A GEOCHEMICAL ANALYSIS OF MAFIC ROCKS AROUND SALIDA, COLORADO

Keith S. Schembs
Whitman College
Walla Walla, WA 9936

INTRODUCTION

The Sawatch and Sangre de Cristo mountain ranges of Colorado are composed primarily of Early Proterozoic volcanic rocks. Most rocks are metamorphosed to lower to upper amphibolite grade (Bickford and Boardman, 1984). Areas near Salida and Gunnison (approximately 75 kilometers west of Salida) have been previously studied and a back-arc setting has been suggested by Boardman and Condie (1986), and Bickford and Boardman (1984). This paper will discuss four areas between Salida and Gunnison. It will then attempt to tie all four areas together and compare the entire region to the previous studies concerning Gunnison and Salida.

This region consists of interlayered metavolcanic and metasedimentary supracrustal rocks. The metavolcanics are a bimodal suite. The mafic suite is composed of high-magnesium tholeiitic basalt to basaltic andesite. The felsic rocks range in composition from dacite to rhyolite (Bickford and Boardman, 1984).

LOCATION DISCRIPTIONS

This paper focuses on three areas in the Southern Sawatch and one area in the Northern Sangre de Cristo ranges, near Salida (figure 1). The Cottonwood Pass region (area A) consists of alternating mafic and felsic metavolcanic units. The samples are poorly foliated amphibolites, with secondary amphiboles and biotite. The Mirror Lake region (area B) consists of alternating metamorphosed intermediate and mafic flows, with relict flow structures. The rocks in this area are within the upper amphibolite facies. Several samples from this area were collected including a fine to medium-grained amphibole rich meta-diorite, a fine-grained intermediate volcaniclastic rock, slightly foliated amphibolites, and three samples from meta-basalt flows with relict pillow structures ranging from .5 to 1.5 meter. Mount Ouray (area C) is the southern most locality studied in the Sawatch Mountains. The local geology consists of meta-volcanogenic mafic rocks with some interlayered meta-gabbroic and felsic volcanogenic rock. These samples have been metamorphosed to the middle amphibolite facies. Volcanic rocks here are extremely

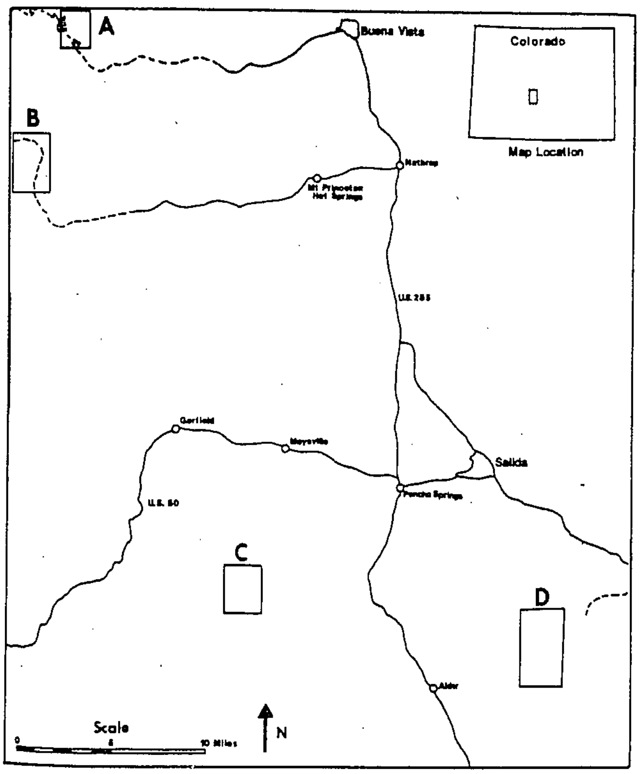

Fig. 1. Map of sampled areas around Salida, Colorado.

dense and dark green to black. The rocks are high in potassium feldspar and actinolite, with many epidote and quartz veins crosscutting the units. There are lithic and feldspathic clasts ranging from .5 to 5 centimeters within the mafic units. Hunt's Lake (area D) is located in the northern Sangre de Cristo Range. This area contains alternating meta-volcanic mafic and felsic rocks. Samples were collected from banded and lensoidal volcanogenic mafic rocks in a sequence of mafic and felsic volcanic flows. The samples are mostly fine-grained amphibolites, rich in hornblende. This area is representative of the upper amphibolite facies. Some amphibolites display weak foliation and occassional relict chilled margins or flow differentiation.

CHEMICAL ANALYSIS

The chemical analysis was accomplished at Battelle Northwest Labs in Richland, Washington. The samples were crushed and powdered to 300 mesh at Whitman College. Samples were screened by thin section and hand sample and only the the freshest samples were chosen for analysis. The samples were trimmed by a diamond saw, polished with grit on lapidary wheels, then crushed and powdered. Crushed samples were hand picked to ensure no contamination from viens or alteration.

At Battelle, the samples were analyzed for major and trace element chemistry. For major element chemistry, Atomic Absorbtion (AA) was used to find the weight percent of Silica, Alumina, Sodium, Magnesium, and Potassium oxides. X-Ray Fluorescence (XRF) was used to obtain the weight percent of Calcium, Iron, Titanium, and Manganese oxides. Battelle uses an energy dispersive X-ray fluorescence with a backscatter fundamental parameter data reduction. This allows for a wide range of trace elements (49). The trace elements analyzed at Battelle were V, Cr, Ni, Cu, W, Zn, Ga, Se, Pb, Sr, Y, Zr, Nb, Rb, and Cs. There was some reported tungsten carbide contamination, which affected W and possibly Cu, Zn, Ga, and Se, giving higher than normal amounts.

Of the twenty-one samples analyzed for major and trace elements, six were selected for Instrumental Neutron Activation Analysis (INAA) at a commercial laboratory in Ontario. INAA was used to obtain amounts of La, Ce, Sm, Eu, Tb, Yb, and Lu. Rare earth data will be important in discriminating a tectonic environment of origin for this suite of rocks.

INTERPRETATION

From the collected data, CIPW Norms were calculated. Interpretation of these norms show that on the basis of normative quartz content, all the rocks are mafics, except for sample CO-25, an intermediate rock, sampled at Mirror Lake. A Ti(ppm)/Zr(ppm) graph is used to screen for evolved versus primitive rocks (figure 2). Sample CO-25 is the only evolved rock, and cannot accurately be used in other basalt discrimination diagrams. This graph also differentiates between arc lavas, within plate lavas and mid-ocean ridge basalts. This plot shows a general grouping of rocks in the arc lava/MORB fields. The Mt. Ouray samples tend to be primitive arc lavas, whereas the Hunt's and Mirror Lake samples (with exception of CO-21) fall in the overlapping MORB region. The Cottonwood Pass samples plot in the arc and within plate lava field each. Figure

3, an AFM plot, shows a tholeiitic trend for the suite. The Mt.

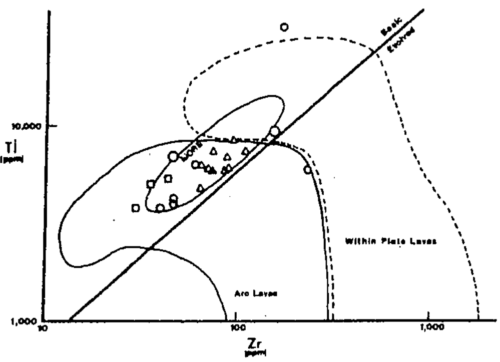

Fig. 2. Zr vs Ti diagram, Pearce and Norry (1979). Symbols: □ Mt. Ouray, ⬡ Cottonwood Pass, Δ Hunt's Lake, O Mirror Lake.

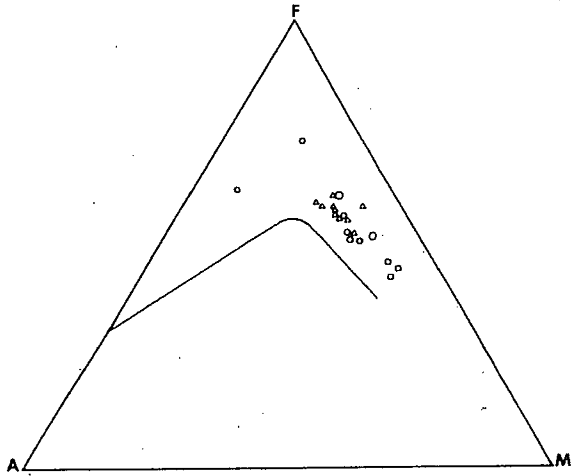

Fig. 3. AFM diagram with tholeittic trend.

Ouray samples lie along the more magnesium-rich end of the trend. The Hunt's and Mirror Lake form a good trend, with CO-21 and CO-25 plotting in the more iron-rich zone of the curve. The two Cottonwood Pass samples were the end members of previous two groups. The ternary plot Ti/100-Zr-Y*3 (figure 4) is used in segregating within-plate from oceanic basalts. Its complimentary plot, Zr/Y-Zr diagram (figure 5) is most useful in discriminating oceanic setting basalts.

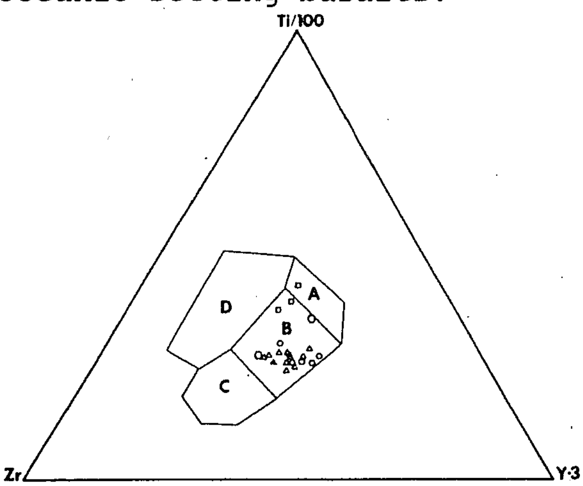

Fig. 4. Ti/100-Zr-Y*3 plot, Pearce and Cann (1973). A&B low K tholeiite, B&C calc-alkaloic tholeiite, both from volcanic arcs, D is continental.

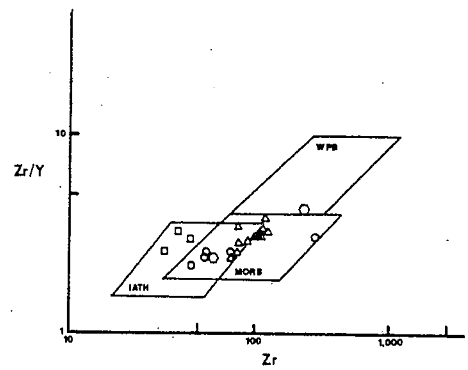

Fig. 5. Zr/Y vs. Zr diagram. Pearce and Norry (1979).

Interpretation of figure 4 indicates a general low potassium tholeiite trend from a volcanic arc environment. All samples plot in the A and B fields, with the Hunt's and Mirror Lake groups plotting close together. The Mt. Ouray samples plot more toward the titanium end of the plot. Comparing this data to data from Bickford and Boardman (1984) indicates the mafic rocks around Salida may be of the same suite and possibly origin. On the Zr/Y-Zr plot data lies in the island arc tholeiite, MORB environments fields for the Hunt's Lake region. The Mt. Ouray group is the only area to lie in the island arc tholeiite field.

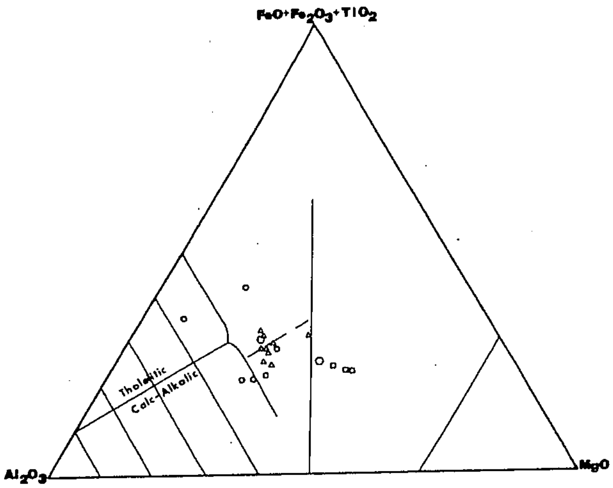

Fig.6. Jensen (1976), cation plot with tholeiitic trend.

Another plot used is the Jensen Cation Plot. This diagram uses Al2O3, FeO+Fe2O3+TiO2, and MgO cations because of the stability of these elements during metamorphism. The plot, figure 6, indicates a general high magnesium, tholeiitic basaltic trend. The Mt. Ouray sample are the most magnesium rich and plot in the basaltic komatiite field. The Mirror Lake samples tend to be more calc-alkalic type basalts with some scatter into the high-iron tholeiitic trend. The Hunts Lake and Cottonwood Pass samples seem to cluster between the other groups. They plot on the border of a high iron and high magnesium tholeiitic basalt.

CONCLUSION

There is an overall tholeiitic trend in the data (Figures 3, 5, and 6). The plots suggest that these areas are related and that this suite and the surrounding areas to be of the same regional suite. Mt. Ouray seems to be more magnesium-rich and the most primitive of the studied areas. Hunt's Lake and Cottonwood Pass plot as the most evolved of the groups. Mirror Lake seems to fall between these two groups.

Based on the chemistry, a tectonic environment of eruption may be either a volcanic arc or MORB. Abundant felsic volcanics in the studied region discount the classic MORB environment. The presence of pillow structure in the mafic flows is indicative of a sub-aqueous environment, thus a volcanic arc is questionable, unless it is in the early stages of formation. Also, The bimodal chemistry is not representative of an island arc setting. The chemistry suggests these rocks may be related to the Salida and Gunnison rocks, and a back-arc basin associated with an island arc is a plausible environment of eruption.

REFERENCES CITED

Bickford, M.E. and Boardman, S.J., 1984, A Proterozoic volcano-plutonic terrane, Gunnison and Salida area, Colorado: Jour. Geol. v.92, p. 657-666.

Boardman, S.J. and Condie, K.C., 1986, Early Proterozoic bimodal volcanic rocks in central Colorado, U.S.A., Part II: Precambrian Research, v.34, p. 37-68.

Jensen, L.S., 1976, A new cation plot for classifying subalkalic volcanic rocks: Ontario Divison Of Mines #66, p. 20.

Pearce, J.A. and Cann, G.M., 1973, Tectonic setting of basic volcanic rocks using trace element analyses: Earth Planet Sci. Letter 19, p. 290-300.

Pearce, J.A. and Norry, M.J., 1979, Petrogenetic implications of Ti, Zr, Y and Nb variations in volcanic rocks: Contrib. Min. Petrol., v. 69, p. 33-47.