MAPPING, LOCATING AND RECOVERING BY-PASSED HYDROCARBONS

TECHNOLOGY CONNECTIONS
PETROLEUM TECHNOLOGY TRANSFER COUNCIL

BOTTOM LINE

By-passed hydrocarbons are best located using a variety of reservoir characterization techniques and technologies. Well-defined petrophysical properties are fundamental to understanding fluid saturation and distribution in reservoirs. New techniques such as Moving Domain, and recent advances in accurate 3-D geologic modeling and nonparametric statistics can significantly improve predictive capabilities.

PROBLEM ADDRESSED

A major problem facing California independent producers is selection of effective techniques to estimate remaining oil in reservoirs that have been inherited from major oil companies. Locating remaining pockets of recoverable oil is neither easy nor is it inexpensive. Part of the solution for these problems is a solid understanding of detection methods and the causes for trapped oil. Reservoir characterization and new computer methodologies such as "Moving Domain" and "Earth Vision" that can make the search more efficient, and thus enhance the bottom line, can facilitate such understanding.

KEY WORDS:
- California
- Geologic Modeling
- Moving Domain
- Reservoir Characterization

TECHNOLOGY OVERVIEW

Fluid distribution and saturation are largely a function of petrophysical properties. Their understanding is fundamental to predicting location of by-passed hydrocarbons through reservoir simulation. Single-phase petrophysical properties include porosity, permeability, permeability-porosity relationships and the tensorial character of permeability. These are all engineering properties, as opposed to geologic or geophysical, because they are needed for flow calculations. Single-phase porosity is an important predictor of hydrocarbon in place. Permeability is an indicator of production rate. They form a central part of the input to numerical simulators. Single-phase properties and their distributions allow geology and geophysics to be inserted into such models.

Two-phase flow properties include capillary pressure, relative permeability and trapped phase saturation. Local heterogeneity (sorting), ratio of pore throats to pore bodies, and wetting state play large roles in quantifying two-phase flow properties. Some two-phase properties have analogs in single-phase flow. Saturation is an analog to porosity and phase permeability is an analog to permeability. Two-phase properties are more complex than in single-phase flow because saturation is introduced and surface or interfacial forces play a central role.

Based on a workshop sponsored by PTTC's West Coast Region on May 22 & 23, 2000, in Long Beach and Bakersfield, California.

SPEAKERS:

Moving Domain Analysis
Thomas Hampton, Holditch-Reservoir Technologies

Reservoir Characterization
Larry Lake, University of Texas at Austin

Value of Geologic Modeling for Reservoir Characterization
Skip Pack, Dynamic Graphics

Interfacial forces, as manifest in capillary pressures, are easily the strongest local forces in multiphase flow. Capillary pressure is the most basic rock-fluid characteristic in multiphase flow. It is a function of interfacial tension (a fluid property), the pore radius (a medium property), and contact angle (a property of both). Because of this mixing and because it is a static property, capillary pressure provides a unique insight into the interrelationships between fluid and rock properties. Insightful interpretation of capillary pressures can greatly aid in understanding fluid distribution within a reservoir. Capillary pressure curves give us important information about heterogeneity through the distinction between pore throats and bodies and through the variable pore throat size. The curves can give information about oil in place, local rock properties and imbibition into fractures.

Relative permeability curves and their associated parameters are the most relevant petrophysical relations for oil displacement. Relative permeability in a two-phase system is the permeability of one of the phases compared to the total permeability. The values can range from 0 to 1.0. Relative permeabilities largely depend upon fluid saturations and the wetting state of the medium.

MOVING DOMAIN

Thomas Hampton from Holditch - Reservoir Technologies introduced "Moving Domain," a method that uses a mosaic of computer-automated and linked production studies and derives empirical and statistical conclusions about individual wells and field performance. The purpose of Moving Domain is to rapidly process field-wide production data sets in order to make profit-enhancing recommendations about current wells and about infill drilling options. Areas for application of this method include infill and stepout well potential, scoping studies, production projections, stimulation evaluation, completion optimization, and others.

Moving Domain analysis workflow includes calculation of "Production Indicators" for each well. Production indicators are statistically analyzed as a function of time and then are used to compare wells. Evidence of depletion is found by comparing new and old wells. Using this methodology, infill wells can be spotted and their recovery potential can be quantified because undrained areas can be identified.

Moving Domain is useful for large data sets from complex reservoirs and when rapid analysis is required. It can rely solely on public data, if necessary. Required data include at least latitude/longitude and monthly production for each well. More advanced analysis requires petrophysical data, such as porosity, permeability, and initial pressure. The software used in Moving Domain is all PC-based: Visual Basic™ programming, Access™ database, Excel™, PROMAT™, and Geographix™ for mapping results.

ACCURATE 3-D GEOLOGIC MODELING

An important aspect of locating by-passed hydrocarbons is accurate 3-D geologic modeling. Jeffrey Schwalm and John Penny of Dynamic Graphics, Inc. discussed some of the latest techniques for 3-D geologic modeling using software called "Earth Vision." The methodology uses a natural order of modeling to yield a plausible 3-D geological model that honors geologic and geophysical interpretations. The 3-D geologic model can then be used as a common earth model from which numeric and visual outputs can be generated.

Using input from geology, geophysics, petrophysics, maps, cross sections, etc., the workflow is accomplished in five steps: (1) determining data range and projection of the model area, (2) modeling faults in 2-D or 3-D grids, (3) modeling horizons as a stratigraphic sequence, (4) modeling rock properties, and (5) generating output. Output consists of contour maps, cross sections, and volumetric computations that can be sent directly to the reservoir simulator.

For information on PTTC's West Coast Region and its activities contact:

Iraj Ershaghi, Director, Petroleum Engineering Program, HEDCO-316
University of Southern California, Los Angeles, CA 90089-1211
Phone 213-740-8076, Fax 213-740-7982, E-mail ershaghi@usc.edu

NONPARAMETRIC STATISTICS

The Spearman rank correlation coefficient has been investigated as a reservoir characterization tool. The technique is a nonparametric statistics, used to determine lateral autocorrelation and permeability trends. It provides an alternative to interference tests. The method can indicate the presence of transmissibility barriers, permeability anisotropy, and, in some instances, range anisotropy. The method appears to be successful as measured by consistency with tracer breakthrough. However, additional research comparing this technique with accurate field results still seems necessary to provide more confidence on Spearman rank correlation coefficient applicability.

CONNECTIONS:

Thomas Hampton
Holditch-Reservoir Technologies
1812 Chastain Way
Bakersfield, CA 93304
Phone: 661-864-4712 Fax: 661-864-4732
E-mail: thampton@slb.com

Larry Lake
University of Texas at Austin
Department of Petroleum & Geosystem Engineering
Austin, TX 78712
Phone: 512-471-8233 Fax: 512-471-9605
E-mail: larry_lake@utpe.pe.utexas.edu

Skip Pack
Dynamic Graphics, Inc.
1015 Atlantic Avenue
Alameda, CA 94501
Phone: 510-522-0700 Fax: 510-522-5670 E-mail: skip@dgi.com

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Petroleum Technology Transfer Council, 2916 West T. C. Jester, Suite 103, Houston, TX 77018
toll-free 1-888-THE-PTTC; fax 713-688-0935; e-mail hq@pttc.org; web www.pttc.org