THE PETROLOGY AND STRUCTURE OF THE HAMMOND-BALDY RIDGE, MID-TERTIARY THIRTYNINE MILE VOLCANIC FIELD, CENTRAL COLORADO.

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The east-west ridge containing Baldy and Hammond Peaks is located in the southwestern portion of the Guffe volcanic center (fig 1), within the mid-Tertiary Thirtynine Mile volcanic field of central Colorado. Th Hammond-Baldy area is a somewhat unique part of the volcanic field in being comprised largely of intrusiv (subvolcanic) rocks of intermediate composition. The geology of the ridge was previously described only briefly b Buchanan (1967) and Morris (1969), students of Rudy Epis at Colorado School of Mines, in their Master's thesi studies of more extensive areas within the Thirtynine Mile field.

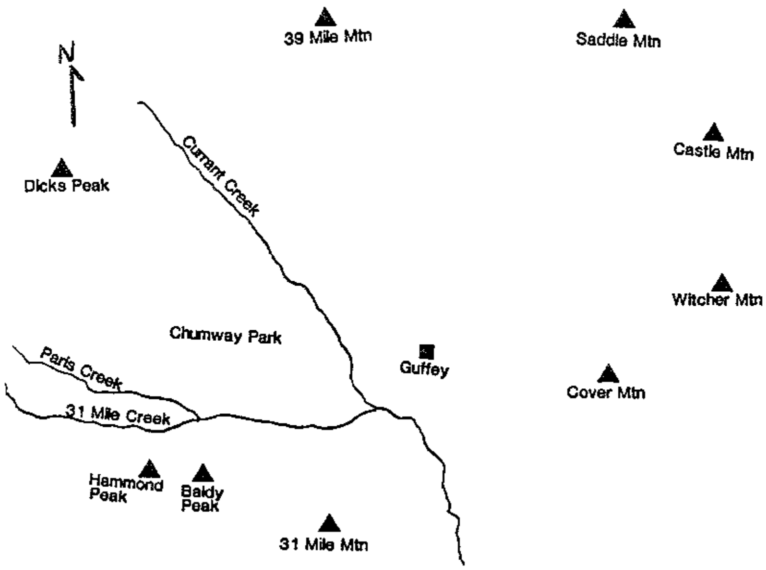

Figure 1. Index map of the Guffey Volcanic Center. The Hammond-Baldy study area is in the southwest corner. Scale: 1 inch = 3 miles.

The area of this study is underlain by a thick sequence of laharic breccias and interlayered flows of trachyte, latite and basalt that were mapped by Epis and his students as the lower member of the Thirtynine Mile Andesite. These flows are Oligocene in age and are found throughout the Guffey area. Intruding the flows in the study area are several large dikes and irregularly shaped bodies which have previously been mapped as biotite andesite and diorite (Morris, 1969; and Buchanan, 1967). They are reclassified here as trachyte and monzonite, respectively.

The lahars and flows are more than 350 meters thick beneath most of Hammond Peak and they also cap Baldy Peak. The lahars appear as dark, disintegrating, rubbly outcrops with the flows forming more resistant, laterally discontinuous outcrops. Baldy is also surrounded by basaltic flows from the Thirtyone Mile volcanic center, immediately to the southeast (Epis and Chapin, 1968), which are very similar at outcrop scale to those of the lower member of the Thirtynine Mile Andesite. The highest ridge of Hammond Peak is composed of two distinct intrusiv phases of monzonite that form a very large (150 meters by 40 meters) east-west trending composite dike. The older of these monzonites is grayish green, medium grained and equigranular to porphyritic. The second (younger) phase is much finer grained and clearly intrudes the medium grained variety. The trachyte is a light gray to white rock wi phenocrysts of biotite; it intrudes the flows on the north and east flanks of Hammond, the summit of Baldy, and all of the intervening hill.

There is a large amount of dark silicified breccia surrounding the monzonite dikes of Hammond Peak with clasts that are derived from the lahars and from the trachytic intrusions. The trachyte on the top and south flank of the hil between Hammond and Baldy appears to be highly silicified and a large portion of it is brecciated as well. A breccia containing a variety of clasts, most unidentifiable but some of Precambrian granite, occurs immediately below the

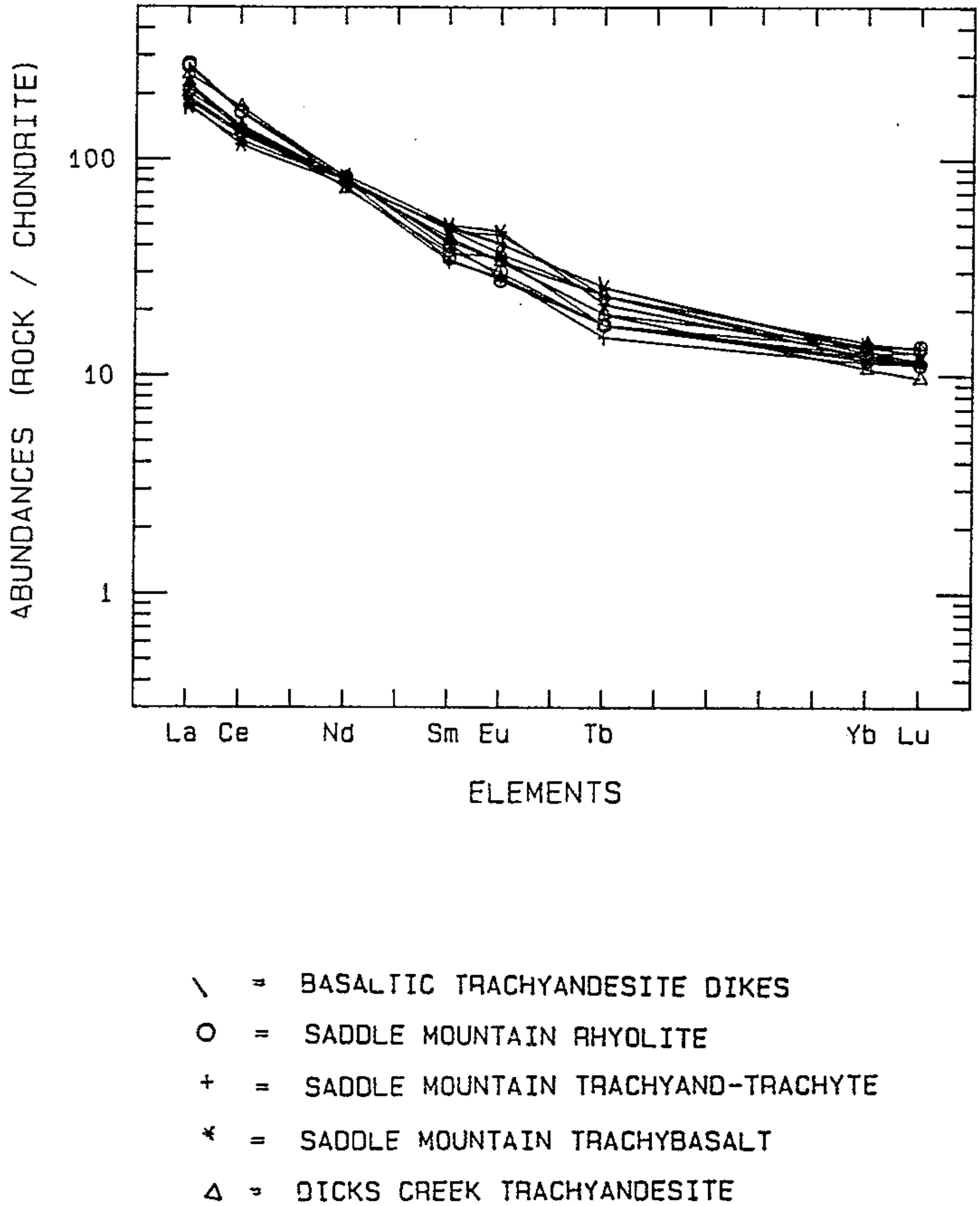

Figure 37: Chondrite-normalized Rare Earth Element (REE) data for the Guffey suite; see text for discussion.

capping flows on the north side of Baldy. An outcrop of very light tuff breccia that is made up almost exclusively of rhyolite fragments appears on the southeast side of the summit of Baldy. The Wall Mountain Tuff, Echo Park Conglomerate, Silver Plume Quartz Monzonite and Minturn formation appear only in the northern portions of the study area.

In terms of age relationships determined in the field, the Thirtyone Mile basalt flows are the oldest volcanics in the study area. These flows are overlain by those of the Thirtynine Mile lower andesite unit. The trachyte bodies intrude the latter unit and small inclusions of the lower andesite are found in some samples. The first phase of monzonite intrusion discordantly intrudes the trachyte bodies and the second phase contains inclusions of the first. There is a thin breccia zone between the two phases that is most likely caused by the emplacement of the second. There are several dark, fine grained dikes scattered throughout the area that cut the laharic breccias and appear to have been emplaced at shallow depths. These dikes have been classified as latite and trachyte, but their ages relative to one another could not be determined in the field.

Two major shear zones in the area are identified by the presence of slickensides, cataclasites, mylonites, silicified breccias and silicification of surrounding rocks. One of these zones follows and encompasses the long axis of the Hammond-Baldy ridge, extending farther in each direction. This zone has an average width of 150-200 meters and was described as part of a ring fault surrounding the Guffey center by earlier workers (Buchanan, 1967). The other shear zone trends northeast-southwest and is located in the western portion of the area. This zone is slightly narrower with a maximum width of about 150 meters. Within this zone, at the western end of Hammond Peak, are the remnants of a vent that has brought up large fragments of rhyolite and perlite along with Precambrian granite and lower Cretaceous Dakota sandstone. This vent is probably associated with the period of shearing, or was at least localized by the shear zone.

Twenty-four samples from the Hammond-Baldy area were studied in thin section and eight were analyzed chemically. The x-ray fluorescence lab at the University of Massachusetts was used to determine major elements as well as Rb, Sr, Th, Pb, Ga, and Y. Other trace elements, including rare earths, were determined by instrumental neutron activation analysis; Nuclear Activation Services of Ann Arbor, Michigan, performed the latter analyses using the Ford nuclear reactor facility. The samples selected for chemical analysis include two older monzonites from Hammond Peak (HD4, HPD), one younger monzonite from Hammond Peak (HB), and one sample of each of the following: the trachyte dike of Baldy summit (D13), the basalt flow of Baldy summit (16B), the quartz monzonite body of Gold Hill (GHD), a latite dike of Hammond's north base (D85), and a trachyte dike of Hammond's west base (D58).

All of the samples that were analyzed have high K_2O contents (3-7%) and high total alkalies. Using the classification of Le Bas and others (1986) for volcanic rocks, the samples all fall within the shoshonite, latite or trachyte fields (fig 2). When plotted on a normative Quartz-Albite-Orthoclase ternary diagram, they fall in fields equivalent to monzonite and quartz monzonite of the I.U.G.S. classification for plutonic rocks (fig 3). The Gold Hill sample (GHD) was collected from an area 4 km to the east and was chosen for comparison with the Hammond monzonites due to its similarity at outcrop and hand specimen scale. However, the sample shows considerably greater SiO_2 and K_2O than the Hammond samples and is apparently an entirely different rock type. When the samples are plotted on an (Na_2O+K_2O)-$FeTO_3$-MgO ternary diagram they fall within Irvine and Baragar's classification of calc-alkaline rocks (fig 4).

The REE plot of the Hammond-Baldy rocks normalized with respect to chondritic meteorites (fig 5), is similar to Lipman's (1987) plot for Oligocene intermediate rocks of the San Juan volcanic field which is located about 100 km southwest of the Guffey center. However, the total rare earth element content is considerably greater (200-300 ppm for the Guffey rocks, compared with a range from about 110-190 ppm for 8 samples from the Platoro and Summer Coon calderas in the San Juan. Chondrite normalized values for the ratio La/Lu are also higher (13-20 for the Hammond-Baldy samples, compared with values <15 for the San Juan samples), indicating a more pronounced light/heavy REE fractionation in the Guffey samples.

Lipman (1981) suggested that Cenozoic volcanism in the Southern Rocky Mountains was due to the low-angle subduction of the Farallon plate beneath the west coast of the U.S.. While calc-alkaline rocks are most often associated with island arc or continental margin volcanism, shoshonitic (high K_2O) rocks are more indicative of volcanism that occurs farther inland. The major element composition of the samples collected in the

Hammond-Baldy study area suggests a rock suite that could be associated with volcanism that has occurred inland of a destructive plate margin. However, the REE content and the La/Lu ratio for the Hammond-Baldy samples are both too high to have been produced by the melting of oceanic crust alone. If the volcanism in this area was in fact asssociated with a subduction zone far to the west, then the lighter, overlying continental crust must have contaminated the magma as it ascended, in order to produce the high total REE values and the strong enrichment in the lighter rare earths

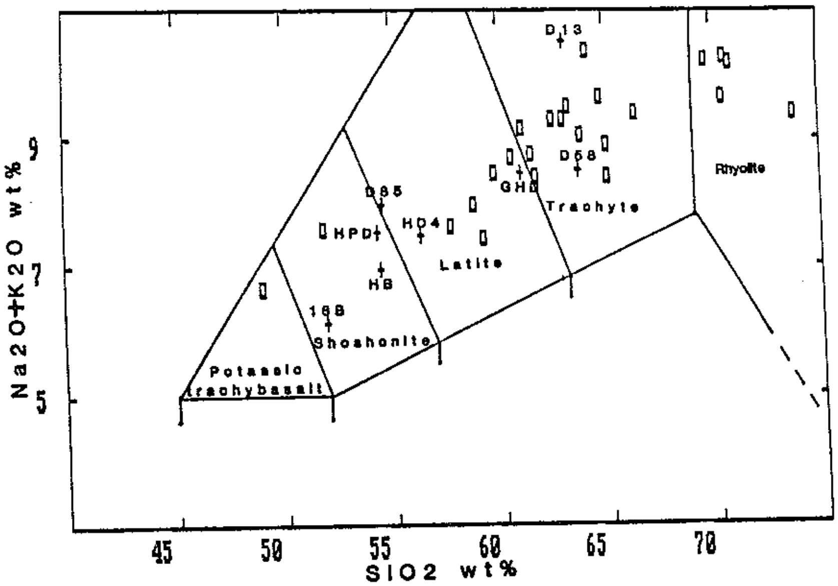

Figure 2. The total alkali-silica diagram with classifications for volcanic rocks (Le Bas *et al*, 1986) showing the location of the Hammond-Baldy samples as crosses and samples of Keating (this volume) and Benjamin (this volume) as rectangles.

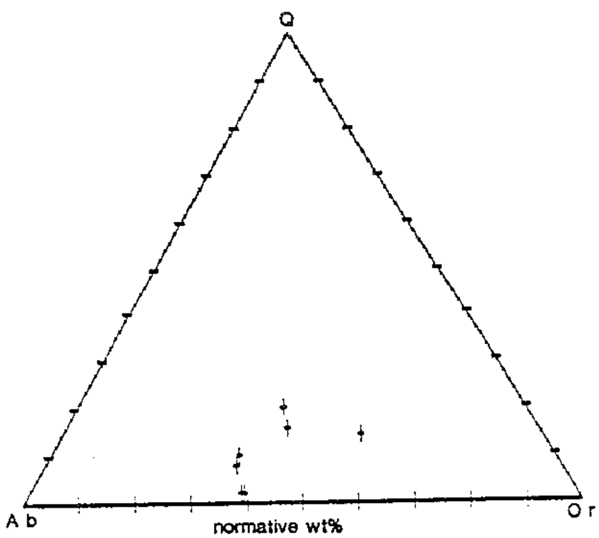

Figure 3. Quartz-albite-orthoclase diagram for Hammond-Baldy samples.

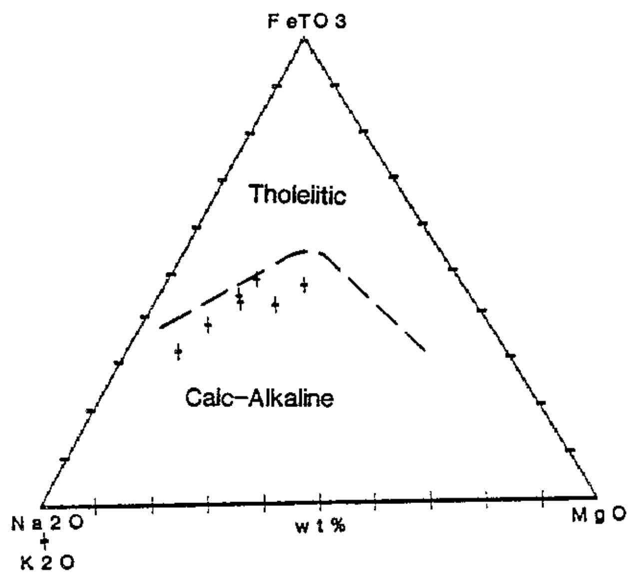

Figure 4. Total alkalies-$FeTO_3$-MgO diagram with Irvine and Baragar's (1971) classification for calc-alkaline and tholeiitic rocks.

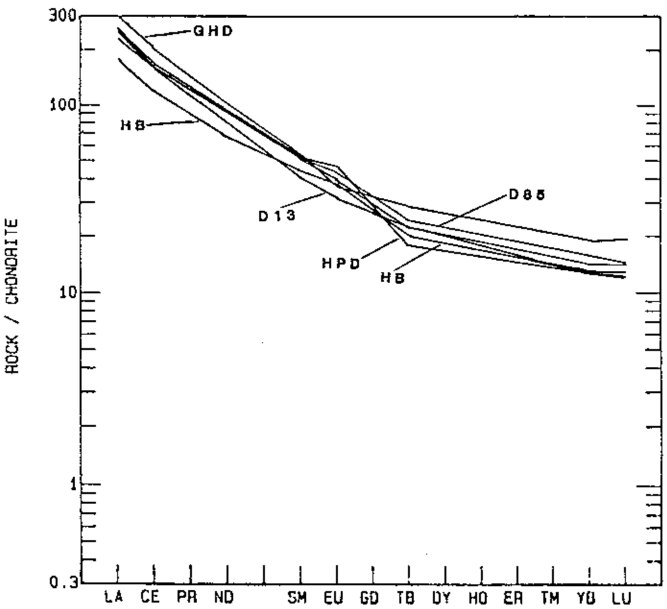

Figure 5. Chondrite-normalized REE compositions in rocks from the Hammond-Baldy ridge.

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The Geology of Cover Mountain, Colorado

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Introduction

The purpose of the Keck Foundation's summer 1987 research project in Colorado was to map an area of the Thirtynine Mile volcanic field and perform geochemistry on samples taken from the entire field area. The area I chose to focus my study on was the Cover Mountain region which lies south along the eastern margin of the Thirtynine Mile volcanic field. The Thirtynine Mile volcanic field is a raised plateau of Oligocene aged volcanic flows and volcaniclastic units located south of South Park, and west of Colorado Springs. The plateau is surrounded by and builds upon Precambrian rocks. The Precambrian strata were eroded to a peneplain during the early Tertiary, thus forming the Echo. Park surface (Epis, et al: 1980). The Oligocene volcanics of the Thirtynine Mile volcanic field were erupted onto this surface. Elevations within the field area range from 8,940 to 10,150 ft. The climate is temperate, with aspen and pines growing on the North facing slopes. Access to the area is off of West Fourmile Creek Rd,turning onto the Park County (105) road which leads into the Cover Mountain Subplot complex, the field area begins at the Nancy Ann Arroy Rd and stretches south from this road to Cover Mountain.

Mapping

Previous mapping of the area was carried out by graduate students from the Colorado school of Mines; and Epis and Chappin discussed the origin of the entire field extensively in several articles (1968,1980). The six square mile field area was mapped using a topographic base map composed of the Whitcher and Cover Mountain quadrangles. The strike and dip of flows were recorded and representative rock samples were taken from each unit. Several relationships were found in the field which differed from those recorded in previous geologic maps of the area.

The major change to the previous map was the re-naming of the Louis Gulch area which had been mapped as a trachyte and was renamed in the field as a biotite-rhyodacite, (this name agrees with the observed petrographic texture). Another change was the addition of a lower hornblende rich andesite unit, similar to the Upper Andesite unit but was found below the Lower Andesite unit and in contact with the Precambrian. The Cover region is significant for the wide variation in rock units which it contains; from basaltic dikes to extremely silcic flows and dikes. In all six volcanic units were found within the Cover Mountain field area, these units are from youngest to oldest: basaltic dikes, rhyolite flows and dikes (with very large plagioclase phenocrysts), upper andesite(a hbl-rich unit), lower andesite (a unit composed of interbeded lahars and cpx-rich flows), biotite-rhyodacite flows (with phenocrysts of biotite and plagioclase), and a lower hornblende andesite flow (added by Mertzman & Rothwarf).