Cooling Ages of Hydrothermal Explosions in Yellowstone National Park

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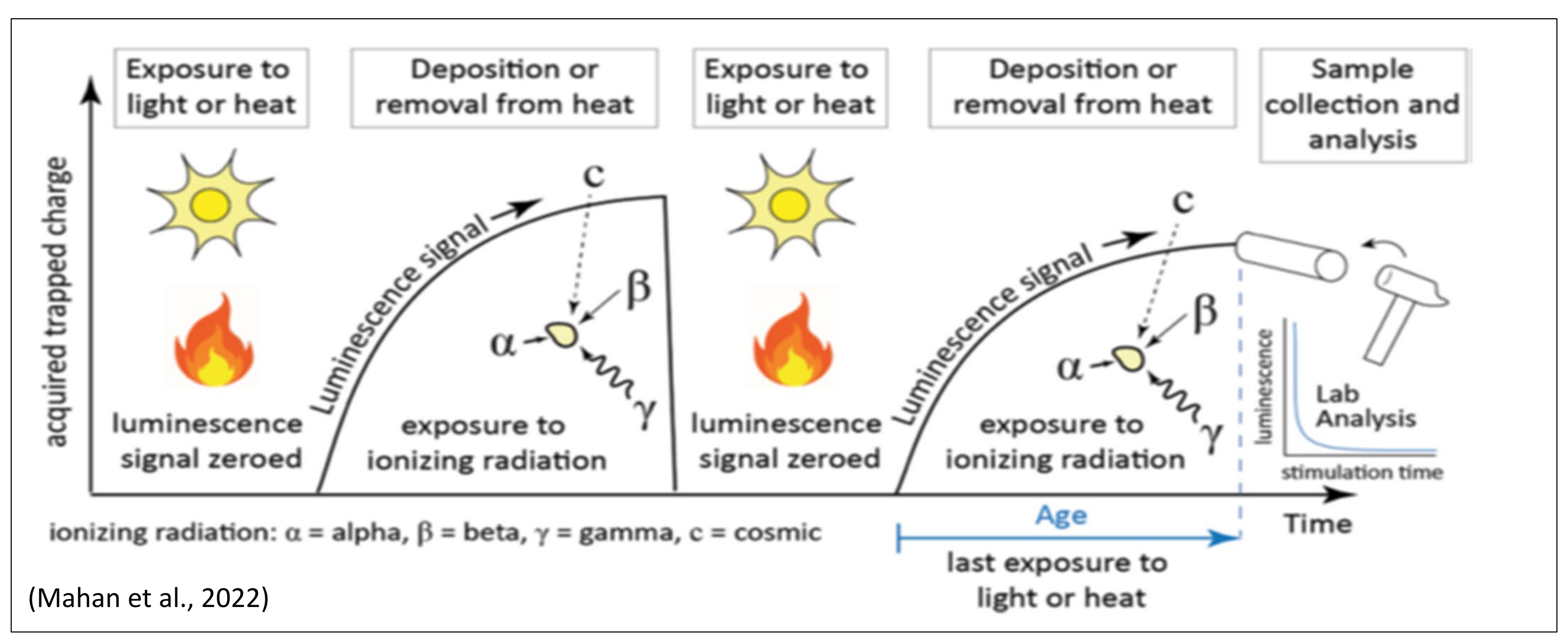
ABSTRACT

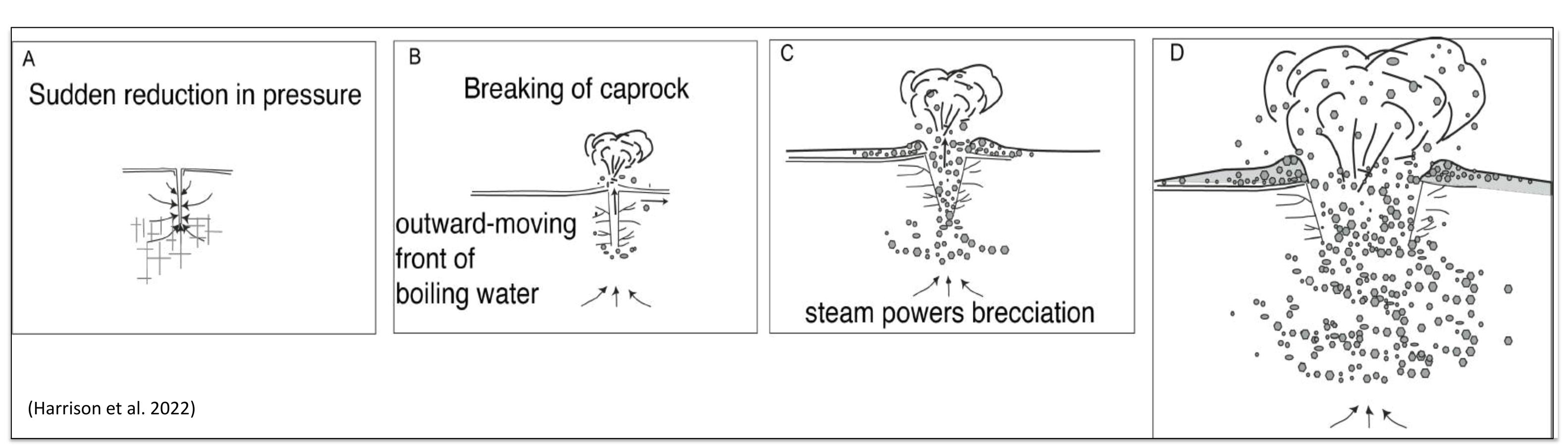
The Yellowstone Plateau volcanic field hosts an active hydrothermal system that has produced some of the largest hydrothermal explosions in the world. Hydrothermal explosions occur when boiling water contained in shallow hydrothermal systems flashes to steam causing a violent release of water, steam, and rock. These hydrothermal explosions can be triggered by events such as seismic activity, pressure release due to deglaciation or draining of a subglacial lake. Yellowstone's hydrothermal activity has been continuous through recent glaciations and has created a variety of phreatic craters throughout the volcanic field. The ages of these craters are poorly constrained, especially from direct dating methods. We use luminescence dating as a part of a larger geochronological study to date explosion craters located in the largest hydrothermal basin in Yellowstone National Park. Here we focus on Pocket Basin, a large explosion crater that is surrounded by associated explosion breccias and debris. We present cooling ages for sediments that were at elevated temperatures in hydrothermal reservoirs prior to explosions events. We use single aliquot regenerative post-infrared infrared stimulated luminescence (post-IR IRSL) on K-feldspar and red thermoluminescence (RTL) on quartz to date the explosion events that formed both craters. Dating these hydrothermal explosions will provide insights into their triggering mechanisms and associated hazards.

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.

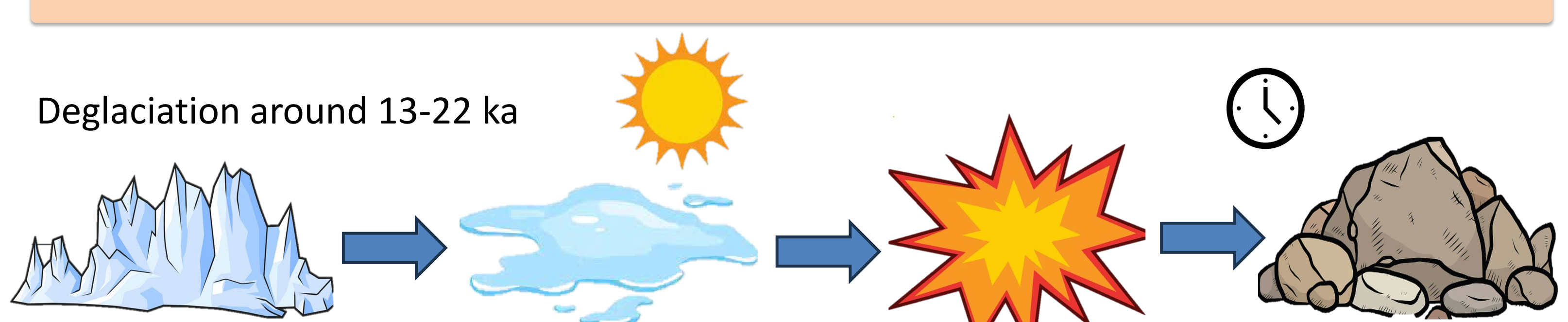
HYDROTHERMAL EXPLOSIONS



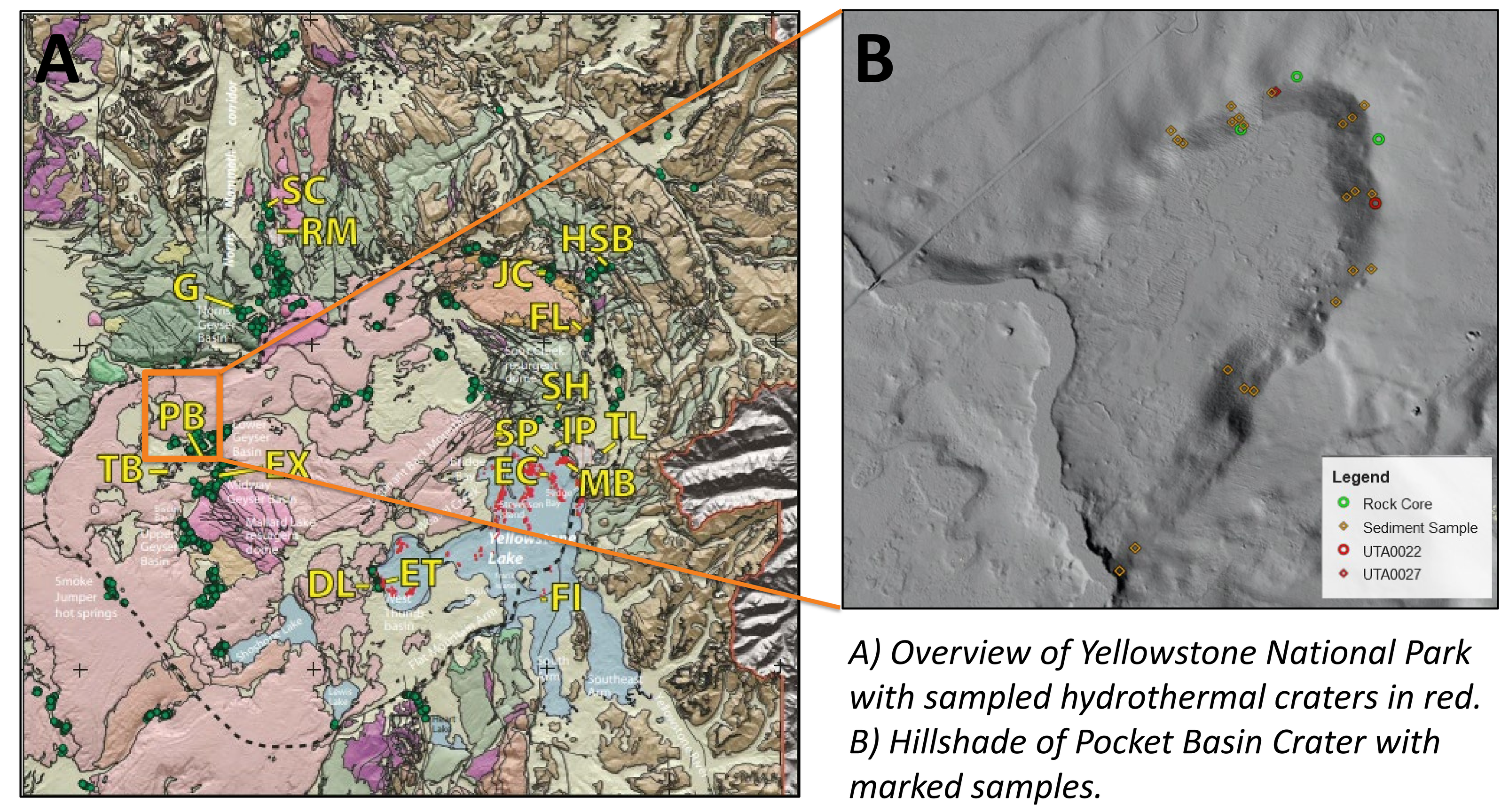
As glaciers melt, the underlying hydrothermal reservoirs experience a reduction in pressure that can potentially trigger an explosion.

Can deglaciation cause hydrothermal explosions?

Deglaciation around 13-22 ka

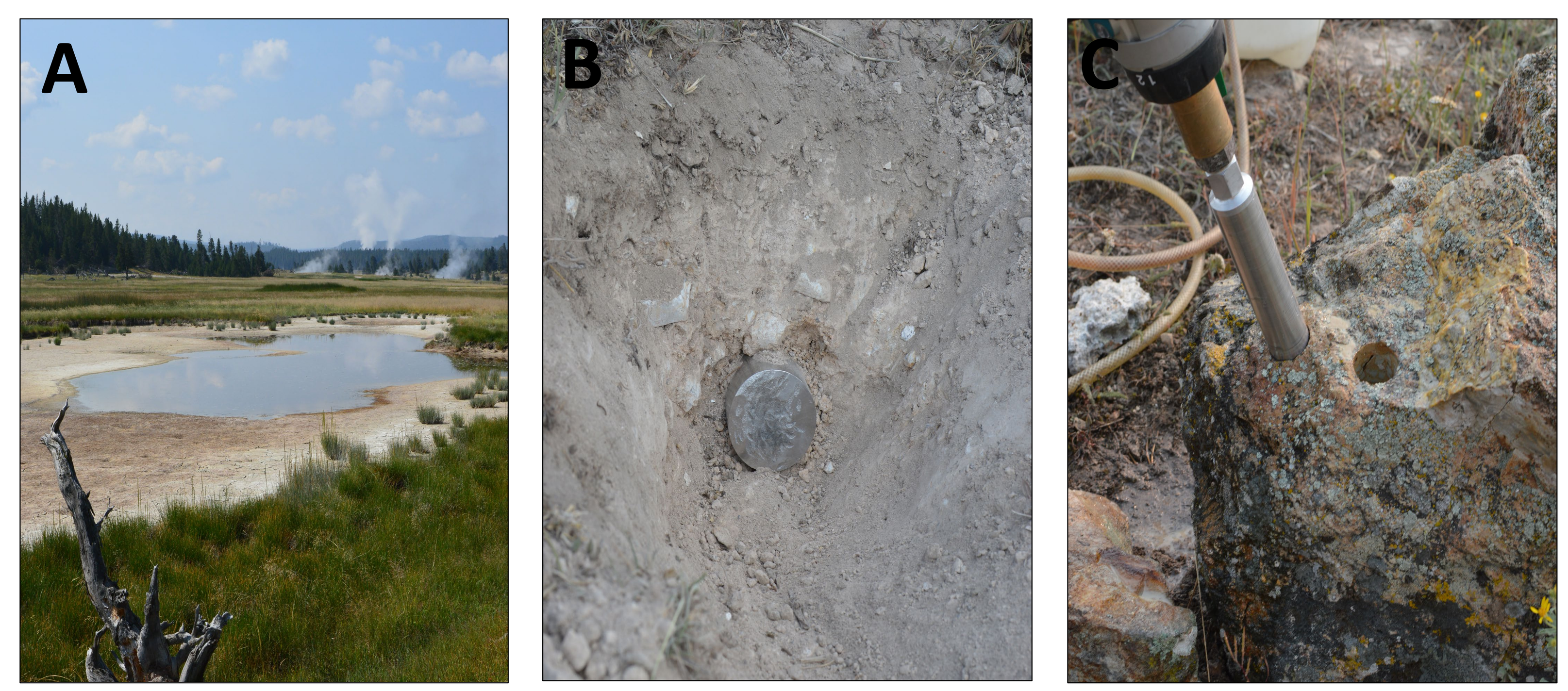


FIELD SITE



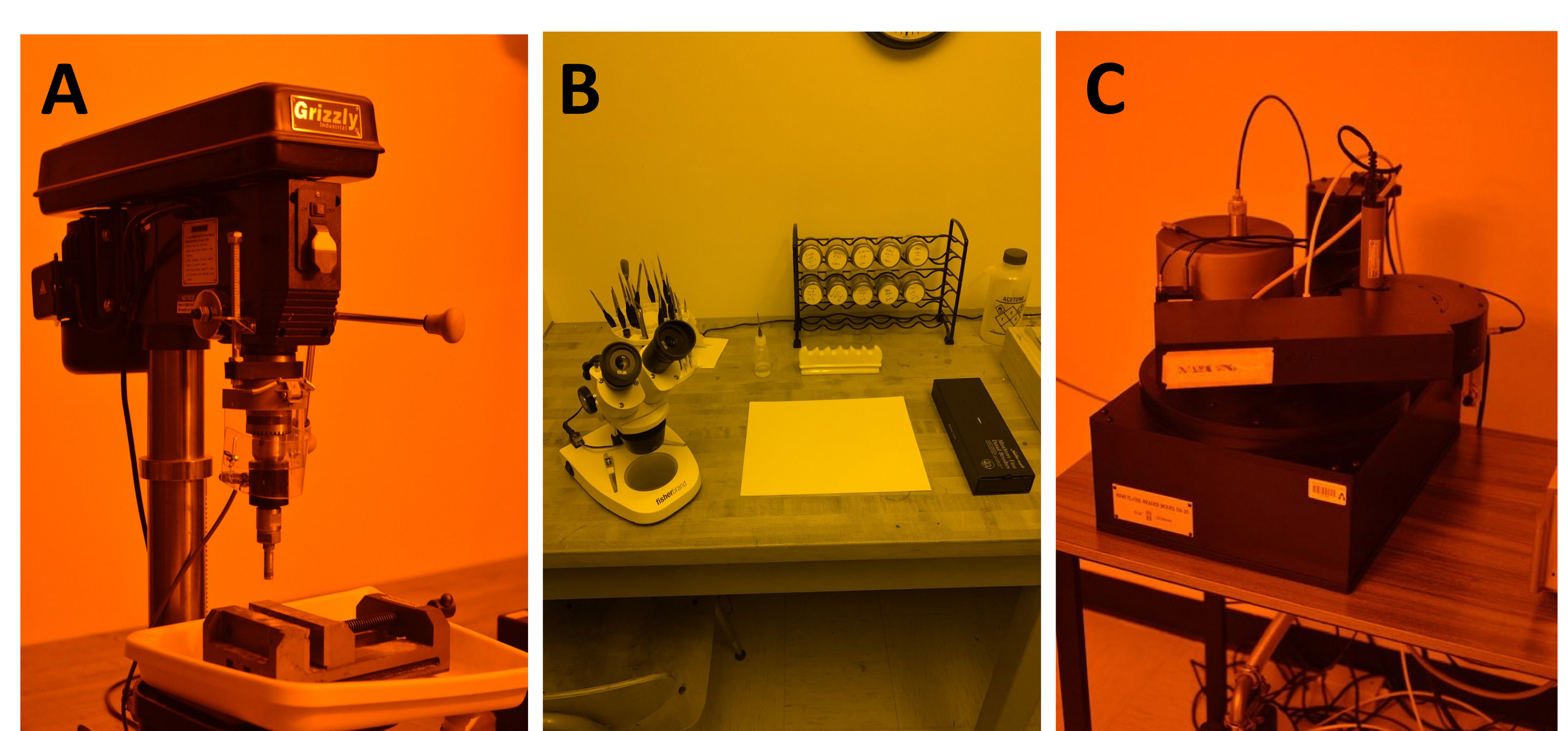
A) Overview of Yellowstone National Park with sampled hydrothermal craters in red. B) Hillshade of Pocket Basin Crater with marked samples.

SAMPLING



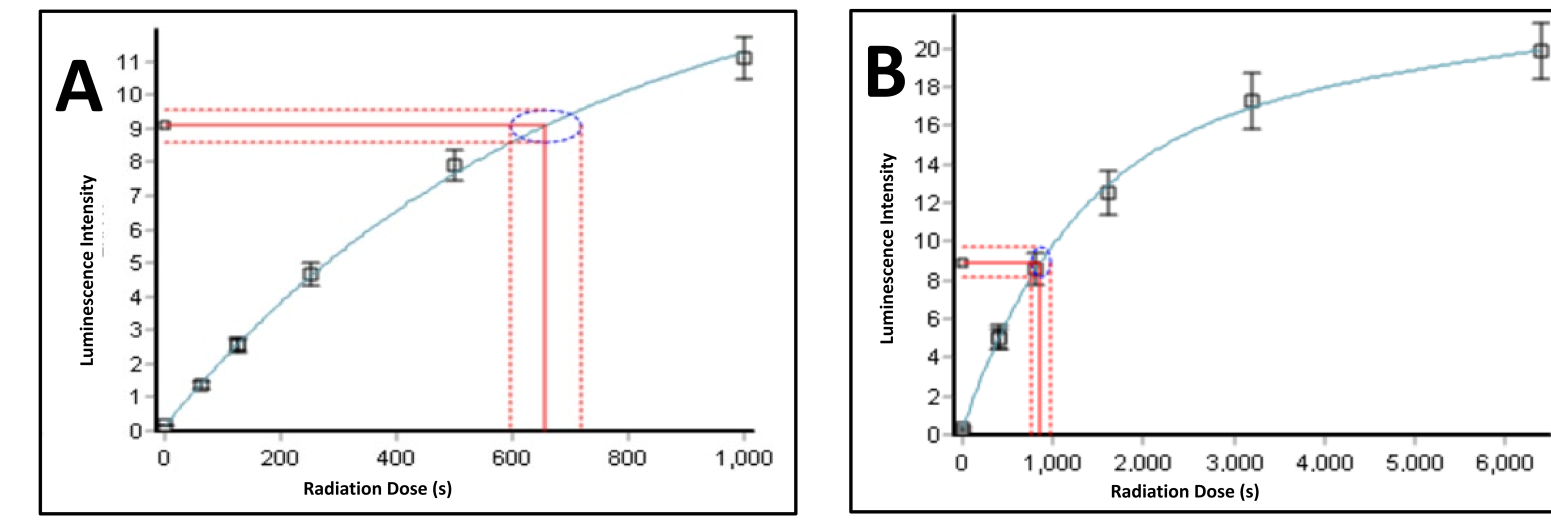
A) Overview of Pocket Basin Crater. B) Sediment sample retrieved from hillside of Pocket Basin crater. C) Rock interior retrieved through coring of explosion thrown boulder.

SAMPLE PREPARATIONS



A) Drill press used to core 1 centimeter diameter cores. B) UTALL laboratory set-up for loading Riso instrument. C) Riso luminescence reader used to measure luminescence signal and radiation does response. All photos are taken in a dark room with an amber light.

RESULTS

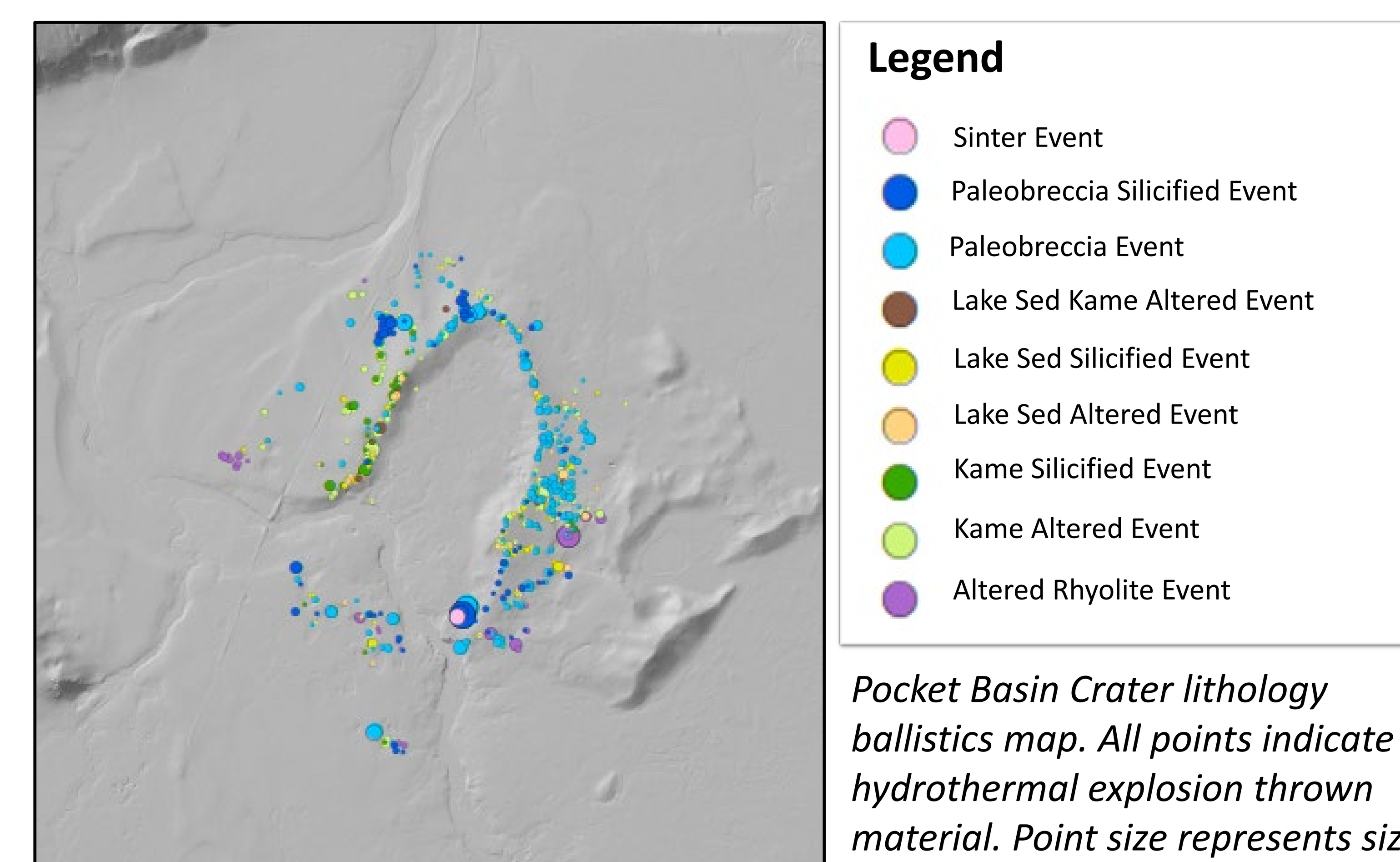


A) Dose response curve of UTA0027 taken from the top of the crater aging 15.40 ± 3.73 ka.

B) Dose response curve of UTA0022 taken from the top of the crater aging 17.75 ± 2.55 ka.

Cooling ages fall within the Pinedale deglaciation event.

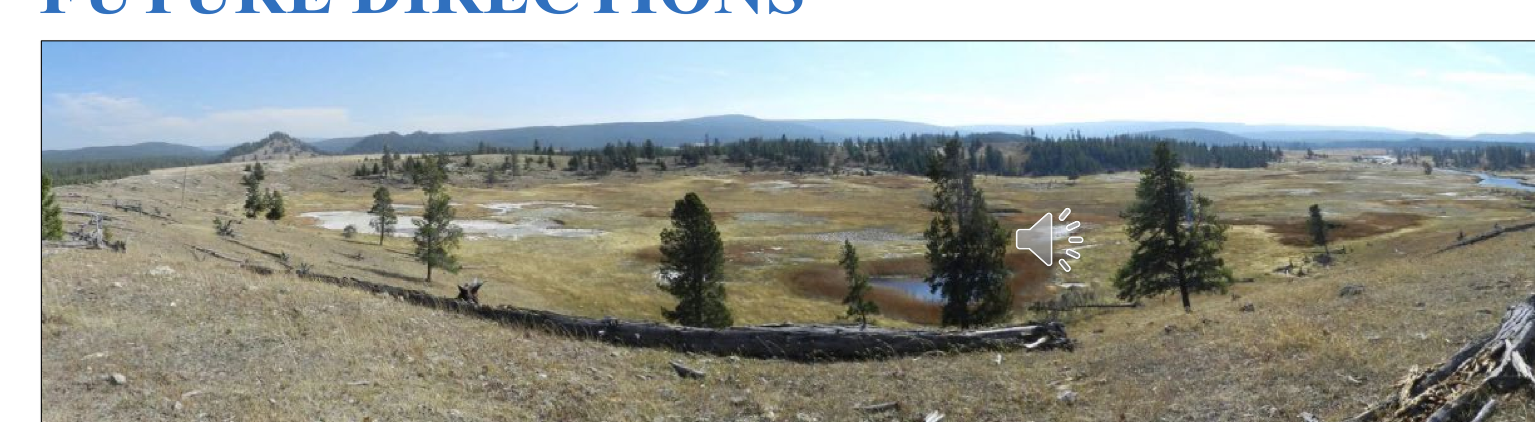
EXPLOSION BALLISTICS



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.

FUTURE DIRECTIONS



- Measure and compare quartz grains to offer an independent age check.
- Compare to other geochronometers including radiocarbon and cosmogenic nuclide dating.
- Sample Mary's Bay crater and compare to radiocarbon dates.