Thermal Springs and Geothermal Exploration

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There is considerable interest in thermal springs because of their potential as a geothermal exploration tool. However, the nature of the relationship between thermal springs and geothermal resources at depth has not been well documented. The case can be made that thermal springs are indicative of an environment with elevated isotherms in the near surface environment but this does not necessarily translate into increased temperatures deeper in the subsurface, particularly those which would allow for electricity generation. In this study, we examine the relationship between temperature, volumetric discharge and heat flow for 890 thermal springs in North America obtained from various databases and government reports. These data are by no means exhaustive and contain only a subset of known thermal springs in North America. In particular, we have selected springs with both temperature and volumetric discharge measurements to facilitate heat flow calculations.

The maximum heat flow value associated with a spring is approximately 10^8 W and such springs are observed at a variety of temperatures and discharge rates, which represents the total heat flow for an area of over 1000 km^2. These higher heat flow springs have volumetric discharge rates ranging from 100 to 10000 L/s, implying recharge areas of up to 100s of km^2. In reality, these areas will likely be considerably larger because not all recharge becomes part of the deeper flow systems discharging at a given spring.

The bulk of thermal springs occur by extracting heat from a relatively large area with a small percentage of groundwater recharge. The variation in volumetric discharge suggests that the hydrogeology of an area is an important control on the development of thermal springs. Specifically, recharge rates must be sufficient to allow for noticeable springs to occur but at higher fluid fluxes, but this increase in downward groundwater flow will actually reduce temperatures in the area. In many cases, the existence of thermal springs may be a strong indication that an area is a poor candidate for geothermal development, particularly for electricity generation. Thermal springs with high temperatures and low volumetric discharges are more likely to indicate conditions necessary for electricity generation because such springs can occur with a negligible effect on a region's heat flow budget.