Matrix and fluid values for various lithologies and mineralogies for porosity calculations

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	Mineral/ lithology	Sonic/Acoustic								Density				Neutron					
		DTCmatrix		DTSmatrix		DTCmatrix		DTSmatrix		RHOmatrix		Pe	Umatrix	PHINLS	PHINLS when PHI*actual* = 0.15				
Matrix Values	sandstone	56.0	184.0	88.0	289	51.3 to 55.6	168 to 182	88.0	289	2.65	2650	1.8	4.8	Phi*actual* > PHINLS	0.107	0.107	0.098	0.1	0.11
	limestone	49.0	161.0	88.4	290	43.5 to 47.6	143 to 156	88.4	290	2.71	2710	5.1	13.8	Phi*actual* = PHINLS	0.15	0.15	0.15	0.15	0.15
	dolomite	44.0	144.0	72.0	236	38.5 to 43.5	126 to 143	72.0	236	2.85-2.87	2850	3.1	9.0	Phi*actual* < PHINLS	0.232	0.174	0.17	0.165	0.21
	anhydrite	50.0	164.0			50.0	164.0			2.98	2980	5.1	15.0	-0.02	Schlumberger CNL; NPHI	Schlumberger CNL; TNPH	Halliburton DSN II	Weatherford CNS	Baker Atlas 2420 CN Log
	salt (halite)	67.0	220.0	120.0	394	67.0	220.0	120.0	394	2.04	2040	4.7	9.5	-0.03					
	shale									(variable)		~3		Phi*actual* < PHINLS					
	gas shale									< 2.53	< 2530			>0.35: swelling clays					
	kerogen	80-160	260-525			80-160	260-525			1.0-1.4	1000-1400		0.18-0.28	0.50 - 0.65					
	coal (average)	>105	>328			>105	>328			~1.3	~1300	~0.18	~0.22	>0.40					
	glauconite									2.86	2860	4.8	14.0	~0.38					
	kaolinite	212.0	698.0	328.0	1078	212.0	698.0	328.0	1078	2.41	2410	1.8	4.4	~0.37					
	chlorite									2.76	2760	6.3	17.0	-0.52					
	illite									2.52	2520	3.5	8.7	~0.30					
	montmorillonite									2.12	2120	2.0	4.0	~0.60					
	pyrite	39.2	128.9	62.1	204.7	39.2	128.9	62.1	204.7	5.00	5000	16.9	82.0	-0.03					
	siderite	47								3.89	3890	15.0	57.0	0.12					
	zircon									4.52	4520	69.0	311.0	-0.03					
	barite	69.7	229	132.7	436	69.7	229	132.7	436	4.09	4090	267.0	1090.0	-0.02					
	hematite	42.9	141	79.3	261	42.9	141	79.3	261	5.18	5180	21.0	111.0	0.11					
	steel	57	187			57	187												
Fluid values	**Fluid**	DTfluid				DTfluid				RHOfluid			Ufluid	PHINfluid	Lithology corrections vary with company and tool type, so it is important to use the chart or algorithm that applies to the specific tool type. One result is not "better" than another; there are just differences in tool response because of tool design.					
	water: **fresh** to *salt saturated*	**210** to *181* (189)	**682** to *587* (620)			**210** to *181* (189)	**682** to *587* (620)			**1.0** to *1.2*	**1000** to *1200*		**0.398** to *1.36*	**1.0** to *0.89*					
	oil-based mud	220 to 240	722 to 787			220 to 240	722 to 787												
	oil	230	755			230	755			~0.6 to 1.0	~600 to 1000	0.119	0.136*ρ_{oil}						
	gas	920	3018			920	3018			< 0.4	< 400	0.095	0.119*ρ_{gas}						
	Units	*µsec/ft*	*µsec/m*	*µsec/ft*	*µsec/m*	*µsec/ft*	*µsec/m*	*µsec/ft*	*µsec/m*	*g/cm³*	*Kg/m³*	*b/e*	*b/cm³*	*v/v decimal*					
		"Empirical" or "Field Observation" Raymer, Hunt, Gardner, 1980				**Wyllie Time-Average** Wyllie et al, 1956				**Density tool measurements**			*From RHOB and PE*	Values vary with company and tool version					

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Comments:

The table lists the commonly-published matrix and fluid parameters for calculating porosity from the common acoustic, density, and neutron porosity logs. Matrix parameters are the zero porosity endpoint values, while fluid parameters are the 100% porosity endpoints.

Values were determined from available data from logging company material and other sources, listed at the bottom of the table. Most of values were very consistent between sources, if not identical.

Columns with white backgrounds show parameter values in US Oilfield units, while columns with yellow backgrounds show parameter values in Metric or Canadian units. The units are noted near the bottom of each column.

Sonic/Acoustic: This section shows parameter values for both compressional waves (DTC) and shear waves (DTS). The section is further divided by the two common slowness-to-porosity transforms, by Wyllie et al, 1958, and by Raymer et al, 1980.

Note that the Wyllie matrix values vary for sandstones from consolidated (51.3 µsec/ft) to unconsolidated sands (55.6µsec/ft). The matrix values for carbonates show a continuum from pure dolomite (38.5 µsec/ft) through a mix of limestone and dolomite (43.5 µsec/ft) to a pure limestone (47.6 µsec/ft).

Density: The density section contains values for matrix and fluid densities (RHOma and RHOfl), and photoelectric effect (Pe). The parameter U is derived from both density and Pe. Its name varies somewhat by logging company (e.g., volumetric photoelectric factor), but all companies use the same symbol, U.

Neutron: Currently-available neutron logs provide "raw" data as a porosity referenced to a specific lithology. Conversion to the appropriate lithology (the lithology of the formation of interest) varies by logging company, vintage of the neutron tool, and sometimes curve name. The values for non-porous minerals and clays are approximate but are sufficient to use in lithology determination techniques that are qualitative, like the Neutron-Density QuickLook.

The porosity examples from the five neutron tools tries to illustrate the values produced by the logs if they were logged through a sandstone, limestone, and dolomite, all of 15% porosity. The example is meant to illustrate the differences in tool responses; between companies, between generations of tools, and even between "porosity" values from the same tool produced by different algorithms (shown as different curve names).

One tool or response is not "better" than any of the others. The differences occur because of different engineering solutions to the same problem, where companies feel that they have a better solution, or that they are avoiding patent infringements.

Older neutron tools which report results in counts, count rate, or API Neutron Units have NO generic conversion to porosity. They can be locally calibrated to porosity by core data in the well, or by comparison to neutron porosity values from newer measurements in nearby wells.

See the illustration on The Discovery Group website titled "Common Openhole Logging Equations" *for the equations that correspond to the parameters shown here.*

This document is intended to be updated periodically as necessary to include new and corrected information.

Questions and comments about this document are welcomed and encouraged. Please contact Dan Krygowski at The Discovery Group; DanKrygowski@Discovery-Group.com.