

Machine Learning; Findings from University of Texas Austin Yields New Data on Machine Learning (Failure Analysis-informed Risk Assessment Framework for Geological Carbon Storage Using Numerical Simulation and Machine Learning)

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2026 MAR 30 (VerticalNews) -- By a News Reporter-Staff News Editor at Journal of Engineering -- Investigators discuss new findings in Machine Learning. According to news reporting out of Austin, Texas, by VerticalNews editors, research stated, "Geological carbon storage (GCS) is recognized as a critical technology for achieving large- scale reductions in anthropogenic carbon dioxide (CO₂) emissions. Ensuring long- term containment and safety requires robust risk assessment frameworks that account for geological uncertainty and identify potential failure scenarios."

Funders for this research include United States Department of Energy (DOE), **Bureau of Economic Geology**.

Our news journalists obtained a quote from the research from the University of Texas Austin, "Among various indicators, the area of review (AoR) serves as a key metric for evaluating storage performance, regulatory compliance, and monitoring design, as it delineates the spatial extent impacted by pressure buildup and plume migration. However, conventional AoR- based risk assessments typically perturb parameters within narrow uncertainty bounds, potentially overlooking rare but high- impact events arising from extreme geological conditions. In this study, we present a failure analysis-informed risk assessment framework for large- scale GCS projects to improve site prescreening and monitoring design. A suite of 300 numerical simulations was generated using stochastic geological models that vary five key parameters: net- to- gross ratio, anisotropy azimuth, porosity multiplier, permeability multiplier, and vertical- to- horizontal permeability ratio. Among these, 200 realizations represent normal geological uncertainty, while 100 additional cases explore extreme yet plausible conditions for failure- case analysis. The AoR was simulated and computed from pressure and CO₂ saturation fields, where the baseline AoR boundary, representing the extent predicted under typical geological uncertainty, was defined as the union of 200 normal- range simulations, and failure was identified when extreme- range cases exceeded this baseline. Results show that incorporating broader parameter uncertainty produces significantly larger AoR extents, underscoring the potential underestimation of risk under conventional uncertainty ranges. Furthermore, spatial probability maps derived from failure- induced AoR exceedance identify regions requiring enhanced monitoring attention. Various machine learning (ML)-based classifiers were developed to predict failure occurrence from geological parameters, with the random forest model achieving the highest performance (F1- score of 0.986). Consistent findings from correlation coefficient, feature importance, and Sobol sensitivity analyses reveal that low net- to- gross ratios and permeability multipliers are the dominant risk drivers, reflecting reduced reservoir connectivity and limited pressure dissipation."

According to the news editors, the research concluded: "Together, these results provide a novel framework for risk- informed site prescreening and monitoring design that explicitly considers rare but high- impact geological scenarios in GCS projects."

This research has been peer-reviewed.

For more information on this research see: Failure Analysis-informed Risk Assessment Framework for Geological Carbon Storage Using Numerical Simulation and Machine Learning. Spe Journal, 2026;31(2):1370-1384. Spe Journal can be contacted at: Soc Petroleum Eng, 222 Palisades Creek Dr, Richardson, TX 75080, USA.

Our news journalists report that additional information may be obtained by contacting Hongsheng Wang, University of Texas Austin, Jackson School of Geosciences, Bur Econ Geol, Austin, TX 78712, United States. Additional authors for this research include Hailun Ni, Ruichang Guo, Seyyed A. Hosseini, Susan D. Hovorka, Tao Bai, Ting Xiao and Yuntian Teng.

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