New CA-TIMS and LA-ICP-MS zircon U-Pb geochronology of the Grizzly Peak magmatic center, CO: confounding chronology of a classic caldera

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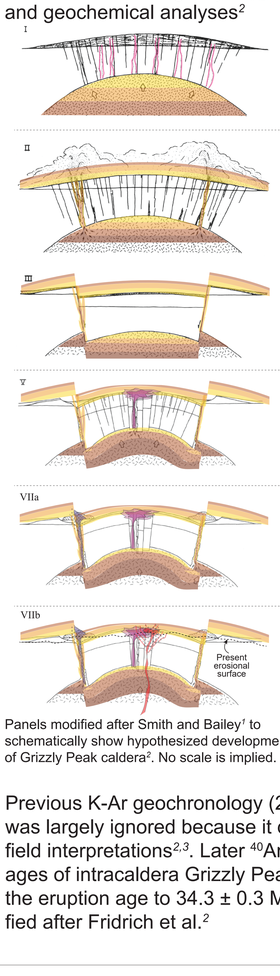
1. Premise

The Eocene Grizzly Peak caldera in the northern Sawatch Range is hypothesized to have followed a single cycle of the resurgent cauldron model[1] on the basis of field work and geochemical analyses[2]



Stage I. **Precaldera diking** and ring fractures owing to tumescence over a growing magma chamber

Stages II–III. **Eruption of 600 km³ Grizzly Peak Tuff** as a single cooling unit. Caldera collapse along inner and outer ring fault zones yielding 17x23 km caldera (230 km²). Up to 3.5 km subsidence in deeper northern ring fault zone. Giant megabreccia lenses dominate the NE caldera. Two vestiges of outflow tuff are proposed.

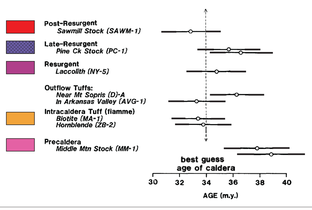
Stage V. A **resurgent laccolith**, comprising two mapped plutons intruded successively, causes doming in the northern part of the caldera.

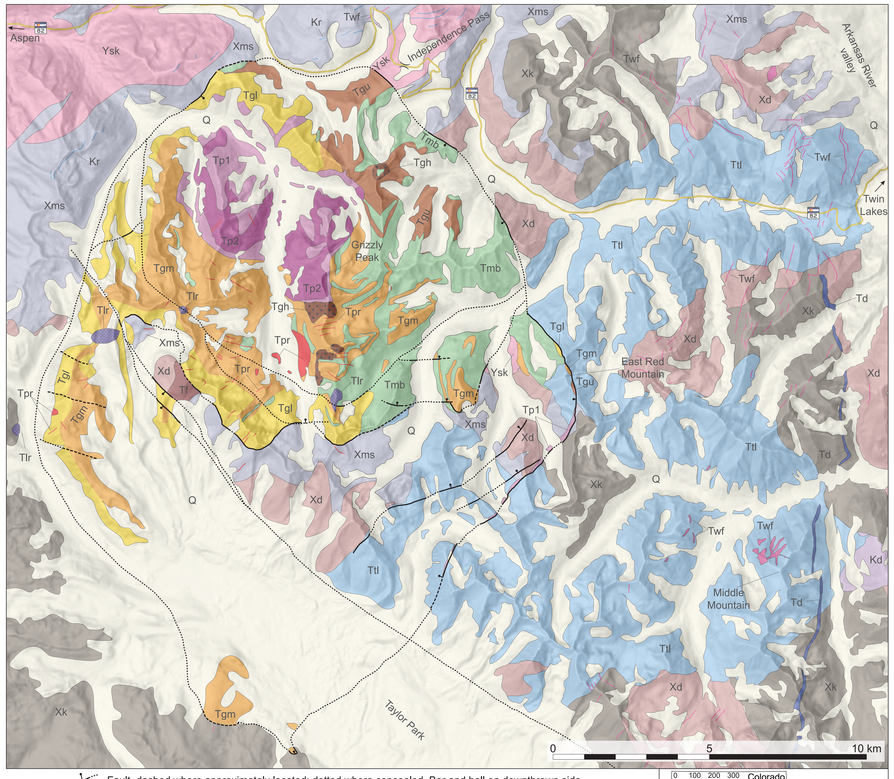
Stage VIIa. **Late-resurgent magmas** intrude ring fracture zones. Hydrothermal alteration, weak stockwork (Mo) mineralization. Interpreted as last gasp of Grizzly Peak magma.

Stage VIIb. **Bimodal post-resurgent magmas** intrude caldera center. Carries boulders of coarse granite interpreted as solidified Grizzly Peak magma. Intepreted as new magma source.

Panels modified after Smith and Bailey[1] to schematically show hypothesized development of Grizzly Peak caldera[2]. No scale is implied.

Previous K-Ar geochronology (2σ uncertainties) was largely ignored because it did not support field interpretations[2,3]. Later $^{40}Ar/^{39}Ar$ sanidine ages of intracaldera Grizzly Peak Tuff refined the eruption age to 34.3 ± 0.3 Ma[4]. Figure modified after Fridrich et al.[2]



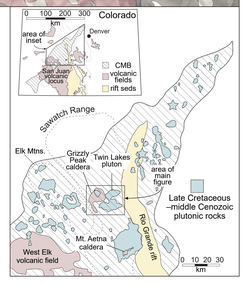


Fault–dashed where approximately located; dotted where concealed. Bar and ball on downthrown side

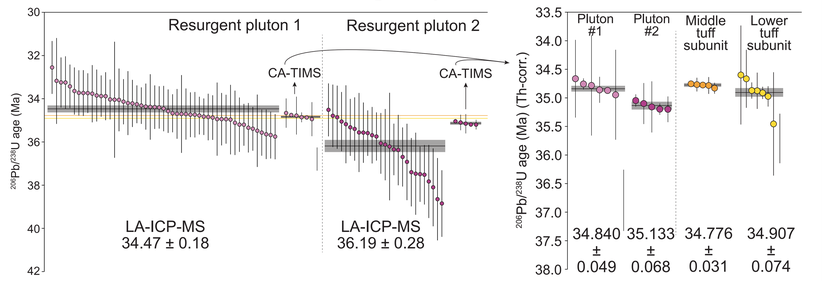
Q	Quaternary (undivided)	Tgm	Grizzly Peak Tuff (middle)	Kr	Granitic dikes
Tp	Post-resurgent pluton and dikes	Tgu	Grizzly Peak Tuff (upper)	Kd	Dioritic intrusive rocks
Tlr	Late-resurgent pluton and hydrothermal alteration	Tm	Megabreccia (undivided)	Ysk	1.4 Ga granitoid plutons
Tr2	Younger resurgent pluton	Tf	Precaldera rhyolite lava	Xd	Denny Creek Granodiorite
Tr1	Older resurgent pluton	Twf	Dikes and stocks of Winfield and Middle Mountain	Xms	Metasedimentary gneiss
Tgh	Grizzly Peak Tuff (heterogeneous)	Tt	Felsic porphyry dike	Xk	Undivided Early Proterozoic rocks
Tgl	Grizzly Peak Tuff (lower)	Tt	Twin Lakes pluton		

Generalized geologic maps after *3, 4, 8.*


Panoramic view looking west from ridge atop a possible debris avalanche deposit near rim of caldera at East Red Mountain.

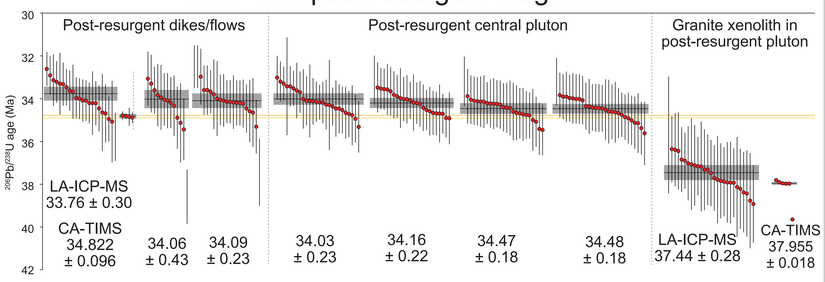


Resurgent plutons



- CA-TIMS and LA-ICP-MS data for resurgent plutons #1 and #2 are distinct
- Resurgent pluton #2 contradicts field interpretations; predates tuff and pluton #1
- Resurgent pluton #2 has similar isotopic composition to tuff[6]; its age of 35.133 ± 0.068 Ma makes it the earliest instance of Grizzly Peak magmatism

Late- and post-resurgent magmatism

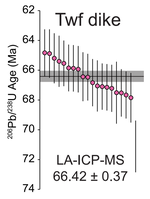


- CA-TIMS data for youngest post-resurgent dike overlap both tuff CA-TIMS ages
- Samples double-dated by both LA-ICP-MS and CA-TIMS indicate Pb-loss
- Magmatic lifespan of Grizzly Peak system may have been <0.5 Ma
- Granitic xenoliths in post-resurgent pluton cannot be related to Grizzly Peak magmatism owing to age and isotopic characteristics[6]

2. New high-precision geochronology

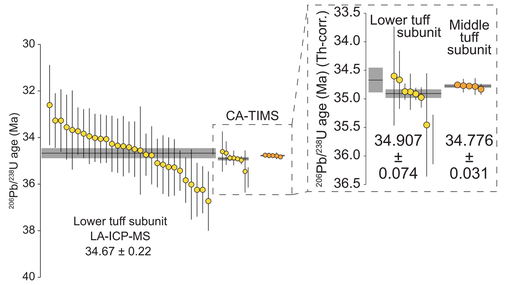
Precaldera units

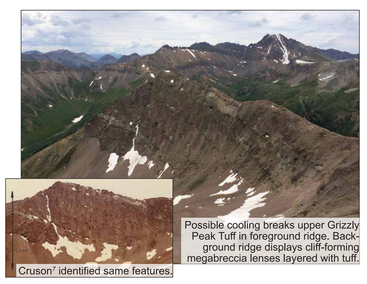

Silicic extracaldera dike on west side of Independence Pass



- Sampled precaldera dike (Twf) is Cretaceous
- Petrographic, sparse geochemical, or spatial correlations are nonunique
- Middle Mtn. porphyry Mo deposit (Twf) also cannot be related to Grizzly Peak magmatism as indicated by recent CA-TIMS zircon U-Pb (36.449 ± 0.048 Ma)[5] and radiogenic isotopic data[6]

Grizzly Peak Tuff

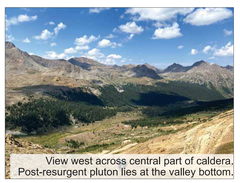




- CA-TIMS data for two tuff subunits are distinguishable outside 2σ uncertainty
- Suggests multiple successive magma pulses; longer assembly for lower subunit?
- Reevaluation of field evidence suggests possible cooling breaks in tuff, permitting the possibility of multiple eruptions


Tuff dike cuts between altered and fresh rock at caldera margin on East Red Mountain


Granitic xenolith in post-resurgent pluton


View west across central part of caldera. Post-resurgent pluton lies at the valley bottom.

3. Discussion and other data

- New geochronologic data condradict previous interpretations of the evolution and expression of magmatism at the Grizzly Peak caldera
- Grizzly Peak magmatism did not follow resurgent cauldron cycle[1]. Plutonism preceded and overlapped tuff eruption, similar to the Mount Aetna caldera
- New age and isotopic data do not support previously proposed outflow tuff
- Perhaps Grizzly Peak caldera was deep but limited in area. Tuff in west (and south?) parts of field area could represent outflow from smaller caldera[7]
- Future isotope (Sr, Nd, Pb, Hf) and electron microprobe work will further test relationships between Grizzly Peak Tuff and post-resurgent units

Acknowledgments, Disclaimer, References

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