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Old Groundwater, Interbasin Groundwater Flow, Magmatic Solutes, and Hydrologic Fluxes of Carbon in a Lowland Costa Rican Rainforest

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Carbon (C), helium (He), and chloride (Cl) concentrations and isotopes were measured in groundwater and surface-water in a lowland Costa Rican rainforest at the foot of Volcan Barva (a 2900 m peak that is one of the largest in the Cordillera Central of Costa Rica). Results are consistent with the presence and mixing of two distinct groundwaters: (1) high-solute bedrock groundwater representing interbasin groundwater flow (IGF) into the rainforest watersheds, and (2) low-solute local groundwater recharged within the lowland rainforest watersheds. In bedrock groundwater, high δ^{13}C (-4.89 $^{o}/_{oo}$), low ^{14}C (7.98 pmC), high R/R$_A$ for He (6.88), and low ^{36}Cl/Cl (17x10^{-15}) suggest that elevated DIC, He, and Cl concentrations are derived from magmatic outgassing and/or weathering of volcanic rock beneath nearby Volcan Barva. In local groundwater, the magmatic signature is absent and data suggest atmospheric sources for He and Cl and a biogenic soil-gas CO_2 source for DIC. ^{14}C dating suggests the age of bedrock groundwater is 2700-4300 years (most likely at the lower end of the range). Local groundwater has ^{14}C$>$100 pmC, indicating the presence of "bomb carbon" and thus ages less than $\sim$50 years for these samples collected in 2006. Overall, the C, He, and Cl data are consistent with a prior conceptual hydrologic model developed with major ion and water-balance data from this tropical rainforest: (1) the large variation in solute concentrations can be explained by mixing of the two distinct groundwaters, (2) bedrock groundwater is much older than local water, (3) elevated solute concentrations in bedrock groundwater are derived from volcanic fluids and/or rock, and (4) local water has not had significant interaction with volcanic rock. Tracers with different behaviors and capabilities converge on the same hydrologic interpretation. Also, transport of magmatic CO_2 into the lowland rainforest (as DIC in the IGF) seems to be significant relative to other large ecosystem-level carbon fluxes. Dissolved carbon export from the watersheds via streamflow is dominated by DIC (DOC accounts for $<$5%). Hydrologic fluxes of carbon, whether associated with IGF or otherwise, merit attention as significant components of the watershed-level carbon budgets in this lowland rainforest.