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UC SANTA BARBARA  
Department of Earth Science

# Earth Science Colloquium

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## Using and tracing reclaimed water for managed aquifer recharge

**Sarah Gerenday**

Earth Science, UC Santa Barbara

Addressing water insecurity requires creative solutions on the part of those who manage it. In developed areas which depend on groundwater, such solutions can include managed aquifer recharge (MAR) and water recycling. MAR is the practice of adding water to aquifers, usually via infiltration from gravel-bottomed basins, to prevent them from becoming depleted. This allows water to be stored for dry periods without the evaporative losses associated with surface reservoirs. Additionally, interaction with soil and microbes, collectively referred to as soil aquifer treatment (SAT), can remove contaminants from the recharge water. SAT is of particular importance when reclaimed water is used for recharge, in which case passage through the subsurface becomes the final step in the treatment process before the water reaches a well and is reincorporated into the municipal supply.

Since the effectiveness of SAT depends on the water spending sufficient time in the aquifer, many MAR

projects using reclaimed water require a tracer study to determine where the water travels and how fast. At an MAR site in the state of Washington, we added two inert chemicals ( $\text{SF}_6$  and  $\text{KBr}$ ) to the recharge water and measured their concentration in nearby wells to trace the water's movement. While  $\text{KBr}$  travels at the same velocity as the groundwater,  $\text{SF}_6$  can exsolve from solution as a gas when it encounters pockets of air, which slows its overall transport. By comparing the travel times of the  $\text{KBr}$  and  $\text{SF}_6$  tracers, we are able to calculate the amount of air trapped in the subsurface below the recharge basins. These pockets of air can contain oxygen, which may be used by microbes that break down contaminants. Thus, knowing both the water's travel time and the amount of air it encounters provides insight on its eventual quality when it reaches a well. Tracer studies are therefore useful in planning and permitting MAR projects, which allow for more sustainable management of water.

## $^{87}\text{Sr}/^{86}\text{Sr}$ of individual olivine-hosted melt inclusions from Mauna Loa, Hawai'i: Implications on the origin of the "ghost plagioclase" signature

**Olivia E. Anderson**

Earth Science, UC Santa Barbara

Melt inclusions with large, positive Sr anomalies have been described in multiple tectonic settings and their origin has been a topic of debate. Plagioclase is involved in these melt inclusions' origin because Sr is compatible in plagioclase and incompatible in other phases found in basalt. Three hypotheses, which all involve plagioclase as the source of the elevated Sr, were proposed to explain the origin of these melt inclusions: (i) direct assimilation of plagioclase, (ii) recycled lower oceanic crust in the mantle source, and (iii) shallow level diffusive interaction between present day lower oceanic crust (i.e., plagioclase-bearing cumulates) and the percolating melt. The latter two hypotheses best explain melt inclusions with a high, positive Sr anomaly and have no significant difference between its major element chemistry and other melt inclusions from the same lava without the large anomaly. The

presence of a high, positive Sr anomaly and the lack of elevated Al (a major element of plagioclase) is called a "ghost plagioclase" signature. This "ghost plagioclase" signature is present in a small subset of melt inclusions from Mauna Loa. A robust test to distinguish between the ghost plagioclase hypotheses is to obtain the  $^{87}\text{Sr}/^{86}\text{Sr}$  of each individual melt inclusion. Here we present new  $^{87}\text{Sr}/^{86}\text{Sr}$  measurements of individual olivine-hosted melt inclusions from Mauna Loa, including the Mauna Loa melt inclusion with the highest reported Sr anomaly for Hawaii. Mauna Loa melt inclusions have  $^{87}\text{Sr}/^{86}\text{Sr}$  values within the range reported previously for the volcano. Shallow-level diffusive interactions between Hawaiian plagioclase-rich cumulates and a percolating mantle-derived melt provides the simplest explanation for the presence of the high Sr anomaly in this small subset of melt inclusions from Mauna Loa.