Update on Dating Hydrothermal Explosions in Yellowstone National Park using Luminescence Dating

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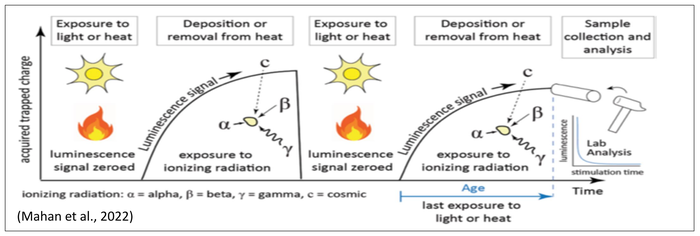
ABSTRACT

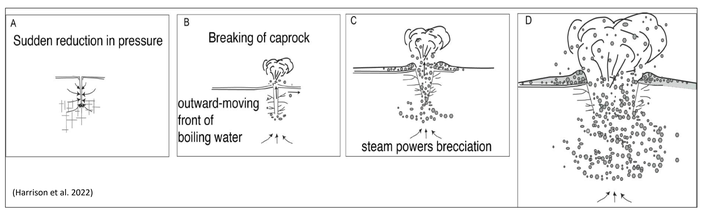
The Yellowstone Plateau Volcanic Field hosts an active hydrothermal system that has produced some of the largest hydrothermal explosions in the world. Hydrothermal activity in Yellowstone National Park has been nearly continuous throughout the recent glaciations and has resulted in explosion craters throughout the volcanic field._ However, the ages of these craters remain poorly constrained, limiting our understanding of their recurrence intervals and associated hazards. Using luminescence dating, we have characterized luminescence signals from K-feldspar and quartz grains that compare well with an independently dated Mary Bay explosion. Single aliquot regenerative post-infrared infrared stimulated luminescence dating of K-feldspar grains and red thermoluminescence dating of quartz grains are used to date these explosions. These measurements produce cooling ages for sediments that experienced elevated temperatures in hydrothermal reservoirs prior to the explosions. Here we focused on two craters, one without previous geochronologic constraints (Pocket Basin) and one (Mary Bay) with a previously determined radiocarbon age as a control on method accuracy. Dating these hydrothermal explosions could provide insights into their triggering mechanisms and associated hazards, allowing for better risk assessments and monitoring strategies to protect against future hazardous events.

LUMINESCENCE DATING



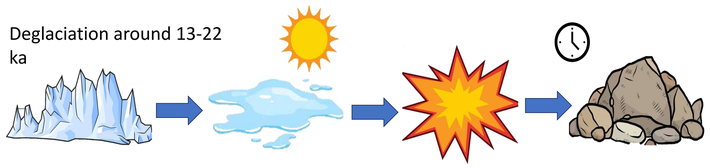
Schematic of luminescence signal accumulation and resetting. Luminescence signal resets with exposure to light and heat while burial allows for the signal to grow.

HYDROTHERMAL EXPLOSIONS

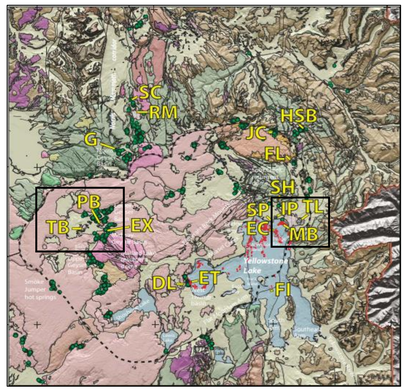


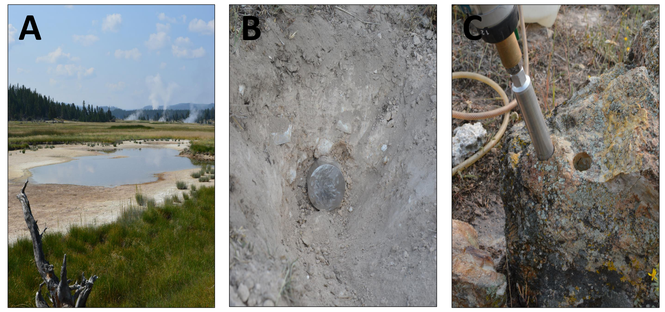
As glaciers melt, the underlying hydrothermal reservoirs experience a reduction in pressure that can potentially trigger an explosion.

Can deglaciation cause hydrothermal explosions?



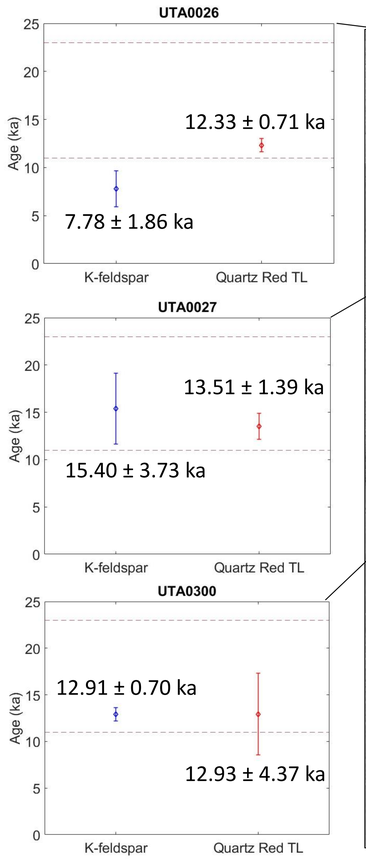
FIELD SITE/SAMPLING





A) Overview of Pocket Basin Crater. B) Sediment sample retrieved from hillside of Pocket Basin crater. C) Rock interior retrieved through coring of explosion thrown boulder.

POCKET BASIN RESULTS



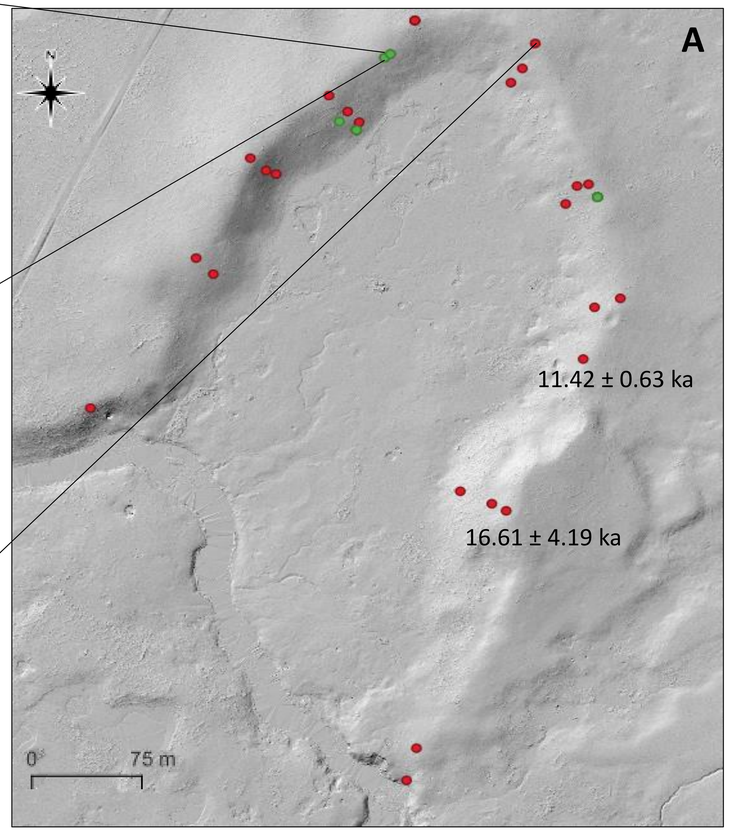
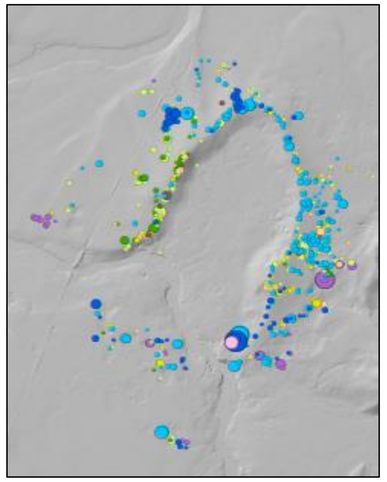
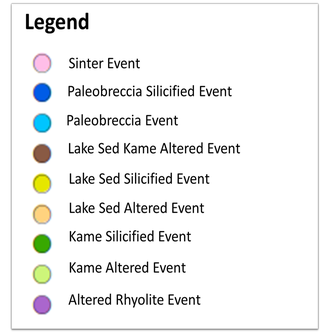


Figure A shows a hillshade of the Pocket Basin crater. Green and red dots represent sediment sampling locations from 2021 and 2023 respectively. K-feldspar pIRIR and quartz red TL luminescence ages are shown around the crater. K-feldspar and quartz are showing age agreement with each other and fall within the Pinedale deglaciation event.

Cooling ages fall within the Pinedale deglaciation event.

EXPLOSION BALLISTICS

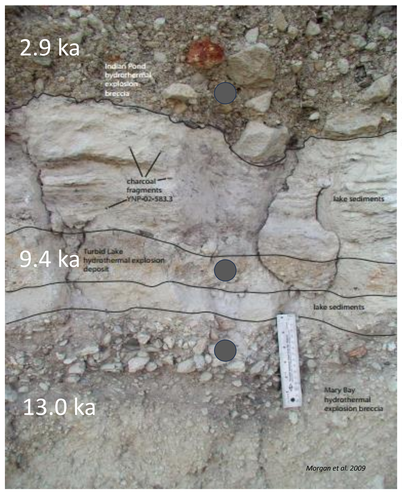


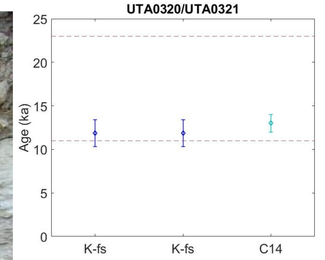


Pocket Basin Crater lithology ballistics map. All points indicate hydrothermal explosion thrown material. Point size represents size of material.

Concentrations of ballistics indicate more than one hydrothermal explosion.

MARY BAY



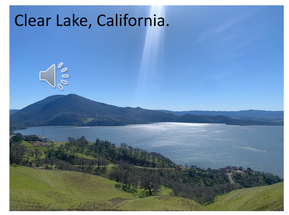


Constrained radiocarbon ages for three hydrothermal explosions (Morgan et al. 2009). Grey circles represent the sample locations for luminescence dating. This allows for a comparison of methodologies.

Agreement of radiocarbon and luminescence ages.

Future Directions

- Continue dating the full extent of Pocket Basin to determine explosion histories.
- Apply this methodologies to other volcanic settings such as the maar eruptions in Clear Lake, California.



References

Morgan, Lisa A, et al. “Hydrothermal Processes above the Yellowstone Magma Chamber: Large Hydrothermal Systems and Large Hydrothermal Explosions.” Geological Society of America EBooks, 1 Jan. 2009, Accessed 8 June 2024.