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Quarterly Reports

DOE/BC-93/2 **Contracts for Field Projects and Supporting Research on Enhanced Oil Recovery. Progress Review No. 74. Quarter ending March 1993. March 1994. 165 pp. Order No. DE93000147.** Status reports are given or various enhanced oil recovery and gas recovery projects sponsored by the Department of Energy. The field tests and supporting research on nhanced oil recovery include chemical flooding, gas displacement, thermal/heavy oil, resource assessment, geoscience technology, microbial echnology, field demonstrations in high-priority reservoir classes, novel echnology, and environmental technology.

DOE/BC-93/3 **Contracts for Field Projects and Supporting Research on Enhanced Oil Recovery. Progress Review No. 75. Quarter ending June 1993. June 994. 173 pp. Order No. DE94000115.** Status reports are given for varius enhanced oil recovery and gas recovery projects sponsored by the Department of Energy. The field tests and supporting research on enanced oil recovery include chemical flooding, gas displacement, thermal/heavy oil, resource assessment, geoscience technology, field demonstrations in high-priority reservoir classes, novel technology, and environmental technology.

Chemical Flooding

DOE/BC/14886-6 **Investigation of Oil Recovery Improvement by Coupling an Interfacial Tension Agent and a Mobility Control Agent in Light Oil Reservoirs. Surtek, Inc. Annual Report. June 1994. 88 pp. Order No. DE94000139.** A study is underway of two major areas concerning conjecting an interfacial tension reduction agent(s) and a mobility control gent. The first area defines the interactions of alkaline agent, surfacants, and polymers on a fluid-fluid and a fluid-rock basis. The second area concerns the economic improvement of the combined technology. This report examines the interactions of different alkaline agents, surfactants, and polymer combinations on a fluid-fluid basis. Alkali and surfactant combine to reduce the interfacial tension between a low acid number, 42 API gravity crude oil and the aqueous solution to values lower than either agent alone. Surfactant structure can vary from linear chain sulfonates to alkyl aryl sulfonates to produce low interfacial tension values when combined with alkali. However as a class, the alkyl aryl sulfonates were the most effective surfactants. Surfactant olefinic character appears to be critical in developing low interfacial tensions. For the 42 API gravity crude oil, surfactants with molecular weights ranging from 370 to 450 amu are more effective in lowering interfacial tension. Ultralow interfacial tensions were achieved with all of the alkaline agents evaluated when combined with appropriate surfactants. Different interfacial tension reduction characteristics with the various alkali types indicates alkali interacts synergistically with the surfactants to develop interfacial tension reduction. The solution pH is not a determining factor in lowering interfacial tension. Surfactant is the dominate agent for interfacial tension reduction.

Thermal Recovery

DOE/BC/14899-9 **Visualization and Simulation of Bubble Growth in Pore Networks - Topical Report. University of Southern California. March 1994. 36 pp. Order No. DE94000116.** Bubble nucleation and bubble growth in porous media is an important problem encountered in processes, such as pressure depletion and boiling. To understand its basic aspects, experiments and numerical simulations in micromodel geometries were undertaken. Experiments of bubble growth by pressure depletion were carried out in 2-D etched-glass micromodels and in Hele-Shaw cells. Nucleation of bubbles and the subsequent growth of gas clusters were visualized. Contrary to the bulk or to Hele-Shaw cells, gas clusters in the micromodel have irregular and ramified shapes and share many of the features of an external invasion process (e.g. of percolation during drainage). A pore network numerical model was developed to simulate the growth of multiple gas clusters under various conditions. The model is based on the solution of the convection-diffusion equation and also accounts for capillary and viscous forces, which play an important role in determining the growth patterns. Numerical simulation results in good agreement with the experimental results.

NIPER-689 (Vol. 1) **The Description and LabVIEW® Executable Code of a General-Purpose Laboratory-Automation Program, Volume I. National Institute for Petroleum and Energy Research. April 1994. 132 pp. Order No. DE94000125.** This report is Volume I (the description) of a two-volume series that describes a general purpose, automation computer program developed by NIPER for data acquisition/control/analysis/presentation. This software was developed to provide interactive computer control of a variety of instruments typically found in laboratories and pilot plants in order to improve efficiency in operation and safe handling of potentially

azardous operations. For example, it is easily adaptable for operating a aboratory that conducts experiments at extreme conditions of pressure nd temperature, such as those found in a steamflooding laboratory. The oftware was developed in an object-oriented graphical language around Iational Instruments' LabVIEW® which is the future trend in automa-ion programming.

NIPER-689 (Vol. 2) **The Descriptive Panels and Diagrams for NIPER Lab WARDEN oftware, Volume 2. National Institute for Petroleum and Energy Research. April 1994. 240 pp. Order No. DE94000126.** This report is the econd volume of a two-volume series on the NIPER Lab WARDEN com-uter program, a modular laboratory or pilot plant automation software esigned for data acquisition/control/analysis/presentation. Volume I f the series is the User Manual that serves all users, whereas this vol-me is the Reference Manual intended for advanced users examining he structure or modifying the program. Volume I contains a brief intro-luction of LabVIEW® and object-oriented programming, various fea-ures of the NIPER Lab WARDEN program, instruction on how to use hese features, and several example problems and their step-by-step so-utions. This volume (Volume 2) contains the complete program code eeded to reproduce or modify the program. It includes the position in ierarchy, the connector pane, the front panel, and the block diagram or each of the virtual instruments (VI) in NIPER Lab WARDEN. The anels and block diagrams contained herein are generated from the com-uter program described in Volume I but are arranged to show and ex-lain the structure and interrelationship between various elements in the rogram.

Geoscience

DOE/BC/14448-11 **Reservoir Heterogeneity in Carboniferous Sandstone of the Black War-ior Basin. Final Report. Geological Survey of Alabama. June 1994. 96 pp. Order No. DE94000134.** Although oil production in the Black Warrior basin of Alabama is declining, additional oil may be produced hrough improved recovery strategies, such as waterflooding, chemical njection, strategies, such as waterflooding, chemical injection, strategic vell placement, and infill drilling. High-quality characterization of res-rvoirs in the Black Warrior basin is necessary to utilize advanced tech-nology to recover additional oil and to avoid premature abandonment f fields. This report documents controls on the distribution and roducibility of oil from heterogeneous Carboniferous reservoirs in the Black Warrior basin of Alabama. The first part of the report summarized he structural and depositional evolution of the Black Warrior basin and stablishes the geochemical characteristics of hydrocarbon source rocks nd oil in the basin. This second part characterized facies heterogeneity nd petrologic and petrophysical properties of Carter and *Millerella* sand-tone reservoirs. This is followed by a summary of oil production in the Black Warrior basin and an evaluation of seven improved-recovery rojects in Alabama. In the final part, controls on the producibility of oil rom sandstone reservoirs are discussed in terms of a scale-dependent eterogeneity classification.

DOE/BC/14660-11 **Oil Recovery Improvement Through Profile Modification by Thermal Precipitation. Final Report. University of Texas. April 1994. 50 pp. Order No. DE94000122.** The objective of this research project has been to investigate the potential for using temperature-dependent (ther-nal) precipitation of chemicals to reduce the porosity and permeability f porous rocks. The method consists of injecting hot water that is satu-rated in a chemical that will precipitate upon cooling. Through this pro-ess, the permeability of thief zones in oil reservoirs could be reduced, llowing improved recovery by secondary and tertiary recovery pro-esses. The chemical literature was reviewed for environmentally safe hemicals that have a suitable temperature-dependent solubility for the hermal precipitation process. Four suitable chemicals were identified: bo-on oxide, potassium carbonate, sodium borate, and potassium chloride. An experimental apparatus was constructed to test the thermal precipitation process at high temperatures and pressures. Data was collected with clastic Berea sandstone cores using two chemicals: potassium carbonate and sodium borate. Data was also collected with limestone cores using potassium carbonate. The porosities and permeabilities were measured before and after being treated by the thermal precipitation process. A theoretical study of the process was also conducted. A model for predicting the fractional reduction in porosity was developed that is based on the temperature-dependent solubility of the chemical used. An empirical model that predicts the fractional reduction in permeability in terms of the fractional reduction in porosity was then developed for Berea sandstone. Existing theoretical models for estimating the permeability of porous media were tested against the measured data. The existing models, including the widely-used Carman-Kozeny equation, underpredicted the reduction in permeability for the thermal precipitation process. This study has shown that the thermal precipitation process has considerable potential for the controlled reduction in porosity and permeability in geologic formations. A design study to determine how the process would work in the field is recommended.

DOE/BC/14446-10 **Development of Nuclear Magnetic Resonance Imaging/Spectroscopy for Improved Petroleum Recovery. Final Report. Texas A&M University. April 1994. 160 pp. Order No. DE94000121.** The overall objectives of this program are to develop and apply Nuclear Magnetic Resonance Imaging (NMRI) and CT X-Ray Scanning methods for determining rock, fluid, and petrophysical properties and for fundamental studies of multiphase flow behavior in porous media. Specific objectives are divided into four subtasks: (1) The development of NMRI and CT scanning for the determination of rock-fluid and petrophysical properties; (2) Development of NMRI and CT scanning for characterizing conventional multiphase displacement processes; (3) Development of NMR and CT scanning for characterizing dispersed phase processes; and (4) Miscible displacement studies. The final reports for each of the subtasks are provided in this document.

DOE/BC/14655-8 **Use of "Rock Typing" to Characterize Carbonate Reservoir Heterogeneity. Final Report. Ikwaukolam Energy Company, Inc. March 1994. 396 pp. Order No. DE94000118.** The objective of the project was to apply techniques of "rock typing" and quantitative formation evaluation to borehole measurements in order to identify reservoir and non-reservoir rock-types and their properties within the "C" zone of the Ordovician Red River carbonates in the northeast Montana and northwest North Dakota areas of the Williston Basin. Rock-typing discriminates rock units according to their pore-size distribution. Formation evaluation estimates porosities and pore fluid saturation. Rock-types were discriminated using crossplots involving three rock-typing criteria: (1) linear relationship between bulk density and porosity, (2) linear relationship between acoustic interval transit-time and porosity, and (3) linear relationship between acoustic interval transit-time and bulk density. Each rock-type was quantitatively characterized by the slopes and intercepts established for different crossplots involving the above variables, as well as porosities and fluid saturations associated with the rock-types. Another family of linear relationships involving shear wave velocity, compressional wave velocity, and porosity were used to characterize the entire "C" zone carbonate section. Slopes and intercepts derived in the combined use of shear and compressional wave velocities are characteristic of carbonates, and corroborate results predicted from other studies. The "C" zone of the Red River carbonates is extremely heterogeneous. The heterogeneities were observed in hand specimen, and corroborated by wide variabilities in porosity, permeability, grain density, the porosity-permeability crossplot, and the results from rock-typing and quantitative formation evaluation. Sixty-four different rock-types were identified in the fifty-two wells studied. Vertical distribution of rock-types shows a non-porous anhydrite rock-type, underlain, in most wells, by combinations of anhydritic dolomite and dolomite rock-types. These in turn are underlain by dolomitic limestone and limestone rock-types. Dolomitic lime-

stone and limestone rock-types are generally non-porous or have low porosities. The thickness of the non–porous dolomite rock-types varies from a few feet in some wells to over hundred feet in others.

DOE/BC/14649-15 Analysis and Evaluation of Interwell Seismic Logging Techniques for Hydrocarbon Reservoir Characterization. Final Report. Southwest Research Institute. June 1994. 200 pp. Order No. DE94000133. The oil and gas industry is presently emphasizing the production and recovery of established reserves rather than exploration of new fields. This has brought into focus the need for a better understanding of reservoir rock properties and geologic structures. Of particular interest are factors that directly affect the distribution of the reservoir fluids, namely the permeability of the rock and the presence and locations of fractures and impermeable boundaries that channel or constrain the movement of fluids. A new conceptual extension of sonic logging is offered in this project for specific application in heterogeneous reservoirs. This concept is one of interwell seismic logging which is made possible by the prevalence of the relatively large number of wells located in the reservoir. In this application, high resolution seismic transmission measurements between a pair of boreholes can provide information equivalent to a seismic section which uniquely is oriented in the plane of the boreholes. These interwell seismic data is analyzed to determine various petrophysical properties of the reservoir under investigation.

DOE/BC/14654-15 Simulation Studies to Evaluate the Effect of Fracture Closure on the Performance of Fractured Reservoirs. Final Report. K & A Energy. March 1994. 176 pp. Order No. DE94000119. A three-year research program to evaluate the effect of fracture closure on the recovery of oil and gas from naturally fractured reservoirs has been completed. The overall objectives of the study were to: (1) evaluate the reservoir conditions for which facture closure is significant, and (2) evaluate innovative fluid injection techniques capable of maintaining pressure within the reservoir. The evaluations of reservoir performance were made by a modern dual porosity simulator, TETRAD. This simulator treats both porosity and permeability as functions of pore pressure. Simulated wellbores can assume any orientation from vertical to horizontal. The Austin Chalk in the Pearsall Field of South Texas was selected as the prototype fractured reservoir for this work. Availability of published data was the principal basis for this selection. Consequently, the simulation models were initialized with properties typical of the Pearsall Field, Austin Chalk reservoir. During the first year, simulations of vertical and horizontal well performance were made assuming that fracture permeability was insensitive to pressure change. Sensitivity runs indicated that the simulator was predicting the effects of critical reservoir parameters in a logical and consistent manner. The results confirmed that horizontal wells could increase both rate of oil recovery and total oil recovery from naturally fractured reservoirs. In the second year, the performance of the same vertical and horizontal wells was reevaluated with fracture permeability treated as a function of reservoir pressure. To investigate sensitivity to in situ stress, differing loading conditions were assumed. The highest condition assumed all principal stress components equaled the overburden stress. The lower stress cases assumed the horizontal stress components were unequal and less than the overburden stress. Simulated natural depletions confirm that pressure sensitive fractures degrade well performance. The severity of degradation worsens when the initial reservoir pressure approaches the average stress condition of the reservoir, such as occurs in over pressured reservoirs. Simulations with water injection indicate that degradation of permeability can be counteracted when reservoir pressure is maintained and oil recovery can be increased when reservoir properties are favorable.

DOE/BC/14444-16 Oil Recovery Enhancement from Fractured, Low Permeability Reservoirs. 1991-1992 Annual Report. Texas A&M University. June 1994. 68 pp. Order No. DE94000138. The results of the investigative efforts for this jointly funded DOE-State of Texas research project achieved during the 1991-1992 year may be summarized as follows. *Geological Characterization* - Detailed fracture system maps measured at outcrops along the Austin Chalk chalk trend have been related to the subsurface. Statistical data obtained from the outcrop studies has been correlated with FMS dipmeter information obtained from Austin Chalk operators. These studies have shown the hierarchical nature and the bed contained fracture development observed in the outcrop may be extrapolated to the subsurface. Well log response in Austin Chalk wells has been shown to be a reliable indicator of both organic maturity and fracturability. Multi-component, vertical-seismic-profile, VSP shear-wave data were reduced to their true orthogonal components by balancing or rotating the source magnitudes and geophone couplings. The resultant method appears to be useful to detect the negligible displacement fractures in the Austin Chalk. Production decline curves have been related to well test or transient pressured analysis methods. Studies on daily production records of Austin Chalk horizontal wells have shown that analysis of production records may be substituted for the more expensive and difficult to obtain transient pressure data. *Development of the EOR Imbibition Process* - Magnetic Resonance Imaging, MRI studies have shown the carbonated water-imbibition displacement process significantly accelerates and increases recovery from oil saturated, low permeability rocks. These studies applied to flow in open and dead-end micro-fractures have shown significant volumes of oil remain undisturbed in the dead-end micro-fractures even when carbonated water is used as the imbibing fluid. *Transfer of Technology* - A number of presentations and publications were made at technical meetings and symposia. Two conferences concerning the results of our investigative efforts on the Austin Chalk were held at Texas A&M.

DOE/BC/14968-1 National Data Repository System. American Geological Institute. March 1994. 72 pp. 500 copies. Order No. DE94000120. The American Geological Institute (AGI) has completed the first phase of a study to assess the feasibility of establishing a National Geoscience Data Repository System to capture and preserve valuable geoscientific data. The study was initiated in response to the fact that billions of dollars worth of domestic geological and geophysical data are in jeopardy of being irrevocably lost or destroyed as a consequence of the ongoing downsizing of the U. S. energy and minerals industry. This report focuses on two major issues. First, it documents the types and quantity of data available for contribution to a National Geoscience Data Repository System. Second, it documents the data needs and priorities of potential users of the system. A National Geoscience Data Repository System would serve as an important and valuable source of information for the entire geoscience community for a variety of applications, including environmental protection, water resource management, global change studies, and basic and applied research. The repository system would also contain critical data that would enable domestic energy and minerals companies to expand their exploration and production programs in the United States for improved recovery of domestic oil, gas, and mineral resources. The results of the initial phase of the feasibility study are extremely positive. Major oil companies, large independent petroleum producers, and minerals companies have indicated they would consider contributing vast amounts of data to a National Geoscience Data Repository System.

DOE/BC/14951-5 Integrated Approach Towards the Application of Horizontal Wells to Improve Waterflooding Performancce. Annual Report. University of Tulsa. June 1994. 54 pp. Order DE94000137. This annual report describes the progress during the first year of the project on Integrated Approach Towards the Application of Horizontal Wells to the Department of Energy's Class I program which is targeted towards improving the reservoir performance of mature oil fields located in fluvial-dominated deltaic deposits. The project involves an integrated approach to characterize the reservoir followed by drilling of horizontal injection wells to improve production performance. The type of data we intend to integrate includes cross borehole seismic surveys, geological interpretation based on logs and cores, and engineering information. This report covers the first phase of the project which includes a detailed reservoir description of the field based on the available information, followed by flow simulation

f the Self Unit to compare the simulated result with the historical performance. Based on the simulated results, a vertical test well was drilled validate our reservoir description. The well will also be used as a source ell for a cross borehole seismic survey. This report discusses the related eophysical, geological, and engineering activities leading to the drilling of the vertical test well. The validation phase and the collection of the oss borehole survey has just begun, and the results will be presented in ie next annual report.

OE/BC/14959-5 **Revitalizing a Mature Oil Play: Strategies for Finding and Producing Unrecovered Oil in Frio Fluvial-Deltaic Reservoirs of South Texas. Annual Report for October 1992–December 1993. The University of Texas. May 1994. 100 pp. Order No. DE94000131.** Progress achieved uring the first year of the project consisted of screening production and eologic databases of fields within the Frio Fluvial-Deltaic sandstone play determine fields suitable for detailed characterization studies, selecting two South Texas fields for detailed studies, and performing initial eservoir studies of each field. Tabulation and statistical analysis of production and engineering data from 346 reservoirs throughout the Frio luvial-Deltaic oil play were performed in order to characterize average eservoir parameters, generate frequency distributions for values of individual reservoir attributes, and calculate playwide resource estimates. wo fields were selected for study: Rincon field, near the Mexico border Starr County, and T-C-B field, in the northern part of the play trend in m Wells County. Project personnel conducted reviews with operators f both fields. Data on drilling history, perforation intervals, formation nd reservoir tops, well logs, core descriptions and analyses, limited conentional core, sidewall core samples, and fluid and pressure tests were cquired from 220 wells in Rincon field and from more than 80 wells in -C-B field.

OE/BC/14959-8 **Identification of Remaining Oil Resource Potential in the Frio Fluial/Deltaic Sandstone Play, South Texas. Topical Report. The University of Texas. May 1994. 73 pp. Order No. DE94000132.** Reservoir atribute data were statistically analyzed from oil and gas fields throughut the geographic area covered by the Frio Fluvial/Deltaic Sandstone il play. General reservoir attributes analyzed in detail included porosy, initial water saturation, residual oil saturation, net pay, reservoir area, nd fluid characteristics. Statistical analysis of variance demonstrated o difference between oil reservoir attributes and gas reservoir attributes, ndicating that oil and gas reservoirs are subsets of a larger genetically milar population. Probability functions that describe attribute frequency istributions were determined for use in risk adjusting resource calculaons. Different functions were found to be most applicable for the varius petrophysical reservoir attributes.

OE/BC/14657-15 **Measuring and Predicting Reservoir Heterogeneity in Complex Depositional Systems. The Fluvial-Deltaic Big Injun Sandstone in West Virginia. Final Report for September 20, 1991–October 31, 1993.** Evidence r heterogeneity in the Big Injun reservoir-forming sandstones on a reional scale is found in the distribution of hydrocarbons into distinct elds across the basin. The easternmost fields traditionally are considred to be updip unconformity traps; those to the west appear to be reionally downdip from the truncated margin of the reservoir. Drilling istory for Granny Creek suggests reservoir heterogeneity as drillers first eveloped the northern and central part of the field in the 1920's and 0's, then the southernmost part. There was sporadic infill drilling roughout the field since initial development. In contrast, Rock Creek eld was developed in two stages, first within the shallower part of this nclinal field, then deeper when drillers accepted higher water saturaons. Evaluation of waterflood performance revealed the non-uniform ressure and production behavior in several patterns in Granny Creek eld. A novel approach was employed to model a fracture between a ell that exhibited low injection pressures and a production well that xperienced early water breakthrough. This led to successful simulaon of waterflood production performance for two adjacent patterns with substantially different behaviors. The results of simulation studies revealed that the communication path must be through a separate zone, most probably the overlying Greenbrier Limestone.

Microbial Technology

DOE/BC/14659-7 **Characterization of Non-Darcy Multiphase Flow in Petroleum Bearing Formation. Final Report. University of Oklahoma. April 1994. 196 pp. Order No. DE94000123.** Slow flow is most common in oil and gas reservoirs and can be adequately described by Darcy's law. Although rapid fluid flow may occur only in certain limited locations, it can affect the productive capacity of in-situ reservoirs significantly. Therefore, for accurate predictability of reservoir productivity, accurate description of deviations from Darcy's law during rapid flow is important. Although rapid flow in porous media, frequently referred to as non-Darcy flow, has been subject to numerous studies, there is still no consensus amongst the researchers as to the accurate way of describing the relevant processes. Therefore, this study has reviewed the previous studies and developed improved formulations and methodologies. In the present study non-Darcy multiphase flow in porous materials is theoretically and experimentally investigated. Background material is presented which demonstrates a need for obtaining new theoretical and experimental results in order to better characterize this important porous media flow regime. Improved models, experimental data, and mathematical correlations are necessary for scientists and engineers to develop the technology that can be used to significantly reduce the cost of finding and producing natural gas and its associated liquids. Non-Darcy multiphase flow in various consolidated porous media and unconsolidated porous media characteristic of hydraulically created propped fractures and gravel pack systems is also investigated. The experimental research is carried out in the new non-Darcy Flow Research Laboratory recently constructed at the University of Oklahoma.

DOE/ID/01570-T171 **Laboratory Methods for Enhanced Oil Recovery Core Floods. Topical Report. Idaho National Energy Laboratory, EG&G Idaho. March 1994. 28 pp. Order No. DE94000117.** Current research at the Idaho National Engineering Laboratory (INEL) is investigating microbially enhanced oil recovery (MEOR) systems for application to oil reservoirs. Laboratory corefloods are invaluable in developing technology necessary for a field application of MEOR. Methods used to prepare sandstone cores for experimentation, coreflooding techniques, and quantification of coreflood effluent are discussed in detail. A technique to quantify the small volumes of oil associated with laboratory core floods is described.

Novel Technology

DOE/BC/14650-15 **A Novel Approach to Modeling Unstable EOR Displacements. Final Report. University of Texas at Austin. April 1994. 216 pp. Order No. DE94000128.** This is the final report of a three-year research project that was aimed at developing a methodology for predicting the performance of unstable displacements in heterogeneous reservoirs. A performance prediction approach that combines numerical modeling with laboratory imaging experiments has been developed. Most enhanced oil recovery (EOR) schemes involve the displacement of a more dense and more viscous oil by a less dense and less viscous fluid in a heterogeneous porous medium. The interaction of heterogeneity with the several competing forces, namely, viscous, capillary, gravitational, and dispersive forces, can conspire to make the displacements unstable and difficult to model and to predict. The objective of this research was to develop a systematic methodology for modeling unstable fluid displacements in heterogeneous media. Flow visualization experiments were conducted using X-ray computed tomography (CT) imaging and a video imaging workstation to (a) gain new insights into the dynamics of unstable displacements, (b) acquire detailed quantitative experimental image data for calibrating numerical models of unstable displacements and (c) image and characterize heterogeneities in laboratory cores geostatistically. High-resolution

umerical models modified for use on vector-architecture ıpercomputers were used to replicate the image data. Geostatistical ıodels of reservoir heterogeneity were incorporated in the numerical ıodels in order to study the interaction of hydrodynamic instability and eterogeneity in reservoir displacements. Finally, a systematic, method-ogy for matching the experimental data with the numerical models ıd scaling the laboratory results to other systems were developed. The ıtcome of the research is a new method for predicting the performance unstable EOR displacements in the field based on small-scale displace-ents in the laboratory.

esource Assessment Technology

OE/BC/14658-9 **Predictability of Formation Damage: An Assessment Study and eneralized Models. Final Report. University of Oklahoma. April 994. 300 pp. Order No. DE94000125.** The project objective is to develop ıproved generalized predictive models to be used for investigation of servoir formation damage and control for various fluid and rock condi-ons and to account for these effects in reservoir simulation. To accom-ish its objective the proposed study first critically studies and evaluates e previous modeling efforts reported in the literature. Then, general-ed predictive models are formulated by combining the previous at-mpts and by improving and generalizing the modeling approaches accommodate for a wide variety of conditions encountered in actual eld applications. A critical review of the previous work addressing their eoretical basis, assumptions and limitations, and the generalized and im-oved models developed in this study are presented in a systematic manner terms of a standardized definition and nomenclature for direct comparison. Case studies with the improved models are presented to demonstrate their capacity and validity. Computer programs implementing the improved modeling approaches are also supplied.

Gas Displacement

DOE/BC/14852-5 **Scale-up of Miscible Flood Processes for Heterogeneous Reservoirs. 1993 Annual Report. Stanford University. May 1994. 130 pp. DE94000130.** Progress is reported for a comprehensive investigation of the scaling behavior of gas injection processes in heterogeneous reservoirs. The interplay of phase behavior, viscous fingering, gravity segregation, capillary imbibition and drainage, and reservoir heterogeneity is examined in a series of simulations and experiments. Compositional and first-contact miscible simulations of viscous fingering and gravity segregation are compared to show that the two techniques can give very different results. Also, analyzed are two-dimensional and three-dimensional flows in which gravity segregation and viscous fingering interact. The simulations show that 2D and 3D flows can differ significantly. A comparison of analytical solutions for three-component two-phase flow with experimental results for oil/water/alcohol systems is reported. While the experiments and theory show reasonable agreement, some differences remain to be explained. The scaling behavior of the interaction of gravity segregation and capillary forces is investigated through simulations and through scaling arguments based on analysis of the differential equations. The simulations show that standard approaches do not agree well with results of low IFT displacements. The scaling analyses, however, reveal flow regimes where capillary, gravity, or viscous forces dominate the flow.

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