Annual Report

Supplemental support for field research and training: Physical and chemical signature of paleoseismicity in hot spring deposits on active faults of the Central Nevada Seismic Belt

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In spring 2021, we received support from the QRC to supplement travel, lodging, and per diems for three University of Washington graduate students during our June 2021 field campaign in central Nevada. The addition of these students allowed us to complete 7 UAV (drone) campaigns at 6 hot spring deposits, the drilling of multiple core holes at two sites, and high-resolution outcrop sampling. In the past year, we have presented results stemming from this campaign at 3 national meetings (Callahan et al., 2021, Brigham et al., 2022a, b) and at the 25th Undergraduate Research Symposium at the University of Washington (Jackson et al., 2022). One manuscript for peer reviewed publication and two extended conference abstracts are in preparation. In addition, we were able to use our experience providing field opportunities for graduate students to leverage additional aid from the NSF GeoALLIES program, which supported four undergraduate field assistants during a two-week field campaign in March 2022.

The broader NSF-supported project seeks to unlock the record of climatic and tectonic events preserved within hydrothermal deposits by systematically evaluating the natural variability in hydrothermal discharge of several fault-hosted hydrothermal systems. Using physical and chemical information now preserved in the stratigraphic record of select travertine deposits, we are investigating: 1) the natural variability of distinct chemical and isotopic compositions, discharge rates, and discharge temperatures emanating from a fault-hosted hydrothermal system 2) the influence of known hydrologic changes on the physical, chemical, isotopic, and thermal stratigraphic records preserved in travertine deposits, and 3) evidence of past seismic events in the morphologic or chemical records preserved in travertine deposits. Field support was essential for the safe and successful collection of samples required by this project. Pandemic restrictions imposed additional costs on the larger budget by requiring travel in multiple vehicles and the use of single occupancy hotel rooms. However, with the support provided by the QRC, we were able to complete a highly successful field campaign and provide field experiences for graduate, and undergraduate, students.

Some highlights of this research include: 1) identification of geomorphic and petrologic evidence that Hyder Hot Springs has persisted in its present location since at least the last highstand of glacial Lake Dixie ~12,000 years ago, 2) documenting the impact of hot spring sinter and hydrothermal alteration on the preservation of Quaternary fault scarp profiles, 3) placing constraints on the temperature of an extinct travertine deposit in the Stillwater Range, 4) documenting significant and opposite trends in stable isotope composition over several meters of stratigraphy at two travertine deposits, and 5) identification of hot spring/fault interaction at Kyle Hot Springs. Intangible products include field training for three graduate students and four undergraduate students.

Products facilitated by QRC support (graduate* and undergraduate† student authors)

Meeting Abstracts:

Brigham, C. A. P.* & Callahan, O. A. (2022). Hot spring sinter, acid sulfate alteration, and morphologic variation in fault scarp profiles from the Stillwater Seismic Gap, Dixie Valley, NV. Annual Geothermal Rising Conference. Reno, Nevada. *4th Place, Student Poster Competition*

Used SFM model acquired with partial QRC support

Brigham, C. A. P.* & Callahan, O. A. (2022). Morphologic variation in fault scarp profiles from the Stillwater Seismic Gap associated with hydrothermal alteration. Seismological Society of America Annual Meeting. Bellevue, WA.

Used SFM model acquired with partial QRC support

Jackson, A.†, Callahan, O. A., Huntington, K., Crider, J. G., (2022). Paleothermometry of an enigmatic travertine deposit. 25th Undergraduate Research Symposium, University of Washington, Friday May 20, 2022.

Used SFM model and rock samples acquired with partial QRC support

Callahan, O. A., Brigham, C.*, Heitmann, E.*, Sullivan, E.*, Huntington, K., Loewy, S., and Crider, J. G. (2021). Geomorphic evidence for long lived hydrothermal circulation at Hyder Hot Springs, Nevada. GSA Annual Meeting. Portland, OR.

Used SFM model and rock samples acquired with partial QRC support

In Preparation:

Callahan, O. A., Brigham, C.*, Jackson, A.†, Heitmann, E.*, Sullivan, E.*, Huntington, K., Lowey, S., Schauer, A., Crider, J. G. (----). Geomorphic and geochemical evidence for persistent hydrothermal circulation through Late Quaternary climate change at Hyder Hot Springs, Nevada. *in preparation for Quaternary Research*

Using SFM model and rock samples acquired with partial QRC support

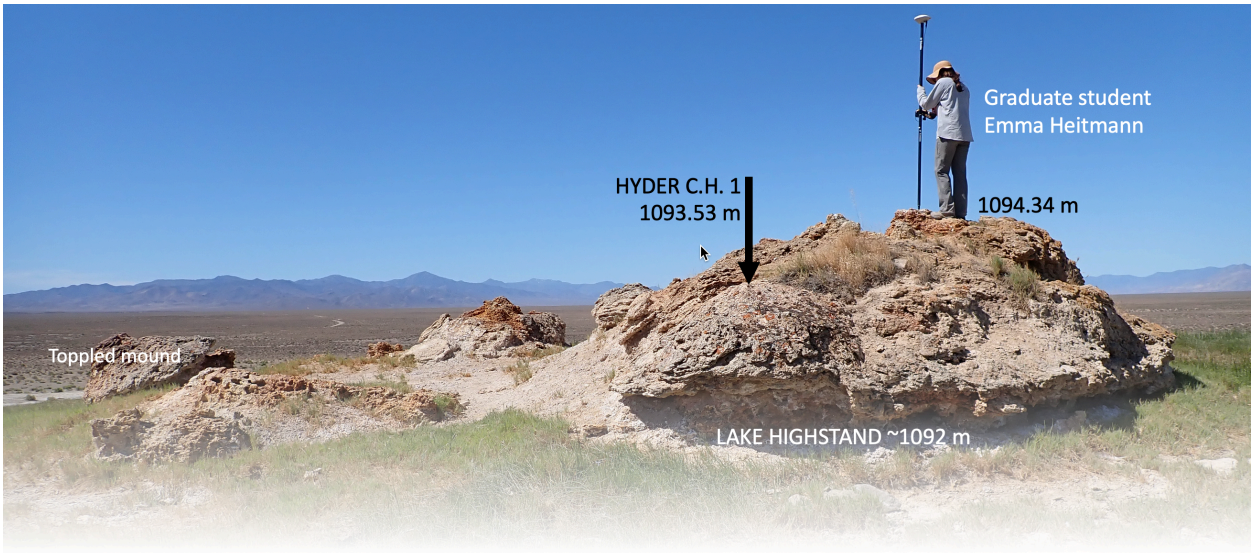
Callahan, O. A., Brigham, C.*, Heitmann, E.*, Sullivan, E.*, Jackson, A.†, Mat, S. R.†, Mudambi, J.†, Osako, J.†, Huntington, K., Crider, J. G. (----). High resolution structure-from-motion models of hydrothermal sites in the Central Nevada Seismic Belt: applications in tectonic, climate, and hydrothermal investigations. *in preparation for 48th Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, February 6-8, 2023*

Using SFM models acquired with partial QRC support

Jackson, A., Callahan, O. A., Heitmann, E.*, Schauer, A., Brigham, C.*, Mat, S. R.†, Mudambi, J.†, Osako, J.†, Sullivan, E.*, Huntington, K., Crider, J. G. (----). Paleothermometry of an enigmatic travertine deposit: Cottonwood Travertine, Stillwater Range, NV. *in preparation for 48th Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, February 6-8, 2023*

Using SFM model and rock samples acquired with partial QRC support

Overview of Hyder Hot Springs, NV. This was basecamp for the June 2021 and March 2022 field campaigns.



UW graduate student Emma Heitmann surveying an extinct travertine mound at the top of Hyder Hot Springs, NV, 2021.

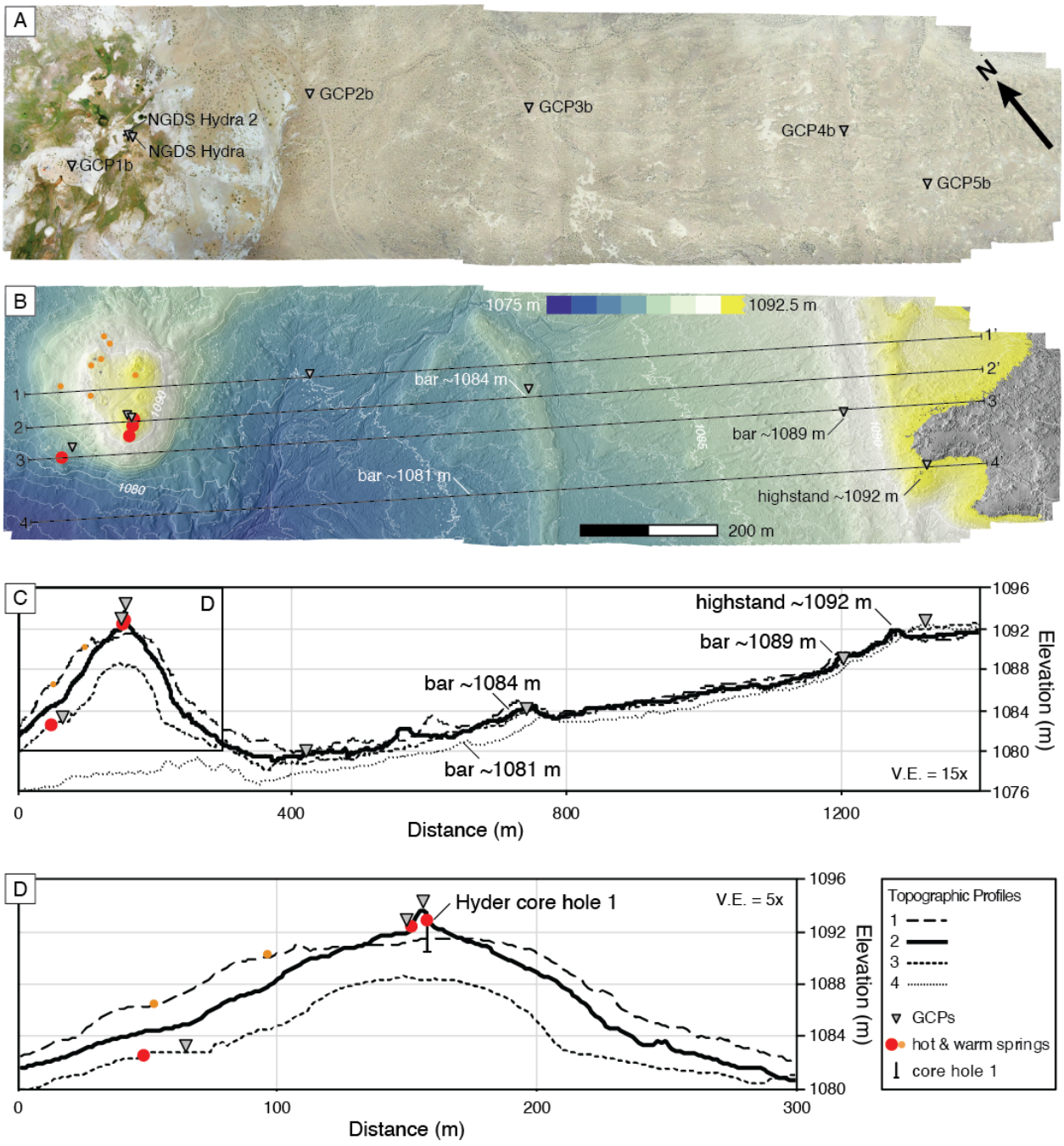


Figure from manuscript in preparation for *Quaternary Research*: A. UAV-acquired orthoimagery from Hyder Hot Springs, Nevada, showing ground control points (GCPs). B. Structure-from-motion shaded relief DEM with 1 m contours showing locations of topographic profiles 1-1' to 4-4'. C. Topographic profiles from NW of Hyder Hot Springs to Late Pleistocene Lake Dixie highstand in the southeast. GCPs, select hot springs, and beach bars plotted. D. Inset of topographic profiles at Hyder mound. GCP symbols larger than error.