Geochemical Studies of Surface Water/Groundwater Interactions in Central Washington, USA

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Central Washington is an agricultural region in the rainshadow of the Cascade Mountains where water availability is limited and issues of both groundwater quality and groundwater mining exist. Geochemical studies of groundwater from three areas in central Washington present contrasting stories of water use and groundwater/surface water interactions.

Most of central Washington lies within the Columbia River Basalt Province, regionally extensive basalt flows interbedded with sedimentary layers that serve as the main water-bearing units. The Columbia River Basalts extend to approximately 80 km east of the Cascade crest; west of this terminus, the hydrogeologic framework is a complex geometry of older bedrock, in which fractures likely control much of the groundwater flow.

The three study areas presented here are: 1) upper Kittitas county, located in the fractured bedrock adjacent to the Cascade crest, where water is limited due to aquifer transmissivities but agricultural water demands are low; 2) the Ellensburg area, a sedimentary basin in a basalt syncline, where irrigation is primarily accomplished using surface water; 3) the Royal Slope region to the east of the Columbia River, where extensive irrigation is accomplished using groundwater drawn largely from basalt aquifers as well as surface water. A variety of geochemical techniques, (major ion, trace element, stable isotope, and Sr isotope analyses) were combined with principal component analysis to decipher different groundwater types and their connectivity with surface water in these study areas. Stable isotope analyses generally differentiate three types of water in central Washington: 1) groundwaters that are heavily influenced by irrigation water, often with elevated nitrate concentrations; 2) shallow groundwater that is isotopically distinct from irrigation water; 3) ancient groundwater that is isotopically lighter than modern waters, usually found in the deeper basalt aquifers. Groundwater geochemistry and patterns of groundwater/surface water interactions depend on aquifer lithologies, characteristics, and depths; groundwater residence times; geologic structures and fracture orientations; and timing and source of irrigation water.