MODELING AND SIMULATION WORFLOW FOR A FRACTURED CARBONATE CO_2 HUFF 'N' PUFF: A CASE STUDY IN THE WILLISTON BASIN, NORTH DAKOTA, USA

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ABSTRACT

A CO_2 huff ‘n’ puff (HNP) enhanced oil recovery (EOR) project was carried out in the E. Goetz 1 well located in the Northwest McGregor Field of Williams County, North Dakota, USA. The HNP is part of the Plains CO_2 Reduction (PCOR) Partnership Phase II field demonstration project in which CO_2 was injected into the Mississippian Madison Formation, a fractured carbonate reservoir, for the dual purpose of CO_2 EOR and associated CO_2 storage. The workflow for building the static geologic model for this study involved data collection and normalization, petrophysical and facies modeling, and dynamic simulation with history matching. The small-scale injection model contained only one well, so a larger-scale model containing several wells was built using sequential Gaussian and indicator simulations to determine trends and anisotropy. Then a smaller downscaled injection model was built using discrete and continuous multiple point statistics to model the gradational mudstone to grainstone sequence common with platform carbonates while using a cropped portion of the large-scale model as a covariable. Through the analysis of core and drill stem test (DST) data, it was determined that, to more accurately model the reservoir, a fracture model was needed which was constructed using discrete fracture network (DFN) simulation. The DFN model was then upscaled to the injection grid to produce a heterogeneous dual permeability and porosity model. This dual property model was then exported into the Computer Modeling Group’s (CMG) Generalized Equation-of-State Model Compositional Reservoir Simulator (GEM), and multiple-point statistics was used to adjust the static model’s petrophysical properties, assisting in the history match of the reservoir’s historical production. Finally, the modeling and simulation work was integrated with time-lapse reservoir saturation tool (RST) data and vertical seismic profile (VSP) data to accurately account for the injected CO_2 and the produced water, oil, and CO_2. By following this type of workflow, the complicated nature of the CO_2 HNP was modeled and matched to the monitoring, verification, and accounting techniques, displaying how this type of a workflow can be applied to other CO_2 storage projects.