Plumbing the depths of Yellowstone' s hydrothermal system: preliminary results from a helicopter magnetic and electromagnetic survey

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Although Yellowstone' s iconic hydrothermal systems are well mapped at the surface, their groundwater flow systems are almost completely unknown. In order to track the geophysical signatures of geysers, hot springs, mud pots, steam vents, and hydrothermal explosion craters at depths to hundreds of meters, we collected 4900 line-km of helicopter electromagnetic and magnetic (HEM) data. The data cover significant portions of the caldera including a majority of the known thermal areas. HEM data constrain electrical resistivity which is sensitive to groundwater salinity and temperature, phase distribution (liquid-vapor), and clay formed during chemical alteration of rocks. The magnetic data are sensitive to variations in the magnetization of lava flows, faults and hydrothermal alteration. The combination of electromagnetic and magnetic data is ideal for mapping zones of cold fresh water, hot saline water, steam, clay, and altered and unaltered rock. Preliminary inversion of the HEM data indicates low resistivity directly beneath Yellowstone Lake as well as beneath most of the area with mapped hydrothermally altered rocks; the majority of these areas are also associated with magnetic lows. In the northern part of Yellowstone Lake, low resistivity zones intersect with the lake bottom in close correspondence with mapped vents, fractures and hydrothermal explosion craters and are also associated with magnetic lows. Coincident resistivity and magnetic lows unassociated with mapped alteration occur, for example, along the southeast edge of the Mallard Lake dome and along the northeastern edge of Sour Creek Dome, suggesting the presence of buried alteration. Low resistivities unassociated with magnetic lows may relate to hot and/or saline groundwater, to which the magnetic data are insensitive. Resistivity and magnetic lows follow interpreted caldera boundaries in places, yet deviate in others. In the Norris-Mammoth Corridor, NNE-SSW trending linear resistivity and magnetic lows align with mapped faults. This pattern of coincident resistivity and magnetic lows may reflect fractures along which water is flowing. In addition, low resistivities underlie highly resistive and magnetic rhyolite flows, and in several cases, suggest interconnection between the different thermal areas.

Keywords: Yellowstone, geophysics, hydrothermal, electromagnetic, magnetic

