ABSTRACT

A CO₂ Huff ‘n’ Puff (HNP) enhanced oil recovery (EOR) project was carried out in the E. Gourie 1 well located in the Northwest McGregor Field of Williams County, North Dakota, USA. The HNP is one of the Phase CO₂ Reduction (PCR) Partnership Phase II pilot projects in which CO₂ was injected into the Mississippian Mission Canyon Formation, a fractured carbonate reservoir, for the dual purpose of CO₂, EOR and associated CO₂ storage. The workflow for building the static geologic model for this study involved data collection and normalization, petrophysical and fracture modeling, and dynamic simulation with history matching. The small-scale injection model contained one well, a larger-scale model containing several wells was built using sequential Gaussian simulation (SGS) 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 geological mimetic to ground sequence common with platform carbonate reservoirs 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) simulations. The DFN model was then up-scaled 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 (CMG) general equation of state model compositional reservoir simulator (GEM), and SGS and indicator simulations were used to adjust the static model petrophysical properties, existing 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 CO₂ and the produced water, oil, and CO₂. By following this type of workflow, the complicated nature of the CO₂ HNP was modeled and matched to the monitoring verification, and accounting (MVA) techniques, displaying how this type of a workflow can be applied to other CO₂ storage projects.

The Phase CO₂ Reduction (PCR) Partnership is a collaborative program assessing regional CO₂ storage opportunities. Its primary sponsor is the U.S. Department of Energy National Energy Technology Laboratory, with additional support from its more than 80 partners.

SUMMARY

The primary goals of this PCR Partnership project included determining the short- and long-term fate of a small volume of injected CO₂ (440 tons) and determining if a CO₂ HNP in a fractured carbonate formation can be used for enhanced oil recovery, while providing an improved understanding of CO₂ injection and storage behavior in fractured rock formations. This project was successful in meeting these goals. The potential incremental oil production, time-lapse RST and VSP were used along with the traditional static and numerical modeling. The VSP was an efficient tool for determining the vertical extent of the injected CO₂ near the wellbore and Kwater(mD) = average permeability from DST (mD)

References:

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