U.S.Geothermal Exploration, Development, and Management of the Neal Hot Springs Geothermal Resource, Malheur County, Oregon

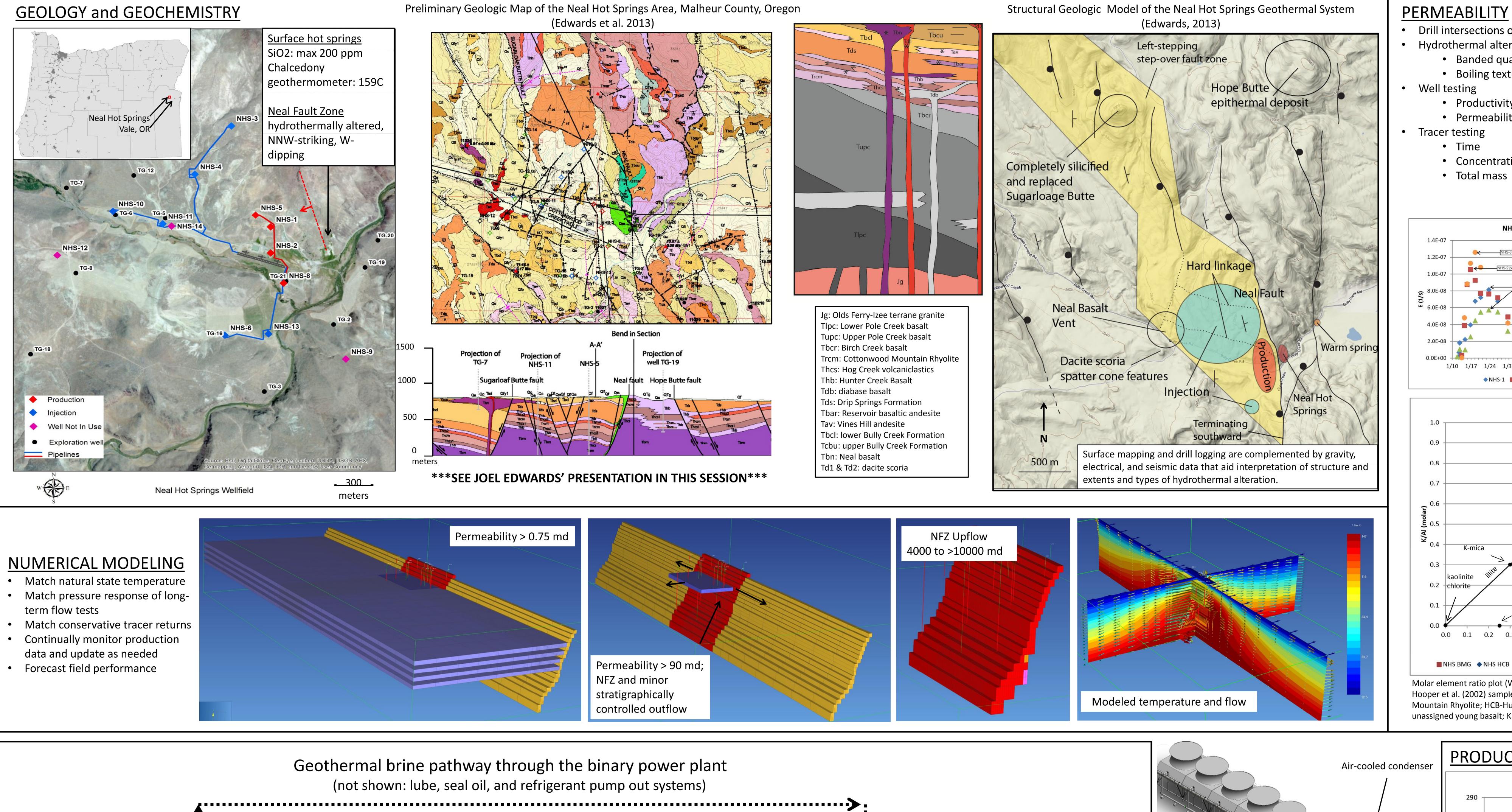
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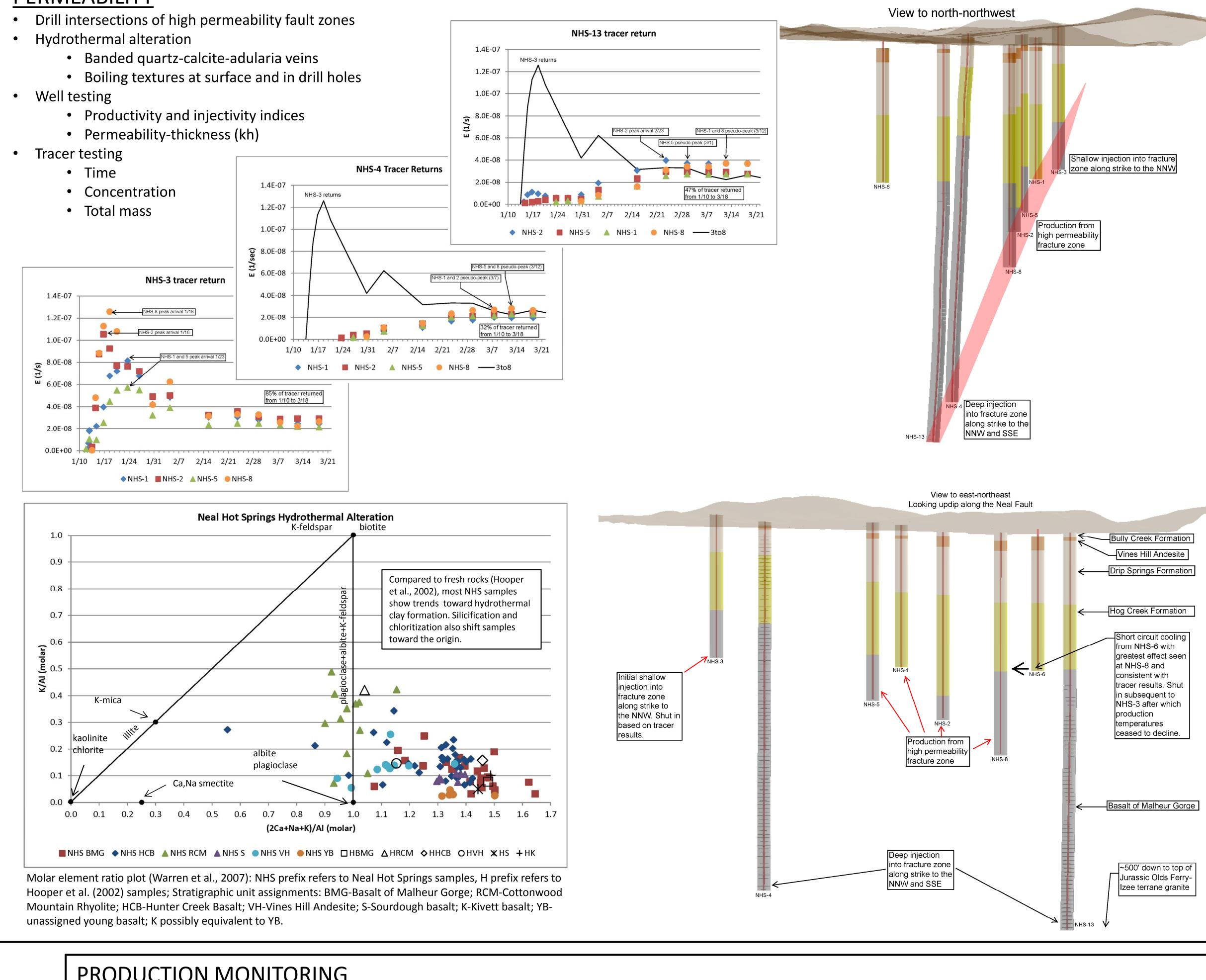
ABSTRACT

Neal Hot Springs is a Basin-and-Range style geothermal system located 20 km northwest of the Known Geothermal Resource Area at Vale, OR. Natural hot springs discharge small volumes of 90 C, neutral pH, chloride water to form opaline sinter near the southward termination of the NNW-striking, W-dipping Neal Fault Zone (NFZ). Brecciated and silicified Miocene volcanic rocks occur along the NFZ surface trace and down dip where they comprise the bulk of the productive reservoir, exhibiting increasing intensity of silica-chlorite-pyrite alteration with proximity to the NFZ. Miocene volcanic rocks are underlain by Jurassic granodiorite at depths >2100 m below surface and at temperatures >150 C.

U.S. Geothermal Inc. acquired and began exploration of the property based on chalcedony geothermometry of surface discharges indicating a resource temperature >145 C and on historic drill intersections indicating high permeability. A simple structural model developed from surface mapping guided the targeting of permeability controlled by the NFZ. Well NHS-1 was highly successful with flow testing confirming a 141 C reservoir with permeability-thickness >300 darcy-meters. Follow-up drilling resulted in completion of six additional wells into the NFZ. Four production wells intersect the NFZ at depths 700 m to 1100 m below surface and feed 700 kg/s of 141 C brine to an air-cooled, binary power plant that produces up to 35 MW (net). Injection is primarily into wells that intersect the NFZ down dip and along strike from production zones at depths 1520 m to 1890 m below surface.

Based on long-term flow test and model simulation results, much of the brine is required to be injected into the NFZ to provide long-term pressure support. Tracer testing showed that moderate depth wells along strike and in the hanging wall returned large percentages of injected tracer mass relatively rapidly to production wells, whereas deep, down-dip wells returned only a few percent of tracer mass relatively slowly. Tracer test results were confirmed when rapid cooling at plant startup was quickly remedied with shut in of the moderate depth injection wells. Currently, the field continues to produce 700 kg/s of 141 C brine, and there is no temperature decline, something that is typically linear with time in Basin-and-Range-type systems.





Compositional Gradients Associated with Epithermal Au-Ag Mineralization: Economic Geology, v. 102, pp. 923–948.

