What You See, Is What You Get
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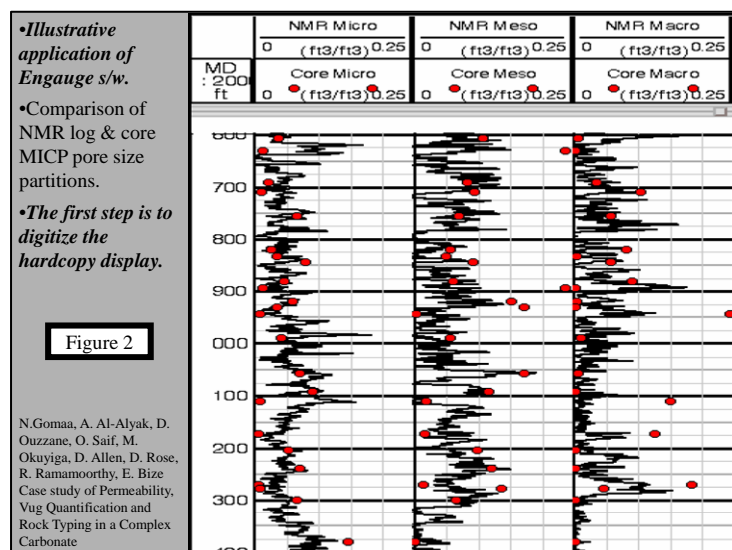*And what you see may depend upon how you look at it.*

Did you ever have one of those 'lightning bolt out of the blue' experiences? The data is just not fitting together, and one hypothesis after another has been discarded, when suddenly 'the light bulb comes on'. In many cases, it is a revision of our mental (and analytical) vision that unlocks the puzzle.

In order to evaluate alternatives, we need the vision (mental and graphical), *and the data in digital form. But it's not uncommon to be presented with a graphical summary* (published literature, historical report, etc), *absent a digital tabulation of the data itself, and in such a situation we are handicapped from the start*. And here I recently experienced one of those 'bolt out of the blue' experiences when my colleague *Shameem Siddiqui* (Texas Tech) pointed me to the shareware at *sourceforge.net*, specifically the *engauge* digitizing software (sourceforge.net/projects/digitizer/files/).
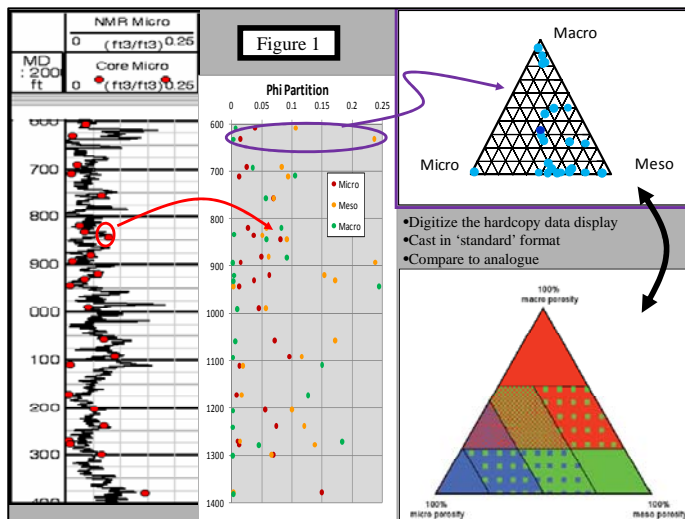
Figure 1

Engauge allows one to use their computer screen as a digitizing tablet. Data displays, seen on screen, may be digitized and those values entered to a spreadsheet or other s/w platform for subsequent digital interpretation: Figure 1.
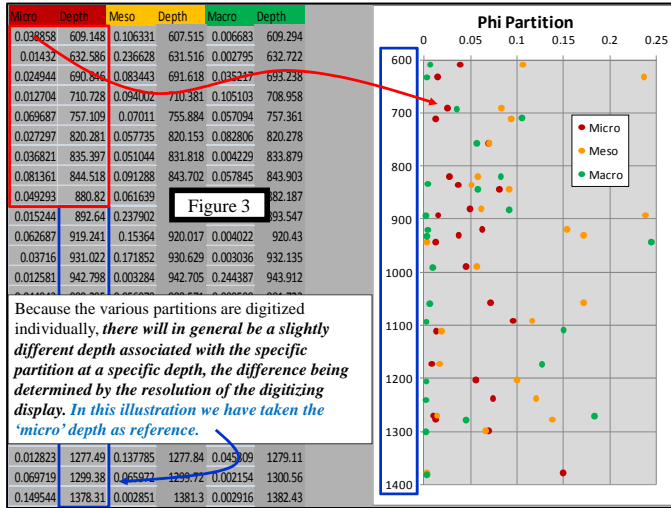
Engauge Basics

- *Illustrative application of Engauge s/w.*
- Comparison of NMR log & core MICP pore size partitions.
- *The first step is to digitize the hardcopy display.*

Figure 2

N.Gomaa, A. Al-Alyak, D. Ouzzane, O. Saif, M. Okuyiga, D. Allen, D. Rose, R. Ramamoorthy, E. Bize Case study of Permeability, Vug Quantification and Rock Typing in a Complex Carbonate

The hardcopy data of interest may come to us as a published public domain PDF, an internal Power Point graphic, or via a JPEG which we have scanned with our PC multi-purpose printer: Figure 2. All scenarios are common, and handled in the same manner.

What we need are the digits, and the protocol is as follows.

1. Save the graph of interest as a .jpg or .png file (copy / paste to Power Point, if necessary, and then Save As).

Figure 3

Because the various partitions are digitized individually, *there will in general be a slightly different depth associated with the specific partition at a specific depth, the difference being determined by the resolution of the digitizing display.* *In this illustration we have taken the 'micro' depth as reference.*

2. Launch Engauge by double-clicking on "engauge.exe".

3. Select File, Import

4. From the menu, navigate (if needed) and select the .jpg (or .png) graph file

5. Select Digitize, Axis Point

6. Click carefully at the "origin" of the x-y graph. Fill the x- and y-value in the dialog box

7. Click carefully at the max value on the x-axis of the graph. Fill the x- and y-value in the dialog box

8. Click carefully at the max value on the y-axis of the graph. Fill the x- and y-value in the dialog box

9. Select Digitize, Curve Point

10. Click carefully, on as many points on the curve. The more, the better!

11. Select File, Save As… Save your file with a suitable name, but do NOT change the file type! (it shoud be .dig)

12. Select File, Export As… Save your file with a suitable name, but do NOT change the file type! (it shoud be .csv)

13. Exit the program.

14. Open in Excel the .csv file created in Step-12 and proceed with your analyses.

In the case of multiple measurements at a single depth, there will generally be a slightly different depth value assigned to each measurement, whereas in fact the reported measurements are from a single sample / depth. This is remedied by simply taking any one of the multiple depth value traces, and using it for all reported values: Figure 3.

Illustrative Linear Application

At the simplest level, one carbonate application would be to 'fingerprint' the mineral assemblage and/or the porosity partition across a specific interval or reservoir.

In 1952 ***Archie told us*** "In discussing the petrophysics of limestone, it is necessary first to classify them in a manner to portray as much as possible the essential pore characteristics of a reservoir". ***The benefits of working within a systematic classification system include***;

- suspect data is more likely to be identified,

- domains in need of additional measurements will be recognized,

- comparison to analogue reservoirs becomes possible.

Depending upon the attribute of interest, there are generally a number of possible classification systems, each with its specific strength. In the case at hand, we're interested in porosity partitions: Figure 4.

The depth oriented display is revealing, but can be improved upon. With the digital values in hand (courtesy Engauge), it is ***straight-forward to 'fingerprint' the interval of interest within the context of a ternary plot***: Figure 5.

The ternary plot fills a niche,

Ternary diagram specifying 8 rock classes based on relative proportions of micro-, meso- and macro-porosity.

Schematic representation of pore space partitioning as proposed by Marzouk et al. (1995).

A New Workflow for Petrophysical and Textural Evaluation of Carbonate Reservoirs. Raghu Ramamoorthy, Austin Boyd, Thomas J. Neville, Nikita Seleznev, Haitao Sun, Charles Flaum, and Juntao Ma. Petrophysics, Vol 51, No 1, February 2010.
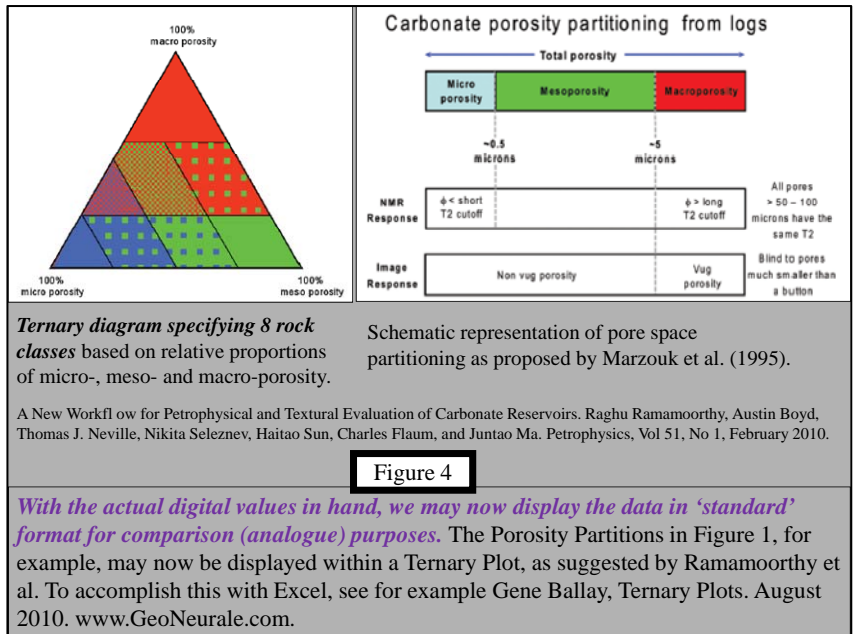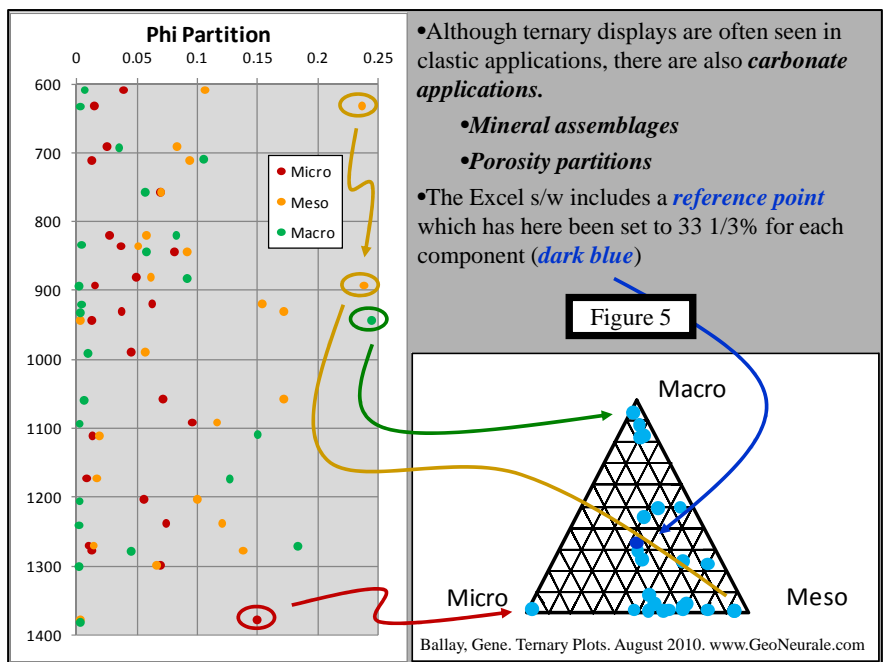
Figure 4

With the actual digital values in hand, we may now display the data in 'standard' format for comparison (analogue) purposes. The Porosity Partitions in Figure 1, for example, may now be displayed within a Ternary Plot, as suggested by Ramamoorthy et al. To accomplish this with Excel, see for example Gene Ballay, Ternary Plots. August 2010. www.GeoNeurale.com.

•Although ternary displays are often seen in clastic applications, there are also ***carbonate applications.***
  •*Mineral assemblages*
  •*Porosity partitions*
•The Excel s/w includes a *reference point* which has here been set to 33 1/3% for each component (*dark blue*)

Figure 5

Ballay, Gene. Ternary Plots. August 2010. www.GeoNeurale.com

somewhat similar to (but more sophisticated than) the histogram, in that it summarizes the relative simultaneous values of three components (whereas the histogram summarizes a single attribute) in a two dimensional format. The display may additionally serve as a kind of Quick Look Fingerprint that allows one to visually recognize (fingerprint) similar three dimensional combinations: Figure 6.

Useful ternary plot www sites include (but are not limited to)

Marshall, Daniel. TernPlot.
        http://serc.carleton.edu/NAGTWorkshops/petrology/plot_programs.html
Ma, Weifeng and Xiaorui Wang. GCDPlot.
        http://sourceforge.net/projects/gcdplot/
Niu, Yaoling. Template for ternary plots.
        http://serc.carleton.edu/NAGTWorkshops/petrology/plot_programs.html

•*The ternary plot fills a niche*, somewhat similar to (but more sophisticated than) the histogram, in that it *summarizes the relative simultaneous values of three components* (whereas the histogram summarizes a single attribute) in a two dimensional format.

•The display *may additionally serve as a kind of Quick Look Fingerprint that allows one to visually recognize similar three dimensional combinations.*

Figure 6

A New Workflow for Petrophysical and Textural Evaluation of Carbonate Reservoirs. Raghu Ramamoorthy, Austin Boyd, Thomas J. Neville, Nikita Seleznev, Haitao Sun, Charles Flaum, and Juntao Ma. Petrophysics, Vol 51, No 1, February 2010.
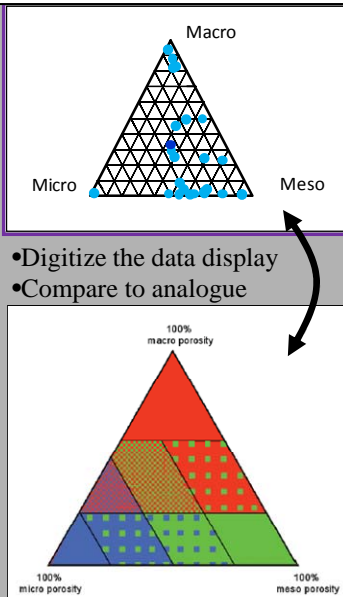
•Digitize the data display
•Compare to analogue

Today's spreadsheets are capable of producing **ternary diagrams**, and so **with an understanding of how to implement and utilize this display technique, we are able to add the capability to our spreadsheet toolbox** (which includes both differential and statistical error analysis, capillary pressure curve fitting, and much more).
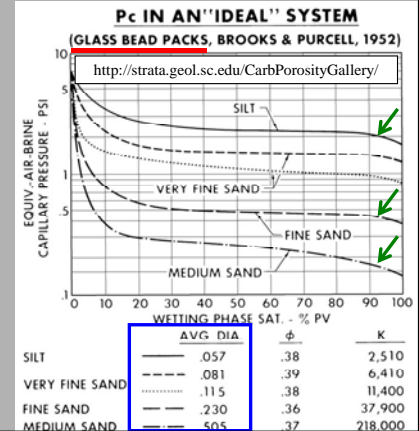
Illustrative Logarithmic Application

In a number of cases the conventional format is semi-log or log-log (Porosity-Permeability, Capillary Pressure, Formation Factor, Resistivity Index, etc.), ***and the 'set up' of Engauge must recognize this***: Figure 7.

Being comfortable with logarithmic displays has value far beyond the ability to digitize, for we will often be presented with someone else's (logarithmic) curve fits, and wish to deduce the slope ('m' or 'n', for example) if the trend were to be drawn differently.
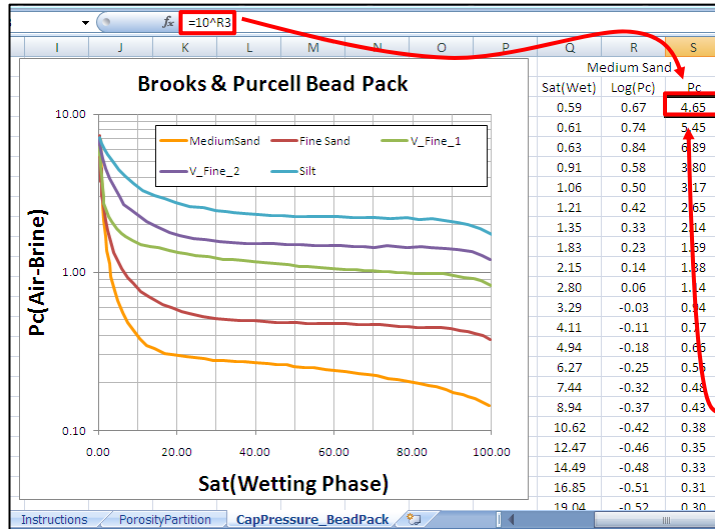
Illustrative Logarithmic Application

•How does one *characterize, at the simplest level, one pore system* (rock quality) *relative to another?*

•The '*appropriate*' or 'possible' pore system *classification methodology is*, in a practical sense, *dependent upon what information is available*.

•*At the well site*, or *in the core shed*, an *obvious attribute to observe* is *grain size.* This *leads to a Lucia approach.*

•In many cases, however, our evaluation is long after the fact, and/or there is little, if any actual rock available to examine and classify.

•If SCAL is available, and includes *capillary pressure*, then the various *Pc curves* may serve as a (first pass) classification protocol, and *Winland becomes an option.*

Figure 7

Pc IN AN "IDEAL" SYSTEM
(GLASS BEAD PACKS, BROOKS & PURCELL, 1952)

http://strata.geol.sc.edu/CarbPorosityGallery/

	AVG DIA	φ	K
SILT	.057	.38	2,510
VERY FINE SAND	.081	.39	6,410
	.115	.38	11,400
FINE SAND	.230	.36	37,900
MEDIUM SAND	.505	.37	218,000

Logarithmic displays have the effect of 'visually' displaying the logarithm of the data, and to account for this we need only define the Engauge axes accordingly. The actual data value is then calculated as ten raised to the value of the digitized point: Figure 8.

Brooks & Purcell Bead Pack

Medium Sand		
Sat(Wet)	Log(Pc)	Pc
0.59	0.67	4.65
0.61	0.74	5.45
0.63	0.84	6.89
0.91	0.58	3.80
1.06	0.50	3.17
1.21	0.42	2.65
1.35	0.33	2.14
1.83	0.23	1.69
2.15	0.14	1.38
2.80	0.06	1.14
3.29	-0.03	0.94
4.11	-0.11	0.77
4.94	-0.18	0.66
6.27	-0.25	0.55
7.44	-0.32	0.48
8.94	-0.37	0.43
10.62	-0.42	0.38
12.47	-0.46	0.35
14.49	-0.48	0.33
16.85	-0.51	0.31
19.04	-0.52	0.30

fx =10^R3

•Logarithmic displays are easily handled, if we remember that the effect of displaying data on a logarithmic axis is to 'visually take the logarithm'.

Figure 8

•In the case of logarithmic displays, *the axes definition within Engauge is the logarithm of the numerical value displayed, and the Engauge result (yield) is the logarithm of the data values.*
•*The actual data value is deduced by raising ten to that logarithm value.*

Quick Look Areas and Volumes

	A	B	C
1		Area	
2	Layer 1	0.2519884	sq unit
3	Layer 2	1.2697407	sq unit
4	Layer 3	3.8042186	sq unit
5	Layer 4	6.6188633	sq unit
6	Layer 5	9.9709071	sq unit
7	Layer 6	13.8911869	sq unit
8	Layer 7	18.7047580	sq unit
9	Layer 8	3.8042186	sq unit
10	Layer 9	35.1082112	sq unit
11	Layer 10	55.2640676	sq unit

In addition to allowing digitization of data displays (already a useful feature), *Engauge will also perform area and volume calculations*: Figure 9.
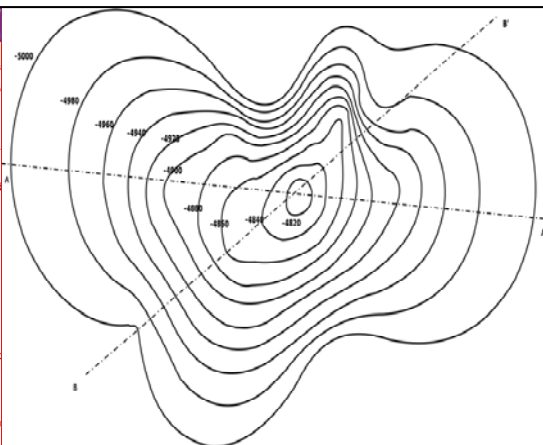
Figure 9

Areas, associated for example with reservoir thickness, etc, can also be digitized, allow quick look *volumetrics.*

Acknowledgement

Sometimes the answer is right in front of us, unrecognized until we are hit with 'a bolt out of the blue'. This one is for my Mother, who is always there, through thick and thin.

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Ramamoorthy, Raghu and Austin Boyd, Thomas J. Neville, Nikita Seleznev, Haitao Sun, Charles Flaum & Juntao Ma. A New Workflow for Petrophysical and Textural Evaluation of Carbonate Reservoirs. Petrophysics, Vol 51, No 1, February 2010.

Biography

R. E. (Gene) Ballay's *34 years in petrophysics* include *research and operations* assignments in Houston (Shell Research), Texas; Anchorage (ARCO), Alaska; Dallas (Arco Research), Texas; Jakarta (Huffco), Indonesia; Bakersfield (ARCO), California; and Dhahran, Saudi Arabia. His carbonate experience ranges from individual Niagaran reefs in Michigan to the Lisburne in Alaska to Ghawar, Saudi Arabia (the largest oilfield in the world).

He holds a *PhD* in *Theoretical Physics* with *double minors in Electrical Engineering & Mathematics*, has *taught physics in two universities*, *mentored Nationals* in Indonesia and Saudi Arabia, published *numerous technical articles* and been designated *co-inventor on both American and European patents*.

At retirement from the Saudi Arabian Oil Company he was the senior technical petrophysicist in the Reservoir Description Division and had represented petrophysics in three multi-discipline teams bringing on-line three (one clastic, two carbonate) multi-billion barrel increments. Subsequent to retirement from Saudi Aramco he established Robert E Ballay LLC, which *provides physics - petrophysics consulting services.*

He served in the US Army as a Microwave Repairman and in the US Navy as an Electronics Technician, and he is a USPA Parachutist and a PADI Dive Master.

Mississippian limestone

Chattanooga shale