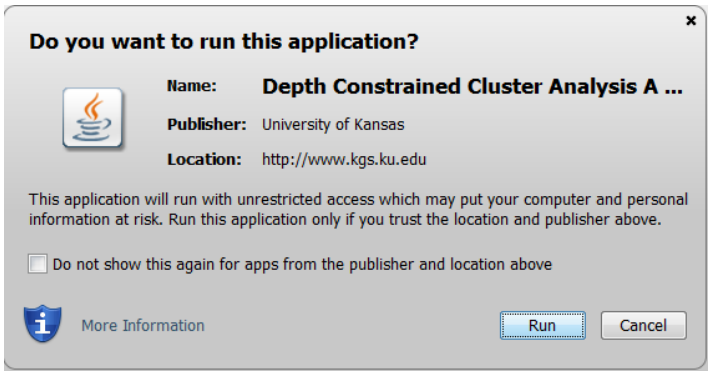
Zonation Applet

by John R. Victorine

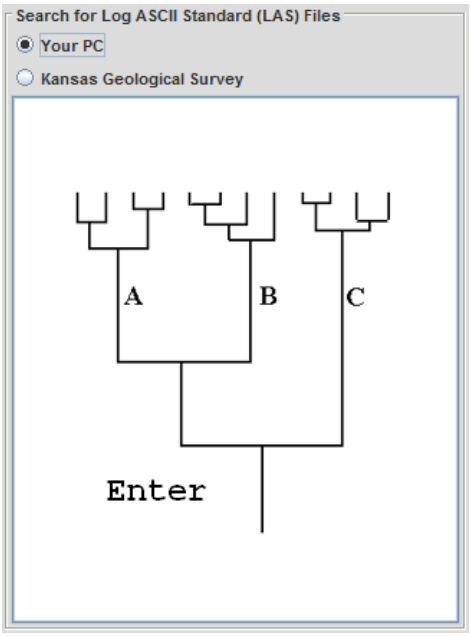
Introduction

The Zonation web app has 2 sources for importing well data, 1) the user's PC or 2) the Kansas Geological Survey (KGS) Server & ORACLE Database. This program allows the user to import Log Data.

There will be occasions when the user would like to inspect the contents of a LAS file. So, for example, the user may wish to find the identity of the well, the types of logs, depth range, well or log parameters. Alternatively, the user can suspect that the file is not coded correctly in LAS format if the Import LAS function fails, and wishes to examine the file to troubleshoot the problem. The LAS file is an ASCII file and can be read by any text editor, i.e. Notepad, WordPad, TextPad, etc. The CSV (Comma Separated Values) files are also ASCII and can be edited in the same way or with Microsoft Excel.



To access Zonation go to http://www.kgs.ku.edu/stratigraphic/ZONATION/. At the top of the web page there is a menu "Main Page|Description|Applet|Help|Copyright & Disclaimer|". Select the "Applet" menu option a "Warning - Security" Dialog will appear. The program has to be able to read and write to the user's PC and access the Kansas Geological Survey (KGS) Database and File Server, ORACLE requires this dialog. The program does not save your files to KGS, but allows you to access the KGS for well information that may be missing in your Kansas logs. The program does not use Cookies or any hidden software it only reads the LAS and CSV files for the Zonation Session. The blue shield on the warning dialog is a symbol that the Java web app is created by a trusted source, which is the University of Kansas.

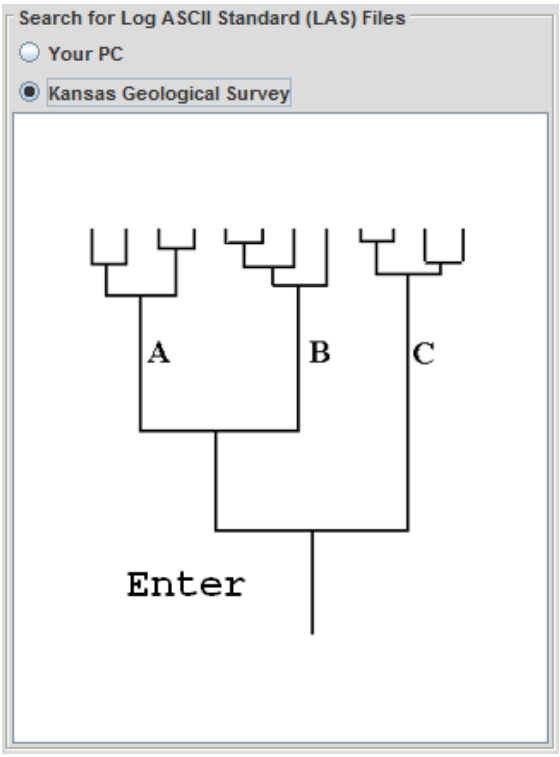


The Zonation “Enter” Panel allows the user to import Log ASCII Standard (LAS) version 2.0 or 3.0 file from the user’s PC (“Your PC” radio button selected) or import Log ASCII Standard (LAS) version 2.0 file from the Kansas Geological Survey’s File Server (“Kansas Geological Survey” radio button selected).

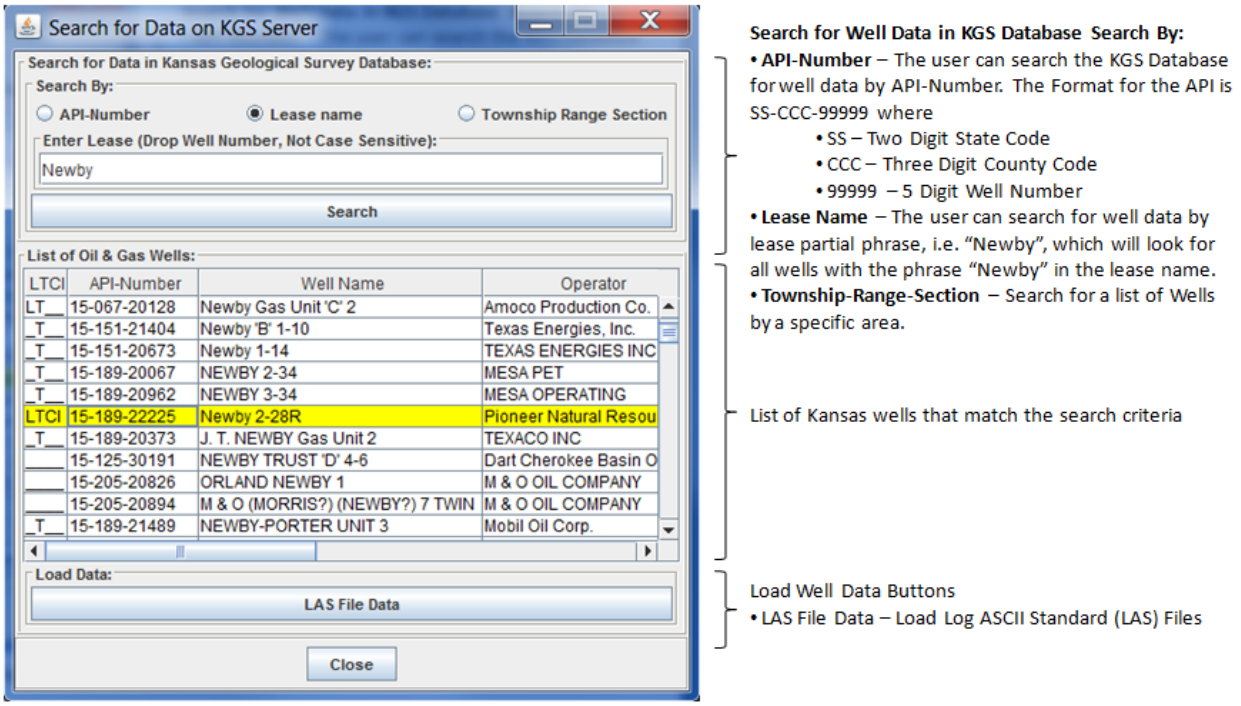
Contents

Importing Kansas Geological Survey (KGS) Log ASCII Standard (LAS) File

The Kansas Geological Survey (KGS) has a good collection of well data stored in the ORACLE Database and File Server as Files Log ASCII Standard (LAS) version 3.0 Files and Core Image Files as Joint Photographic Experts Group (JPEG) images as well as Tagged Image File Format (TIFF) images. In this example the user will download the Log ASCII Standard (LAS) version 2.0 File from the KGS. The Well Header Information and the LAS File Information will be retrieved from the ORACLE Database as Stored Procedure PL/SQL calls to the ORACLE Database from which an Extensible Markup Language (XML) data stream is created containing the well data that is passed back to the web app making the request.



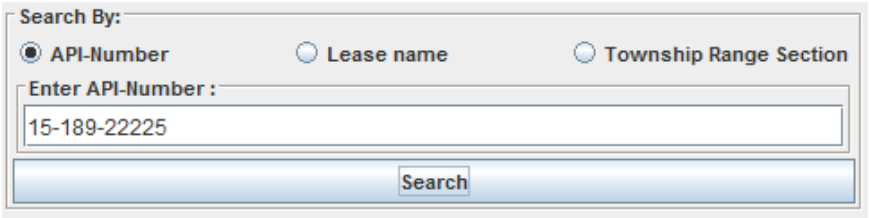
Select the "Kansas Geological Survey" radio button in the "Search for Log ASCII Standard (LAS) Files" Panel. Select the "Enter" icon button to display the "Search for Data on KGS Server" dialog. This dialog allows the user to search the KGS database for well data. In this example, the well of interest will be the Newby 2-28R, this well contains all the well data that can be retrieved from the KGS Database, i.e. Log Data (LAS version 3.0 File



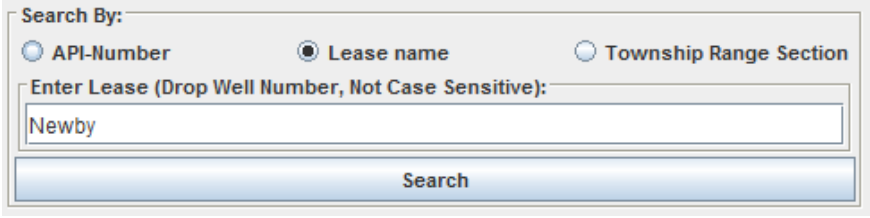
NOTE: LTCI Column in Table: L-LAS Files; T-Formation Tops; C-Measured Core Data; I-Core Images

As the Summary image suggests there are 3 methods for searching for the well data within this dialog,

- By API-Number – KGS has a specific format for the API-Number, i.e.SS-CCC-99999 where SS is the state code for Kansas 15, CCC is the county code for Newby 2-28R it is 189 for Stevens County and the 5-Digit Well Number for Newby 2-28R it is 22225.

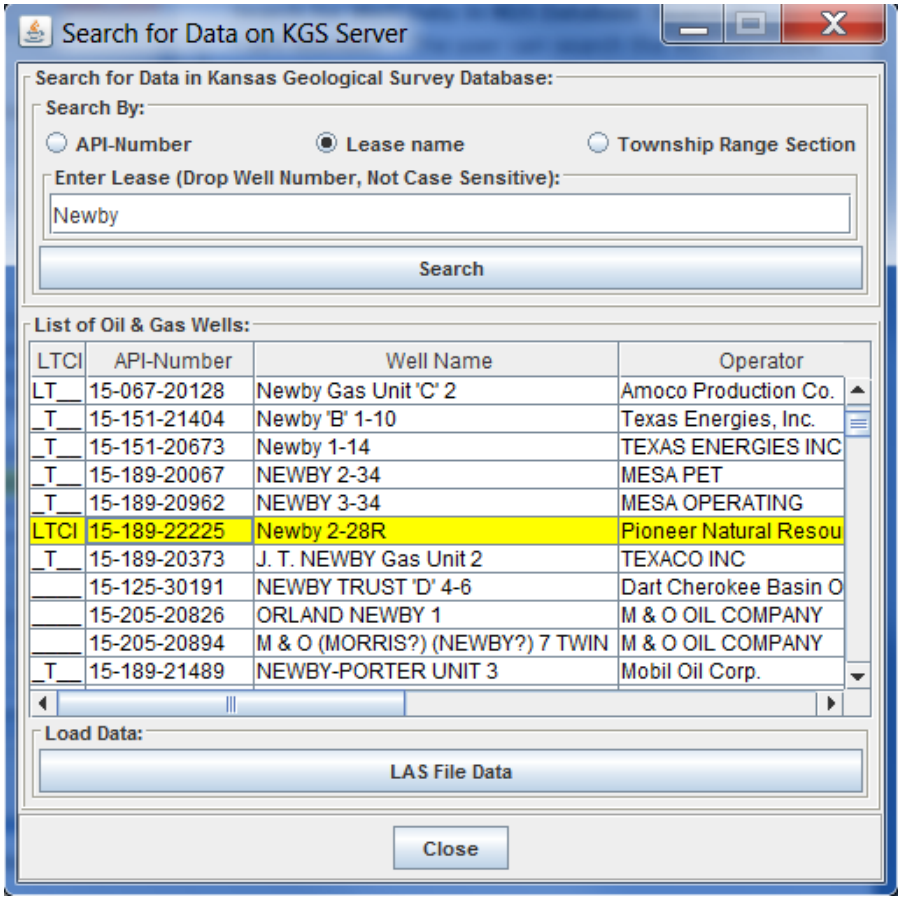


- By Partial Lease Name – The stored procedure used to retrieve the well header information allows the user to enter a partial phrase, in this example Newby. The program places a '%' in front and back of the phrase and sends the request to the Database, i.e. "%Newby%".



- By Township Range Section – This search is by location in Kansas, this search also allows the user to enter just the Township and Range to search for wells, e.g. to look for the Newby 2-28R, enter Township as 31 set the S (South) Radio button and Range as 37 set the W (West) Radio button.

The user only needs to enter the above data and select the "Search" Button to display the list of Wells in the Kansas Database that match the search criteria. In the image below the Lease Name "Newby" was entered to search for all wells in Kansas with the Phrase Newby in it. The user searches through the list until they find the well of interest. In this example it is the Newby 2-28R, which is highlighted.



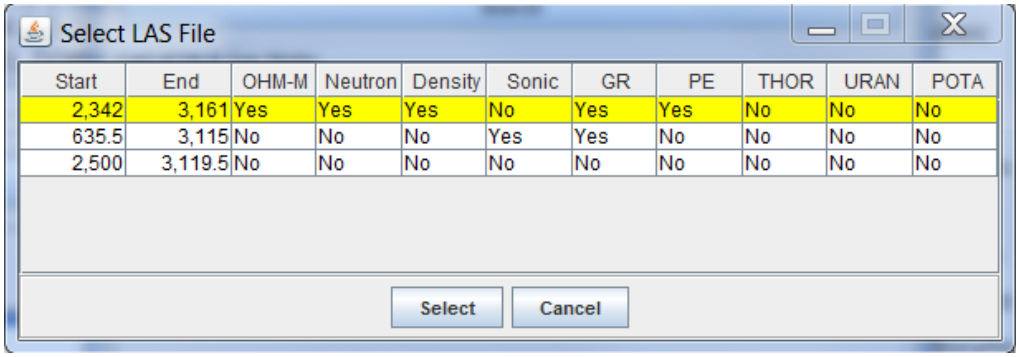
Notice that the LTCI represents the type of data that the well contains. It is a visual aid that lets the user see what is available before trying to download the data. If you require a LAS file you would want to see an L in that column. The LTCI labels stand for the following,

- L – Log ASCII Standard (LAS) version 2.0 Files
- T – Tops Data (Stratigraphic Unit Horizons)
- C – Measured Core Data
- I – Core Joint Photographic Experts Group (JPEG) Image Files

This dialog allows the user to now download each of the data types that are available.

Load KGS Well Data – LAS File Data

The "Search for Data on KGS Server" Dialog allows the user to download data from the KGS Database & Server to the web app. The "LAS File Data" Button will display the "Select LAS File" Dialog with a list of LAS version 2.0 Files that are available.

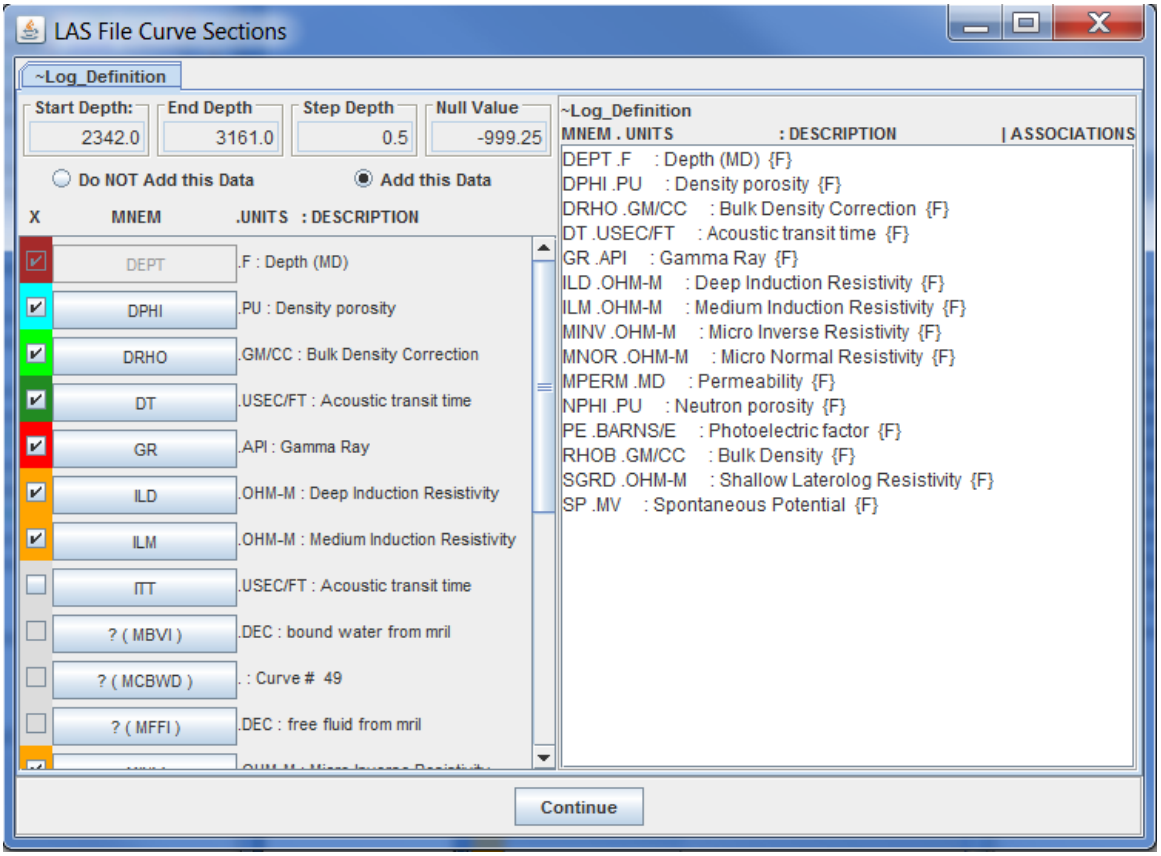


In this example there are three LAS files available, with a table suggesting the log data type in the file. In the beginning of the GEMINI Project (2000-2003) a precursor to the GEMINI Tools the KGS populated the Tool Types from every log that was in the KGS Server at that time. Unfortunately KGS has not maintain that table for wells uploaded after 2003 so the LAS File may have "No" for all the log types, which is not accurate. The user will need to open or download the file or search for the Well on the KGS Master List of Oil and Gas Wells in Kansas Web Page (http://www.kgs.ku.edu/Magellan/Qualified/index.html) to see what is in the File Header before deciding to download data from this program. For this example the first log has most of the data necessary except the Spectral Gamma Ray Logs. The Table above identifies the following log types,

- OHM-M – Resistivity Logs
- Neutron – Neutron Porosity Log
- Density – Bulk Density and/or Density Porosity Log
- Sonic – Acoustic Transit Time and/or Sonic Porosity Log
- GR – Gamma Ray (API units) Log
- PE – Photoelectric Factor Log
- THOR – Thorium Concentration
- URAN – Uranium Concentration
- POTA – Potassium Concentration)

In this example the first log contains the data needed, highlight the first log and click on the "Select" Button to display the "LAS File Curve Sections" Dialog. The "LAS File Curve

Sections" Dialog allows the user to map unknown LAS Curve Mnemonics to the KGS "Standard" Curve Mnemonics so they will be plotted in the Profile Plot. This program reads the "LAS Tool Curve Mnemonics map to KGS Standard Mnemonics" XML File (http://www.kgs.ku.edu/software/gemini/data/las_standard_tools.xml), which will automatically maps the Curve Mnemonics from the LAS file to one of 31 KGS "Standard" Curve Mnemonics.



As you can see this log has all the log types of interest, Gamma Ray API, Resistivity, Neutron/Density, Photoelectric Factor, Sonic and Permeability. If a curve Mnemonic is not recognized the program will place a "?" in front of the Mnemonic, e.g. "?(MPERM16)" for the ". : Curve # 51" Log Curve. If the user is satisfied with the automatic curve selections, which are checked and color coded, they only need to select the "Continue" Button at the bottom of the Dialog to import the file. The next section will take the user through a series of examples in changing the curve selections and mapping unknown curve mnemonics.

Notice that some of the check boxes are colored with different colors, which shows that the curves were automatically selected, but also to represent the curve type by color.The Curves are colored by type (data units) as follows,

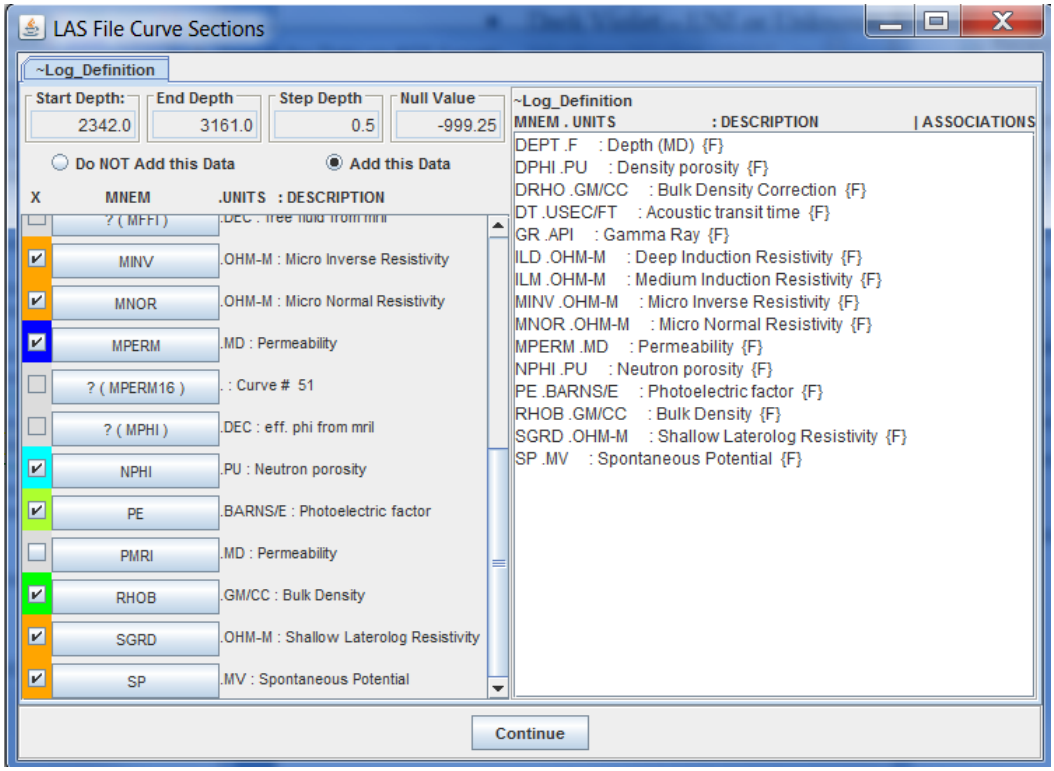
- Orange - OHM-M or Resistivity Logs
- Cyan – PU or porosity Logs, Neutron Porosity, Density Porosity, etc.
- Greenish yellow – BARNS/E or Photoelectric Factor Logs
- Green – GM/CC or Bulk Density Log

- Forest Green – USEC/FT or the Acoustic Transit Time Log
- Red – API, PPM or "%" as Radioactive logs, Gamma Ray, Spectral Gamma Ray, etc.
- Blue – MD or Permeability Logs
- Brown – F, FT or IN or Depth
- Middle yellow – FRAC, or other log curve types.
- Dark Violet – UNI or Unknown Linear Curves
- Medium Violet – UNL or Unknown Logrithum Curves

The color coding of the selected curves were added to also help the user visually recognize that a curve was selected or not.

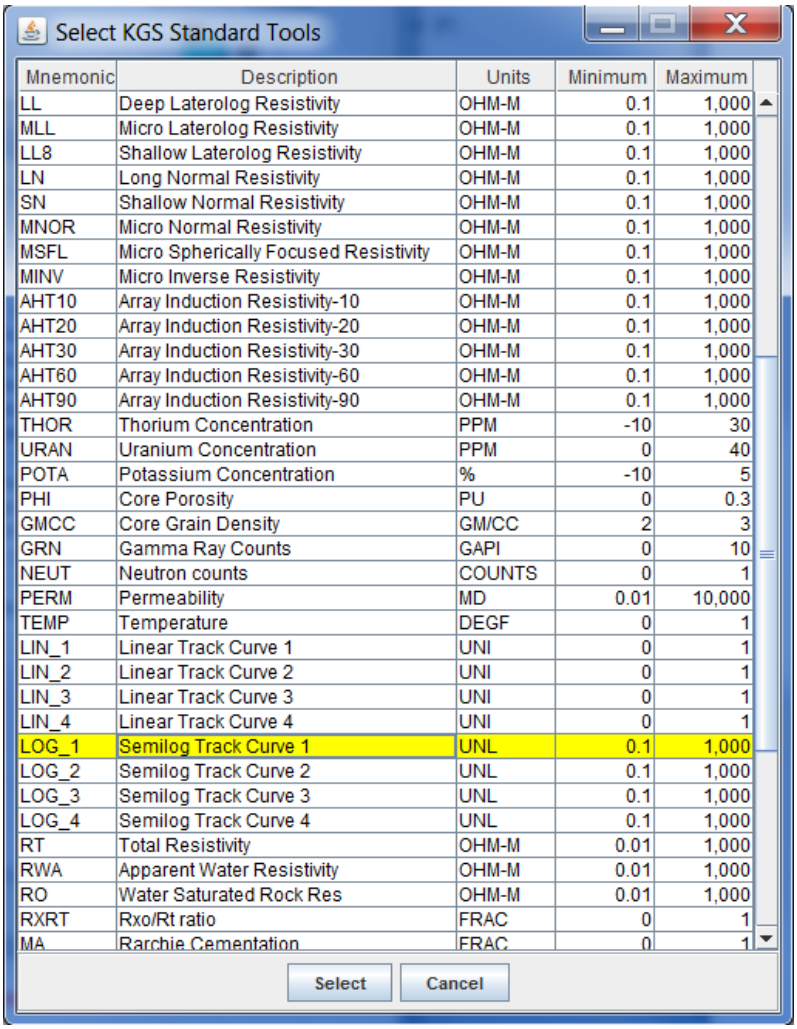
Map Curves & Change Curve Selections

Some logs will have curve mnemonics that are not recognized as one of the KGS "Standard" Curve Mnemonics. The user will need to map the log curve to one of the KGS standard curves if they want to display the curve. Slide the scroll bar down to the Permeability Curves MPERM and ?(MPERM16).



Click on the "?(MPERM16)" Button to display the "Select KGS Standard Tools" Dialog. This dialog provides a list of the KGS "Standard" Curve Mnemonics, from which the user can map an unrecognized log curve to one of the KGS standard curve mnemonics. The KGS "Standard" Curve Mnemonics List was created as a way to standardize the alpha bit soup of Log Mnemonics. Each logging company has their own curve mnemonics to represent similar tools. The Profile program is a later version of code from the GEMINI Project LAS File Viewer

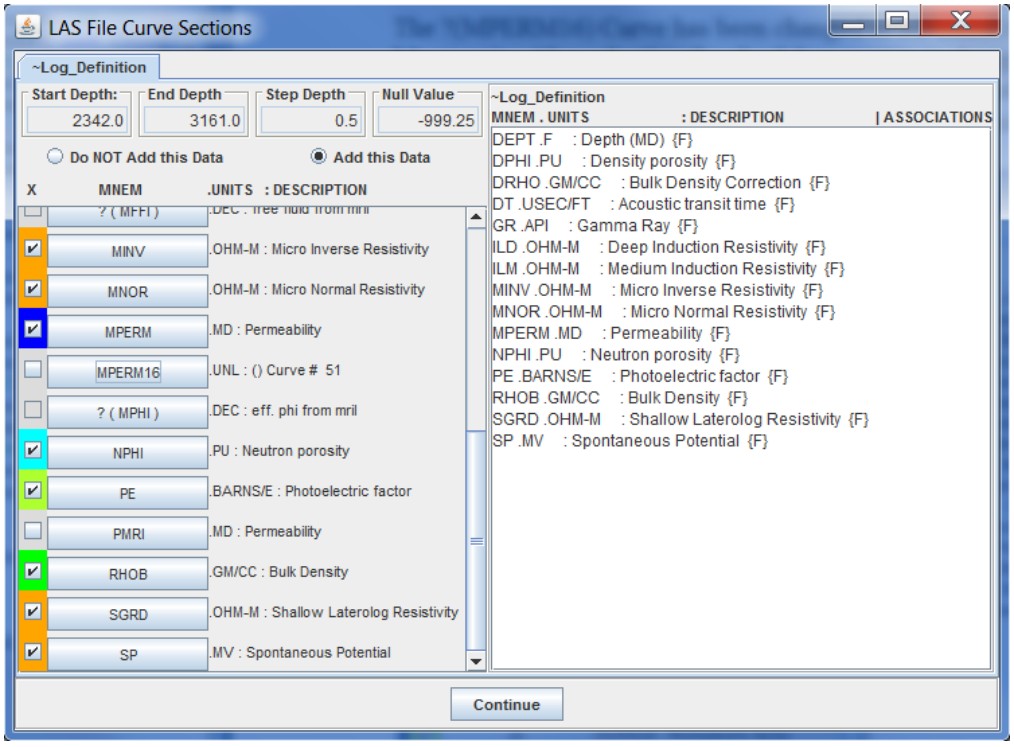
Module, which needed to standardize the log curves so the curves could be automatically read and assigned a plot track. The "LAS Tool Curve Mnemonics map to KGS Standard Mnemonics" XML File was created to map the log curves from logs that were part of the KGS LAS File Collection which is not a complete list of possible curve mnemonics.



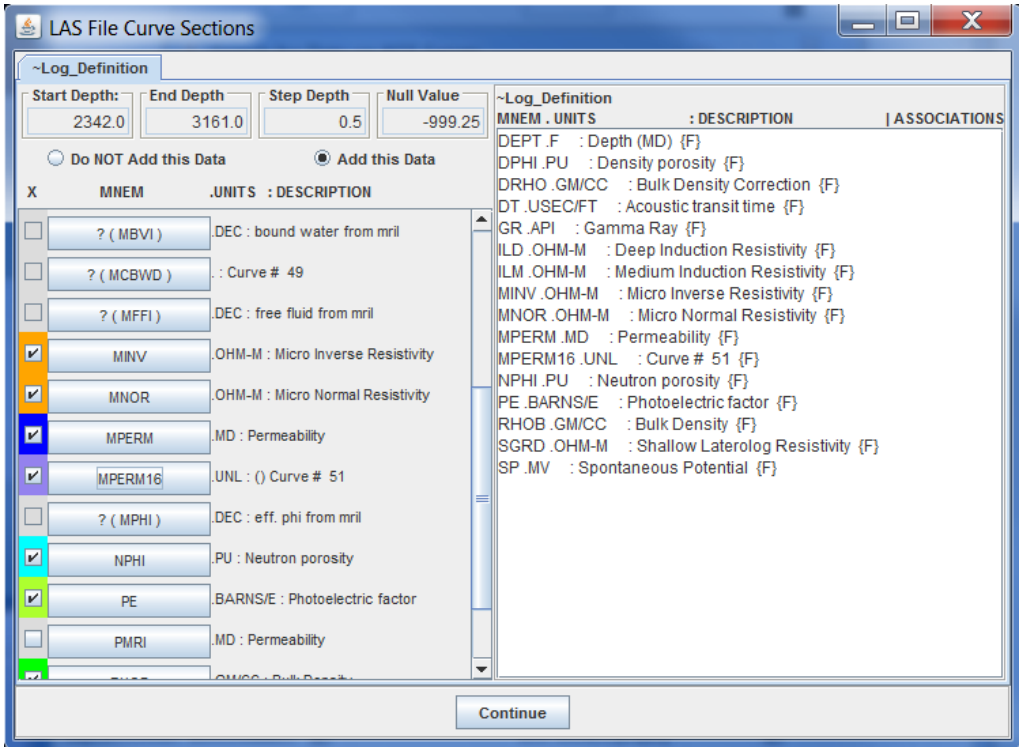
Mnemonic	Description	Units	Minimum	Maximum
LL	Deep Laterolog Resistivity	OHM-M	0.1	1,000
MLL	Micro Laterolog Resistivity	OHM-M	0.1	1,000
LL8	Shallow Laterolog Resistivity	OHM-M	0.1	1,000
LN	Long Normal Resistivity	OHM-M	0.1	1,000
SN	Shallow Normal Resistivity	OHM-M	0.1	1,000
MNOR	Micro Normal Resistivity	OHM-M	0.1	1,000
MSFL	Micro Spherically Focused Resistivity	OHM-M	0.1	1,000
MINV	Micro Inverse Resistivity	OHM-M	0.1	1,000
AHT10	Array Induction Resistivity-10	OHM-M	0.1	1,000
AHT20	Array Induction Resistivity-20	OHM-M	0.1	1,000
AHT30	Array Induction Resistivity-30	OHM-M	0.1	1,000
AHT60	Array Induction Resistivity-60	OHM-M	0.1	1,000
AHT90	Array Induction Resistivity-90	OHM-M	0.1	1,000
THOR	Thorium Concentration	PPM	-10	30
URAN	Uranium Concentration	PPM	0	40
POTA	Potassium Concentration	%	-10	5
PHI	Core Porosity	PU	0	0.3
GMCC	Core Grain Density	GM/CC	2	3
GRN	Gamma Ray Counts	GAPI	0	10
NEUT	Neutron counts	COUNTS	0	1
PERM	Permeability	MD	0.01	10,000
TEMP	Temperature	DEGF	0	1
LIN_1	Linear Track Curve 1	UNI	0	1
LIN_2	Linear Track Curve 2	UNI	0	1
LIN_3	Linear Track Curve 3	UNI	0	1
LIN_4	Linear Track Curve 4	UNI	0	1
LOG_1	Semilog Track Curve 1	UNL	0.1	1,000
LOG_2	Semilog Track Curve 2	UNL	0.1	1,000
LOG_3	Semilog Track Curve 3	UNL	0.1	1,000
LOG_4	Semilog Track Curve 4	UNL	0.1	1,000
RT	Total Resistivity	OHM-M	0.01	1,000
RWA	Apparent Water Resistivity	OHM-M	0.01	1,000
RO	Water Saturated Rock Res	OHM-M	0.01	1,000
RXRT	Rxo/Rt ratio	FRAC	0	1
MA	Rarchie Cementation	FRAC	0	1

To map the unknown curve mnemonic "?(MPERM16)" you first notice that it similar to the MPERM curve above, which is a permeability curve. In this example both curves will be plotted together, but the Permeability Plot Track can only plot one curve. The web app has the ability to allow the user to plot up to 4 unknown logrithum curves and 4 unknown linear curves. The permeability is usually plotted as logrithmic. Click on the "?(MPERM16)" Button to display the

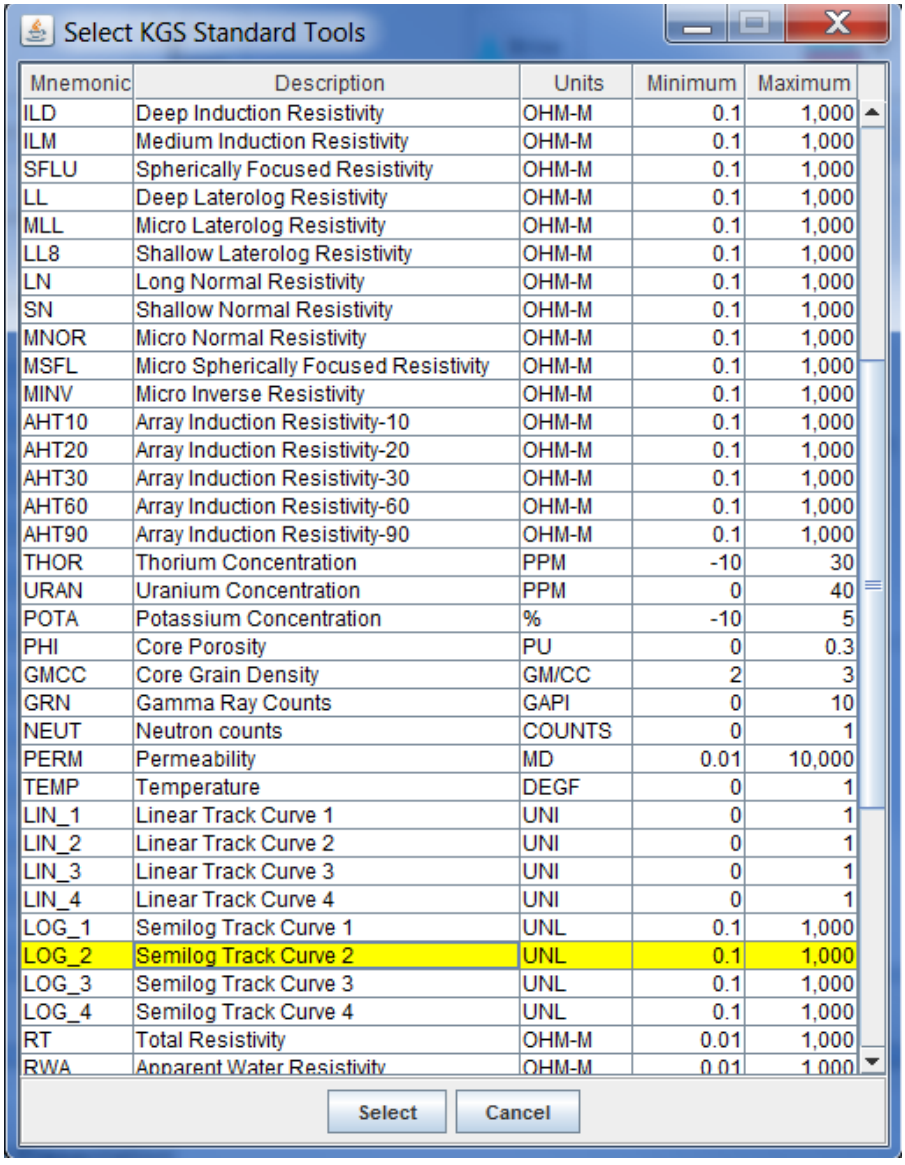
"Select KGS Standard Tools" Dialog. Slide the scroll bar down to the "LOG_1" Mnemonic – Semilog Track Curve 1 and highlight that curve. Click on the "Select" Button to map the "?(MPERM16) to the Semilog Track Curve 1.



The ?(MPERM16) Curve has been changed to MPERM16 removing the ?() around the Curve Mnemonic. Also select the check box next to it, which changes to a dark violet.

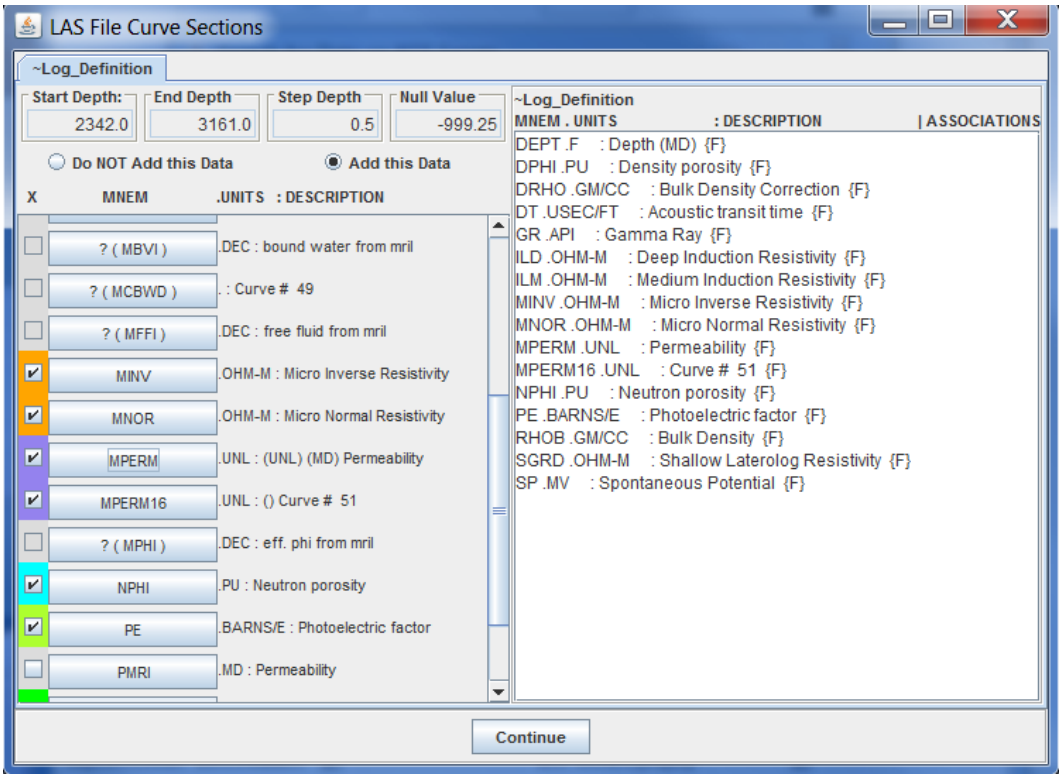


In order to plot both Permeability Curves on the same track, the MPERM must be assigned to the unknown Log Curves with MPERM16. Click on the MPERM Mnemonic Button to display the



Mnemonic	Description	Units	Minimum	Maximum
ILD	Deep Induction Resistivity	OHM-M	0.1	1,000
ILM	Medium Induction Resistivity	OHM-M	0.1	1,000
SFLU	Spherically Focused Resistivity	OHM-M	0.1	1,000
LL	Deep Laterolog Resistivity	OHM-M	0.1	1,000
MLL	Micro Laterolog Resistivity	OHM-M	0.1	1,000
LL8	Shallow Laterolog Resistivity	OHM-M	0.1	1,000
LN	Long Normal Resistivity	OHM-M	0.1	1,000
SN	Shallow Normal Resistivity	OHM-M	0.1	1,000
MNOR	Micro Normal Resistivity	OHM-M	0.1	1,000
MSFL	Micro Spherically Focused Resistivity	OHM-M	0.1	1,000
MINV	Micro Inverse Resistivity	OHM-M	0.1	1,000
AHT10	Array Induction Resistivity-10	OHM-M	0.1	1,000
AHT20	Array Induction Resistivity-20	OHM-M	0.1	1,000
AHT30	Array Induction Resistivity-30	OHM-M	0.1	1,000
AHT60	Array Induction Resistivity-60	OHM-M	0.1	1,000
AHT90	Array Induction Resistivity-90	OHM-M	0.1	1,000
THOR	Thorium Concentration	PPM	-10	30
URAN	Uranium Concentration	PPM	0	40
POTA	Potassium Concentration	%	-10	5
PHI	Core Porosity	PU	0	0.3
GMCC	Core Grain Density	GM/CC	2	3
GRN	Gamma Ray Counts	GAPI	0	10
NEUT	Neutron counts	COUNTS	0	1
PERM	Permeability	MD	0.01	10,000
TEMP	Temperature	DEGF	0	1
LIN_1	Linear Track Curve 1	UNI	0	1
LIN_2	Linear Track Curve 2	UNI	0	1
LIN_3	Linear Track Curve 3	UNI	0	1
LIN_4	Linear Track Curve 4	UNI	0	1
LOG_1	Semilog Track Curve 1	UNL	0.1	1,000
LOG_2	Semilog Track Curve 2	UNL	0.1	1,000
LOG_3	Semilog Track Curve 3	UNL	0.1	1,000
LOG_4	Semilog Track Curve 4	UNL	0.1	1,000
RT	Total Resistivity	OHM-M	0.01	1,000
RWA	Apparent Water Resistivity	OHM-M	0.01	1,000

"Select KGS Standard Tools" Dialog. Slide the scroll bar down to the "LOG_2" Mnemonic – Semilog Track Curve 2 and highlight that curve. Click on the "Select" Button to map the "MPERM to the Semilog Track Curve 2.



Click the check box next to the MPERM Mnemonic Button you will notice that it has the same color as MPERM16, which now groups the two curves together. Select the “Continue” Button to load the LAS File into the web app.

Importing PC Data – Log ASCII Standard (LAS) version 2.0 File

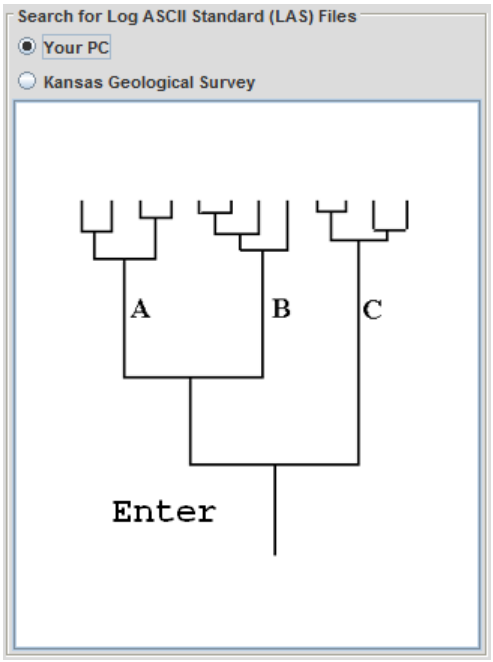
Download either the ASCII Text Files directly or the Zip files extracting the contents into a directory. The problem with the ASCII Text Files being downloaded directly from a web page is that the web page will alter the contents so it does not retain the basic structure and add HTML text to the file. The preferred method if you have Zip or WinZip is to download the zip files to your PC and extract.

Well Data: Wellington KGS 1-32, Sumner County, Kansas

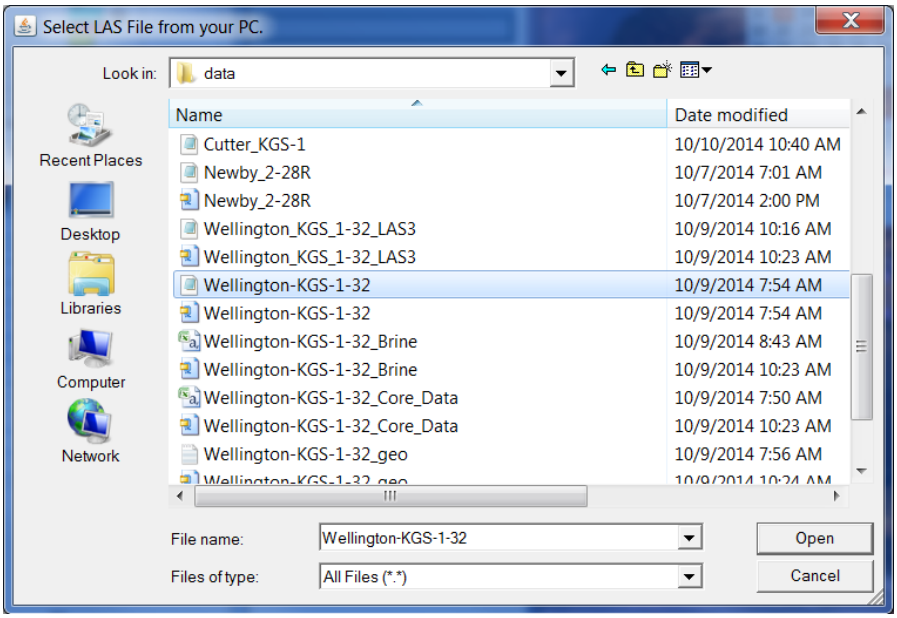
Type	ASCII Text Files
LAS 2.0	http://www.kgs.ku.edu/Gemini/Tools/documentation/Wellington-KGS-1-32.las

Type	Zip Files
LAS 2.0	http://www.kgs.ku.edu/Gemini/Tools/documentation/Wellington-KGS-1-32.zip

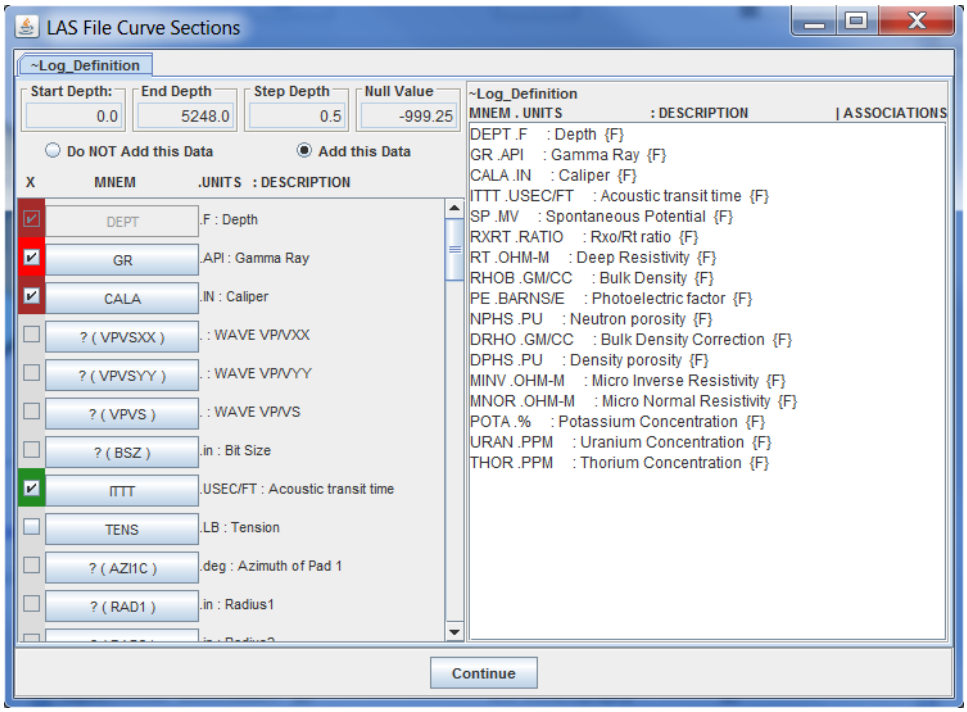
Most of the web apps will use the same input dialogs to import Log ASCII Standard (LAS) version 2.0 or 3.0 files. In this example a Log ASCII Standard (LAS) version 2.0 file is being imported into the web app.



Select the "Your PC" radio button in the "Search for Log ASCII Standard (LAS) Files" Panel. Select the "Enter" icon button to display the "Select LAS File from your PC" Dialog. This dialog allows the user to search their PC for the file of interest. In this example it is the LAS version 2.0 file Wellington-KGS-1-32.las, highlighted below. Select the Open button to display the "LAS File Curve Sections" Dialog.



The "LAS File Curve Sections" Dialog allows the user to map unknown LAS Curve Mnemonics to the KGS "Standard" Curve Mnemonics so they will be plotted in the Profile Plot. This program reads the "LAS Tool Curve Mnemonics map to KGS Standard Mnemonics" XML File (http://www.kgs.ku.edu/software/gemini/data/las_standard_tools.xml), which will automatically maps the Curve Mnemonics from the LAS file to one of 31 KGS "Standard" Curve Mnemonics. If a curve Mnemonic is not recognized the program will place a "?" in front of the Mnemonic, e.g. "?(BSZ)" for the ".in : Bit Size" Log Curve.



If the user is satisfied with the automatic curve selections, which are checked and color coded, they only need to select the "Continue" Button at the bottom of the Dialog to import the file. The next section will take the user through a series of examples in changing the curve selections and mapping unknown curve mnemonics.

Notice that some of the check boxes are colored with different colors, which shows that the curves were automatically selected, but also to represent the curve type by color.The Curves are colored by type (data units) as follows,

- Orange - OHM-M or Resistivity Logs
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- Dark Violet – UNI or Unknown Linear Curves
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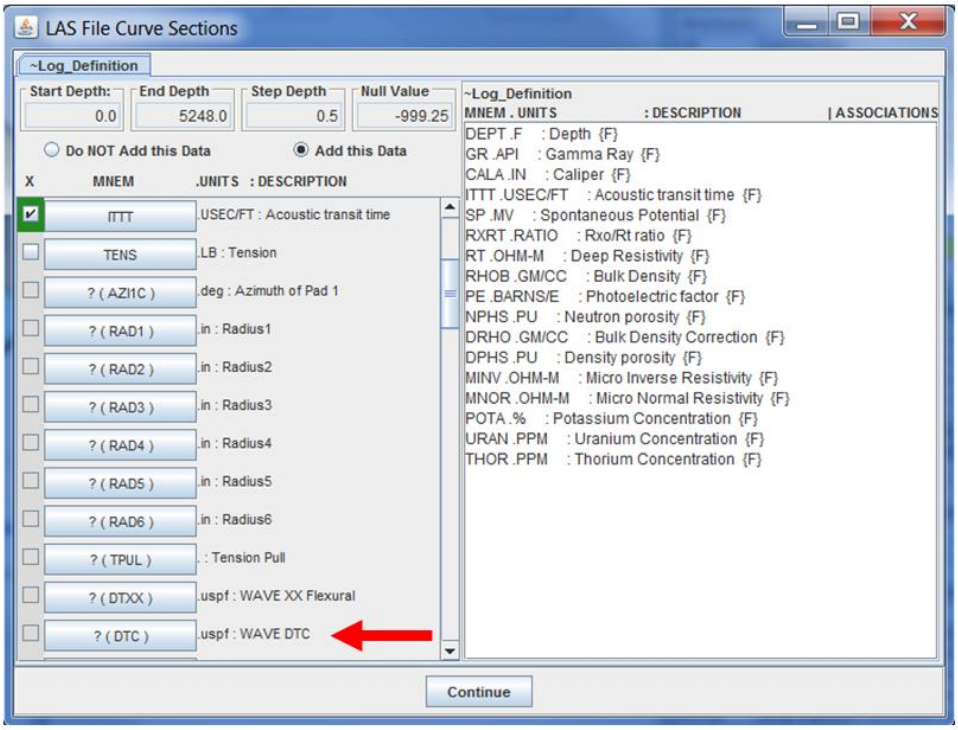
The color coding of the selected curves was added to help the user visually recognize that a curve was selected or not.

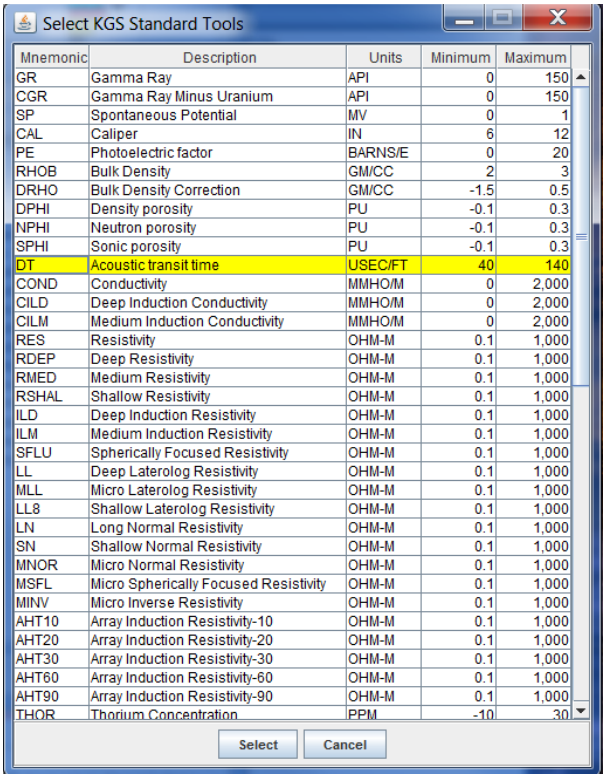
Map Curves & Change Curve Selections

Some logs will have curve mnemonics that are not recognized as one of the KGS "Standard" Curve Mnemonics. The user will need to map the log curve to one of the KGS standard curves if they want to display the curve. The first example is to map the Acoustic Transit Time (DT),which is labeled as ".uspf : WAVE DTC" log curve in the LAS File. Also notice that the button label "?(DTC)" is not recognized by the PROFILE web app.

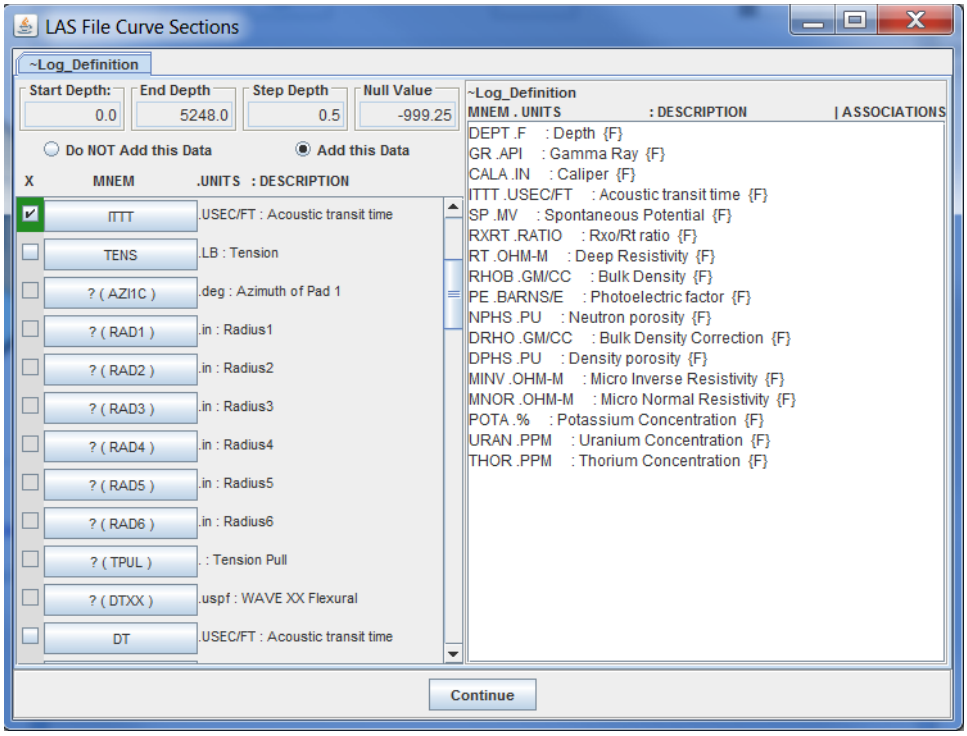
Click on the "?(DTC)" Button to display the "Select KGS Standard Tools" Dialog. This dialog provides a list of the KGS "Standard" Curve Mnemonics, from which the user can map an unrecognized log curve to one of the KGS standard curve mnemonics. The KGS "Standard" Curve Mnemonics List was created as a way to standardize the alpha bit soup of Log Mnemonics. Each logging company has their own curve mnemonics to represent similar tools. The Profile program is a later version of code from the GEMINI Project LAS File Viewer Module, which needed to standardize the log curves so the curves could be automatically read and assigned a plot track. The "LAS Tool Curve Mnemonics map to KGS Standard Mnemonics" XML File was created to map the log curves from logs that were part of the KGS LAS File Collection which is not a complete list of possible curve mnemonics.



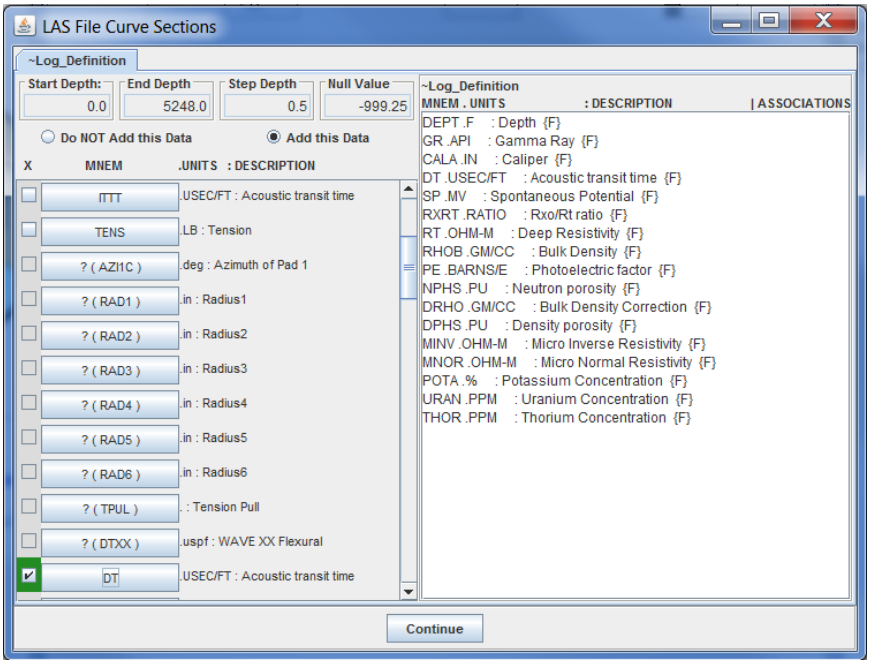
To map the unknown curve mnemonic "?(DTC)" you first notice that the unit is "uspf" (micro seconds per foot) a unit of time. Also the Acoustic Transit Time Curve Mnemonic is similar to the KGS "Standard" Curve Mnemonic "DT". By selecting the "?(DTC)" Button you will display the "Select KGS Standard Tools" Dialog.



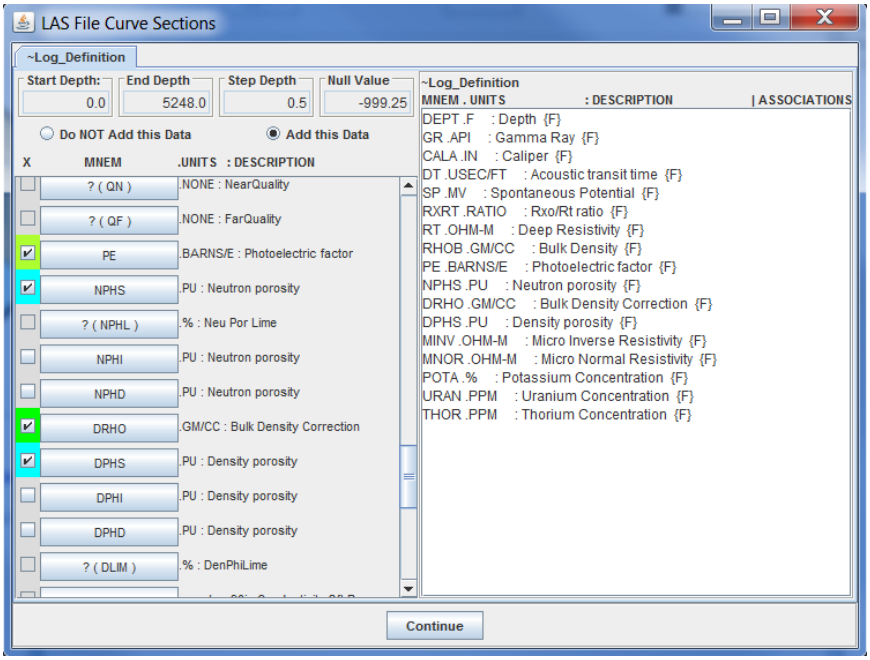
Highlight the “DT” Mnemonic Row and click on the “Select” Button to map the “?(DTC)” Curve Mnemonic to “DT” KGS Standard Curve Mnemonic.



The “?(DTC). .uspf : WAVE DTC” has changed to “DT.usec/ft : Acoustic transit time”. We want to change the selected “ITTT” Log Curve to “DT” Log Curve. The reason is that “ITTT” is the wrong curve type for the Acoustic Transit Time. The program found the curve mnemonic as similar to the “DT” Standard Curve Mnemonic, but this curve will not plot correctly in the Profile Plot. Just click on the green check box in front of the “ITTT” Mnemonic Button to deselect the curve and then click on the check box in front of the “DT” Mnemonic Button to select it. Also notice that the ~Log_Definition Text Area was modified to show the change.

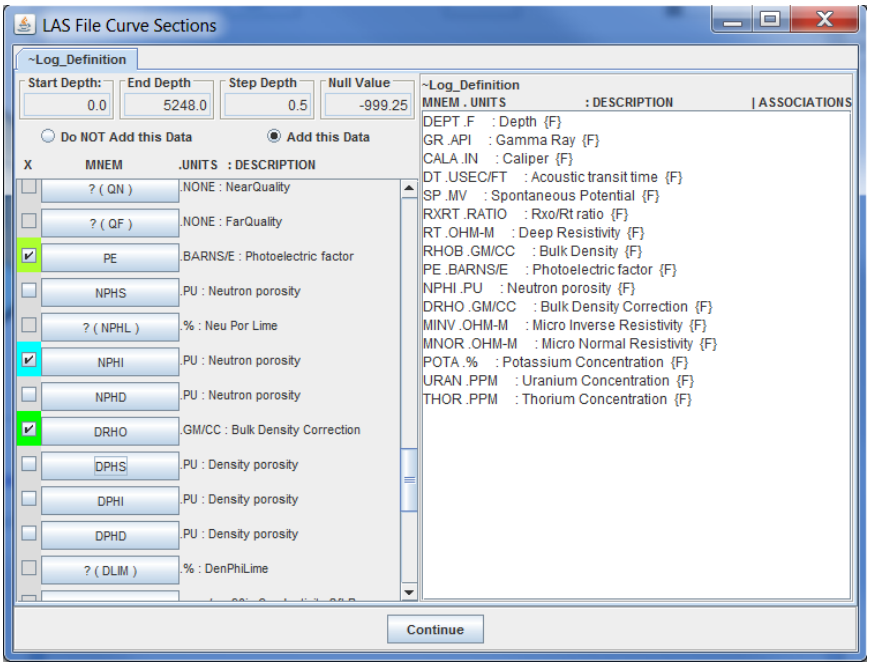


Moving the scroll bar down to the porosity curves, Neutron Porosity, and Density Porosity.

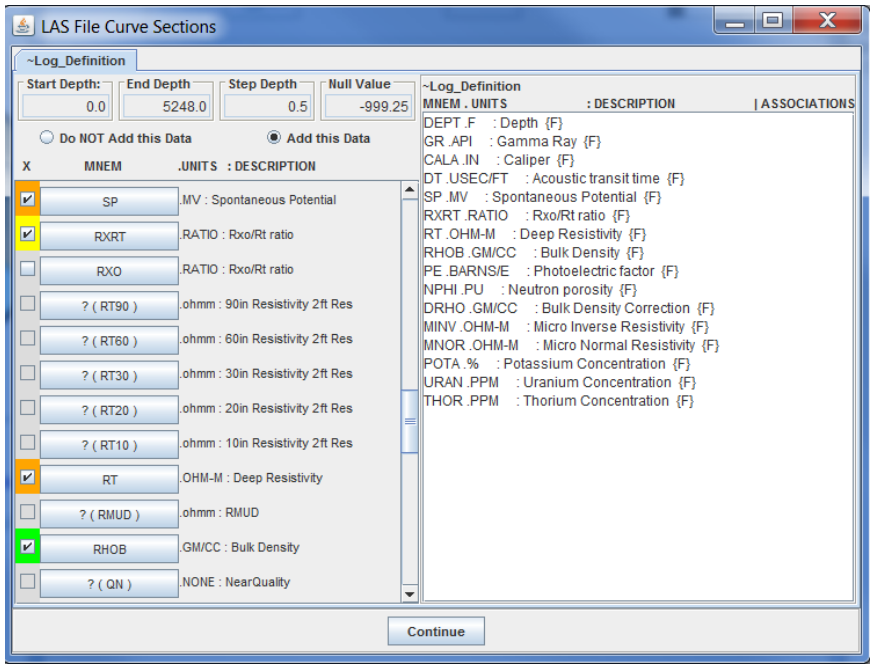


The LAS File Read will select the first curve that it recognizes and selects and color codes the curve. In this case the Neutron porosity mnemonic selected is “NPHS”, which is a valid curve, but the “NPHI” curve is desired so like the Acoustic Transit Time, you can deselect the “NPHS” and then select the “NPHI” Curve. Also the “DPHS” Density Porosity Curve can be deselected since the “RHOB” Bulk Density Curve has been selected. The reason for deselecting the Density Porosity Curve, if the Bulk Density Curve is present, is to force the PROFILE program to recompute the Density Porosity using a Limestone Matrix. If the Neutron Porosity, Bulk

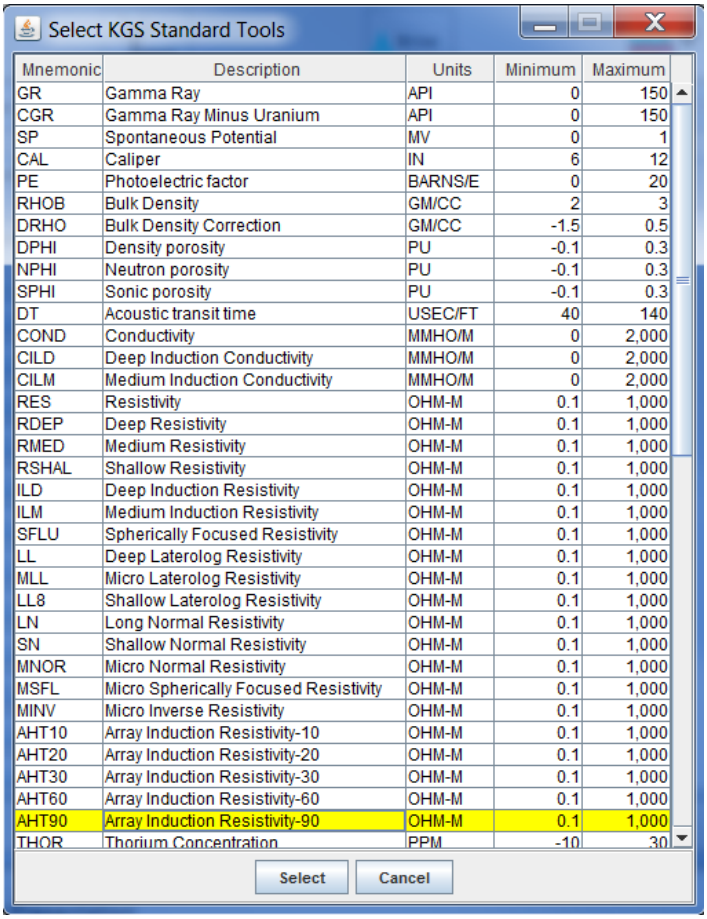
Density, Gamma Ray with/without a Photoelectric Factor Logs are present then the program will automatically compute a Lithology Composition Plot, but the Density Porosity has to be computed with a Limestone Matrix or the Lithology Composition Plot will not be computed corectly.



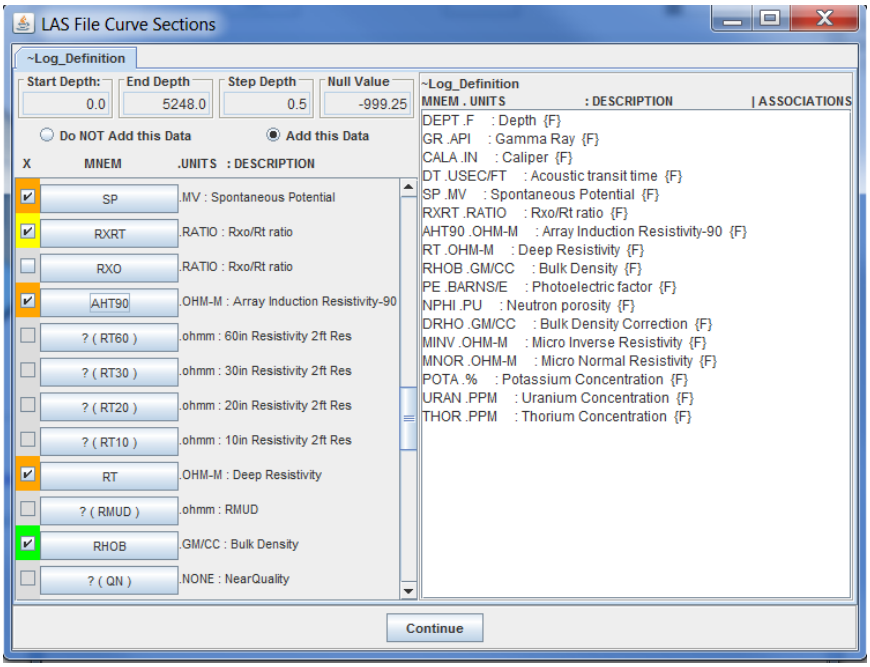
The above dialog represents the changes made for the neutron/density porosity logs. The last curves to be modified are the Array Induction Logs. Haliburton uses a different curve mnemonic for these logs. Move the scroll bar up to find the Array Induction Logs, RT90, RT60, etc.



Like the Acoustic Transit Time the "?(RT90).ohmm: 90in Resistivity 2ft Res" through "?(RT10).ohmm : 10in Resistivity 2ft Res" are not recognized. These curves can be map to the "AHT90 Array Induction Resistivity-90" to "AHT10 Array Induction Resistivity-10" KGS Curves Respectively. Click on the "?(RT90)" Mnemonic Button to display the "Select KGS Standard Tools" Dialog.

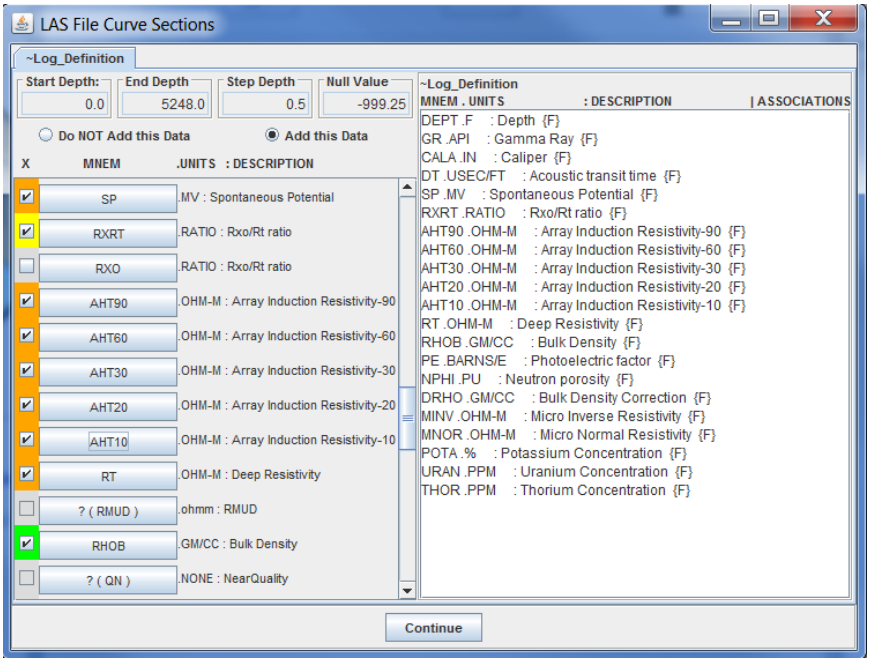


Highlight the AHT90 and click on the "Select" Button.



The "(?AHT90).ohmm : 90in Resistivity 2ft Res" has changed to "AHT90.OHM-M : Array Induction Resistivity-90" and the orange check box is selected. The rest of the Array Induction Log Curves each are mapped to the respective KGS Mnemonic Curve as follows,

(?RT90).ohmm : 90in Resistivity 2ft Res to AHT90.OHM-M : Array Induction Resistivity-90
(?RT60).ohmm : 60in Resistivity 2ft Res to AHT60.OHM-M : Array Induction Resistivity-60
(?RT30).ohmm : 30in Resistivity 2ft Res to AHT30.OHM-M : Array Induction Resistivity-30
(?RT20).ohmm : 20in Resistivity 2ft Res to AHT20.OHM-M : Array Induction Resistivity-20
(?RT10).ohmm : 10in Resistivity 2ft Res to AHT10.OHM-M : Array Induction Resistivity-10



Select the Continue Button to read and parse the LAS log curves selected into the PROFILE Web App. Notice that the "Data Source Filenames:" Panel lists the LAS version 2.0 File that was just read in as well as the type of data, i.e. Log Data from LAS Data Type.

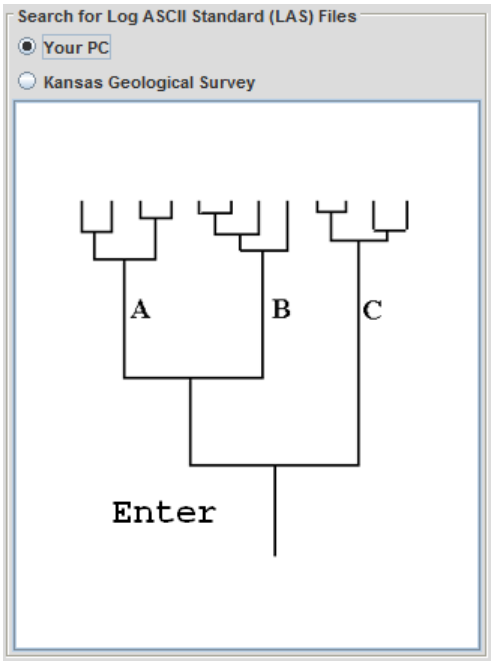
Example: Meyer 'B' 5

Download either the ASCII Text Files directly or the Zip files extracting the contents into a directory. The problem with the ASCII Text Files being downloaded directly from a web page is that the web page will alter the contents so it does not retain the basic structure and add HTML text to the file. The preferred method if you have Zip or WinZip is to download the zip files to your PC and extract.

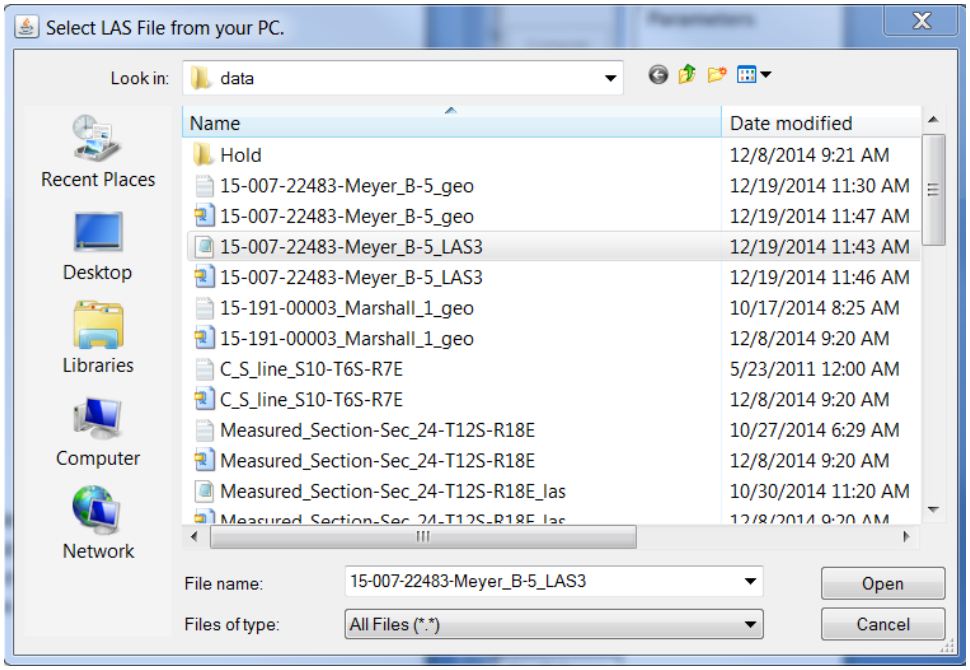
Well Data: Meyer 'B' 5, Barber County, Kansas

Type	ASCII Text Files
LAS 3.0	http://www.kgs.ku.edu/Gemini/Tools/documentation/15-007-22483-Meyer_B-5_LAS3.las

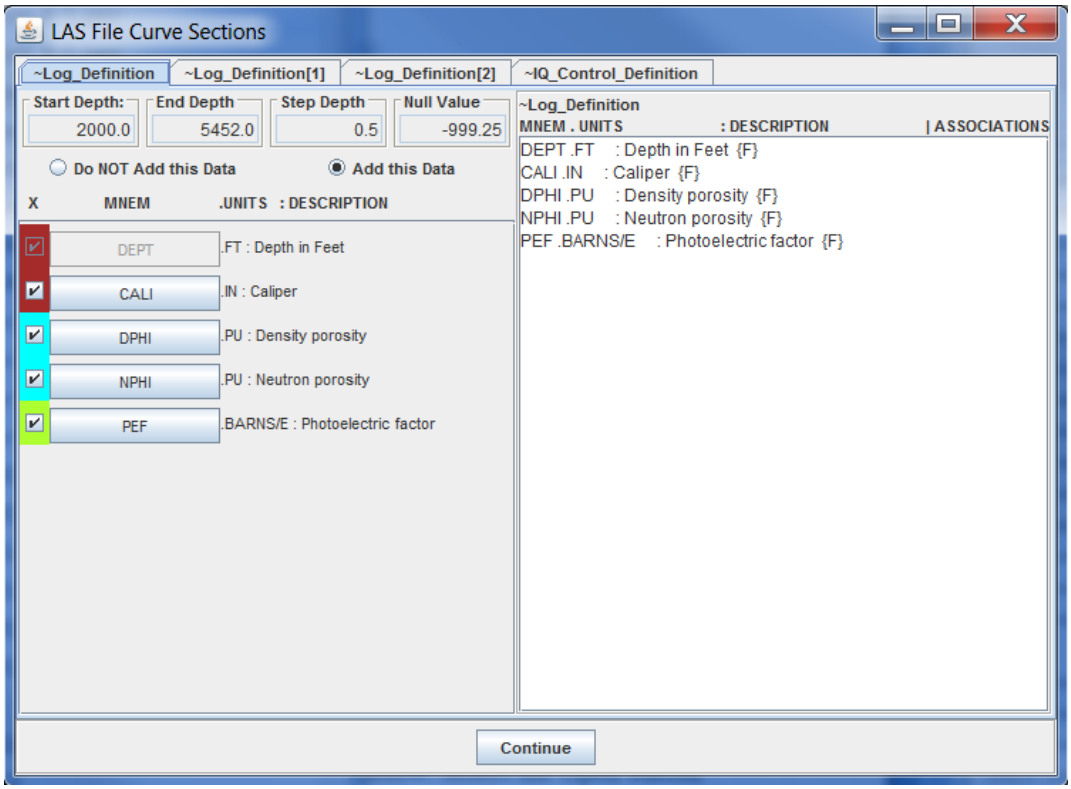
Type	Zip Files
LAS 3.0	http://www.kgs.ku.edu/Gemini/Tools/documentation/15-007-22483-Meyer_B-5_LAS3.zip



Select the "Your PC" radio button in the "Search for Log ASCII Standard (LAS) Files" Panel. Select the "Enter" icon button to display the "Select LAS File from your PC" Dialog. This dialog allows the user to search their PC for the file of interest. In this example it is the LAS version 3.0 file, 15-007-22483-Meyer_B-5_LAS3.las, highlighted below. Select the Open button to display the "LAS File Curve Sections" Dialog.



The "LAS File Curve Sections" dialog allows the user to map unknown LAS Curve Mnemonics to the KGS "Standard" Curve Mnemonics so they will be plotted in the Profile Plot. This program reads the "LAS Tool Curve Mnemonics map to KGS Standard Mnemonics" XML File (http://www.kgs.ku.edu/software/gemini/data/las_standard_tools.xml), which will automatically maps the Curve Mnemonics from the LAS file to one of 31 KGS "Standard" Curve Mnemonics.



The user will notice that there are 3 ~Log_Definition tabs, if open and viewed the 15-007-22483-Meyer_B-5_LAS3.las file, you will notice that there are 3 log data sections. This program reads each log data section and combines the data into one data set. There were originally 3 Log ASCII Standard (LAS) version 2.0 files, but the LAS 3.0 file format allows that each separate log is maintained by a separate data section within the LAS 3.0 file. The logs were downloaded from the KGS Web site and combined into one LAS 3.0 File. The original logs were a Neutron/Density/Photoelectric Factor Log, Spectral Gamma Ray Log and a partial Array induction log. Select the "Continue" button to display the "Zonation By Depth-Constrained Cluster Analysis" control dialog.

Zonation a Depth-Constrained Cluster Analysis

The Zonation by depth-constrained multivariate cluster analysis segments the entire depth interval based on user-specified set of logs. A hierarchical cluster is used to produce subintervals that are as homogeneous as possible and distinct as possible from each other, in terms of their log characteristics. The software employs Ward's method which, at each step of the clustering process, joins the two groups (subintervals) whose merger produces the least possible increase in the total within-groups sum-of-squares. The sum-of-squares for a single group, k, is given by

$$W_k = \sum_{i=1}^{n_k} ||x_i - \underline{x}_k||^2$$

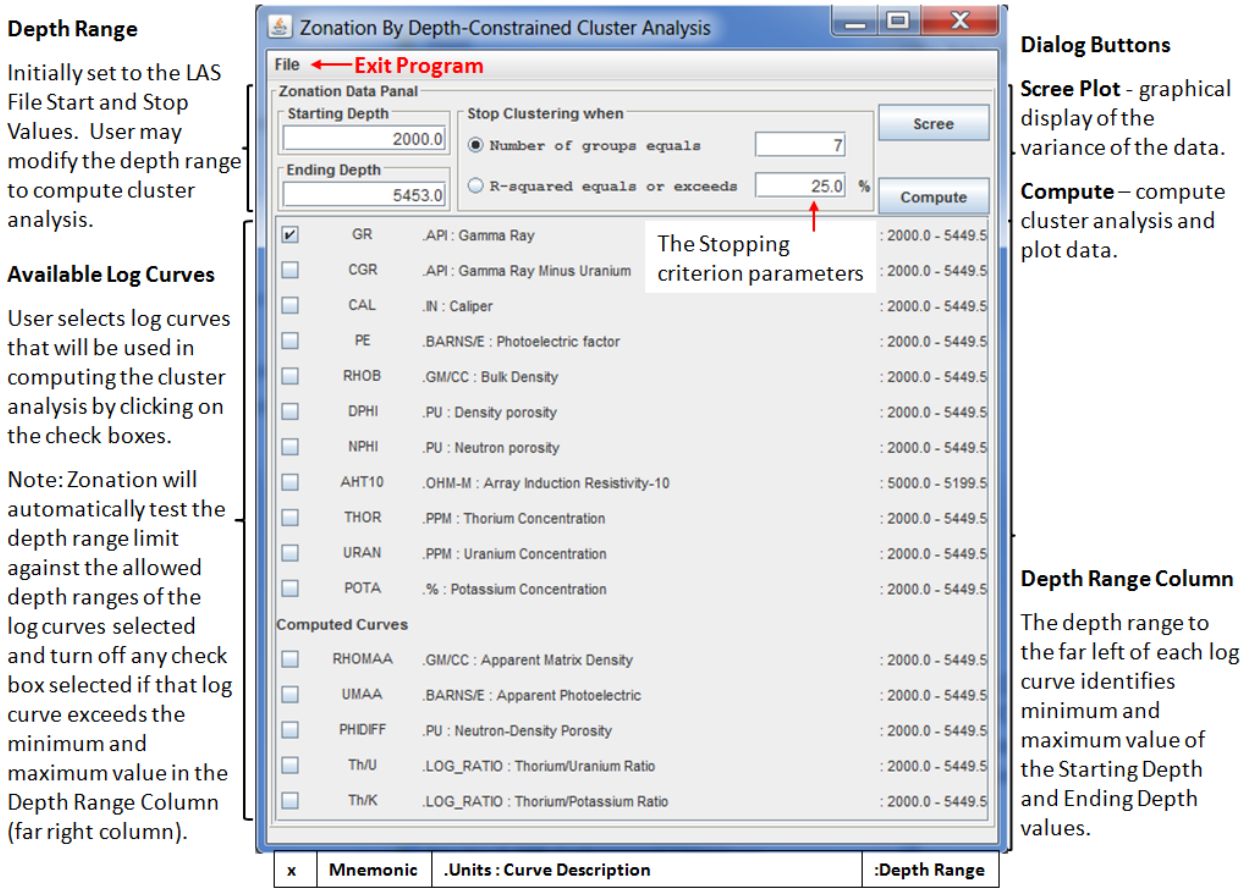
where $||x_i - \underline{x}_k||^2$ is the squared distance between the vector of the log values for data point i, x_i, and the vector mean for group k, x_k. The within-groups sum-of-squares, W, is simply the sum of the W_k values over all groups. At each step of the clustering process, the number of groups is reduced by one and the within-groups sum-of-squares increases. When all the data are joined into a single group, the total within-groups sum of squares equal the total sum-of-squares, T, given by the sum of the squared distances from all the data points to the global mean. At any step in the process, the relative amount of variation "explained" by the grouping can be measured by the value $R^2 = W/T$. R^2 increases with every merger and equals 100% when all the data points are joined in a single group.

The depth-constrained cluster analysis implemented in Zonation only allows vertically adjacent groups (subintervals) to be joined, greatly reducing the amount of computation relative to a more general cluster analysis, which would allow the possibility of joining any possible pair of groups at each step. The depth- constrained cluster analysis always produces a sequence of group memberships, represented as integers, beginning with 1 at the top of the interval and proceeding sequentially downward.

The "Zonation By Depth-Constrained Cluster Analysis" Dialog will display. The depth range panel initially displays the depth range of the log data. The user must set the Starting Depth and Ending Depth within the selected Log Curves or the log curves will be dropped when you select the "Compute" Button.

The stopping criterion can be specified either in terms of the number of groups (clustering will stop when the number of groups has be reduced to the number specified) or in terms of R^2 (clustering will stop when the R^2 equals or exceeds the specified value).

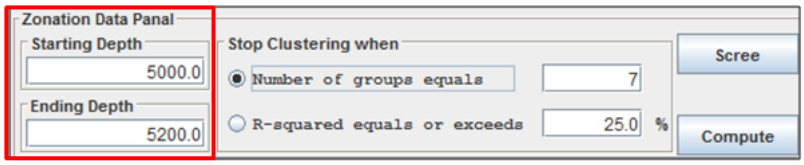
If you noticed on the dialog the log curves are listed together and only the Array induction (AHT10) log curve has measurements from 5000 to 5199.5 feet, but the other curves go from 2000 to 5449.5 feet.



Note: This analysis will not process zones with LAS File Null values in the data. The Available log curves are presented in the Zonation dialog with the non Null value depth ranges of the individual curves. The program will turn off your curve selection if the depth range you select has a Null value. Try varying the depth by subtracting 5-10 feet on the end depth if you see the curves being deselected.

With this example first decide what depth range you wish to perform the depth constrained cluster analysis. Note: you can do the whole log, but if you select "R-squared equals or exceeds" radio button you will only get a maximum of 50 groups.

In the "Zonation Data Panel" change the Starting Depth to 5000.0 and the Ending Depth to 5200.0.



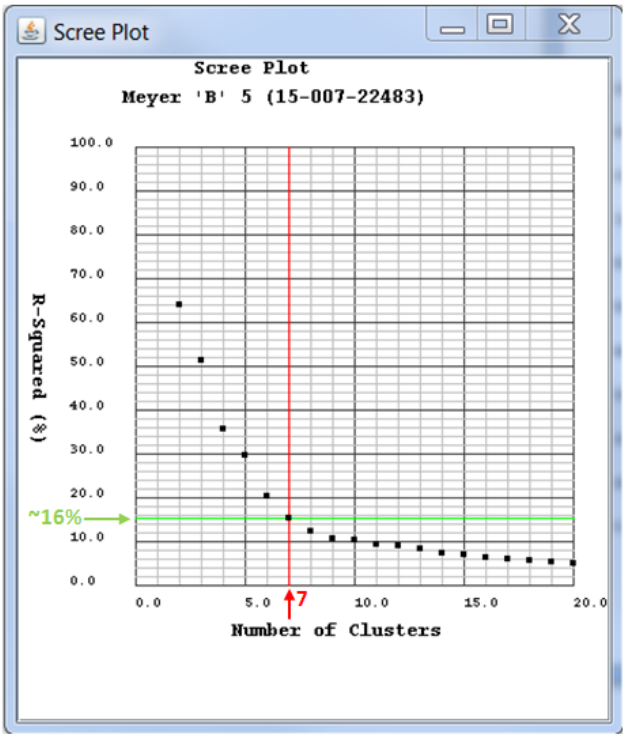
This depth range looks at the bottom of the Mississippian and Viola. You only need to select 1 curve to run the analysis, but combining multiple curves will give you better results. This example will combine the Gamma Ray (GR), Photoelectric Factor (PE), Bulk Density (RHOB) and the Neutron Porosity (NPHI) log curves for the cluster analysis.

Now Select the Gamma Ray (GR), Photoelectric Factor (PE), Bulk Density (RHOB) and the Neutron Porosity (NPHI) log curves by selecting the check boxes next to the desired curves.

Note: Each of the selected log curves have a range from 2000.0 to 5449.5, which are the minimum and maximum values that can be inserted in the Starting and Ending Depth text fields.

☑	GR	.API : Gamma Ray	: 2000.0 - 5449.5
☐	CGR	.API : Gamma Ray Minus Uranium	: 2000.0 - 5449.5
☐	CAL	.IN : Caliper	: 2000.0 - 5449.5
☑	PE	.BARNS/E : Photoelectric factor	: 2000.0 - 5449.5
☑	RHOB	.GM/CC : Bulk Density	: 2000.0 - 5449.5
☐	DPHI	.PU : Density porosity	: 2000.0 - 5449.5
☑	NPHI	.PU : Neutron porosity	: 2000.0 - 5449.5
☐	AHT10	.OHM-M : Array Induction Resistivity-10	: 5000.0 - 5199.5
☐	THOR	.PPM : Thorium Concentration	: 2000.0 - 5449.5
☐	URAN	.PPM : Uranium Concentration	: 2000.0 - 5449.5
☐	POTA	.% : Potassium Concentration	: 2000.0 - 5449.5
Computed Curves			
☐	RHOMAA	.GM/CC : Apparent Matrix Density	: 2000.0 - 5449.5
☐	UMAA	.BARNS/E : Apparent Photoelectric	: 2000.0 - 5449.5
☐	PHIDIFF	.PU : Neutron-Density Porosity	: 2000.0 - 5449.5
☐	Th/U	.LOG_RATIO : Thorium/Uranium Ratio	: 2000.0 - 5449.5
☐	Th/K	.LOG_RATIO : Thorium/Potassium Ratio	: 2000.0 - 5449.5

You now need to set the stopping criterion. The stopping criterion can be specified either in terms of the number of groups (clustering will stop when the number of groups has been reduced to the number specified) or in terms of R^2 (clustering will stop when the R^2 equals or exceeds the specified value). Select the "Scree" button to display the Scree Plot, which will assist in deciding the stopping criteria for this data set.

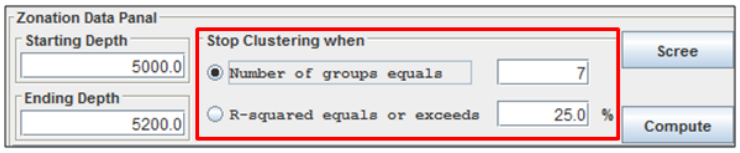


*A **scree plot** is a graphical display of the variance of each component in the dataset which is used to determine how many components should be retained in order to explain a high percentage of the variation in the data.*
Reference:
http://www.stats.gla.ac.uk/glossary/?q=node/451

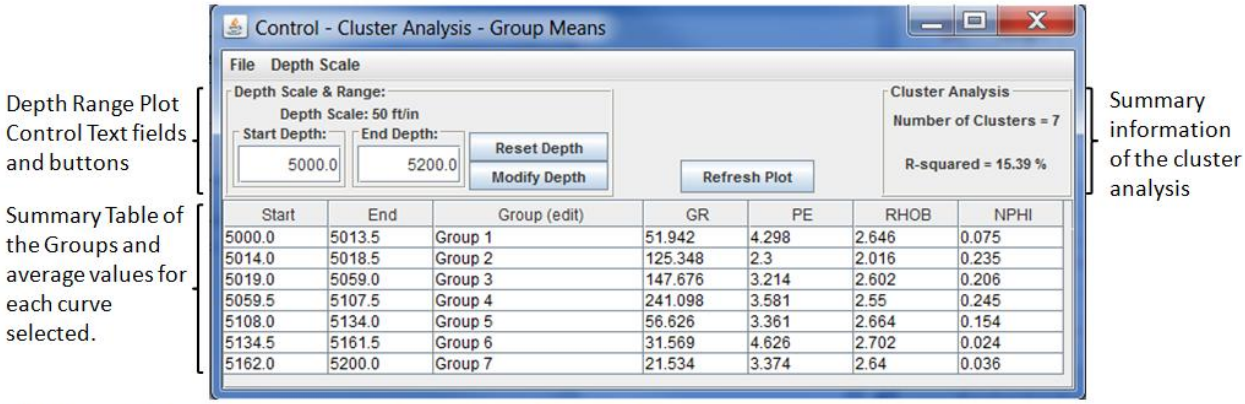
Click on the "Scree" button to create a scree plot, which can assist the user in selecting the Stop Criteria Parameters in the "Stop Clustering when" text fields.

Since the "Number of groups equals" radio button is selected you will see a vertical red line on 7 "Number of Clusters" equal to the value entered in the text field. You will also see a horizontal green line, which will illustrate the R^2 (%) value of ~16%.

The Scree Plot illustrates that "Number of groups equal" radio button selected with 7 groups would be an adequate number of groups (zones) to split the depth range entered.



When the Compute button is selected in the Zonation Data Panel, this program will perform the cluster analysis. For the sake of the cluster analysis, each of the input variables is standardized to zero mean and unit variance. It is more than likely that the selected logs will be in incommensurate units and will thus differ greatly in magnitude. The standardization assures that each variable will be given approximately equal weight in the analysis. The analysis begins with each data point (zone) considered as a separate group (subinterval) and proceeds either until the stopping criterion is achieved. At that point the "Cluster Analysis - Group Means" Plot Dialog will be displayed with the results.



Depth Range Plot Control Text fields and buttons

Summary Table of the Groups and average values for each curve selected.

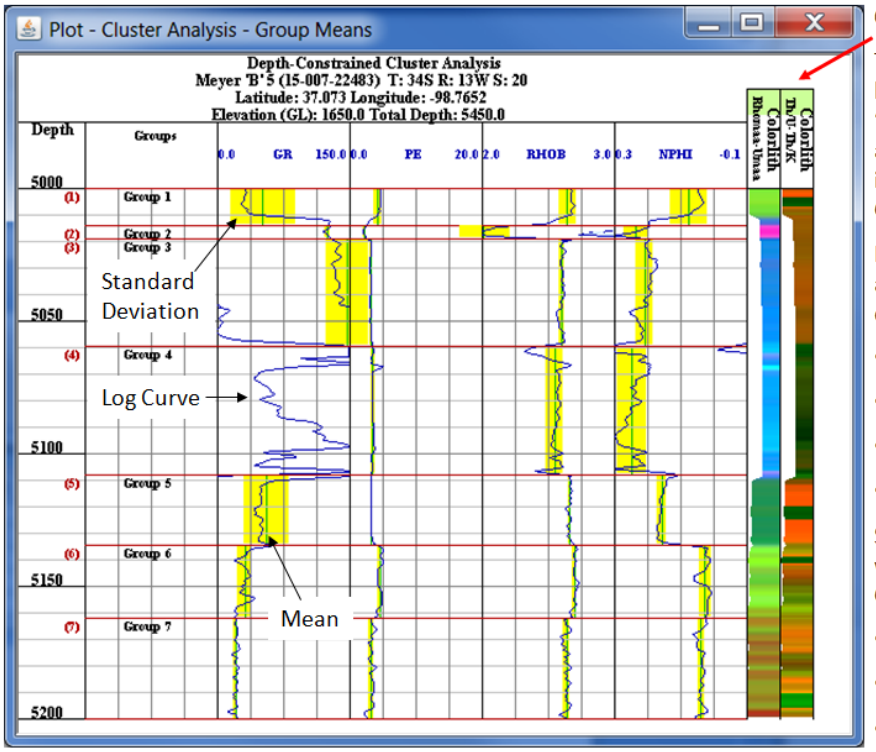
Summary information of the cluster analysis

File Menu Option:

Create Portable Document Format (PDF) & Portable Network Graphics (PNG) of Cluster Analysis Plot, Group Data Table and Curve Descriptions.

Depth Scale Menu Option:

Allows the user to change the plot depth scale.



Log Curve is blue, the Mean within each group is green and the Standard Deviation (1 sigma) is yellow.

Colorlith Plot Tracks:

The Colorlith tracks provide a visual bed separation and a visual "goodness" indicator. Colorlith assigns a log curve to a single color, i.e. Rhomaa – Red, Umaa – Green, Gamma Ray-Blue.

Rhomaa-Umaa Colorlith will only appear if all the litho-density log curves are present,

- GR – Gamma Ray
- NPHI – Neutron Porosity
- RHOB – Bulk Density
- PE – Photoelectric Factor

Spectral Gamma Ray Ratio Colorlith will only appear if all the Spectral Gamma Ray curves are present,

- Th – Thorium
- U – Uranium
- K - Potassium

References:

Pfeffer-Pro (Petrofacies Evaluation of Formation for Engineering Reservoirs), Kansas Geological Survey, Release Date February 1998. Zonation by Depth-Constrained Cluster Analysis pages 141 to 144.