Another Look at the ~950-Year-Old Glass Mountain Rhyolite Tephra: New Insights Into Volume, Eruption Column Height, and Geochemistry

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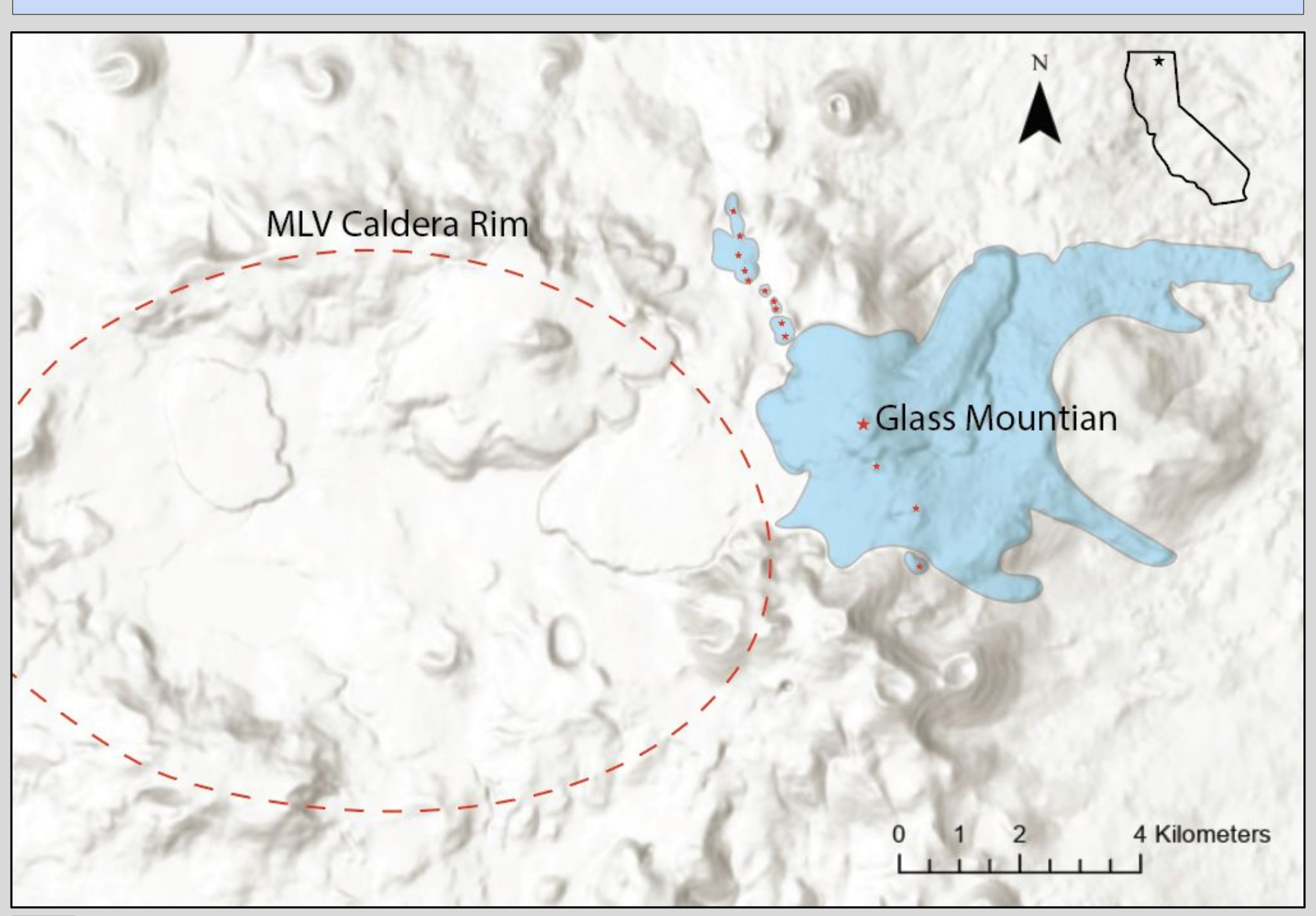
Introduction

The eruption of Glass Mountain at Medicine Lake Volcano (MLV) initiated explosively along a ~5 km long fissure vent system producing an aphyric rhyolite pumice. After the conclusion of explosive activity, dacite and rhyolite lava erupted from the vents forming a large flow and numerous lava domes (Donnelly-Nolan et al., 2016). MLV is designated as a "high threat volcano" by the United States Geological Survey due to its high frequency of eruptions, ability to produce explosive volcanism, such as the Glass Mountain eruption, and its location relative to regional infrastructure (Donnelly-Nolan et al., 2007).

Research Questions

1. What was the volume of tephra and dense rock equivalent (DRE) erupted at Glass Mountain?
2. What was the maximum eruption column height?
3. How did the eruption evolve over time in terms of mass flux, vent erosion, and magma supply?
4. How do the petrologic and geochemical characteristics of the white and grey pumices differ and do they represent a second erupting magma composition?

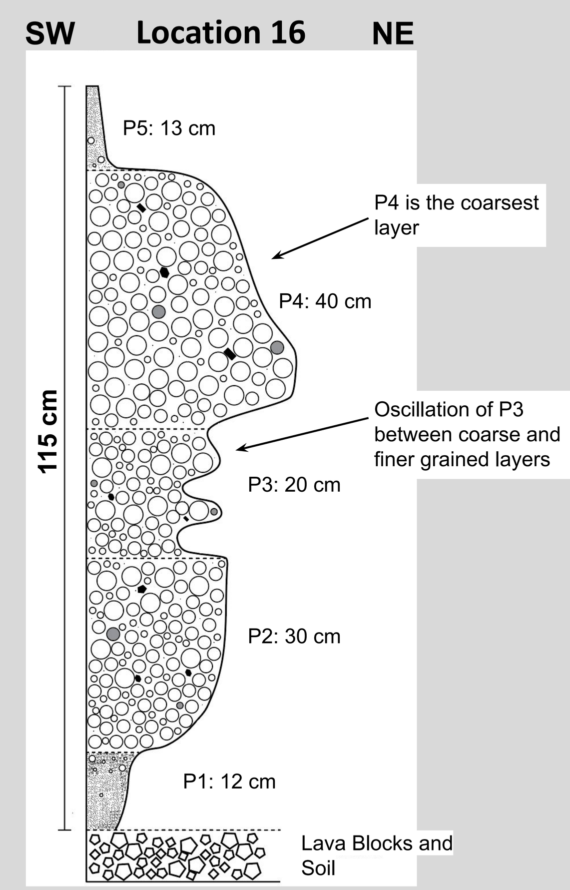
Geologic Setting



Extent of Glass Mountain lavas ★ Approximate vent locations

Glass Mountain is located on the eastern rim of the MLV caldera in northeastern California. MLV is located at the intersection of multiple tectonic features including the Walker Lane transform fault zone and the southern extent of the Klamath Graben which transitions into the Basin and Range fault system. These areas of crustal weakness encroach on the main subduction related Cascade volcanic arc allowing for magma to utilize north-south trending faults as preferential pathways to rise to the surface and erupt.

Stratigraphic Observations



Five distinct layers were observed within proximal tephra deposits and designated P1 - P5.

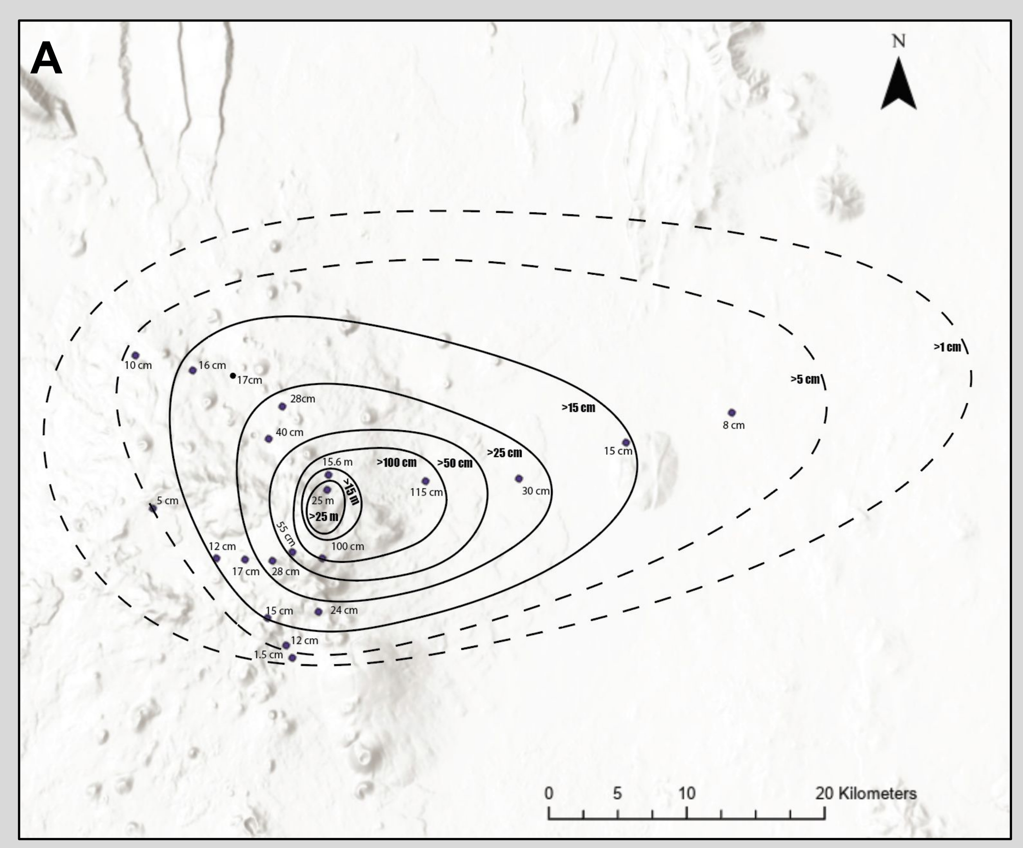
P1 and P5: Fine ash layer with sparse pumice clasts.

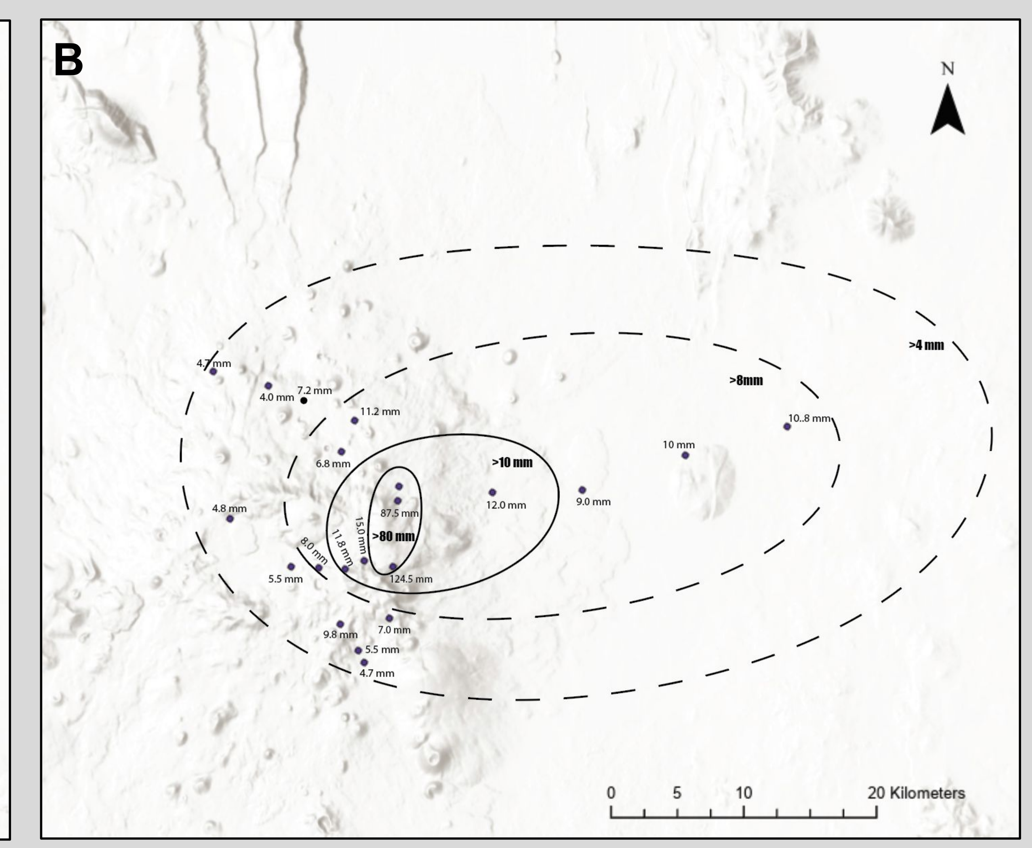
P2: Coarse grained and poorly sorted angular, pumice clasts normally grading into layer P3.

P3: Relatively finer grained and poorly sorted, angular pumice clasts with oscillation in average grain size. Reversely grades into layer P4.

P4: Poorly sorted, angular pumice clasts with the largest average grain size of the entire deposit.

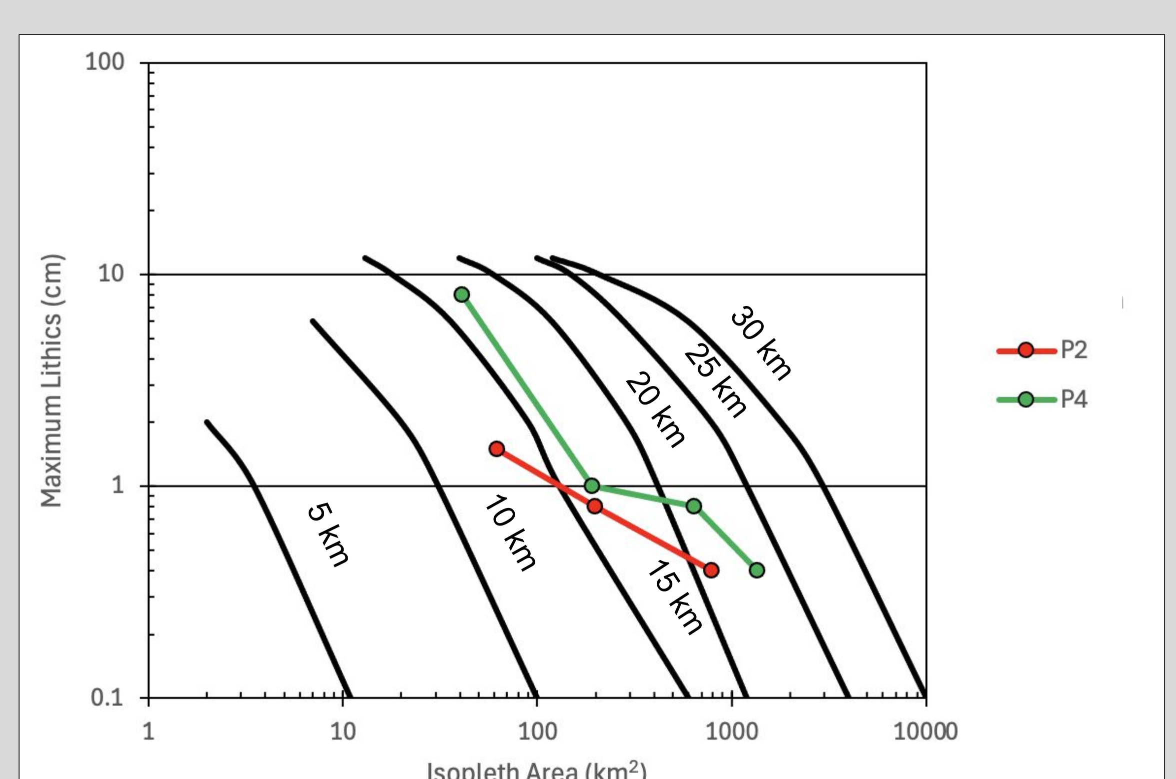
Isopach and Isopleth Mapping





A: Isopach map created using overall deposit thicknesses measurements representing the dispersal of the Glass Mountain tephra. This map was utilized to estimate the total volume of tephra erupted. The volume of tephra represented by this map was calculated using the method of Fierstein and Nathenson (1992).

B: Isopleth map created using the average diameter of the three largest lithics measured in layer P4 of the deposit. This map was utilized to estimate the maximum column height.

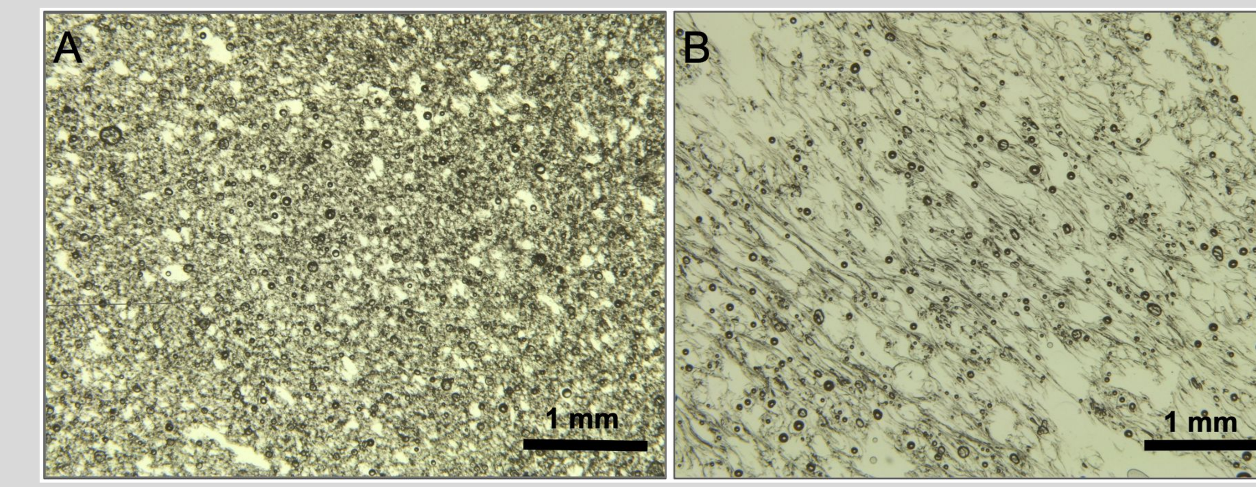


Maximum column heights were estimated for both layers P4 and P2 using the model proposed by Carey and Sparks (1986). Layers P4 and P2 were chosen because they are the coarsest grained layers indicating the eruption intensity was highest during their expulsion and deposition.

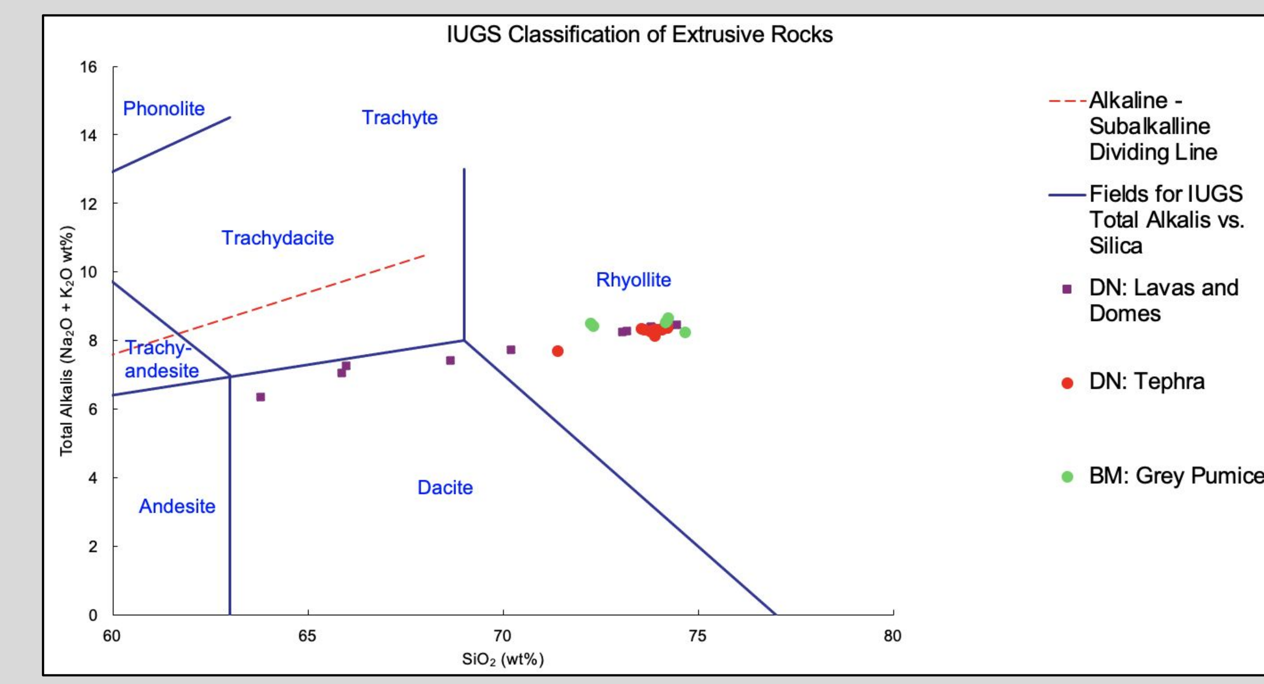
P2 Estimation: 13 - 21 km

P4 Estimation: 16 - 24 km

Petrography and Geochemistry



Groundmass textures of grey (A) and white (B) pumices.



Compositionally, the two pumice varieties are both rhyolites and plot on trend with other Glass Mountain eruptive products analysed by Donnelly-Nolan et al., (2016).

Answers to Research Questions

1. A total volume of 1.170 to 1.178 km^3 of tephra and 0.529 to 0.532 km^3 of DRE erupted as tephra at Glass Mountain.
2. A maximum column height of 16 - 24 km was produced by the most energetic phase of the eruption.
3. The eruption initiated as vulcanian style with discrete explosions driven by overpressurization of roof rock above the rising magma ejecting fine ash and tephra. It then evolved into a subplinian style eruption as a somewhat unsteady supply of fragmented magma drove a buoyant column into the atmosphere. As energy decreased, the eruption concluded with vulcanian explosions transitioning into the effusive eruption of lavas.
4. The grey and white pumice are both rhyolites with no distinguishable geochemical differences. The grey pumices are distinguishable in thin section by a higher density groundmass and a higher volume percentage of crystals when compared to the white variety.

References:
Carey, S., and Sparks, R. S. J., 1986, Quantitative models of the fallout and dispersal of tephra from volcanic eruption columns. Bulletin of Volcanology, v. 48, no. 2–3, 13 p. 109–125.
Donnelly-Nolan, J. M., Champion, D. E., and Grove, T. L., 2016, Late holocene volcanism at Medicine Lake Volcano, Northern California Cascades. Professional Paper.
Donnelly-Nolan, J. M., Nathenson, M., Champion, D. E., Ramsey, D. W., Lowenstern, J. B., and Ewert, J. W., 2007, Volcano hazards assessment for Medicine Lake volcano, northern California (No. 2007-5174-A). Geological Survey (US).
Fierstein, J., and Nathenson, M., 1992, Another look at the calculation of fallout tephra volumes. Bulletin of Volcanology, vol. 54, no. 2, p. 156–167