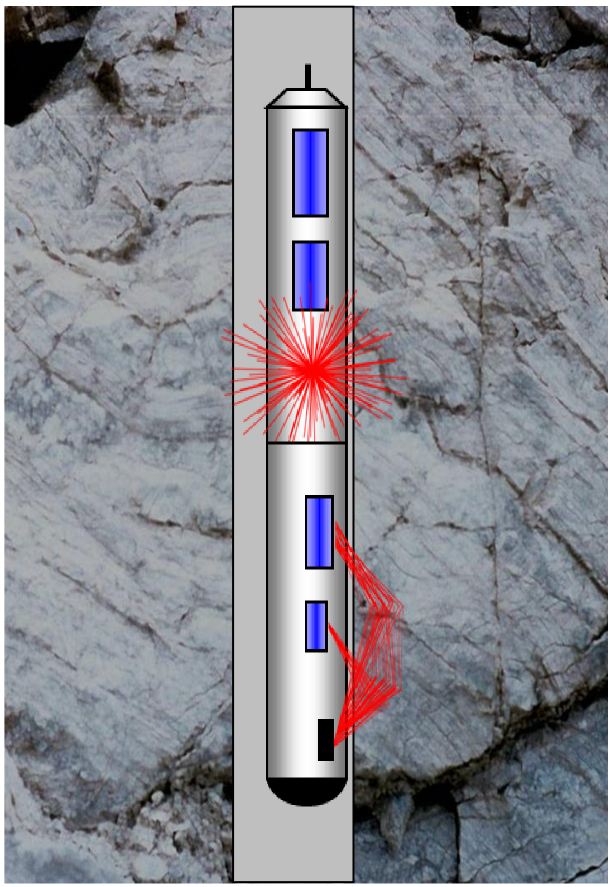
Oilfield Nuclear

Computer Modeling of Wireline & LWD Nuclear Tools

Response Equations and Environmental Corrections

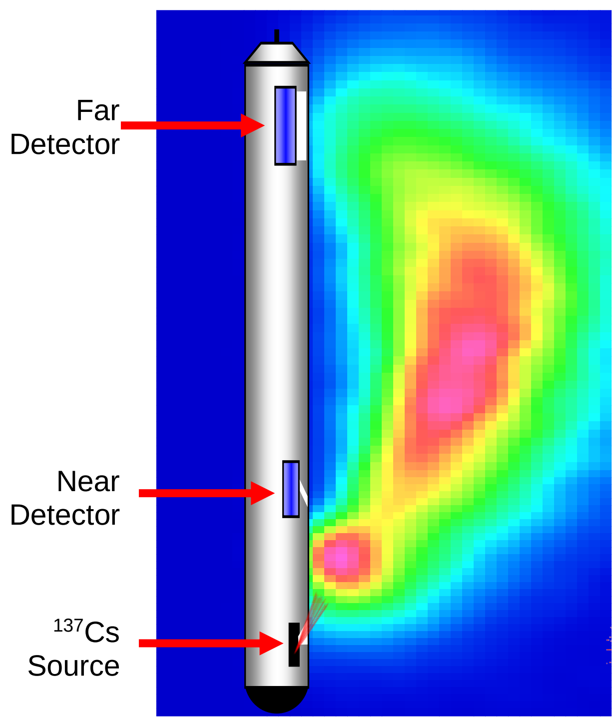


Technology / Capabilities

- Cased Hole Interpretation : Sigma and C/O Response Equations
- Corrections for Casing Size, Weight, Tubing, Cement, Water, Oil, Gas and CO_2
- Quantitative Interpretation
- Environmental corrections
- Comparison studies of logging tools
- Nuclear R&D and logging tool design

What is Monte Carlo Computer Modeling?

Monte Carlo modeling is a mathematical technique for predicting the response of nuclear logging tools. It relies on probabilistic sampling of neutron and gamma-ray interactions and dispersion. A Monte Carlo simulation is called a "random walk" because no two particles follow the same path. It is well suited for complex geometries like logging tools in cased hole wells. Even though a Monte Carlo simulation will model billions of particles and trillions of interactions, the speed of computers today makes computer modeling more valuable than ever. For example, the figure below shows the density sensitivity of a ^{137}Cs litho-density tool.



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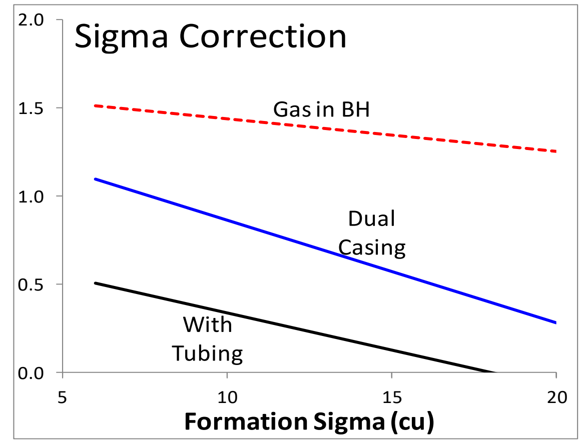
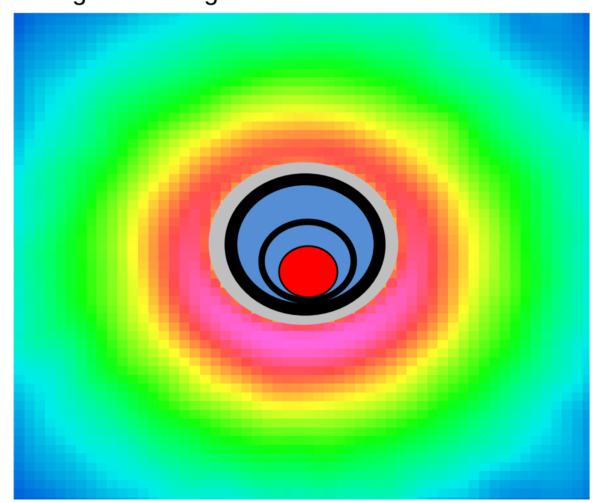
Sigma - Thermal Decay-Time Measurement

Measuring the true formation sigma is difficult because neutrons and gamma rays must pass through the tool, borehole fluid, casing and cement. It is not possible to develop general response equations for all the possible combinations of hardware, materials and fluids. By modeling the well conditions - casing and tubing, matrix composition, and fluid properties - accurate interpretation of the measured data will provide accurate answers. While the corrections are typically less than 1 capture unit, that can be critical in many cases.

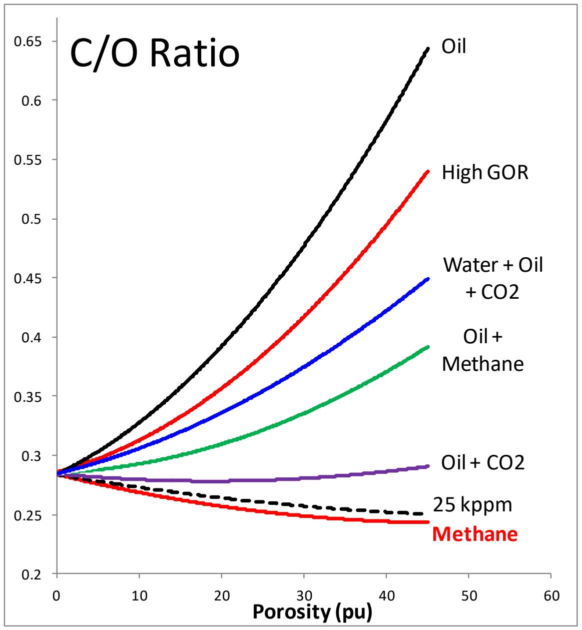


Modeling can also be used to understand the extent of a sigma or C/O measurement. The sigma sensitivity map for a sigma tool in a 7"BHOD with casing and tubing is shown below.



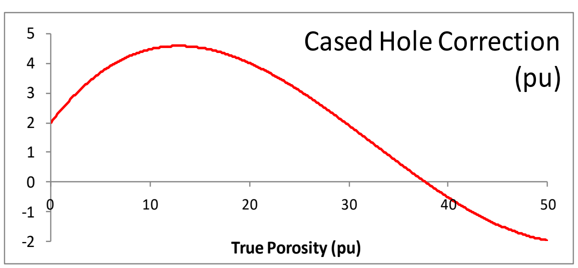
Carbon / Oxygen (C/O) Measurement

When salinities are low, a C/O log is needed to identify hydrocarbons. The problem is even more complicated when a water or CO_2 flood is in progress. Understanding the measured data requires modeling of the specific conditions of the well. Below are the C/O response curves for a well with oil in the borehole and different formation fluids including water, oil, gas and CO_2.



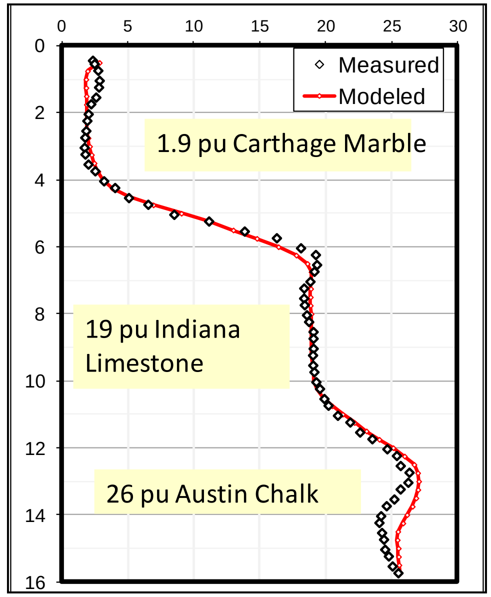
Cased Hole Neutron Porosity

Neutron porosity logs are run in cased holes to find bypassed pay. Computer modeling can be used to correct the measured data for the casing, cement and fluids. Below is an example of the correction for a 8.5" BHOD with 7"/23# casing and Class H cement. The correction peaks at 4.6 pu which shows the importance of cased hole environmental corrections.



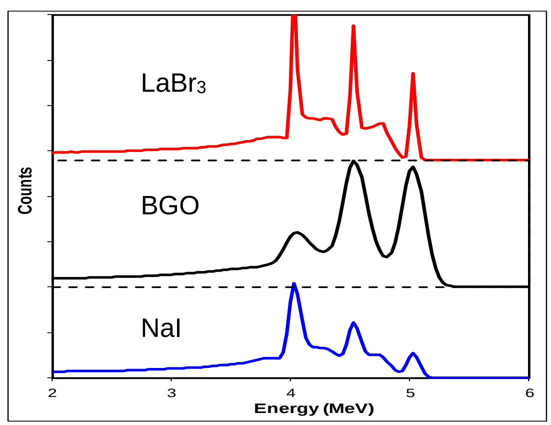
Measured vs. Modeled

The response of a neutron porosity tool in the University of Houston API pits was modeled and the agreement between measured and modeled is very good and shows the capabilities of modeling.



Detector Modeling

The figure below shows the detector response for NaI, BGO and $LaBr_3$ detectors for 5 MeV gamma rays. While NaI is the most widely-used crystal, BGO has high detection efficiency but poor resolution (broad peaks). $LaBr_3$ is a relatively new crystal that has many advantages over other crystals, including a very good energy resolution which is needed for elemental identification.



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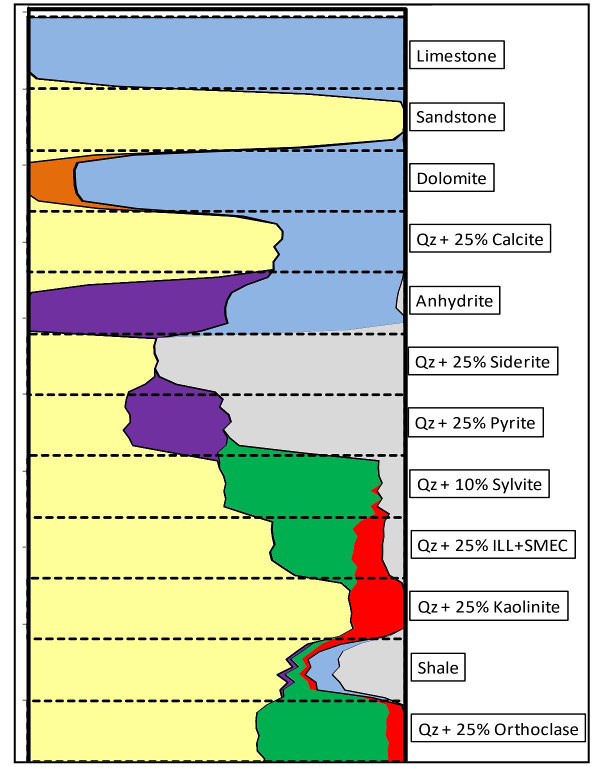
Capture Spectroscopy Modeling

A Monte Carlo simulated log of 12 zones of different minerals is shown below. Understanding the tool response is critical when converting the raw counts into elemental concentrations.



The capture spectroscopy log above shows the count rate yield for the main capture elements. The elements H, Cl and Na, which vary with porosity and salinity, are not included in the yields determination.

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