Geyser Instability

The geyser instability that is so familiar to visitors to Yellowstone National Park and other areas of geothermal activity, has some similarities to the Ledinegg instability, but also has important differences. It has been studied in some detail in smaller scale laboratory experiments (see, for example, Nakanishi *et al.* 1978) where the parametric variations are more readily explored.

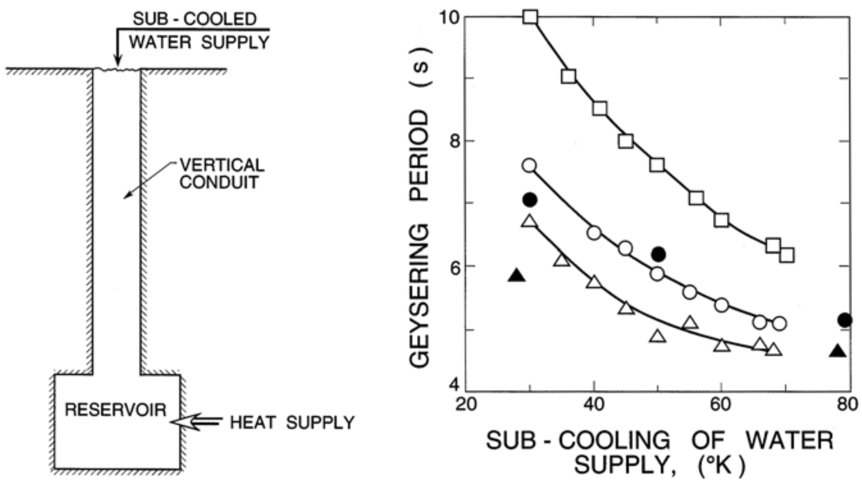

Figure 1: Left: The basic components for a geyser instability. Right: Laboratory measurements of geysering period as a function of heat supply ($200W$: □, $330W$: ◯, $400W$: ⋄) from experiments (open symbols) and numerical simulations (solid symbols). Adapted from Tae-il *et al.* (1993).

The geyser instability requires the basic components sketched in Figure 1, namely a buried reservoir that is close to a large heat source, a vertical conduit and a near-surface supply of water that can drain into the conduit and reservoir. The geyser limit cycle proceeds as follows. During the early dormant phase of the cycle, the reservoir and conduit are filled with water that is being heated by the geothermal source. Once the water begins to boil the vapor bubbles rise up through the conduit. The hydrostatic pressure in the conduit and reservoir then drops rapidly due to the reduced mixture density in the conduit. This pressure reduction leads to explosive boiling and the eruption so widely publicized by *Old Faithful*. The eruption ends when almost all the water in the conduit and reservoir has been ejected. The reduced flow then allows sub-cooled water to drain into and refill the reservoir and conduit. Due to the resistance to heat transfer in the rock surrounding the reservoir, there is a significant time delay before the next load of water is heated to boiling temperatures. The long cycle times are mostly the result of low thermal conductivity of the rock (or other solid material) surrounding the reservoir and the consequent low rate of transfer of heat available to heat the sub-cooled water to its boiling temperature.

The dependence of the geysering period on the strength of the heat source and on the temperature of the sub-cooled water in the water supply is exemplified in Figure 1 which presents results from the small scale laboratory experiments of Tae-il *et al.* (1993). That figure includes both the experimental data and the results of a numerical simulation. Note that, as expected, the geysering period decreases with increase in the strength of the heat source and with the increase in the temperature of the water supply.