Automated processing of large data volumes for development of the Hugoton-Panoma geomodel

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Processing Steps

- Generation of geologic constraining variables (logs) from tops set
- Prediction of lithofacies from logs
- Porosity log correction
- Computation of water saturation, OGIP
- Back-calculation of free water level

Solution strategy

- Excel add-in Kipling2.xla used for prediction of lithofacies from logs (neural net code in Visual Basic)
- Remaining steps accomplished with special-purpose Excel workbooks
  - Spreadsheet input driving VB code
  - Batch processing of LAS files

Geologic constraining variables

- Depositional environment code (MnM)
  - 1 for nonmarine
  - 2 for marine
  - 3 for tidal flat
- Relative position curve (RelPos)
  - 0 at bottom of interval to 1 at top
- Added to well logs for facies prediction

The solution: GenMnM.xls

- Spreadsheet with table of tops, depositional environment codes for each interval
- Attached VB code generates LAS files with depositional enviornment code (MnM) and relative position (RelPos) curves

GenMnM.xls

	A	B	C	D	E	F	G	H	I	J
1										
2	Output folder:	D:\HugPan\MnMCurves				Generate MnM Files				
3	Depth increment:	0.5								
4										
5	Formation	HRNGTN	PADDOCK	KRIDER	ODELL	WINF	GAGE	TWND	B/TWND	FTRLY
6	Code	3	3	2	1	2	1	2	3	2
7	Default Thickness	10	10	5	10	10	10	0	10	10
8	UWI/API									
9	15075205440000	2736	2744	2750	2756	2780	2802	2842		2876
10	15075205670000	2704	2713	2715	2718	2748	2769	2791		2846
11	15075205800000	2701	2710	2715	2722	2744	2763	2792		2842
12	15075205450000	2714	2719	2722	2736	2756	2776	2798		2850
13	15075205630000	2710	2718	2727	2737	2756	2774	2796		2847
14	15075205650000	2683	2683	2683	2694	2728	2743	2762		2816
15	15075205460000	2644								
16	15075205730000	2648								
17	15075205470000	2395								
18	15093208740000	2482								
19	15075204350000	2390								
20	15075202120000	2438								
21	15187000570000	2348								

MnM15055000700000.las - WordPad

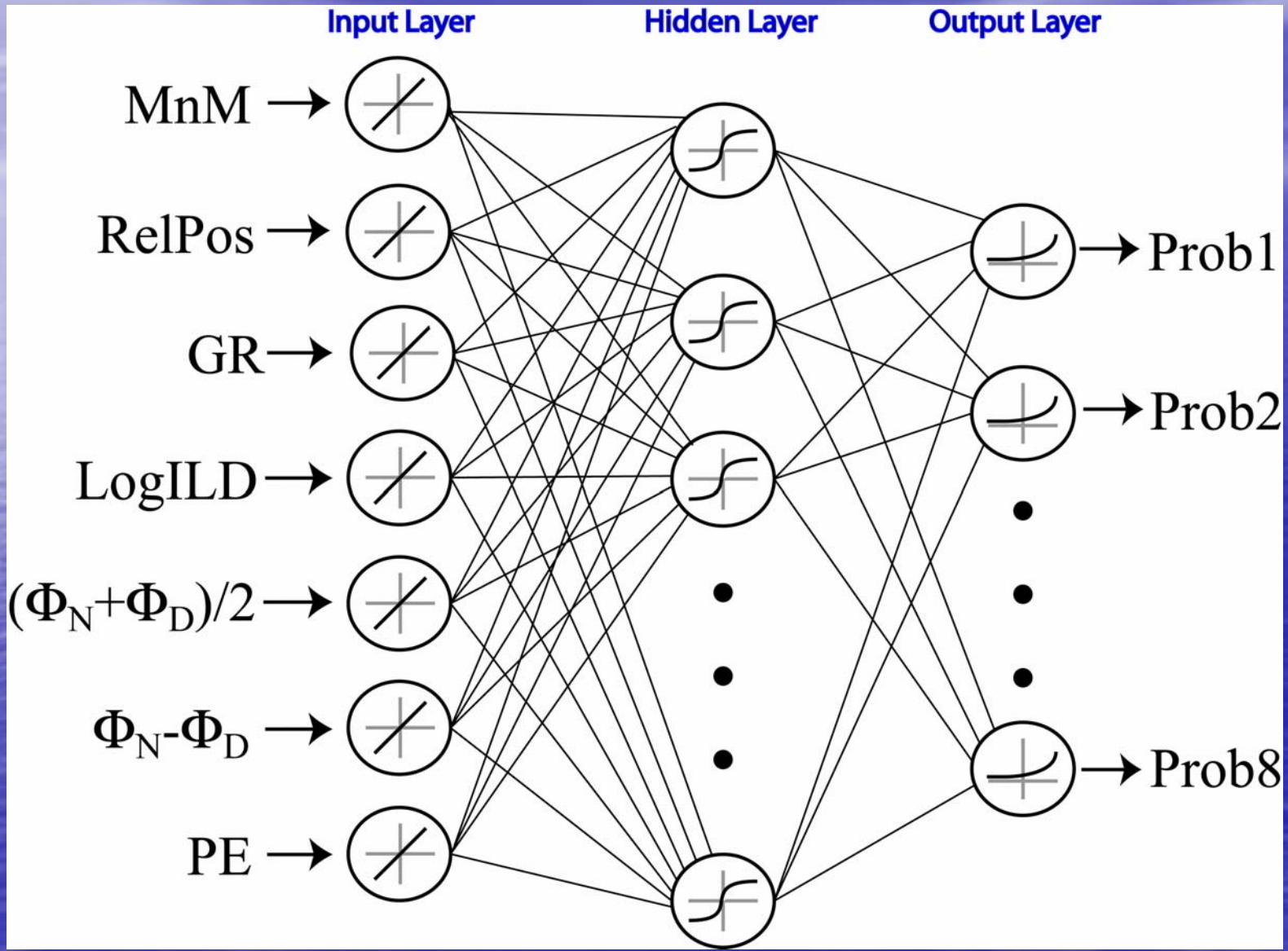
File Edit View Insert Format Help

```
FM22.              3018.0              : B5_SH TOP DEPTH; dep env code: 1
FM23.              3022.0              : B5_LM TOP DEPTH; dep env code: 2
FM24.              3040.0              : C_SH TOP DEPTH; dep env code: 1
FM25.              3071.0              : C_LM TOP DEPTH; dep env code: 2
FM26.              3125.0              : D_SH TOP DEPTH; dep env code: 1
~A  DEPTH    NM_M   RelPos FMNO
2612.0   3.0   1.000   1
2612.5   3.0   0.971   1
2613.0   3.0   0.941   1
2613.5   3.0   0.912   1
2614.0   3.0   0.882   1
2614.5   3.0   0.853   1
2615.0   3.0   0.824   1
```

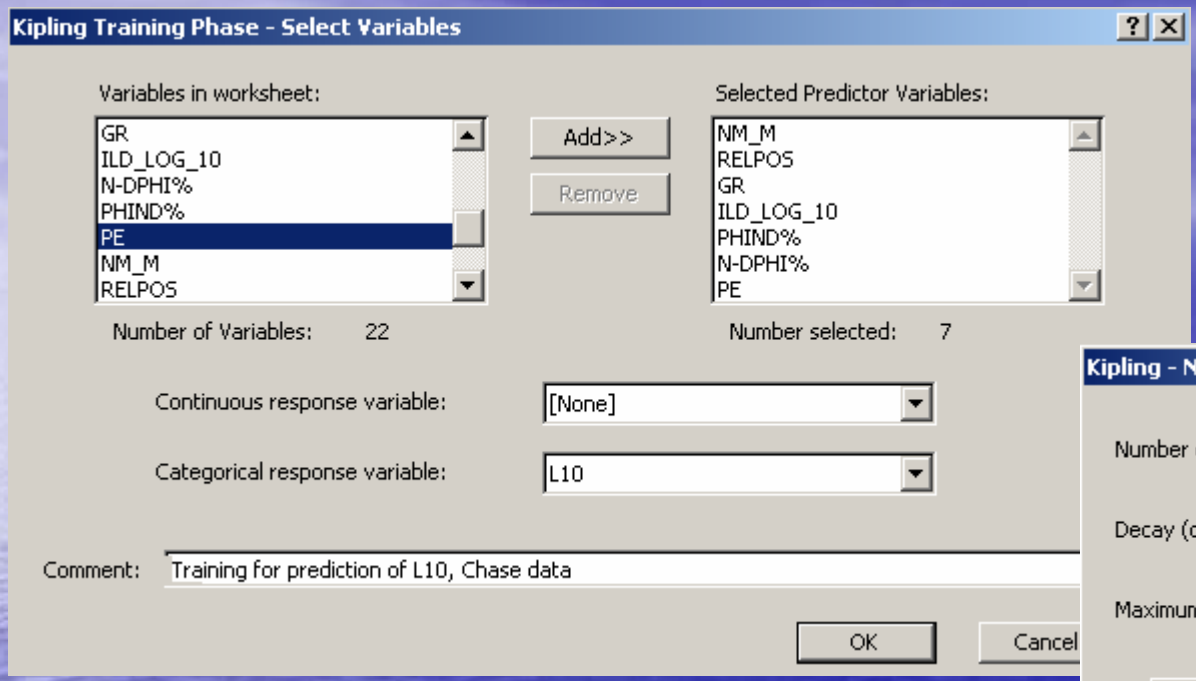
Prediction of facies from logs

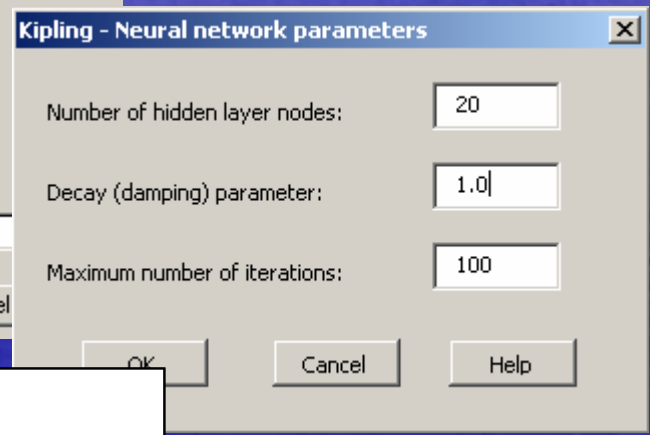
- Using neural net in Excel add-in Kipling2.xla
- Until recently, Kipling2.xla called neural net function in “R” statistical language for training; now all in VB
- Includes batch prediction over LAS files

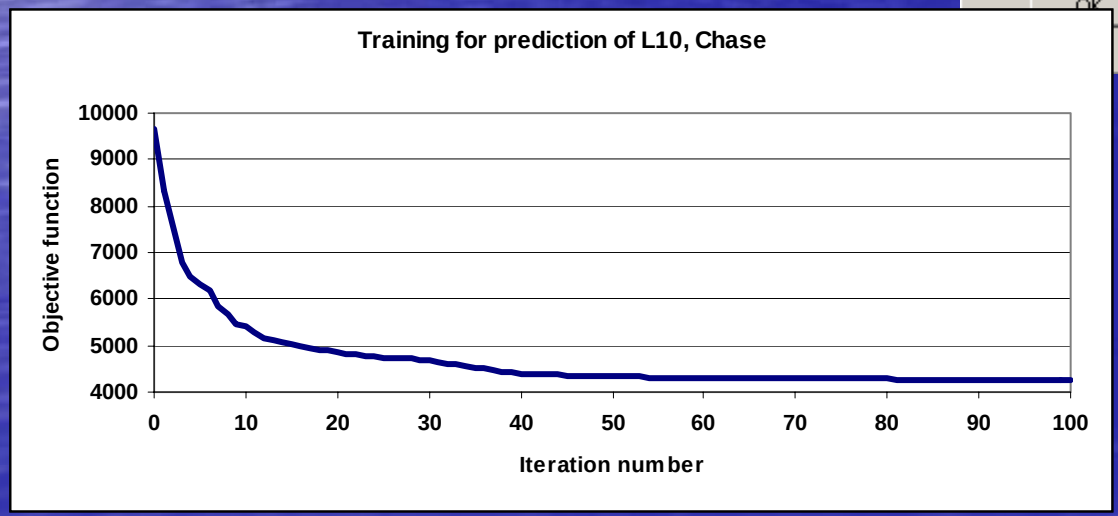
Neural Net


Input Layer
Hidden Layer
Output Layer
MnM
RelPos
GR
LogILD
$(\Phi_N+\Phi_D)/2$
$\Phi_N-\Phi_D$
PE
Prob1
Prob2
Prob8

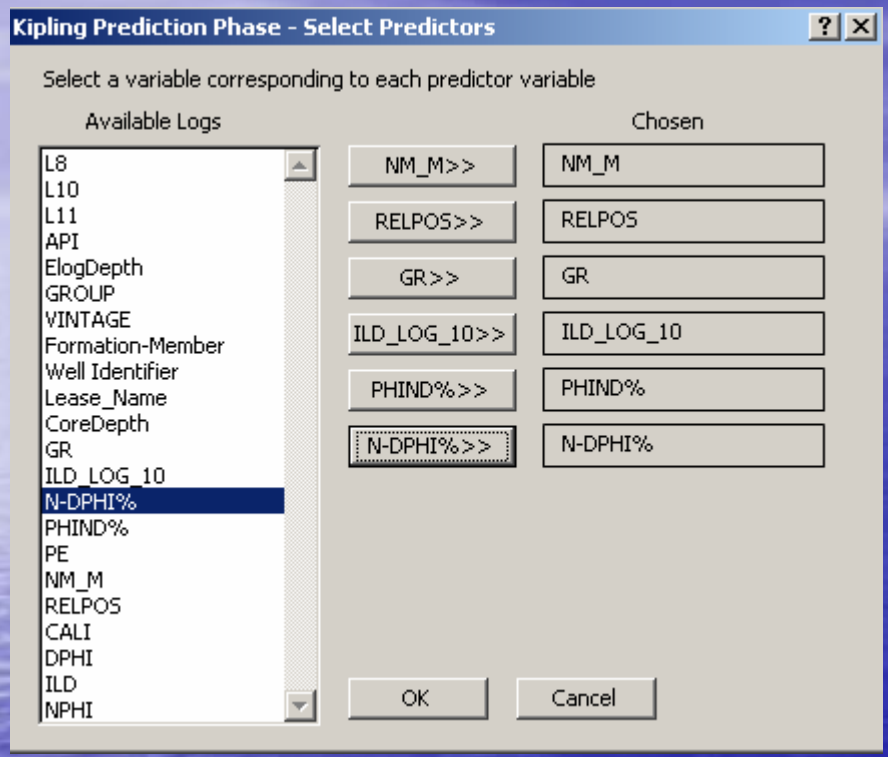
Training the neural net

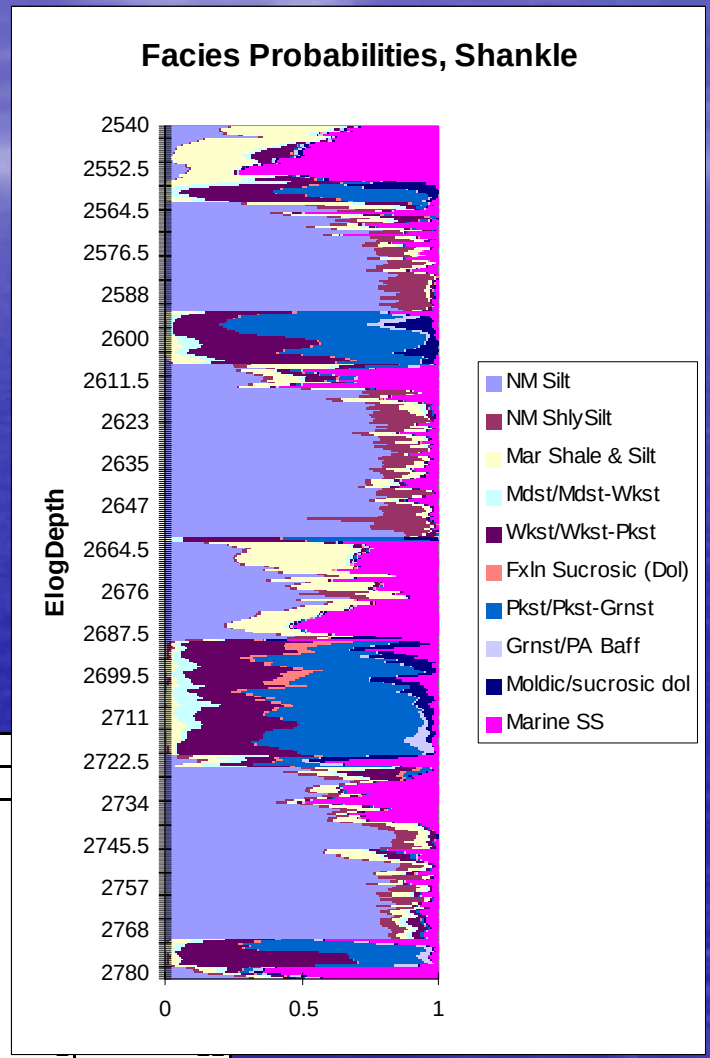






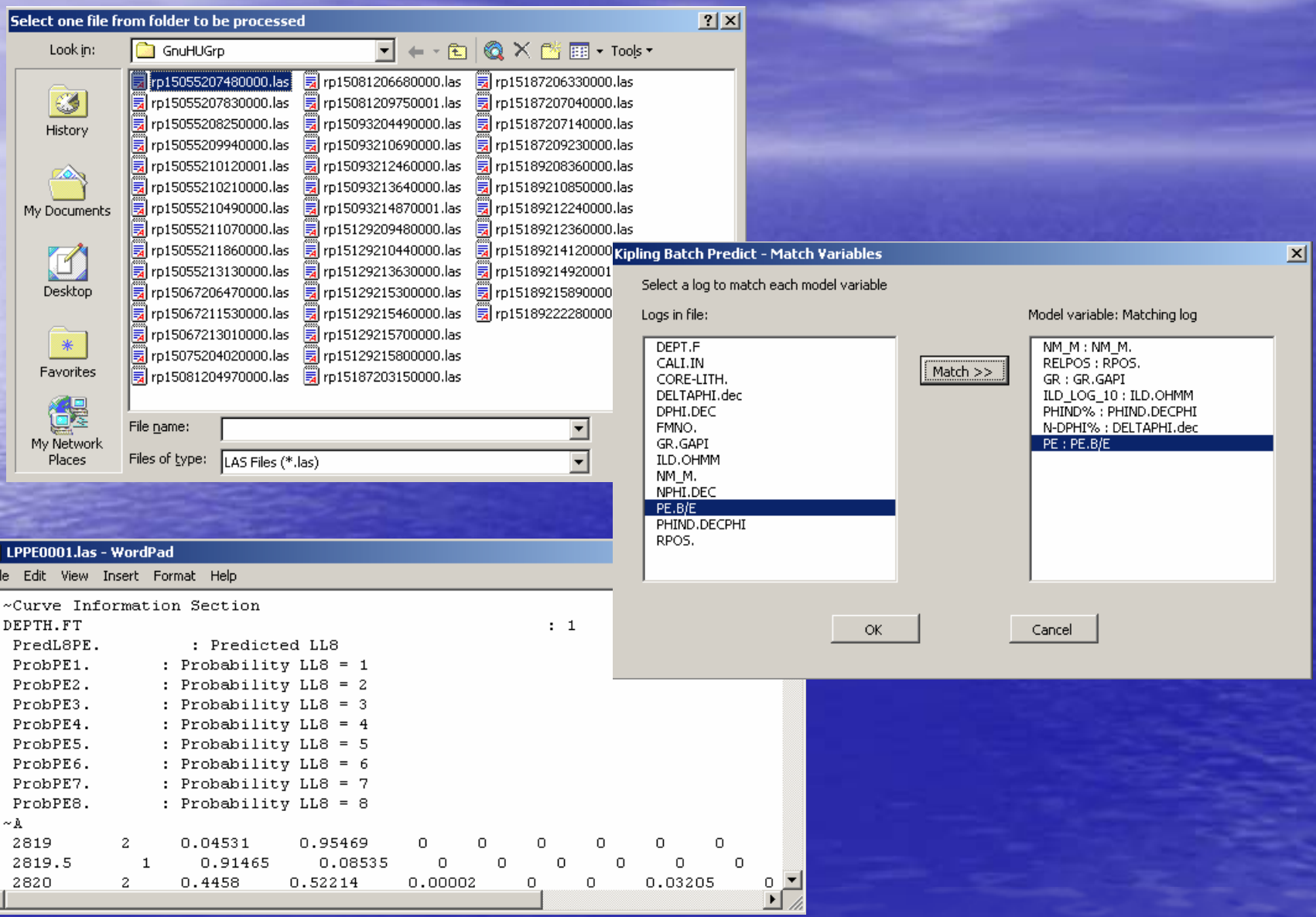
Prediction on spreadsheet data





Count of Pred.	Pred. L10							
L10	1	3	4	5	7	9		
1	241	16		1	2			
2	8	1						
3	5	5						
4					1			
5	5			17	21			
6			1	2		1		
7	3			12	43			
8					10			
9				3	4	2		9
10		1					14	15
Grand Total	262	23	1	35	81	3	58	463

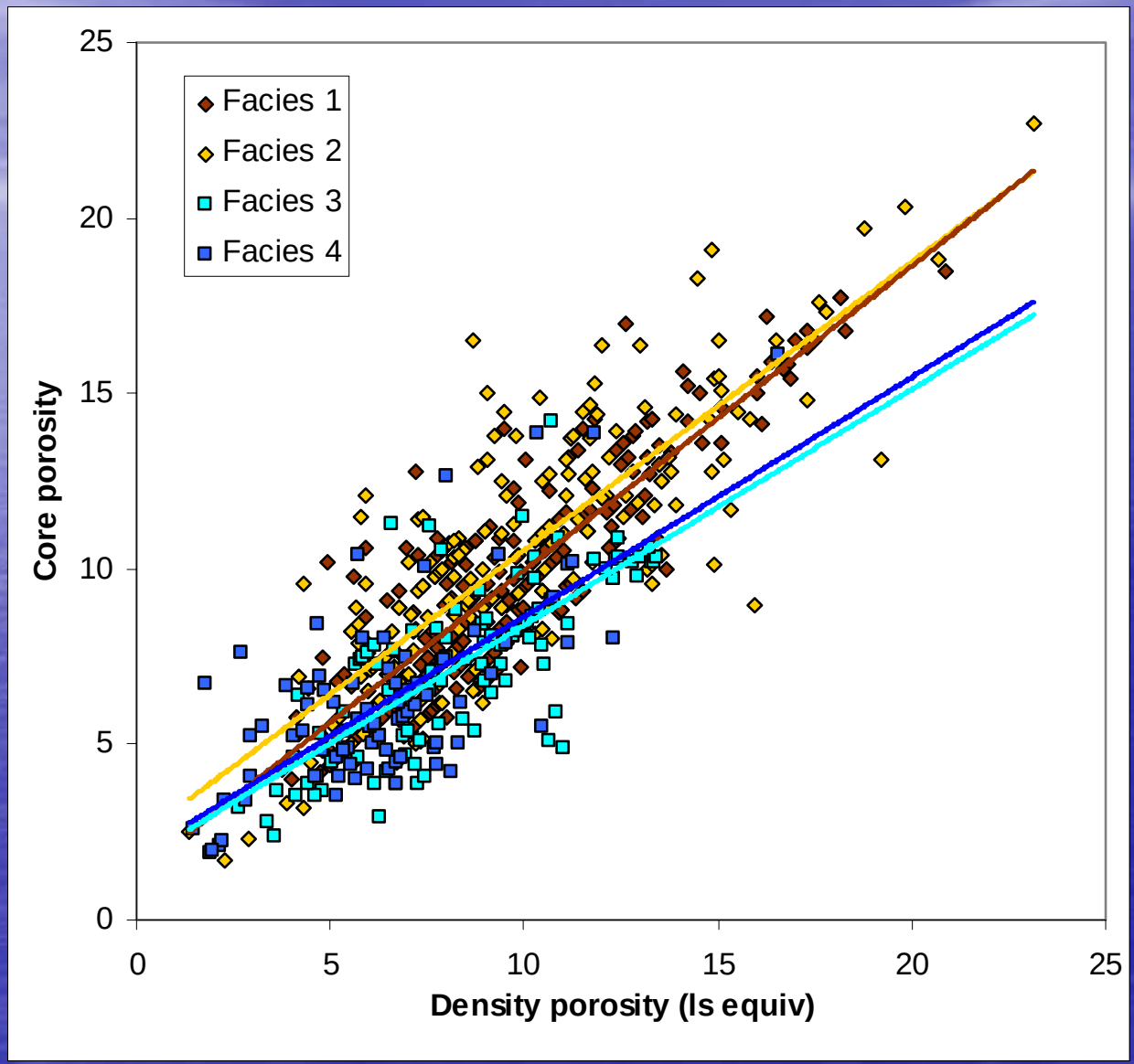
Batch prediction on LAS files



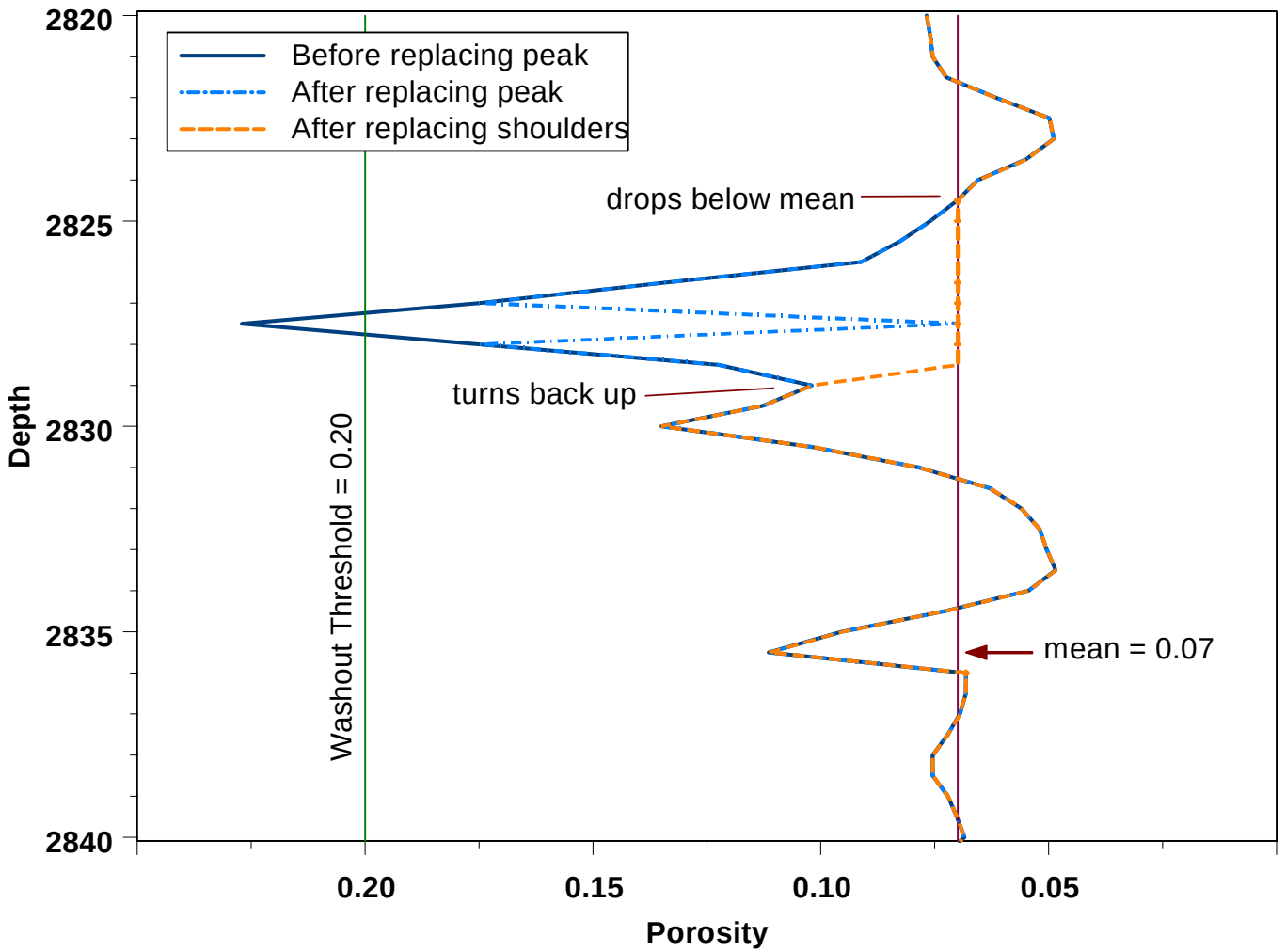
Porosity log correction

- Variations from reference mineralogy (limestone)
  - Regression of log vs. core porosities
- Washouts in shales
  - Remove spikes and associated shoulders
- Excel worksheet with VB code attached
  - Processes LAS files in specified folder

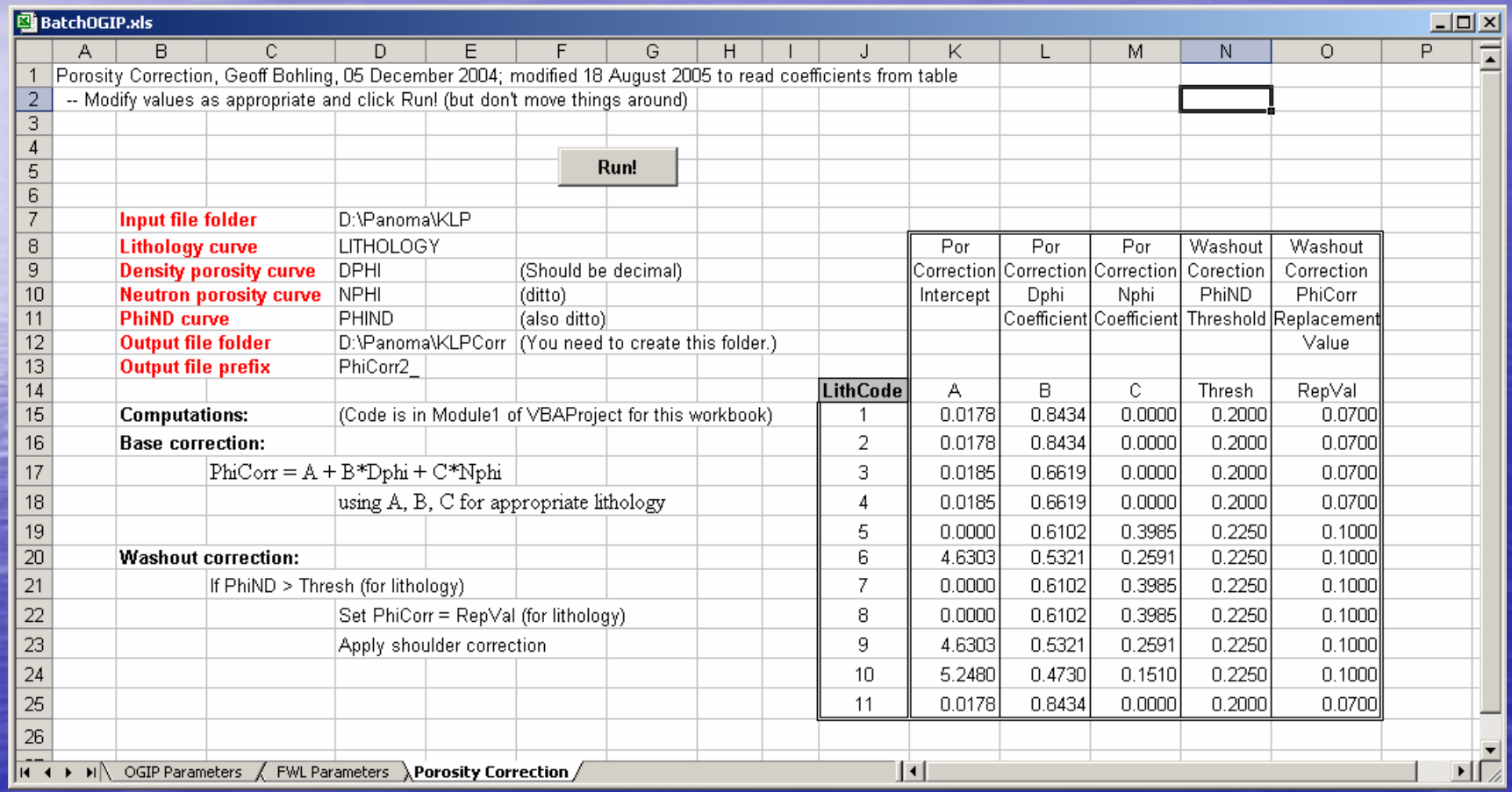
Log-core porosity relationships



Washout correction



Porosity correction worksheet



BatchOGIP.xls

Porosity Correction, Geoff Bohling, 05 December 2004; modified 18 August 2005 to read coefficients from table

-- Modify values as appropriate and click Run! (but don't move things around)

Run!

Input file folder	D:\Panoma\KLP
Lithology curve	LITHOLOGY
Density porosity curve	DPHI (Should be decimal)
Neutron porosity curve	NPHI (ditto)
PhiND curve	PHIND (also ditto)
Output file folder	D:\Panoma\KLPCorr (You need to create this folder.)
Output file prefix	PhiCorr2_

Computations: (Code is in Module1 of VBAProject for this workbook)

Base correction:

PhiCorr = A + B*Dphi + C*Nphi

using A, B, C for appropriate lithology

Washout correction:

If PhiND > Thresh (for lithology)

Set PhiCorr = RepVal (for lithology)

Apply shoulder correction

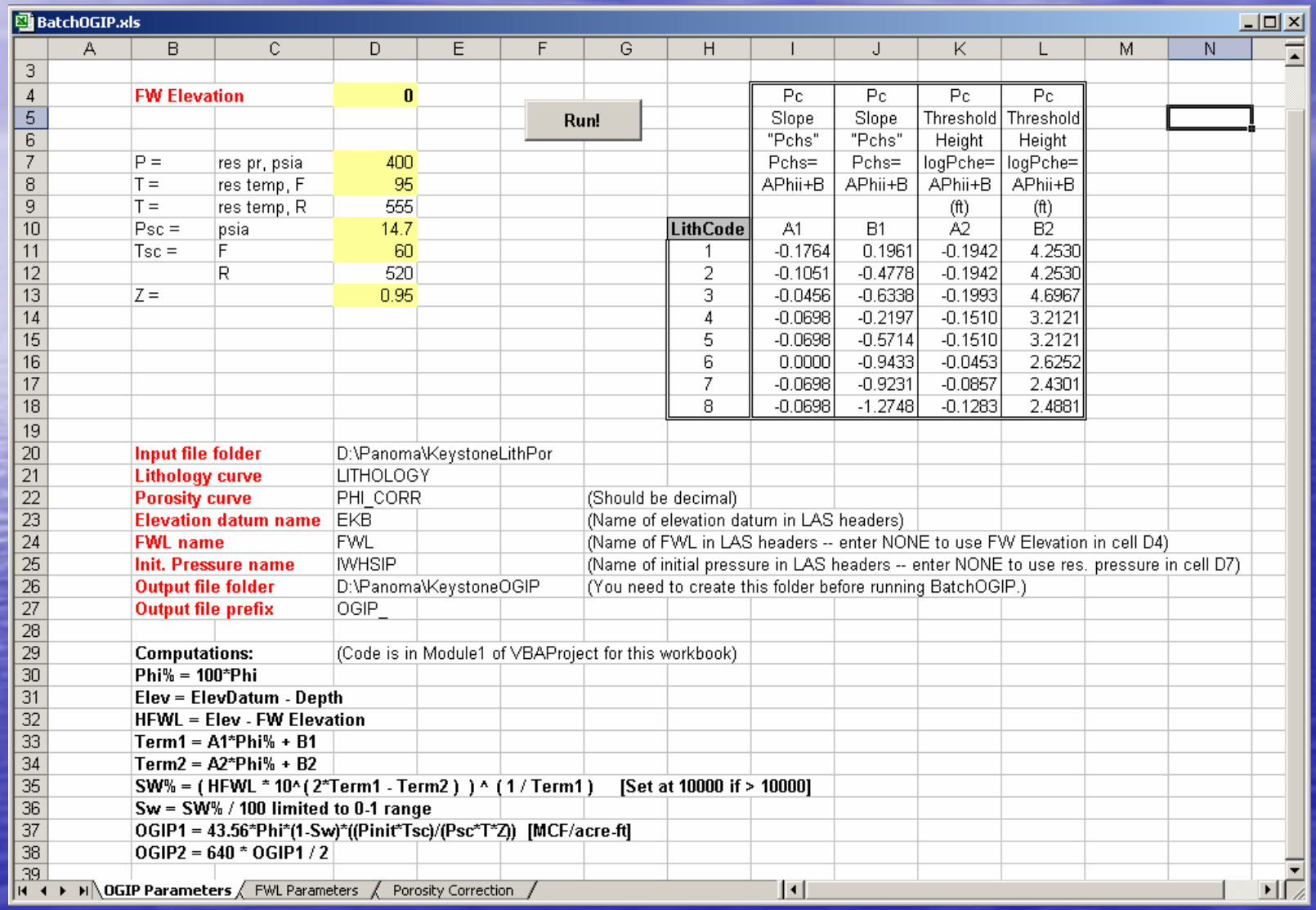
LithCode	Por Correction Intercept A	Por Correction Dphi Coefficient B	Por Correction Nphi Coefficient C	Washout Corection PhiND Threshold Thresh	Washout Correction PhiCorr Replacement Value RepVal
1	0.0178	0.8434	0.0000	0.2000	0.0700
2	0.0178	0.8434	0.0000	0.2000	0.0700
3	0.0185	0.6619	0.0000	0.2000	0.0700
4	0.0185	0.6619	0.0000	0.2000	0.0700
5	0.0000	0.6102	0.3985	0.2250	0.1000
6	4.6303	0.5321	0.2591	0.2250	0.1000
7	0.0000	0.6102	0.3985	0.2250	0.1000
8	0.0000	0.6102	0.3985	0.2250	0.1000
9	4.6303	0.5321	0.2591	0.2250	0.1000
10	5.2480	0.4730	0.1510	0.2250	0.1000
11	0.0178	0.8434	0.0000	0.2000	0.0700

OGIP Parameters | FWL Parameters | **Porosity Correction**

Batch OGIP calculation

- Computes Sw & OGIP vs. depth at wells from facies, porosity in LAS files
- Uses porosity-Sw transforms by facies; need HFWL and initial pressure
- Constant FWL (from spreadsheet) or by well (from headers)
- Ditto for initial pressure
- Generates LAS files with Sw, OGIP curves

Batch OGIP spreadsheet



BatchOGIP.xls

3													
4		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			(Should be decimal)						
23		Elevation datum name		EKB			(Name of elevation datum in LAS headers)						
24		FWL name		FWL			(Name of FWL in LAS headers -- enter NONE to use FW Elevation in cell D4)						
25		Init. Pressure name		IWHSIP			(Name of initial pressure in LAS headers -- enter NONE to use res. pressure in cell D7)						
26		Output file folder		D:\Panoma\KeystoneOGIP			(You need to create this folder before running BatchOGIP.)						
27		Output file prefix		OGIP_									
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) [Set at 10000 if > 10000]											
36		Sw = SW% / 100 limited to 0-1 range											
37		OGIP1 = 43.56*Phi*(1-Sw)*((Pinit*Tsc)/(Psc*T*Z)) [MCF/acre-ft]											
38		OGIP2 = 640 * OGIP1 / 2											
39													

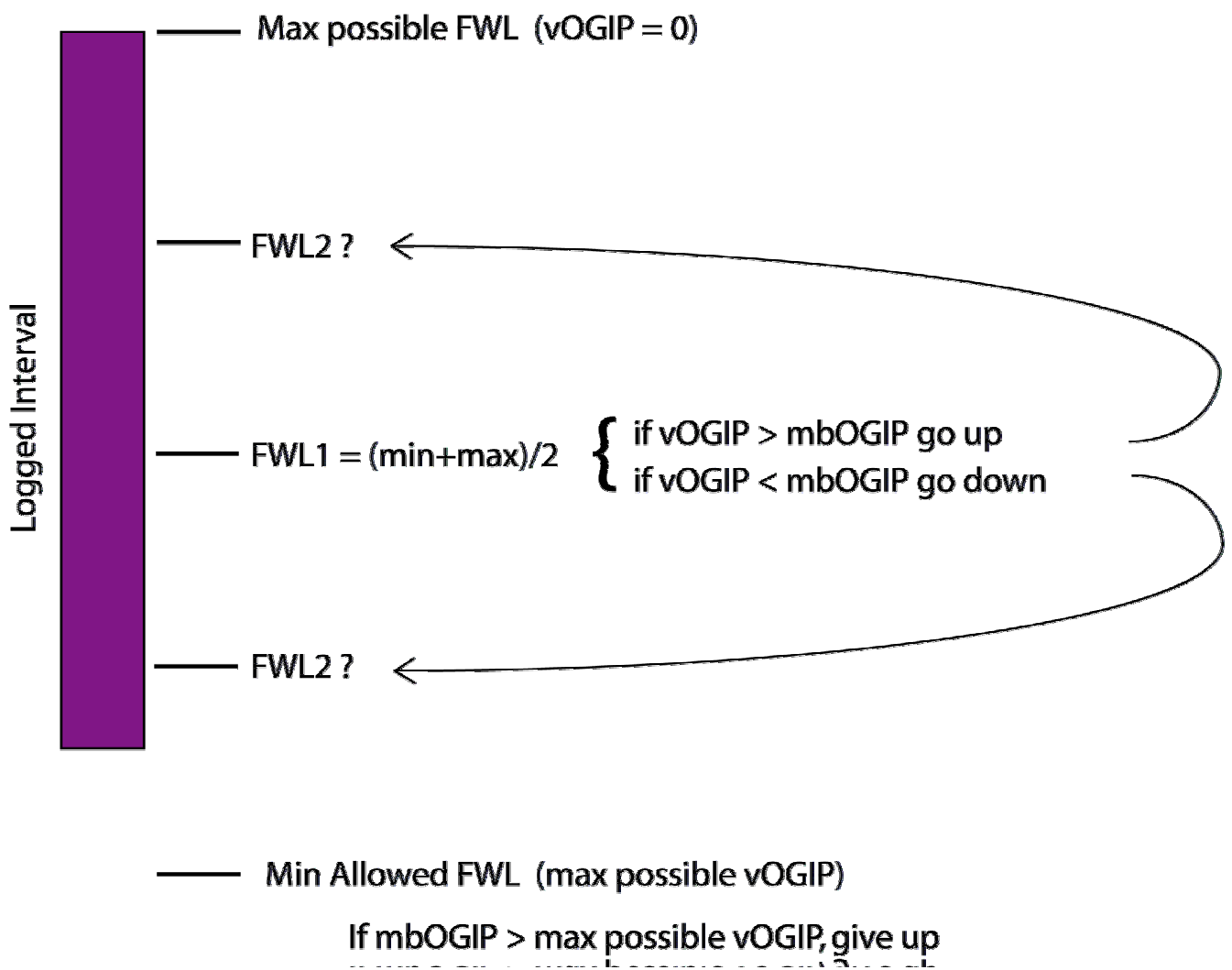
	H	I	J	K	L
		Pc Slope "Pchs" Pchs= APhii+B	Pc Slope "Pchs" Pchs= APhii+B	Pc Threshold Height logPche= APhii+B (ft)	Pc Threshold Height logPche= APhii+B (ft)
10	LithCode	A1	B1	A2	B2
11	1	-0.1764	0.1961	-0.1942	4.2530
12	2	-0.1051	-0.4778	-0.1942	4.2530
13	3	-0.0456	-0.6338	-0.1993	4.6967
14	4	-0.0698	-0.2197	-0.1510	3.2121
15	5	-0.0698	-0.5714	-0.1510	3.2121
16	6	0.0000	-0.9433	-0.0453	2.6252
17	7	-0.0698	-0.9231	-0.0857	2.4301
18	8	-0.0698	-1.2748	-0.1283	2.4881

OGIP Parameters | FWL Parameters | Porosity Correction

Backcalculating FWL from OGIP

- Computes FWL at each well that produces best match between volumetric OGIP and mass balance OGIP
- Mass balance OGIP (target) for each well read from LAS headers
- Other than fitting FWL, works like Batch OGIP

Bracketing search for FWL



Concluding remarks

- Flexible, easy batch processing crucial to a project of this scale
- Excel with VB provides reasonably accessible & inexpensive environment for developing customized processing code

Hugoton Asset Management Project industry partners

- Anadarko Petroleum Corporation
- BP America Production Company
- Cimarex Energy Company
- ConocoPhillips Company
- E.O.G. Resources Inc.
- Medicine Bow Energy Corporation
- Osborn Heirs Company
- OXY USA, Inc.
- Pioneer Natural Resources USA, Inc.