Electrical Conductivity Distributions of Discrete Fluid-Filled Fractures

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Hydraulically fractured systems are becoming increasingly common with enhanced oil recovery, geothermal power, and CO_2 sequestration all seeking purchase. Determining the spatial distribution of fluid through these fractures is critical to understanding and even predicting how geologic media responds to hydraulic fracturing. Inversion of data characterizing the distribution of electrical conductivity can be used to estimate fluid distributions. Here, we demonstrate how Inversion of synthetic electrical conductivity data can be used to derive fluid distributions in millimeter-scale fractures. We replicated model and well geometries from a hydraulic fracturing experiment performed at Blue Canyon Dome in Socorro, NM for generating synthetic data. The experiment deployed 16 temporary electrodes in the central stimulation borehole and 64 permanent electrodes in the monitoring wells (16 each) emplaced in the cardinal directions.
A 5 × 5 × 30-m^3 model comprising one million cells was built. We implemented both smooth-constraint and blocky inversion of the electrical response across the model domain, which included three fractures with dimensions of 3 × 0.005 × 4 m^3 separated by 1 m. High conductivity contrast is noticeable in all fractures, but is most evident in the portions of the fractures within 50 cm radius of the electrodes. Blocky inversion revealed distinct fracture boundaries and outperformed smooth inversion, which returned smeared fracture boundaries. This study shows that blocky inversion of electrical conductivity using real well geometries can be used to derive conductivity distributions, which are representative of the spatial distribution of fluid in fractured systems.