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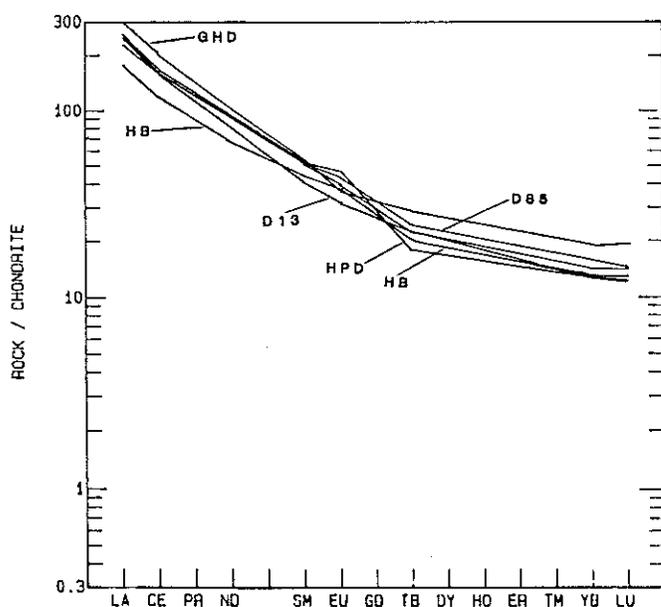
Figure 5. Chondrite-normalized REE compositions
in rocks from the Hammond-Baldy ridge.

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Petrography

Thin sections of thirty samples were examined, and six rock categories were found. These arbitrary categories were delineated on the basis of phenocryst mineralogy. The categories were: basalts, basaltic andesites, hornblende andesites, biotite rhyodacites, and rhyolites. The mineral assemblage typical of the basaltic rocks contained olivine, clinopyroxene, titanium-oxide, apatite, and plagioclase phenocrysts, in an intergranular groundmass which contained microlites of plagioclase, FeTi-oxides and clinopyroxene. In some samples olivine phenocrysts suffered substantial low temperature alteration to iddingzite; and both olivine and clinopyroxene phenocrysts contained poikilitic grains of magnitite.

As the units became more silicic the phenocryst assemblage changed to become more hornblende and biotite rich. Within the rhyodacite units biotite is the primary mafic and is the only mafic found within some samples. The rhyodacite and rhyolite samples also contained zircron, apatite,hornblende, some Ti-oxides (a product of the dehydration reaction of biotite as the magma neared the surface just prior to extrusion) and large plagioclase phenocrysts within a groundmass composed of sanidine microlites. Thus, within the most silicic units biotite, and hornblende were the primary mafic phases.

Additional petrographic observations of the samples suggest general trends within the rock categories concerning the phenocrysts of FeTi-oxides, apatite, and orthopyroxene. FeTi-oxides, such as magnitite and chromite, are found as phenocrysts in all of the petrologic units with few exceptions. Apatite is found in a substantial number of flows as a microphenocryst phase. It was also found poikilitically enclosed within early crystallizing phases like clinopyroxene. A few samples contained orthopyroxene grains, usually surrounded by clinopyroxene grains. This association suggests that an earlier crystallization assemblage existed, and that orthopyroxene grains later converted to clinopyroxene, preserving only a few relict grains within the samples.

Chemistry

Twenty-two samples were analyzed at F&M for major and trace element geochemistry, using X-ray fluorescence techniques developed by Mertzman (personal communication). Nine representative samples were analyzed by INAA techniques for REE and additional trace element data. The INAA data was analyzed by Nuclear Activation Services, Inc. of Ann Arbor,MI. The nine samples all plotted within a restricted range on a chondrite normalized REE abundance diagram, and showed a trend of LREE enrichment as a function of increasing SiO_2.

The major and trace element geochemistry shows a pattern of K_2O enrichment as the samples become more silicic. Thus, using the Le Bas et al (1986) chemical classification model the Cover Mountain flows are: sub alkali basalts, potassic trachybasalts,shoshonites,latites, and trachytes. Figure 1 shows the twenty two samples on a Le Bas diagram of total alkali (Na_2O +K_2O) versus silica (SiO_2). The chemical data were also used to create many descriptive x-y plots. Particularly informative is the plot of total iron over

magnesium, which shows a linear trend with bimodal distribution within the Cover Mountain region (Fig. 2).

Interpretation

An examination of the petrography and chemistry of the Cover mountain volcanics allows certain conclusions to be made about the source of the magma and conditions which existed in the magma prior to its extrusion. The poikilitic grains of magnetite found within olivine and clinopyroxene, and the large oxide phenocrysts, indicate that oxides crystallized early from the magma. This suggests a relatively high oxygen fugacity within the magma body. As a result of the high oxygen fugacity, the magma chamber was characterized by a high Fe^{+3}/Fe^{+2} and magnetite was stabilized as a liquidus phase early in the crystallization sequence. The early crystallization of oxides withdrew Fe^{+3} from the remaining liquid, and thus later flows were more silicic and no iron enrichment occurred, as is seen in figure 2. The total iron versus magnesium for the Cover mountain region appears linear with some scatter. A similar plot for the entire Eastern region of the Thirtynine mile volcanic field depicts perhaps a weak initial trend of Fe-enrichment.

The nine representative samples chosen for INAA all plotted within a restricted range, and showed a trend of light REE enrichment, with no Eu anomaly. Thus the primary volcanic units derived from a similar magmatic source area. The presence of olivine within the mafic flows, and primary biotite within the silicic flows further limits the conditions which acted upon the magma chamber to produce such a potassium rich range of units. Meen (1987) modeled the conditions needed to produce shoshonites and found that shoshonites would only contain olivine if the magma was generated at shallow pressures and under hydrous conditions. Thus the presence of primary biotite attests to hydrous conditions within the magma chamber. The conversion of biotite and hornblende to anhydrous phases resulted from dehydration reactions during the magma's assent to the surface. The relict orthopyroxene grains found within a few mafic samples may indicate previous high pressure conditions within the magma chamber; Meen's model stipulates that in high pressure (10 Kbar) models pyroxenes will form instead of olivine (1987). Thus, both INAA data and petrographic observations support the theory that these volcanics were generated from similar source material and that fractional crystallization and possibly crustal contamination were important near surface magmatic processes.

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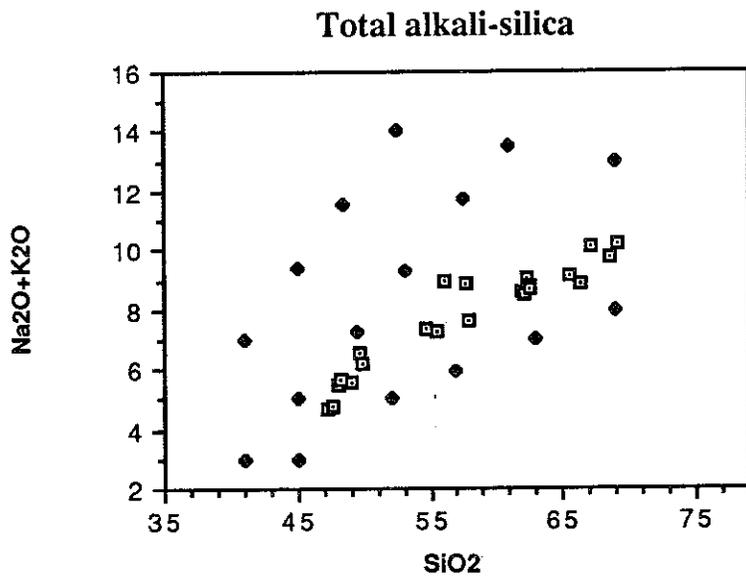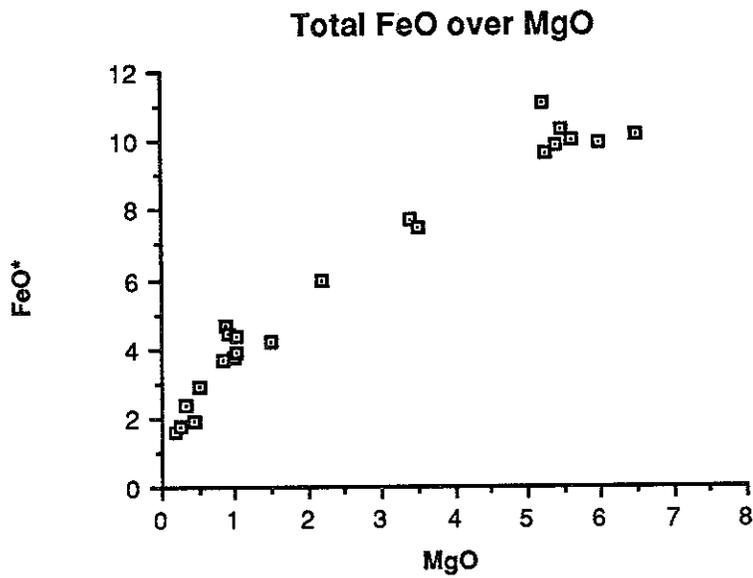
Figure 1.

Total alkali-silica

Figure 2.

Total FeO over MgO

ABSTRACT

The Stratigraphy, Petrography, and Chemistry
of the Saddle Mountain Area,
Thirtynine Mile Volcanic Field,
Central Colorado

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The Saddle Mountain area lies within the Oligocene Thirtynine Mile Volcanic Field in southcentral Colorado. Models for the petrogenesis of the area were created through the use of suite chemistry, petrography, and field relations. The Saddle Mountain sequence contains the following volcanic units from oldest to youngest: pyroxene-hornblende trachyandesites, laharic breccias and interbedded basaltic trachyandesite flows, hornblende-biotite rhyolites, hornblende-biotite trachyte dikes, biotite-hornblende trachyte flows, olivine-clinopyroxene basaltic trachyandesite dikes, and olivine-clinopyroxene trachybasalt flows. These units, when combined with samples from the Dicks Creek volcanics (Keating, 1988) comprise a bimodal alkali-calcic, shoshonitic suite characterized by high alkalis, particularly K_2O, high total REE contents, large LREE/HREE ratios, and a lack of fractionation in the tightly-clustered REE values.

Chemical trends indicate that the rocks are genetically related. The clustering of chondrite normalized REE values and the smooth linear to curvilinear trends on the diagrams of several major elements plotted versus silica support this claim. Of the two evolutionary models considered, fractional crystallization and partial melting, fractional crystallization is the favored model as it is supported by the near-logarithmic depletion of compatible trace elements at low silica contents. The chondrite normalized REE plots, however, do not agree with this model because fractionation trends for the REE contents of mafic versus felsic volcanic rocks are absent.

Two further scenarios were proposed to explain the bimodality and the origin of this suite; both involved the initial eruption of intermediate to felsic volcanics followed by mafic dikes and flows that resulted from the replenishment of chamber or chambers with basaltic liquid. Although no clear-cut solution to the problem of the petrogenesis of these complexly-evolved Saddle Mountain and Dicks Creek volcanic rocks has been proposed, this study does provide a groundwork on which further research can build or rebuild to formulate a model that adequately explains all geochemical, petrographic, and stratigraphic characteristics of the suites from the Thirtynine Mile Volcanic Field.