NMR MICROSCOPY FOR FLUID IMAGING AT PORE SCALE IN RESERVOIR ROCK

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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.