

The Petrography and Geochemistry of the Southeastern Portion of Thirtynine Mile Mountain,  
Central Colorado

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Units of the Tertiary Thirtynine Mile volcanic field cover approximately 2000 km<sup>2</sup> of central Colorado. The pre-volcanic, late Eocene erosion surface and ash-flow deposits of the Wall Mountain Tuff formed the base of the volcanic field. Subsequent volcanic activity was previously determined to have begun approximately 35 million years ago. A petrographic and geochemical study of the volcanic activity north of the Guffey volcanic center was undertaken in an attempt to make regional stratigraphic correlations, to determine the volcanic processes active during their formation, and to determine whether a caldera-forming event was involved in the formation of the present-day topography surrounding Guffey.

A stratigraphic column has been established for the lower and upper members of the Thirtynine Mile Andesite (Epis and Chapin, 1974). The oldest unit in the lower member, an olivine pyroxene basalt, contains large clinopyroxene (cpx) phenocrysts (1-7 mm) at 5-7 modal percent. Occasional fresh but usually iddingsitized olivine at 1 modal percent could be seen in hand sample. Overlying the olivine basalt is a biotite hornblende andesite unit with approximately 10% phenocrysts in a dark blue to grey aphanitic groundmass. Above the andesite is a well-jointed pyroxene basalt flow approximately 6-9 feet thick with 6-8 modal percent cpx phenocrysts (1-6 mm), which are most evident on the weathered surfaces. Interwoven within these layers are prominent laharic breccias of both hornblende andesite and pyroxene basalt. The breccia usually appears as a very corroded, vesicular, thin (a few feet thick), but laterally expansive outcrop.

Contrary to the description given on the Geologic Map of the Guffey Quadrangle (1979) for the Upper Andesite member, the andesite on Thirtynine Mile Mountain consists of approximately 90% vesicular, non-monolithologic laharic breccias containing clasts ranging from a few inches to boulder size. Graded and reversed graded beds are also evident. The remaining approximately 10 percent consists of a hornblende pyroxene andesite with an aphanitic, sugary, brown to grey groundmass. Cpx (1-6 mm) comprises the majority of the phenocrysts (usually 7-10% and rarely 10-20%), but hornblende (1-5 mm) and plagioclase phenocrysts are also evident.

Dikes are common in both members of the Thirtynine Mile Andesite. Rock names range from a rhyolite with biotite and hornblende phenocrysts in an aphanitic, light blue to grey, sugary groundmass to well-developed, flow-jointed, olivine pyroxene basalt with large pyroxene phenocrysts and approximately 1 percent fresh olivine. Several outcrops of hypabyssal, black and white speckled diorite were found on the southeastern edge of the map area.

Common phenocryst assemblages in the forty-two thin sections examined consisted of plagioclase, biotite, hornblende, augite, olivine, apatite, and magnetite. Other phenocrysts such as orthopyroxene, calcite, quartz, zircon, zeolite, chrome spinel, and sericite mica were rarely encountered. The chemical heterogeneity resulted in a wide range of rock names, from olivine pyroxene basalt to hornblende andesite, and diorite. (LeBas et al, 1986). The textures vary from

pilotaxitic in the andesites to intergranular in the basalts with a secondary trachytic flow alignment of plagioclase evident in some of the thin sections. Plagioclase phenocrysts are abundant in most thin sections; it was a primary constituent of the groundmass, as well.

Based on phenocryst relationships it has been determined that apatite and magnetite must have been on the liquidus early in the crystallization histories of most of these rocks. Pleochroic apatite (due to the presence of numerous opaque inclusions aligned parallel to the C-axis), was observed in several thin sections and has been previously interpreted as an indicator of higher pressure crystallization (Green, 1981). Magnetite and apatite are present in every slide.

Augite appears often as a phenocryst but it was apparent that all of the phenocrysts were not formed by the same series of magmatic events. Cpx phenocrysts in one thin section appear to have been in disequilibrium as indicated by the chemical zonation, while cpx in another probably underwent fairly rapid crystallization as demonstrated by sector zoning. Some cpx in other samples were twinned, and/or showed significant alteration. With the cpx, fresh and iddingsitized olivine was present as phenocrysts up to 3 modal percent. Some olivine occurred with cpx, plagioclase, and oxides as glomeroporphyritic clumps. Although Bowen's reaction series suggests that olivine is likely to be the first mineral crystallizing, this was often not the case. Olivine is seen completely enclosing augite and apatite indicating the crystallization of these minerals prior to olivine. In other thin sections it was also apparent that apatite and olivine had crystallized nearly simultaneously.

Forty-two samples were analyzed for major and trace elements at Franklin and Marshall College; six samples were analyzed for rare earth elements (REE) by Activation Laboratories Ltd., in Canada, using instrumental neutron activation.  $\text{SiO}_2$  values range from 47 to 70 percent. Cr and Ni have very low abundances (Cr averages 30.4 ppm, Ni averages 12.9 ppm), whereas Rb values range between 90 and 430 ppm. Enrichment of other large ionic lithophile (LIL) elements was noted. Total alkalis range from 6 to 10 percent.

Rb plotted vs MgO (Figure 1) results in a trend of increasing Rb as MgO decreases with the exception of several data points which fall completely off the trend. On the other hand, Be vs MgO (Figure 2) depicts a flat to slightly decreasing Be pattern as MgO decreases. These contrasting behavior patterns of two LIL elements is difficult to reconcile with any simple petrogenetic model.

Based on the field work, petrographic descriptions, and geochemical analyses completed to date, the data does not support generation of these volcanics by any single magmatic process. Possibilities at this point include crystal fractionation, assimilation, magma mixing, as well as partial melting of different source areas. Some of the observed trends suggest certain processes more than others. The complex trend apparent in the  $\text{Al}_2\text{O}_3$  vs  $\text{SiO}_2$  (Figure 3) diagram supports crystal fractionation as the mechanism which relates the data sets within each group. However, the relationship which ties one group to another is not presently clear. If crystal fractionation was the only process at work, however, the Be vs MgO plot should show an increase in Be as MgO decreases. Instead, the trend seems to be flat to slightly decreasing. These two diagrams are at odds with one another. Further petrographic and geochemical analyses of rock units in the surrounding areas may aid in the unravelling of the complex magmatic processes at work.

## References

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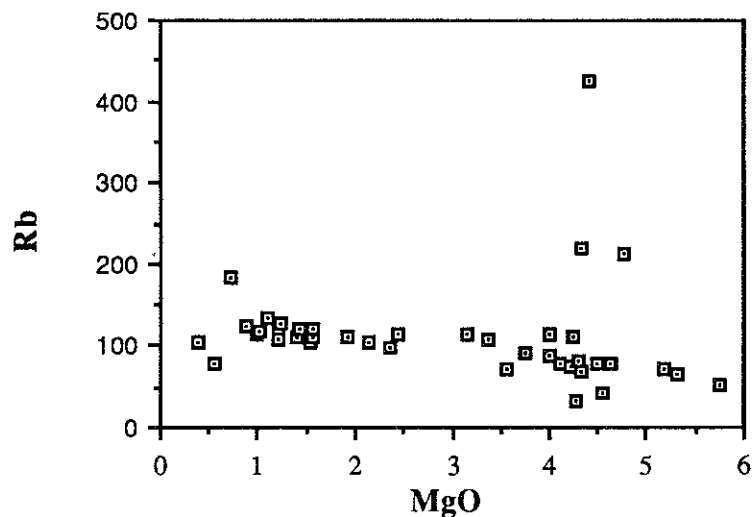


Figure 1. Rb vs MgO

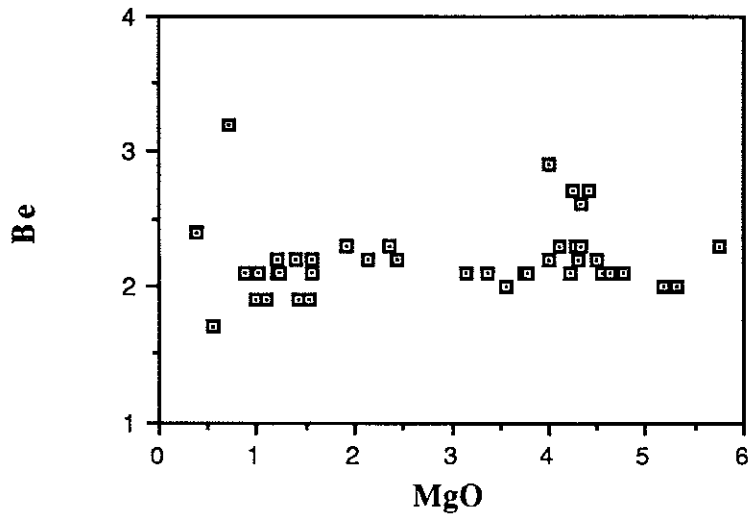


Figure 2. Be vs Mgo

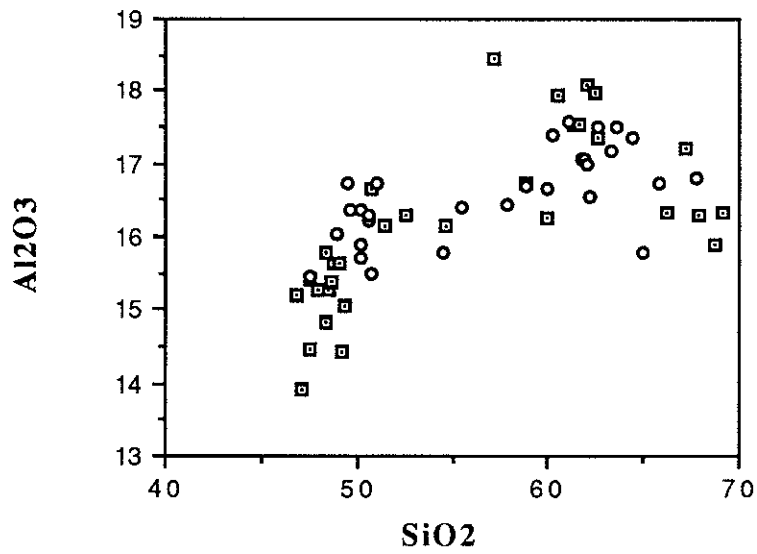


Figure 3. Al<sub>2</sub>O<sub>3</sub> vs SiO<sub>2</sub>. Squares with dots in the center are my data points; the circles are supplementary data points.