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Sampling and Charcterization of Rock and Fluids for Heavy Oil Reservoir Management

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Abstract

Heavy oil resources have become a major asset base in the portfolio of many energy companies. Representative sampling and characterization of rock and fluids are essential for efficient and economical development of heavy oil reservoirs. This paper describes the challenges inherent in fluids and rock sampling, PVT and viscosity modeling, and fluid flow property measurements for heavy oil reservoirs.

The key elements in obtaining representative bottom-hole fluid samples from an extra-heavy oil reservoir are described in this paper with examples. Special laboratory techniques are presented for obtaining equilibrium PVT and viscosity data on heavy oil samples. A compositional PVT model that captures the unconventional phase behavior and a viscosity model that quantifies the variations of viscosity with pressure, temperature, and GOR are also presented. Customized equipment and special techniques were employed to measure high-quality relative permeability data and to accurately determine the endpoint saturations such as critical gas saturation, remaining oil saturation, and the corresponding relative permeability. Examples of successful measurements of reservoir conditions steady-sate water-oil relative permeability are presented along with the unique equipment and techniques.

This paper highlights a systematic approach for rock and fluid characterization of heavy oil reservoirs and identifies new technologies that have lead to its successful application.

Introduction

Heavy oil resources are a growing part of the energy industry. These fluids are defined as having gravity between 7 and 25°API. These reservoirs represent new opportunities in field management and cannot easily be correlated with conventional resource characterizations. Reservoir characterization can be invaluable for reservoir management throughout the field life cycle from discovery to abandonment. Two sources of data that yield exceptionally useful characterization information are fluid property (PVT) analyses and SCAL (Special Core Analysis) measurements.

Characterization of *in-situ* fluids is an essential input for reservoir simulation, the quality of which can dramatically alter simulation results and thus reservoir management decisions. Determining the type of fluid at discovery can aid in development/depletion planning, facilities construction, and reserves estimation. Fluid characteristics can change over time, therefore periodic sampling during production should aid in refining the development plan and eventually determining the best course of action for abandonment. This characterization can range from simple compositional analysis to much more complex PVT analysis. Compositional analysis breaks the fluids down to determine the concentrations of specific compounds in each fluid phase. At times these concentrations may be segregated into plus fractions where concentrations of all compounds heavier than a certain point are added together (i.e., C_{7+} equals the concentration of all components of heptane or higher) (Whitson, 1983). PVT analyses are more complex including both state and path dependent properties. Important state properties include viscosity, density, and compressibility while path dependent properties include formation volume factors and ratios of gas to liquids. Heavy oils present unique challenges during fluid testing due to the long times required for fluid equilibration. All of these properties are used as inputs to complete mathematical equation-of-state (EOS) modeling, the results of which are subsequently used as input for reservoir simulators.