

Fluid-Rock Characterization for NMR Well Logging and Special Core Analysis

DE-FC26-04NT15515

Goal

The objective of this project is to develop the techniques and interpretation methods to determine the maximum information about fluid and rock properties and interactions from in-situ measurements by nuclear magnetic resonance (NMR) well logging and fluid sampling and from special core analysis of formation material. The approach to this objective is from two directions: 1) development of NMR techniques and interpretations for in-situ measurement of these properties by NMR well logging and 2) quantification of pore structure and wettability at the microscopic level to develop forward models for interpretation of multiphase fluid flow and NMR response.

Performers

Rice University
Houston, TX

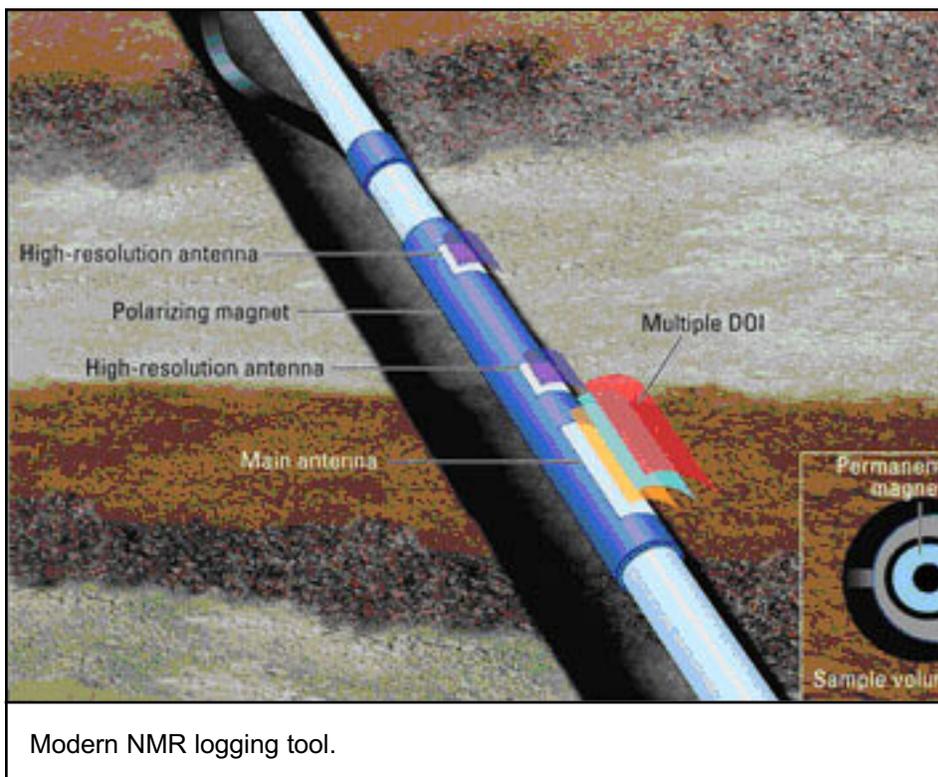
University of Houston
Houston, TX

Results

A method was developed to interpret the irreducible water saturation in systems with diffusional coupling between microporosity and macroporosity. This was presented at the SPWLA Annual Meeting in June 2005. Graduate student Mark Flaum was awarded the SPE Cedric Ferguson Medal for his contribution to the SPE paper Wettability, Saturation, and Viscosity from NMR Measurements, that he coauthored with R. Freedman, N. Heaton, C. Flaum, G. Hirasaki, and M. Hurlimann. This award recognizes significant contributions to the permanent technical literature of the profession by a member under age 33. Effects of OBM Invasion on Irreducible Water Saturation: Mechanisms and Modifications of NMR Interpretation was presented at the 2004 SPE annual technical conference and exhibition.

Benefits

The introduction of commercial NMR well logging in the early 1990s was a great contribution to formation evaluation. Initially, it was thought that the interpretation of the NMR well logs required differ-



Modern NMR logging tool.

ent parameters, depending only on whether the formation was sandstone or carbonate and the hydrocarbon was oil or gas. Since then, many improvements have been made to the logging tools and the interpretation methods. The project researchers have participated in several of the improvements. The proposed research seeks to identify reservoir conditions where exceptional interpretation is required and to develop the recommended interpretation method.

Low-field NMR spectroscopy has become a common instrument in core analysis service companies and research laboratories. Initially, the laboratory measurements were in support of NMR well logging by providing a core-to-log calibration. Recent advances in NMR technology have offered the possibility of determining information about pore structure and wettability that cannot be achieved by other means.

Background

This research program was initially funded by DE-AC26-99BC15201 in 1999 as Fluid-Rock Characterization and Interactions in NMR Well Logging. The most significant finding of this project was the recognition of the gas/oil ratio as a parameter in live oil relaxation time. Also, significant contributions were made in the recognition of the role of wettability and internal field gradients on relaxation time and that natural gas

components ethane and propane have much longer relaxation times compared with methane.

Summary

Project researchers determined:

- Diffusional coupling of microporosity and macroporosity. The degree of independence or coupling of the relaxation time of micropores and macropores was correlated by a dimensionless coupling parameter. This parameter is the ratio of relaxation and diffusion rates in a two-dimensional system. A method to estimate the irreducible water saturation, or BVI, was presented.
- Effect of wettability alteration by OBM on estimation of BVI. The surfactants in oil-based drilling fluids can alter wettability and thereby increase the relaxation time of bound water.

Current Status (January 2006)

This project began in October 2004. It is in the first year of a three-year program.

Funding

This project was selected in response to DOE's Oil Exploration and Production solicitation DE-PS26-04NT15450-2C, Reservoir Characterization and Management.

Publications

The first semi-annual report has been submitted to DOE.

Hidajat, I., Mohanty, K.K., Flaum, M., and Hirasaki, G., Study of Vuggy Carbonates Using NMR and X-Ray CT Scanning, SPE RE&E, October 2004, 365-377.

Flaum, M., Chen, J., and Hirasaki, G.J., NMR Diffusion Editing For D-T2 Maps: Application To Recognition Of Wettability Change, Petrophysics, March-April 2005.

Hirasaki, G., and Mohanty, K.K., Fluid-Rock Characterization for NMR Well Logging and Special Core Analysis, first annual report to U.S. DOE, May 2005.

Project Start: October 1, 2004

Project End: September 30, 2007

Anticipated DOE Contribution: \$799,553

Performer Contribution: \$254,025 (24% of total)

Contact Information

NETL – Virginia Weyland (virginia.weyland@netl.doe.gov or 918-699-2041)

Rice U. – George J. Hirasaki (gjh@rice.edu or 713-348-5416)