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Quarterly Reports

DOE/BC–92/2 **Contracts for Field Projects and Supporting Research on Enhanced Oil Recovery. Progress Review No. 70. Quarter ending March 31, 1992. March 1993. 185 pp. Order No. DE93000110.** Status reports are given for various enhanced oil recovery and gas recovery projects sponsored by the Department of Energy. The field tests and supporting research on enhanced oil recovery include chemical flooding, gas displacement, thermal/heavy oil, resource assessment, geoscience technology, microbial technology, novel technology, and environmental technology.

DOE/BC–92/3 **Contracts for Field Projects and Supporting Research on Enhanced Oil Recovery. Progress Review No. 71. Quarter ending June 30, 1992. June 1993. 140 pp. Order No. DE93000116.** Status reports are given for various enhanced oil recovery and gas recovery projects sponsored by the Department of Energy. The field tests and supporting research on enhanced oil recovery include chemical flooding, gas displacement, thermal/heavy oil, resource assessment, geoscience technology, microbial technology, novel technology, and environmental technology.

General

NIPER–664 **1991 Annual Report. October 1, 1990-September 30, 1991. National Institute for Petroleum and Energy Research. May 1993. 84 pp. Order No. DE93000137.** The eighth year of research was completed under the cooperative agreement established in 1983 between the Department of Energy (DOE) and IIT Research Institute for operation of the National Institute for Petroleum and Energy Research (NIPER). During the year, research at NIPER was conducted in three areas: (1) enhanced oil recovery, (2) alternative fuels testing and evaluation, and (3) environmental technology. FY91 was the first year of research under the DOE National Energy Strategy – Advanced Oil Recovery Program, an integrated, highly targeted research, development, and demonstration program focusing on near-, mid-, and long-term objectives to bring new and advanced recovery technologies to the field within the earliest possible time frame.

Thermal Recovery

NIPER–578 **Feasibility Study of Heavy Oil Recovery in the Permian Basin (Texas and New Mexico). Topical Report. National Institute for Petroleum and Energy Research. May 1993. 40 pp. Order No. DE93000141.** This report is one of a series of publications assessing the feasibility of increasing domestic heavy oil production. Each report covers select areas of the United States. The Permian Basin of West Texas and Southeastern New Mexico is made up of the Midland, Delaware, Val Verde, and Kerr Basins; the Northwestern, Eastern, and Southern shelves; the Central Basin Platform, and the Sheffield Channel. The present day Permian Basin was one sedimentary basin until uplift and subsidence occurred during Pennsylvanian and early Permian Age to create the configuration of the basins, shelves, and platform of today. The basin has been a major light oil producing area served by an extensive pipeline network connected to refineries designed to process light sweet and limited sour crude oil. Limited resources of heavy oil (10° to 20° API gravity) occurs in both carbonate and sandstone reservoirs of Permian and Cretaceous Age. The largest cumulative heavy oil production comes from fluvial sandstones of the Cretaceous Trinity Group. Permian heavy oil is principally paraffinic and thus commands a higher price than asphaltic California heavy oil. Heavy oil in deeper reservoirs has solution gas and low viscosity and thus can be produced by primary and by waterflooding. Because of the nature of the resource, the Permian Basin should not be considered a major heavy oil producing area.

NIPER–675 **Evaluation of NIPER Thermal EOR Research, State-of-the-Art and Research Needs. Topical Report. National Institute for Petroleum and Energy Research. June 1993. 152 pp. Order No. DE93000145.** Research was conducted in elucidation of the mechanisms of steam oil recovery; effect of steam temperature on wettability modification; quantification of the temperature dependency of capillary pressures; development of techniques to measure capillary pressure of unconsolidated cores at steamflood conditions; elucidation of the mechanism of steam diversion with foam; development and evaluation of analytical and numerical thermal oil recovery models; field-scale simulation studies to assess the steamflood potential of non-California heavy oil reservoirs; domestic heavy oil database development; domestic heavy oil resource and refinery capacity assessment; thermal enhanced oil recovery environmental impact assessment; and laboratory automation software development and testing. This report summarizes the research that has been conducted under the program, analyzes the contributions of the research, describes how the technology was transferred to potential users, analyzes current trends in thermal research and thermal oil production, and makes suggestions for future research.

DOE/BC/14600–43 **Capillary Effects in Drainage in Heterogeneous Porous Media: Continuum Modeling, Experiments and Pore Network Simulations. Topical Report. University of Southern California. April 1993. 40 pp. Order No. DE93000134.** An investigation was conducted on the effects of capillary heterogeneity induced by variations in permeability in the direction of displacement in heterogeneous porous media under drainage conditions. The investigation is three-pronged and uses macroscopic simulation, based on the standard continuum equations, experiments with the use of an acoustic technique and pore network numerical models. It is found that heterogeneity affects significantly the saturation profiles, the effect being stronger at lower rates. A good agreement is found between the continuum model predictions and the experimental results based on which it can be concluded that capillary heterogeneity effects in the direction of displacement act much like a body force (e.g. gravity). A qualitative agreement

is also found between the continuum approach and the pore network numerical models, which is expected to improve when finite size effects in the pore network simulations diminish. The results are interpreted with the use of invasion percolation concepts.

DOE/BC/14600–45 Alkaline Assisted Thermal Oil Recovery: Kinetic and Displacement Studies. Topical Report. University of Southern California. June 1993. 156 pp. Order No. DE93000144. This report deals with two major issues of chemical assisted flooding — the interaction of caustic, one of the proposed additives to steamflood, with the reservoir rock, and the displacement of oil by a chemical flood at elevated temperatures. A mathematical model is developed to simulate the kinetics of silica of silica dissolution and hydroxyl ion consumption in a typical alkaline flooding environment. The model is based on the premise that dissolution occurs via hydrolysis of active sites through the formation of an intermediate complex, which is in equilibrium with the silicic acid in solution. Both static (batch) and dynamic (coreflood) processes are simulated to examine the sensitivity of caustic consumption and silica dissolution to process parameters, and to determine rates of propagation of pH values.

DOE/BC/14600–48 Visualization and Simulation of Immiscible Displacement in Fractured Systems Using Micromodels: I. Drainage. Topical Report. University of Southern California. June 1993. 36 pp. Order No. DE93000146. Consideration is given to drainage processes in model geometries that represent a matrix block-fracture system. Flow visualization in etched glass micromodels was carried out for various pairs of fluids, injection rates (capillary numbers) and viscosity ratio values. The experiments were then modeled with the use of a pore network simulator based on meniscus displacement. It was found that displacement occurs only in the fracture as long as the flow rate is below a critical value. Invasion of the matrix block occurs after this critical value (capillary number threshold) is exceeded. Numerical and experimental results were compared and found in good agreement. A theory for the invasion process and the critical capillary number was then developed. Displacement efficiencies were evaluated as a function of the capillary number and the mobility ratio. The process is reminiscent of a capillary pressure-saturation curve, with the notable exception that the role of capillary pressure is here played by the capillary number, and that the process is dynamic rather than quasi-static. Finally, effective relative permeabilities for the matrix-fracture system were calculated. Contrary to homogeneous systems, these curves depend on the mobility ratio.

DOE/BC/14600–42 Multivariate Optimization of Production Systems — The Time Dimension. SUPRI TR 90. Stanford University. April 1993. 116 pp. Order No. DE93000131. Traditional analysis of oil and gas production systems treats individual nodes one at a time. This only calculates a feasible solution which is not necessarily optimal. Multivariate optimization is able to determine the most profitable configuration, including all variables simultaneously. The optimization can also find the optimal recovery over a period of time, rather than just at a single instant as in traditional methods. This report describes the development of multivariate optimization for situations in which the decision variables may change as a function of time. For example, instead of estimating a tubing size which is optimal over the life of the project, this approach determines a series of optimal tubing sizes which may change from year to year. Examples show that under an optimal strategy, tubing size can be changed only infrequently while still increasing profitability of a project. The methods used in this work considered the special requirements of objectives which are not smooth functions of their decision variables. The physical problems considered included artificial lift production systems.

Resource Assessment Technology

DOE/ID/12842–2 BOAST II for the IBM 3090 and RISC 6000. Final Report. May 1993. Louisiana State University. 152 pp. Order No. DE93000138. BOAST II, a three-dimensional three-phase black oil applied simulation tool, was modified for efficient use on IBM mainframe computers. A vectorized code was prepared that will run on the IBM Risc 6000 workstation as well as other large scale platforms. Pre-processing and post-processing programs were written to assist in data preparation and output analysis. This manual is a modification of the previously released manual by Fanchi, Kennedy, and Dauben. It was written to provide documentation for the revised software available as a result of the work done by Louisiana State University for the Department of Energy.

Fundamental Petroleum Chemistry

NIPER–659 The Thermodynamic Properties of Thianthrene and Phenoxathiin. Topical Report. National Institute for Petroleum and Energy Research. April 1993. 60 pp. Order No. DE93000124. Measurements leading to the calculation of the ideal-gas thermodynamic properties are reported for thianthrene (Chemical Abstracts registry number [92-85-3]) and phenoxathiin (registry number [262-20-4]). Experimental methods included combustion calorimetry, adiabatic heat-capacity calorimetry, vibrating-tube densitometry, comparative ebulliometry, inclined-piston gauge manometry, and differential-scanning calorimetry (d.s.c.). Critical properties were estimated for both materials based on the measurement results. Entropies, enthalpies, and Gibbs energies of formation were derived for the ideal gas for both compounds for selected temperatures between 298.15 K and 700 K. The property-measurement results reported here for thianthrene and phenoxathiin provide the first experimental gas-phase Gibbs energies of formation for tricyclic diheteroatom-containing molecules.

Microbial Technology

DOE/BC/14126–11 Microbial Field Pilot Study. Final Report. University of Oklahoma. May 1993. 216 pp. Order No. DE93000140. A multi-well microbially enhanced oil recovery field pilot has been performed in the Southeast Vassar Vertz Sand Unit in Payne County, Oklahoma. The primary emphasis of the experiment was preferential plugging of high-permeability zones for the purpose of improving waterflood sweep efficiency. Studies were performed to determine reservoir chemistry, ecology, and indigeneous bacteria populations. Growth experiments were used to select a nutrient system compatible with the reservoir that encouraged growth of a group of indigenous nitrate-using bacteria and inhibit growth of sulfate-reducing bacteria. A specific field pilot area behind an active line drive waterflood was selected. Surface facilities were designed and installed. Injection protocols of bulk nutrient materials were prepared to facilitate uniform distribution of nutrients within the pilot area.

DOE/BC/14205–17 Mechanism and Environmental Effects on MEOR Induced by the Alpha Process. Final Report. Alpha Environmental, Inc. April 1993. 108 pp. Order No. DE93000133. The purpose of this project was to investigate in parallel laboratory and field studies: (1) the response of a portion of the Shannon Sandstone reservoir to two single-well treatments with a commercial microbial enhanced oil recovery (MEOR) system, (2) basic bacteria/rock interactions, and (3) mechanisms of oil release. The MEOR system consisted of a mixed culture of hydrocarbon-utilizing bacteria, inorganic nutrients, and other growth factors. Parallel field and laboratory investigations into the effect and mechanisms of the treatment were carried out by independent principal investigators.

Geoscience Technology

DOE/ID/01570–T164 Alaska North Slope National Energy Strategy Initiative. Analysis of Five Undeveloped Fields. Idaho National Engineering Laboratory, EG&G, Inc. May 1993. 356 pp. Order No. DE93000142. The U.S. Department of Energy was directed in the National Energy Strategy to establish a federal interagency task force to identify specific technical and regulatory barriers to the development of five undeveloped North Slope Alaska fields and make recommendations for their resolution. The five fields are West Sak, Point Thomson, Gwydyr Bay, Seal Island/Northstar, and Sandpiper Island. Analysis of environmental, regulatory, technical, and economic information, and data relating to the development potential of the five fields lead to a number of conclusions discussed in this report.

NIPER–646 Techniques for Mapping the Types, Volumes, and Distribution of Clays in Petroleum Reservoirs and for Determining Their Effects on Oil Production. Final Report. National Institute for Petroleum and Energy Research. May 1993. 36 pp. Order No. DE93000143. This report presents the results of correlation of log signatures with information on distribution of the types and volumes of clays in sandstone pore spaces determined from detailed CT-scan, XRD, SEM, and thin section analyses of core samples from three sandstone reservoirs. The log signatures are then analyzed to determine if suitable mathematical/statistical parameter(s) could be calculated from the logs to determine their effects on permeability and oil production.

DOE/BC/14475–12 Geophysical and Transport Properties of Reservoir Rocks. Final Report for Task 4: Measurements and Analysis of Seismic Properties. University of California. May 1993. 176 pp. Order No. DE93000139. The principal objective of research on the seismic properties of reservoir rocks was to develop a basic understanding of the effects of rock microstructure and its contained pore fluids on seismic velocities and attenuation. Ultimately, this knowledge would be used to extract reservoir properties information such as the porosity, permeability, clay content, fluid saturation, and fluid type from borehole, cross-borehole, and surface seismic measurements to improve the planning and control of oil and gas recovery.

RESERVOIR CHARACTERIZATION III

Edited by Bill Linville

Contents

Divided into five sections, each representing a different technical session at the Third International Reservoir Characterization Technical Conference, *Reservoir Characterization III* is a unique integration of data and studies from many disciplines – geology, hydrology, petrophysics, and much more.

Session 1
Heterogeneities/Anisotropies

Seven specific subjects were discussed in Session 1, a few of those include: • *Permeability Heterogeneities of Clastic Diagenesis* • *Optimal Scales for Representing Reservoir Heterogeneity* and • *Determining Orientation and Conductivity of High Permeability Channels in Naturally Fractured Reservoirs.*

Session 2
Field Studies and Data Needs

Subjects discussed in this session include: • *Quality Control of Special Core Analysis Measurements* • *Comparison of Different Horizontal Fractal Distributions in Reservoir Simulations* • *Investigating Infill Drilling Performance and Reservoir Continuity Using Geostatistics* • *A Comparison of Outcrop and Subsurface Geologic Characteristics and Fluid-Flow Properties in the Lower Cretaceous Muddy J Sandstone* • *Comparison of Geostatistical Characterization Methods for the Kern River Field*

Session 3
Modeling/Description of Interwell Region

A highly praised session with more than 15 speakers and 7 areas of interest, this session included discussion on: • *Variograms and Reservoir Continuity* • *Artificial Intelligence Developments in Geostatistical Reservoir Characterization* • *Integration of Seismic and Well Log Data in Reservoir Modeling* and much more!

Session 4
The Optimization of Reservoir Management session included topics like: • *Screening Enhanced Oil Recovery Methods* • *Reservoir Description and Modelling of the Pen Field, Graham County, Kansas* and • *Assessment of Uncertainty in the Production Characteristics of a Sand Stone Reservoir.* Three other topics were also discussed.

Session 5 was the final of the conference and included **Poster Presentations**. With more than 24 of these presentations included, areas of focus ranged from *How to Estimate the Reliability of Reserves* to *Reservoir Simulation of Fluvial Reservoirs.*

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