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Publication Date
2004-10-01

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"Hidden" geothermal systems are those systems above which hydrothermal surface features are lacking. Emissions of moderate to low solubility gases may be one of the primary near-surface signals from these systems. A tool to discover new geothermal systems may therefore be the detection of these gas emissions. We investigate the potential for CO_2 detection and monitoring in the subsurface and above ground in the near-surface environment to serve as a means to discern hidden geothermal systems. We focus the investigation on CO_2due to (1) its abundance in geothermal systems, (2) its moderate solubility in water, and (3) the wide range of technologies available to monitor CO_2 in the near-surface environment. However, monitoring in the near-surface environment for CO_2 derived from hidden geothermal reservoirs is complicated by the large variation in CO_2 fluxes and concentrations arising from natural biological and hydrologic processes.

In the near-surface environment, the flow and transport of CO_2 at high concentrations will be controlled by its high density, low viscosity, and high solubility in water relative to air. Numerical simulations of CO_2 migration show that CO_2 concentrations can reach very high levels in the shallow subsurface even for relatively low geothermal source CO_2 fluxes. However, once CO_2 seeps out of the ground into the atmospheric surface layer, surface winds are effective at dispersing CO_2 seepage.

In natural ecological systems in the absence of geothermal gas emissions, near-surface CO_2 fluxes and concentrations are predominantly controlled by CO_2 uptake by photosynthesis, production by root respiration, and microbial decomposition of soil/subsoil organic matter, groundwater degassing, and exchange with the atmosphere. Available technologies for monitoring CO_2 in the near-surface environment include (1) the infrared gas analyzer (IRGA) for measurement of concentrations at point locations, (2) the accumulation chamber (AC) method for measuring soil CO_2 fluxes at point locations, (3) the eddy covariance (EC) method for measuring net CO_2 flux over a given area, (4) hyperspectral imaging of vegetative stress resulting from elevated CO_2 concentrations, and (5) light detection and ranging (LIDAR) that can measure CO_2 concentrations over an integrated path.

To meet the challenge of detecting potentially small-magnitude geothermal CO_2 emissions within the natural background variability of CO_2, we propose an approach that integrates available detection and monitoring techniques with statistical analysis and modeling strategies. Within the area targeted for geothermal exploration, point measurements of soil CO_2 fluxes and concentrations using the AC method and a portable IRGA, respectively, and measurements of net surface flux using EC should be made. Also, the natural spatial and temporal variability of soil CO_2 fluxes concentrations should be quantified within a background area with similar geologic, climatic, and ecosystem characteristics to the area targeted for geothermal exploration. Statistical analyses of data collected from both areas should be used to guide sampling strategy, discern spatial patterns that may be indicative of geothermal CO_2 emissions, and assess the presence of geothermal CO_2 within the natural background variability with a desired confidence level. Once measured CO_2 concentrations and fluxes have been determined to be of anomalous geothermal origin with high confidence, more expensive vertical subsurface gas sampling and chemical and isotopic analyses can be undertaken. Integrated analysis of all measurements will determine definitively if CO_2 derived from a deep geothermal source is present, and if so, the spatial extent of the anomaly. The suitability of further geophysical measurements, installation of deep wells, and geochemical analyses of deep fluids can then be determined based on the results of the near surface CO_2 monitoring program. Acknowledgement: This work was completed at Lawrence Berkeley National Laboratory, under U.S. Department of Energy Contract No. DE-AC03765F00098.