ABSTRACT

Travertines and Springs in Grand Canyon National Park

Laura Crossey & Karl Karlstrom
Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, NM

Grand Canyon, to a hydrologist, is a spectacular incised aquifer system: the Colorado River has cut down and "exposes" the anatomy of the ground water system of the Colorado Plateau. Travertines and travertine-depositing springs of the Grand Canyon region are a spectacular geologic, hydrologic, and biologic phenomenon within this system. Examples include the azure waters of the Little Colorado river and Havasu Creek, and their terraced dams and waterfalls. Other types of travertine accumulations include stone drapes and cones such as Travertine and Ribbon Falls, as well as features such as Pumpkin Spring. The travertines are an important part of the Quaternary geologic record of Grand Canyon, providing information about both incision and past hydrologic conditions and paleoclimate. To make use of this record, a detailed understanding of how the deposits form is critical. These features have long been thought to form from infiltration of surface waters on the Plateau, dissolution of carbonate strata during progressive "downward" migration of the groundwater, and ultimately discharging into the incised Grand Canyon where the release of CO_2 results in the precipitation of calcite. However, recent geochemical study of water and gas has resulted in a new paradigm for understanding a more complex groundwater mixing story and an "upward" migrating fluid component.

Geochemical analyses show what boatmen have known all along: that springs in Grand Canyon have marked variability: cool and fresh (like Tapeats Creek) versus warm and salty (like the LCR and Lava Warm springs). Waters associated with active travertine accumulations from **lower world** or "endogenic" waters are more saline, much richer in CO_2 (i.e., carbonated or ‘sparkling’ waters), and elevated in $^{87}Sr/^{86}Sr$ compared to springs derived dominantly the **upper world** or "epigenic" from surface recharge waters. It turns out it is the deeply derived CO_2 that allows large volumes of the calcium carbonate to be dissolved from the limestone in the first place. Lower world waters and associated travertine are preferentially located along basement-penetrating faults (like the Elves Chasm area associated with the Monument fold) suggesting that lower world fluids are conveyed upward via both magmatism and seismicity to mix with upper world recharge waters. This model (Crossey et al., 2006) is supported by: (1) gas analyses from spring waters with high He/Ar and He/N_2 and $^3He/^4He$ ratios indicating the presence of mantle-derived He; (2) large volumes of travertine and CO_2-rich gases in springs recording high CO_2 fluxes; and (3) $^{87}Sr/^{86}Sr$ in these springs that indicate circulation of waters through Precambrian basement. Lower world waters are volumetrically minor but they are very "juicy" and have significant effects on water chemistry. Until now, they have been a largely unrecognized component of the hydrogeochemistry and neotectonics of the Grand Canyon region.