Process-based approach to CO2 leakage detection by vadose zone gas monitoring at geologic CO2 storage sites

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Abstract:

A critical issue for geologic carbon sequestration is the ability to detect CO2 in the vadose zone. Here we present a new process-based approach to identify CO2 that has leaked from deep geologic storage reservoirs into the shallow subsurface. Whereas current CO2 concentration-based methods require years of background measurements to quantify variability of natural vadose zone CO2, this new approach examines chemical relationships between vadose zone N2, O2, CO2, and CH4 to promptly distinguish a leakage signal from natural vadose zone CO2. The method uses sequential inspection of the following gas concentration relationships: 1) O2 versus CO2 to distinguish in-situ vadose zone background processes (biologic respiration, methane oxidation, and CO2 dissolution) from exogenous deep leakage input, 2) CO2 versus N2 to further distinguish dissolution of CO2 from exogenous deep leakage input, and 3) CO2 versus N2/O2 to assess the degree of respiration, CH4 oxidation and atmospheric mixing/dilution occurring in the system. The approach was developed at a natural CO2-rich control site and successfully applied at an engineered site where deep gases migrated into the vadose zone. The ability to identify gas leakage into the vadose zone without the need for background measurements could decrease uncertainty in leakage detection and expedite implementation of future geologic CO2 storage projects.

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