Eruptions at Lone Star Geyser, Yellowstone National Park, USA: Energetics and Eruption Dynamics

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Geysers provide a unique natural laboratory to study multiphase eruptive processes. We present results from a four day experiment at Lone Star geyser in Yellowstone National Park, USA. We measured simultaneously water discharge, acoustic emissions, infrared intensity, and visible and infrared video to quantify the energetics and dynamics of eruptions, occurring approximately every three hours. We define four phases in the eruption cycle: 1) a 28 ± 3 minute phase with liquid and steam fountaining, maximum jet velocities of 16–28 m/s, steam mass fraction of 0.5–2.5$\%$, intermittently choked flow, and unsteady flow oscillations with periods increasing from 20 to 40 s, coincident with a decrease in jet velocity and an increase of steam fraction, 2) a 26 ± 8 minute post-eruption relaxation phase with no fluid discharge from the vent, infrared (IR) and acoustic power oscillations gliding between 30 and 40 s, and ~ 8 s lag between the peak in acoustic and IR signals, 3) a 59 ± 13 minute recharge period during which the geyser reservoir progressively refills, and 4) a 69 ± 14 minute pre-play period characterized by a series of 5–10 minute–long steam puffs, small volumes of liquid water discharge, 50–70 s oscillations, and no lag between IR and acoustic signals. The erupted waters ascend from a $163 \pm 5°$C – $186 \pm 2°$C reservoir and the volume discharged during the entire eruptive cycles is 20.8 ± 4.1 m^3. Assuming isentropic expansion, we calculate a heat output of 1.5–1.7 MW, which is $< 0.1\%$ of the total heat output from Yellowstone Caldera.