Manual for GPR Viewer

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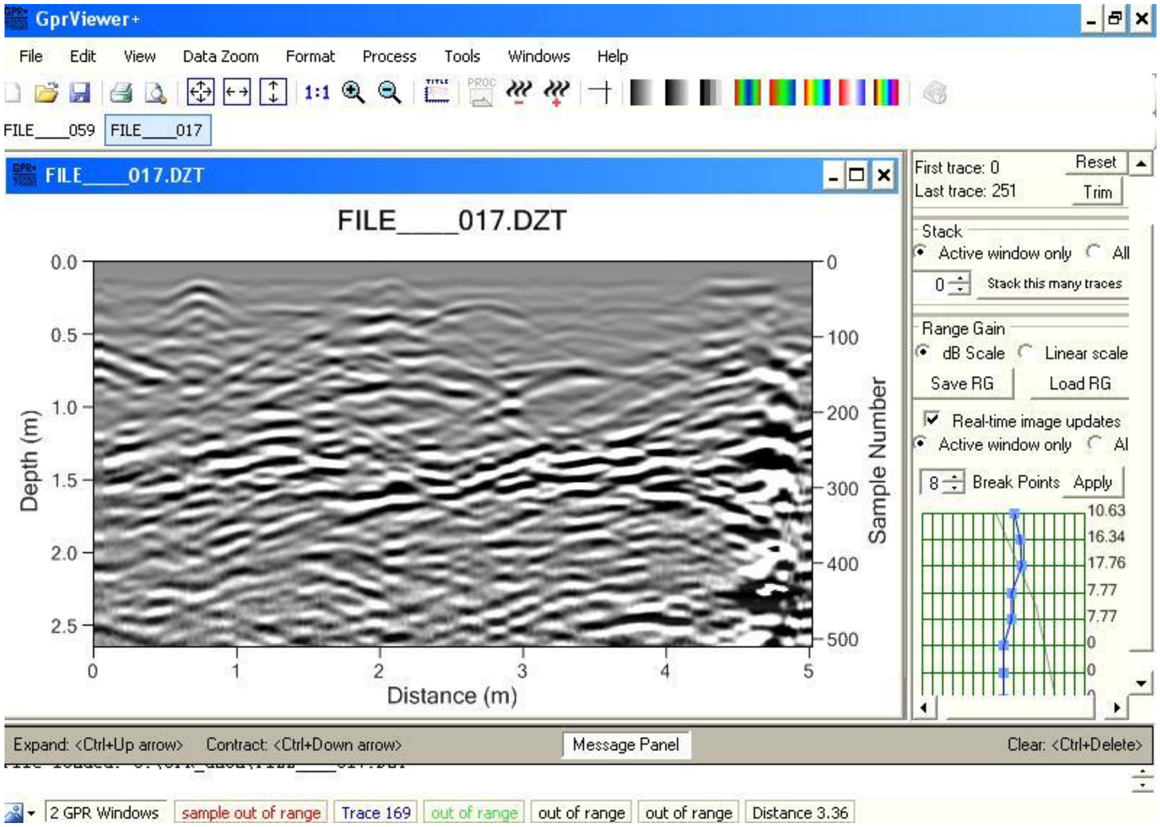
Introduction

GprViewer is a .NET 4 application produced to view, manipulate and process GPR reflection data. The USGS has developed this software in cooperation with the University of Denver and the U.S. Army Corps of Engineers. This software is based on the C-code GPR processing and display DOS programs that were developed in the 1990s and published in 2000 by the USGS (Jeffrey Lucius and Michael Powers). Some of these programs were incorporated into a Java GUI program in 2004, which has been used by the University of Denver and others. That program was used as a basis for this new software, which is written in C# (compiled with Visual Studio 2008). This newer version of GPR Viewer expands on and improves the capabilities of that 2004 Java application. Please note that this beta version does not yet have all the features active, as are noted below.

This software is written only for PC computers for Windows of any version. ***It is not compatible with Apple (Mac) operating systems or other computer operating systems.***

Please also note that because versions of Windows continue to change, take a small file library, zipped with the .exe file, called OX.copyable.dll, and place it in the same folder as GPRViewer.exe. This will allow GPR Viewer to work with any version of windows.



This software was written to produce two-dimensional reflection profiles of standard GPR data files. The software performs many basic data processing steps to produce images of reflections in the ground along transects. These processing and image processing steps are:

1. **place all reflection traces into a profile and assigning colors or gray scales to positive and negative amplitude reflections.**
2. **adjust axes of profiles for any vertical or horizontal exaggeration needed**
3. **placing reflection into accurate depth and distance**
4. **change and adjust axes, labels and titles**
5. **range-gaining reflections to adjust amplitudes for visualizing reflections of importance throughout the time window.**
6. **data processing to produce adjusted images that include:**
   a. **background removal**
   b. **trace stacking**
   c. **horizontal smoothing of traces**
   d. **spatial and time filtering *not yet in operation***
   e. **analytic signal processing *not yet in operation***
   f. **amplitude adjustment *not yet in operation***
7. **adjustments for time zero and depth corrections based on nominal RDP calculations**
8. **image exporting as BMP, GIF, JPG, PNG, TIF and WMF formats.**
9. **saving processed files for analysis by other software processing such as amplitude mapping or isosurface image production. Also allows saving in other GPR file formats for Sensors and Software and Mala systems, and also SEGY format.**

10. **zooming in on features of interest**
11. **view header information from original acquisition parameters**
12. **hyperbola fitting for velocity analysis**
13. **topographic corrections that adjust all reflections for surface elevation changes.**

Loading software on your computer

Nothing special needs to be done other than take the file called **GPRViewer.exe** and put it in a folder on your computer where you can find it again. Then just click on the icon that looks like this , or right click on this icon and create a "shortcut", which will produce a second icon and drag and drop that to your desktop. You can then start the program directly by clicking on that icon. Please also note that because versions of Windows continue to change, take a small file library, zipped with the .exe file, called OX.copyable.dll, and place it in the same folder as GPRViewer.exe. This will allow GPR Viewer to work with any version of windows.

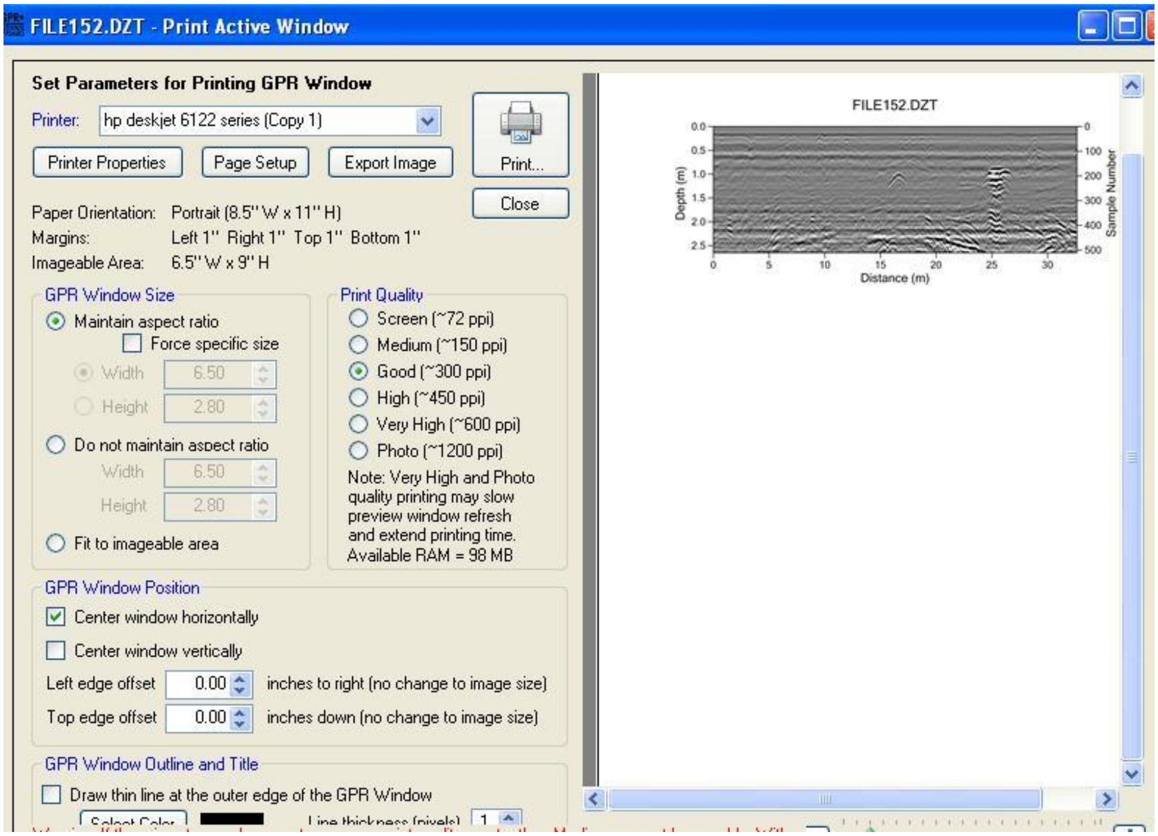
Opening GPR files

The following common GPR file formats can be opened by GPR Viewer:

A. GSSI files collected from SIR-2, 10, 20, 2000, 3000 systems and 4000 systems (.dzt)
B. Sensors and Software (.dt1)
C. Mala (.rd3) (.rd7)
D. SEG-Y files (.sgy): based on seismic reflection software
E. ***Soon to include IDS files***
    1. file-open or 
    2. browse for where your files are located on your computer hardware
    3. choose the file format of your data, GPR files or all files from the "files of types"
    4. the default image will have depth on the left axis, sample number on the right axis, distance on the bottom axis (if data were collected with a survey wheel this will be automatic), with the top axis showing the name of the file. These axis labels and scales can be adjusted, as discussed below.

File processing that can be done immediately from the icons in the window

1. **file-save as**  : you can immediately save this file in a different format, or this can be used to save your file after you have processed in many ways it with this software
2. **print active window** this will make a paper copy of the profile presently being analyzed. There are many different features for this printing function. You can also export the image as an image file from this menu.



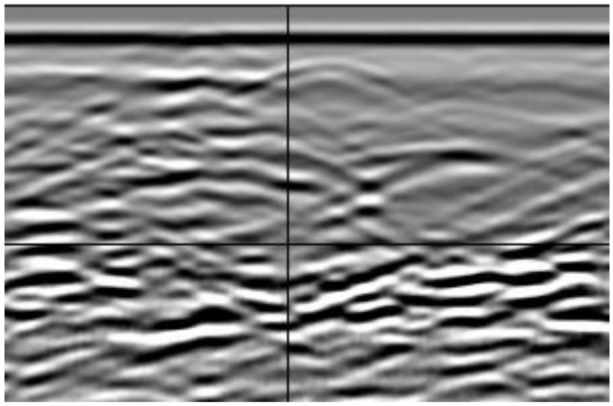
3. **fit to window, fit to window width, fit to window height, one pixel to sample, zoom in, zoom out** 1:1 ***I usually adjust the image by dragging the corners of the image around. The "zoom in" icon is very helpful in hyperbola fitting, which will be discussed below.***

4. **format image** : this will take you to a menu that allows you to change many aspects of the image including titles, units, fonts, grid lines, markers and colors. More on this below in the section titled..

5. **select processing sequence** ***this icon is not yet operable.*** You can also get into processing steps by clicking on "Process" at the top of the window. More will come later on different processing steps, where this icon will be useful in the future.

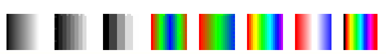
6. **remove background, restore background** **:** the icon with the negative below the wave symbol will remove a background wavelet. This processing step produces a composite trace that includes all reflections in all traces that occur at the same recorded time and removes those waves from every trace in the reflection profile. In this way the horizontal background noise is effectively removed from the profile. The background can be put back in by clicking on the red plus icon.

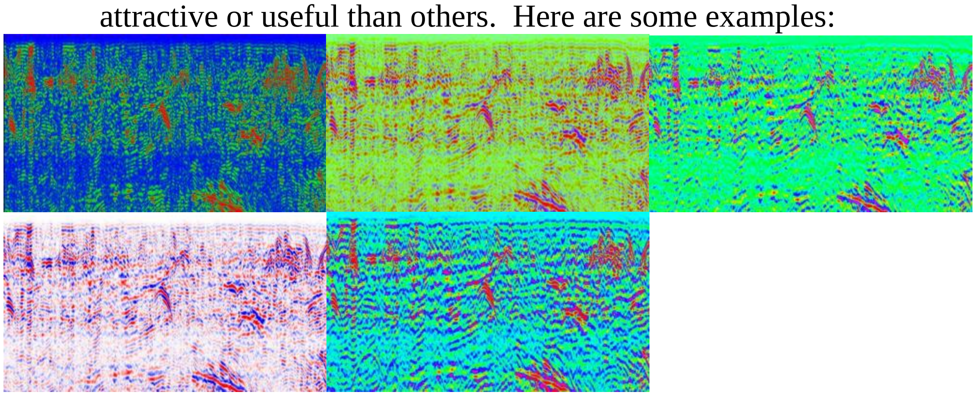
7. **turn cross hairs on and off** : you can produce cross hairs and move them around the reflection profile image, which looks like this:

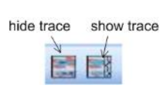


At the bottom of the window, a number of parameters related to where that cross hair is pointing will be displayed, an example that is shown below:

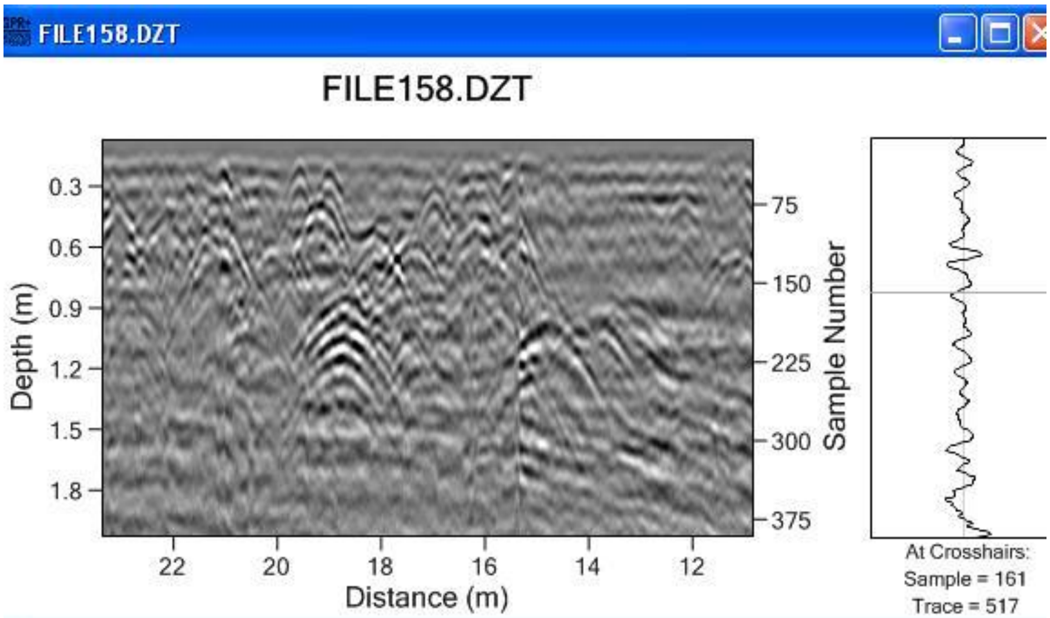
a. sample number (sample number in the trace at the cross hair)
b. the trace number in that profile
c. the amplitude (can be positive or negative value and related to the original gains that were saved during data collection or the gains you have placed on the image during processing)
d. the two-way travel time to that point in the profile (in nanoseconds)
e. the depth at that point (calculated based on the RDP you input, discussed below)
f. the distance along the profile (if you collected these data with a survey wheel that was accurately calibrated, or if you have .xyz and .mrk files in the same folder as the reflection profile file, which allow for the spatial placement of all traces in the reflection profile if you placed manual marks in the data during collection)

8. **adjust color pallets** : there are a number of shades of gray and colors that can be used to display reflections. Some are more attractive or useful than others. Here are some examples:



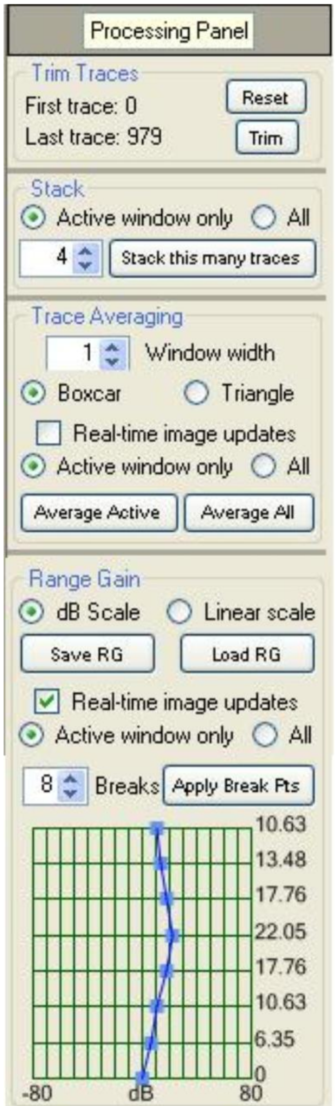
9. **show wiggle trace panel…** 

this is a very useful way to view individual traces, as you move the curser around the profile. When you click on the right icon the trace where you have the cursor on will appear on the right. This can be especially useful to determine the depth of energy attenuation (where the traces become very “spiky” and “noisy”). Also you can use it to look for polarity changes in reflections to determine velocity changes at depth (and which reflections might have been produced from void spaces).



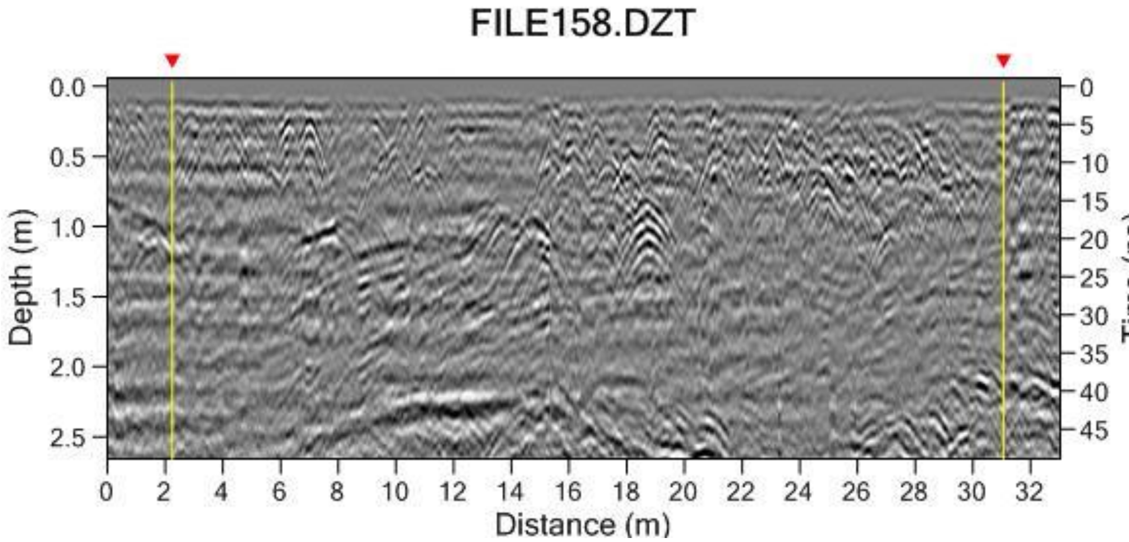
Processing panel: ***these are the most important steps that I use in my initial analyses of reflection profiles.* They are trace stacking, trace averaging and range gain adjustments.**

On the right side of the main window is the **processing panel** window that allows for immediately processing of the reflection profile image. This window looks like this:



a. **Trim Traces**: This step can "clean up" profiles that have portions tht include traces that are not needed in your interpretation. For instance, you can remove the first and last 30 traces of a profile, or whatever you wish.

- Right click on the left of the image where you wish to begin trimming to create a new profile. A window will then appear and choose "select this trace for start of trimming". And on the right side of the profile do the same thing but "select this trace for end of trimming". The yellow lines are the areas to be trimmed.

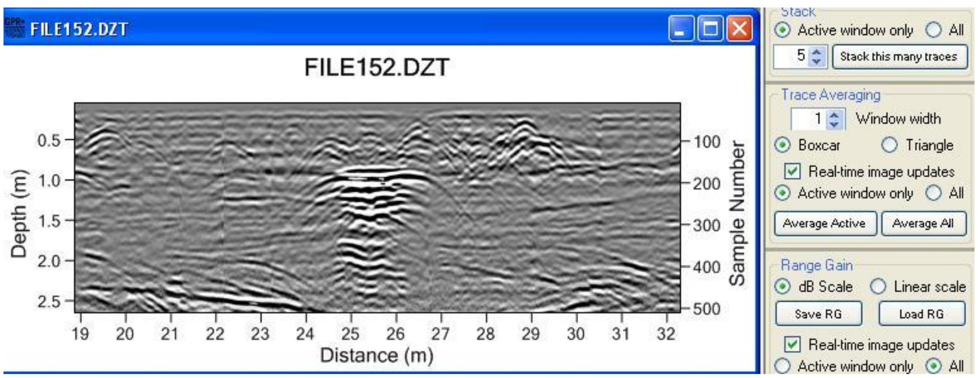


- Then click on "trim" and the traces to the left and right of where you have chosen to trim will no longer be part of this profile. The distance of the newly trimmed profile will then be adjusted accordingly. You may then save this new file as a different file. I suggest you NOT save it as the same name as the original file, but call it something like file153_tr.dzt or something like that so that you know it is the trimmed file.

b. **Stack:** this processing step begins by choosing a certain number of traces, which you input, by adjusting the up and down arrows for "stack this number of traces". The processing step will then average those number of traces and produce a new reflection profile with only the new averaged traces. For instance, if you choose a stack number of 4, it will take the first 4 traces in the profile and average them, and create a new trace #1 of those averaged traces. It will then go to traces 5, 6, 7 and 8 (the next 4) and produce a new trace #2 of those average traces. You will end up with a reflection profile produced from only 1/4th of the original traces. The distance scale will remain the same on the bottom axis after this operation. In this way an average reflection profile is created. You may choose "active window" or "all". Active window will do this processing step only for the profile you are working on in the visible window, and "all" will perform the same operation on all profiles that are active on the screen at the time (assuming you have opened up a number of profiles and are working on them all). It will NOT make these adjustments on any profiles that have been opened and then minimized, even if they could still potentially visible in the software window.

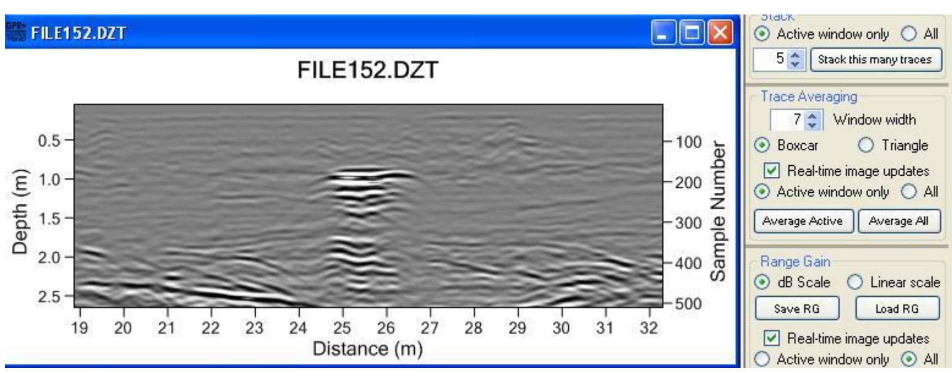
- Use the up or down arrows to choose the number of traces you wish to stack, or just input the number in the box and use the "enter" button on your keyboard to input that stack number.
- Click on "stack this many traces"
- Notice that too much stacking will remove hyperbolic point-source reflections and other small scale details. So be careful about doing too much stacking, as you can potentially remove important spatially-restricted reflections.

c. **Trace Averaging:** this process is much like stacking, but it does a "running average" of the amplitudes in a profile to smooth the reflections. There are two types of averaging. Boxcar averaging moves a box of a certain width (defined by a number of traces) through the profile, averaging the traces within that "boxcar" in front and behind each and every trace in the profile. This will create a smoother, more averaged profile and the number of traces in the profile will remain the same at the end of the operation. The trace averaging values are always odd numbers, as it is taking a certain number of traces prior to and after the trace that is being averaged. So if you choose a trace averaging of 5 it will average 2 traces in front and two behind, with the averaged trace in the middle. That trace in the middle will then be replaced with this average trace in the new processed profile.



If you click on "real-time image updates" you can see how your averaging operation affects the profile. The distance scale will remain the same after this averaging process.

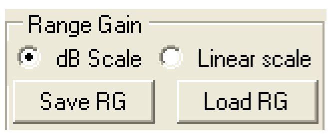
If you average too many traces, many of the smaller, potentially important reflection features will be removed just as in stacking, such as those from the tree roots visible in the upper 50 cm of the profile above. When averaged in a boxcar 5 traces wide, notice how all these small features are averaged out, and only the large prominent feature from 24-27 meters remains in the image, seen below.



The "triangle" trace averaging processing step works much the same way as a boxcar, but weights the traces differently during averaging. In this step a greater weight is given to the trace in the middle of the boxcar, and less on the traces farther away from the middle of the boxcar. This averaging is done on a linear scale. Always click "real-time image updates" so you can see how your processing step affects the amplitudes in your profiles.

d. Range gain: this processing step is very important and will increase the amplitudes of reflections, especially those deeper in the time window. By increasing the amplitudes, be aware that you will also be increasing the amplitudes of background noise. That noise will then have to be removed by clicking on the "remove background" icon every time you change the gains. Too much gain will "clip" the reflection amplitudes and produce "oversaturated" reflections in profiles. So this step requires some experiment on each dataset to get the gains so that all the reflections are visible at the depth you are interested in.

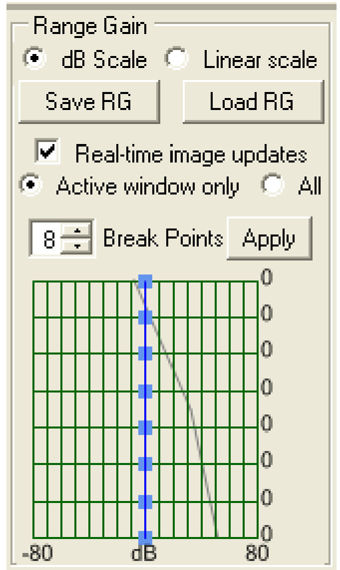
- **You may choose two scales: linear or dB.** dB is a logarithmic amplitude scale, and linear is arithmetic.
- **Save RB or load RB:** ***This allows you to save gains you are happy with for future processing of other profiles.***



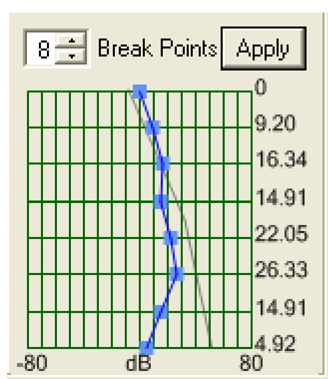
This will save the gain settings in the folder where your reflection data are saved in this way:

You can re-load them at any time in the future for further processing, even if you have closed out the program.

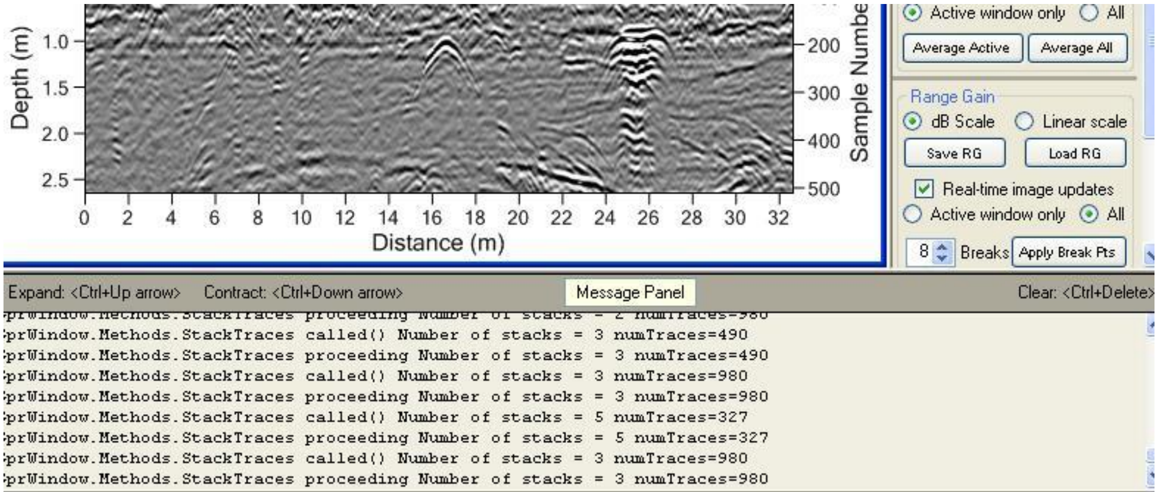
- **Real-time image updates**: click on this box. The program will then change the amplitudes in the profile in real time and allow you to see the results in the displayed profile as you change the gain amounts.



- Above are the gain points in blue, which you can adjust to enhance amplitudes. ***The black line represents the gains that were applied in the field and saved in the original file. By moving the blue "break points" with the mouse you are increasing those already saved gains to enhance the amplitudes on the profile being viewed. Only GSSI files (.dzt) save the gains applied in the field. Other formats save files with no gains, so you must always re-gain them to make them visible.*** Many prefer to use 8 break points, which will allow you to adjust amplitudes higher in some parts of the time window, and lesser elsewhere. The maximum number of gain points is 16. When you change the gain points click on "apply" and it will save those, and then you can adjust gains in the same way.
- Take your mouse and move the gain points in blue to the right, which will increase the amplitudes. As long as the "real-time image update" box is checked you can see what the reflection profile will look at the image to the left and see how those adjustments have altered the strength of the reflections. When you click "all", every profile you open after this will automatically have their gains adjusted with the points you have on the screen and all other profiles that are active in the window at the time.



Message Panel: At the bottom of the profile is a panel that shows all the original collection parameters, and also the processing steps you have gone through in analyzing the reflection profile you are presently working on. In this image below you can see all the stacking steps I used to process this image.

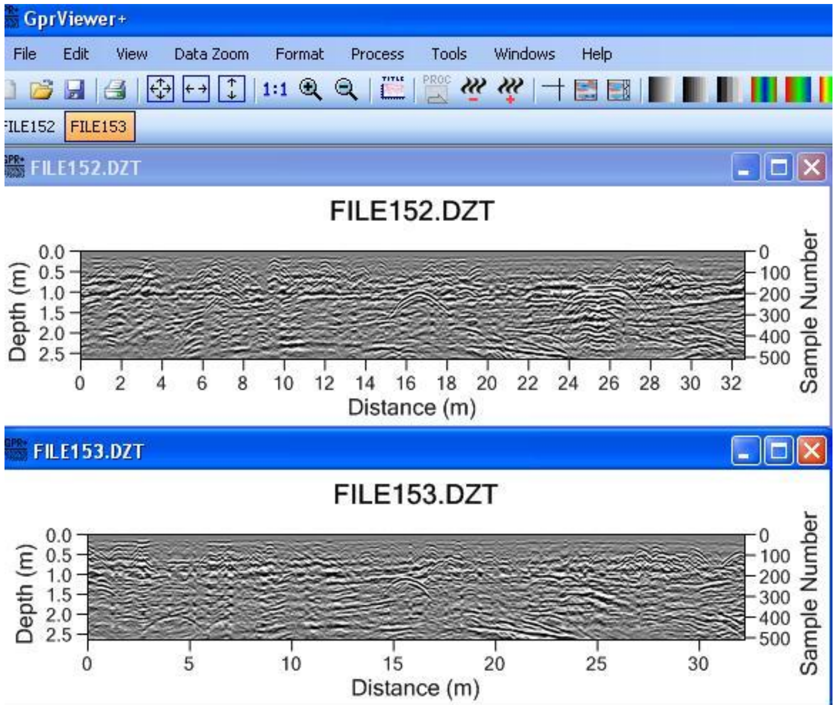


Perhaps a more important use of this message panel box is looking up all the original collection parameters. In this image below you can see some of those, which can be viewed by using the scroll bar on the right and moving it up to the top.

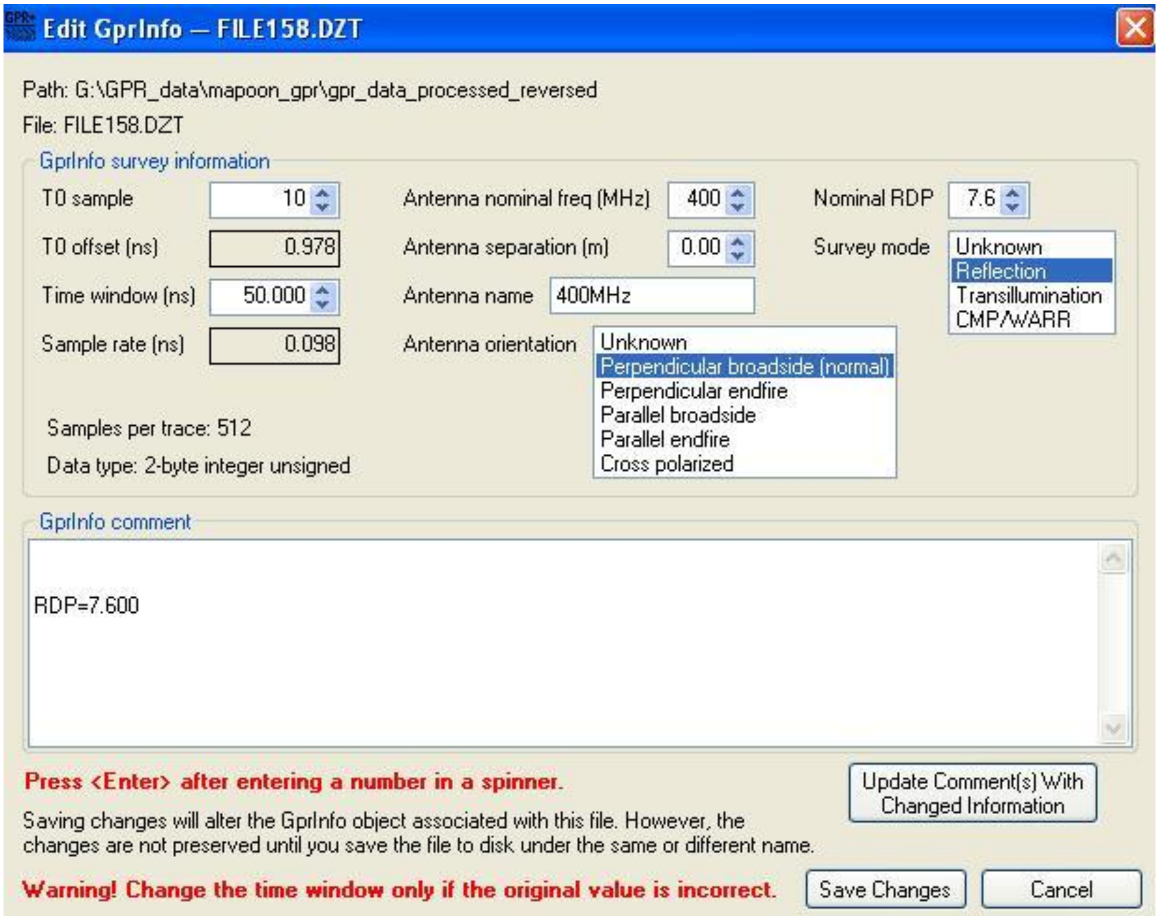
The message panel takes up some room on your computer screen that could otherwise be used to view your profile. Depending on the size of your screen you might like more or less of the message panel displayed. To change its size you can expand it by using the "control" and the "up-arrow" keys simultaneously. To make the window smaller use the "control" and "down-arrow". ***I prefer to make the message panel as small as possible during my usual processing steps, and then expand it only when I need to look at the data stored there.***

Other important processing and display steps.

a. **change how the profiles are displayed on the screen**: this allows you to tile multiple profiles in a number of different ways on the screen so you can view and analyze more than one profile simultaneously. To get into this part of the program click on "Windows" and click on "cascade", tile vertically, or tile horizontally and you will see a number of different displays.



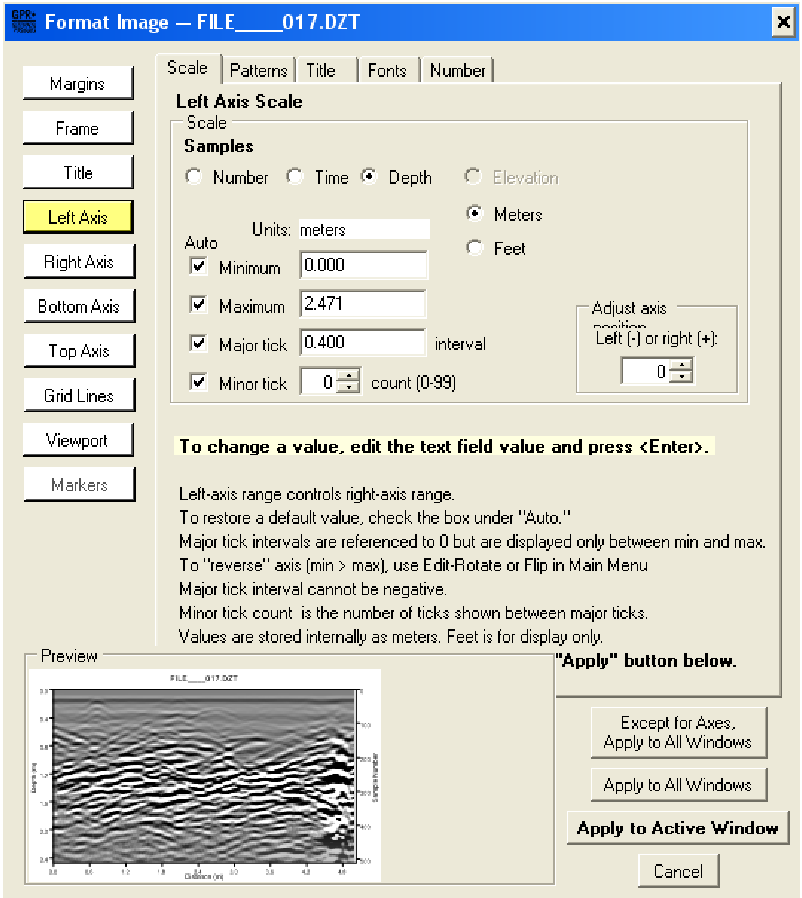
b. **set time zero and change the RDP to adjust depths for velocity:** both of these adjustments will allow you to create more accurate reflection profiles in depth. If you know what your time zero was when you set it in the field, you can use that value to adjust all traces so that the ground surface is at the top of the profile in GPR Viewer. If you do not know that time zero value, you can open a reflection file in GPR Viewer and find the first "direct" wave in nanoseconds and note that value by looking at individual wiggle traces. As you move the cursor around, look at the bottom of the GPR Viewer window and find that sample number where the first significant deflection is in the trace (in samples or two-way travel time). Then go to "tools"- "get **GPRInfo** for active file" This window will open:



a. **time zero adjustment:** adjust T0 sample up and down. These values are in samples in the trace. As you adjust this value you will see the T0 offset change in nanoseconds in the window below. In the window above the time zero is .978 nanoseconds, which is at sample number 10.

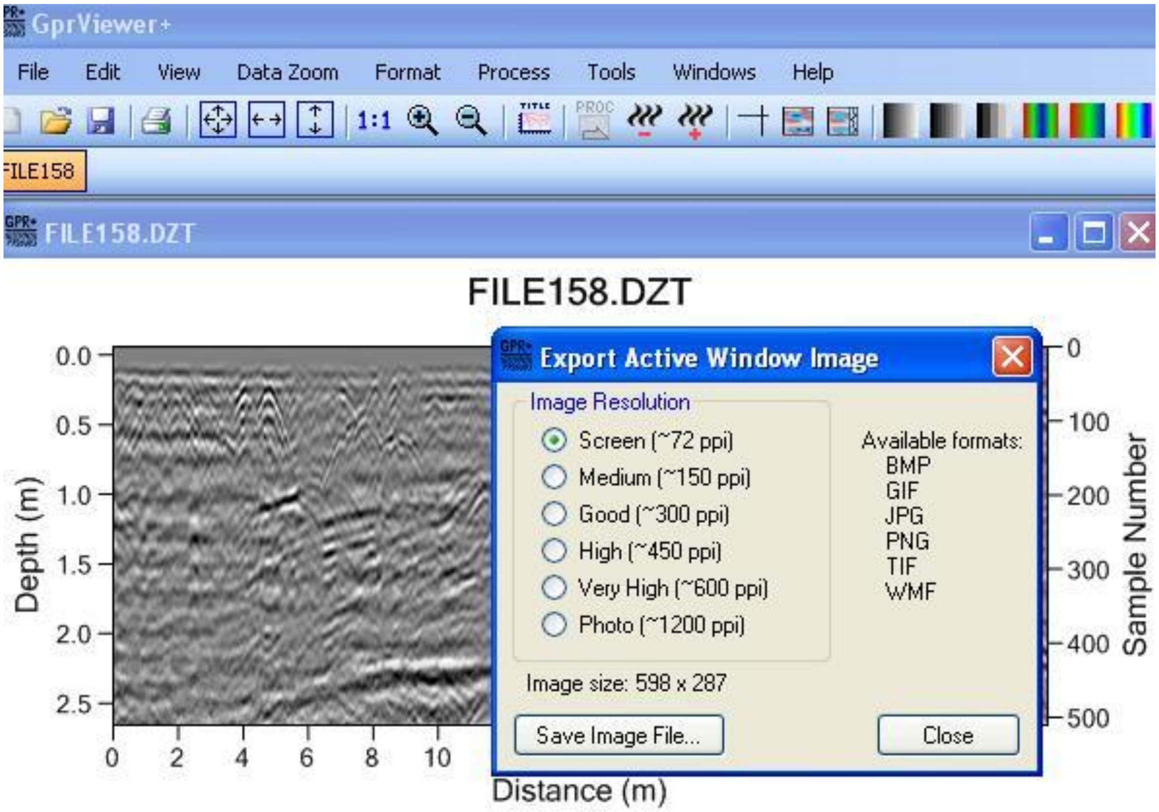
b. **RDP adjustment to adjust time to depth:** the default in the program is an RDP of 8. To correct your radar travel times to depth you need to know velocity (RDP is a proxy measurement for velocity). There are many ways to get this value (Conyers and Lucius 1996; Conyers, 2004: 99). Below is a discussion of hyperbola fitting, which is part of this program to arrive at RDP. When you change this RDP value with the up and down arrows you must then click on "save changes". Or you can input a RDP value in the box and then type the "enter" key to save it. All times on the left axis of the profile will then be correctly adjusted for this velocity, as will all profiles that you open after you have made this adjustment. If you close the program and then open it up again, you will need to make these adjustments again for the correct velocity adjustments.

c. **Other adjustments to the image:** you can change many aspects of the image including fonts, axes, colors, decimal points in values, tick marks and scales. To get into that menu go to "format" –"format image" or this icon . This window comes up:



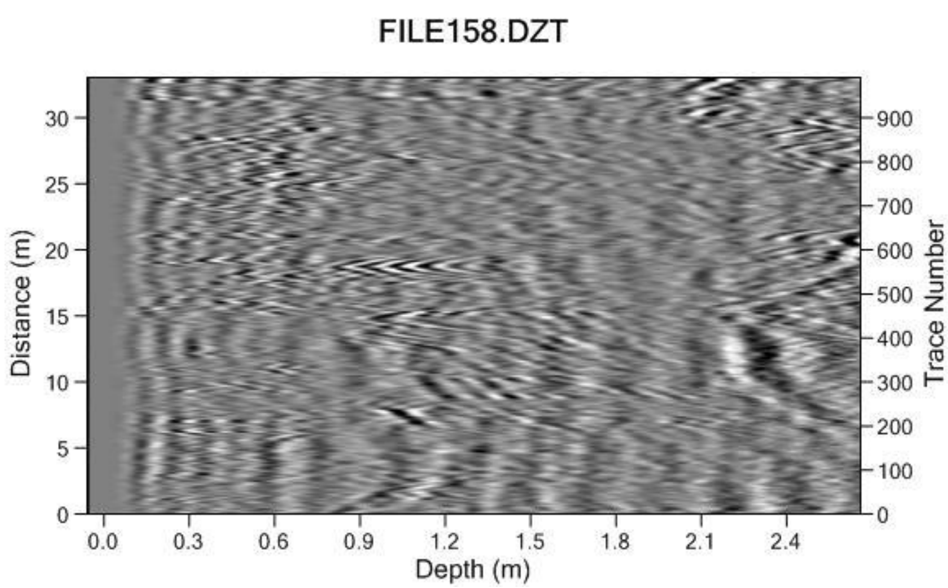
There are many buttons and adjustments on this window, which will allow you to produce a different image style. A preview of your changes can be seen at the bottom of this window. When you have changed what you want click on "Apply to Active Window" or "Apply to All Windows" if you want these changes to be the same for all profiles you open in this session.

- **Produce an image of your file**: This is a very important step to save profiles for reports or other displays. You can then take the new image files and annotated them in other software programs to point out interesting reflection features you are interested in. Click on "File", "Export Image". This window then opens up:

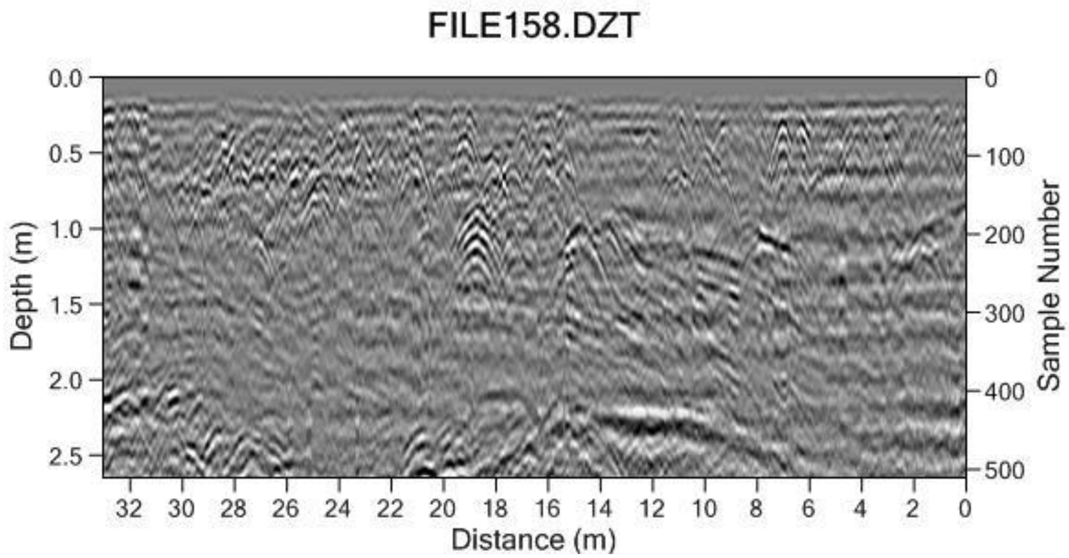


You can now save this image in different file formats with different resolutions in ppi (pixels per inch). Click "Save Image File" and browse for the location where you want the file saved, calling it whatever you want.

- **Flip profiles horizontally, vertically or rotate them:** There are a number of ways you can change the view of the profiles. Click on "Edit" and then you can choose "Rotate", "Flip Horizontally" or "Flip Vertically".
  a. **Rotate** is an interesting command, ***but one I can't see myself using***. ***You can get all kinds of interesting views, none of which I have figured out a good reason to use.*** Rotated 90 degrees looks like this:



b. **Flip Horizontally** will reverse the lines. This can be useful when you have collected data in a grid with alternating profiles starting and stopping at different edges of grid baselines. But remember when this flipping is done, the program saves the distances that were originally collected in the field. In the case below the beginning of the line collected is now on the right, and it can be seen as the 0 meters on this profile below.



A better way to reverse alternating many lines in a grid is to actually reverse them using a different program called "GPR Process", which will allow you to created new reflection profiles where the first trace is the last, and the last the first (http://mysite.du.edu/~lconyer/misc_software.htm). Using this program all traces in files you can choose are reversed so that all start and stop at the same distances in a grid.

c. **Flip vertically** is even less useful than the other options. I have heard that people who collect 'borehole" GPR, where reflections are collected from the bottom of a hole up might be interested in this option. The rest of us will not ever use this.

Hyperbola fitting for velocity analysis and to obtain RDP values

While there are a number of direct ways to calculate velocities, and then convert two-way travel time to depth (Conyers and Lucius 1996), the best indirect way after returning from the field is hyperbola fitting. This method uses point-source hyperbolas, generated from buried objects, pipes, tops of walls, stones and many other materials of this sort in the ground. All will generate hyperbolic shaped reflections with broad-band GPR antennas, which transmit energy into the ground in a cone. This energy spreads out with depth, and therefore generates hyperbolas from buried aerially-restricted objects in reflection profiles (Conyers, 2004: 57). The shape of the hyperbola axes is a function of the velocity of radar energy traveling into the ground. When you can match the shape of a hyperbola in this command to those produced from buried objects, this program can be used to approximate velocity.

There are four variables that must be known in order to arrive at velocity using hyperbola fitting:

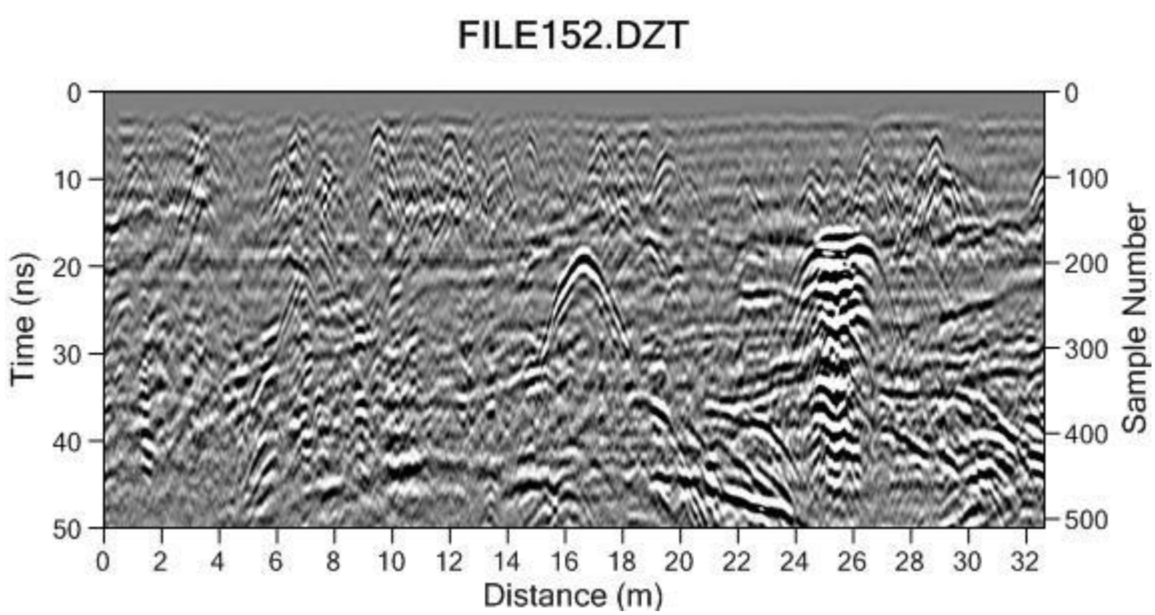
1. two-way travel time (**measured directly by the GPR system**)
2. measured distance on the ground (**recorded by the survey wheel or other measurement device at the surface**)
3. distance between the surface transmitting and receiving antennas (**can be measured or estimated**)
4. the radius of the object in the ground producing the hyperbola (**usually not known, so it must usually be estimated**)

Once these variables are input in the program, hyperbolas can be "fit" to those visible in the profile and relative dielectric permittivity (RDP, which is an approximation of velocity) can be obtained. That value can then be input in "Tools" "Edit GPRInfo for Active File" in order to convert travel times to depth in the ground for the profiles being processed.

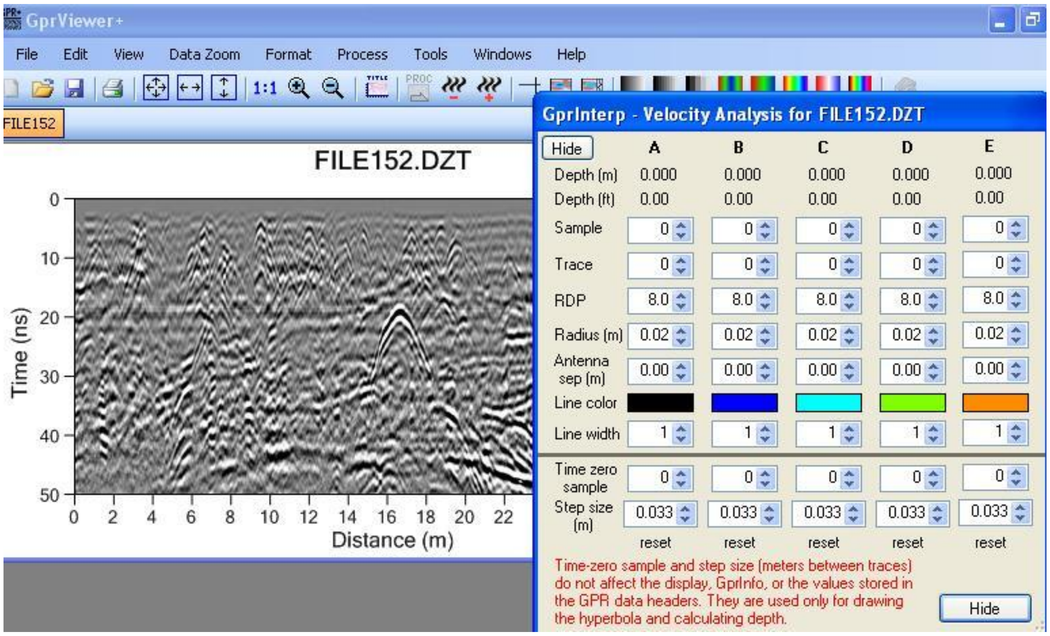
Follow these steps to calculate RDP:

- Open a file that has a hyperbola in it.

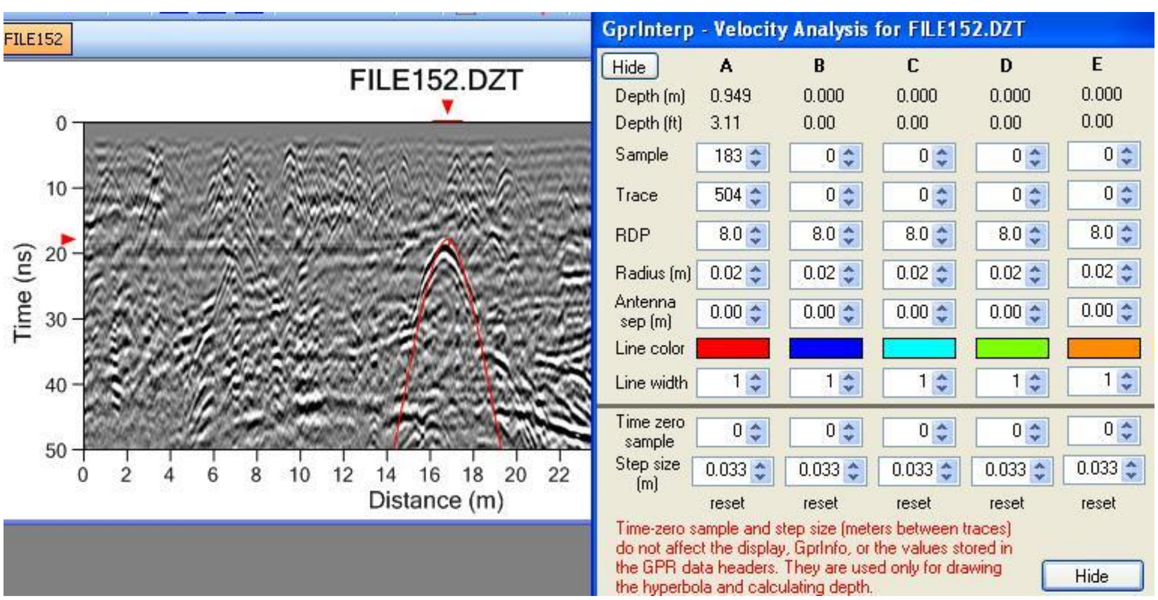
- Change the left axis on the profile to time from the default, which is distance. To do this: "Format Image", "Left Axis", choose "time", then "apply to window".



- right click anywhere on the profile. When you do this, a new window will open. In that window choose "show hyperbola fitting panel". This box will then appear for hyperbola fitting

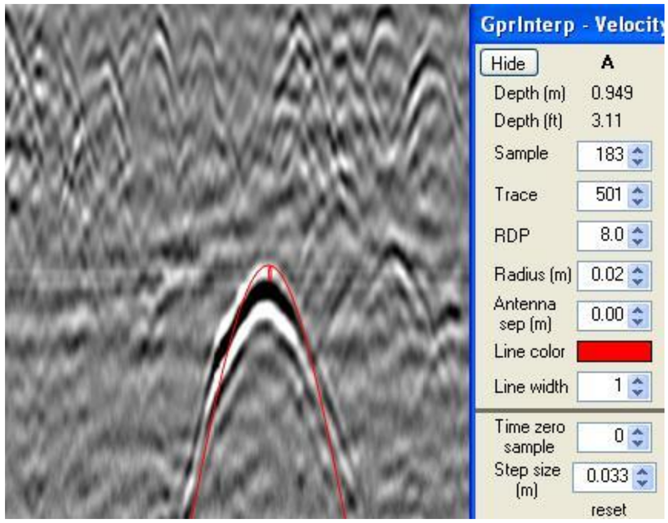


- move the cursor to close to the apex of the hyperbola to be tested. Right click and a different window will open. Choose "Select this sample and trace for hyperbola fitting". Don't worry if you have not chosen exactly the correct location of the hyperbola axis at this point. You can refine this location in steps to follow. When you do this, a hyperbola will appear on the screen. This is called test A. You have the ability to test 5 hyperbolas simultaneously in each profile. You can change hyperbola colors by double clicking on the color boxes for each hyperbola test (A-E).

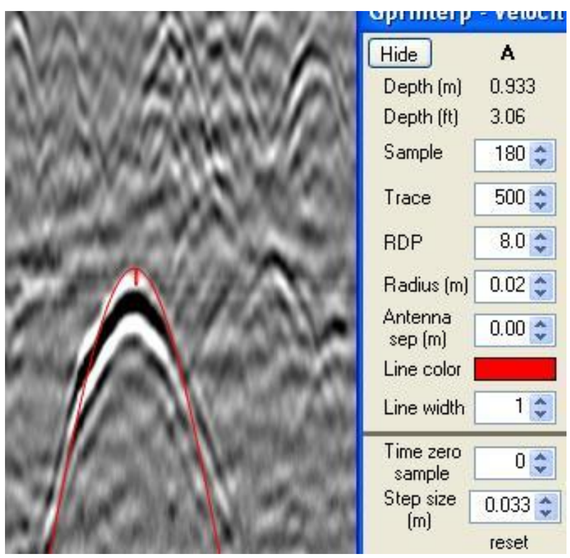


- there are a number of values that need to be input in the Velocity Analysis window:
  - **sample and trace**: changing these will move the apex of the hyperbola to exactly the correct spot, if you did not click on the perfect location above when you started this process. You will always have to change this location somewhat. Before you attempt to change the

sample and trace, which will move the hyperbola, click on the  icon, which is the “zoom in” icon. This will allow you to see the hyperbola better, and then you can drag and drop the window with the hyperbola parameters on it to you can see the hyperbola and adjust sample and trace to the apex of the hyperbola in the profile precisely.

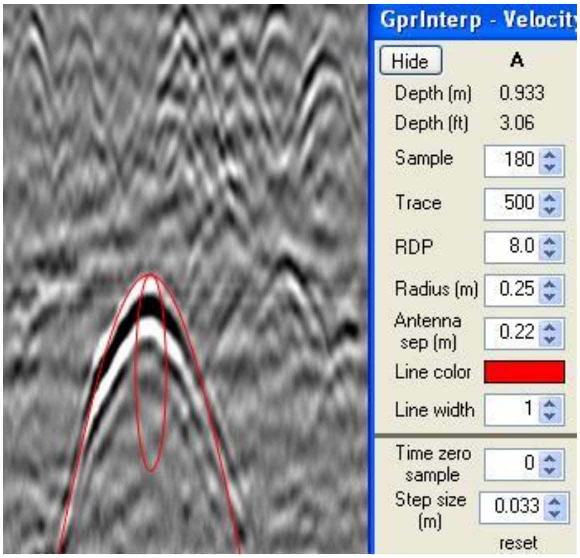


At this point you have changed the sample values and the trace values, to move the generated hyperbola so that its apex is directly at the top of the “white” portion of this hyperbola. This will then allow you to precisely fit the model hyperbola to this reflection in the profile.

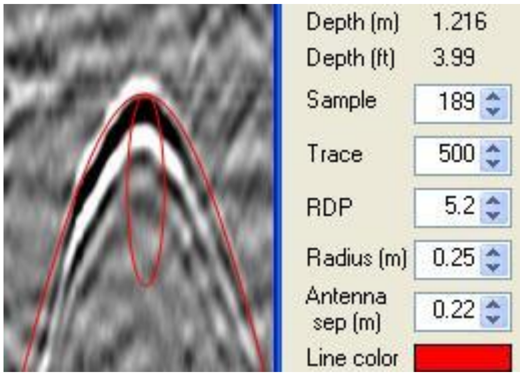


- Now it is time to refine your velocity estimate. The default RDP is 8. To get a correct RDP you must make a few minor adjustments in some of the windows. One is the antenna separation. With GSSI antennas the 400 MHz and 900 MHz antennas are separated about 16 centimeters. The 270 MHz antennas are separated about 22 centimeters and the 200 MHz about 34 cm (values are shown in the box in meters, not centimeters). If you have other antennas, you can estimate separation, or measure them. ***Small errors in***

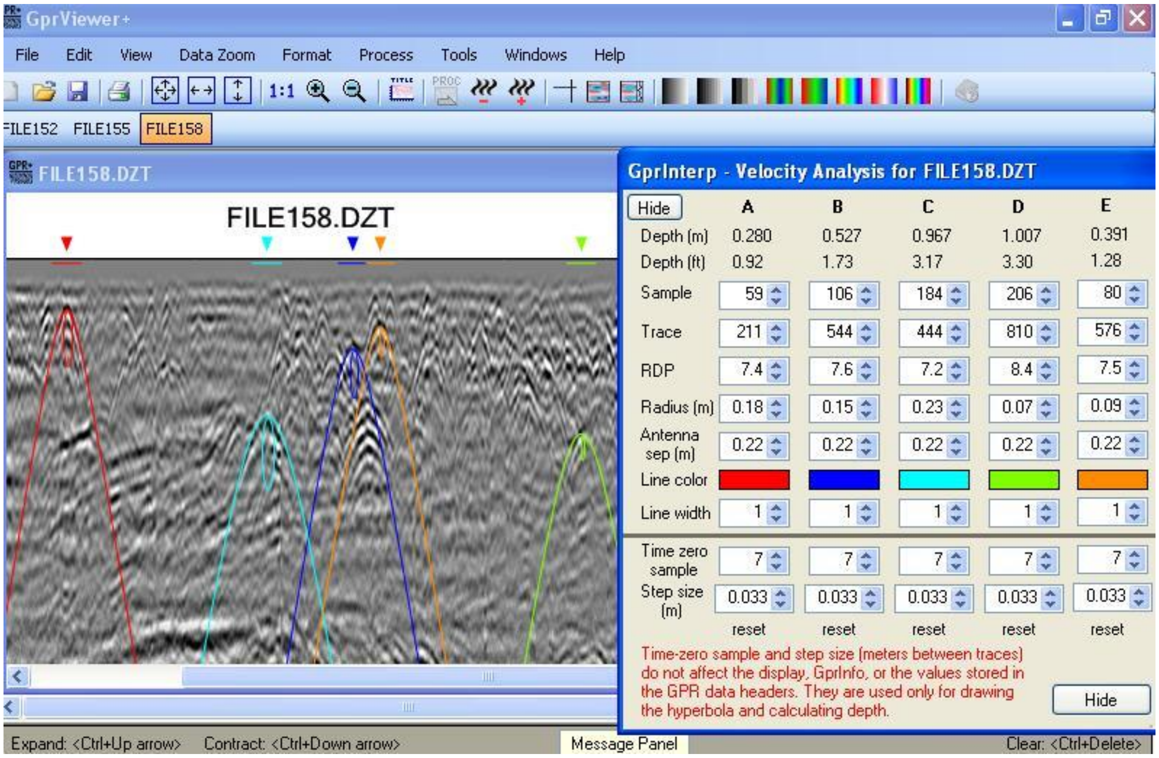
antenna separation measurements here will make very little difference in your velocity estimates, so don't worry about this too much. I know that the target in this profile that generated the hyperbola has a radius of about 25 cm. When that radius is changed, an oval appears that shows the approximate shape of that point source in the ground, as if it was the top of a wall, or some other feature of that sort. Also change the time zero to whatever the time in nanoseconds is where the first wave was recorded at the top of each trace.



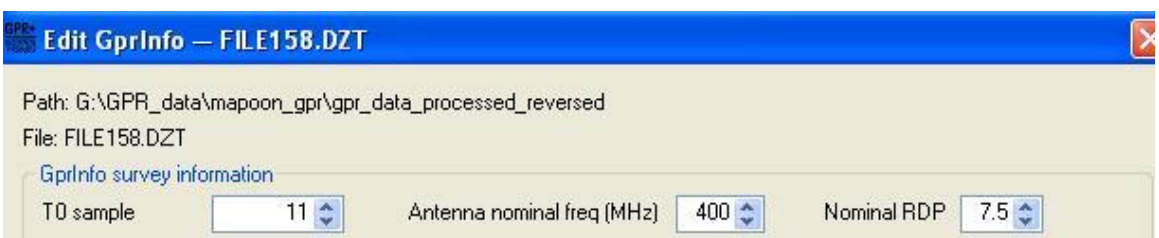
- you can now change the values of RDP until the hyperbola you have generated with the program is directly on the hyperbola generated in the ground. Just move the RDP up or down arrows to slowly change the modeled hyperbola so it fits that in the profile. In the example below the best fit shows an RDP of about 5.2. It also gives the depth of the top of the point source at 1.216 meters, or 3.99 feet.



- if you have many hyperbolas in a profile and want to calculate an average velocity along a transect, you can fit a number of hyperbolas, and then get an average velocity. In this profile below the RDPs vary from 7.2 to 8.4. You can average them and use this velocity for all processing, or use different RDP values for different depths depending on where your target reflections are located in the ground.



Now that you have an RDP, or series of RDP values you are happy with, you can go back to the main GPR Viewer panel and adjust RDP, and then change the vertical scale to distance so that all radar travel times are converted to depth in the ground. To do this go to "Tools", "Get GPR Info for Active File". This menu will then show up, and you can change the RDP to that you have calculated in hyperbola fitting.

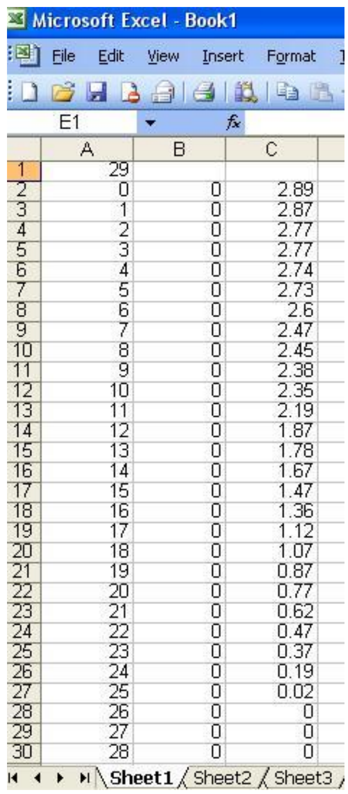


You can now go to "Format Image", "Left Axis", and check "distance". That depth will now be adjusted for the RDP value you have input. Make sure you change the Time Zero value also in this screen so that depth is as exact as you can get it.

Topographic corrections to adjust for ground surface variations

This function is very important if there is any variation in surface elevations along transects. It is only possible if you have a method to obtain elevations along each transect to be adjusted. Those elevations can be obtained with usual surveying methods, such as a total station, or using GPS. It is important to have elevations at every break in slope or other significant change in elevation. In areas that are flat, or sloping gently and with little variation, survey points can be spaced greater distances apart. The program interpolates between elevation points, so if the ground is very un-even, it is important to have many topographic points for the adjustment function in GPR Viewer.

Each profile must have a corresponding text file that contains the survey points. That file must be named the same as the data file, but called .xyz. And it must be located in the same folder on your computer as the data file. For instance, if the data file you wish to topographically adjust is called **FILE____028.dzt** then the data file with topographic points on it for the adjustment needs to be called **FILE____028.xyz**. There are many ways to produce these .xyz files. I often use Excel spreadsheets to prepare them. In this example below I have one survey point every meter along the reflection profile. The profile is 28 meters long, and so therefore there are 29 survey points (one every meter along the transect, and one at the beginning and one at the end of the line. Here is the Excel spreadsheet I used for this file:

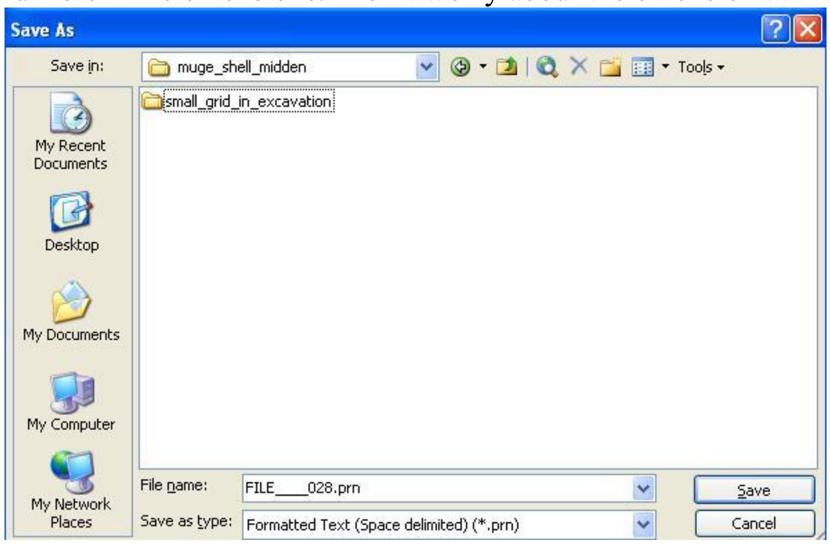


	A	B	C
1	29		
2	0	0	2.89
3	1	0	2.87
4	2	0	2.77
5	3	0	2.77
6	4	0	2.74
7	5	0	2.73
8	6	0	2.6
9	7	0	2.47
10	8	0	2.45
11	9	0	2.38
12	10	0	2.35
13	11	0	2.19
14	12	0	1.87
15	13	0	1.78
16	14	0	1.67
17	15	0	1.47
18	16	0	1.36
19	17	0	1.12
20	18	0	1.07
21	19	0	0.87
22	20	0	0.77
23	21	0	0.62
24	22	0	0.47
25	23	0	0.37
26	24	0	0.19
27	25	0	0.02
28	26	0	0
29	27	0	0
30	28	0	0

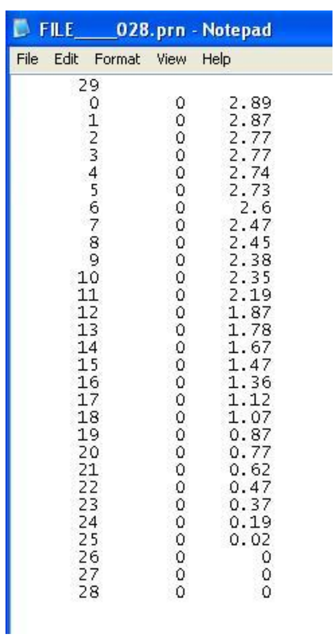
In this example the first row in column 1 tells the software how many survey points to expect (in this case with a 28 meter long line with one point every meter, there are 29 survey points). The remainder of the numbers in column 1 are the distances along this profile where data were obtained. Row two in this case are all zeros. Just leave them that way. This column will come in handy for later version of the software. Column three are the elevations used for the topographic adjustments. The data I am using for this adjustment are relative values of meters above a temporary datum, which is zero. But they can be any values (meters above sea level, meters above some other datum…whatever you want). The values in column one need not be whole numbers, as in the example above. They can be decimal numbers, or any values you obtain from your survey. Be careful that your last survey point along the line (in the case above at 28 meters) is not beyond the distance you actually collected data. For instance if you have a survey point at 28, but your profile is only 27.5 meters long, the program will choke up looking to adjust reflections beyond where you actually have data. ***These values need***

not be meters, but you can input them in feet, if your data were collected in feet also and saved that way.

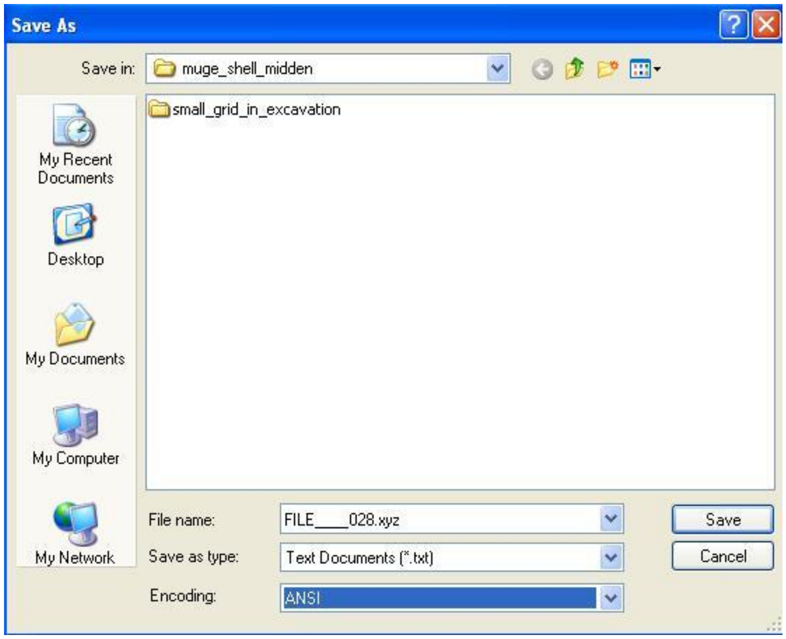
You can then take your spreadsheet and save it to produce a **space delimited, tab delimited, comma delimited or semicolon delimited** text file. Each of these text file formats have different file extensions. Don't worry about the extension at this point.



At this point you might have a file with a .txt file extension or perhaps .prn or .csv, depending on you saved it. You can open it in Notepad or any other text file editor.

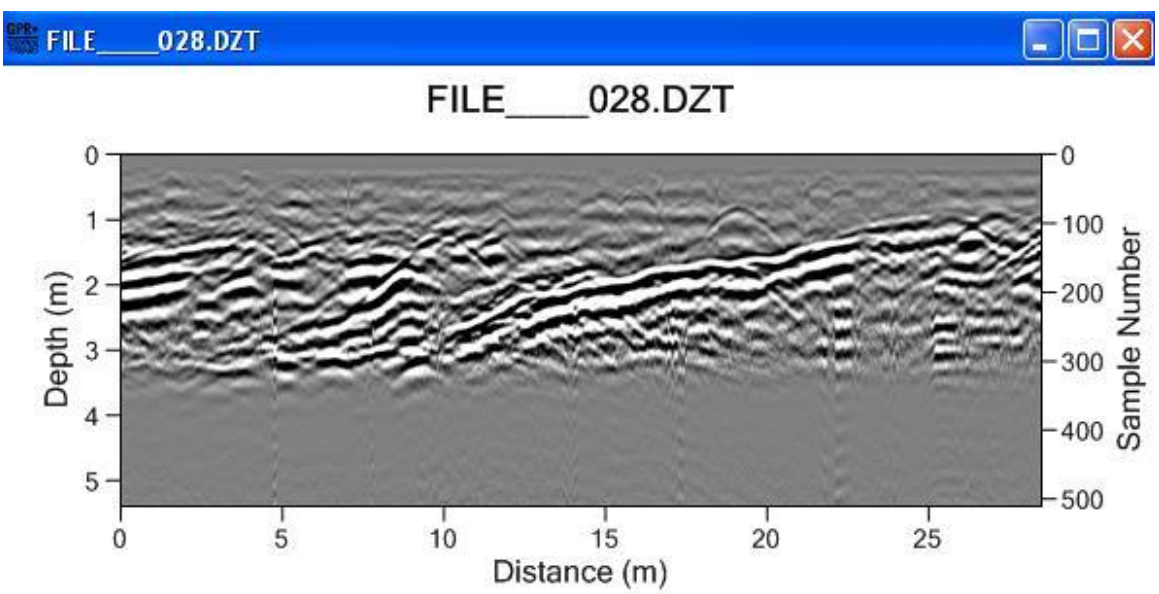


You must then do a "save as" and save this same file with an .xyz file extension. ***It must be called the same name as the data file, but with an .xyz file extension.***

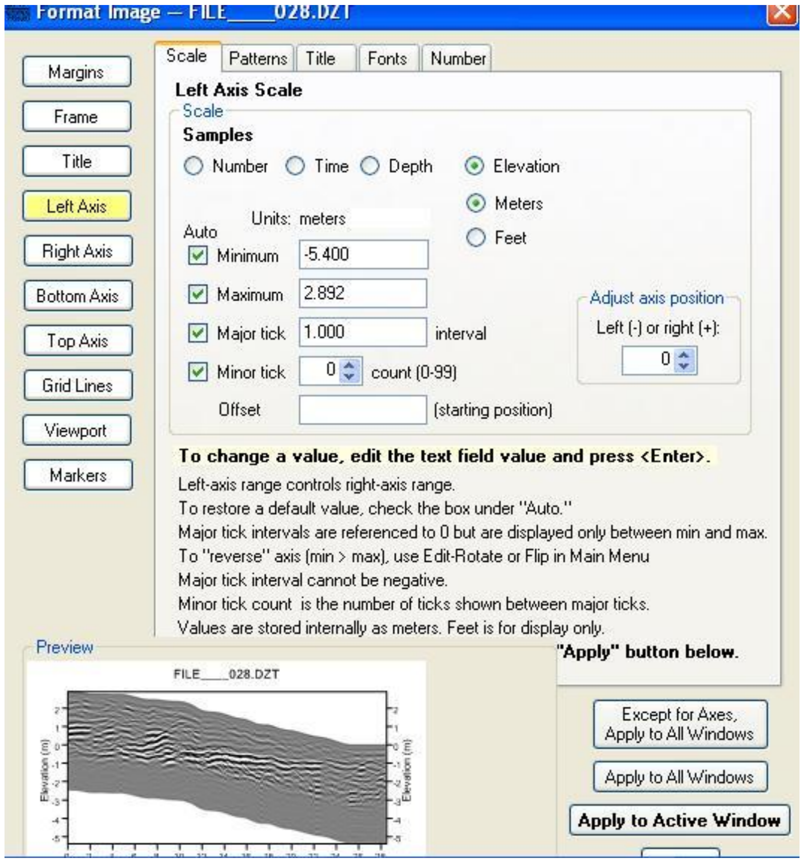


Your file editor might warn you at this point about different possible problems with a "save as", but don't worry about them. Just continue to save it.

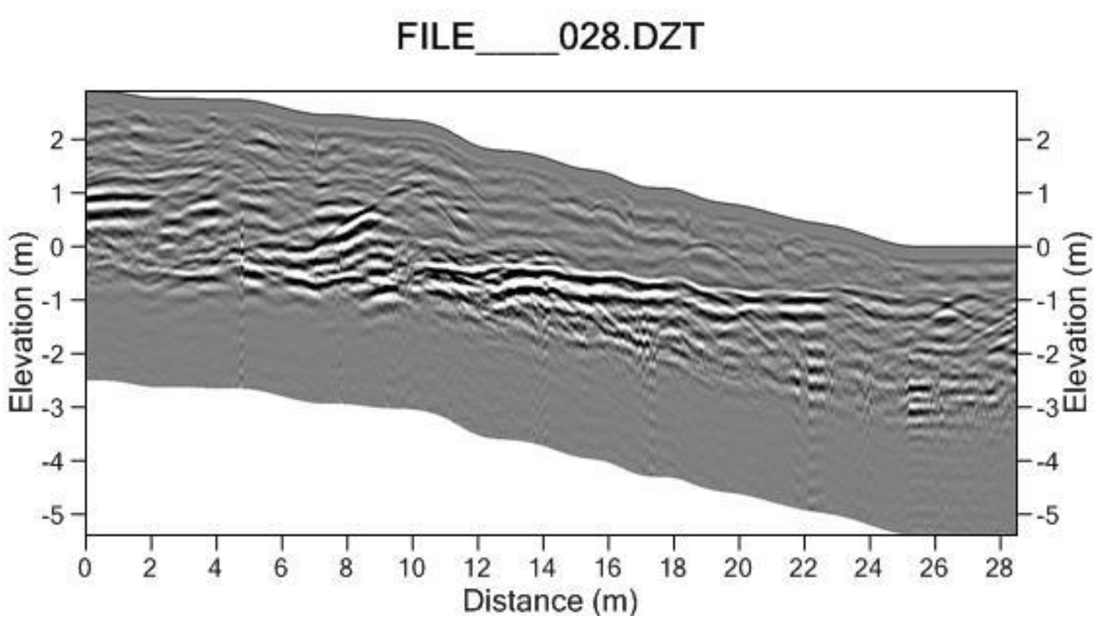
Do this for every file you want to have topographically adjusted, each named separately. You can then open up a GPR reflection file in the usual way with GPR Viewer, and it will display it un-adjusted for topographically. You can process these data to remove background, increase or decrease gains, or whatever is important to interpret the reflections you are interested in.



When you are ready to adjust this profile for topography do a "Format Image" and for the Left Axis click the "Elevation" circle. This will then adjust all the traces in the profile for topography. You can do this in either meters or feet, depending on how you collected the reflection data. Notice at the bottom of this window there is a small window that shows what your profile will look like when this function has been completed. Then choose “Apply to Active Window”, and the adjusted profile will be generated on the screen.



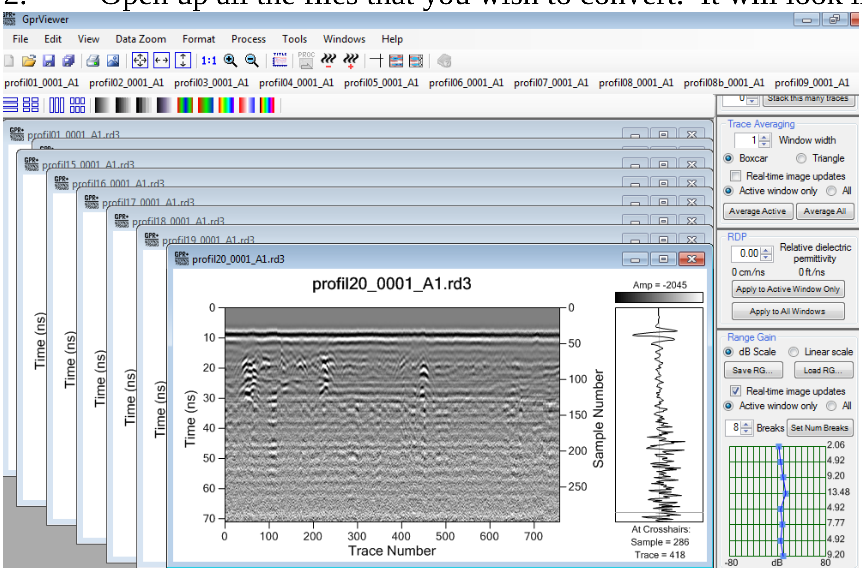
You can still change gains and adjust the reflections in other ways after the topographic corrections have been completed.



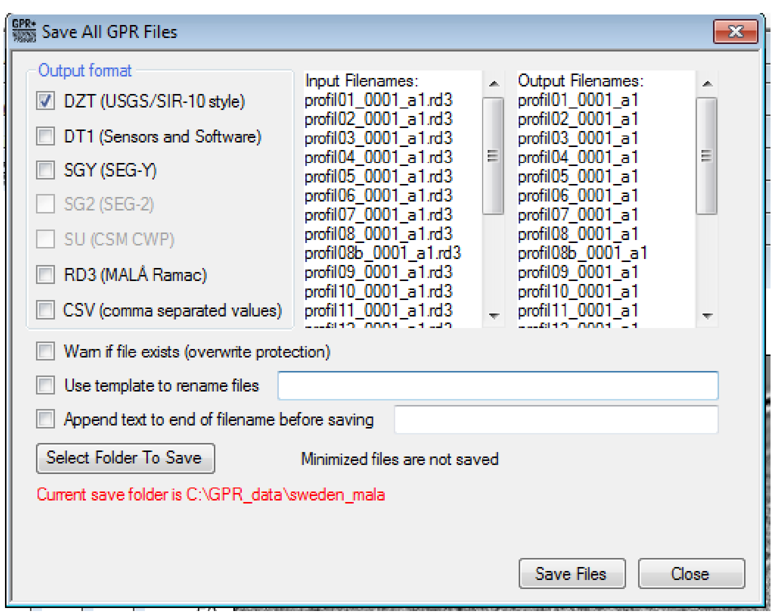
Using GPR Viewer to convert other file formats to .dzt files

This is very important if you have reflection data from other GPR systems (so far only Mala, Sensors and Software, and soon to have IDS capabilities) and convert them to GSSI format. Our GPR Process software is used to slice grids of files into horizontal slices***. To use this program you will need to have converted to the SIR-10 version of .dzt files. The same is true for SIR-3000 and SIR-4000 system files by GSSI.***

1. Prior to converting the files make sure that the accompanying header information files are in the same folder as the reflection profile files. Each GPR company has little 1 KB files that include information about the number of traces distance of the files, and much other important material of that sort. For Mala those data files are called. .rad files. Each company has their own "header files" of this sort. The older versions of GSSI files include this information within the .dzt files. The new SIR-4000 systems now have little header files that go with each profile
2. Open up all the files that you wish to convert. It will look like this:



3. Then go to the menu bars on the top of the screen and choose "File", "Save all files". This window will open:



Click on the "dzt" USGS SIR-10 style

As soon as you do this, you will see the output file names in the box on the right, which will be converted, using the same names that you have in the old format, but they all will have .dzt extensions.

Note: we have not yet completed the template to rename the files…this is important if you want to use GPR Process, because following very old GSSI methods, all files must start with the word "file" and be in sequential order, such as file1.dzt, file2.dzt. Until that rename template is finished, you will have to re-name them manually after they are converted, or use some of the share-ware renaming tools that are available on the internet for batch renaming. We hope to have this done soon.

This is what a window looks like where I have converted Mala files to .dzt, and then am in the process of re-naming them.

Name	Date modified	Type	Size
file7.dzt	12/21/2016 11:20 ...	DZT File	1,070 KB
file8.dzt	12/21/2016 11:20 ...	DZT File	768 KB
file9.dzt	12/21/2016 11:20 ...	DZT File	1,071 KB
file10.dzt	12/21/2016 11:20 ...	DZT File	1,065 KB
file11.dzt	12/21/2016 11:20 ...	DZT File	1,058 KB
file12.dzt	12/21/2016 11:20 ...	DZT File	781 KB
file13.dzt	12/21/2016 11:20 ...	DZT File	763 KB
file14.dzt	12/21/2016 11:20 ...	DZT File	758 KB
file15.dzt	12/21/2016 11:20 ...	DZT File	765 KB
file16.dzt	12/21/2016 11:20 ...	DZT File	765 KB
profil16_0001_a1.dzt	12/21/2016 11:20 ...	DZT File	764 KB
profil17_0001_a1.dzt	12/21/2016 11:20 ...	DZT File	759 KB
profil18_0001_a1.dzt	12/21/2016 11:20 ...	DZT File	760 KB
profil19_0001_a1.dzt	12/21/2016 11:20 ...	DZT File	756 KB
profil20_0001_a1.dzt	12/21/2016 11:20 ...	DZT File	760 KB
profil01_0001_a1.mrk	12/21/2016 11:20 ...	MRK File	8 KB
profil02_0001_a1.mrk	12/21/2016 11:20 ...	MRK File	8 KB
profil03_0001_a1.mrk	12/21/2016 11:20 ...	MRK File	8 KB
profil04_0001_a1.mrk	12/21/2016 11:20 ...	MRK File	8 KB

References

Conyers, Lawrence B. and Jeffrey E. Lucius, 1996, Velocity analysis in archaeological ground-penetrating radar studies. *Archaeological Prospection* 3: 312-333.

Conyers, Lawrence B

- **2016: *Ground-penetrating Radar for Geoarchaeology*,** Wiley-Blackwell

Publishers, London.

- **2013*: Ground-penetrating Radar for Archaeology, Third Edition***. Rowman and Littlefield Publishers, Alta Mira Press, Latham, Maryland
- **2012: *Interpreting Ground-penetrating Radar for Archaeology***. Left Coast Press, Walnut Creek, California.

Important web sites for other GPR processing programs

1. Amplitude analysis (GPR Process for slice maps) , and other programs for processing reflections using frequency filtering and other analyses
http://www.gpr-archaeology.com/software/

2. Surfer for making amplitude maps of the data produced in GPR Process
http://www.goldensoftware.com/

3. The original DOS programs from which some of these applications originated, with back up on those codes:
http://pubs.usgs.gov/of/2002/ofr-02-0166/