GEM™ Elemental Analysis Tool

OVERVIEW

The Halliburton GEM™ elemental analysis tool offers quick and precise evaluations of complex mineralogies, using proven interpretation processes and integrated petrophysical analysis. A neutron-induced capture gamma ray spectroscopy logging system, the GEM tool is designed to derive elemental contributions contained within the total measured gamma-ray energy spectrum.

The GEM tool can measure elemental yields that are important to mineralogical evaluations in open holes to accurately assess the reservoir and complete the well.

The GEM logging software calculates elemental concentration logs by using an oxides-closure methodology that can be used for quick-look or detailed mineralogical evaluations. These elemental concentrations can be used to identify geometrical-stratigraphic correlations from well to well. Elemental concentrations can also be used to calculate matrix-grain density and thermal neutron-absorption (sigma) properties.

The GEM tool uses a chemical source to promote wider application due to cost savings associated with its durability, shorter length, and simple usage requirements. The detector is enclosed in a flask with a eutectic heat sink to enable extended operation at downhole conditions. In addition, the software provides on-site or remote visualizations of the resulting data quickly and accurately, with proven, robust post-processing solutions.

BENEFITS

» Improves accuracy of integrated petrophysical analysis

» Mineral fractions such as gypsum or anhydrite, carbonate, coal, pyrite, salt, siderite, quartz, feldspar, mica, and clay from complex formation analysis

» Matrix-density values for more accurate porosity calculation

» Sigma matrix for cased and openhole sigma saturation analysis and improved neutron-porosity environmental corrections

» Improves permeability estimates based on mineralogy

» Quick cool down of eutectic heat sink for rapid job turnaround

» Borehole shielding for reduced sensitivity to borehole fluids
**Hardware Characteristics**

Source Type: 15-Ci Americium-Beryllium

Sensor Type: One BGO Scintillation Counter

Sensor Spacings: Proprietary

Sampling Rate: 4 samples/ft (10 samples/m)

Sampling Rate: 30 ft/min (9.1 m/min)

Sensor Spacings: 24 in. (60.96 cm)

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Sampling Rate: 15 ft/min (4.6 m/min)

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Tool Positioning: Centralized

Tool Positioning: Eccentricized

**Borehole Conditions**

Recommended Logging Speed: 15 ft/min (4.6 m/min)

Borehole Fluids: Salt, Fresh, Oil, Air

Weight: 368 lb (166.9 kg), 413 lb (187.3 kg)

Max Hole: 24 in. (60.96 cm)

Max Hole: 5 in. (12.70 cm)

Min Hole: 6 in. (15.24 cm)

**Measurement**

Measurement Principle: Elemental yield based on neutron-induced capture gamma ray spectroscopy

Range of Measurement: 600 keV to 9.5 MeV

Vertical Resolution (90%): 18 in. (45.72 cm)

Depth of Investigation (50%): 6 in. (15.24 cm)

Output Curves: Mg, Al, Si, S, K, Ca, Ti, Mn, Fe, and Gd elemental weight fractions from oxides closure

Primary Curves: H, C, O, Mg, Al, Si, S, Cl, K, Ca, Ti, Mn, Fe, and Gd elemental yields

Secondary Curves: Mg, Al, Si, S, K, Ca, Ti, Mn, Fe, and Gd elemental weight fractions from oxides closure

**Statistical Precision**

<table>
<thead>
<tr>
<th></th>
<th>Mg (wt. %)</th>
<th>Al (wt. %)</th>
<th>Si (wt. %)</th>
<th>S (wt. %)</th>
<th>K (wt. %)</th>
<th>Ca (wt. %)</th>
<th>Ti (wt. %)</th>
<th>Mn (wt. %)</th>
<th>Fe (wt. %)</th>
<th>Gd (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austin Chalk**</td>
<td>0.04±0.2</td>
<td>0.06±0.1</td>
<td>0.02±0.05</td>
<td>0.02±0.06</td>
<td>0.01±0.03</td>
<td>39.89±0.27</td>
<td>0.01±0.01</td>
<td>0±0</td>
<td>0±0</td>
<td>2.19±0.3</td>
</tr>
<tr>
<td>Indiana Limestone**</td>
<td>0.09±0.27</td>
<td>0.24±0.2</td>
<td>0.21±0.26</td>
<td>0.1±0.10</td>
<td>0.05±0.08</td>
<td>39.42±0.48</td>
<td>0.01±0.01</td>
<td>0.01±0.01</td>
<td>0.02±0.03</td>
<td>1.08±0.34</td>
</tr>
<tr>
<td>Kasota Dolomite†</td>
<td>11.06±1.48</td>
<td>1.07±1.02</td>
<td>6.53±0.89</td>
<td>0.61±0.29</td>
<td>1.99±0.44</td>
<td>16.59±1.55</td>
<td>0.12±0.04</td>
<td>0.14±0.03</td>
<td>0.81±0.16</td>
<td>0±0</td>
</tr>
<tr>
<td>Berea Sandstone†</td>
<td>0.35±0.7</td>
<td>1.62±1.43</td>
<td>37.55±2.05</td>
<td>1.14±0.43</td>
<td>2.36±0.45</td>
<td>3.75±0.76</td>
<td>0.09±0.06</td>
<td>0.16±0.05</td>
<td>1.19±0.22</td>
<td>0±0</td>
</tr>
<tr>
<td>Massillon Sandstone†</td>
<td>0.44±0.89</td>
<td>1.19±1.47</td>
<td>38.58±2.29</td>
<td>0.99±0.41</td>
<td>2.39±0.42</td>
<td>3.32±0.92</td>
<td>0.16±0.07</td>
<td>0.13±0.05</td>
<td>1.02±0.2</td>
<td>0±0</td>
</tr>
</tbody>
</table>

* From stationary logs recorded at 15 ft/min simulated logging speed in the Halliburton Sonde Acceptance Wells

** Freshwater-filled 8-in. borehole

† 166 Kppm saltwater-filled 8-in. borehole

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