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Application of ^{85}Kr, ^{3}H, ^{39}Ar, and ^{14}C, noble gas thermometry, and modeling to constrain mountain-front recharge to basin-fill aquifers

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Large populations in critically water-stressed regions currently depend on basin groundwater sourced from mountain-front recharge (MFR), or are pivoting to groundwater to meet growing demands, as surface water supplies decline from overallocation and drought. MFR is predicted to decline with decreasing winter precipitation and increasing temperatures in the US southwest from climate change [1], and Pleistocene to Holocene recharge rates are relatively unknown. In addition, parsing out MFR rates, elevations, flowpaths, and transit times is challenging with often limited information from mountain blocks [2], yet important to constrain impacts of past to present climate change and development on groundwater resources.

This study utilizes long-screened production wells within a basin-fill aquifer system in Arizona to evaluate groundwater age distributions, using multiple age tracers (^{3}H, ^{85}Kr, ^{39}Ar and ^{14}C) that cover age ranges from years to tens of thousands of years, to distinguish and quantify various MFR components [3]. Relatively old water (i.e., no detectable ^{3}H), representing diffuse mountain block recharge (MBR), was detected in weathered bedrock at the mountain front, while wells within the basin-fill aquifer near the mountain front show binary mixtures between mostly modern (surface MFR) and older (diffuse MBR) water. Wells further away from the mountain front contain groundwater on the order of thousands of years old. ^{3}H and ^{39}Ar were the most informative tracers for determining the best-fit age distributions. Importantly, traditional noble gas thermometry using lapse rates derived from air and spring temperatures at various elevations in the moutain block produced improbable recharge elevations for basin groundwater. Numerical experiments using flow and energy transport modeling suggest that cold, high elevation derived runoff infiltrated into permeable basin-fill aquifers can locally suppress water table temperatures at the mountain front. These results have important implications for the application of new noble gas tracers (e.g., ^{39}Ar, ^{85}Kr) to constrain intermediate groundwater age distributions, as well as the application of noble gas thermometry in semi-arid, intermontane basin-fill aquifers that are sustained by snowmelt-derived recharge at the mountain front.

[1] Meixner et al. (2016) J. Hydrol. [2] Markovich et al. (2019) *Water Resour. Res.* [3] Markovich et al. (2021) *Water Resour. Res*.