Detection of Hidden Geothermal Systems Based on Near-Surface CO_2

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RESEARCH OBJECTIVES

The majority of hydrothermal systems with obvious surface expressions in the U.S. have been explored to determine their development potential. Consequently, discovery of new geothermal systems will require exploration of areas where the resources are hidden. Emissions of moderate-to-low solubility gases may be one of the primary near-surface signals from hidden geothermal systems, and detection of anomalous gas emissions may be a tool by which to discover new resources. Carbon dioxide shows promise because it is the major noncondensible gas present in geothermal systems, has moderate solubility in groundwater, and is measurable by numerous technologies. The objective of this work is to design an integrated measurement, modeling, and analysis strategy to identify geothermal CO_2 in the near-surface environment, with the goal of discovering hidden geothermal systems.

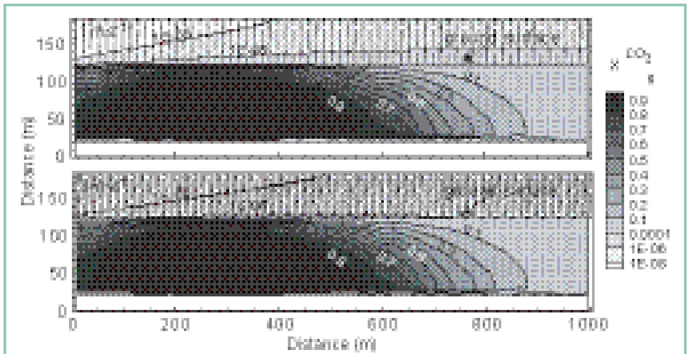

Figure 1. Coupled CO_2 subsurface migration and surface-layer mixing at t = 200 years for one heterogeneous permeability realization, source CO_2 flux = 576 g m^{-2} d^{-1}, and constant wind speeds of 1 m s^{-1} (upper plot) and 3 m s^{-1} (lower plot). CO_2 concentration is in mole fraction.

APPROACH

Simulations were conducted using the numerical code T2CA, a coupled subsurface-atmospheric surface layer flow and transport model, to estimate near-surface CO_2 concentrations and fluxes that might result when CO_2 leaks from a hidden geothermal system at depth. The geologic framework of the modeled hidden geothermal system was based on an arid Basin and Range Province system. Observed sources, as well as the spatial and temporal variability of natural background CO_2 fluxes and concentrations in the near-surface environment, were also evaluated. Methods were designed to detect geothermal CO_2 emissions within the background variability of CO_2, integrating field measurement technologies with statistical analysis and modeling approaches.

ACCOMPLISHMENTS

Near-surface CO_2 fluxes and concentrations were simulated for different geothermal source CO_2 fluxes, homogeneous and heterogeneous permeability structures, and constant wind speeds. Results show that CO_2 concentrations can reach high levels in the shallow subsurface, even for relatively low geothermal source CO_2 fluxes (Figure 1). However, winds are effective at dispersing CO_2 seepage. Technologies to detect CO_2 in the near-surface were evaluated for detection capability and cost. An exploration strategy was proposed involving integrated measurement, modeling, and statistical analysis to characterize the spatial and temporal variability and source of CO_2 in a background system and the area targeted for exploration. Emphasis was placed on using time- and cost-efficient methods to determine whether CO_2 derived from a geothermal source is present, and if so, the spatial extent of the anomaly.

SIGNIFICANCE OF FINDINGS

The proposed near-surface CO_2 monitoring and analysis strategy is designed to search for relatively small geothermal CO_2 signals within the background variability of CO_2, using relatively low-cost and time-efficient methods. Further geophysical measurements, installation of deep wells, and geochemical analyses of deep fluids can be guided by the results of the near-surface CO_2 investigation.

RELATED PUBLICATION

Lewicki, J.L., and C.M. Oldenburg, Near-surface CO_2 monitoring and analysis to detect hidden geothermal systems. Proceedings, 30th Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, 2005. Berkeley Lab Report LBNL-56900.

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