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Geophysical investigations of a vapor-dominated hydrothermal area in Yellowstone National Park, USA

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In vapor-dominated systems, steam and gas ascend from a deep boiling water reservoir though a narrow conduit ("heat pipe") and condense near the surface beneath a low-permeability cap layer. Liquid water then descends through fractures driven by gravity. In this study, we investigate a vapor-dominated system in the Solfatara Plateau Thermal Area (SPTA) near the northern rim of the Yellowstone Caldera. The SPTA is within a rhyolite flow which is locally covered by cemented glacial deposits. We combine magnetic, electromagnetic and geoelectrical methods to image the structures that facilitate hydrothermal flow, the geometry of the heat pipe and the distribution of hydrothermal alteration. Inversion of the magnetic data and of the transient-electromagnetic soundings indicate a basin of glacial deposits that coincides with the edge of a younger flow overlaying the Solfatara Plateau flow. Steam may therefore originate from discharge of pressurized fluids flowing at the brecciated base of the younger flow into the higher permeability glacial deposits where decompression results in boiling and steam separation. Our 3-D model of electrical conductivity shows a conductive body interpreted as a steam pathway focused within a narrow conduit (heat pipe), which coincides at the surface with heat and CO_2 flux maxima. Results from the magnetic survey and superficial magnetic susceptibility measurements indicate that destruction of magnetic minerals mainly occurs in the shallow subsurface, where acid-sulfate water dissolves magnetic minerals, but is largely absent at greater depth in the system.