Petra tips and tricks for working with log data

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The Discovery Group Inc.
RMAG Spring short course,
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Objectives

- We assume you already know how to use the software,
- Our goal is to present a series of user tips and tricks that will:
  - Improve workflows
  - Let you do things that may not have been obvious how to do
  - Workaround limitations in the software or substitute for features that are not explicitly designed into the package
  - Generally save you time, effort, and money
- I am *NOT* going to teach a log analysis school today

Log analysis tips and tricks

- Petra has a general purpose, flexible log calculation engine built into it.
- It does NOT aim to be a high end petrophysical modeling or model development package
  - *DISCLOSURE:* Discovery Group does not attempt to force fit Petra into that mold, we have several specialized petrophysics packages available for our workflows
  - We DO use Petra for batch processing of large numbers of wells, for computing pore volumes and HCPV over entire fields, and for its integration with cross-sections, mapping, and other well data
  - We use it EVERY DAY in our petrophysical studies

What Petra does well

- Manage and organize log data, including support for log aliases
- Allow you to splice curves or log runs, edit curves, & perform some basic curve normalization
- Compute shaliness, porosity, and fluid saturations
- Compute flag curves using a variety of criteria
- Compute “net pay”, net of user defined cutoffs
- Run processes on large numbers of wells very quickly
- Allows you to write and save flexible user equations, and to some extent user programs

What Petra does not do…..

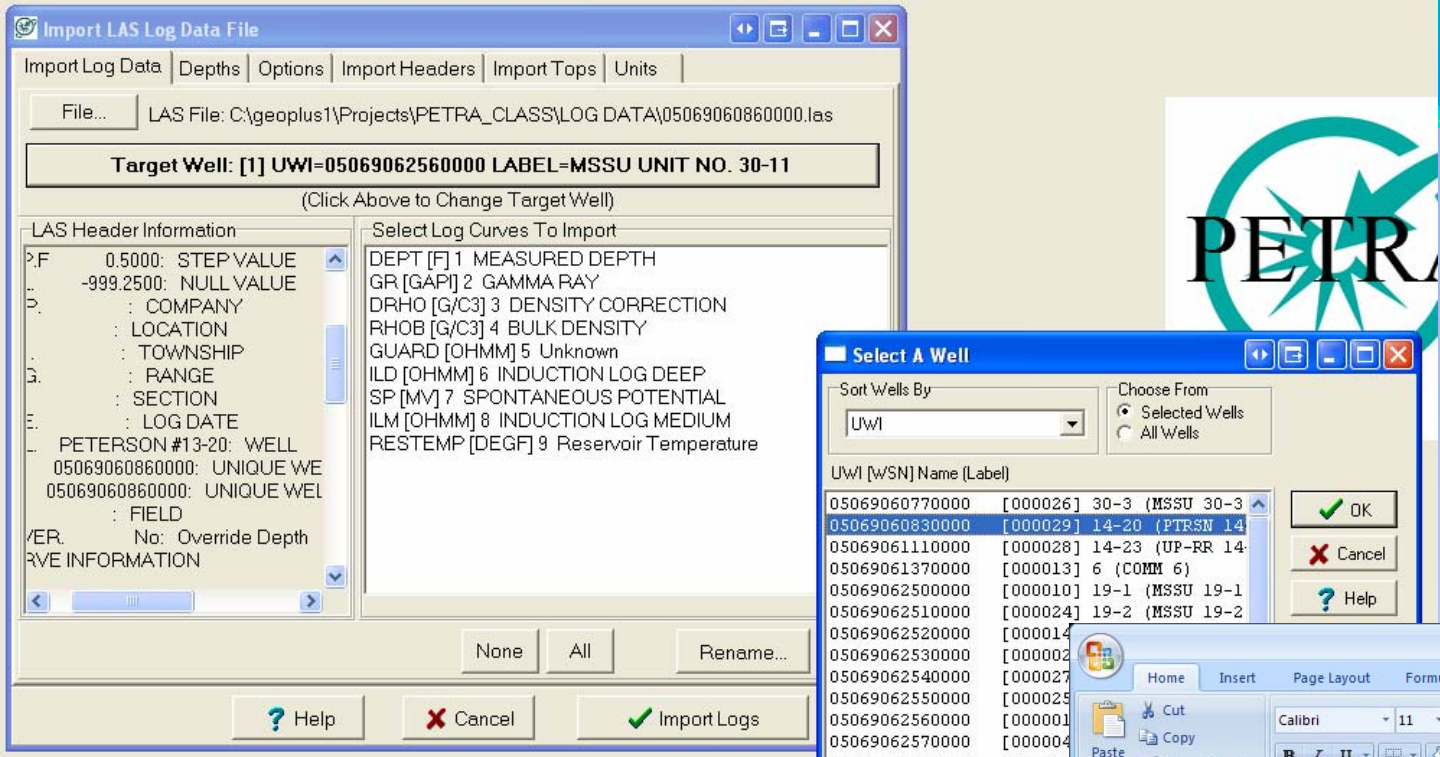
- Run vendor and tool specific environmental corrections
- Support 1 or 2-point normalization using histogram overlays
  - at least without using a printer and a light table…
- Use standard cross-plot routines to compute porosity from multiple logs (e.g. neutron-density)
- Compute multi-mineral volumes (e.g. Vdol-Vls-Vqtz)
- Link to outside codes in standard languages (e.g. VisualBasic, C++, Java, etc.)

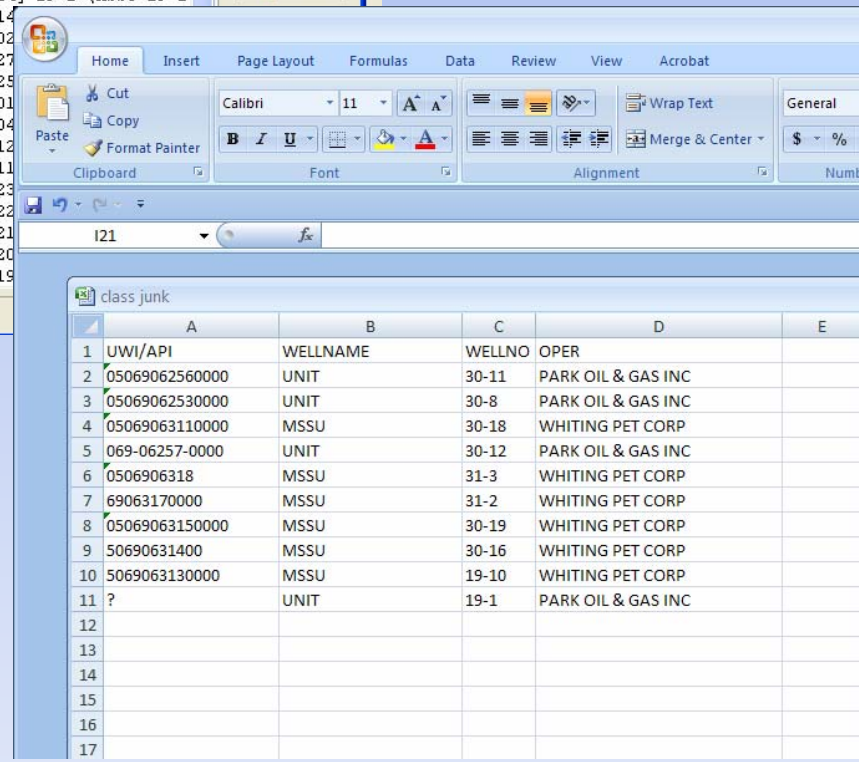
Left for another day……

- Normalization
- Cross-plotting
- Multi-mineral models
- The “Advanced User Models” language

A. How do I bring log data into Petra, and what are the pitfalls of using the batch LAS import function?

- API numbers critical, can't live with 'em, can't live without 'em
- Wrong API = Wrong association with a well in Petra.
- You cannot assume the vendor or digitizer got it right.
- Solutions:
  - Import wells one at a time
  - Open each LAS file in a text editor and add/fix them
  - Extract the API numbers from the LAS files, edit them in a spreadsheet, write them back into the LAS files.





	A	B	C	D	E
1	UWI/API	WELLNAME	WELLNO	OPER	
2	05069062560000	UNIT	30-11	PARK OIL & GAS INC	
3	05069062530000	UNIT	30-8	PARK OIL & GAS INC	
4	05069063110000	MSSU	30-18	WHITING PET CORP	
5	069-06257-0000	UNIT	30-12	PARK OIL & GAS INC	
6	0506906318	MSSU	31-3	WHITING PET CORP	
7	69063170000	MSSU	31-2	WHITING PET CORP	
8	05069063150000	MSSU	30-19	WHITING PET CORP	
9	50690631400	MSSU	30-16	WHITING PET CORP	
10	5069063130000	MSSU	19-10	WHITING PET CORP	
11	?	UNIT	19-1	PARK OIL & GAS INC	
12					
13					
14					
15					
16					
17					

B. How do I import LAS header data to Petra, and what are the differences between LAS 1.2 and 2.0 formats?

- LAS 1.2 and 2.0 headers use a different format for the Well information block, including information such as the API number
  - PETRA recognizes both formats, and automatically flips them into the standard (2.0) order
- The critical data to capture are anything used in log calculations or useful for log evaluations
  - Logging date, run number, and service company
  - Mud type, weight, Rm@T___, Rmf@T___
  - Max recorded temperature, LTD, base of csg

LAS version 1.2 Well Information Section.

```
~Well Information Section
#MNEM.UNIT      Data Type                 Information
#---------      -------------             -----------------------------
STRT.M           635.0000:
STOP.M           400.0000:
STEP.M           -0.1250:
NULL.           -999.25:
COMP.            COMPANY:                 ANY OIL COMPANY INC.
WELL.           WELL:                     ANY ET AL A9-16-49-20
FLD .           FIELD:                    EDAM
LOC .           LOCATION:                 A9-16-49-20W3M
PROV.           PROVINCE:                 SASKATCHEWAN
SRVC.           SERVICE CO:               ANY LOGGING COMPANY INC.
DATE.           LOG DATE:                 13-DEC-86
UWI .           UNIQUE WELL ID:           100091604920W300
```

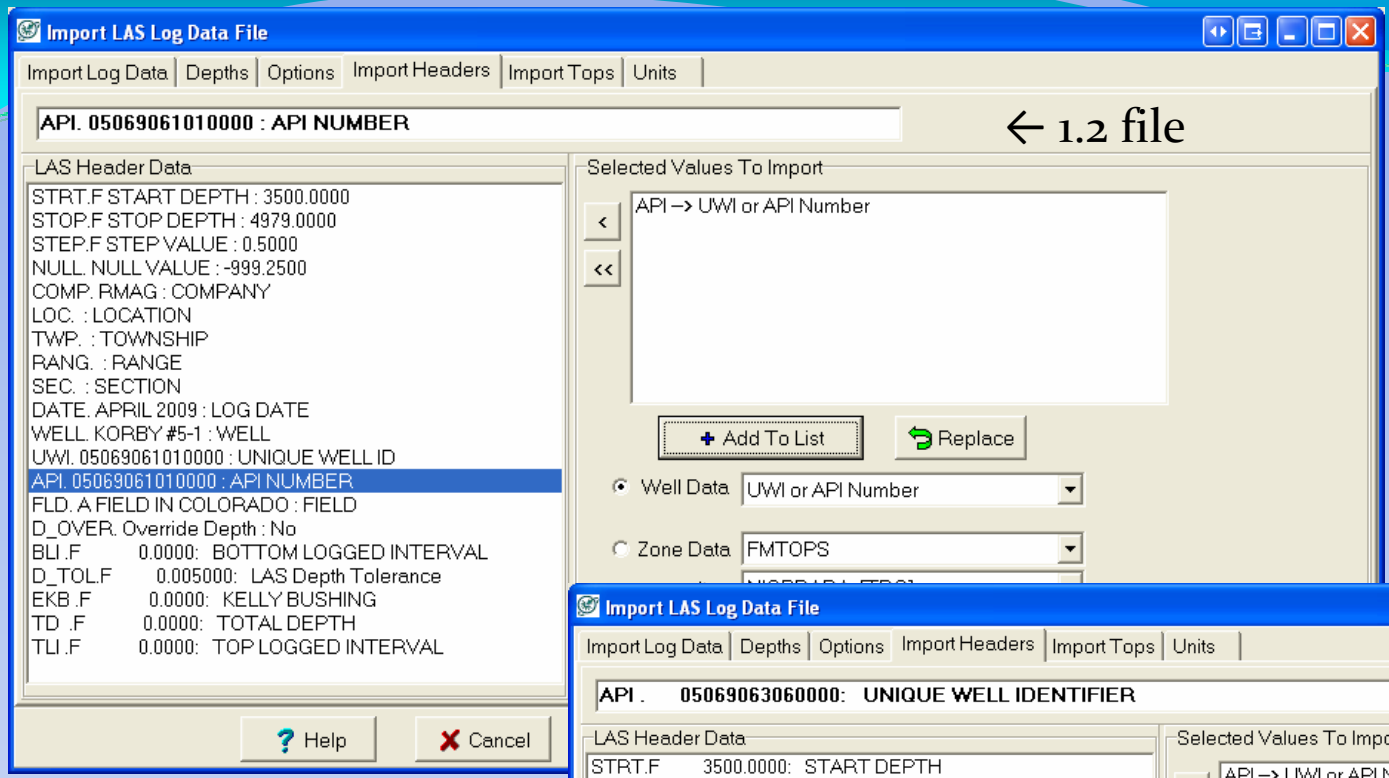
LAS version 2.0.

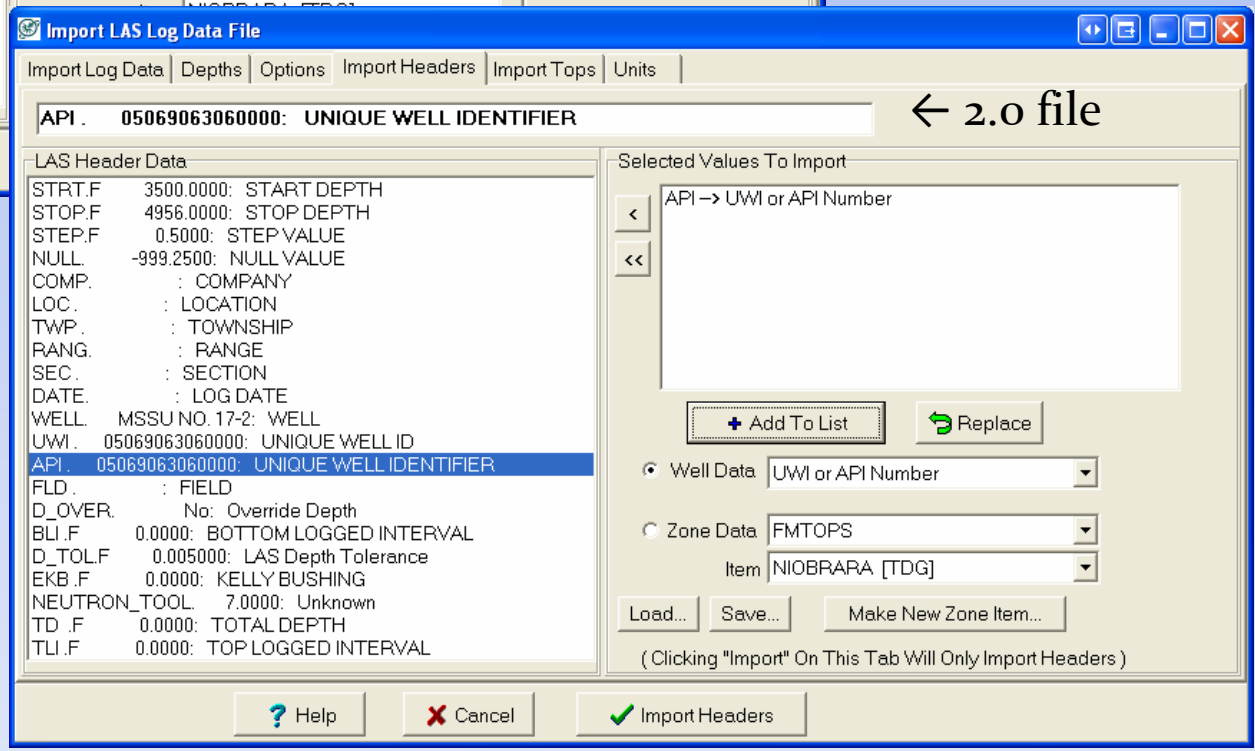
```
~Well Information Section
#MNEM.UNIT     VALUE/NAME                DESCRIPTION
#--------       --------------            ---------------------
STRT.M          635.0000                  :START DEPTH
STOP.M          400.0000                  :STOP DEPTH
STEP.M          -0.125                    :STEP
NULL.           -999.25                   :NULL VALUE
COMP.           ANY OIL COMPANY INC.      :COMPANY
WELL.           ANY ET AL 12-34-12-34     :WELL
FLD .           WILDCAT                   :FIELD
LOC .           12-34-12-34W5M            :LOCATION
PROV.           ALBERTA                   :PROVINCE
SRVC.           ANY LOGGING COMPANY INC.  :SERVICE COMPANY
DATE.           13-DEC-86                 :LOG DATE
UWI .           100123401234W500          :UNIQUE WELL ID
```

Look at the order of the Data Type and Information in an LAS 1.2 header.....

vs. the order in an LAS 2.0 header. The order is now consistent in all data blocks

- Headers are imported separately, and the header import will create a new well if it cannot find an API number match
- The mapping between header data and zone data fields is vendor specific- with a few exceptions the LAS standard does not specify parameter or curve mnemonics. Logging companies and digitizers cook up their own abbreviations!
- You can save the mapping for reuse.
  - It has to already exist to be used in a batch import.

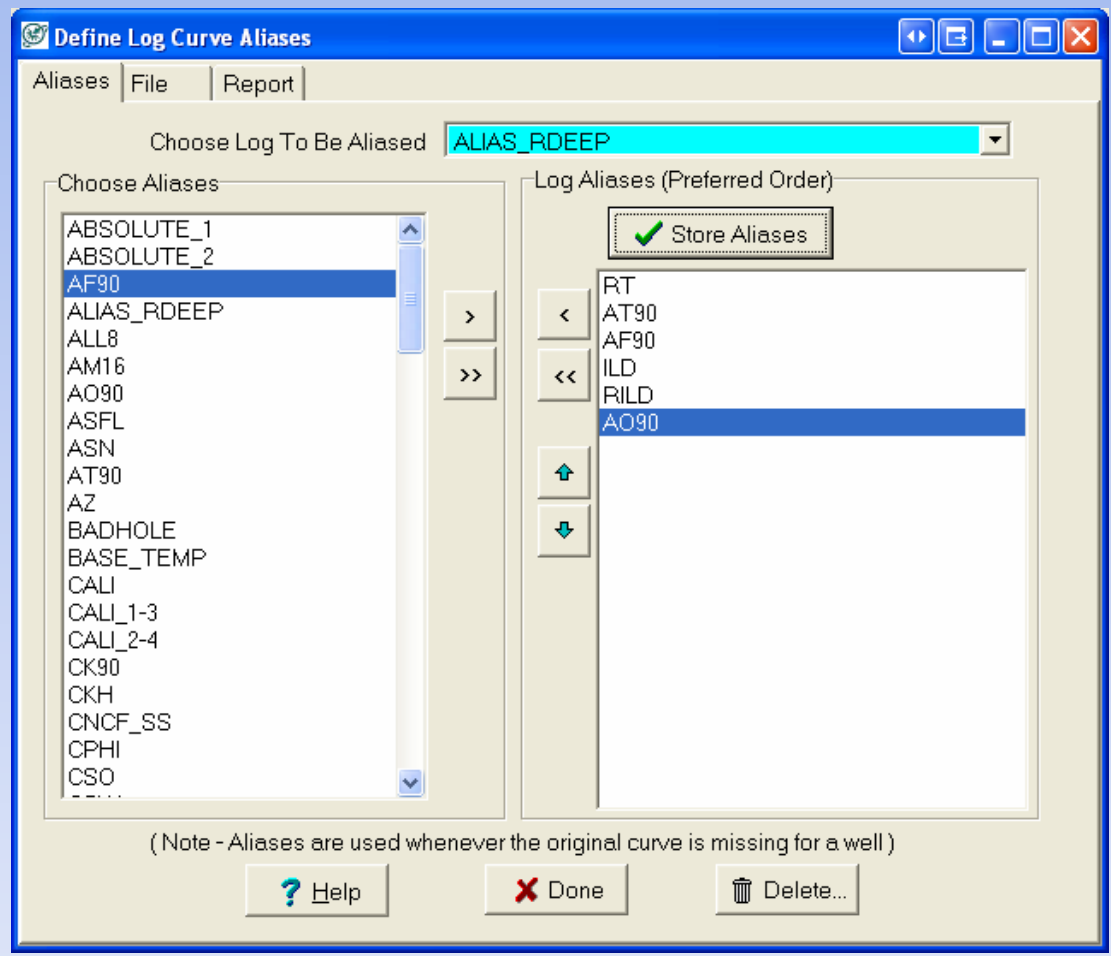

Import LAS Log Data File
Import Log Data
Depths
Options
Import Headers
Import Tops
Units
API. 05069061010000 : API NUMBER
← 1.2 file
LAS Header Data
STRT.F START DEPTH : 3500.0000
STOP.F STOP DEPTH : 4979.0000
STEP.F STEP VALUE : 0.5000
NULL. NULL VALUE : -999.2500
COMP. RMAG : COMPANY
LOC. : LOCATION
TWP. : TOWNSHIP
RANG. : RANGE
SEC. : SECTION
DATE. APRIL 2009 : LOG DATE
WELL. KORBY #5-1 : WELL
UWI. 05069061010000 : UNIQUE WELL ID
API. 05069061010000 : API NUMBER
FLD. A FIELD IN COLORADO : FIELD
D_OVER. Override Depth : No
BLI .F 0.0000: BOTTOM LOGGED INTERVAL
D_TOL.F 0.005000: LAS Depth Tolerance
EKB .F 0.0000: KELLY BUSHING
TD .F 0.0000: TOTAL DEPTH
TLI .F 0.0000: TOP LOGGED INTERVAL
Selected Values To Import
API –> UWI or API Number
Add To List
Replace
Well Data
UWI or API Number
Zone Data
FMTOPS
Help
Cancel


Import LAS Log Data File
Import Log Data
Depths
Options
Import Headers
Import Tops
Units
API . 05069063060000: UNIQUE WELL IDENTIFIER
← 2.0 file
LAS Header Data
STRT.F 3500.0000: START DEPTH
STOP.F 4956.0000: STOP DEPTH
STEP.F 0.5000: STEP VALUE
NULL. -999.2500: NULL VALUE
COMP. : COMPANY
LOC . : LOCATION
TWP . : TOWNSHIP
RANG. : RANGE
SEC . : SECTION
DATE. : LOG DATE
WELL. MSSU NO. 17-2: WELL
UWI . 05069063060000: UNIQUE WELL ID
API . 05069063060000: UNIQUE WELL IDENTIFIER
FLD . : FIELD
D_OVER. No: Override Depth
BLI .F 0.0000: BOTTOM LOGGED INTERVAL
D_TOL.F 0.005000: LAS Depth Tolerance
EKB .F 0.0000: KELLY BUSHING
NEUTRON_TOOL. 7.0000: Unknown
TD .F 0.0000: TOTAL DEPTH
TLI .F 0.0000: TOP LOGGED INTERVAL
Selected Values To Import
API –> UWI or API Number
Add To List
Replace
Well Data
UWI or API Number
Zone Data
FMTOPS
Item
NIOBRARA [TDG]
Load...
Save...
Make New Zone Item...
(Clicking "Import" On This Tab Will Only Import Headers)
Help
Cancel
Import Headers

C. How do I use curve name aliases, and how should they be organized?

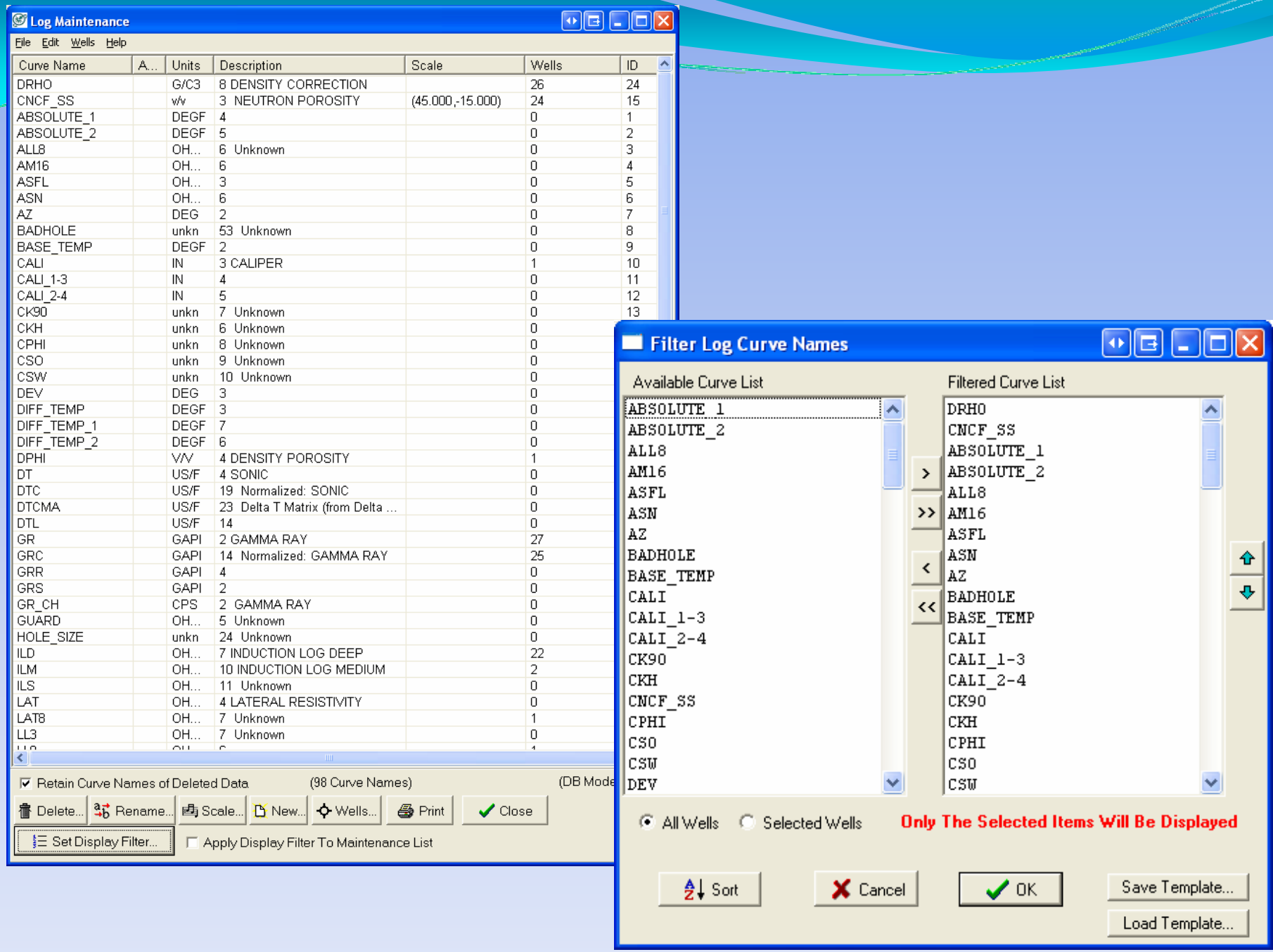
- Aliases are public and project wide.
- Aliases are NOT nested.
  - You need to list curves in the hierarchy you want them to be used. E.g., if you want to use 2 ft resolution resistivity curves in preference to 1 ft curves, put them higher in the list.
- We recommend either:
  - Use the most common curve names as your aliases (GR, NPHI, DPHI), and alias all the synonyms to them; or
  - Set up special aliases like “ALIAS_GR” so it is obvious which are the aliased curve names

- Since Petra uses the first curve it finds in an alias list, if you have multiple runs with different curve names you will need to splice runs to create a single curve that appears higher in the alias list



D. I have way too many curve names- how can I clean it up and simplify my curve database?

- Dean already talked about this.
- We export the curve listing, with well counts, to a spreadsheet before any serious organizing
- It helps to categorize curves by logging vendor, tool type, vintage, & data source
- Use suffixes and prefixes to set apart special curve classes (flags, aliases, normalized curves, etc.)
- Consider adjective/noun order.
  - There is a reason the military names things the way they do!
- We like to preserve original logging vendor mnemonics, there is often information in them that might not be obvious to a non-specialist
  - e.g. an Atlas CNC and CNCF are different
  - Porosity logs are only useful when you know the matrix assumptions (SS, LS, DOL), make them part of the name!

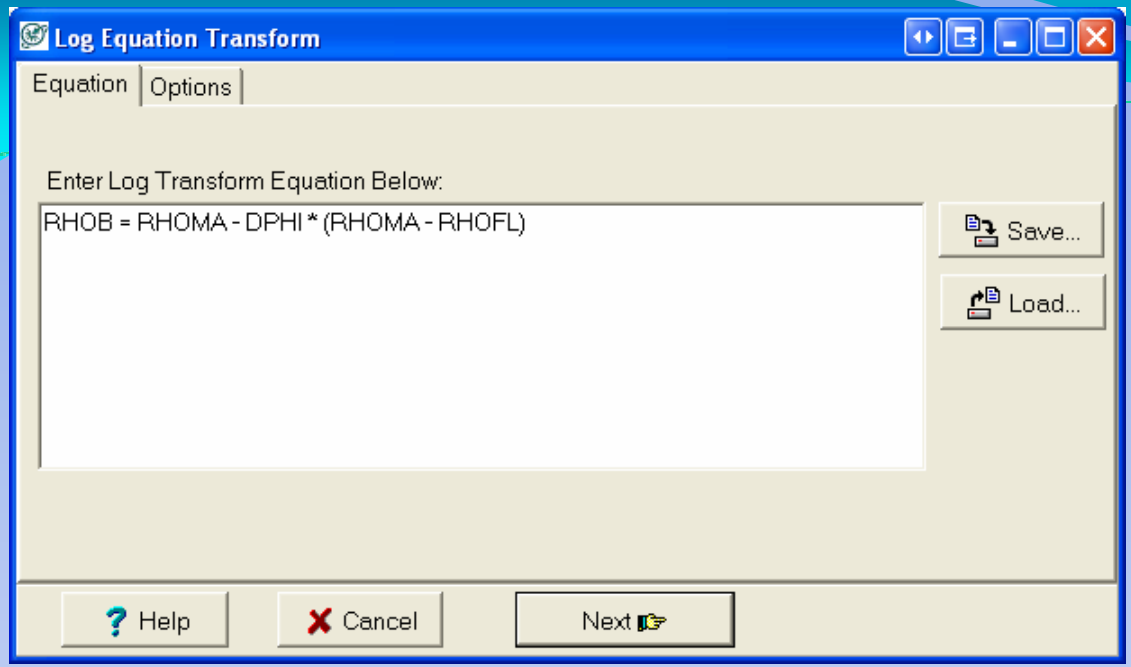

Log Maintenance
File Edit Wells Help
Curve Name | A... | Units | Description | Scale | Wells | ID
DRHO | | G/C3 | 8 DENSITY CORRECTION | | 26 | 24
CNCF_SS | | v/v | 3 NEUTRON POROSITY | (45.000,-15.000) | 24 | 15
ABSOLUTE_1 | | DEGF | 4 | | 0 | 1
ABSOLUTE_2 | | DEGF | 5 | | 0 | 2
ALL8 | | OH... | 6 Unknown | | 0 | 3
AM16 | | OH... | 6 | | 0 | 4
ASFL | | OH... | 3 | | 0 | 5
ASN | | OH... | 6 | | 0 | 6
AZ | | DEG | 2 | | 0 | 7
BADHOLE | | unkn | 53 Unknown | | 0 | 8
BASE_TEMP | | DEGF | 2 | | 0 | 9
CALI | | IN | 3 CALIPER | | 1 | 10
CALI_1-3 | | IN | 4 | | 0 | 11
CALI_2-4 | | IN | 5 | | 0 | 12
CK90 | | unkn | 7 Unknown | | 0 | 13
CKH | | unkn | 6 Unknown | | 0 |
CPHI | | unkn | 8 Unknown | | 0 |
CSO | | unkn | 9 Unknown | | 0 |
CSW | | unkn | 10 Unknown | | 0 |
DEV | | DEG | 3 | | 0 |
DIFF_TEMP | | DEGF | 3 | | 0 |
DIFF_TEMP_1 | | DEGF | 7 | | 0 |
DIFF_TEMP_2 | | DEGF | 6 | | 0 |
DPHI | | V/V | 4 DENSITY POROSITY | | 1 |
DT | | US/F | 4 SONIC | | 0 |
DTC | | US/F | 19 Normalized: SONIC | | 0 |
DTCMA | | US/F | 23 Delta T Matrix (from Delta ... | | 0 |
DTL | | US/F | 14 | | 0 |
GR | | GAPI | 2 GAMMA RAY | | 27 |
GRC | | GAPI | 14 Normalized: GAMMA RAY | | 25 |
GRR | | GAPI | 4 | | 0 |
GRS | | GAPI | 2 | | 0 |
GR_CH | | CPS | 2 GAMMA RAY | | 0 |
GUARD | | OH... | 5 Unknown | | 0 |
HOLE_SIZE | | unkn | 24 Unknown | | 0 |
ILD | | OH... | 7 INDUCTION LOG DEEP | | 22 |
ILM | | OH... | 10 INDUCTION LOG MEDIUM | | 2 |
ILS | | OH... | 11 Unknown | | 0 |
LAT | | OH... | 4 LATERAL RESISTIVITY | | 0 |
LAT8 | | OH... | 7 Unknown | | 1 |
LL3 | | OH... | 7 Unknown | | 0 |
Retain Curve Names of Deleted Data
(98 Curve Names)
(DB Mode
Delete... Rename... Scale... New... Wells... Print Close
Set Display Filter...
Apply Display Filter To Maintenance List
Filter Log Curve Names
Available Curve List
ABSOLUTE_1
ABSOLUTE_2
ALL8
AM16
ASFL
ASN
AZ
BADHOLE
BASE_TEMP
CALI
CALI_1-3
CALI_2-4
CK90
CKH
CNCF_SS
CPHI
CSO
CSW
DEV
Filtered Curve List
DRHO
CNCF_SS
ABSOLUTE_1
ABSOLUTE_2
ALL8
AM16
ASFL
ASN
AZ
BADHOLE
BASE_TEMP
CALI
CALI_1-3
CALI_2-4
CK90
CKH
CPHI
CSO
CSW
>
>>
<
<<
All Wells
Selected Wells
Only The Selected Items Will Be Displayed
Sort
Cancel
OK
Save Template...
Load Template...

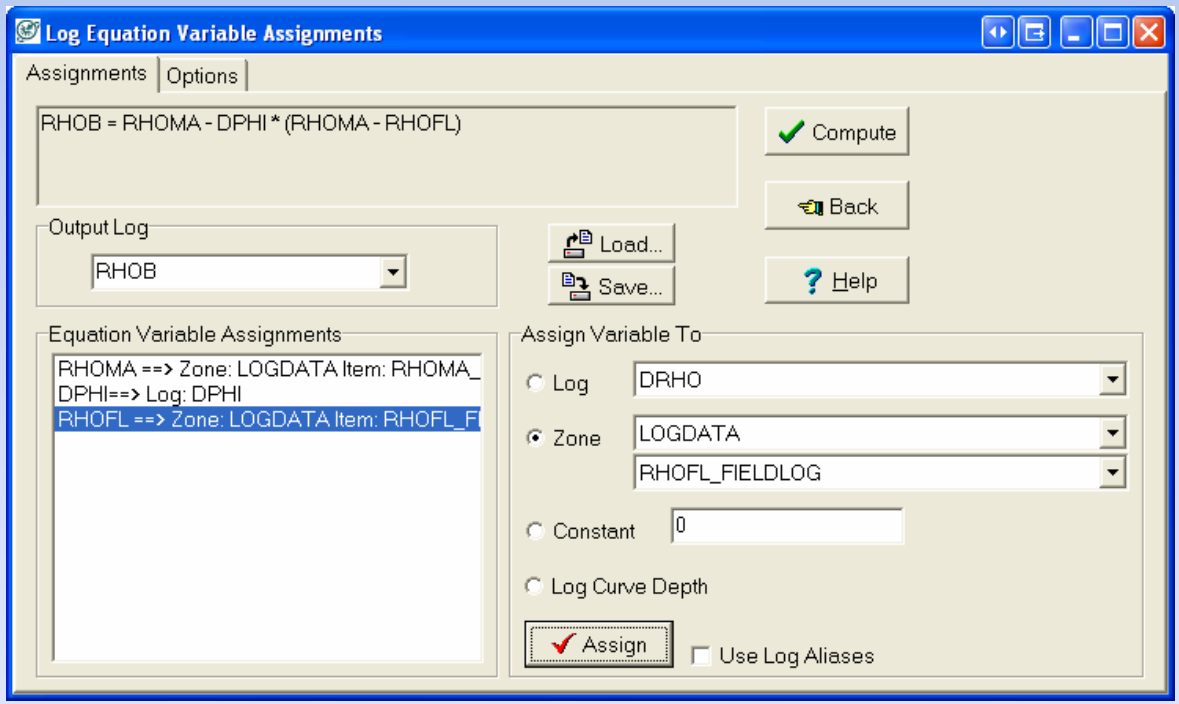
E. My porosity logs are variously in decimal (v/v) and percent (pu) units. How do I clean that up so they plot correctly on cross-sections and compute saturations right?

- Find them all first
  - Easiest to compute log statistics and then use well select by data criteria function
- Convert them all to the same basis. Most equations want fractional porosity.
- Recompute the stats and check your work
- *Pitfall*: log run changes with different vendors. This is a cleanup problem that needs to be fixed when curves are spliced.

F. Some of my wells have density porosity, others have bulk density, some both, what should I use and how do I get them all on a common basis?

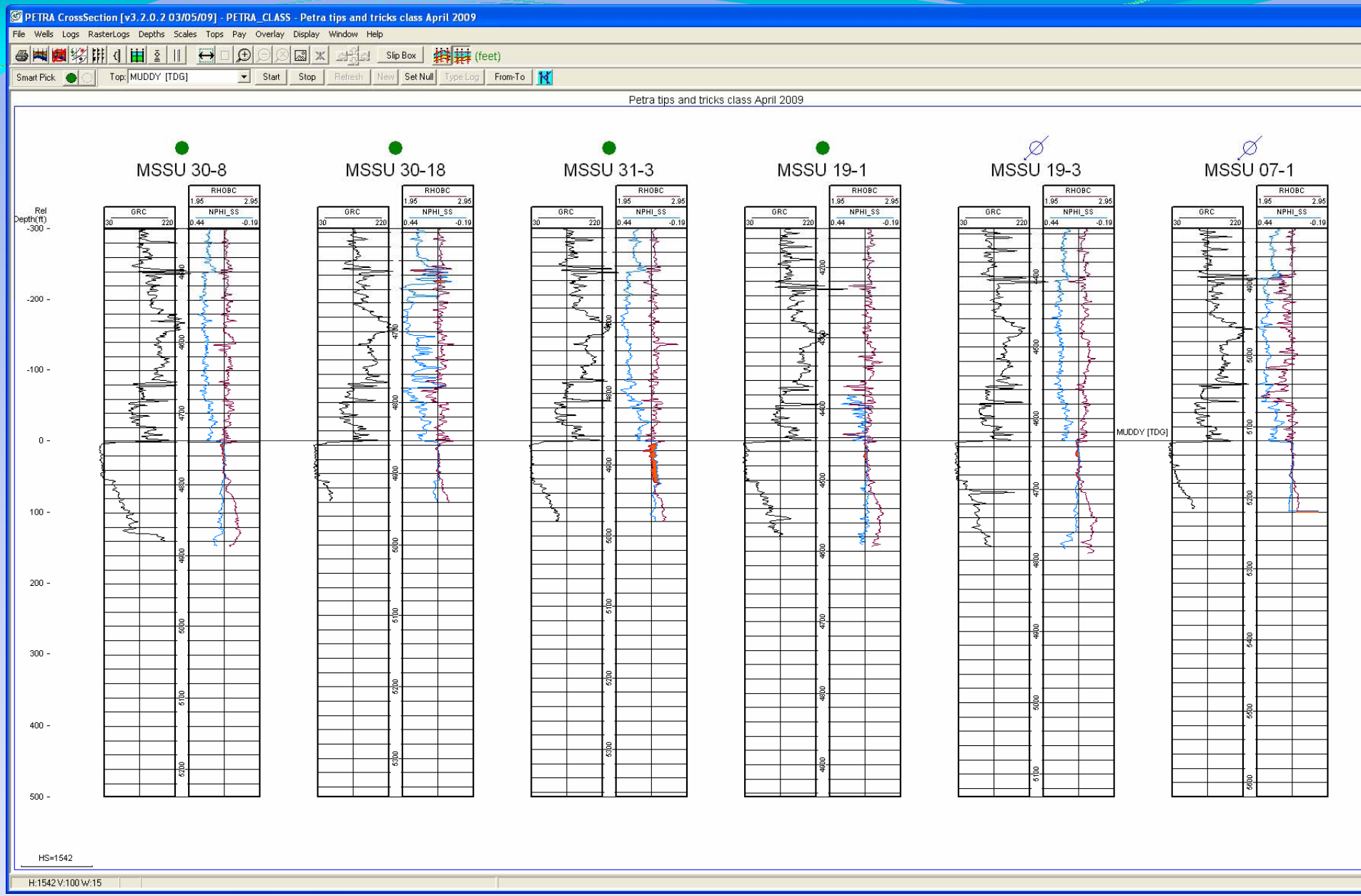
- As before, find them first using the well select by data criteria functions.
- Density porosity curves are ALWAYS ambiguous, since they made a matrix density and fluid density assumption in the field when curve was computed
  - LAS headers rarely record these values. You have to look them up on the paper logs/rasters.
  - Beware of mid-log scale changes
  - Enter the values as zone parameters; we set up a special “petrophysics” or “logging” zone for this and other data.

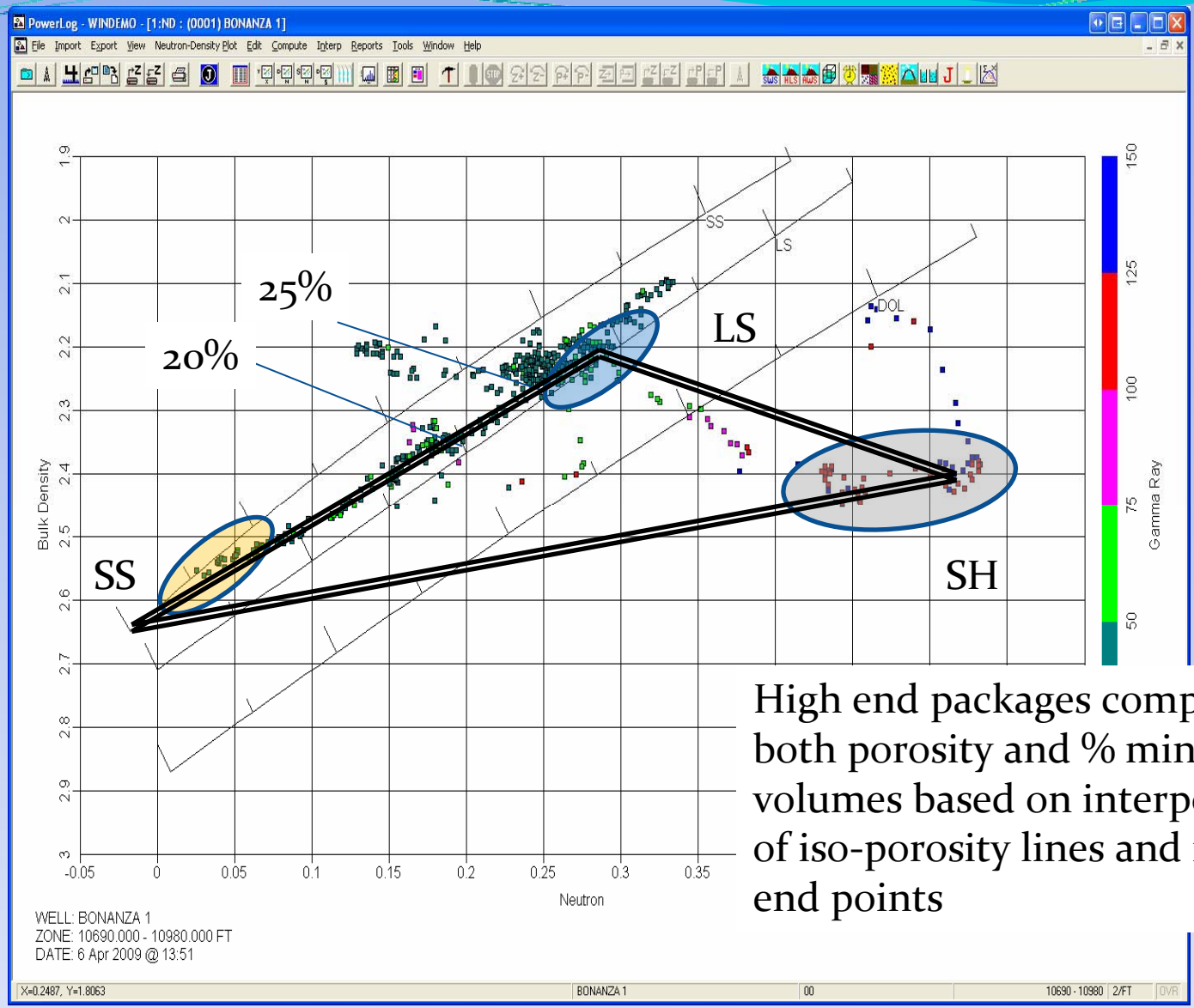

Log Equation Transform
Equation
Options
Enter Log Transform Equation Below:
RHOB = RHOMA - DPHI * (RHOMA - RHOFL)
Save...
Load...
Help
Cancel
Next


Log Equation Variable Assignments
Assignments
Options
RHOB = RHOMA - DPHI * (RHOMA - RHOFL)
Compute
Back
Output Log
RHOB
Load...
Save...
Help
Equation Variable Assignments
RHOMA ==> Zone: LOGDATA Item: RHOMA_
DPHI==> Log: DPHI
RHOFL ==> Zone: LOGDATA Item: RHOFL_F
Assign Variable To
Log
DRHO
Zone
LOGDATA
RHOFL_FIELDLOG
Constant
0
Log Curve Depth
Assign
Use Log Aliases

G. Some of my wells have neutron porosity in LS units, others are in SS, what should I use and how do I get them all on a common basis?

- Eqn's to convert from LS→SS and SS→ LS are not published by the service companies
  - You can digitize the chartbooks and fit eqn's to the curves yourself
- LS units are the true basis of neutron logging. Other matrices are output as a convenience for log analysis "on the hood of a Chevy"
- The relationships are all non-linear *except in limestone*. They vary from company to company, tool to tool.
- Finding problem wells is difficult because the mnemonics generally do not include the matrix.
  - Look them up on the paper copies
  - Plot special x-sections and look for distinctive separation


PETRA CrossSection [v3.2.0.2 03/05/09] - PETRA_CLASS - Petra tips and tricks class April 2009
File Wells Logs RasterLogs Depths Scales Tops Pay Overlay Display Window Help
Slip Box
(feet)
Smart Pick
Top: MUDDY [TDG]
Start
Stop
Refresh
New
Set Null
Type Log
From-To
Petra tips and tricks class April 2009
MSSU 30-8
MSSU 30-18
MSSU 31-3
MSSU 19-1
MSSU 19-3
MSSU 07-1
Rel Depth(ft)
GRC
RHOBC
NPHI_SS
MUDDY [TDG]
HS=1542
H:1542 V:100 W:15



High end packages compute both porosity and % mineral volumes based on interpolation of iso-porosity lines and mineral end points

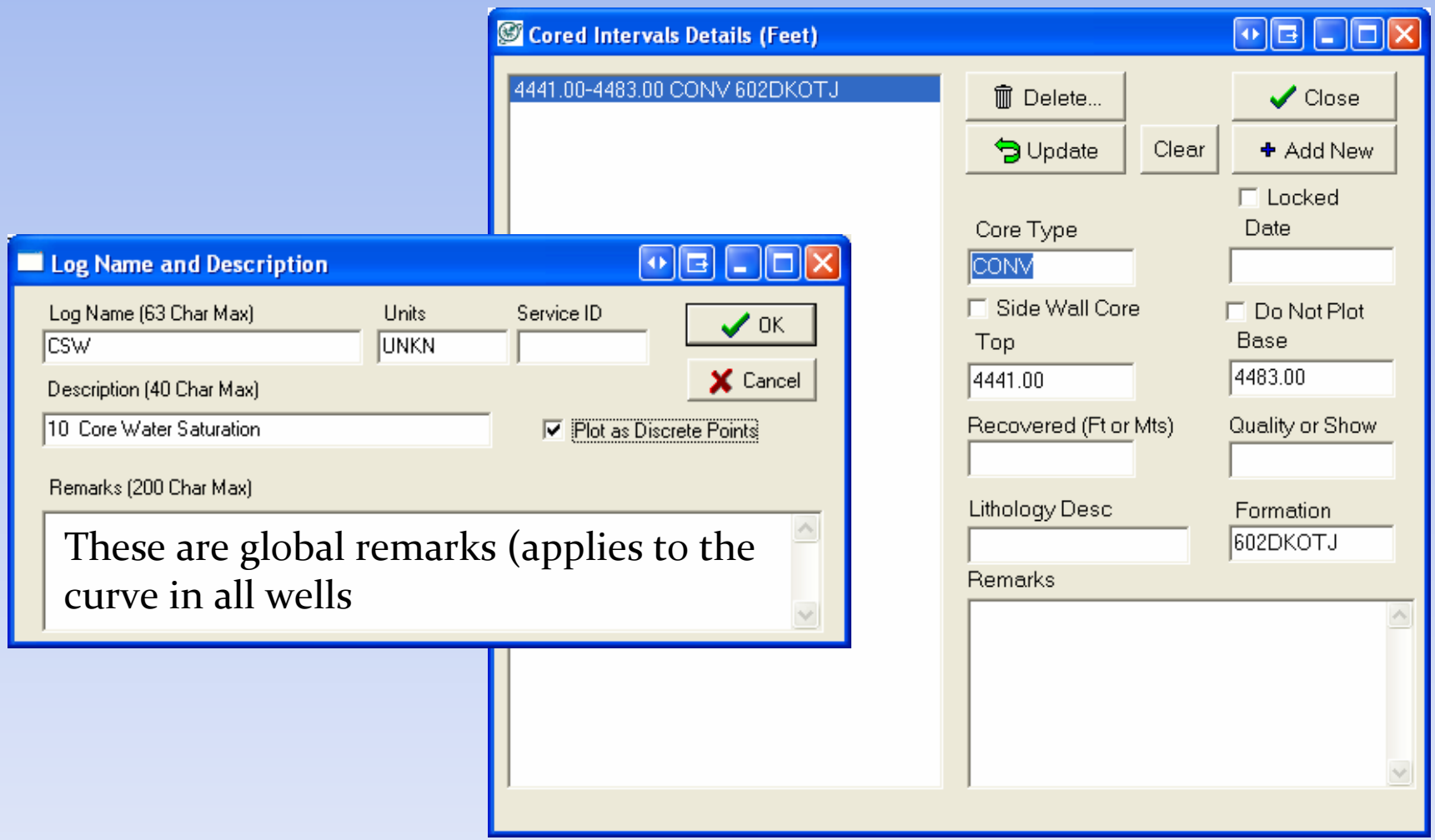
Useful resources (outside Petra)

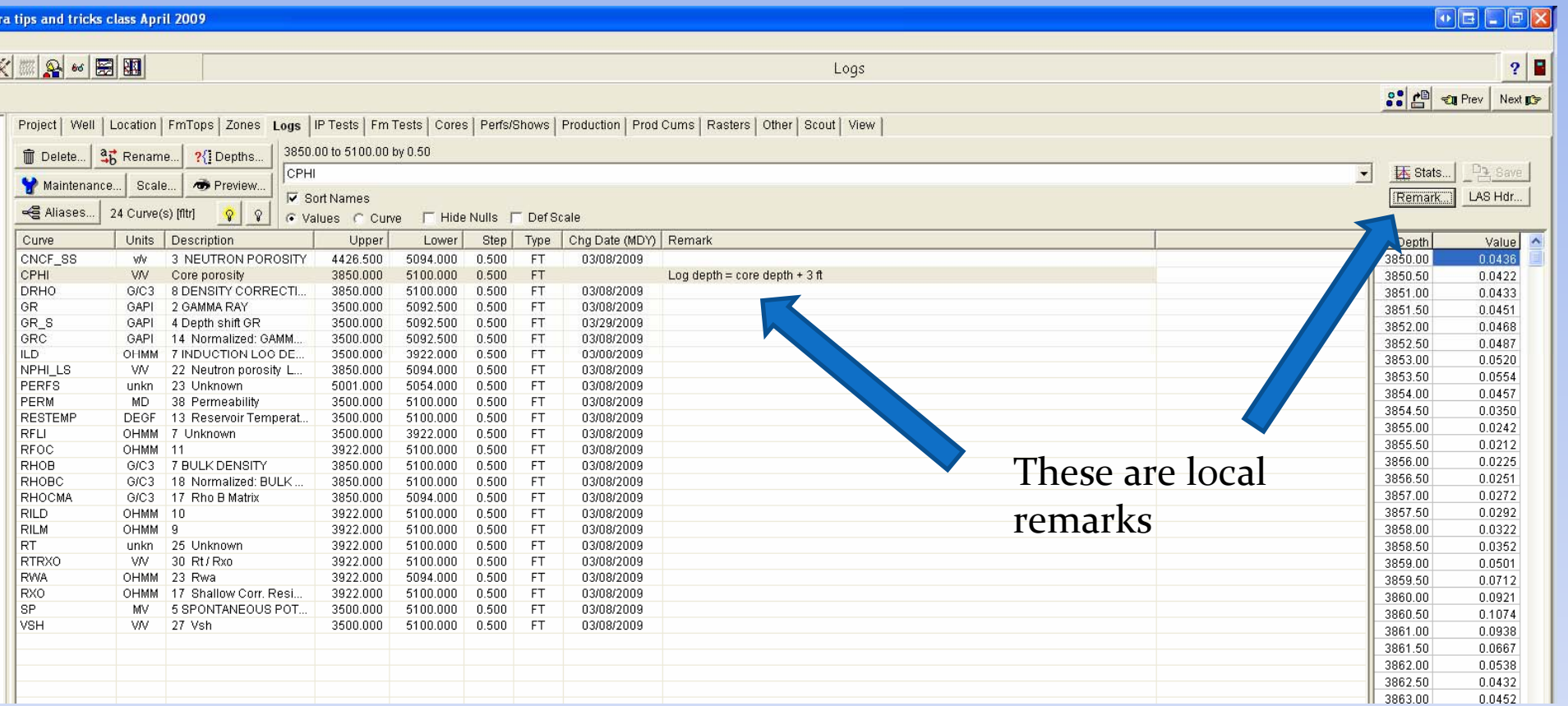
- Didger 4.0 – onscreen digitizing software from Golden Software
- Grapher 7.0 has 11 pre-defined curve-fitting algorithms that fit most common chartbook curves
- Excel has very basic curve-fitting functionality; you can also purchase an add-in that expands on this
- At the high end, TableCurve2D and TableCurve3D fit thousands of pre-defined functions to a dataset
- Learn some linear algebra if you want to do-it-yourself

H. What is the best way to bring core data into Petra, and what should go into the core tab vs. what goes into the log curve database?

- Core data live in two places in Petra:
  - The Cores Tab, which stores information on core type, cored interval, date cored, recovery, etc. This can be posted on logs and sections
  - The Logs tab, where actual numerical core data is stored with the log data
- Core data can be imported as LAS or as ASCII files, depth shifted, plotted, and manipulated like any log data

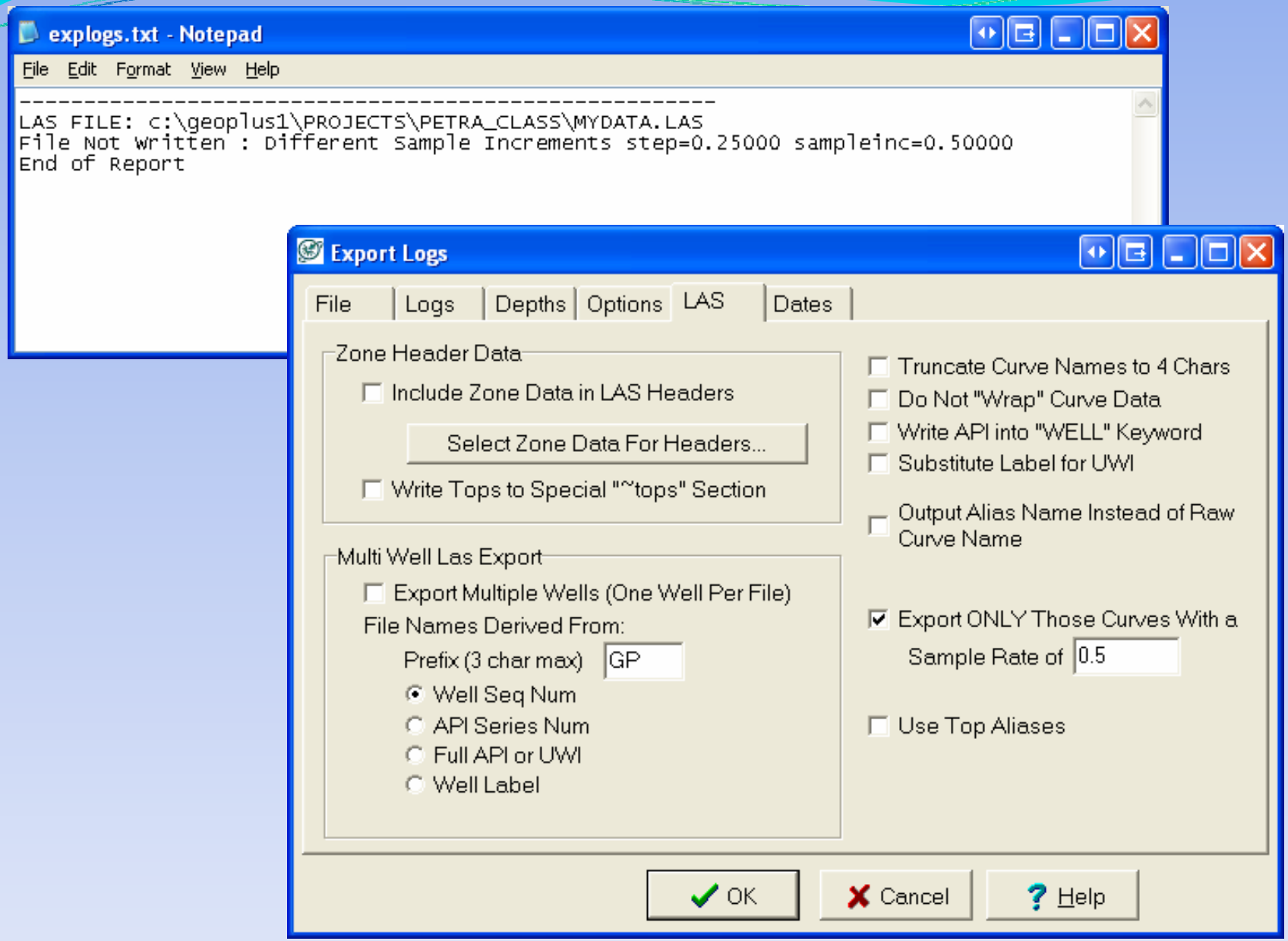
- Core depth shifts can be recorded on the Cores tab, or as remarks to each curve in the Log tab



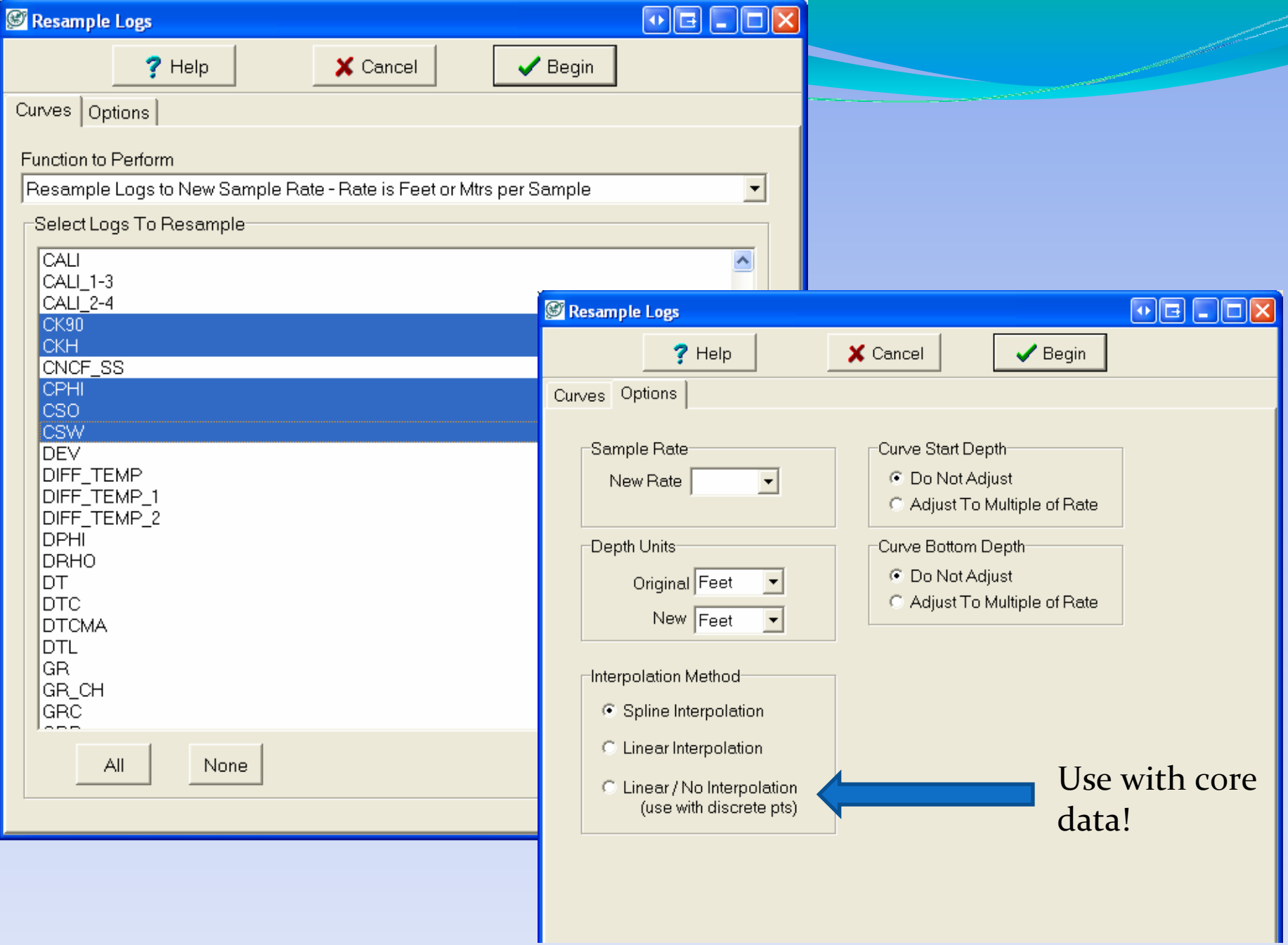

ra tips and tricks class April 2009
Logs
Prev
Next
Project | Well | Location | FmTops | Zones | Logs | IP Tests | Fm Tests | Cores | Perfs/Shows | Production | Prod Cums | Rasters | Other | Scout | View
Delete... Rename... Depths...
Maintenance... Scale... Preview...
Aliases... 24 Curve(s) [filtr]
3850.00 to 5100.00 by 0.50
CPHI
Stats... Save
Remark... LAS Hdr...
Sort Names
Values Curve Hide Nulls Def Scale
Curve | Units | Description | Upper | Lower | Step | Type | Chg Date (MDY) | Remark
CNCF_SS v/v 3 NEUTRON POROSITY 4426.500 5094.000 0.500 FT 03/08/2009
CPHI V/V Core porosity 3850.000 5100.000 0.500 FT Log depth = core depth + 3 ft
DRHO G/C3 8 DENSITY CORRECTI... 3850.000 5100.000 0.500 FT 03/08/2009
GR GAPI 2 GAMMA RAY 3500.000 5092.500 0.500 FT 03/08/2009
GR_S GAPI 4 Depth shift GR 3500.000 5092.500 0.500 FT 03/29/2009
GRC GAPI 14 Normalized: GAMM... 3500.000 5092.500 0.500 FT 03/08/2009
ILD OHMM 7 INDUCTION LOG DE... 3500.000 3922.000 0.500 FT 03/08/2009
NPHI_LS V/V 22 Neutron porosity L... 3850.000 5094.000 0.500 FT 03/08/2009
PERFS unkn 23 Unknown 5001.000 5054.000 0.500 FT 03/08/2009
PERM MD 38 Permeability 3500.000 5100.000 0.500 FT 03/08/2009
RESTEMP DEGF 13 Reservoir Temperat... 3500.000 5100.000 0.500 FT 03/08/2009
RFLI OHMM 7 Unknown 3500.000 3922.000 0.500 FT 03/08/2009
RFOC OHMM 11 3922.000 5100.000 0.500 FT 03/08/2009
RHOB G/C3 7 BULK DENSITY 3850.000 5100.000 0.500 FT 03/08/2009
RHOBC G/C3 18 Normalized: BULK ... 3850.000 5100.000 0.500 FT 03/08/2009
RHOCMA G/C3 17 Rho B Matrix 3850.000 5094.000 0.500 FT 03/08/2009
RILD OHMM 10 3922.000 5100.000 0.500 FT 03/08/2009
RILM OHMM 9 3922.000 5100.000 0.500 FT 03/08/2009
RT unkn 25 Unknown 3922.000 5100.000 0.500 FT 03/08/2009
RTRXO V/V 30 Rt / Rxo 3922.000 5100.000 0.500 FT 03/08/2009
RWA OHMM 23 Rwa 3922.000 5094.000 0.500 FT 03/08/2009
RXO OHMM 17 Shallow Corr. Resi... 3922.000 5100.000 0.500 FT 03/08/2009
SP MV 5 SPONTANEOUS POT... 3500.000 5100.000 0.500 FT 03/08/2009
VSH V/V 27 Vsh 3500.000 5100.000 0.500 FT 03/08/2009
Depth | Value
3850.00 0.0436
3850.50 0.0422
3851.00 0.0433
3851.50 0.0451
3852.00 0.0468
3852.50 0.0487
3853.00 0.0520
3853.50 0.0554
3854.00 0.0457
3854.50 0.0350
3855.00 0.0242
3855.50 0.0212
3856.00 0.0225
3856.50 0.0251
3857.00 0.0272
3857.50 0.0292
3858.00 0.0322
3858.50 0.0352
3859.00 0.0501
3859.50 0.0712
3860.00 0.0921
3860.50 0.1074
3861.00 0.0938
3861.50 0.0667
3862.00 0.0538
3862.50 0.0432
3863.00 0.0452
These are local remarks

I. How do I deal with data on different depth increments (e.g. 0.5 ft log data and 1 ft core data)?

- Petra is database oriented, not tied to a specific frame increment like an LAS file
  - It allows data on different depth steps to co-exist
- The problem arises when you *EXPORT* data to an LAS file, because LAS files require a specific step value
- Petra will not resample curves on the fly, but it will allow you to only export data with a specific sample rate

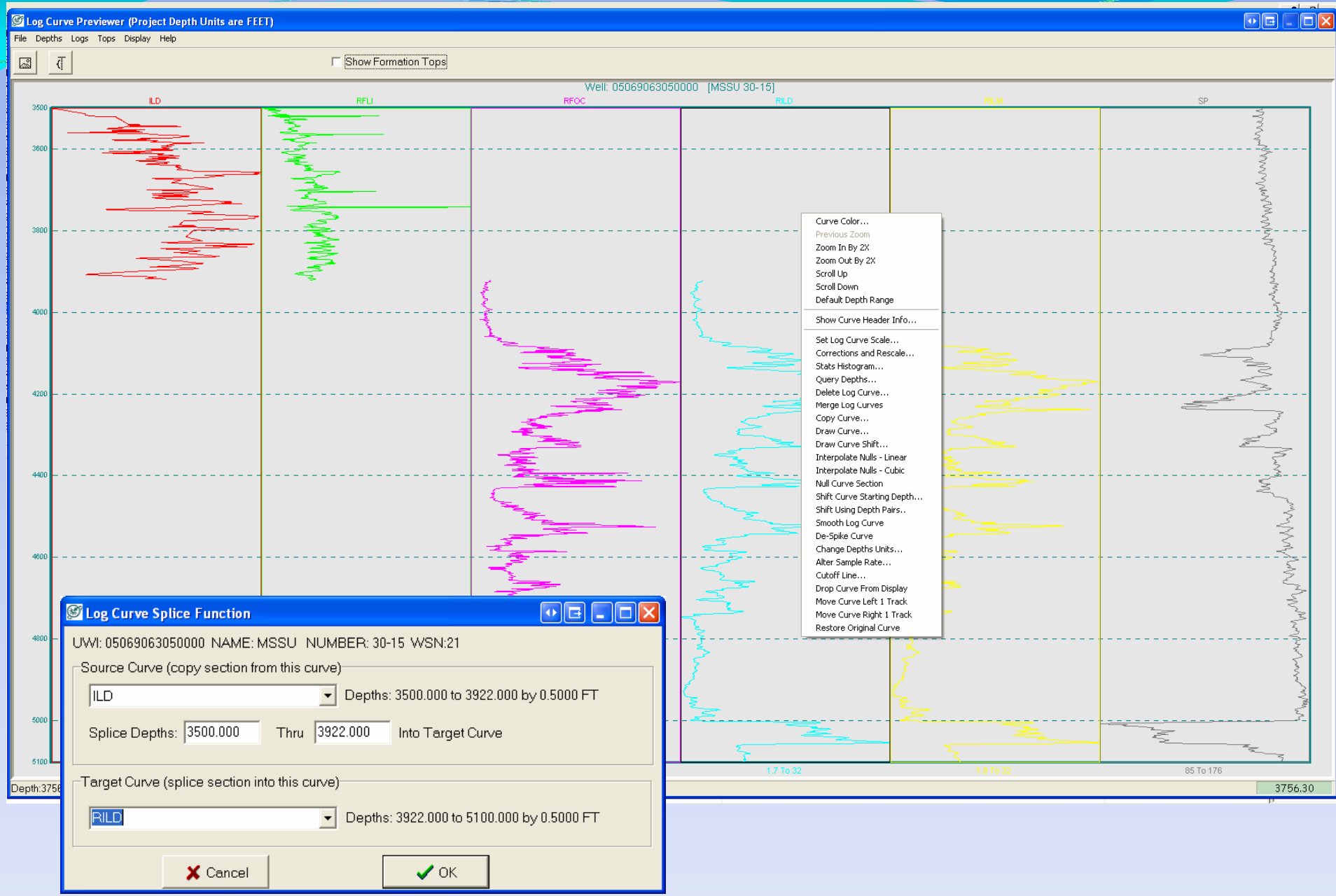

explogs.txt - Notepad
File Edit Format View Help
LAS FILE: c:\geoplus1\PROJECTS\PETRA_CLASS\MYDATA.LAS
File Not Written : Different Sample Increments step=0.25000 sampleinc=0.50000
End of Report
Export Logs
File
Logs
Depths
Options
LAS
Dates
Zone Header Data
Include Zone Data in LAS Headers
Select Zone Data For Headers...
Write Tops to Special "~tops" Section
Multi Well Las Export
Export Multiple Wells (One Well Per File)
File Names Derived From:
Prefix (3 char max)
GP
Well Seq Num
API Series Num
Full API or UWI
Well Label
Truncate Curve Names to 4 Chars
Do Not "Wrap" Curve Data
Write API into "WELL" Keyword
Substitute Label for UWI
Output Alias Name Instead of Raw Curve Name
Export ONLY Those Curves With a
Sample Rate of
0.5
Use Top Aliases
OK
Cancel
Help

- Best solution is to resample curves prior to export using Log Transformations → Transforms → Resample curves
  - Note: this function OVERWRITES the original curve, so you might want to work on a curve copy
  - Also, be careful when resampling core data, as interpolated values might not be what you want


Resample Logs
Help
Cancel
Begin
Curves
Options
Function to Perform
Resample Logs to New Sample Rate - Rate is Feet or Mtrs per Sample
Select Logs To Resample
CALI
CALI_1-3
CALI_2-4
CK90
CKH
CNCF_SS
CPHI
CSO
CSW
DEV
DIFF_TEMP
DIFF_TEMP_1
DIFF_TEMP_2
DPHI
DRHO
DT
DTC
DTCMA
DTL
GR
GR_CH
GRC
All
None
Resample Logs
Help
Cancel
Begin
Curves
Options
Sample Rate
New Rate
Curve Start Depth
Do Not Adjust
Adjust To Multiple of Rate
Depth Units
Original
Feet
New
Feet
Curve Bottom Depth
Do Not Adjust
Adjust To Multiple of Rate
Interpolation Method
Spline Interpolation
Linear Interpolation
Linear / No Interpolation
(use with discrete pts)
Use with core data!

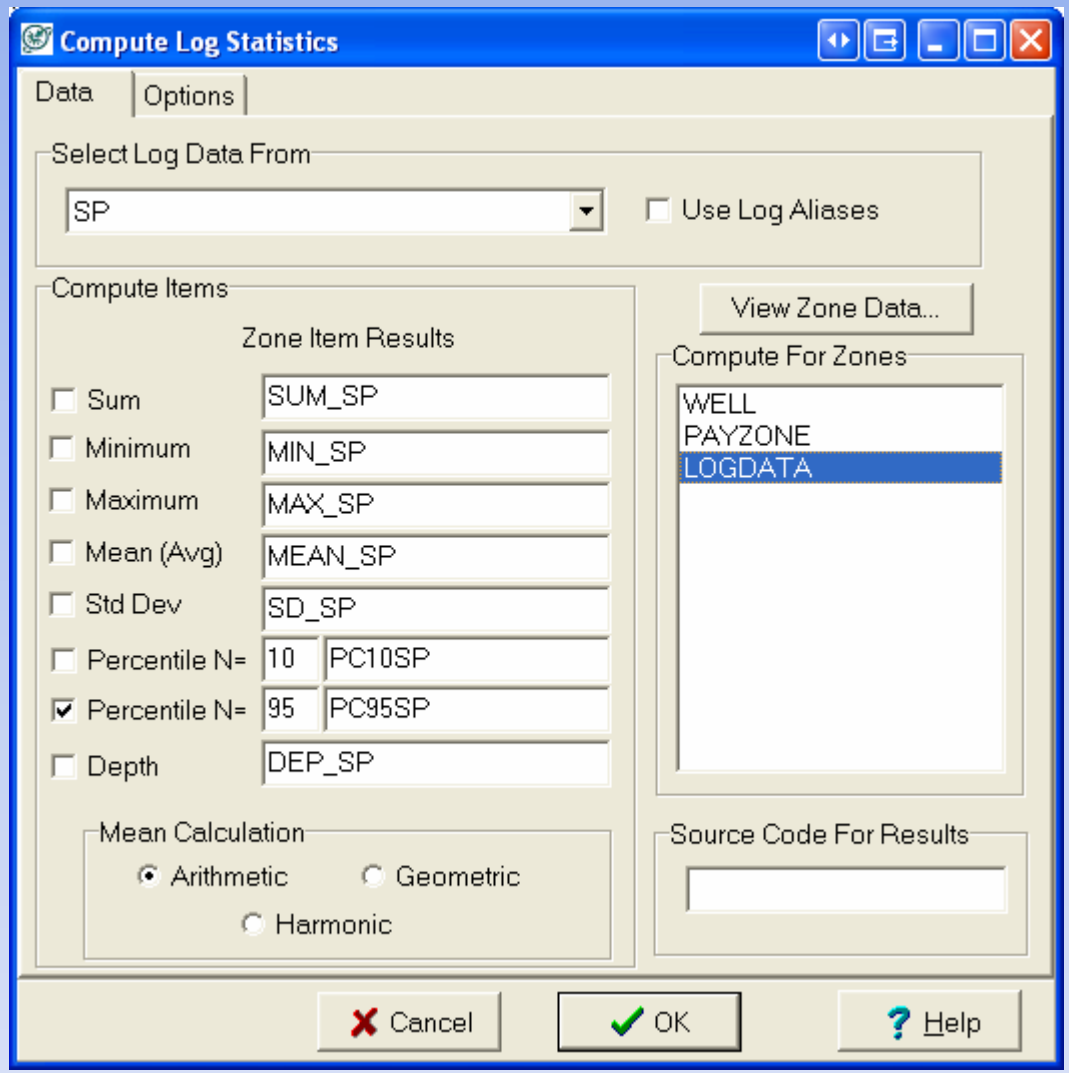
J. What is the easiest and cleanest way to splice curves, null bad data, tool pickup, etc. in Petra?

- Easiest is in the Log Curve Previewer, accessed from the Logs tab
- You can null sections, smooth, and despike curves all in this panel
- Curve splicing is done in Logs → Splice Curves


Log Curve Previewer (Project Depth Units are FEET)
File Depths Logs Tops Display Help
Show Formation Tops
Well: 05069063050000 [MSSU 30-15]
ILD
RFLI
RFOC
RILD
RILM
SP
3500
3600
3800
4000
4200
4400
4600
4800
5000
5100
Curve Color...
Previous Zoom
Zoom In By 2X
Zoom Out By 2X
Scroll Up
Scroll Down
Default Depth Range
Show Curve Header Info...
Set Log Curve Scale...
Corrections and Rescale...
Stats Histogram...
Query Depths...
Delete Log Curve...
Merge Log Curves
Copy Curve...
Draw Curve...
Draw Curve Shift...
Interpolate Nulls - Linear
Interpolate Nulls - Cubic
Null Curve Section
Shift Curve Starting Depth...
Shift Using Depth Pairs...
Smooth Log Curve
De-Spike Curve
Change Depths Units...
Alter Sample Rate...
Cutoff Line...
Drop Curve From Display
Move Curve Left 1 Track
Move Curve Right 1 Track
Restore Original Curve
1.7 To 32
1.8 To 32
85 To 176
Depth:3756
3756.30
Log Curve Splice Function
UWI: 05069063050000 NAME: MSSU NUMBER: 30-15 WSN:21
Source Curve (copy section from this curve)
ILD
Depths: 3500.000 to 3922.000 by 0.5000 FT
Splice Depths: 3500.000 Thru 3922.000 Into Target Curve
Target Curve (splice section into this curve)
RILD
Depths: 3922.000 to 5100.000 by 0.5000 FT
Cancel
OK

K. I want to baseline shift all my SP logs so they are at ~0 mV along the shale baseline. What do I do?

- This is quick if you just need a basic baseline shift
- Start by cleaning up the curves, including nulling tool pickup and intervals behind casing
  - If you don't, those sections will be counted in the log statistics and could skew your baseline
- Fix any obvious offsets between logging runs
- Compute → From Logs → Statistics, and calculate the 95th percentile of the SP using the arithmetic mean. Save this in an appropriate zone (like "Petrophysics")


Compute Log Statistics
Data
Options
Select Log Data From
SP
Use Log Aliases
Compute Items
Zone Item Results
Sum
SUM_SP
Minimum
MIN_SP
Maximum
MAX_SP
Mean (Avg)
MEAN_SP
Std Dev
SD_SP
Percentile N=
10
PC10SP
Percentile N=
95
PC95SP
Depth
DEP_SP
Mean Calculation
Arithmetic
Geometric
Harmonic
View Zone Data...
Compute For Zones
WELL
PAYZONE
LOGDATA
Source Code For Results
Cancel
OK
Help

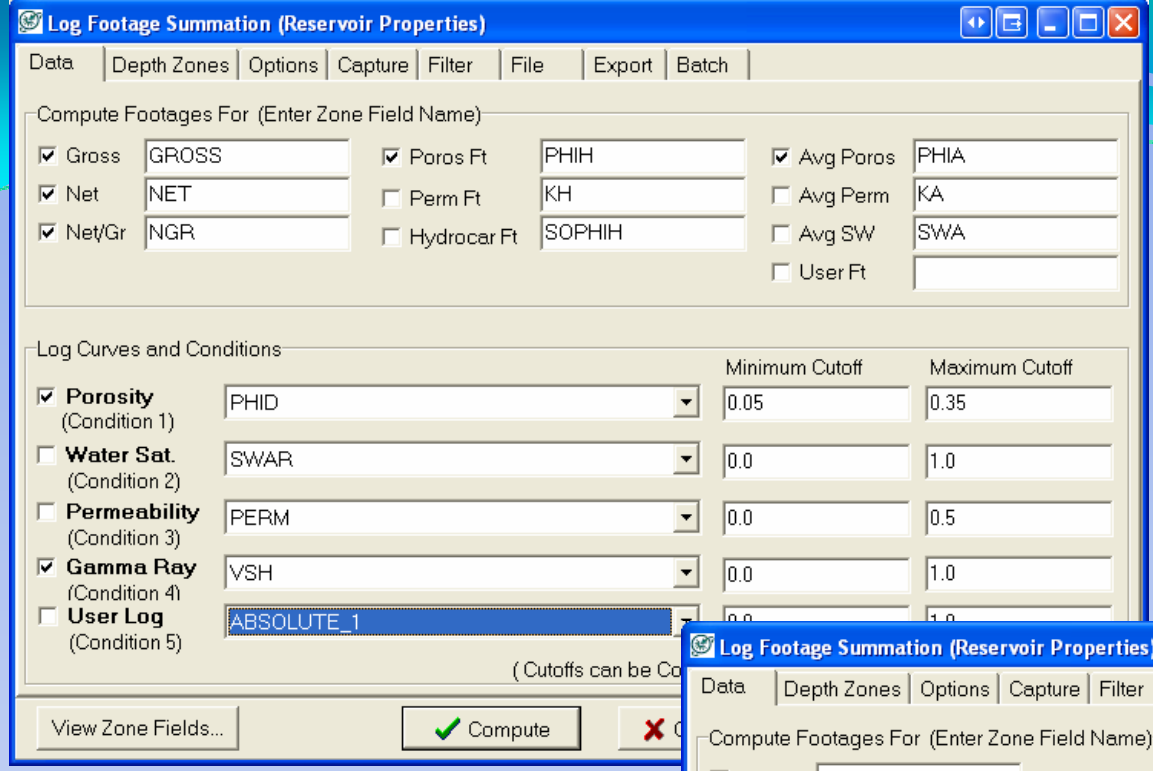
- Using Compute → From Logs → Equation Expression,
  - SP_BLS = SP – PC95SP
  - Assing the appropriate curve name to SP, using aliases if necessary, and assign the zone parameter calculated before to PC95SP
- All of your SP logs will be baseline shifted to a value of zero at the 95th percentile.
- This does not correct for drift with depth, it is a simple baseline shift.
- Unlike the normalization function, this does not rescale the SP curves – it is just an offset correction.

L. What is meant by "net pay" and how do I compute it in Petra?

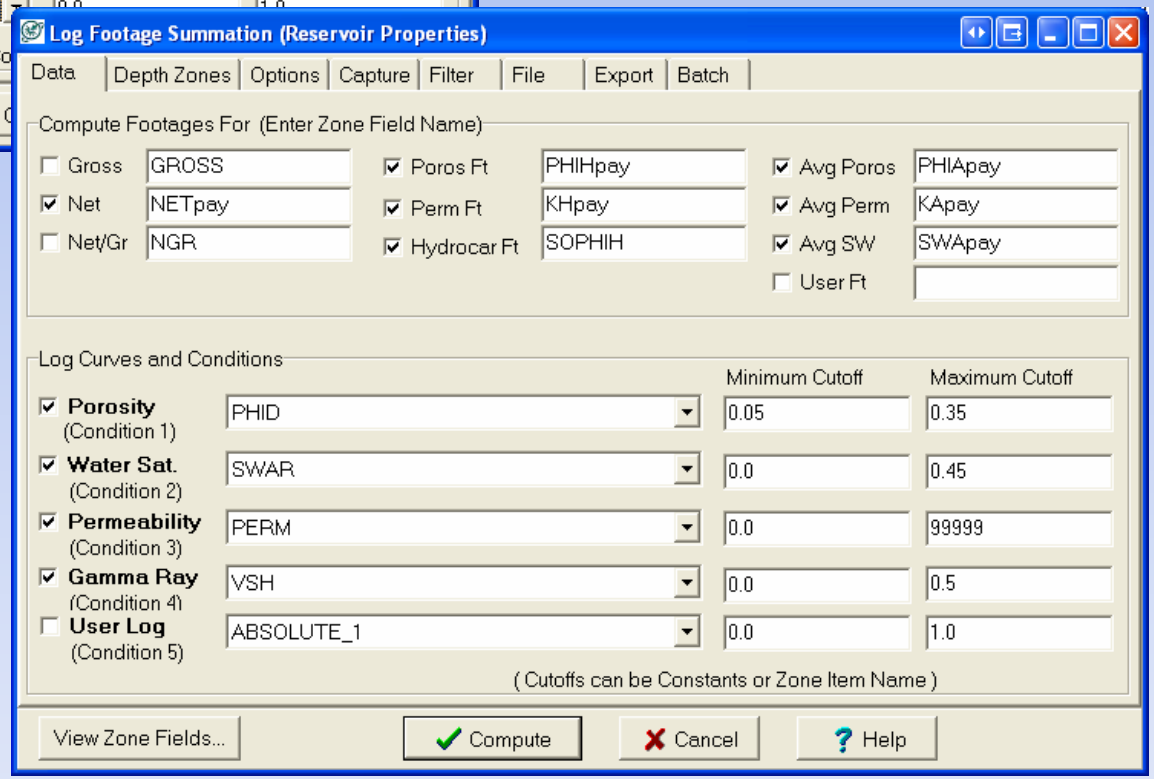
- Petras "net pay" module is actually a general purpose summation module, accessed via Compute → From Logs → Footages (Reservoir Properties). It is one of Petra's greatest strengths.
- *Definitions:*
  - GROSS = the total interval. Calculated using the Compute → From Zones → Isopach function.
  - GROSS SAND = sand net of a shaliness (GR) cutoff only, set by Condition 4 in the Log Footage Summation screen.
  - NET SAND = sand net of shaliness and porosity cutoffs, ignoring fluid saturation. This is set by conditions 1 and 4 in Petra. Engineers want this to define the total container volume.

- NET PAY = sandstone net of shaliness, porosity, and water saturation cutoffs. Petra also adds a Permeability condition and a User Log condition, for example a flag curve to exclude certain lithologies (e.g. coal)

- Because Petra defines “net” as passing ALL checked conditions, you need to be careful. If you want to calculate net pore volume, irrespective of Sw, you cannot check the Sw condition, or else you have to open up the cutoff range.
  - We often run this module twice, once to get reservoir volumes, a second time to get “net pay” volumes.



First run gets net reservoir properties

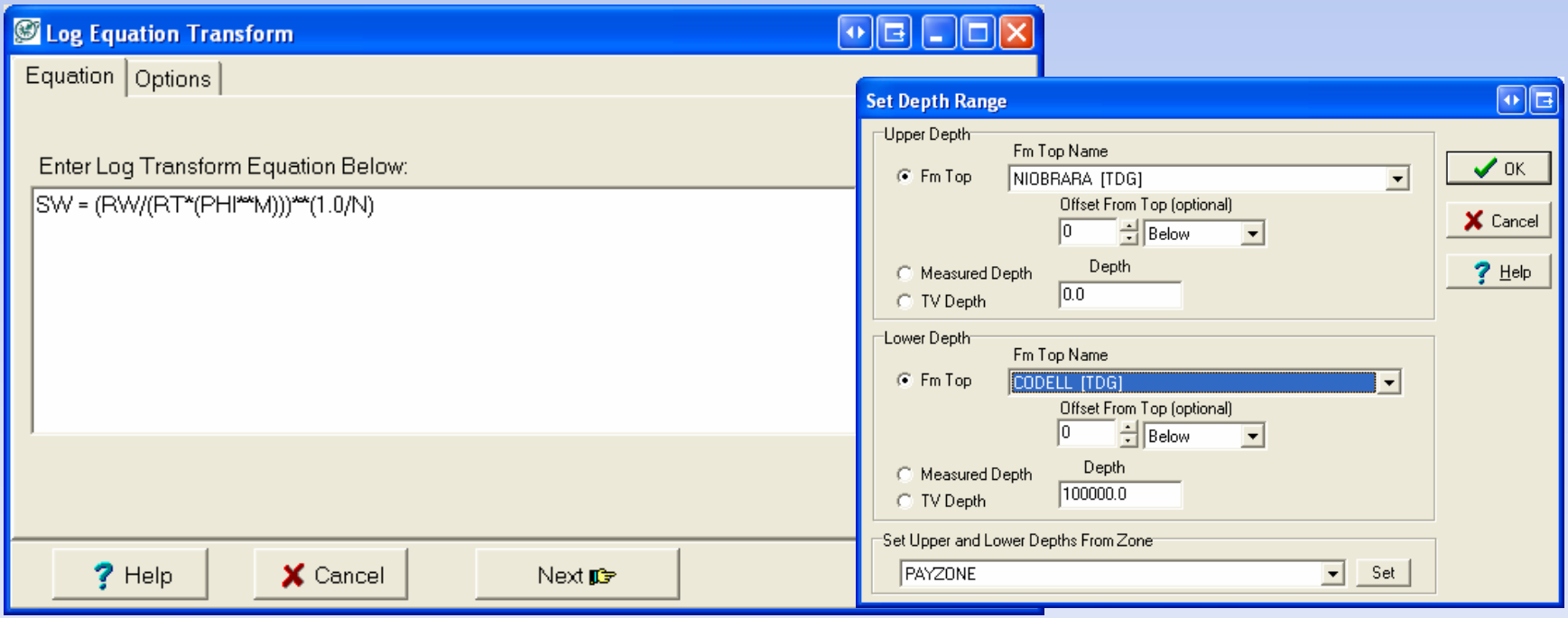


Second run computes "pay" properties

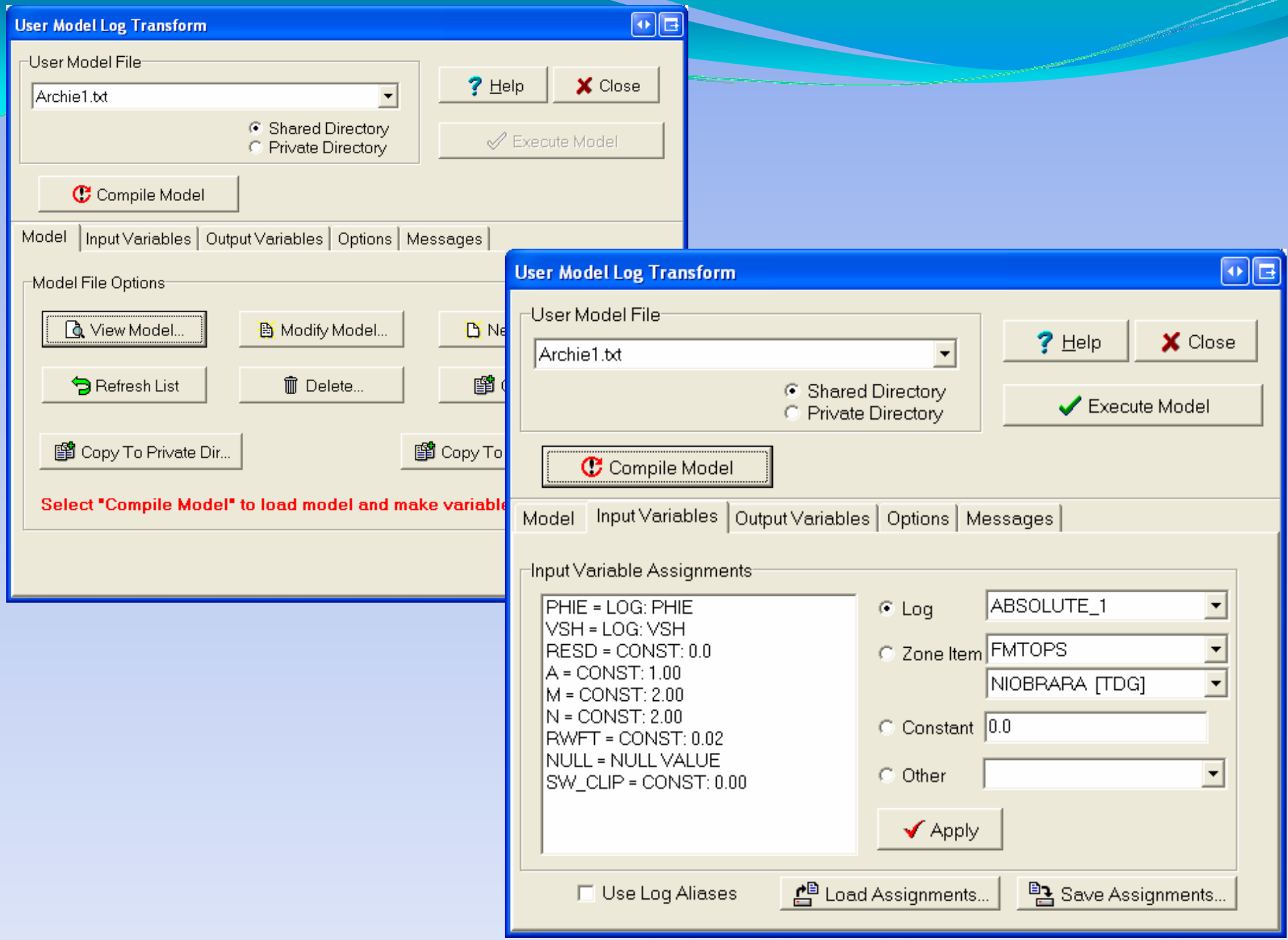
- You can create flag curves in this module on the Capture tab
- You can save predefined setup screens as templates and run them in Batch mode to do more than one step, or calculate net pay sensitivity to some key criteria
  - e.g. net pay > 6% ϕ, >8% ϕ, and >10% ϕ

M. How do I compute Sw on a large number of wells over a big area where some key parameter, like Rw, varies from well to well?

- You have two choices:
  - Run each zone individually using equation expressions, which can be saved in your equation list.



- Or, use the Compute →From Logs → Advanced Log Transforms → User Model Log Transform module.
- Programming language is similar to Basic and is undocumented. Only the examples provided with Petra serve as a guide to what can be done.
  - GOTO, IF-THEN, BEGIN-END and DONE statements
- All input logs, constants, and output logs are declared at the start. If the model compiles, you get a screen that allows you to assign all of those to logs or zone parameters in Petra.
- You can run the model over selected zones or the entire well.


User Model Log Transform
User Model File
Archie1.txt
Shared Directory
Private Directory
Help
Close
Execute Model
Compile Model
Model
Input Variables
Output Variables
Options
Messages
Model File Options
View Model...
Modify Model...
Refresh List
Delete...
Copy To Private Dir...
Select "Compile Model" to load model and make variable
User Model Log Transform
User Model File
Archie1.txt
Shared Directory
Private Directory
Help
Close
Execute Model
Compile Model
Model
Input Variables
Output Variables
Options
Messages
Input Variable Assignments
PHIE = LOG: PHIE
VSH = LOG: VSH
RESD = CONST: 0.0
A = CONST: 1.00
M = CONST: 2.00
N = CONST: 2.00
RWFT = CONST: 0.02
NULL = NULL VALUE
SW_CLIP = CONST: 0.00
Log
ABSOLUTE_1
Zone Item
FMTOPS
NIOBRARA [TDG]
Constant
0.0
Other
Apply
Use Log Aliases
Load Assignments...
Save Assignments...

c:\geoplus1\USERMOD\Archie1.txt

File

```
LOG    VSH    IN;          ! VOLUME OF SHALE (FRACTIONAL)
LOG    RESD   IN;          ! RESISTIVITY OF ZONE (OHM-M)

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! OUT LOGS USED IN THE MODEL
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
LOG     SWA   OUT;          ! WATER SATURATION


!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! CONSTANTS USED IN THE MODEL
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
CONST   A    1.0;    ! SAND=0.62   CARBONATES=1.0
CONST   M    2.0;    !    =2.15           2.0
CONST   N    2.0;    !    =2.00           2.0
CONST   RWFT  0.015;
CONST   NULL;

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! SWITCHES
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
CONST   SW_CLIP  0;    ! 0=NO,1=YES TO CLIP SWA BTWN 0 AND 1



SWA = 1.0;
IF ( PHIE = NULL ) THEN GOTO DONE;
IF ( VSH = NULL ) THEN GOTO DONE;
IF ( PHIE .LE. 0.0 ) THEN GOTO DONE;
IF ( VSH  .GE. 1.0 ) THEN GOTO DONE;

SWA = (A*RWFT/(PHIE**M)/RESD)**(1/N);

IF ( SW_CLIP .NE. 0.0 ) THEN BEGIN;
  SWA = MIN(SWA,1.0);
  SWA = MAX(SWA,0.0);
END;

DONE:
ENDMOD;
```