Geomechanics for Geologic Storage of Carbon Dioxide from an Ethanol Plant in North Dakota

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Abstract

The Energy & Environmental Research Center (EERC) and Red Trail Energy (RTE) have implemented novel monitoring techniques at a carbon capture and storage (CCS) project in North Dakota, in partnership with the North Dakota Industrial Commission Renewable Energy Program and the U.S. Department of Energy. This novel monitoring research was also supported by the Plains CO_2 Reduction Initiative, which includes over 200 partners developing and demonstrating technologies for geologic carbon dioxide (CO_2) storage. RTE is an investor-owned 64-million-gallon dry mill ethanol production plant in Richardton, North Dakota. RTE captures about 180,000 tonnes of CO_2 annually and injects it into the Broom Creek Formation, a deep saline aquifer, for permanent on-site geologic storage. As part of the novel monitoring research at the RTE CCS site, CO_2 plume monitoring is conducted using fiber-optic data; a scalable, automated, sparse seismic array (SASSA) technique; and surface deformation data from satellite-based interferometric synthetic aperture radar (InSAR) imagery. The fiber-optic data, which are sponsored by Research Institute of Innovative Technology for the Earth (RITE) from Japan, consist of distributed temperature-sensing, distributed acoustic-sensing, and distributed strain-sensing. They were installed in the flowline, injection well, and monitoring well at the RTE CCS site. The SASSA sensors are distributed around the injection well in an eight mi^2 study area. Additionally, the EERC built a site-specific 3D geomechanical model (or mechanical earth model [MEM]) for improved stress modeling. The following comprehensive processes were applied to build the 3D MEM. 1D MEMs were built, initially, with well-logging data and geomechanical lab measurements. After the 1D MEMs were created, they were calibrated with additional measurements from the RTE CCS site: drilling events (field observations), lab measurements, and several geomechanical scenarios. This calibration process is critical to building a 3D MEM. The stress values of the 3D MEM simulation should be calibrated with the 1D MEMs. Next, the site-specific geologic and reservoir models based on CO_2 injection scenarios were integrated into the 3D MEM. During integration of the reservoir models, the geomechanical simulation time was synchronized with the reservoir simulation time, and 3D stresses were calculated accordingly. Finally, the 3D MEM results were compared with the vertical surface deformations measured by InSAR. The 3D MEM will be calibrated more comprehensively in future studies when more monitoring data from fiber-optic, SASSA, and downhole pressure gauge data are available. With more calibration data, the 3D MEM can support more accurate predictions of the subsurface stress changes due to CO_2 injection, including vertical surface deformation. These results will provide more effective monitoring for CCS sites.