

Using the Batch LAS Curve Processing Tools in BatchCurveProc.xls

The Excel workbook BatchCurveProc.xls contains three worksheets specifying input parameters for three different processes:

1. Computing curves of incremental OGIP by half-foot interval based on input lithology and porosity curves in a set of LAS files and height above free water level; the computed incremental OGIP (and related curves) are written to a set of output LAS files.
2. Estimating free water level at each well based on input lithology and porosity curves and a mass balance estimate of OGIP at the well; FWL is adjusted to produce an OGIP estimate based on Byrnes's porosity-Sw transforms that matches the mass balance estimate; curves representing height above FWL, Sw, and incremental OGIP are written to a set of output LAS files, with the estimated FWL at each well included in the header lines.
3. Generating corrected porosity curves from a set of log porosity curves based on log vs. core porosity regression relationships for each facies.

All three processes work pretty much the same way. You make changes to the appropriate cells on the worksheet and click the **Run!** button to make it go. You can make copies of the worksheets within the same workbook and change the parameters on the different copies or you can make a new copy of the whole workbook and things will still work. However, if you use "Move or Copy Sheet" to make a copy of the worksheet in a different workbook, things will not work because the Visual Basic code belongs to the workbook, not the worksheet. The VB code is available for viewing and modification in Module1 of the VB Project for the workbook, which you can view in the VB editor (Alt-F11).

You can annotate the input parameter worksheets to your heart's desire, with one restriction: you cannot relocate the cells containing the actual input parameters. The code looks for each parameter in a particular cell.

OGIP Computation

The OGIP computation worksheet looks like this:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N																																																																																										
1	BatchOGIP.xls by Geoff Bohling, 02 March 2004 -- Last modified 11 May 2006																																																																																																							
2	-- Modify values as appropriate and click Run! (but don't move things around)																																																																																																							
3	ELEVEN FACIES LITH CODE (Geomod 3D-092705)																																																																																																							
4	FW Elevation		0		Run!		<table border="1"> <thead> <tr> <th></th> <th>Pc</th> <th>Pc</th> <th>Pc</th> <th>Pc</th> </tr> <tr> <th>Slope</th> <th>Slope</th> <th>Threshold</th> <th>Threshold</th> <th></th> </tr> <tr> <th>"Pchs"</th> <th>"Pchs"</th> <th>Height</th> <th>Height</th> <th></th> </tr> <tr> <th>Pchs=</th> <th>Pchs=</th> <th>logPche=</th> <th>logPche=</th> <th></th> </tr> <tr> <th>APhii+B</th> <th>APhii+B</th> <th>APhii+B</th> <th>APhii+B</th> <th></th> </tr> <tr> <th></th> <th>(ft)</th> <th>(ft)</th> <th>(ft)</th> <th></th> </tr> </thead> <tbody> <tr> <td>LithCode</td> <td>A1</td> <td>B1</td> <td>A2</td> <td>B2</td> </tr> <tr> <td>1</td> <td>-0.1530</td> <td>0.0990</td> <td>-0.1940</td> <td>4.2500</td> </tr> <tr> <td>2</td> <td>-0.1530</td> <td>0.0990</td> <td>-0.1940</td> <td>4.4300</td> </tr> <tr> <td>3</td> <td>-0.1530</td> <td>0.0990</td> <td>-0.2060</td> <td>4.3460</td> </tr> <tr> <td>4</td> <td>-0.0660</td> <td>-1.1500</td> <td>-0.1220</td> <td>3.3000</td> </tr> <tr> <td>5</td> <td>-0.0420</td> <td>-1.0000</td> <td>-0.1190</td> <td>3.0600</td> </tr> <tr> <td>6</td> <td>0.0041</td> <td>-1.2190</td> <td>-0.0540</td> <td>2.6300</td> </tr> <tr> <td>7</td> <td>-0.0063</td> <td>-1.6570</td> <td>-0.0550</td> <td>1.9700</td> </tr> <tr> <td>8</td> <td>0.0000</td> <td>-1.6300</td> <td>-0.0310</td> <td>1.5200</td> </tr> <tr> <td>9</td> <td>0.1280</td> <td>-3.8980</td> <td>-0.0540</td> <td>1.7000</td> </tr> <tr> <td>10</td> <td>0.1980</td> <td>-5.1390</td> <td>-0.0795</td> <td>2.5170</td> </tr> <tr> <td>11</td> <td>0.1980</td> <td>-5.3190</td> <td>-0.1940</td> <td>4.0500</td> </tr> </tbody> </table>									Pc	Pc	Pc	Pc	Slope	Slope	Threshold	Threshold		"Pchs"	"Pchs"	Height	Height		Pchs=	Pchs=	logPche=	logPche=		APhii+B	APhii+B	APhii+B	APhii+B			(ft)	(ft)	(ft)		LithCode	A1	B1	A2	B2	1	-0.1530	0.0990	-0.1940	4.2500	2	-0.1530	0.0990	-0.1940	4.4300	3	-0.1530	0.0990	-0.2060	4.3460	4	-0.0660	-1.1500	-0.1220	3.3000	5	-0.0420	-1.0000	-0.1190	3.0600	6	0.0041	-1.2190	-0.0540	2.6300	7	-0.0063	-1.6570	-0.0550	1.9700	8	0.0000	-1.6300	-0.0310	1.5200	9	0.1280	-3.8980	-0.0540	1.7000	10	0.1980	-5.1390	-0.0795	2.5170	11	0.1980	-5.3190	-0.1940	4.0500
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22	Porosity curve	PHI_GM3																																																																																																						
23	Elevation datum name	ELEV_KB																																																																																																						
24	FWL name	B_CG70_Z-SUB																																																																																																						
25	Init. Pressure name	NONE																																																																																																						
26	Output file folder	D:\BatchProcessOut																																																																																																						
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The input parameters for the process are in cells D4, D7-D13, D20-D27, and the parameter table starting with the first LithCode in cell H11. As the comment at the top of the sheet says, you should modify the parameters as appropriate, but don't move them around. Everything else on the worksheet is a comment or label and could be deleted or moved without causing a meltdown. The table of coefficients can be expanded or contracted as you please, but needs to be arranged as shown, starting with LithCode 1 in cell H11 and proceeding sequentially downward. There should be a blank cell under the last LithCode entry. (Cell H22 on this sheet is actually blank; the contents of cell G22 just slops over it.)

The computations are exactly as listed in the comments towards the bottom of the sheet. The SW% computation is the world-famous Byrnes Sw-porosity transform, using the lithology-appropriate set of coefficients from the coefficient table.

The input parameters are:

FWL elevation (cell D4): The default free water level elevation

P (cell D7): The initial reservoir pressure (“Pinit” in the comments)

T (cell D8): The reservoir temperature in Fahrenheit – cell D9 (temperature in “absolute Fahrenheit”) is computed from cell D8 and is what is actually used in the equations

Psc (cell D10): Critical pressure

Tsc (cell D11): Critical temperature, in Fahrenheit – cell D12, critical temperature in absolute Fahrenheit is computed from cell D11 and is what is actually used in the equations

Z (cell D13): Compressibility ratio

Input file folder (cell D20): Name of folder containing the LAS files to be processed; files must at least contain curves of lithology (represented in terms of the same set of integer codes used in the coefficient table on this worksheet) and porosity – which should be a corrected porosity and should be decimal, not percentage. Each file also needs to contain a reference elevation value in its header lines. I think you have to type in the full path to the folder. Sorry about that.

Lithology curve name (cell D21): The name of the curve (as specified in the Curve Section of the LAS file headers) containing the lithology codes – the code will not process the file if it can’t find a curve by this name.

Porosity curve name (cell D22): The name of the porosity curve (corrected, in decimal) – the code will not process the file if it can’t find a curve by this name.

Elevation datum name (cell D23): The name (mnemonic) by which the elevation datum for the well is represented in the well header lines – code punts on file if it can’t locate this elevation datum because this is need to compute height above free water level.

FWL name (cell D24): If a name other than “NONE” is given here, then the code looks in each well header for a field by that name and uses it as the free water level for the well, instead of the default free water level given in cell D4. If it can’t locate a header line containing this name (mnemonic), then it uses the default FWL for that well.

Initial pressure name (cell D25): Just like FWL name except for initial pressure – you can enter a well-by-well initial pressure in the well headers if you care to.

Output file folder (cell D26): Name of folder to hold output files. You have to create the folder in advance. The code will not overwrite previously existing files, so you also need to delete (in advance) any files with the same names as the ones you are about to create . . . I think.

Output file name prefix: The output LAS files will have the same names as the input files, except with this prefix stuck on the beginning – as is the way with prefixes.

And then there are the coefficients for the porosity-Sw transforms, in the coefficient table.

So, modify the input parameters to shoot your porpoises and click the **Run!** button. If all goes well, the output folder that you specify should fill up with LAS files that look something like:

```

~Version Information
VERS.                2.0:
WRAP.                NO:
END.                 PETRA:GeoPLUS Corporation
~Well Information Block
#MNEM.UNIT          Data Type          Information
#-----
STRT.F              2626.5000:
STOP.F              2861.0000:
STEP.F              0.5000:
NULL.               -999.25:
COMP.                : COMPANY
FLD.                PANOMA              : FIELD
LOC.                 : LOCATION
DATE.               19-MAY-2004         : DATE
WELL.               BEATY              : Well Name
LABL.               UPDATE-MKD          : Well Label
APIN.               15093201340000       : API Number
UWI.                15093201340000       : Unique Well Number
NUMB.               2-E                : Well Number
OPER.               AMOCO PRODUCTION CO : Operator Name
~Parameter Block
#MNEM.UNIT          VALUE              Description
#-----
EKB.F               3179.0 : KB Elevation
ELEV_KB.            3179.00000 : WELL - Kelly Bushing Elevation
~Curve Information Block
Depth.ft            : Depth (ft)
Elev.ft             : Elevation (ft) [ ElevDatum - Depth ]
HFWL.ft             : Height above free water level (ft)
SW.%                : Calculated SW(%), truncated at 10000
SW.DEC              : Decimal saturation, truncated at 1
OGIP1.mcfaf        : OGIP (MCF/acre-ft)
OGIP2.mcfs          : OGIF (MCF/section)
~A
2626.5  552.5  552.5  33.78  0.3378  92.898  29727.52
2627.0  552.0  552.5  62.70  0.6270  40.549  12975.74
2627.5  551.5  551.5  110.51  1        0        0
2628.0  551.0  551.0  179.06  1        0        0
2628.5  550.5  550.5  196.25  1        0        0

```

Most of the header lines just echo the header lines from the corresponding input file. The meanings of the output curves are written there in the curve information block.

Running Free Water Level Estimation

The input worksheet for the estimation of free water level looks almost exactly like that for OGIP calculation:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Batch FWL calculation by Geoff Bohling, 23 May 2004 -- Last modified 11 May 2006													
2	-- Modify values as appropriate and click Run! (but don't move things around)													
3														
4		Minimum FW Elevation		0										
5										Run!				
6														
7	P =	res pr, psia		400										
8	T =	res temp, F		95										
9	T =	res temp, R		555										
10	Psc =	psia		14.7										
11	Tsc =	F		60										
12		R		520										
13	Z =			0.95										
14														
15														
16														
17														
18														
19														
20	Input file folder		D:\Panoma\KeystoneLithPor											
21	Lithology curve		LITHOLOGY											
22	Porosity curve		PHI_CORR											
23	Elevation datum name		EKB											
24	Init. Pressure name		IWHSIP											
25	Target OGIP name		CG_OGIP-MB											
26	Output file folder		D:\Panoma\KeystoneFWL											
27	Output file prefix		FWL_											
28														
29	Computations:		(Code is in Module1 of VBAProject for this workbook)											
30	Phi% = 100*Phi													
31	Elev = ElevDatum - Depth													
32	HFWL = Elev - FW Elevation													
33	Term1 = A1*Phi% + B1													
34	Term2 = A2*Phi% + B2													
35	SW% = (HFWL * 10^(2*Term1 - Term2)) ^ (1 / Term1)													
36	Sw = SW% / 100 limited to 0-1 range													
37	OGIP1 = 43.56*Phi*(1-Sw)*((Pinit*Tsc)/(Psc*T^Z))													
38	OGIP2 = 640 * OGIP1 / 2													
39														
40														
41														

The difference here is that cell D4 contains your estimate for a minimum free water level elevation and a new entry is added to the list of names-of-things: the Target OGIP name, in cell D25. For the FWL elevation estimation, each LAS file should contain a target OGIP value in the header lines, represented by whatever mnemonic you enter in cell D25. The code then adjusts the free water level estimate for each well to create a saturation-based OGIP that matches the target OGIP for that well. The adjustment is done using a bracketing search that starts with the "bracket" extending from the minimum FWL elevation that you enter in cell D4 to the elevation of the top of the logged interval in the well (or the top of the data that you are providing, anyway). When in doubt, set the minimum FWL elevation to something lower than you think it really is. Setting it really low will only add a few more iterations to the search, but nothing significant in terms of run time. Setting it too high may cause the search to fail for some wells, since the code will not look any lower than minimum FWL elevation that you specify.

The output files from the FWL computation will look something like:

```

~Version Information
  VERS.                2.0:
  WRAP.                NO:
  END.                 PETRA:GeoPLUS Corporation
~Well Information Block
#MNEM.UNIT           Data Type           Information
#-----
STRT.F              2614.5000:
STOP.F              2849.5000:
STEP.F              0.5000:
NULL.              -999.25:
COMP.               : COMPANY
FLD.                HUGOTON                : FIELD
LOC.                : LOCATION
DATE.               19-MAY-2004          : DATE
WELL.               LUKE GU                : Well Name
LABL.               UPDATE-MKD           : Well Label
APIN.               15187206610000        : API Number
UWI.                15187206610000        : Unique Well Number
NUMB.               4                    : Well Number
OPER.               AMOCO PROD           : Operator Name
~Parameter Block
#MNEM.UNIT           VALUE           Description
#-----
EKB.F               3226.0 : KB Elevation
ELEV_KB.            3226.00000 : WELL - Kelly Bushing Elevation
IWHSIP.PSIA         480.0 : Initial pressure
CG_OGIP-MB.MKD      2089697.00000 : WELL - target OGIP (Mat.Bal.)
OGIP_CALC.         2087806.48675 : Calculated OGIP (MCF/section)
FWL.FT             447.05487 : Estimated FWL
dFWL.FT           0.03732 : FWL Error
ITER.             13 : Number of iterations
~Curve Information Block
Depth.ft            : Depth (ft)
Elev.ft             : Elevation (ft) [ ElevDatum - Depth ]
HFWL.ft             : Height above free water level (ft)
SW.%                : Calculated SW(%), truncated at 10000
SW.DEC              : Decimal saturation, truncated at 1
OGIP1.mcfaf         : OGIP (MCF/acre-ft)
OGIP2.mcf           : OGIP (MCF/section)
~A
2614.5      611.5      164.4      252.61      1      0      0
2615.0      611.0      163.9      253.21      1      0      0
2615.5      610.5      163.4      381.58      1      0      0
2616.0      610.0      162.9      521.37      1      0      0

```

The header lines shown in bold contain the target (mass balance) OGIP value for the well, the cumulative Sw-based OGIP (**OGIP_CALC**) value for the well computed using the final estimate for the FWL, the final FWL estimate itself (**FWL.FT**), the “error” in the FWL estimate (**dFWL.ft**, representing the width of the bracketing interval at the final iteration), and the number of iterations (**ITER**) required to reach the final estimate. The iteration stops when the bracketing interval is less than 0.1 foot.

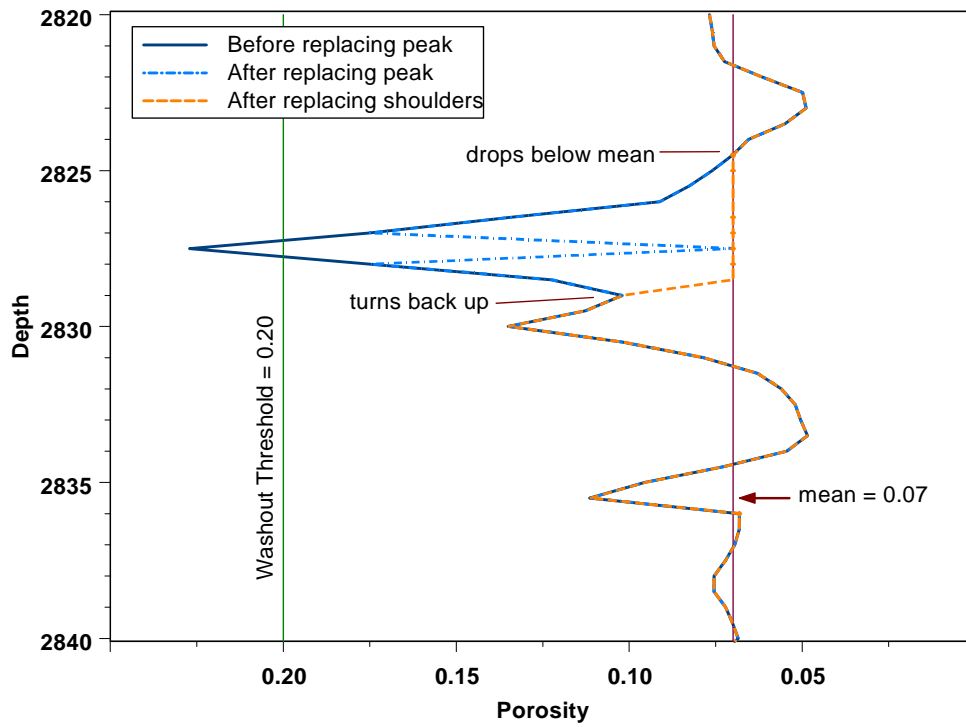
Running Porosity Correction

The porosity correction worksheet looks like this:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Porosity Correction, Geoff Bohling, 05 December 2004; last modified 11 May 2006															
2	-- Modify values as appropriate and click Run! (but don't move things around)															
3																
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9																
10																
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20																
21																
22																
23																
24																
25																
26																
27																

Coefficients from M. Dubois, 19 April 2006					
	Por Correction Intercept	Por Correction Dphi Coefficient	Por Correction Nphi Coefficient	Washout Correction PhiIND Threshold	Washout Correction PhiCorr Replacement Value
LithCode	A	B	C	Thresh	RepVal
1	0.017803	0.8434	0.0000	0.2000	0.0700
2	0.017803	0.8434	0.0000	0.2000	0.0700
3	0.018539	0.6619	0.0000	0.2000	0.0700
4	0.018539	0.6619	0.0000	0.2000	0.0700
5	0.000000	0.6151	0.3900	0.2250	0.0600
6	0.047523	0.5304	0.3081	0.2250	0.0600
7	0.000000	0.6151	0.3900	0.2250	0.0600
8	0.000000	0.6151	0.3900	0.2250	0.0600
9	0.047523	0.5304	0.3081	0.2250	0.0600
10	0.063699	0.5610	0.0000	0.2250	0.0600
11	0.013516	0.8414	0.0000	0.2000	0.0600

This works pretty much like the other two spreadsheets, with the name of the folder containing input files, the names of the lithology curve, density porosity, neutron porosity, and average porosity (PhiND), output file folder and output file name prefix specified in cells D7 – D13. The table to the right contains the three parameters, A, B, and C, used in the core vs. log porosity regression equations developed by John Doveton and the PhiND threshold and PhiCorr replacement values used for the washout correction code. The washout correction identifies any interval with a PhiND greater than the specified threshold value for that interval's lithology as a washout and used the value specified in the "RepVal" column as the corrected porosity value for that interval, rather than the value originally computed using the regression equations. The replacement values shown here are assumed average porosities for each lithology. The code also modifies the values on either side of the identified peak so as not to leave jagged shoulders in the corrected curves. This is accomplished by replacing every value leading monotonically up to an identified washout with the replacement value, except where the original value is less than the replacement value, as illustrated below:



Again, modify the parameters as appropriate and click **Run!** and the code will write out LAS files with corrected porosity curves to the specified output folder.