Xenowhiffs: Mantle gases in hydrologic systems

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Throughout the western U.S., Quaternary travertine and lacustrine carbonate deposits record long-lived interactions of deeply-sourced ("endogenic") carbonic fluids with the near-surface hydrologic regime. These were deposited by springs analogous to modern CO$_2$ springs that occur along faults and fracture zones associated with both local and regional extension (e.g., Rio Grande rift; Basin and Range; Colorado Plateau; Arizona transition zone; Hurricane fault, Utah). Upwelling groundwaters containing ‘xenowhiffs’ (deeply-derived gases entrained in hydrologic systems) emerge along basin margins as well as mix with aquifer waters in shallower hydrologic systems. Gas and water chemistry from hot springs, gas vents, CO$_2$-rich cool springs, and high-PCO$_2$ groundwaters of the western U.S. indicate a regionally extensive flux of deeply sourced volatiles. A measurable mantle-derived helium component ($^{3}$He/$^{4}$He > 0.1 RA) occurs in nearly all springs. The highest flux of mantle volatiles ($^{3}$He/$^{4}$He =1 to 8 RA) occurs above regions of lowest mantle velocity indicating direct fast-pathways from the sublithospheric mantle to the surface hydrologic system. The total CO$_2$ flux into the western U.S. near-surface system (>10$^{11}$ moles per year) rivals that of mid-ocean ridges and subaerial volcanism (each ~10$^{12}$ mol/yr). Important components of the CO$_2$ are derived from the lithosphere and from active asthenospheric upwelling. We use interdisciplinary datasets integrating tectonic setting, mantle velocity models, water and gas chemistry, and microbial community analysis for a suite of CO$_2$-rich springs of the western U.S. The spring vent environments exhibit a range of temperature, pH and salinity but share key geochemical similarities to chemolithotrophic microbial ecosystems found in oceanic hydrothermal systems. Degassing in continental extensional settings supports microbial assemblages that are analogous to chemolithotrophic communities at mid-ocean ridges and continental volcanic hydrothermal systems as indicated by the widespread presence of archea and thermophilic organisms in cool as well as hot springs.

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