Risk analysis for CO2 sequestration at enhanced oil recovery sites

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Carbon dioxide (CO_2) is an attractive displacing agent for enhanced oil recovery. Because a large portion of the injected CO_2 remains in place in depleted reservoirs after enhanced oil recovery, this method could also be an option for permanently sequestering CO_2 to mitigate global warming. Los Alamos scientists and collaborators have developed a generic multi-scale statistical framework for CO_2 accounting and risk analysis in CO_2-enhanced oil recovery sites. This analysis method provides information to aid decision-making for applications of oil recovery and CO_2 sequestration. _Environmental Science & Technology_ published the research.

Significance of the work

The CO_2 enhanced oil recovery process presents potential benefits and some technical and operational challenges. The very low viscosity of CO_2 may cause it to break through to production wells, and poor mobility control may leave large areas of the reservoir unswept. To overcome this disadvantage, current CO_2 enhanced oil recovery projects alternately inject gas and water (or brine) as slugs in the water-alternating-gas method to control CO_2 mobility and flood conformance. This method can be very effective. However, more detailed studies of the interaction of CO_2 with oil, formation water, and heterogeneous sediments are needed to understand the mechanism of CO_2 geological sequestration in oil/gas reservoirs and evaluate the total amount of CO_2 irreversibly stored in reservoirs.

The exact values of the reservoir parameters are not well known in most CO_2-enhanced oil recovery sites. However, enough information may be obtained to define the uncertainty distributions of these parameters. The research team used these distributions to perform multi-scale simulations of the CO_2-oil-water flow and transport. The investigators expressed the risk factors as measurable quantities to gain insight into project risk (e.g., environmental and economic risks). This approach eliminated the need to generate a rigorous consequence structure of CO_2 injection rate, cumulative CO_2 storage, cumulative water injection and cumulative oil/gas production. The results provide insights to understand CO_2 storage potential and the corresponding environmental and economic risks of commercial-scale CO_2 sequestration in depleted reservoirs.

Achievements

The researchers used the CO_2 enhanced oil recovery site in the Farnsworth Unit in Texas to investigate their multiscale statistical approach for CO_2 accounting and risk analysis. The exact values of the reservoir parameters are not well known. Therefore, the team used distributions to sample the uncertain parameters and conduct geostatistical-based Monte Carlo simulations.

The researchers performed multi-scale simulations of the CO_2-oil-water flow and transport in the heterogeneous reservoir. They used a pattern of four injection wells in the corners of a square and a production well in the center. The team conducted 1000 separate reservoir simulations, including injected CO_2 and water as well as produced CO_2, water, oil and gas. The investigators developed a simple economic model to calculate the profitability of CO_2-enhanced oil recovery for the site. This information aids understanding of the impact of the reservoir heterogeneity and other operational parameters for economic decision-making and the cost-effectiveness of CO_2 sequestration through enhanced oil recovery at other depleted reservoirs.

The research team

The team was composed of Zhenxue Dai, Hari Viswanathan and Richard Middleton of the Laboratory's Computational Earth Science group; Feng Pan, Wei Jia, Ting Xiao and Brian McPherson of University of Utah—Salt Lake City; William Ampomah, Robert Balch and Reid Grigg of New Mexico Institute of Technology; Changbin Yang of University of Texas—Austin; Si-Yong Lee of Schlumberger Carbon Services; and Mark White of Pacific Northwest National Laboratory.

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