

Reactive transport of common hydrological tracers in porous media – an experimental study

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Groundwater flow is commonly studied by means of tracer tests. The tracers commonly used involve inorganic salts and organic compounds. The results of such tests in porous rocks are based on the assumption that the tracers are inert, i.e. do not react with the solutions and/or minerals of the groundwater system.

In this study the chemistry of commonly used organic hydrological tracers were studied experimentally upon flow in porous rocks. The tracers studied included Fluorescein, Rhodamine B, Sodium Naphthionate, Pyranine, Amino Rhodamine G and Amino G in solutions of pH 3, 6 and 9 with three types of porous sand, quartz, rhyolitic and basaltic sand. The experiments were conducted using a Teflon flow-through reactor packed with the sand of interest. Experimental solutions with and without the tracers were alternatively pumped at fixed flow rates through the reactor and the tracer concentration at the outlet of the reactor continuously monitored spectrophotometrically. The major chemistry of the outflow solution was further studied. The experimental results were supported by 1-D reactive transport simulations conducted with the aid of the PHREEQC program. In the simulations, dissolution of the solids and formation of secondary minerals was taken into account as well as possible sorption processes. According to the experimental results and the reactive transport simulations the primary rocks alter to form secondary minerals and solutes that are partially transported out of them column (system). Some of the hydrological tracers studied were observed to be non-reactive, however, others seem to be affected by processes like adsorption and desorption. The results imply that simulation of groundwater flow in porous rocks based on tracer tests may not be valid in some cases without considering reactive transport and incorporating sorption reactions of the tracer used.

Melt inclusion constraints on the origin of the Peridot Mesa phonotephrite, San Carlos, Arizona

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The Peridot Mesa vent in San Carlos, Arizona, USA, is known for its striking array of upper mantle xenoliths, and the gem quality peridot that is mined from them. While many studies have been conducted on the xenoliths, surprisingly little is known regarding their host magma. Our previous petrographic, analytical, and experimental work [1, 2] showed that the Peridot Mesa lava is not a basanite as previously thought [3], but an evolved phonotephrite, and that the phenocrysts are consistent with crystallization of anhydrous magma during rapid ascent. Phase equilibrium experiments on the lava composition failed to reproduce the observed phenocryst assemblage however, regardless of a variety of pressures, temperatures, and volatile contents [2].

Given the energetic magmatic environment required to entrain and erupt such large (up to 50 cm dia) mantle xenoliths on the surface, one hypothesis for the inability of phase equilibrium experiments to crystallize the observed assemblage is that the erupted lava is the final product of mixing of two or more magmas that had different crystallization paths. This possibility is supported by the observation that there are several older occurrences of eruptions with similar characteristics in the area [4], indicating a well-developed pathway for such magmas.

As this mixing hypothesis must be ruled out before further phase equilibrium experiments are considered, an effort has been undertaken to identify and measure the composition of melt inclusions in the phenocrystic phases found in rapidly quenched scoria. Preliminary results from the electron microprobe on the bulk composition of the melt inclusions show that, similar to the residual glass, there is not significant variation in the liquid composition, suggesting that magma mixing and/or assimilation of xenolithic material is not an important process, or is extremely rapid and efficient, resulting in a homogeneous magma.

[1] Gullikson *et al.* (2010) *AGU Fall Meeting Abstracts*, 2263.

[2] Gullikson *et al.* (2012) *Mineralogical Magazine* **76**, 1790.

[3] Frey & Prinz (1978) *E.P.S.L.* **38**, 129–176. [4] Wrucke *et al.*, (2004) *Geological Investigation Series*, U.S.G.S., **I-2780**.