Major and trace element variations in a large Proterozoic ignimbrite deposit, St. Francois Mountains, Missouri: Zoned chamber with mafic recharge?

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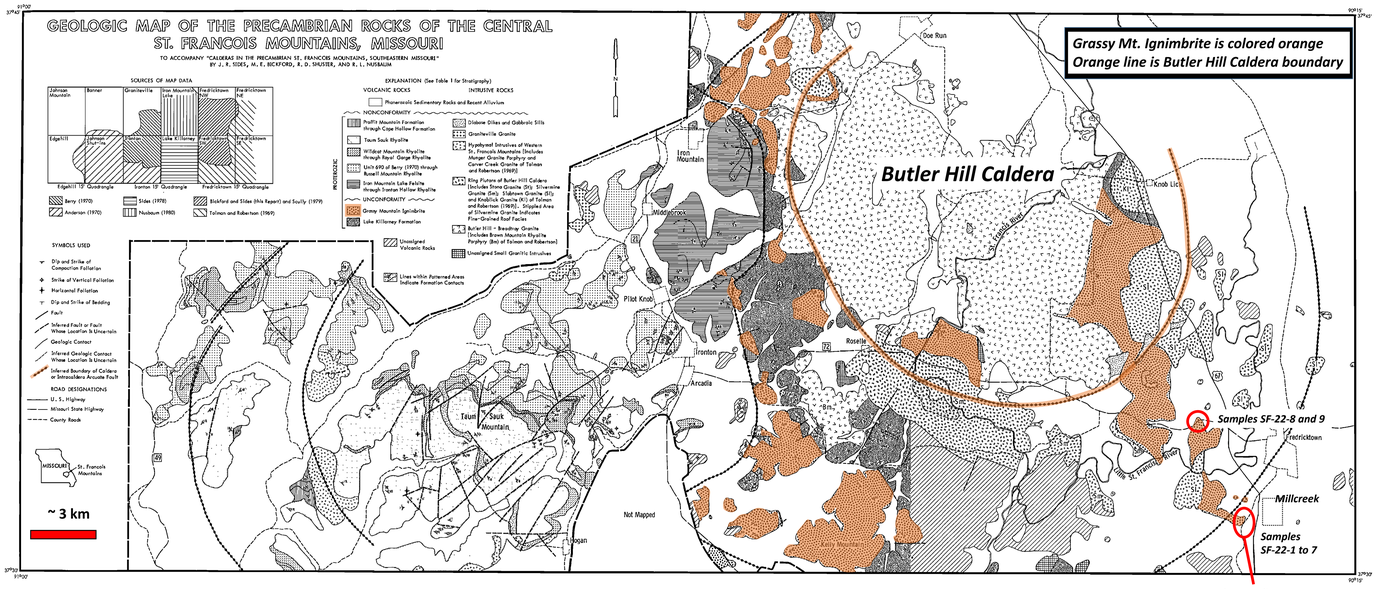
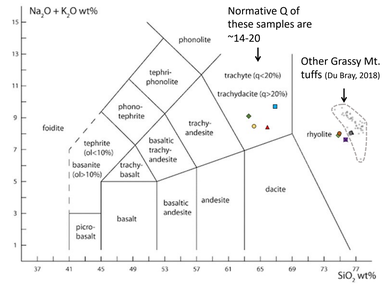
Background and objectives

- The St. Francois Mts. Igneous Terrane is a Proterozoic (~1.5 Ga) volcano-plutonic terrane in southeastern Missouri (Kisvarsanyi, 1980)
- The Grassy Mountain Ignimbrite is one of the largest and most continuously exposed ashflow tuffs in the terrane and is associated with the collapse of the Butler Hill Caldera (Kisvarsanyi, 1980; Sides et al., 1981)
- Previous geochemical work on the Grassy Mt. Ignimbrite focused on the western exposures with only one sample from the east (see compilation by Du Bray et al., 2018)
- Previous petrographic and geochemical work showed the Grassy Mt. Ignimbrite to be fairly uniform with no distinct zoning (see compilation by Du Bray, 2018; data on figures here), which is somewhat unusual compared to more recent large ignimbrite eruptions (e.g. Hildreth and Wilson, 2007)
- ***What are the geochemical characteristics of the Grassy Mt. Ignimbrite in the eastern areas?***
- ***What units are exposed in the relatively new roadcut at Millcreek and what are their geologic relationships?***
- ***How uniform/homogeneous is the Grassy Mt. Ignimbrite?***

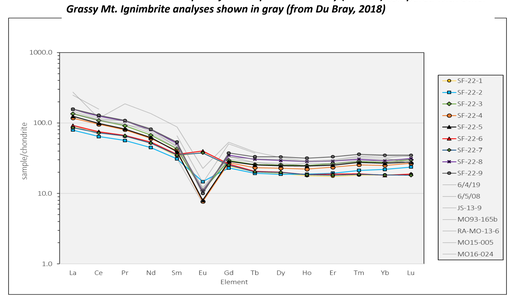


Geologic map of igneous units in part of the St. Francois terrane. The Grassy Mountain Ignimbrite is colored orange; the inferred Butler Hill Caldera margin is an orange line. (Map from Sides et al., 1981)

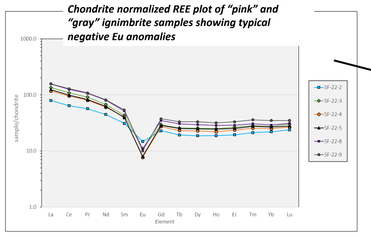
Volcanic rock classification of samples in this study (colored data points). The Grassy Mt. ignimbrites include trachytes, not just rhyolites, some of which have positive Eu anomalies (see REE plots)



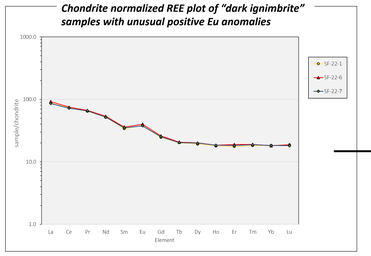
Chondrite normalized REE plot of all samples in this study (colored) compared with other Grassy Mt. Ignimbrite analyses shown in gray (from Du Bray, 2018)



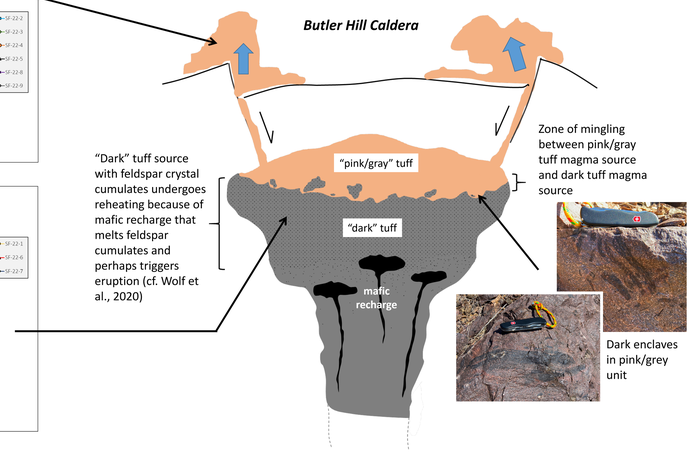
Chondrite normalized REE plot of "pink" and "gray" ignimbrite samples showing typical negative Eu anomalies



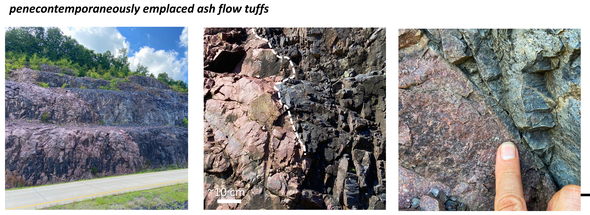
Chondrite normalized REE plot of "dark ignimbrite" samples with unusual positive Eu anomalies



Tentative model for the origin of the Grassy Mt. Ignimbrite based on the mapped and analyzed units in the Millcreek outcrop area. The Butler Hill caldera magma chamber was zoned. The upper section consisted of the abundant, typical, fractionated, high silica rhyolite. A deeper section of trachytic magma where feldspar crystals accumulated lies below. A zone of magma mingling is in-between. Mafic recharge reheated the dark trachytic unit (and melted the feldspar cumulates there). The Butler Hill caldera eruption taps the upper pink/grey unit as well as the mingling zone and the upper section of the dark tuff source. The eruption was possibly triggered by the mafic recharge/reheating event.

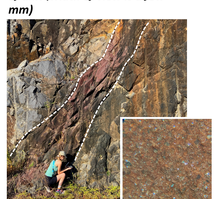


Contact between the "pink" and "dark" ignimbrite units that is interpreted as a depositional contact between penecontemporaneously emplaced ash flow tuffs

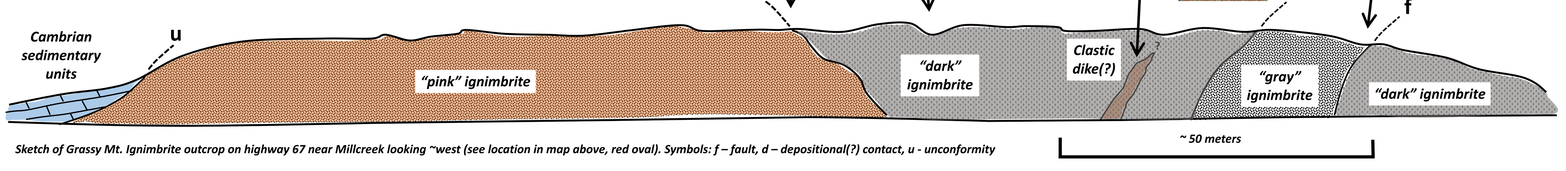


Broken quartz grains (~1 mm diameter) in the "dark" unit consistent with it being a pyroclastic rock like the more typical pink and gray Grassy Mt. Ignimbrite.

Reddish clastic(?) dike intruding the "dark" unit. Inset is close-up of unit (width of view is a few mm)



Fault contact between the "gray" (left) and "dark" (right) ignimbrite units



Sketch of Grassy Mt. Ignimbrite outcrop on highway 67 near Millcreek looking ~west (see location in map above, red oval). Symbols: f – fault, d – depositional(?) contact, u - unconformity

Findings / Conclusions and tentative model

- We describe a newly identified "dark" ignimbrite at the Millcreek section
- The "dark" unit appears to be in depositional contact with the typical "pink" unit
- The "pink" (and possibly the "grey") units are geochemically similar to the previously analyzed Grassy Mt. Ignimbrite samples with negative Eu anomalies, albeit slightly less evolved
- The "dark" unit has a positive Eu anomaly, but apparently no higher abundance of feldspar
- The Grassy Mt. Ignimbrite probably erupted from a zoned magma chamber
- We tentatively suggest that the Grassy Mt. magma chamber had the pink unit above the dark unit which had cumulate feldspar
- The dark unit was remelted by the introduction of mafic magma.
- The remelted layer was then erupted as the dark unit, penecontemporaneously with the pink unit

Further work

- Thin section analyses / petrography
- Additional geochemical analyses, including "gray" unit and dark enclaves

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