Researchers modeling the potential for induced seismicity

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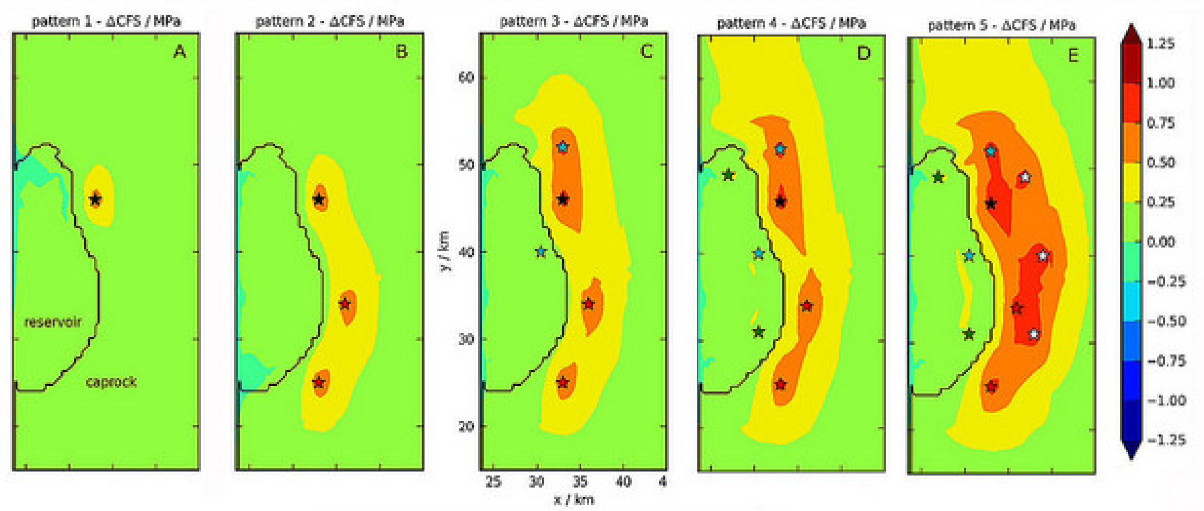

Capture and storage of carbon dioxide (CO_2) produced by large stationary emitters (e.g., coal and gas-fired power plants) is a proposed technology for mitigating rises in atmospheric greenhouse gases. To safeguard long-term storage of CO_2 in the primary storage reservoir, it is necessary to ensure the fidelity of the low-permeability caprock that form the primary trap for buoyant CO_2. Los Alamos researchers conducted modeling studies to better understand triggers of induced earthquake activity caused by injection of large volumes of liquid CO_2. The *International Journal of Greenhouse Gas Control* published their findings.

Significance of the research

One scenario for the creation of a leakage pathway through an otherwise low-permeability caprock is by reactivation of an existing fault. The concept requires direct pressure communication between the fault and injection well, which implies that faults not hydraulically connected to the injection well are in some sense “safe” from induced earthquakes. An imperfect knowledge of small- to regional-scale faults that do not express at the surface and the state of stress on these features present challenges for modeling induced seismicity in this scenario.

LANL’s modeling study considers hypothetical injection scenarios at a naturally occurring CO_2 reservoir near Springerville, Ariz. to determine if the injection could cause earthquakes on nearby faults. While the CO_2 bearing layers in this area are too shallow to function as practical repositories, the Springerville reservoir can serve as an analogue to yield valuable insights into the geological and structural characteristics that both facilitate and limit gas transport. The authors have demonstrated a second mechanism for induced earthquakes that does not rely on hydraulic connection or fault pressurization. In this scenario, injection into a reservoir causes a poroelastic expansion similar to the inflation of a balloon. Formations that overlie the expanding reservoir are stretched laterally in response to the uplift. This lateral extension compounds and reinforces the local tectonic forcing in regions of tectonic extension. These changes in the caprock bending stress might eventually pose difficulties in moving CO_2 sequestration operations from pilot demonstration projects to an industrial and economic scale.

Research achievements

The team used the LANL subsurface flow code FEHM (Finite Heat and Mass Transfer) to build a numerical model of the underground flow of CO_2-water mixtures and the coupled effects on the Earth’s state of stress. They applied the model to hypothetical scenarios of industrial scale injection into CO2 bearing layers at the Springerville site. The scientists used up to 10 injection wells to emplace several tens of megatons of CO_2 over a ten-year period.

Following emplacement, the researchers calculated the induced deformation and stress changes in the reservoir and the overlying seal formations. It is the low permeability of these formations that is relied upon to prevent upward migration of the stored CO_2. The authors developed a new methodology for visualizing bulk stress changes in a 3-D volume to show the increase in shear stress. The scientists determined that the increases are enough to cause failure on critically stressed faults in the seal formations across much of the well field. The team concluded that undiscovered faults that transect these seals are at risk of rupture. In addition, pressure interaction between neighboring wells in the reservoir is non-linear. Stresses induced in the overlying seals are compounded, particularly between wells.

The research team

Los Alamos authors include David Dempsey, Sharad Kelkar, Rajesh Pawar, and Elizabeth Keating of the Computational Earth Science group and David Coblentz of Geophysics. This work is part of the Laboratory’s participation in the DOE National Risk Assessment Partnership (NRAP) project, a multi-lab collaborative effort to better understand the risks associated with geologic CO_2 sequestration. The research supports the Laboratory’s Energy Security mission area and the Information, Science, and Technology science pillar.