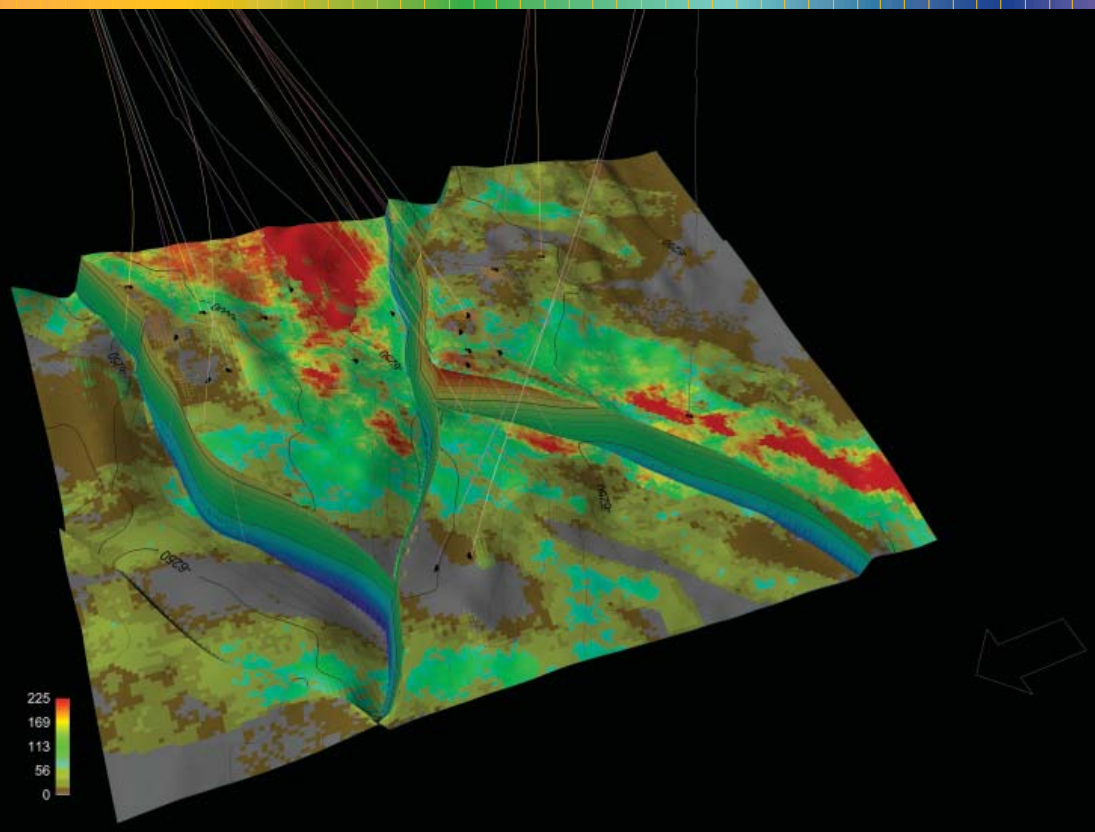
UPSTREAM TECHNOLOGY



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Volume 2 Number 6
June 2007

Reservoir Modeling's 'New Look' Identifies More Bypassed Pay

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Advanced petrophysical, geological and engineering software to find bypassed pay is changing how oil and gas companies manage their producing fields worldwide. Originally an outgrowth of Nuclear Magnetic Resonance, NMR has become less critical in most basins through years of model enhancements.

The foundation of a new, proprietary process is to use a textural element for pore size distribution to show an enhanced view of reservoir variability through an inter-disciplinary approach utilizing the NuLook™, NuView™ and NuStim™ processes. These services provide dramatically new perspectives of reservoir understanding that can identify more bypassed pay, whether evaluating new field developments or mature field rejuvenation.

Advanced modeling

Through this new approach that utilizes proprietary software coupled with expert analyses that are process-controlled, bypassed pay existing within new or old reservoirs is identified as a result of the advanced modeling techniques. Modeling engineers begin by linking certain relationships that exist in the subsurface log information to a pore size distribution that exists within the effective porosity. This link was initially learned through advancements in magnetic resonance technology and the influence of pore size on that measurement. The pore size spectrum is broken into specific bins or pore size groups from the smallest to largest grains.

In this type of evaluation, for example, modelers utilize conventional log data to subdivide the pore space using inputs from resistivity, neutron/density, gamma ray, sonic or any other relevant log data acquired at the well site. The log data is input into a certain modeling package, the output of which is the pore size distribution, defining the textural variations that exist within the effective and total pore space. The permeability can then be determined as a function of rock texture from the pore size distribution versus other relationships that exist, such as porosity

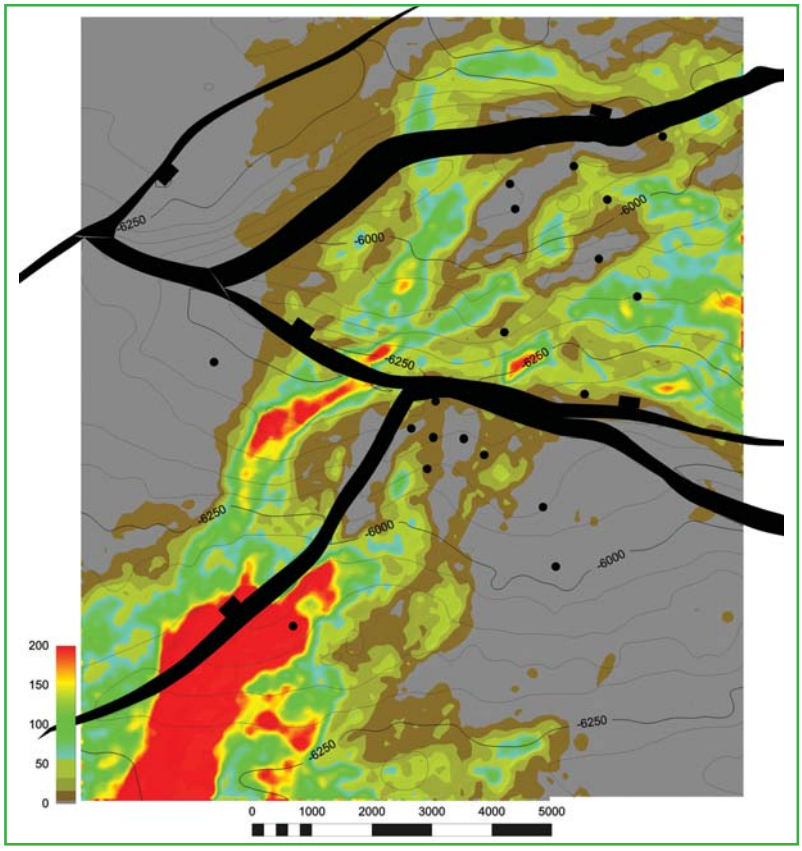

Figure 1. 2D view of NuLook permeability (NuPerm) distribution overlaying target structure.

and free fluid from magnetic resonance.

Another advantage to this approach is the relationship of the pore size components to resistivity measurements, which links texture to petrophysics. The smaller the pore size, the higher the bound water, typically defined as the silt volume. The quantification of the bound water component within the pore size spectrum then allows the petrophysically controlled process (NuLook) to balance the resistivity measurements with water saturation calculations. Benefits produced as a result of this NuLook process include water salinity determination, low resistivity/low contrast pay identification, and free water detection and quantification.

Last, by utilizing the bound water component, or silt, within the textural distribution in the shales, the true clay volume can be computed to further enhance the NuLook process for identifying bypassed pay intervals.

Process Is Key

Process is key to the modeling success. Proprietary modeling and the resulting relationships are important and yield an array of valuable information, but must be utilized properly within an expert evaluation process. By methodically adhering to this process, a consistent petrophysical analysis with outputs of textural permeability, the pore size distribution, lithology identification, hydrocarbon saturations, and free water identification can be obtained. Sands are analyzed in terms of quality, allowing newly identified pay intervals to be ranked by risk.

These outputs are qualified at the end of the seven-step NuLook process. Once the NuLook process is complete, expert analysis of the data set and its output is utilized to determine if the analysis is reasonable. Any outliers that appear during the balanced process could indicate that there is a change in the petrophysical parameters, such as R_w, or that a conductive mineral has affected the log responses. Once identified, these events are dealt with independently in order to characterize the reservoir accurately.

Another application where pay is typically overlooked based on conventional log analysis is in fractured carbonate reservoirs, where the primary production mechanism is from natural fractures and, in most cases, there is no primary porosity. Fracture Intensity Vision (FIV) is a product that has been developed to enhance the NuLook analysis by identifying natural fractures based on multiple fracture indicators produced from well log responses in these types of environments. This new FIV product shows precisely where the fracture intensity may be increasing and results in another mappable attribute to incorporate into the reservoir model.

Finally, a new developmental product is in the works that will address carbonates with bimodal, or dual porosity components where the secondary porosity is not connected. NuPlex will address complex carbonates in a much more robust, interpretive and predictive manner to provide more accurate permeability and saturations in these depositional systems.

Understanding Reservoirs Through Geological Modeling

Individual wells represent single data points that collectively fill in the bigger picture of the field-wide reservoir system. The NuView 3D Reservoir Vision process was developed in order to integrate multiple NuLook analyses into a spatial relationship for a better understanding on a field level. NuView takes multiple sources of information that have been collected on a well-by-well basis and analyzed via the NuLook process, incorporating these with advanced geological modeling and proprietary workflow processes to obtain an enhanced understanding of reservoirs, reservoir performance and bypassed pay opportunities.

The NuView workflow combines all known information about the reservoir and distributes the NuLook properties within a geological interpretation using a variety of techniques applicable for the particular depositional setting. By understanding the pore size and permeability relationships at each well, it is now possible to fill in the areas between wells and the surrounding area to understand better how the properties vary throughout the entire field. This level of modeling allows operators to identify previously unswept and unidentified regions of the reservoir as well as to select optimal drilling targets and pay opportunities.

The NuView process is an eight-step process that allows geoscientists and modeling engineers to incorporate all known information such as the well logs and NuLook outputs, structural framework, seismic attributes, geological depositional environment(s), and well production performance into a single, integrated 3D geocellular reservoir model. With this model, the geologists and engineers are taken from a single well vantage point to an all-encompassing understanding of how all the data and interpretation fit together, why the reservoir responded historically and how it will perform in the future. Each step is very controlled so that the petrophysical attributes make sense in the same way that the original log data made sense once the NuLook process was completed. Then, in an innovative approach termed Composite Stratographic Integration Module (CSIM), multiple realizations are used to build confidence in the reservoir model to minimize uncertainty and risk.

The CSIM approach is analogous to having multiple experts analyzing the information to determine the probability of favorable reservoir properties and important geological features for identifying untapped pay opportunities and the expected volumes thereof. The entire

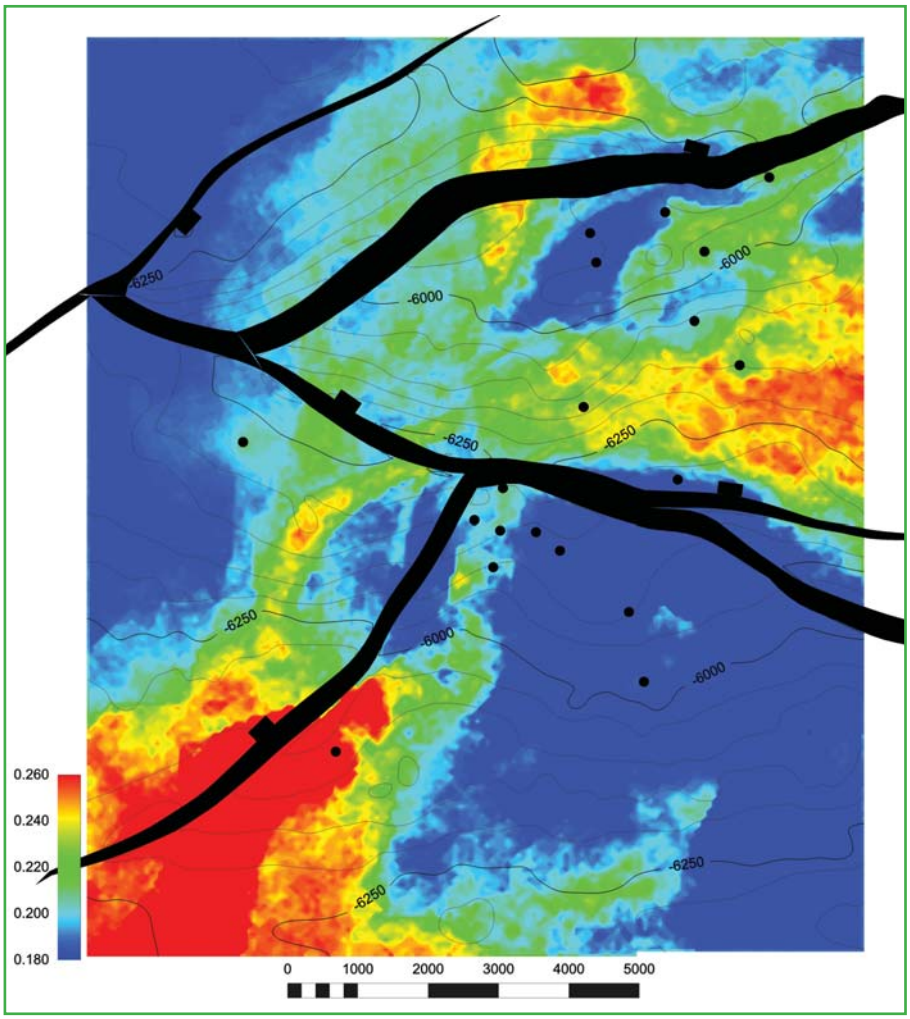

Figure 2. 2D view of NuLook porosity (Phie) distribution overlaying target structure.

process is all controlled by the appropriate geological depositional system or environment. This innovative new module may transform how the industry views reservoir models.

Tying it all together

Once the processes have identified the presence of hydrocarbons, especially in intervals that would have been bypassed based on conventional analysis alone, the next concern is quantifying those hydrocarbons. While recognizing that some reservoirs will produce naturally while others require stimulation, another proprietary program and engineered process has been developed called NuStim.

This proprietary process utilizes the NuLook petrophysical attributes to identify rock properties and build a localized model that links the reservoir analysis to the production response. Applications of the NuStim process range from forecasting natural production in high-permeability reservoirs to identifying economically viable completion strategies for tight intervals that may not be commercial otherwise.

The NuStim process incorporates model calibration via analysis of existing well data in a field in order to become predictive on new completions. In wildcat areas where there is no existing well data, the NuFIT (NuTech Fracture Injection Test) are employed to measure formation properties directly prior to stimulation. The injection test is used when no past completion history is available and measures the key ingredients necessary for fracture optimization.

All three processes (NuLook, NuView and NuStim), referred to collectively as NuVision, share a common foundation in the textural element, or pore size distribution discussed earlier. Together, the processes result in an enhanced understanding of the well-reservoir system, enabling operators to make proactive decisions based on their unique reservoir. The NuLook analysis unlocks the door texturally, but is only one piece of information and should be understood spatially within the 3D model, NuView. The NuStim model provides the link between reservoir, fracture and production modeling. The complete NuVision package identifies the best opportunities for operators and provides a risk-assessed ranking and planning associated with the specific opportunities.

The Textural Vision Perspective

All these techniques and software packages are focused on looking at the subsurface relationships strictly from a textural vision perspective. With 80% of the world's oil and gas markets effectively addressed by texture due to sand deposition or reworked carbonates, this approach makes imminent sense. What it means to oil and gas companies is this: by understanding the textural nature of the pore system, structure may not be as important as being able to locate the permeability "sweet spot" within the reservoir. That is very critical in finding the best opportunities in today's markets.

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