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Origin of hydrologic responses to earthquakes: constraints from the response of the Alum Rock Springs to the 2007 Alum Rock earthquake

M. Manga (1) and J.C. Rowland (2)

(1) UC Berkeley, Earth and Planetary Science (manga@seismo.berkeley.edu), (2) Los Alamos National Laboratory (joel.c.rowland@gmail.com)

The origin of increased stream flow and spring discharge following earthquakes has been the subject of controversy, in large part because there are many models to explain observations and few measurements suitable for distinguishing between hypotheses. On October 30, 2007 a magnitude 5.6 earthquake occurred near the Alum Rock springs, California, USA. We had been monitoring these springs for the previous 5 years in order to provide a benchmark for post-seismic changes in discharge and water composition. Immediately after the earthquake we documented a three-fold increase in discharge and a change in the composition of the water. Over the following year, we have monitored a gradual (but not yet complete) return towards pre-earthquake properties.

Increased discharge at these springs occurs for earthquakes that cause static volumetric expansion and those that cause contraction, supporting models in which dynamic strains are responsible for the subsurface changes that cause flow to increase. The Alum Rock springs discharge waters that represent a mixture between local ("shallow") meteoric water and old ("deep") connate waters expelled by regional transpression. After the earthquake, the increased discharge was accompanied by a decrease in the fraction of connate water in the spring discharge. Hence, the increased discharge has a "shallow" origin. We show models in which the permeability of the fracture system feeding the springs increases after the earthquake are in general consistent with both the flow and hydrogeochemical changes.