Measuring and interpreting borehole strainmeter data to improve CO2 storage

Injecting fluids into a well deforms the enveloping rocks in a complex pattern that increases in magnitude and expands outward with time, and measurements of this strain field may be useful for monitoring the injection process. A pair of instruments capable of measuring four components of strain and two components of tilt has been developed. One instrument is designed to be removeable, whereas the other one is grouted in place. The removeable strainmeter provides versatility and lower cost because it can be relocated, whereas the grout-in instrument provides better coupling to the formation, which should improve the strain signal. The new strainmeters have been deployed along with a Gladwin strainmeter at the Avant Field, an oil field north of Tulsa, Oklahoma. Oil and water are being pumped out, and water is being injected in multiple boreholes that intersect the Bartlesville formation at a depth of approximately 500 m at the Avant Field. The strainmeters have been deployed at a depth of 30 m near well 9A, an injection well near the edge of the field. Results from a brief, 4-hr-long injection test into well 9A show that the radial and circumferential strain increase (become tensile) with time during injection, reaching a maximum of several 10s of nanostrain. In another example, data from the Gladwin strainmeter showed the strain field changing with time when an injection well 1 km away was shut-in. This caused the strain along a radial direction to become tensile, while the circumferential strain became compressive. This trend reversed a week later when injection into the well resumed. The major axis of the principle strain aligned with the shut-in well. The observed strain signals are similar to results from poroelastic analyses, and preliminary inverse analyses sugest that strain signals can be used to estimate reservoir characteristics at the Avant Field.

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