

NMR MICROSCOPY FOR FLUID IMAGING AT PORE SCALE IN RESERVOIR ROCK

By Daryl A. Doughty and Liviu Tomutsa

For presentation at
33rd Annual Symposium of the
Society of Professional Well Log Analysts
Co-sponsored by the Society of Core Analysts
Oklahoma City, Oklahoma
June 14-17, 1992

COPYRIGHT WAIVER

By acceptance of this article for publication, the publisher recognizes the Government's (license) rights in any copyright, and the government and its authorized representatives have unrestricted rights to reproduce in whole or in part said article under any copyright secured by the publisher.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

IIT Research Institute
National Institute for Petroleum and Energy Research
P.O. Box 2128
220 N. Virginia Avenue
Bartlesville, Oklahoma 74005
Telephone 336/2400

NMR MICROSCOPY FOR FLUID IMAGING AT PORE SCALE IN RESERVOIR ROCK

by Daryl A. Doughty and Liviu Tomutsa

ABSTRACT

Fluids in reservoir rocks exhibit nuclear magnetic resonance (NMR) characteristics more like those of solids than liquids. Very short T_2 relaxation times and broad natural line widths are caused primarily by paramagnetic components in the rock matrix. These characteristics place severe constraints on the NMRI methodology that can be used to obtain high-resolution, pore-scale images of fluid in reservoir rock. Because the relaxation and line broadening are not caused by dipolar coupling, multiple-pulse line narrowing techniques developed for NMRI in solids will not work. Very strong imaging gradients (75 to 150 Gauss/cm) are required to achieve meaningful voxel resolutions which severely limit the rapid switching of gradients required for most NMR slice-imaging techniques. An NMRI protocol based on 3D back-projection is presented and its advantages (high resolution in three dimensions, multi-planar slice selection) and limitations (RF pulse power, acquisition time, data file size, computational demands) are discussed. Using this protocol, images of two-phase fluid systems in rock samples have been obtained using 65536 projections and 256 complex points per projection about spherical coordinate space. Resolutions as high as 25 microns per pixel have been obtained. A brief discussion of sample preparation requirements is presented. Results are presented showing one- and two-phase fluid distributions in reservoir rock at the pore level.