Integrating Crosswell Electromagnetic Imaging and Reservoir Data for Dynamic Modeling of Water Injection in Carbonate Reservoir.

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Crosswell Electromagnetic (EM) tomography is a recently developed technology to estimate the formation resistivity distribution in the interwell volume. The data are acquired by fixing receivers in one well, and measuring the magnetic field as a solenoid source broadcasts a continuous sinusoidal signal as it moves up the well in a second well some distance. The resistivity distribution is then estimated through non-linear inversion of the data with respect to an initial resistivity model. In this project time-lapse crosswell EM images are used to monitor apparent saturation changes in a water injection pilot in basal low-reservoir quality units of a giant carbonate field in the Middle East. The evolution of water saturation is deduced from the inverted resistivity distributions. Note that to obtain a detailed image of apparent saturation changes, the initial model incorporates realistic representations of the small-scale heterogeneities common to carbonate reservoirs. These include detailed thickness variations and thin dense layers interbedded in some reservoir units. The highly constrained images are then compared to dynamic reservoir simulation results derived from models of various levels of complexity. Simulations show that if flow barriers are not included between various reservoir units, the injected water will move upward across the reservoir units which is inconsistent with the EM. Successive adjustments were therefore applied on the dynamic model to honor the EM images as well as the injection pressure results. Properly constrained with seismic geologic and flow data the EM results provide useful information about the location and behavior of the fluid front in the formation and allow identifying the adequate level of geological details that needs to be preserved in a dynamic model.