Complex fluid flow revealed by monitoring CO_2 injection in a fluvial formation

GCCC Publication Series #2012-05

J. Lu
P.J. Cook
S.A. Hosseini
C. Yang
K.D. Romanak
T. Zhang
B.M. Freifeld
R.C. Smyth
H. Zeng
S.D. Hovorka

Keywords: fluid flow model, reservoir

Cited as:

Lu, J., P.J. Cook, S.A. Hosseini, C. Yang, K.D. Romanak, T. Zhang, B.M. Freifeld, R.C. Smyth, H. Zeng, S.D. Hovorka, 2012, Complex fluid flow revealed by monitoring CO_2 injection in a fluvial formation, GCCC Publication Series #2012-05, originally published in *Journal of Geophysical Research: Solid Earth*

Abstract

At Cranfield, Mississippi, United States, a large-scale carbon dioxide (CO_2) injection through an injection well (~3,080 m deep) was continuously monitored using U-tube samplers in two observation wells located 68 and 112 m east of the injector. The Lower Tuscaloosa Formation injection zone, which consists of amalgamated fluvial point-bar and channel-fill deposits, presents an interesting environment for studying fluid flow in heterogeneous formations. Continual fluid sampling was carried out during the first month of CO_2 injection. Two subsequent tracer tests using sulfur hexafluoride (SF6) and krypton were conducted at different injection rates to measure flow velocity change. The field observations showed significant heterogeneity of fluid flow and for the first time clearly demonstrated that fluid flow evolved with time and injection rate. It was found the wells were connected through numerous, separate flow pathways. CO_2 flowed through an increasing fraction of the reservoir and sweep efficiency improved with time. The field study also first documented in situ component exchange between brine and gas phases during CO_2 injection. It was found that CH_4 degassed from brine and is enriched along the gas–water contact. Multiple injectate flow fronts with high CH_4 concentration arrived at different times and led to gas composition fluctuations in the observation wells. The findings provide valuable insights into heterogeneous multiphase flow in rock formations and show that conventional geological models and static fluid flow simulations are unable to fully describe the heterogeneous and dynamic flow during fluid injection.