INVESTIGATING ELECTRICAL-IMPEDEANCE TOMOGRAPHY AS A TECHNIQUE FOR REAL-TIME SATURATION MONITORING

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Keywords:
Electrical-impedance tomography, saturation, reservoir engineering

ABSTRACT

3D electrical-impedance tomography (EIT) is a technique that has the potential to provide estimates of reservoir saturation at multiple scales by determining the resistivity distribution within the subsurface. In theory, EIT is well suited for researching oil and brine systems because of the large contrast in resistivity between the two phases. Here, in our initial laboratory investigation, we have applied the EIT technique to measure the saturation distribution of water within a core.

The initial EIT experiment presented here used a Berea-sandstone core with 48 electrodes attached in three rings of 16. The core was open to the atmosphere, with saturation occurring by natural imbibition and desaturation occurring by evaporation. The voltage-potential field was measured by applying a direct-current (DC) pulse across the core and measuring the voltage potential at all electrodes, essentially applying the four-wire resistance technique over all electrodes in turn. The result was a data set that embodies the resistivity distribution within the core, and, by inversion, the resistivity distribution was reconstructed, which allowed for the inference of the saturation.

The data processing was accomplished by using the Electrical Impedance Tomography and Diffuse Optical Tomography Reconstruction Software (EIDORS) toolkit, which was developed for application to this nonlinear and ill-posed inverse problem. The procedure uses a finite-element model for forward calculation and a regularized nonlinear inverse solver to obtain a unique and stable inverse solution.

Experiments have indicated that EIT is a viable technique for studying the displacement characteristics of fluids with contrasting resistivity and is capable of detecting displacement fronts in near to real time. The current system is also a quantitative technique able to measure saturation distributions accurately between 15% < Sw < 65% in a Berea sandstone core. These limitations were imposed because of connate-water connections to the electrodes and ion-mobility effects caused by the DC voltage source. It is anticipated that the applicability of EIT will increase with the implementation of an alternating-current (AC) voltage source.

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