Product Index Included as Option in CGG PowerLog Clay Volume Module

Calculating Clay Volume

In the Clay Volume module, you can calculate the volume of clay by using clay indicators in individual curves and in crossplots.

To set up and run the Clay Volume module:

1. Select **Interpret > Clay Volume** from the PowerLog menu bar or click the **Clay Volume** icon near the right end of the toolbar.
   The Clay Volume window opens.
2. Specify the standard parameters:
   - **Wells** – Verify that the appropriate wells or well groups are listed for the calculation. You can click the **Browse Wells** icon to locate and change the current selection.
   - **Intervals** – Specify the intervals to use for the computation. If you use zone parameters as inputs, indicate which zone to use as the parameter source in each interval.
   - **Sampling Grid** – Set the sample spacing for the output curves by selecting one of the options. Specify a curve to use as a sampling grid reference if necessary.
3. On the **Main Curves** tab, specify the following values:
   - **Curve** – Specify one or more curves to use for calculating clay: Enter the curve names in the **Curve** fields on the rows for **Gamma Ray**, **SP**, **Resistivity**, and **Neutron**.
   - **Clean** and **Clay** – For each of the input curves, define the clean and clay points by entering curve names or values.
   - **PassThru** – (*Optional*) Include a "pass-through" curve, which typically is a previously calculated clay volume.
4. *Optional* – On the **Additional Curves** tab, specify any of the following input types that you want to use: Spectralog, interval transit time, neutron lifetime, or neutron scaled in API units.
5. *Optional* – On the **Crossplots** tab, specify any crossplots that you want to use as inputs:
   - **N-D** – Neutron-Density crossplot
   - **N-S** – Neutron-Sonic crossplot
   - **N-R** – Neutron-Resistivity crossplot
   - **S-D** – Sonic-Density crossplot
   - **S-R** – Sonic-Resistivity crossplot
   - **D-R** – Density-Resistivity crossplot
   - **M-N** – M-N crossplot

   For each of the inputs that you use, define the matrix and fluid points, as well as the curve name and clay value. The applicable fields are activated when you select any of the checkboxes: *N-D, N-S, N-R, S-D, S-R, D-R,* and *M-N.*

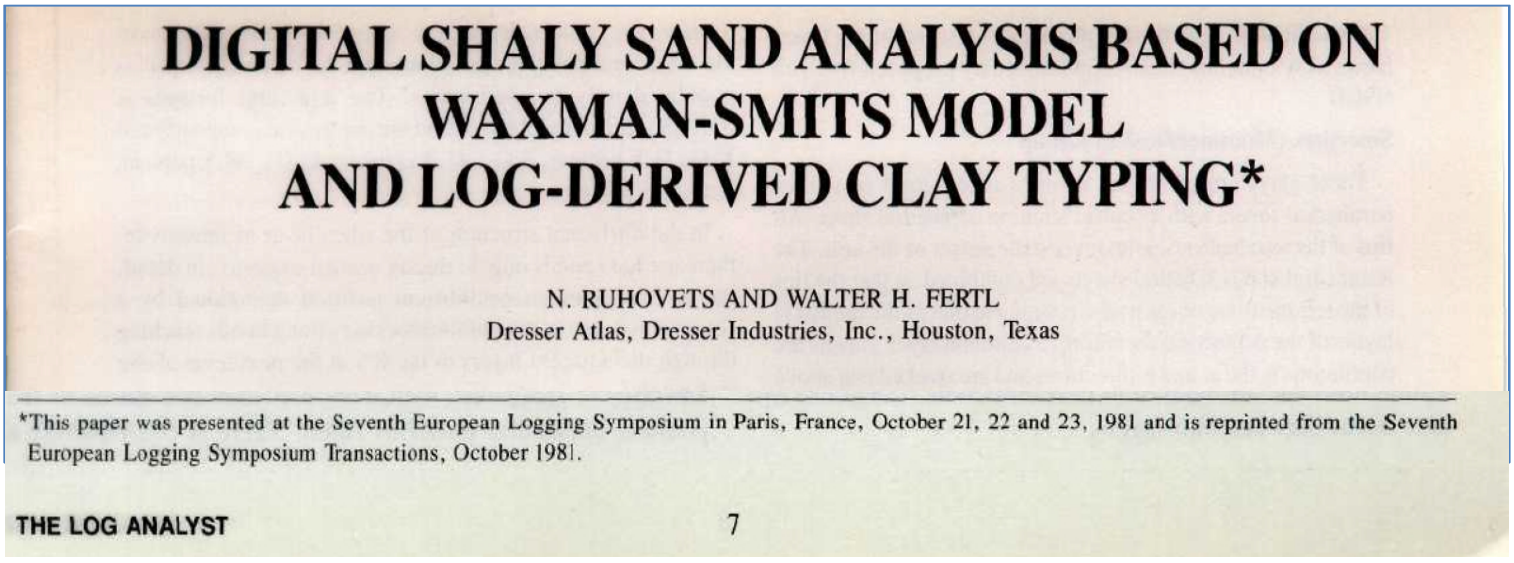
   For example, to specify values from an N-D crossplot, select the **N-D** checkbox, then enter the neutron and density matrix and fluid points (in the **N Matrix Point**, **D Matrix Point**, **N Fluid Point**, and **D Fluid Point** fields). Also enter values in the following fields: **Neutron Curve**, **Neutron Clay Value**, **Density Curve**, and **Density Clay Value**.

   To use an M-N crossplot, select the **M-N** checkbox, then enter the *m* and *n* matrix and fluid points (in the **M Matrix Point**, **N Matrix Point**, **M Fluid Point**, and **M Fluid Point** fields). Also enter values in the following fields: **Neutron Curve**, **Density Curve**, **Sonic Curve**, **M at Clay**, **N at Clay**, **Delta T Fluid**, and **Fluid Density**.
6. *Optional* – Select the **Product Index** tab and specify the following values:
   - **Spectral Gamma Ray Product Index, PI = (K + a)(Th+b)**
   - **Zero Offset Constant for K**
   - **Zero Offset Constant for Th**
   - **K**
   - **Th**
   - **Product Index Clean**
   - **Product Index Clay**

Reference:

Lawrence, T. Proposed Spectralog Product Index for Clay Volumes. Interoffice correspondence, Dresser Atlas, Houston, 1980.

Documented in: Ruhovets, N., & Fertl, W. H. (1982, May 1). Digital Shaly Sand Analysis Based On Waxman-Smits Model And Log-Derived Clay Typing. Society of Petrophysicists and Well-Log Analysts



DIGITAL SHALY SAND ANALYSIS BASED ON WAXMAN-SMITS MODEL AND LOG-DERIVED CLAY TYPING*

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Product Index Excerpt in Referenced Publication:

SP deflection is influenced by clay type; in addition, thin reservoirs can be missed by using this method. In our opinion, one of the best ways to determine clay volume is by using natural gamma ray spectral data. This technique has the capability of determining separately the quantitative, individual contributions of thorium, potassium, and uranium. Thus, in any clay volume determination, the uranium content can be excluded, thereby drastically reducing the influence of silt. Thorium and potassium content varies for different types of clay. Thus, usage of only one of these indicators for clay volume determination could lead to erroneous results. In our new program both Th and K curves are used simultaneously by calculating the so called "*product index*" of thorium and potassium.

The advantage of the product index is that it is virtually independent of clay types. This product index method of clay determination was proposed by Lawrence (1980) on the basis of typical potassium, uranium, and thorium concentrations for several clays and minerals (Fertl, 1979). Using these concepts, a crossplot of potassium versus thorium shows that illite, glauconite, biotite, and muscovite have high potassium and low thorium concentrations; while kaolinite, montmorillonite, bentonite, and bauxite are high in thorium, but low in potassium values (Fig. 3). These clays tend to form a hyperbolic pattern on the K versus Th crossplot (Fig. 4). On the basis of this crossplot, the product index (PI) is calculated as follows:

$$PI = (K + a)\,(Th + b) \qquad (2)$$

where a, b = zero offset constants
K = potassium in percent
Th = thorium in ppm

Product Index Excerpt in Referenced Publication:

The product index can then be used for clay volume deter-

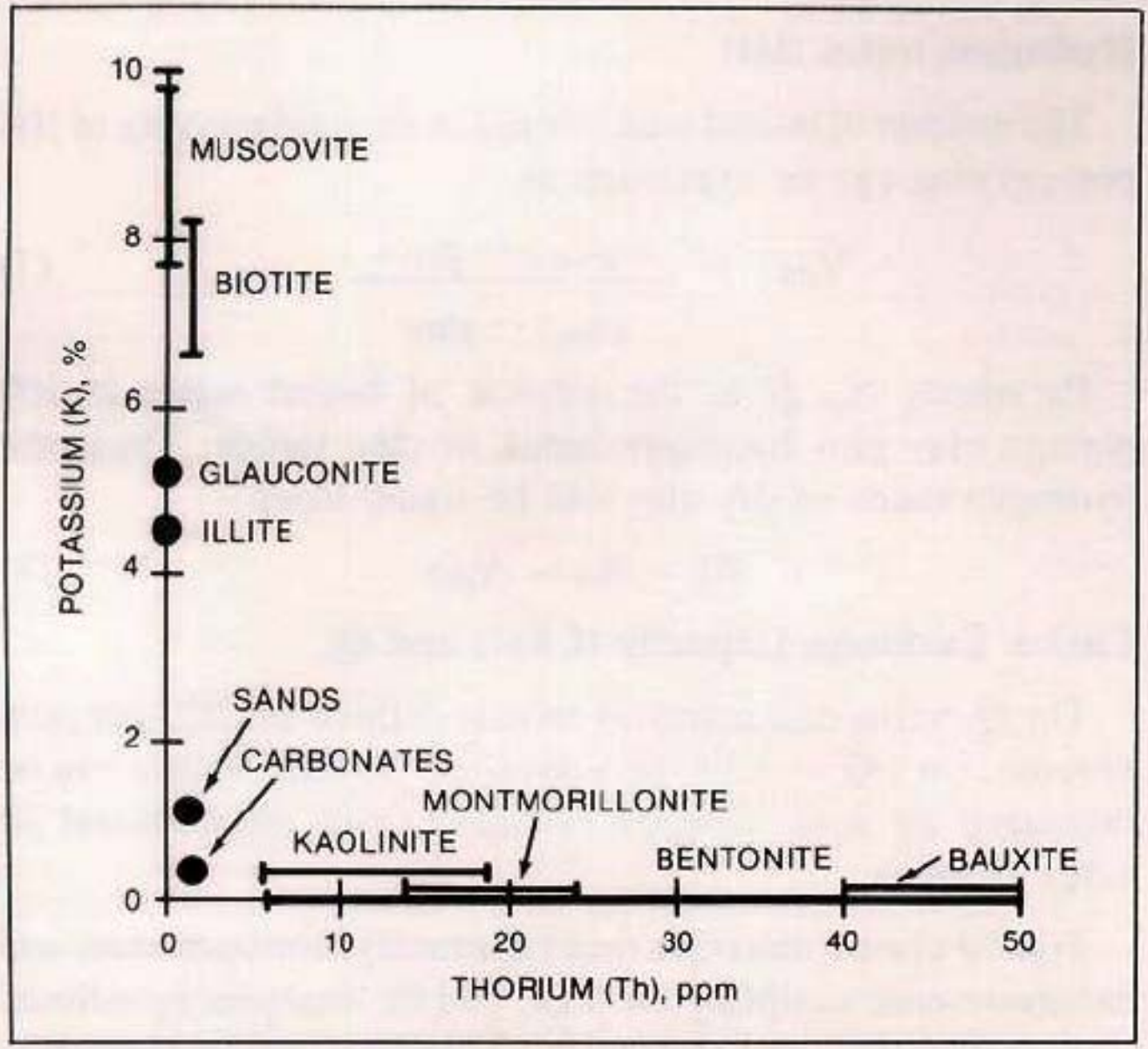

Figure 3. Typical potassium and thorium concentrations for different clay minerals.

Product Index Excerpt in Referenced Publication:

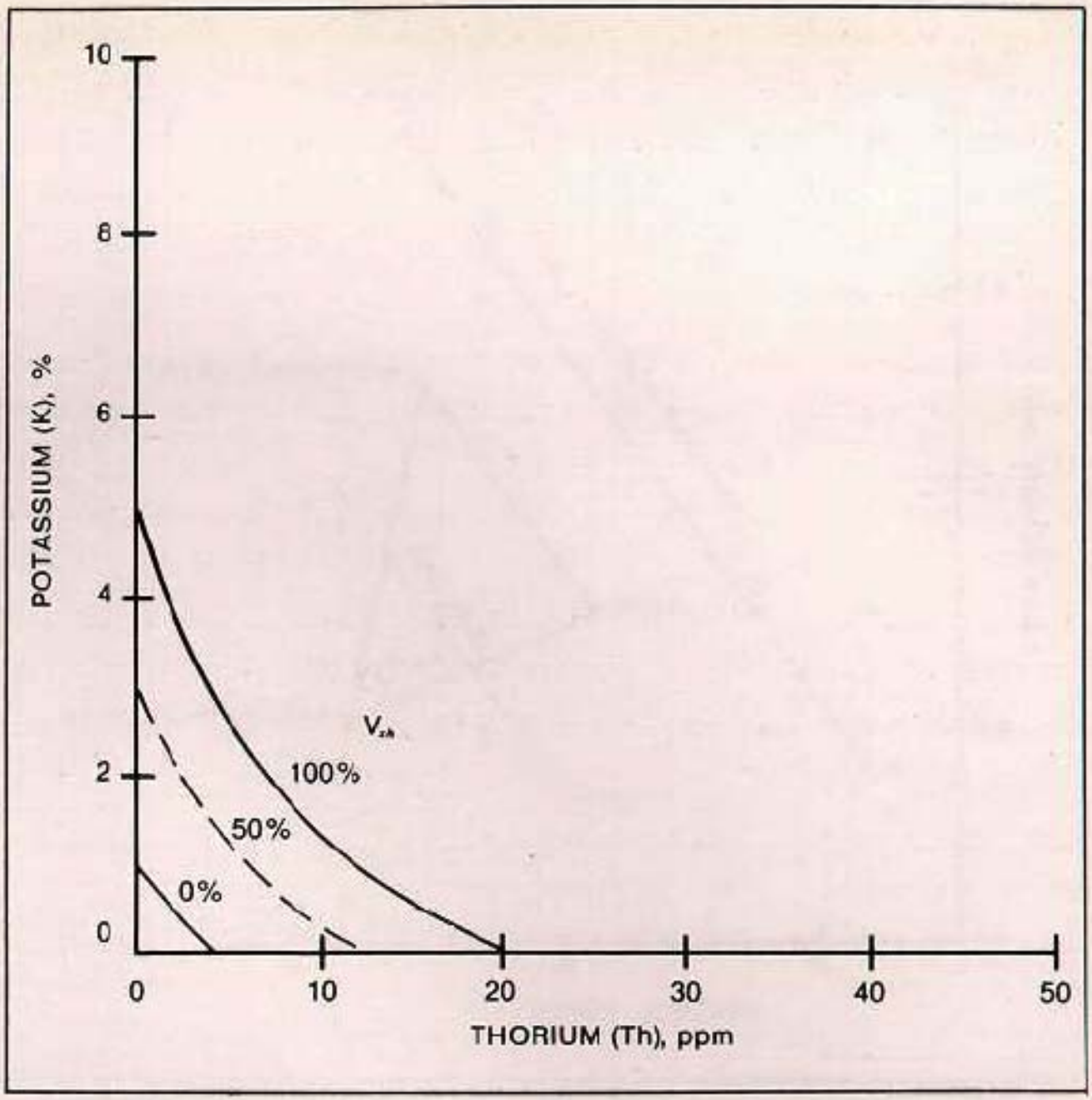

Figure 4. Product index clay volume for natural gamma ray spectral data (Lawrence, 1980).

mination in a manner similar to GR or SP, i.e., by selecting a maximum reading for 100 percent clay and minimum value in clean intervals.

Product Index Excerpt in Referenced Publication:

K_i — potassium index
K_w — water relative permeability, fraction
K_o — oil relative permeability, fraction
K_g — gas relative permeability, fraction
K_{HC} — hydrocarbon relative permeability, fraction
m — cementation exponent
n — saturation exponent
N_{cl} — neutron log response to 100% clay
PI — product index of Th and K (Spectralog)
Q_v — concentration of clay exchangeable cations per unit pore volume, meq ml^{-1}
R_{BW} — bound water resistivity, ohmm
R_{FW} — free water resistivity, ohmm
R_o — resistivity of water-saturated formation, ohmm
R_t — formation resistivity, ohmm
R_w — formation water resistivity, ohmm
S_w — water saturation, fraction of ϕ_{max}
S_{we} — effective water saturation, fraction of ϕ_e
S_{wi} — irreducible water saturation, fraction of ϕ_t
S_{BW} — bound water saturation, fraction of ϕ_t
S_{wie} — irreducible water saturation in effective pore space, fraction of ϕ_t
S_{wt} — total water saturation, fraction of ϕ_t
V_{BW} — volume of bound water in 100% clay, fraction
V_{cl} — clay volume, fraction
V_{clD} — dispersed clay volume, fraction
V_{clL} — laminated clay volume, fraction
V_{clS} — structural clay volume, fraction
ϕ_{BW} — bound water volume in shaly sand, fraction
ϕ_e — effective porosity in shaly sand, fraction
ϕ_{max} — porosity in clean sand, fraction
ϕ_t — total porosity of shaly sand, fraction
ρ_{BW} — density of bound water, g/cc
ρ_{cl} — clay density, g/cc
ρ_{ma} — matrix density, g/cc
$\rho_{ma_{cl}}$ — density of dry clay, g/cc

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