Geothermal Resources Council, SPECIAL REPORT NO. 13, May 1983

Controls on the Location and Intensity of Magmatic and Non-Magmatic Geothermal Systems in the Basin and Range Province

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ABSTRACT

Geothermal systems of known or probable magmatic control are located along the eastern and western margins of the Basin and Range province, at or very near its contact with the Colorado Plateau and Sierra Nevada provinces. These include Roosevelt Hot Springs and possibly Cove Fort, Utah, along the eastern boundary; and Coso Hot Springs and Long Valley, California, and Steamboat Springs, Nevada, along the western boundary. No geothermal system located away from the margin of the Basin and Range province is believed to have active magmatic source.

Magmatic systems are characterized by very youthful silicic volcanism, with emplacement of major plutons occurring at depths of perhaps 5 to 10 km. There is limited evidence that these occur at the intersection of northeast-trending fracture zones or lineaments with the province boundaries. Where depth to groundwater is relatively great, thermal emissions are weak to absent. Shallow groundwater is associated with stronger thermal emissions, as at Steamboat Springs or Long Valley. Temperatures in magmatic systems are higher at comparable depth than in non-magmatic systems. Therefore, it is not surprising that magmatic systems are commercially productive at shallower depth. At least 3 of the magmatic systems (Coso, Steamboat and Roosevelt) are present within fractured granitic basement.

High-temperature, non-magmatic systems (over 200°C) discovered to date are located in the western half of the northern Basin and Range province. Several of these fall along important northeast-trending zones of topographic flexures, linear river valleys and left-lateral strike-slip faults that have been active during the Quaternary. From this, it is assumed that a deep-seated set of northeast-trending fractures leaks heated fluids more intensely than do fractures of other orientation.

Although most non-magmatic systems have surface expression along range-front faults, several (Soda Lake, Desert Peak, Humboldt House and Salt Wells) have little or no leakage manifestation. In these cases, either the water table is deep, or controlling faults are not well-defined. The ultimate source of heat for these systems is the very thinness of the crust in the northern Basin and Range (22-25 km). However, it appears that the temperature in the crystalline basement is, in many cases, related to or controlled by the thickness of low-conductivity sedimentary cover. Undoubtedly, there is convective transfer of heat along faults and other fractures, to depth of perhaps 3 to 4 km. This would account for the linear or arcuate pattern of both the surface emissions and the underlying high-temperature system.

In the final analysis, the distribution of high-temperature versus moderate-temperature non-magmatic systems may be controlled by the thinness of the crust and the thickness of low-conductivity cover.