Identifying origins of and pathways for spring waters in a semiarid basin using He, Sr, and C isotopes: Cuatrociénegas Basin, Mexico

GCCC Digital Publication Series #12-19

B. D. Wolaver
L.J. Crossey
K.E. Karlstrom
J.L. Banner
M.B. Cardenas
C. Gutiérrez Ojeda

Keywords:
Field study, Monitoring, Monitoring-tracers, Monitoring-groundwater-USDW, Natural Analogues

Cited as:
Wolaver, B.D., Crossey, L.J., Karlstrom, K.E., Banner, J.L., Cardenas, M.B., Ojeda, C. Gutiérrez, 2012, Identifying origins of and pathways for spring waters in a semiarid basin using He, Sr, and C isotopes: Cuatrociénegas Basin, Mexico: Geosphere, v. 9, no. 1, p. 113-115. GCCC Digital Publication #12-19.

Abstract:

He, C, and Sr isotopes are used to infer spring sources in a water-stressed area. Spring-water origins and pathways in the Cuatrociénegas Basin are revealed by linking structure and geochemistry via regionally extensive fault networks. This study presents the first dissolved noble gas and He isotopic data from northeastern Mexico. Basement-involved faults with complex reactivation histories are important in northeastern Mexico tectonics and affect hydrogeologic systems. The importance of faults as conduits for northeastern Mexico volcanism is recognized, but connections between faulting and the hydrogeologic system have not been extensively investigated. This research tests the hypothesis that Cuatrociénegas Basin springs are divided into two general classes based upon discharge properties: (1) regional carbonate aquifer discharge (mesogenic) mixed with contributions from deeply sourced (endogenic) fluids containing ^{3}He and CO_2 from the mantle that ascend along basement-involved faults; and (2) carbonate aquifer discharge mixed with locally recharged (epigenic) mountain precipitation. Carbonate and/or evaporite dissolution is indicated by Ca-SO_4 hydrochemical facies. He isotopes range from 0.89 to 1.85 R_A (R_A is the $^{3}He/^{4}He$ of air, 1.4×10^{-6}) and have minimal ^{3}H, from which it is inferred that basement-involved faults permit degassing of mantle-derived He (to 23% of the total He) and CO_2 ($pCO_2 \leq 10^{-1}$ atm). Mantle degassing is compatible with the thinned North American lithosphere, as shown in tomographic images. Sr isotopes in both Cuatrociénegas Basin springs and spring-deposited travertine ($^{87}Sr/^{86}Sr$ = 0.707428–0.707468) indicate that carbonate rocks of the regional Cupido aquifer ($^{87}Sr/^{86}Sr$ = 0.7072–0.7076) are the main source of Sr. Rock-water interactions with mafic volcanic rocks ($^{87}Sr/^{86}Sr$ = 0.70333–0.70359) are not inferred to be an important process. Groundwater-dissolved inorganic C origins are modeled using major elements and C isotopes. C isotope data show that ~30% ± 22% of CO_2 in spring water is derived from dissolution of aquifer carbonates (C_{carb} = 30%), 24% ± 16% is from soil gas and other organic sources (C_{org} = 24%), and 46% ± 33% is from deep sources [C_{endo} (endogenic crust and mantle) = 46%]. This study demonstrates the presence of mantle-derived ^{3}He and deeply sourced CO_2 that ascend along basement-penetrating faults and mix with Cupido aquifer groundwater before discharging in Cuatrociénegas Basin springs.

To access full text, please contact the author or visit:
http://geosphere.geoscienceworld.org/content/9/1/113.full