Click on **Close** to end the Import wizard.

2.2 Analysis

2.2.1 Calculation of Borehole Thermal Resistance

The Thermal Resistance is calculated at the time of the first fluid exchange in the BHE after the heating power is switched on. It is your task to specify this point of time. The program suggests a time, based on the volume and the flow rate:

$$t_w = \frac{Vol_S + Vol_G}{V}$$

with

Vol_S: Volume of tube

Vol_G: Volume of TRT device

V: Flow rate; if a variable flow rate is given the program uses an averaged value.

The equitation used to calculate the Thermal Resistance R_B is

$$R_B = \frac{2\pi}{Q_H}\Delta\vartheta_R$$

with

Q_H: Heat flow

$\Delta\vartheta_R$: logarithmic mean temperature difference at the time of fluid exchange

This equitation looks quite simple, but we want to explain some details here too:

Logarithmic mean temperature difference

The logarithmic mean temperature difference $\Delta\vartheta$ is defined as

$$\Delta\vartheta = \frac{\vartheta_V - \vartheta_R}{ln\left(\frac{\vartheta_V - \vartheta_U}{\vartheta_R - \vartheta_U}\right)}$$

with

ϑ_V: Temperature in

ϑ_R: Temperature out

ϑ_U: Temperature of undisturbed underground

Heat flow

The Heat flow Q_H is defined as

$$Q_H = \frac{Q}{H}$$

mit

Q: Heating Power [W]

H: Tube length [m]

Heating Power

The Heating Power Q is calculated by using the temperature difference.

$$Q = \rho C_P V(\vartheta_V - \vartheta_R)$$

with

ρ: Density of fluid [kg/m³]

C_P: Specific heat capacity of fluid [kJ/kg/K]

V: Flow rate of fluid [m³/s]

When calculating the Thermal resistance R_B the program uses the flow rate at the time of the fluid exchange or the next value later; there is no averaging of flow rate.

Fluid characteristics

GeoLogik TRT supports 5 fluids:

1. Water
2. Propylene glycol 25%
3. Propylene glycol 33%
4. Ethylene glycol 25%
5. Ethylene glycol 33%

Density and specific heat capacity are functions of temperature. If the program takes the T (in) or T (out) to calculate them depends on the given Instrument position for the flow rate.

Density of fluid

The program uses a polynomial within a temperature range of 0 to 100°C.

Specific heat capacity of fluid

Within a temperature range of 0 to 100°C the program uses a polynomial of 1. degree. Table interpolation is used for water.

2.2.2 Calculation of Thermal conductivity and Heat capacity

The calculation can be done using either **line source** of **cylinder source** model. To switch the model click on the link at the bottom of the results panel.

If the cylinder source is used the ration L/D is displayed, whereas L = tube length and D = 2 x effecive radius.

The cylinder source model required much more CPU power, thus the program might react slower. The calculation time to depends also on the number of data points. It can be a good idea to filter the data points.

Line source

The Difference in temperature $\Delta\vartheta$ is a function of the radius r and time t and is given by

$$\Delta\vartheta(r,t) = Q_H\left(\frac{R_B}{2\pi} + \frac{1}{4\pi\lambda}Ei\left(\frac{r^2}{4at}\right)\right)$$

with

Q_H : Heat flow

R_B : Thermal resistance

λ : Thermal conductivity

a : Thermal diffusivity = λ / ρC_P (Thermal conductivity/volumetric heat capacity)

Ei : Exponential integral

Cylinder source

The Difference in temperature $\Delta\vartheta$ at z=0 (half height of cylinder) is

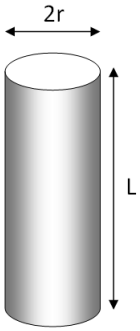
$$\Delta\vartheta(r,t) = \frac{Q_H}{2\pi}\left(R_B + \frac{1}{\lambda} \int_{\sqrt{\frac{r^2}{2at}}}^{\infty} \frac{e^{-u^2}}{u} I_0(u^2) Erf\left(\frac{L}{2r}\frac{u}{\sqrt{2}}\right) du \right)$$

with

I_0: modified Bessel-Function 0. order

Erf: Gauss error function

L: Length of cylinder



The equitation above cannot be solved analytically. In the program the solution is obtained by numerical approximation.

Variable heat power calculation - applying the principles of super position

For a line source applies:

$$\Delta\vartheta(t) = Q_{H1}\left(\frac{R_B}{2\pi} + \frac{1}{4\pi\lambda} Ei\left(\frac{r^2}{4at}\right)\right) + \sum_{i=2}^{n} (Q_{Hi} - Q_{Hi-1})\left(\frac{R_B}{2\pi} + \frac{1}{4\pi\lambda} Ei\left(\frac{r^2}{4a(t-t_{i-1})}\right)\right)$$

with

Q_{H1} = Heat flow starting at t=0

Q_{Hi} = Heat flow of i-th step

n = number of steps

What happen if "Fit to data points" is clicked?

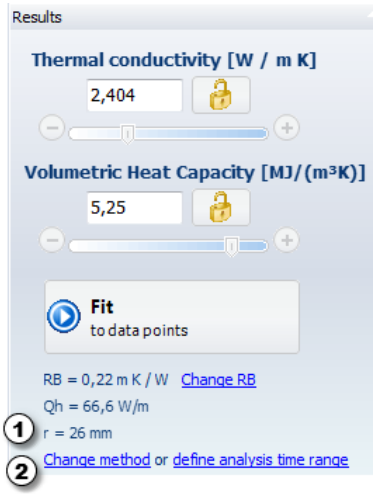
If you click on "Fit to data points" the program modifies the parameters Thermal conductivity and Specific heat capacity in a way, that the sum of squared errors is minimized:

$$\sum (\Delta\vartheta_{Mess} - \Delta\vartheta_{Theo})^2 \rightarrow min!$$

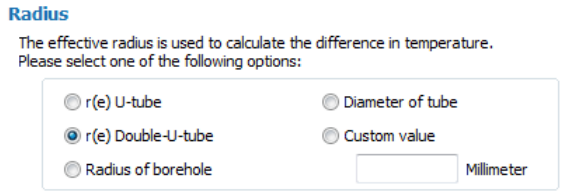
GeoLogik TRT uses a numerical optimization algorithm.

2.2.2.1 Effective radius

The difference in temperature between Fluid and underground is a function of the radial distance r. In the results panel the utilized r is displayed (1).



Click on **Change method** (2) to show the the dialog **Method of calculation**. The following options are available for the radius:



r(e) U-tube:

$$r_w = \sqrt{2}\left(\frac{d}{2} - s\right)$$

r(e) Double-U-tube:

$$r_w = 2\left(\frac{d}{2} - s\right)$$

with

d = outer diameter of tube

s = wall thickness of tube

Radius of borehole

Diameter of tube: r = d

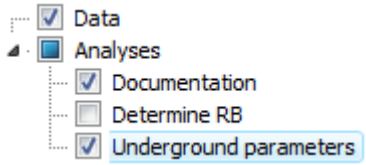
Custom value: You can enter your own value for r here..

When you create a new analysis using **Analysis** | **Determine Thermal parameters** the program uses **r(e) U-tube** or **r(e) Double-U-tube**, depending on the **Type of BHE** already selected. If the **Type of BHE** is changed later, existing analyses are not effected. You need to change them manually.

2.3 Printing reports

You can view and select reports for printout on the page Reports. The zoom factor can be set in the combo box above the print preview. There are also buttons for the **Full page** and **Page width** zoom factors. If a report contains multiple pages, e.g. data report, you can browse through using **Next Page** and **Previous Page** buttons.

The tree view on the left side allows to select the reports for printout. All reports checked in the tree view will be printed as soon as you click on **Print**.

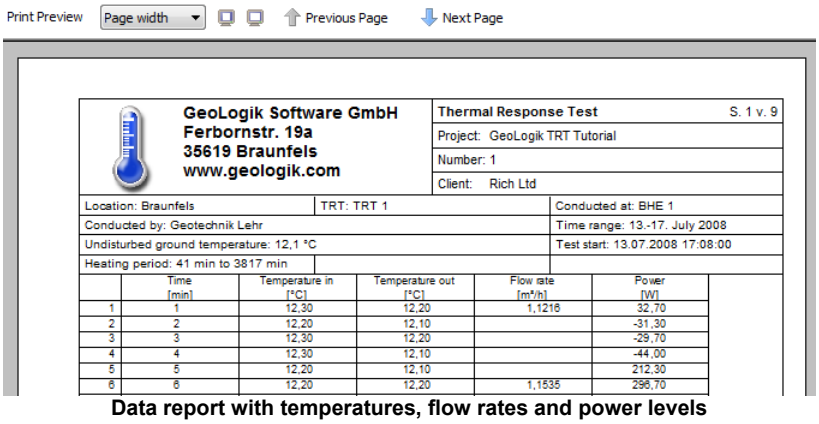


Printing begins immediately, no dialog will show, To change printer settings or to select another printer click on **File** | **Printer Setup** before starting to print.

The program has two types of reports:

- Data
- Analyses

The data report show all recorded data in chronological sequence. Data for Heat power and fluid flow rate also appear in the data report if they are **variable**. When tey are constant the values are shown in the header section of the report.



Data report with temperatures, flow rates and power levels

Part III

3 Tutorial

In this Tutorial you will learn how to enter the data of an TRT and how the analysis is performed. The data in this example are based on a really conducted test.

The steps in detail:

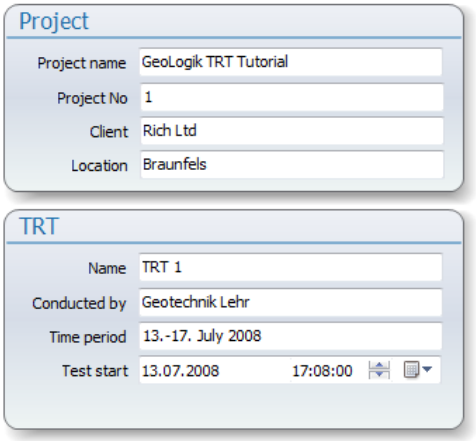
- Entering and importing data
- Creating the documentation
- Determining R_B
- Calculating underground parameters
- Printing reports

All sample files are located in the folder TRT\SAMPLES under the Public files folder.

3.1 Entering and importing data

Start the program **GeoLogik TRT**. After start up the program already contains an empty file and project.

On the page **Thermal Response Test** enter the following information into the panels **Project** and **TRT**:

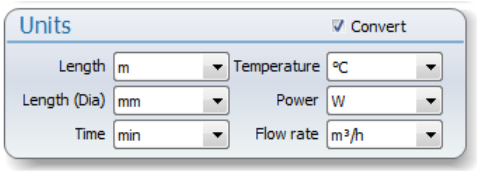


The only "real hard" information which is used for calculating is the **Test start** value, because all time information is given as elapsed time since test start. For now you do not have to enter the value given above, because it will be set later on.

All other entries can be changed as you like, because they serve as information only. However, do not leave them blank, because it is easier to located them on the report if they are filled out.

Setting the units

Look for the panel Units and set them as shown below:

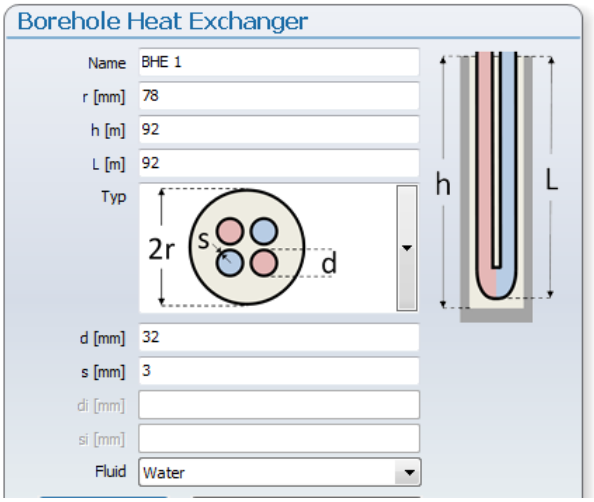


Length is used for location of the borehole and the tube length. **Länge (Dia)** is used for the geometry of the BHE, i.e. radius of borehole and diameter and wall thickness of the tube.

Tip:
Under **Tools** | **Options** you can set the **default units** on the page **Environment**.

Entering BHE data

Geometry and fluid are specified in the panel Borehole Heat Exchanger. For our sample enter the data below:

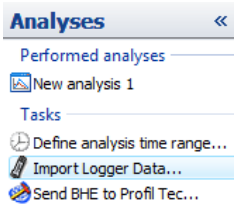


In that case we use a Double-U type BHE and Water as fluid.

That is all for now on the page **Thermal Response Test.**

Importing data

In this example the data comes from a data logger file. To start importing locate the **Tasks** section in the panel **Analyses** and click on **Import Logger data**.

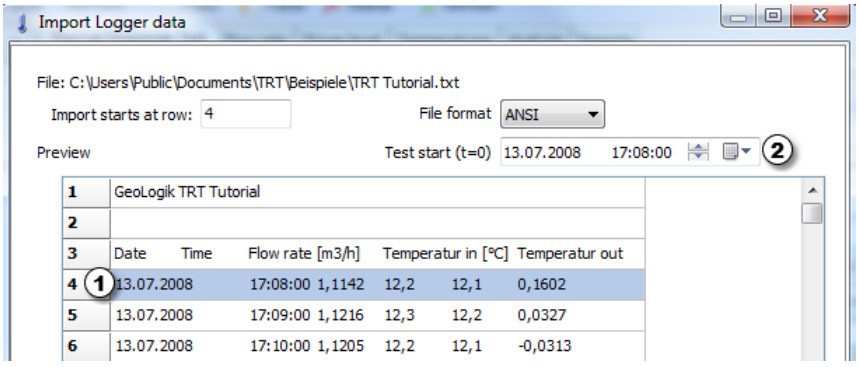


In the File open dialog browse to the SAMPLES folder, select the file **TRT Tutorial.TXT** and click on **Open**.

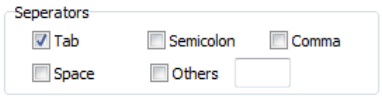
Now the **Import Logger data** wizard shows up.

1. Click on the 4th row in the table to specify the beginning of the data (**Import starts at row**).

2. Set the **Test start (t=0)** to 13. July 2008 at 17:08:00 h.



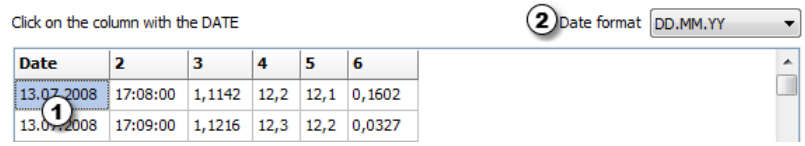
Click on **Next** to continue. Now the separator is selected which is used to split the data into columns.



Select the **Tab** as a separator and click on **Next**.

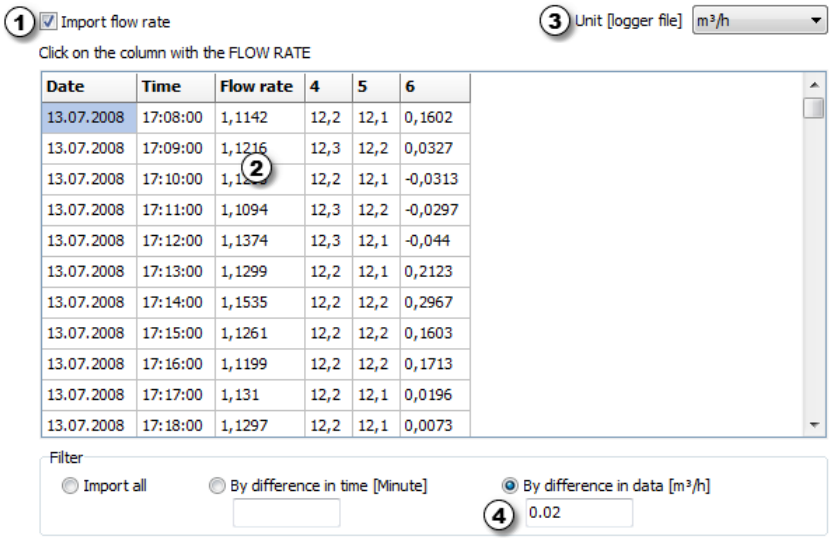
Now the column holding the date information is selected.

1. Click on the first column. The column header changes to **Date**.
2. You can keep the Date format **DD.MM.YY** if it shows up, otherwise change it to that format. It will import correctly even if the year has 4 digits.



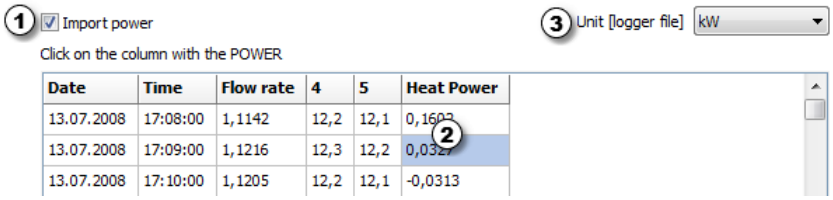
Click on **Next**. Now the column with the time information must be selected. Click on the 2nd column and then on **Next**.

1. Check the box **Import Flow rate** because we want to import that data.
2. Click on the 3rd column which holds the flow rate information.
3. Ensure that the **Unit [logger file]** is set to **m³/h**.
4. We will not import all data. In the **Filter** section select **By difference in data** and enter **0.02** m³/h as threshold.



Click on **Next** to continue with importing the Heating power.

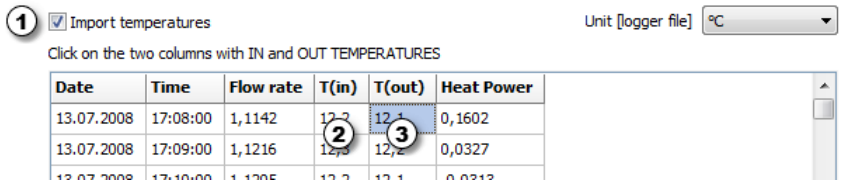
1. Select **Import power**.
2. Click on the last column because it contains the power information. This is not obvious from the first measurements, since the values are quite small and even negative.
3. The power values in the logger file are given in kW. That is the reason for the small values. Since we have selected **W** in the beginning of that lesson change the **Unit [logger file]** to **kW** now.



We are going to import all data points. So just leave the default **Filter** settings to **Import all**. Click on **Next** to continue with importing the temperatures.

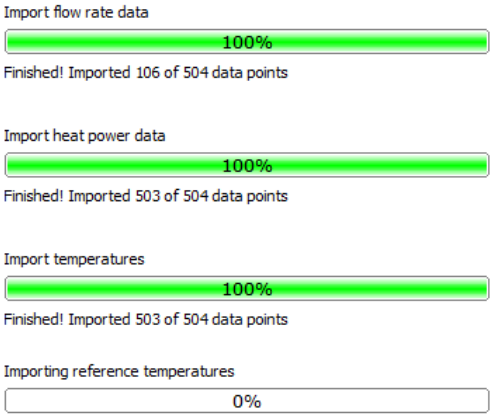
1. Select Import temperatures. The is no need to change the Unit °C.
2. Click on the 4th column to select it as Temperature (in).

3. Click on the 5th column to select it as Temperature (out).



We will also import all temperature data, so you do not have to change the Filter setting. Click on Next to continue with importing reference reading. There is no data for it, so uncheck **Import reference reading** and click on **Next** to start the import.

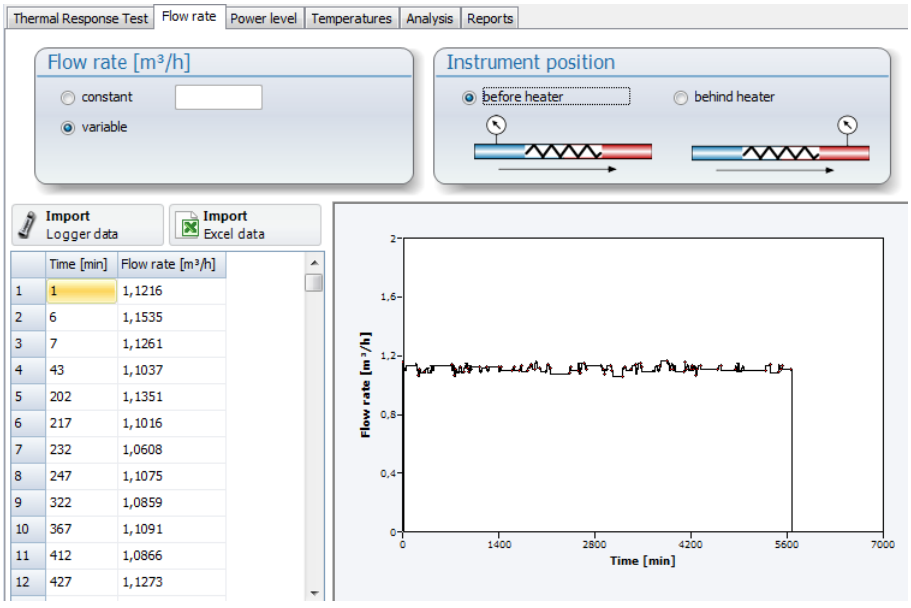
The last screen will inform you about the success of the import process:



Click on **Close** to exit the Import Logger data wizard.

Flow rate

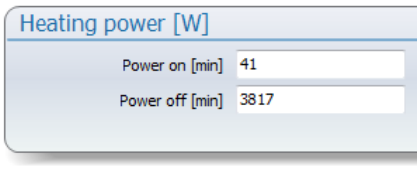
Back in the main window go to the page Flow rate. It looks like this:



If it is not already set change the **Instrument position** to **before heater**.

Power level

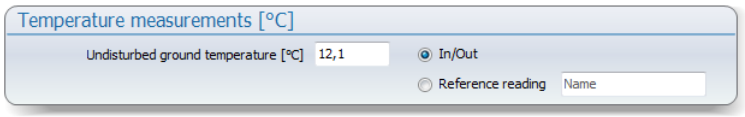
Go to the page Power level. If you scroll down in the data table you will find out that the Power is switch on at about 41 min and switched off at 3817 min. Enter this two values in the text boxes above the table:



Temperatures

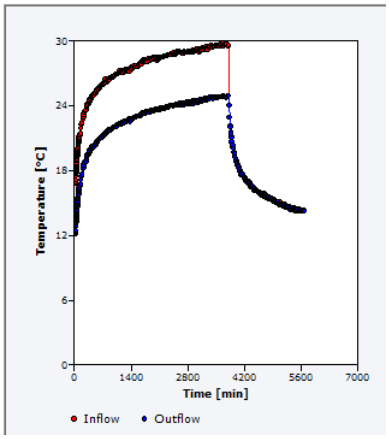
Go to the page **Temperatures**. Enter **12.1** °C as the **Undisturbed ground temperature**.

Resize the window to have a better look at the data table.In the column Q the program displays the Power based on the difference in temperatures. Rows where the data is within the heating period appear in a different color.



Import Logger data | Import Excel data | Filter reduce datapoints

	Time [min]	T (in) [°C]	T (out) [°C]	ΔT(ln) [°C]	ΔT(lin) [°C]	Q [W]
34	34	12,3	12,2	0,14	0,15	129
35	38	12,2	12,2		0,1	0
36	39	12,2	12,2		0,1	0
37	40	12,2	12,2		0,1	0
38	41	16,8	12,1	0	2,35	6065
39	42	16,9	12,1	0	2,4	6194
40	43	16,8	12,1	0	2,35	6065
41	44	16,9	12,1	0	2,4	6194
42	45	16,8	12,2	1,19	2,4	5936
43	46	16,9	12,2	1,21	2,45	6065
44	47	16,9	12,3	1,45	2,5	5936
45	48	16,9	12,3	1,45	2,5	5936
46	49	17	12,2	1,23	2,5	6194
47	50	16,9	12,3	1,45	2,5	5936

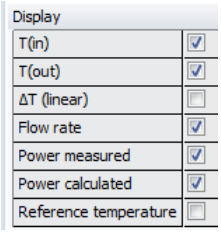


By now all required data is entered into the program. The next lesson shows how to create the documentation of the TRT.

3.2 Creating the documentation

This lesson is based on the data entered in the previous lesson. Select **Analysis** | **Create documentation** from the menu. The program will select the page **Analysis** automatically.

Expand the panel **Display** (on the right hand side of the graph) and apply the following settings:



The program will draw a marker for every data point. Since we have a lot of data points it is recommended to hide the markers. Expand the panel **Diagram** and set the value of **Marker size** to **0**.

Changes become visible if you hit the Return (Enter) key of leave the text box.

To show a legend select **bottom** for the option **Legend**, which is also in the panel **Diagram**. In case the legend overlaps with the graph increase the value for **Lower margin**, e.g. to **15** mm.

Axis scaling

The temperature axis scales from 10 to 30 °C, which is a good range for the sample data.

Eventually the intervals of the axis labeling are "not nice", e.g. every 4 °C (10, 14, 18, etc.). To change this set the **Major unit** in the panel **Temperature axis** to **4**.

Change the **Value format** to **0.0** to display only one digit after the decimal separator.

The Value format uses 0 for a digit which is displayed always. The # is used for an optional digit. The dot . is used as the placeholder for the decimal separator set up in Windows.

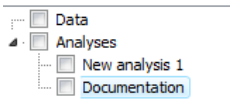
On the **Time axis** the **Maximum** is set to **Auto**, thus the maxium value displayed is 7000. Change it from **Auto** to **6000** and enter **6** as the **Major unit**. Now every 1000 a number label is displayed.

Expand the panel **Power** axis and change the **Major unit** to **4** and the **Maximum** to **8000** W.

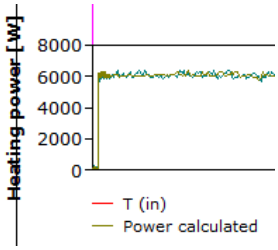
In the panel panel **Flow Axis** change the **Major unit** to **3** and the **Maximum** to **1,5** m³/h.

Report preview

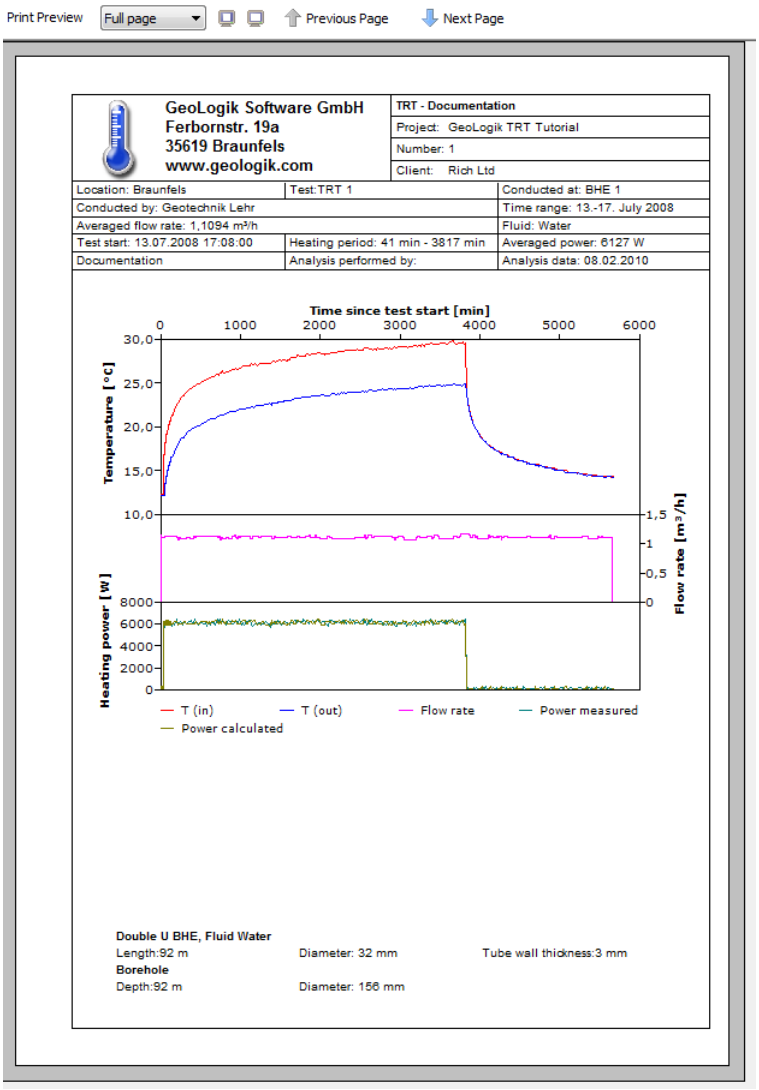
The diagram now looks pretty clear. Go to the **Reports** tab and have a look at the Print preview. Select the **Documentation** from the tree view:



Sometimes the axis label draw beyond the frame:



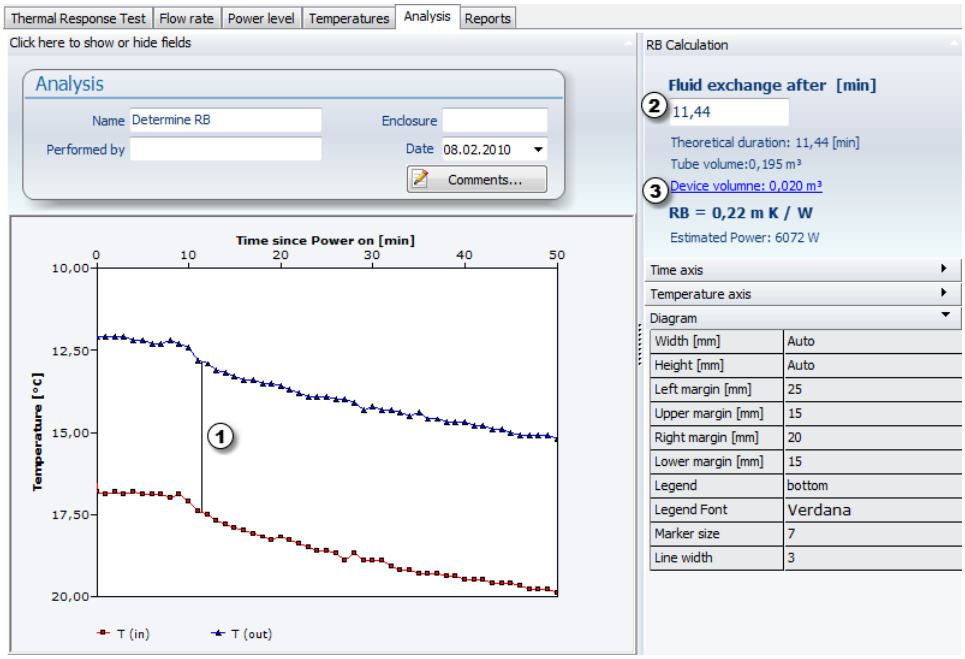
In that case go back to the Analysis tab, open the panel **Diagram** and increase the value for the Left Margin, e.g. to 25 mm. Go back to the print preview, it should look like this:



3.3 Determining Thermal resistance

This lessen continues the previous chapter. Select Analysis | Determine RB from the menu. The program changes to the Analysis tab, and the diagram looks quite good already. Now you can

1. shift the straight line by clicking on it and holding down the left mouse button to change time for the first fluid exchange, or
2. entering a numerical value for the time of the first fluid exchange
3. change the **Device volume** (TRT device + tubes to the BHE); the default volume is set under **Tools** | **Options** on the **Device** tab. This value is used to calculate the theoretical duration and has no direct impact on the calculation of R_B.

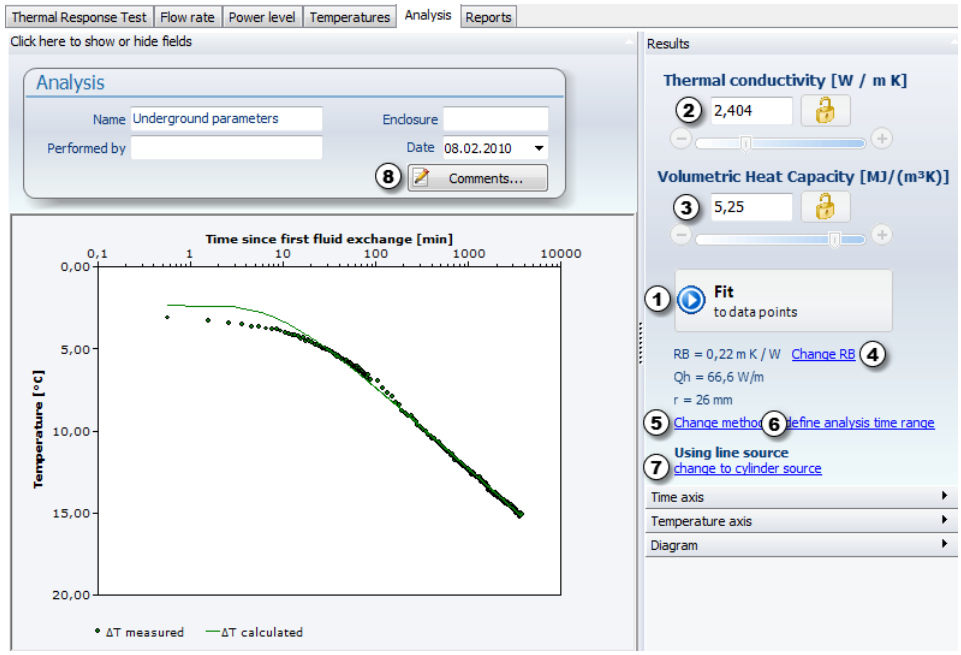


As described in the previous chapter you can change axis scaling and preview the report.

3.4 Calculating underground parameters

This lesson is based on the data entered in the previous lesson. Select **Analysis** | **Determine Thermal parameters** from the menu. The program will select the page **Analysis** automatically. Now you can:

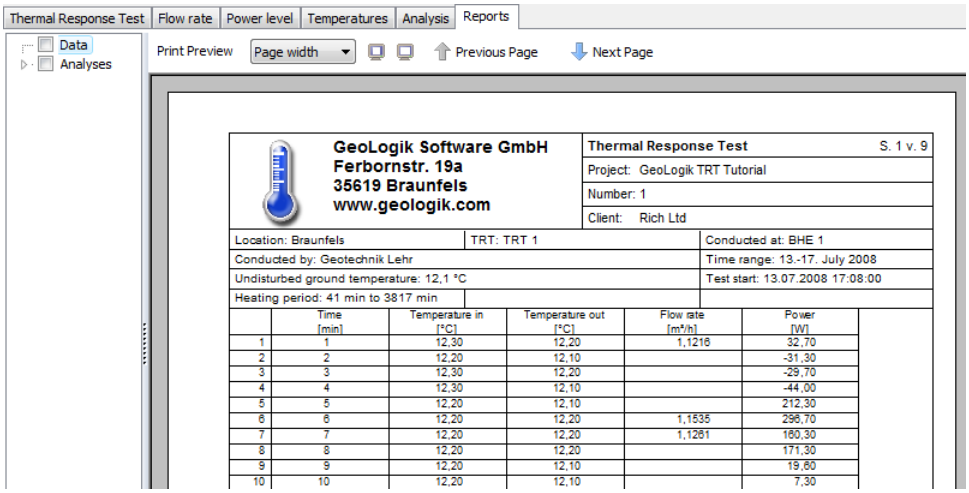
1. Perform an automatic **Fit**. This will change **Thermal Conductivity** and **Volumetric Heat Capacity** in a way that deviation from the data points is minimized. Click on **Fit** now to do it.
2. The **Thermal Conductivity** can be changed by entering a numerical value in text box. You can also use the slider control below the text box. The graph is updated automatically. In the semilog view below the change of the thermal conductivity changes the slope of the straight line section.
3. The same applies to the **Volumetric Heat Capacity**. In the semilog view below the change of the Volumetric Heat Capacity will shift the line vertically. The button with the padlock on it will lock a parameter, so it will not change if a automatic Fit is performed.
4. Click on **Change RB** to select a Thermal resistance or to enter it.
5. If you click on **Change method** a dialog will show up providing options for the calculation. For example, the program can either calculate the heating power from the differences in temperatures or use directly measured data. Also the value for the effective radius can be set here.
6. Another option is to **define an analysis time range**. This allows you to select a different interval in time; by default the program uses the time after the first fluid exchange as a starting point, and the power off of the heater as the ending point.
7. You can also change the calculation model here. The default model is the **line source**. Be aware that the program becomes slower if you select the **cylinder source**, since the calculation is more time consuming.
8. Click on **Comments** to write remarks for the analysis.



This chapter ends the lessons about analyzing a TRT.

3.5 Printing reports

Assuming you have worked through the previous lesson click on the **Reports** tab now. In the tree view click on **Data** to see the print preview of the report:



	Time [min]	Temperature in [°C]	Temperature out [°C]	Flow rate [m³/h]	Power [W]
1	1	12,30	12,20	1,1216	32,70
2	2	12,20	12,10		-31,30
3	3	12,30	12,20		-29,70
4	4	12,30	12,10		-44,00
5	5	12,20	12,10		212,30
6	6	12,20	12,20	1,1535	296,70
7	7	12,20	12,20	1,1261	160,30
8	8	12,20	12,20		171,30
9	9	12,20	12,10		19,60
10	10	12,20	12,10		7,30

In the picture above the zoom factor is set to **Page width**. You can do this by clicking on the appropriate icon or selecting **Page width** from the combo box. In the preview you can see in the top right corner of the page that the document has 9 pages. Use the buttons **Previous Page** and **Next Page** to browse.

Selecting a printer

The program starts to print immediately if the Print icon is clicked, no dialog is shown. If you want to select a different printer or change the print settings select **File** | **Printer Setup** from the menu. Do this now and select a printer you want to use for our example. A total of 12 pages will be printed, so we recommend using a PDF driver instead of a real printer.

Selecting the reports

Check the **Data** node and the **Analyses** node in the tree view and click on Print.

In case you are printing to a PDF driver: The program will create 4 documents, one for the data

report and one for each analysis (we have 3 of them). Some PDF drivers provide an option to conflate these documents into a single document, so you have to distribute only one PDF file for the TRT.

Part IV

4 Appendix

4.1 Technical Support

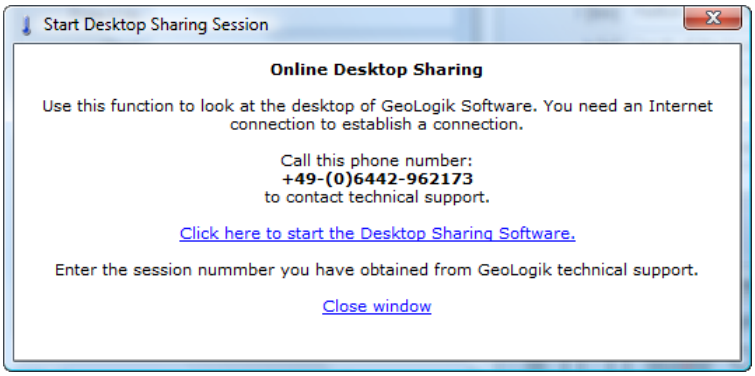
Technical support for GeoLogik TRT can be obtained

- on our website www.geologik.com
- via phone +49 - (0) 64 42 - 96 21 73
- via E-mail info@geologik.com

Desktop-Sharing

We also provide desktop sharing as a special service to getting support. You need to have an Internet connection to use it. During a desktop sharing session the screen content is transferred, either your screen to GeoLogik or vice versa. The conversation takes place via phone.

To start a desktop sharing session select **Help** | **Desktop-Sharing** from the menu and follow the instructions.



4.2 References

Loose, P. (2007): Erdwärmenutzung.- 2. Aufl., C. F. Müller, Heidelberg.

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