THE GEOLOGY, PETROLOGY AND GEOCHEMISTRY OF A SILICIOUS DOME AND VENT IN THE THIRTYNINE MILE VOLCANIC FIELD, NEAR GUFFEY, COLORADO

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INTRODUCTION

Located in the southern portion of the Thirtynine Mile volcanic field near Guffey, Colorado, are the remains of a volcanic dome and a volcanic vent. These Oligocene-age features are in sections 13 and 24 of T15S, R74W and section 19 of T15S, R73W of the Thirtyone Mile Mountain and Black Mountain 15' quadrangles. A dome is a steep sided hill that forms when very viscous lava piles up over and around a vent. Domes can form by the piling up of several short flows or by new lava being squeezed from a vent distending the overlying mass. A vent is an opening at the earths surface though which volcanic material is extruded, often forming a mound or hill of interbedded lava flows and tephra.

DOME

The dome, a light-gray, tracyte-trachydacite, is 1.2 km wide and 180 m thick (see western half of map, Fig1). Its sides are very steep and outcrops show numerous joint sets as well as a hint of vertical flow alignment. The dome was extruded up through the Oligocene Wall Mountain Tuff and Eocene Echo Park Alluvium with lava supplied from below. Its relationship to the surrounding laharic breccias is unclear; the dome could have been extruded on top of the lahars or the lahars could have flowed around the dome.

The holocrystalline trachyte-trachydacite contains plagioclase and biotite phenocrysts (5-17 modal %) in a groundmass of plagioclase laths (30-60 modal %), opaques and cryptocrystalline material (20-60 modal %). The plagioclase phenocrysts are subhedral, twinned and zoned, with an average core composition of An_{50} and rim composition of An_{24}. The biotites are also subhedral and have rims of secondary hematite and opaques. Most of the biotites have been slightly resorbed with cryptocrystalline matrix filling the embayments. The groundmass of each sample has a trachytic to orthophyric texture, grading to pilotaxitic to felsophyric where cryptocrystalline material is abundant. The groundmass plagioclase laths are 0.01x0.08 mm to 0.15x0.38 mm, subhedral, twinned and strongly zoned, with core compositions of An_{43} and rim compositions of An_{23}. The rest of the groundmass is composed of cryptocrystalline material with low birefringence, probably plagioclase, quartz and potassium feldspar.

VENT

The vent, a feature 120 m thick and 300 m wide, can be divided into three zones: the eastern zone, the western zone and the central zone (see central hill on map, Fig 1). In the western zone a 6 m thick rhyolitic unit of possible pyroclastic origin overlies a laharic breccia. This rhyolitic unit forms a cliff and contains large, randomly-oriented, banded inclusions of a similar rhyolitic material. In the eastern zone the same cliff-forming rhyolite is found at a lower elevation. It is overlain by slightly banded flows 0.5-1 m thick. Micro-faults with vertical offset disrupt the flow banding and red-pink hydrothermal alteration is concentrated along these faults. In the central zone there is a reddish and blue-gray flow banded rock, which forms an autobreccia at low elevations. This central unit cuts across the rhyolitic unit of the eastern and western zones and spreads out to cover the top of the hill. The thick, possibly pyroclastic rhyolite, the thin flows of the eastern zone, the hydrothermal alteration and the autobreccia suggest that all of these units formed in close proximity to a vent. It appears that the vent opening was located in the central zone and first erupted the rhyolite and flow units of the eastern and western zones, then extruded the flow/autobreccia of the central zone which covered the top of the hill, filled the vent opening and caused the collapse of the eastern zone.

The rhyolitic cliff-forming unit and its inclusions, the flows of the eastern zone and the flow/autobreccia of the central zone are petrographically similar. All are holocrystalline rocks with small amounts of plagioclase and biotite phenocrysts in a fine grained to cryptocrystalline groundmass. The felsophyric to pilotaxitic texture of the groundmass is exhibited by plagioclase laths (0.01x0.05 mm - 0.1x0.2 mm) much smaller than those in the dome. Some of the samples contain up to 15% vesicles and trace amounts of tridymite with a radial habit. The biggest difference seen in the various rocks of the vent area is the percentage of cryptocrystalline matrix, which ranges from

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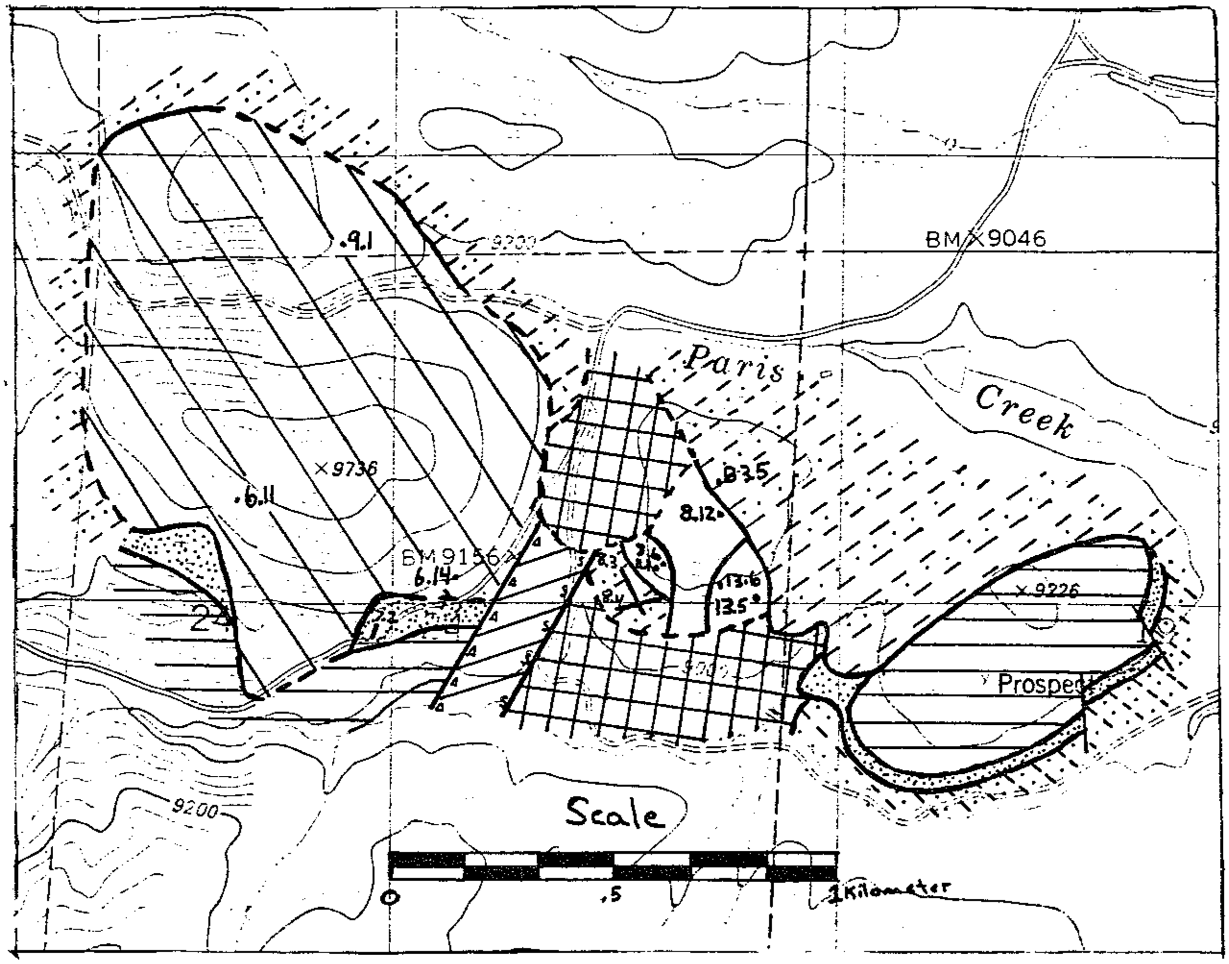

Figure 1: Map of the silicious dome and vent in the Thirtynine Mile volcanic field.

KEY TO LITHOLOGIES

- Holocene Alluvium
- Laharic Breccias
- Vent Rhyolites
- Dome Trachytes-Trachydacites
- Felsic Dike (ѕ sheared, Δ brecciated)
- Dikes
- Eocene Echo Park Alluvium
- Oligocene Wall Mountain Tuff
- Pennsylvanian Minturn Formation

50-75 modal % and probably indicates different cooling rates for the various units. The autobrecciated unit, in thin section, is nearly uniform mineralogically, but different parts of the section have flow orientation in different directions, revealing the brecciated fabric of the rock.

DIKES

A felsic dike is located in the Eocene Echo Park Alluvium at the base of the dome and a felsic dike cuts a mafic dike in the lahar at the base of the western zone of the vent. The dikes are less than four meters wide and cannot be traced for more than 15 m.

The felsic dike at the base of the dome is a latite containing 20 modal % plagioclase phenocrysts, 55 modal % plagioclase laths in the groundmass, 8 modal % altered ferromagnesian minerals, 2 modal % biotite and 15 modal % cryptocrystalline material. The plagioclase phenocrysts of this intersertal to intergranular rock are subhedral, twinne and zoned. The centers of many of these crystals have been slightly resorbed and exhibit sieve texture. The plagioclase laths are twinned, zoned and subhedral. Altered orange subhedral crystals indicate that amphibole and pyroxene were primary minerals in this dike and there are some biotite crystals scattered through the rock. The cryptocrystalline material has low birefringence and occurs in anhedral patches.

The mafic dike in the lahar of the vent, contains 4 modal % olivine, 2 modal % pyroxene, 10 modal % plagioclase phenocrysts and 84 modal % groundmass. The olivines and pyroxenes are subhedral and somewhat altered. The plagioclase phenocrysts are subhedral, zoned and twinned. Some exhibit a sieve texture that reflects internal resorption, while others have serrated edges resulting from marginal resorption. The groundmass is made (slender pyroxene prisms, subhedral plagioclase laths, small, evenly distributed opaques, altered ferromagnesian minerals and interstitial cryptocrystalline material. This rock has a intersertal to intergranular texture.

The felsic dike cutting through the lahar of the vent contains 20 modal % plagioclase phenocrysts, 6 modal % biotite and 74 modal % matrix. The plagioclase phenocrysts are twinned, zoned and subhedral while the biotites are subhedral and slightly resorbed. The matrix is made of small, subhedral crystals of feldspar and ferromagnesian minerals and anhedral patches of quartz, plagioclase and potassium feldspar. This rock has an intersertal to intergranular texture.

CHEMISTRY

Representative samples of the dome, vent and dikes were analysed for major and trace element chemistry. Sever samples were sent for instrumental neutron activation analysis (INAA) at Nuclear Activation Services Incorporated of Ann Arbor, Michagan and twelve samples, the seven plus five others, were analysed for major and trace element chemistry by x-ray fluorescence spectrometry (XRF) at the University of Massachusetts. Samples were powdered using a tungsten carbide shatterbox for x-ray fluorescence spectrometry or an alumina shatterbox for neutron activation to prevent contamination with trace metals from the tungsten carbide. The samples analysed at the University were fused into glass disks for major element chemistry and pressed into pellets for trace element analysis, according to the University of Massachusetts procedures.

The twelve samples were choosen to characterise and compare the individual field units: the dome, the vent and the dikes. All of the samples were analysed for SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, Y, Sr, Rb, Th, Pb and Ga, while only seven were analysed by INAA for Ta, Th, U, La, Ce, Nd, Sm, Eu, Tb, Yb, and Lu. The rocks were named according to the classification of LeBas (1986), as recommended by the IUGS Subcommission on the Systematics of Igneous Rocks (Fig. 2). Chemically, all the rocks are more K-rich than typical calc-alkaline andesites or rhyolites. The dome rocks are all trachytes-trachydacites with 64.1-66.4 % SiO_2 and the vent rocks are all rhyolites with 73.8-79.7 % SiO_2. The dikes are each different and include a latite (dike near the dome), a shoshonite (the mafic vent dike) and a trachydacite (the felsic vent dike).

The fact that the different structures found in the field have distinct chemistries is significant. Harker diagrams certain elements, such as P_2O_5, K_2O and Fe_2O_3, result in linear patterns that suggest the rocks of the dome, the vent and the dikes are co-genetic, but other elements, such as Sr, do not show linear variation. The REE pattern shows light REE enrichment, with a La_N/Lu_N ratio = 10 and a concave upward pattern. These features are similar to the REE patterns of high-K rock suites associated with convergent plate margins (Gill, 1981). The possible relationship of the dome and vent to each other and to other rocks of the volcanic field, is currently under investigation.

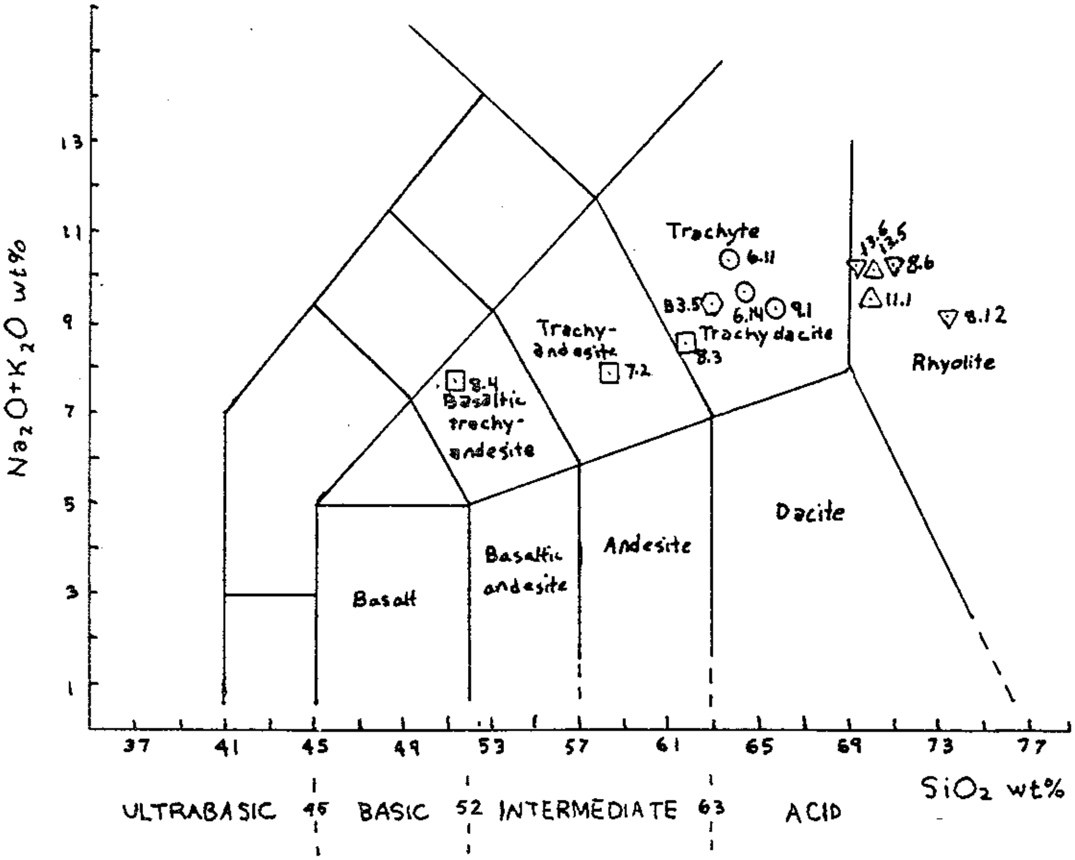

Figure 2. The total alkali-silica (TAS) diagram showing the 12 analysed samples.
(○Dome, △ Vent,☐Dikes,○Inter-laharic flow)

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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