Curves are referenced to LIMESTONE, the most common display format.
Curves referenced to LIMESTONE, with crossplot porosity, PhiNDxplot, and apparent matrix density, RHOMaa, calculated.
Curves referenced to SANDSTONE. Note the change in scales of RHOB and NPHI_SS.
**Comments:**

This technique allows calculation of porosity and estimation of lithology with no numerical calculations.

**The display (Page 1):**

- Neutron porosity is referenced to limestone.
- Density porosity is referenced to limestone (RHOma = 2.71 g/cm³), **OR**
- Bulk Density is scaled to be equivalent to density and limestone neutron porosity (NOTE the scales in the pages above, for both limestone- and sandstone-referenced curves).

**Methodology:**

- Lithology is estimated from the position of the neutron curve with respect to the density curve.
- Porosity is estimated from the average of the curves (both using a porosity scale).
- Pore fluid is assumed to be oil or water, but NOT gas.
- The technique works with just the neutron and density curves, but PE and gamma ray curves (and others) may decrease ambiguity in, or confirm, your interpretation.

**General comments about lithologies:**

- Shale: Neutron > Density: the amount of separation will depend on local shale conditions.
- Limestone: Neutron = Density
- Sandstone: Neutron < Density: “crossover,” but this is due to lithology, not the presence of gas.
- Dolomite: Neutron > Density: looks the same as shale; Pe values are the same. Look for gamma ray differences (usually, shale is high; dolomite is low).
- Anhydrite: Neutron slightly negative, Density very negative; this is a “classic” pattern that you should be able to recognize very easily and quickly.
- Salt: Neutron slightly negative, bulk density very low or density porosity very high.
- Coal: Neutron very high, bulk density very low or density porosity very high.
- Mixed lithologies: The response of Neutron and Density will be an approximate linear combination of the pure lithology endpoints.

**General comments about porosities:**

- A very good estimate of porosity is determined by taking the average of the neutron and density porosities at a given depth. You can either read both values and take the average, or estimate a value between the two curves (Dan’s “eyeball average”). The value of porosity determined in this way will be within 1 or 2 porosity units of a Neutron-Density crossplot porosity.
- If you plotted the bulk density instead of the density limestone porosity, and you have scaled the curves properly (see below), get the density limestone porosity by reading the value on the neutron limestone porosity scale, using the location of the bulk density curve.

**Page 2** shows the same display, but with the Neutron-Density crossplot porosity, PhiNDxplot, and the apparent matrix density, RHOmaa, calculated. NOTE that the petrophysical software from which this came rounds all negative porosities to zero.

The apparent matrix density is calculated from bulk density, neutron-density crossplot porosity, and fluid density. This is a numerical representation of lithology.

**Page 3** shows the same lithologies, but the Neutron and Density are referenced to SANDSTONE instead of limestone. NOTE that the scales have changed, but the bulk density scale is still equivalent to the neutron scale. The curve patterns are not as distinctive as in the limestone-referenced case, but there
have been several requests for a display with the curves referenced to lithology, so that display is presented here.

**The origins of the display:**

When porosities from two measurements are displayed in the same log track, the porosity values are always displayed on the same scale, and are referenced to the same lithology. When the neutron and bulk density measurements are displayed together, either the density porosity or the bulk density can be displayed, with the bulk density scaled to be equivalent to the density porosity scale.

Referenced to sandstone:
\( \text{RHO}_{\text{ma}} = 2.65 \, \text{g/cc}, \quad \text{RHO}_{\text{fl}} = 1.0 \, \text{g/cc} \)

Referenced to limestone:
\( \text{RHO}_{\text{ma}} = 2.71 \, \text{g/cc}, \quad \text{RHO}_{\text{fl}} = 1.0 \, \text{g/cc} \)

By displaying the data in that way, one can either read the bulk density values directly, or one can read the equivalent density porosity (referenced to the same lithology as the neutron porosity) without having to do calculations, but by using the neutron porosity scale to obtain the density porosity value. The two values won't be exact but will be sufficiently close, especially for reconnaissance work.

An example:

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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.