A Petrologic and Geochemical Study of a Portion of the Thirynine Mile Volcanic Field Central Colorado

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Introduction

The Thirtynine Mile volcanic field of central Colorado is of Tertiary age, covering nearly 2000 km^2 and consists of several volcanic centers. The processes that produced the extrusive rocks found at these centers is still under debate. The Guffey volcanic center, located north of the town of Guffey is marked by a large roughly circular depression which encloses both dome-like structures as well as several small intrusive bodies. The goals of my research can be described as follows: to develop a definite stratigraphic sequence using map units defined by Epis and Chapin (1974), to use thin section and whole rock chemical analysis to understand the petrology and geochemistry of the extrusives in my field area, and to integrate the data into one cohesive picture to explain the volcanism that occurred.

Fieldwork

My particular research project was focused on a nearly nine square mile area to the northwest of the town of Guffey sandwiched between Dicks Peak to the south and Three Mile Creek to the north. Field mapping showed several clear stratigraphic relationships. The lowest stratigraphic unit, a Pre-Cambrian biotite gneiss outcrops in two distinct areas in the southern portion of the field area, but in the northern section of the map area it appears only as small barely recognizable knobs that are not covered by the younger volcanic layers. The Wall Mountain tuff is an Oligocene ash flow unit that appears only in the northern part of the map area, usually occurring near and possessing the same outcrop pattern as the biotite gneiss. The next youngest unit is the Oligocene Hornblende Andesite, which consists primarily of a dark grey aphanitic groundmass that contains between 5 and 8 modal percent hornblende. This unit covers approximately three square miles of the southeastern portion of the map area. Further to the southeast it intercalates with the Lower member of the Thirtynine Mile Andesite. Its primary outcrop is along Sheep Gulch where the stream has cut down through the unit, exposing cliffs with 300 feet of relief. The average strike and dip indicate that the source of this unit was in the direction of Dicks Peak. The lower member of the Thirtynine Mile Andesite consists of layers of monolithologic clinopyroxene basaltic laharic breccias which are interspersed with three different types of andesite lavas. These lavas include a dark glassy andesite with only an occasional hornblende phenocryst, a light grey completely aphanitic andesite, and a dark grey hornblende andesite which contains about 5 and 8 modal percent hornblende. This unit is generally confined to the lower elevations of the map area and is more expansive than any of the other units. Above this unit lies the upper member of the Thirtynine Mile Andesite. This unit is found as basaltic flows and monolithologic clinopyroxene laharic breccias which are generally confined to the tops of hills. The clinopyroxene basalt flows typically contain between 4 and 6 percent anhedral clinopyroxene phenocrysts(1-6mm) with plagiclase microlites evident in the groundmass. This unit is distinguished from the lower member by its massive well lithified outcrop pattern and lack of interspersed andesites. The final unit is Piney Creek Alluvium, a Holocene unit consisting of soils and gravels eroded from older units, found only in Sheep Gulch where , presumably, the down cutting has been extensive enough to produce these alluvial deposits.

Sixty-six samples were collected from locations all around the map area and from these, 31 samples were chosen for both thin section and whole rock chemical analysis. These samples were chosen to best represent the entire spectrum of rock types, field relationships, and geographical locations of the units in the field area.

Petrography

Petrographic analysis of the thin sections shows , as was observed in the field relationships, that the rocks are bimodal in nature, consisting of a silicic end (the andesites) and a mafic end (the basalts). Close examination of the grain to grain relationships show that the basaltic rocks contain mineral assemblages of plagioclase, clinopyroxene, Fe-Ti oxides, olivine, and apatite. The andesites contain mineral assemblages of plagioclase, hornblende, biotite, Fe-Ti oxides, and apatite. The basalts have a crystallization sequence in which apatite and Fe-Ti oxides were early liquidus phases, followed by olivine, clinopyroxene and plagioclase with each phase persisting into the groundmass. The andesites have a similar crystallization history with apatite and Fe-Ti oxides as early liquidus phases, followed by hornblende, biotite and plagioclase with these phases also persisting into the groundmass. The textures are generally intergranular to intersertal in the basalts and pilotaxitic to trachytic in the andesites. Several thin sections have secondary alteration products such as interstitial calcite and zeolites. Some andesites show resorption of hornblende and biotite phenocrysts, a primary feature probably due to the P_{H_2O} changing to zero during magma ascent to the surface. In many instances only pseudomorphs remain. Other minerals show some degree of primary resorption including, Fe-Ti oxides, clinopyroxene and plagioclase.

Orthopyroxene grains with a clinopyroxene reaction rims appear rarely in some of the basalts and resorbed quartz grains with clinopyroxene reaction rims were also observed in several andesites. The infrequency of orthopyroxene grains and the reaction rims that accompany them may indicate magma mixing at some scale and the resorbed quartz grains may represent either crustal assimilation or high pressure crystallization of quartz at depth(Green,1968).

Chemistry

Major and trace element data was gathered through X-ray fluorescence and inductively coupled plasma techniques at Franklin and Marshall College. By comparing values obtained for nine runs of USGS standards W-2 and QLO-1 to the accepted values the average accuracy of the methods was determined to be 1.73% for analysis of major elements . The precision of the techniques was evaluated by preparing four separate disks of sample 90- C- 44 for both major and trace element analysis and comparing the values to each other. The most striking feature noted is the bimodality of the samples, supporting the earlier observations of both hand sample and thin sections. The chemical classification of the rocks was based on the $Na_2 + K_2O$ vs. SiO_2 diagram(Fig.1) (Le Bas et al., 1986) which indicate the samples are mainly potassic trachy-basalts and latites. The total iron vs. SiO_2 diagram shows no iron enrichment occured and Harker diagrams of the LIL elements (K, Rb, Sr, Ba, Zr) vs. SiO_2 depict positive, typically incompatible trends.

Discussion:

Combining field, petrographic, and chemical data it is possible to develop an understanding of this part of the volcanic field. The rocks in the field area are primarily potassic trachy-basalts and latites and the alkaline nature of these rocks is indicated by the presence of olivine in the groundmass, and the absence orthopyroxene reaction rims around the olivine in thin section. The lack of iron enrichment and the appearance of oxides early on the liquidus suggest that the oxygen fugacity was relatively high. The enrichment of LIL elements in the melt and the depletion of elements such as Mg, Ti, and Ca and other elements that are concentrated in the minerals observed in thin section(Fig.2 and 3) suggest fractional crystallization may have had a significant role to play in magma evolution. The bimodality of these rocks, however, indicates that fractional crystallization may relate the rocks within each group, but this process alone does not relate the individual group to each other. Petrographic evidence, such as the infrequent orthopyroxene grains with clinopyroxene reaction rims and the resorbed quartz grains suggest that magma mixing and crustal assimilation may also be involved. The generation and differentiation of the source magma for the thirtynine mile extrusive units cannot be explained by any single process alone and probably represent the involvement of several processes interacting together.

References

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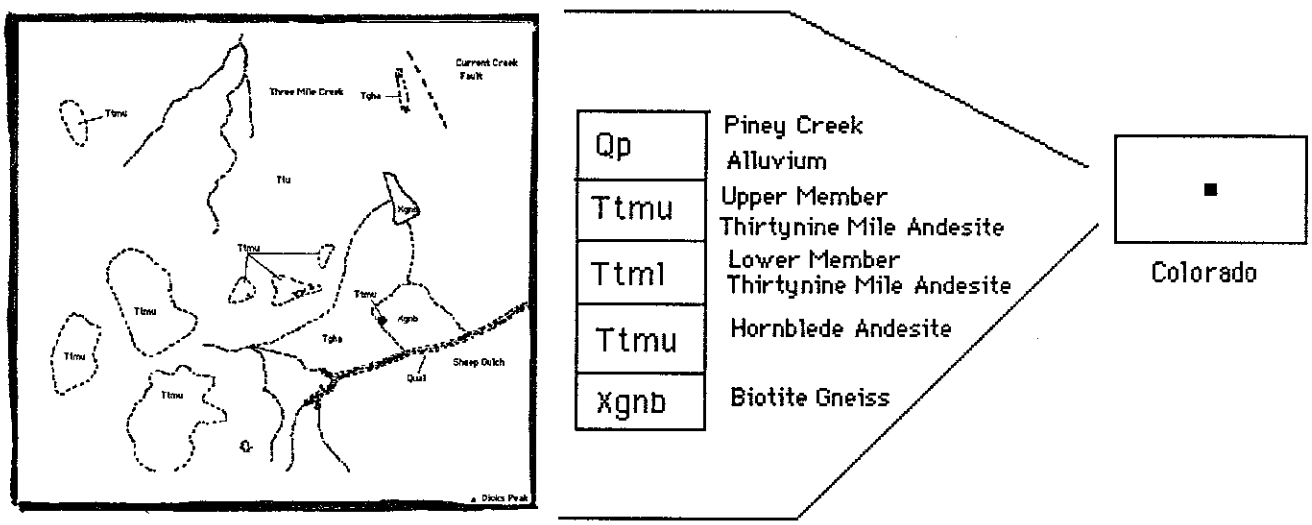

Geologic Map of Sheep Gulch Area

Na2O + K2O vs. SiO2

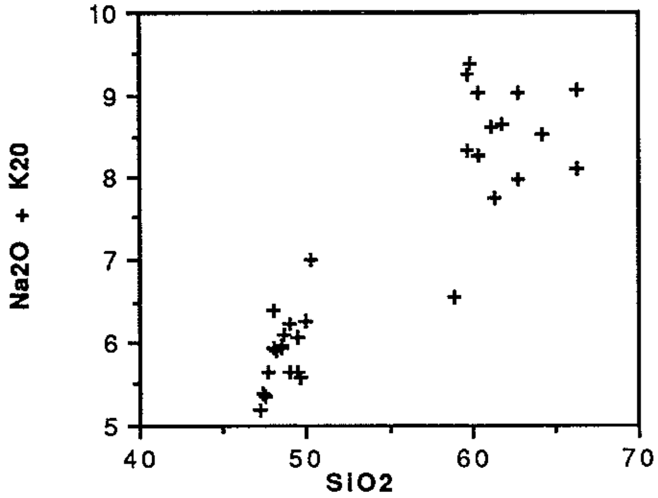

Figure 1

MgO and CaO vs. SiO2

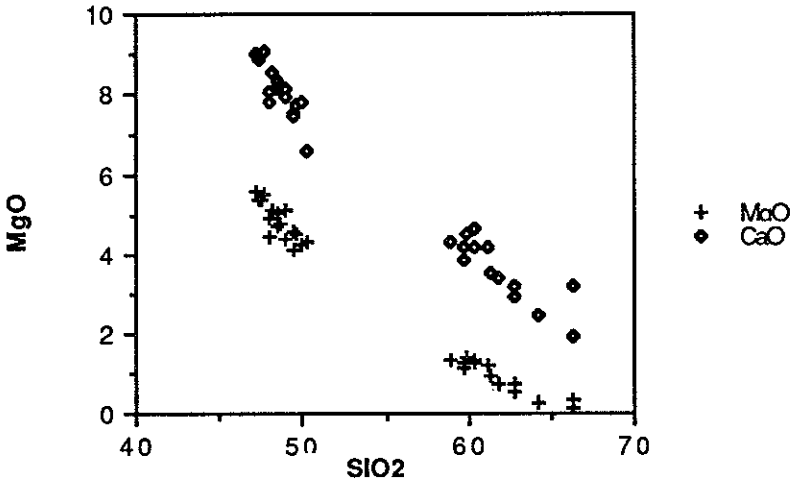

Figure 2

Rb and Zr vs. SiO2

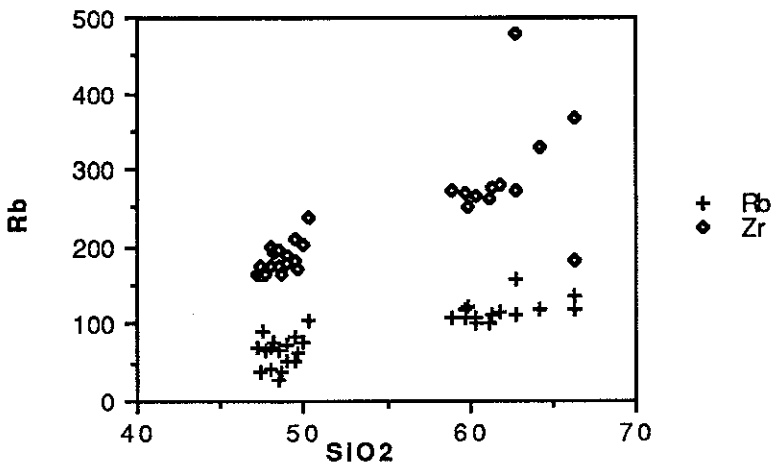

Figure 3