THE PETROLOGY AND GEOCHEMISTRY OF CASTLE AND MCINTYRE MOUNTAINS, GUFFEY, COLORADO

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The Thirtynine Mile Volcanic Field is a Tertiary volcanic region covering about 4400 square kilometers in central Colorado. In the early Oligocene, beginning about 34 million years ago, (Epis, et al., 1980) andesitic-type volcanism occurred in the area surrounding the present location of the town of Guffey, Colorado. The Guffey region has been called a "caldera"--formed by the collapse of a composite volcano composed of the 34 Ma andesitic lavas and associated laharic breccias. The northeast flank of the caldera is reportedly represented today by Thirtynine Mile, Saddle, Castle, McIntyre, and Witcher Mountains. The andesitic volcanism of the Thirtynine Mile Volcanic Field and, specifically, the volcanics in the Guffey caldera region, have been linked in both tectonic origin and in time to the Tertiary volcanics of the San Juan Mountains in southwestern Colorado. Through field interpretation and geochemical and petrographic analyses of rock samples from the Castle and McIntyre Mountain areas of the Guffey caldera, I propose that, although nearly contemporaneous with late San Juan volcanism, the Oligocene volcanic activity in Guffey began as a result of diapiric rise of a magma generated by partial melting of a lower crust/upper mantle source region depleted in compatible trace elements.

Detailed mapping of Castle and McIntyre Mountains revealed two broad types of volcanic rocks: 1) the mafic flow (termed "basaltic" in hand sample) with associated dikes and laharic breccia, and 2) "andesitic" flows with laharic material and somewhat fewer accompanying dikes. The mafic flows typically contained visible phenocrysts of clinopyroxene and/or olivine, at times in conjunction with hornblende, in a dark, crystalline matrix usually containing flow-aligned acicular plagioclase. The more "andesitic" flows typically contained hornblende and/or biotite phenocrysts in a lighter matrix--plagioclase was a phenocryst phase in some of these samples.

Castle Mountain was one of the few locations in the Guffey area with complete stratigraphic control of volcanic flow successions. The upper half of the southern face of the mountain showed a "stair-step" pattern of mafic five-meter-high flows alternating with laharic breccia. The north-trending ridge of Castle had a unique dike-swarm--a series of at least forty large and small mafic dikes with no common structural trend. McIntyre Mountain was a cone-shaped feature composed predominantly of laharic breccia with a few interlayered minor flows of the "andesitic" type; only one stratigraphically significant flow capped McIntyre. The lowlands between and to the southwest of both mountains were typified by laharic breccia and smaller, intercalated flows of "basalt" and "andesite". Thirty samples of flows and dikes were collected for analytical purposes from regions on and around the two mountains.

Petrographic analysis of twenty samples revealed various phenocryst combinations of plagioclase, clinopyroxene, olivine, hornblende, biotite, magnetite, and minor apatite. Modal names ranged from hornblende andesite to olivine basalt. The samples were distinct in their lack of orthopyroxene, except for one which contained a few resorbed orthopyroxene phenocrysts. The texture of the samples was generally intergranular to trachytic, especially in the dikes. The dominant phenocryst phase was clinopyroxene, often found as subhedral crystals between 0.5 and 3.0 mm in size. Modally, clinopyroxene composed from five to 20 percent of any rock sample. Cpx existed either singly or in glomeroporphyritic clusters. Cpx always existed either with olivine or hornblende; biotite was found as a primary and secondary mineral phase in combination

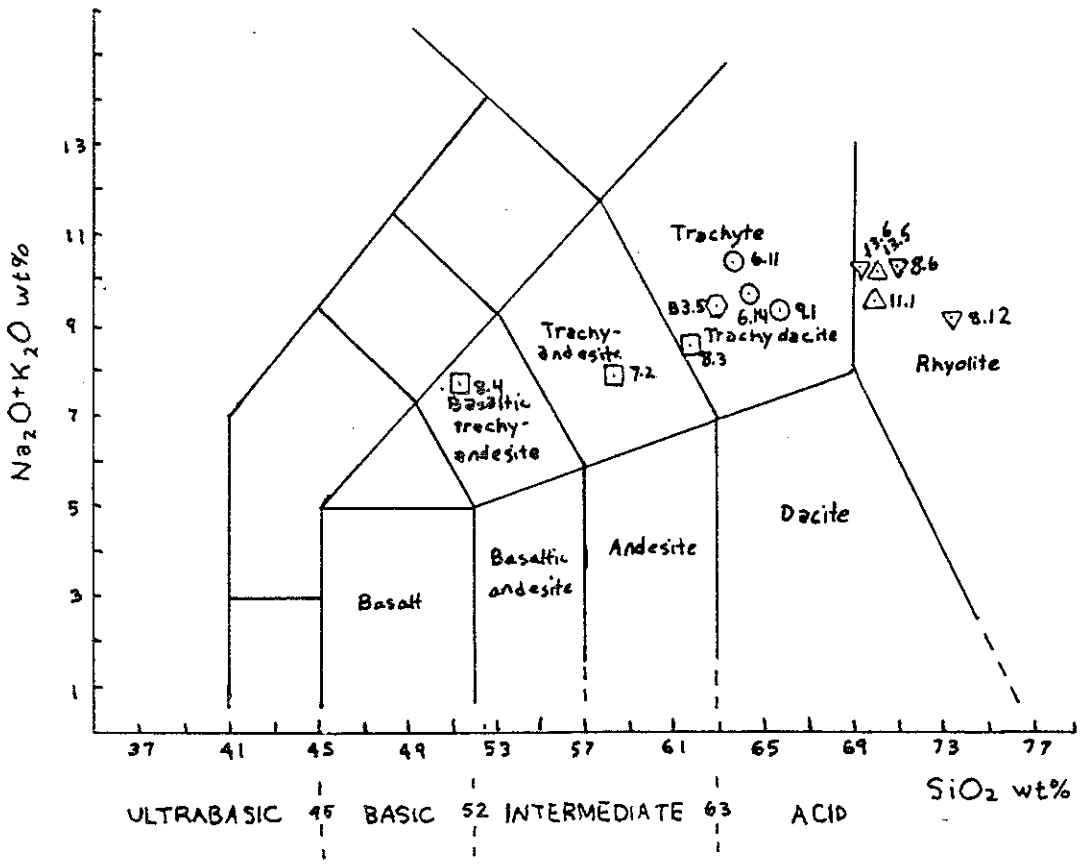

Figure 2. The total alkali-silica (TAS) diagram showing the 12 analysed samples.
(○Dome, △ Vent,□Dikes,⬡Inter-laharic flow)

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with both cpx/olivine and cpx/hornblende assemblages.

Olivine was often iddinsitized but remained pristine in some samples. Phenocrysts ranged in size from about 0.1 to 2 mm. It was often found as discrete crystals within a sample, but was observed in contact with cpx in some glomeroporphyritic arrangements. Modally, olivine existed up to five percent in the samples. Hornblende was found in only five of the twenty samples analyzed and never existed without some cpx as a phenocryst phase. Magnetite existed as a phenocryst phase in every sample observed; it was found either as discrete phenocrysts or in phenocryst clusters on and around mafic assemblages of cpx, olivine, and/or hornblende. Plagioclase was never very well preserved either in the groundmass or as phenocrysts--it presumably destabilized upon rise of the magma from depth. Apatite was found in four samples--modally up to one percent of the rock--and only in mineral assemblages that included hornblende or biotite with cpx. In nearly every sample, mafic phenocrysts (and, where present, apatite) persist to the groundmass; the oxides, especially give the groundmass a "peppery" appearance.

Several conclusions about these volcanic flows and dikes follow from the petrographic observations: 1) cpx/biotite and hornblende/biotite were both coprecipitating mafic phases under partially hydrous magmatic conditions, 2) pervasive magnetite phenocrysts indicate that it was on the liquidus early and, therefore, precluded any Fe-enrichment, 3) persistence of cpx/olivine/magnetite microphenocryst phases typifies alkaline olivine basalts where olivine and the liquid do not react to form orthopyroxene, and 4) the presence of just two resorbed phenocrysts of orthopyroxene in thirty samples leads to speculation that the extruded magmas of the region had spent some time in a magma chamber, perhaps crystallizing and fractionating opx at depth.

Chemical analysis of twenty samples reveals rocks of predominantly basaltic composition with SiO2 ranging between 48 and 53 percent. Four of the analyzed samples reach the andesitic range with 56-61% SiO2. The K2O content averages between three and four percent, with Na2O/K2O close to unity. Using the terminology of Le Bas et al., 1985, these samples are shoshonites and potassic trachybasalts with minor trachyandesite-latite flows. An AFM diagram places these samples on the border between tholeiitic and calc-alkaline trends. A diagram plotting total FeO versus MgO shows a positive linear relationship and then a plateau of total FeO as MgO continues to increase (figure 1).

Trace element analyses show enrichment in some LIL elements; average Ba values are greater than 1400 ppm and Sr values range in two groups from 900-1200 ppm and 1500-1800 ppm. The Sr values vary with no corresponding changes in whole rock chemistry. Rb contents are typically low, ranging between 70-80 ppm. Compatible trace elements Ni and Cr are typically depleted in these samples with Ni values averaging 20 ppm and Cr about 35 ppm. K/Rb varies only slightly between values of 300 and 450. Nine samples analyzed for REE show enrichment in LREE and no Eu anomaly. A diagram plotting La/Yb versus K2O shows a linear trend--a positive correlation exists between increasing LREE and K2O contents (figure 2).

The chemistry of these rocks tends to support petrographic observations. Total FeO versus MgO shows no Fe-enrichment; likewise, lack of an Eu anomaly indicates high fO2 during crystallization. These trends support the petrographic evidence for both plagioclase and magnetite as early liquidus phases. High K2O contents apparently parallel both LREE and LIL values. Magmas rising through continental crust and possibly residing in an upper level magma chamber would incorporate these components readily. Bimodal variations in Sr values suggests a heterogeneous magma source area. The presence of abundant olivine phenocrysts without high Ni and Cr contents indicates a source depleted in compatible trace elements.

Conclusions:

1) Mineral assemblages and chemical compositions of the volcanic rocks of the

northeast region of the Guffey caldera are significantly different from any previously cited analogs in the San Juan Volcanic Field to the southwest.

2) Field relationships in the northeast "flank" of the Guffey area did not definitively prove the existence of a caldera collapse structure.

3) Major differences in chemistry and field relationships between the San Juan region and the Guffey area of the Thirtynine Mile Volcanic Field question the validity of a shallow subduction mechanism for the latter.

4) Chemistry and petrography of the Guffey region suggest an origin by partial melting of a heterogeneous source area, probably located in the lower crust. A possible causal mechanism for volcanism in this area could be a rising mantle diapir associated with the advent of the Rio Grande Rift. A mantle plume could have initiated crustal extension and established a pathway by which a partial melt could rise from the lower crust toward the surface.

Figure 1.

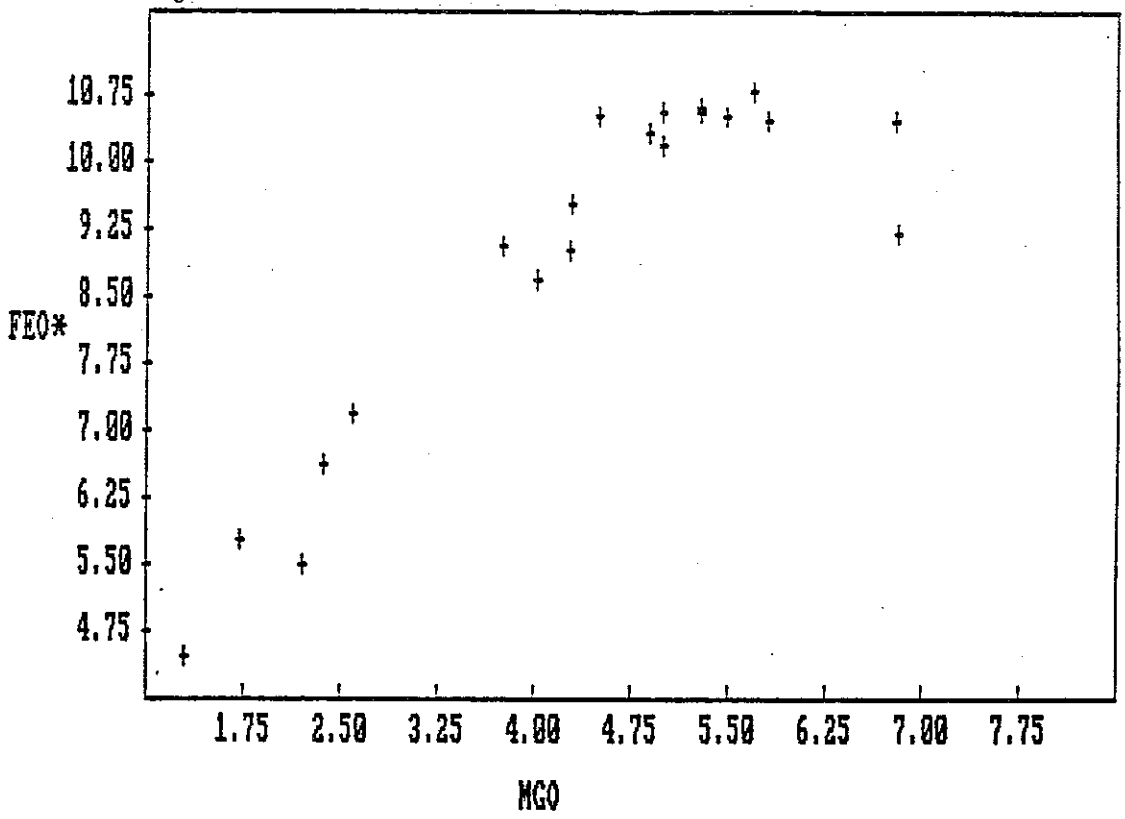
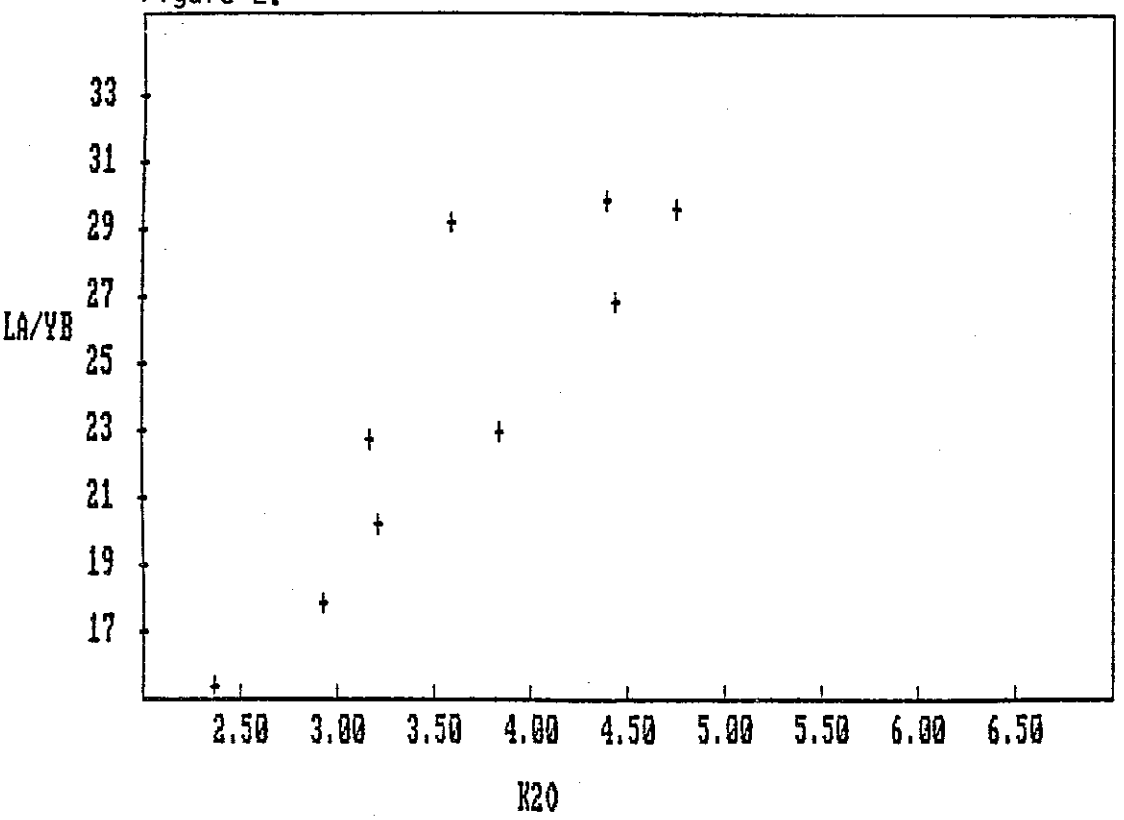


Figure 2.



THIRTYNINE MILE VOLCANIC FIELD
THE GEOLOGY OF WITCHER MOUNTAIN

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Based on field relationships, the volcanic rocks of Witcher Mountain on the eastern edge of the Thirtynine Mile volcanic field in Central Colorado can be divided into two general categories. The fi category is characterized by extensive flows and associated laharic material. The second category inc dikes that crosscut the flows and a small rhyodacitic dome sitting on the upper flows of Witcher Mountain.

There are two distinct flow units. The first, and volumetrically most significant, flow is a basaltic andesite. The unit is characterized by clinopyroxene phenocrysts and olivine phenocrysts high in magnesium relative to iron oxide (66% MgO:34% FeO). Phenocrysts of plagioclase are rare. The majo of plagioclase exists as groundmass laths (An_{x-y}). Fe-Ti oxides are also present with titanium oxide content ranging from 7-20 weight percent. The second flow is andesitic with normally zoned plagio phenocrysts. Plagioclase laths are dominant in the fine-grained matrix and are more sodic than the plagioclase phenocrysts. Hornblende and biotite are the dominant mafic phenocrysts with traces of s clinopyroxene phenocrysts also present. In addition, Fe-Ti oxides are present with titanium oxide co ranging from 10-40 weight percent.

The basaltic dikes crosscutting the flows are characterized by an abundance of clinopyroxene phenocrysts. Olivine exists as phenocrysts as well (59% MgO:41% Feo). Fe-Ti oxides are also present. Titanium oxide content ranges from 12-20 weight percent. The groundmass consists of clinopyroxe and calcic plagioclase laths.

The rhyodacitic unit is characterized by the presence of hornblende and biotite phenocrysts. An phenocrysts are also present. The Fe-Ti oxides present have a range of titanium oxide from 15-35 weight percent. The groundmass consists of alkali feldspar.