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Origins of Thermal Waters in Colorado

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Chemical geothermometers indicate that reservoir temperatures for many thermal waters manifested as hot or warm springs in Colorado are significantly hotter than the temperatures at which the waters emerge at the surface. For most of these waters there is no young (<1 Ma) volcanism within 10 km of springs, and a component of volcanic shallow heat is thought to be unlikely. The spring waters are thought to have been heated by the circulation of groundwater to depth and heated by the ambient temperatures at depth: some of these temperatures may be higher than normal in association with high geothermal gradients and/or high heat flow.

Heated water may rise to the surface after circulation to depth either by groundwater flow driven by piezometric gradients (differences in height of the water table) or by thermal buoyancy (differences in density associated with temperature differences), or a combination of both. The former mechanism requires a combination of piezometric gradients and a permeability system than directs flow to depth for heating, then back to the surface. The rate of flow must be carefully balanced so that it is not so slow that the water cools on its ascent to the surface, but not so fast that it cools the rocks at depth. If the water is constrained to fracture flow, this may limit the total productivity of the system to its surface discharge. If the flow is in a confined sedimentary aquifer, however, only a small fraction of which discharges at the surface, a significant reservoir may remain subsurface. Such systems may exist in the Rio Grande rift in the San Luis Basin, and are probably common in the rift basins of New Mexico and West Texas.

For thermal waters to rise under thermal buoyancy, a nearvertical, low-permeability pathway must exist for the ascent of these waters. The coincidence of thermal springs in some areas of Colorado with accommodation zones in valley-bounding normalfault systems, as in the Upper Arkansas Valley of Chaffee County, suggests that these zones may provide such vertical pathways. Water is probably prevented from rising elsewhere in the valley by horizontally-stratified low-permeability layers in the valley fill, and water is channeled to the basin margins by basinwarddipping strata. In these systems the thermal waters rising to the surface probably represent only a fraction of the hot-water reservoir at depth.

Understanding the origins of thermal waters is thus useful in predicting the expected sizes of reservoirs likely to be associated with surface thermal springs.