Fluid Oscillations in a Laboratory Analog Geyser with Steam Injection and a Bubble Trap

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It has been known for over two centuries that geyser eruptions are caused by instabilities associated with a pressure build-up in the subsurface plumbing system. However, fundamental features, such as the difference in dynamics of cone and pool geysers or the controls over periodicity and oscillation frequency, are still not understood. In 2011, researchers discovered through both seismic and video data that many geysers contain an impermeable cavity that is offset from the main eruption conduit. The presence of a so-called “bubble trap” cavity allows a buildup of steam, which can store both thermal and potential energy as it compresses under pressure. As more steam and hot water are added to the geyser through hydrothermal flow, the total energy available for eruption significantly increases. We use a laboratory analog geyser to investigate under what conditions eruptions are initiated and terminated and the determinants of physical properties of the bubble trap geyser. Our lab geyser includes both electric heaters and a steam injection system, to simulate the feeding and driving systems of natural geysers. We measure the frequency of oscillations for cold water geysers (to confirm the results from Rudolph et al 2018), hot water geysers, and steam-injected geysers. For the cold and hot water geysers, we instigated a perturbation in the conduit by pumping a small quantity of air into the bubble trap and varied the water level in the tank and the pressure in the bubble trap (reflected by the height of water in the conduit). For steam-coupled geysers, instead of pumping air, we added a controlled volume of steam into the geyser, adding both mass and heat into the system. We present relations between the system’s geometry, initial conditions, and observables such as eruption periodicity and oscillation frequency, which can help decipher the internal processes at natural geysers in the future.