New $^{40}Ar/^{39}Ar$ sanidine dates for the Green Canyon Flow, Yellowstone Volcanic Field, and implications for a revised volcanic stratigraphy

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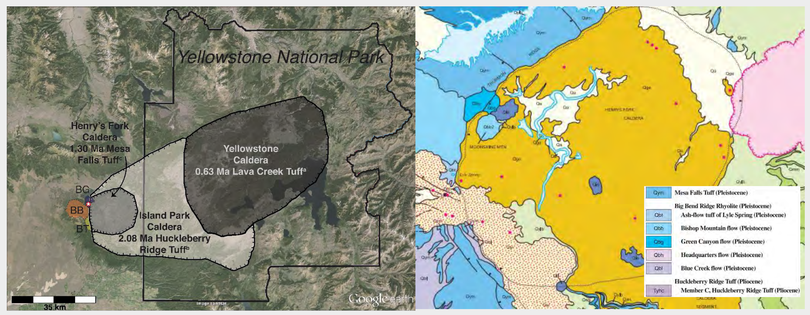
Introduction

In the Yellowstone Volcanic Field, the Green Canyon Flow is one of several effusive lavas comprising the Big Bend Ridge Rhyolites that erupted between two caldera-forming eruptions: the Huckleberry Ridge and Mesa Falls Tuffs. The flow straddles the rim of Henry's Fork Caldera, which was generated from the eruption of the Mesa Falls Tuff(1).

Objectives:

1) Determine a more accurate and precise $^{40}Ar/^{39}Ar$ age for the Green Canyon Flow.
2) Establish the stratigraphic relationship of the Green Canyon Flow relative to the Mesa Falls Tuff.
3) Refine the volcanic stratigraphy of the flow in relation to the Big Bend Ridge Rhyolites.

Location & Geologic Background



Two Conflicting Hypotheses:

1) Green Canyon Flow erupted concurrently with the Mesa Falls Tuff and flowed into the newly formed caldera(2)
2) Green Canyon Flow erupted prior to the Mesa Falls Tuff and faulted during caldera collapse(1)

Volcanic stratigraphy

1.30 Ma Mesa Falls Tuff caldera-forming eruption(3)		
Big Bend Ridge Rhyolites	K/Ar ages(4)	Unit
	1.16 ± 0.03	Bishop Mountain Flow (BB)
	1.17 ± 0.03	Green Canyon Flow (BG)
	1.19 ± 0.03	Tuff of Lyle Spring (BT)
	1.25 ± 0.03	Moonshine Mountain Flow
	1.77 ± 0.05	Blue Creek Flow
	1.81 ± 0.03	Headquarters Flow
2.08 Ma Huckleberry Ridge Tuff caldera-forming eruption(5,6)		

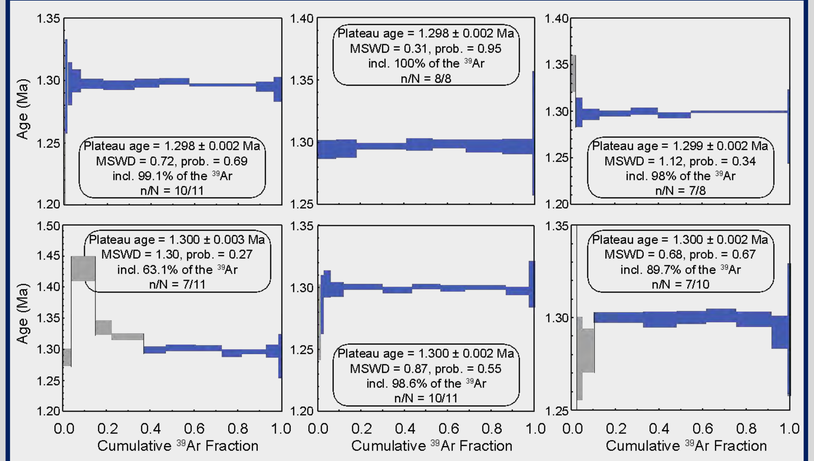
Hand Sample & Thin Sections

The hand sample is white with a porphyritic texture. The individual phenocrysts within the rock are largely composed of sanidine, plagioclase, and quartz. There are additional phenocrysts of biotite, which is overall quite rare in the Yellowstone Volcanic Field. The groundmass is devitrified, with a spherulitic texture in thin section.

$^{40}Ar/^{39}Ar$ Dating Methods

Sanidine crystals ranging from 1-3 mm were separated from a bulk rock sample and irradiated with the Alder Creek Rhyolite standard(7). Single crystals were incrementally heated in order to assess trapped excess argon within the crystal. $^{40}Ar/^{39}Ar$ analyses were conducted at the WiscAr Geochronology Lab using a Nu Instruments Noblesse multi-collector mass spectrometer and 60W CO_2 laser.

$^{40}Ar/^{39}Ar$ Sanidine Results



All six incremental heating experiments produced a plateau with ages ranging from 1.298 to 1.300 ± 0.002 Ma (including uncertainty on *J*). A weighted mean of the six experiments yields an age of 1.2989 ± 0.0009 Ma. (MSWD = 1.13)

Interpretations

- As determined by $^{40}Ar/^{39}Ar$ dating, the Green Canyon Flow erupted at 1.2989 ± 0.0009 Ma.
- This places the flow in close temporal proximity to the Mesa Falls Tuff caldera forming eruption with an $^{40}Ar/^{39}Ar$ age of 1.3001 ± 0.0006 Ma(3).
- This age also suggests the flow erupted ~150 ka after the Bishop Mountain Flow(8) and Lyle Spring Tuff(9), making it the youngest of the Big Bend Ridge Rhyolites.

Conclusions

- The Green Canyon Flow is the youngest of the Big Bend Ridge Rhyolites, but is indistinguishable from the eruption age of the caldera-forming Mesa Falls Tuff.
- Additional field mapping will assist in resolving the sequence of eruption events at this time.
- To better constrain the connection between small volume rhyolite flows and caldera-forming eruptions, future work on the Green Canyon Flow will examine zircon grain morphology and zoning patterns, trace element geochemistry, and U-Pb dating

References

(1) Christiansen, R.L., 2001. The Quaternary and Pliocene Yellowstone Plateau Volcanic Field of Wyoming, Idaho, and Montana. United States Geological Survey Professional Paper 729-G.

(2) Hamilton, W., 1965. Geology and petrogenesis of the Island Park caldera of rhyolite and basalt eastern Idaho, Geological Survey Professional Paper 504-C.

(3) Rivera, T.A., Schmitz, M.D., Crowley, J.L., Jicha, B.R., in revision. Zircon petrochronology and $^{40}Ar/^{39}Ar$ sanidine dates for the Mesa Falls Tuff: crystal scale records of magmatic evolution and the short lifespan of a large Yellowstone magma chamber, Journal of Petrology.

(4) Obradovich, J.D., 1992. Geochronology of the Late Cenozoic volcanism of Yellowstone National Park and adjoining areas, Wyoming and Idaho. U.S. Geological Survey. Open-File Report 92-408

(5) Rivera, T.A., Schmitz, M.D., Crowley, J.L., Storey, M., 2014. Rapid magma evolution constrained by zircon petrochronology and $^{40}Ar/^{39}Ar$ sanidine ages for the Huckleberry Ridge Tuff, Yellowstone, USA. Geology 42, 643-646.

(6) Singer, B.S., Jicha, B.R., Condon, D.J., Macho, A.S., Hoffman, K.A., Dierkhising, J., Brown, M.C., Feinberg, J.M., Kidane, T., 2014. Precise ages of the Réunion event and Huckleberry Ridge excursion: Episodic clustering of geomagnetic instabilities and the dynamics of flow within the outer core. Earth and Planetary Science Letters 405, 25-38.

(7) Rivera, T.A., Storey, M., Schmitz, M.D., Crowley, J.L., 2013. Age intercalibration of $^{40}Ar/^{39}Ar$ sanidine and chemically distinct U/Pb zircon populations from the Alder Creek Rhyolite Quaternary geochronology standard. Chemical Geology 345, 87-98.

(8) Furlong, R.V., Rivera, T.A., Schmitz, M.D., Jicha, B.R., 2016. New $^{40}Ar/^{39}Ar$ ages of the Bishop Mountain Flow from the Yellowstone Volcanic Field. Geological Society of America Rocky Mountain Section Meeting. Abstract #276178.

(9) Vincent, J. Rivera, T.A., Schmitz, M.D., Jicha, B.R., 2016. $^{40}Ar/^{39}Ar$ age and petrography of the Tuff of Lyle Spring, Yellowstone Volcanic Field, Idaho. Geological Society of America Rocky Mountain Section Meeting. Abstract #276221.

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