The Chemistry and Mineralogy of Sinter Deposits from Two Large Geysers in the Upper Geyser Basin, Yellowstone National Park

USGS science for a changing world

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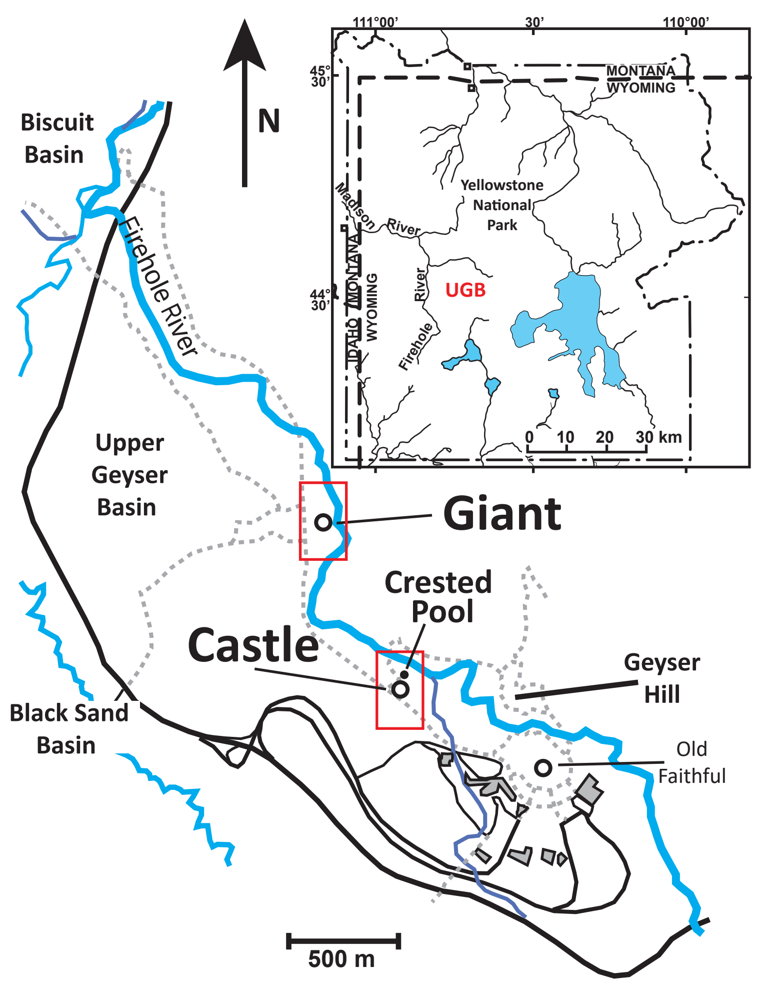
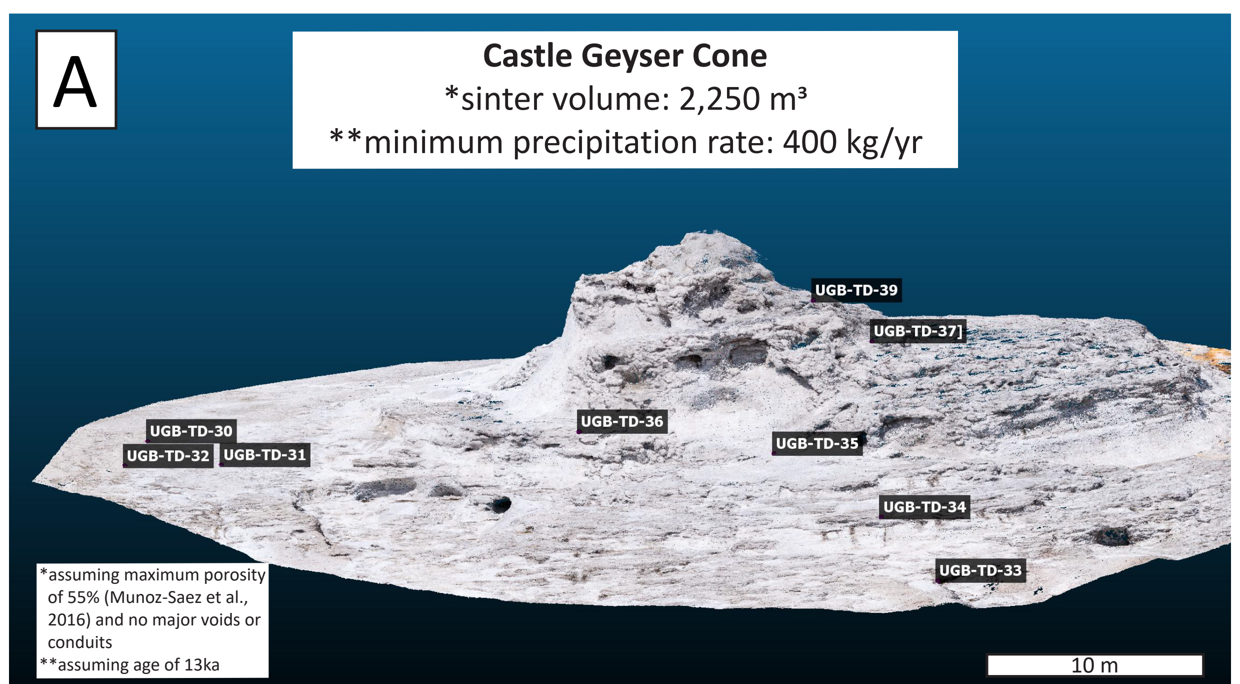
Questions

-How long does it take to build large geyser cones?
-What are the volumes of large geyser cones and the minumum precipitation rates?
-Was hydrothermal activity continuous in the park since deglaciation (~13 ka)?
-What are the timescales of mineralogical transformations and chemical changes of silica sinter deposits?

Background

Yellowstone's Castle (A) and Giant (B) geysers were stratigraphically sampled in 2018



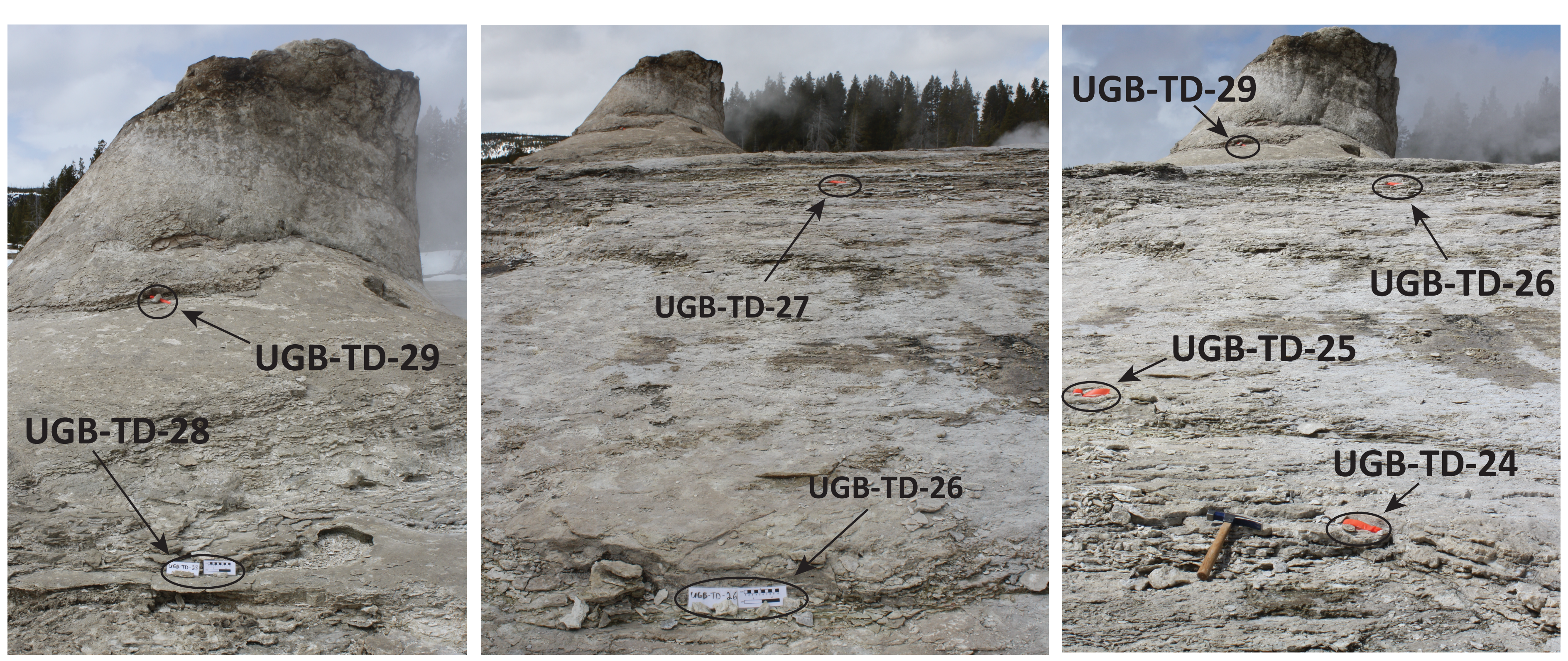


Research conducted under Yellowstone Research Permit YELL-2018-SCI-8030

Previously, old and young sinter units were mapped at Castle Geyser (Muffler, 1982) and dated by Foley (2006)

B

Giant Geyser had not been previously dated



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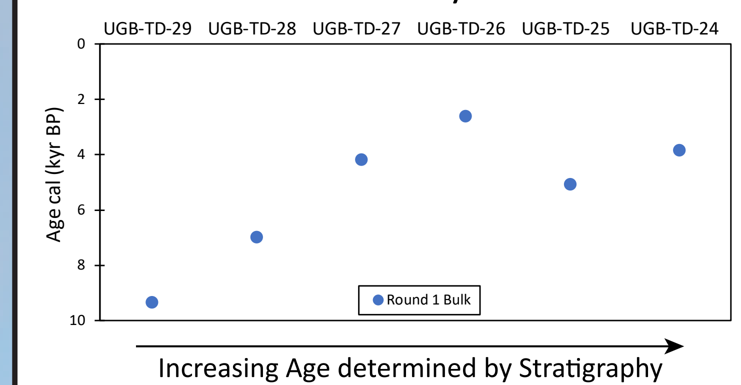
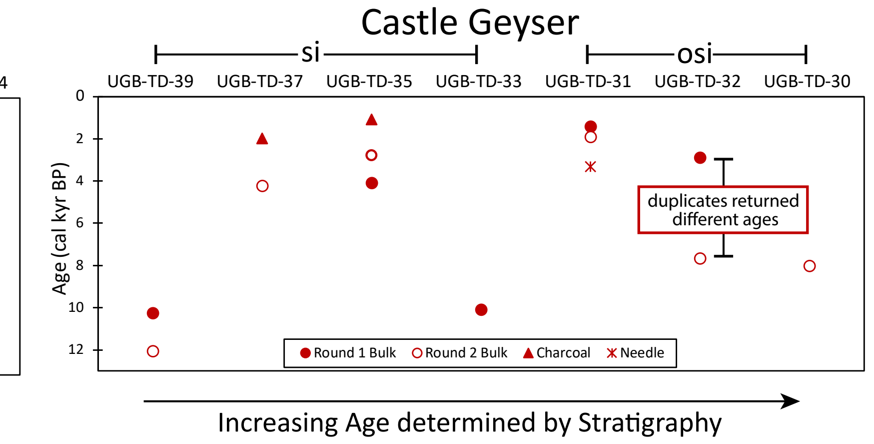
Results

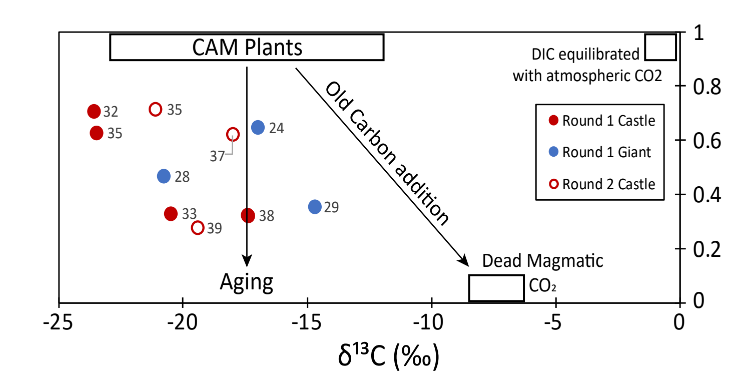
Radiocarbon Dating

C¹⁴ ages are stratigraphically out-of-sequence and imprecise

This may be attributed to:
1) Physical mixing of sinter and recycling of organic material
2) Old carbon in thermal waters incorporated into microbial mats forming on the sinter



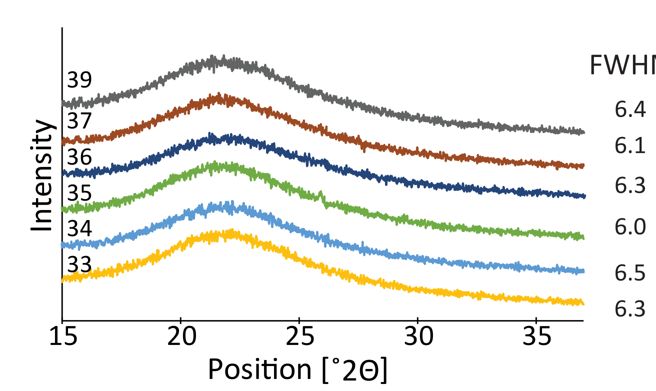


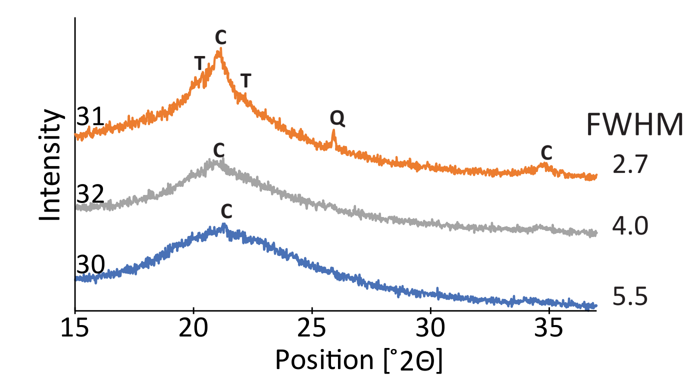


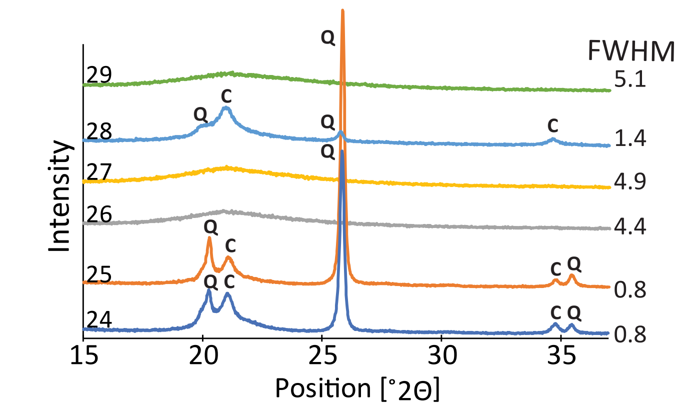
Mineralogy

XRD

C - cristabalite
Q - quartz
T - tridimite





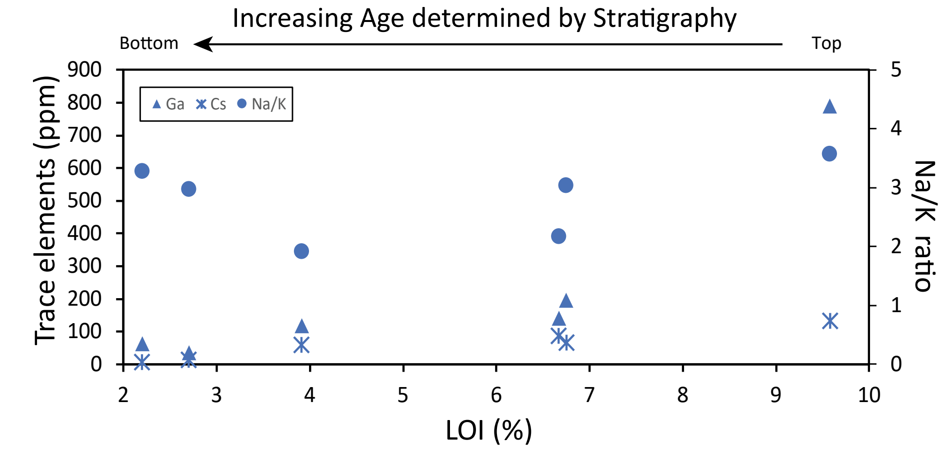


Least Mature → Most Mature

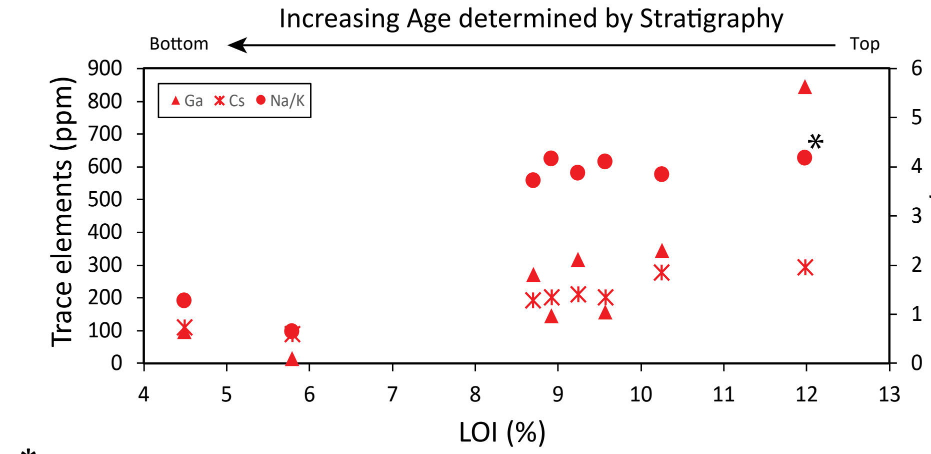
Increasing Age determined by Stratigraphy

Geochemistry

XRF



With increasing age, sinter dehydrates, the concentrations of most major and trace elements decrease, and the concentration of silica increases



*Water collected from nearby Crested Pool has a Na/K mass ratio of ~22, whereas the highest Na/K in sinter from Castle Geyser is ~4. This implies preferential incorporation of K in Opal A.

Conclusions

-Bulk radiocarbon ages of sinter do not accurately reflect deposition age
-Mineralogical, geochemical, and dehydration data can serve as an indicator for relative sinter age
-Castle Geyser cone is at least 2 ka and has a minimum precipitation rate of 400 kg/yr; its associated "old" shield is at least 3.3 ka and is mineralogically distinct from the cone
-Based on mineralogy Giant Geyser is older than Castle Geyser