The utility of paired isotopic and diffuse soil CO_2 flux investigations in geothermal systems

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The measurement of diffuse soil CO_2 flux has been utilized as a tracer to identify geothermal areas and/or zones of upflow within geothermal systems. While these investigations have utility in fields with high diffuse soil CO_2 flux, many geothermal systems have low permeability zones which can mask the efflux from a geothermal feature at depth. Isotopic measurements have been shown to be a powerful tool to apportion the diffuse soil gas flux associated with volcanic systems. Here we evaluate paired diffuse soil gas flux and isotopic investigations in high (Taupo Volcanic Zone, NZ) and low (Alpine Fault, NZ) enthalpy geothermal systems to identify and apportion geothermal additions. We found that CO_2 flux in isolation is often insufficient to identify geothermal activity in low flux areas due to the presence of biogenic soil gas flux. Despite this, paired isotopic and flux analyses are able to discriminate between end-member additions at very low fluxes (<10 $gm^{-2}day^{-1}$). This allows the identification of up-flow areas regardless of the prevalence of very low fluxes (some high enthalpy fields have a maximum diffuse gas flux of 217 $gCO^2m^{-2}day^{-1}$). Additionally, isotopic investigations can allow the apportionment of CO_2 flux amongst end-member compositions. In low enthalpy systems, areas of geothermal upwelling can be identified by coupled isotopic and flux investigations; however, the end-member composition is not well constrained and, as such, apportionment is more difficult. These findings put forth that paired isotopic and soil gas flux investigations are useful in the identification and analysis of geothermal systems.