PETROLOGY AND GEOCHEMIISTRY OF A PROTEROZOIC METADIORITE FROM LITTLE COCHETOPA CREEK, CENTRAL COLORADO

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INTRODUCTION

A dioritic rock unit found within the bimodal metavolcanic terrane of central Colorado could help put constraints on models that explain the origin of Proterozoic rocks in this region. Most current tectonic models suggest that a series of Early Proterozoic island arc systems were accreted onto the Archean Wyoming craton in the north (Bickford, 1988). These accreted arcs extend from southern Wyoming to New Mexico, becoming younger to the south. The rocks of central and southern Colorado are predominantly bimodal metavolcanics (Bickford, 1988). As volcanic island arc systems, Proterozoic Colorado rocks should ideally be similar to rocks which have been found in other island arc systems around the world. However, the rocks which have been studied in and around the Salida area in central Colorado have been found to be characteristic of an immature back-arc basin environment or some other extensional setting near a continental margin (Boardman and Condie, 1986). Bimodal assemblages are known to occur in some modern immature island arc systems, yet the rock types most characteristically associated with island arcs are andesites, or rocks of intermediate composition. Very few intermediate rocks have been found in Central Colorado (Bickford, 1988; Boardman and Condie, 1986). The basic problem, then, is that there is a back-arc basin but no arc.

LOCAL GEOLOGY

One area in central Colorado which has not been studied thoroughly is the Mt. Ouray area, located in the southern-most part of the Sawatch Range, 25 km southwest of Salida (Fig. 1). Reconnaissance mapping has been done on portions of this area by several Carleton students (Beard, 1986; Carey, 1987; Sauer, 1988). The rocks are predominantly interlayered felsic and mafic volcanic and volcaniclastic rocks, intruded by gabbroic sheets and younger granitic pegmatites. Geochemically, the rocks are believed to be similar to those around Salida (Beard, 1986). Ultramafic Proterozoic komatiites have been found in the Pass Creek Valley, which lies immediately north of Little Cochetopa Creek (Sauer, 1988). The rocks in the Mt. Ouray area have been metamorphosed in the middle to upper amphibolite facies and have undergone two Precambrian structural deformations, yet primary structures remain very well preserved in many places (Carey, 1987).

The focus of this project was in Little Cochetopa Creek drainage, the valley immediately north of Mt. Ouray. In order to map this area, the metamorphic stratigraphy was divided into six units (Fig 2). Two of the units have been studied further in detail. Poppy Staub analyzed the lowest mafic unit, a high-Mg meta volcanic rock, while I concentrated on a dioritic body (unit 3). In our measured section, unit 3 is 220 meters thick, but seems to be absent in the cirque which lies less than a kilometer to the east. This unit was selected for study because if it is a meta-diorite it would be one of the very few rocks of intermediate composition found in this area. The thick, massive, poorly foliated character of unit 3 and cross-cutting contact relationship with the unit below it suggests an igneous parent. Yet the lack of xenoliths or chilled margins and the concordant upper contact are more indicative of a sedimentary origin. To determine the parent rock type and stratigraphic variations within the unit, samples were taken from various places within it for petrographic and chemical analysis.

Another interesting characteristic of unit 3 is a 10 meter thick zone of intense shearing, roughly conformable with the foliation and lithologic layering located in the other units. The rock appeared to be the same unit above and below the shear zone, yet it was not clear from field relations whether or not the rock within the zone is unit 3. Samples were taken at measured distances up to 30 m above and below the shear zone as well as within it to test this hypothesis. An undeformed 1.5 m thick Proterozoic pegmatitic dike cuts both the shear zone and unit 3, which shows that the shear zone is also Precambrian. To the west, the shear zone could be traced into what appeared to be the plane of a thrust fault. Unit 3 was repeated between sections of unit 4, suggesting the existence of thrust faults. Samples were taken from the neighboring cirques to see if they were in fact unit 3.

PETROGRAPHY

The samples which were taken throughout the section and along strike within unit 3 were made into thin sections and analyzed petrographically. The rock is gray, medium to fine grained, equigranular and slightly foliated. The main minerals in samples taken from the measured section are biotite, hornblende, microcline, and plagioclase. The biotite commonly displays zoning, and occasionally alters to chlorite. There is little variation in the relative amounts of these minerals throughout the section. Accessory minerals consist of epidote, calcite, apatite, quartz, sphene, and occasional muscovite. Within the shear zone, the rock contains aligned biotite, but no hornblende. Microcline is the only abundant felsic mineral, and most of the accessory minerals which are found in unit 3 are absent. The samples taken throughout unit 3, including the part of the section immediately above and below the shear zone, are very similar both in mineralogy and texture. This suggests that the unit is the same above and below the shear zone, and that the upper portion of unit 3 may be repeated by thrusting. Samples taken from outside the measured section in the western part of the field area contain no hornblende and may represent a different unit. Because many other volcaniclastic sedimentary units in the area display well-preserved bedding and other primary features, it is unlikely that unit 3 is a clastic sediment.

GEOCHEMISTRY

Major element analysis of 26 rocks was done using Carleton College's Philips PW 1404 spectrometer. Trace element analyses were done at X-ray Assay Labs in Ontario. The results show that the rocks were of the expected intermediate composition, with an average SiO_2 value of 57%. The other major elements are similar to typical andesite and diorite compositions as well. There were local minor variations in chemistry within the section, but overall the compositions remained constant and no trends were observed. Inside the shear zone, Ti, Ca, P, Fe, Sr and Y are significantly less abundant, while K, Al, Cr and Rb are more abundant than in unit 3.

The samples were also compared to other samples taken from previous years in the Mt. Ouray area. When plotted on an AFM diagram (Fig 3), the rocks seem to be an extension of the felsic rock trend of the area. This is also the case in the Alk-SiO_2 diagram (Fig 4), and in the variation diagrams which plot either MG# vs. various trace elements (Fig 5), or incompatible vs. compatible immobile elements. In most of these diagrams, the rocks lie within the felsic zone and at the bottom of the mafic zone, but not directly between them. Rare earth element plots also show more similarities to the felsic rocks than the mafic rocks.

DISCUSSION

Both chemical and petrographic analysis suggests that the unit is igneous in origin, although this could not be proved because metamorphism could have produced the slightly-foliated granitic texture. There are a few different models which could be considered to explain the formation of this intermediate rock. It could be a mixture of the felsic and mafic rocks of the area, or related to either one of them. If it were a mixture, one would expect the chemistry to plot between that of the felsic and mafic rocks. Most of the plots show the unit to be associated with the two, but not on a straight line which could be drawn between them. This suggests that mixing of the magmas is not a likely possibility.

On chemical plots, unit 3 analyses seem to be much more closely associated with the felsics than the mafics. In the graphs in which they plot near both the mafics and the felsics, they follow the same trends as the felsics. The felsic rocks may have been produced by partial melting of the crust, caused by heating from the mantle-derived mafic magmas in the area (Boardman and Condie, 1986). If unit 3 were intrusive, as field relationships suggest, the magma must have been produced after much of the felsic and mafic volcanism had occurred. Yet because the diorite is chemically similar to the felsics, it is likely to have been emplaced shortly after the felsics, perhaps from the same magma chamber. One scenario to explain this is that the chamber was stratified with more felsic material above and the intermediate magma below. The felsic magma could have erupted first, leaving the intermediate magma to intrude later. In this model, a rock of intermediate composition could be found within a back-arc basin environment and is not necessarily indicative of an island arc setting.

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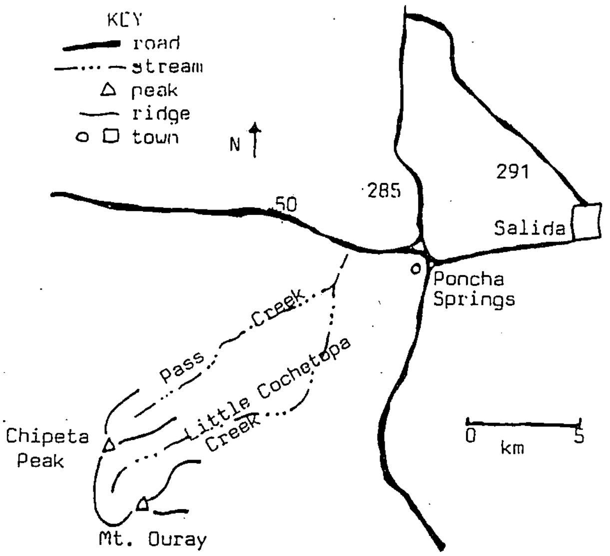

Figure 1

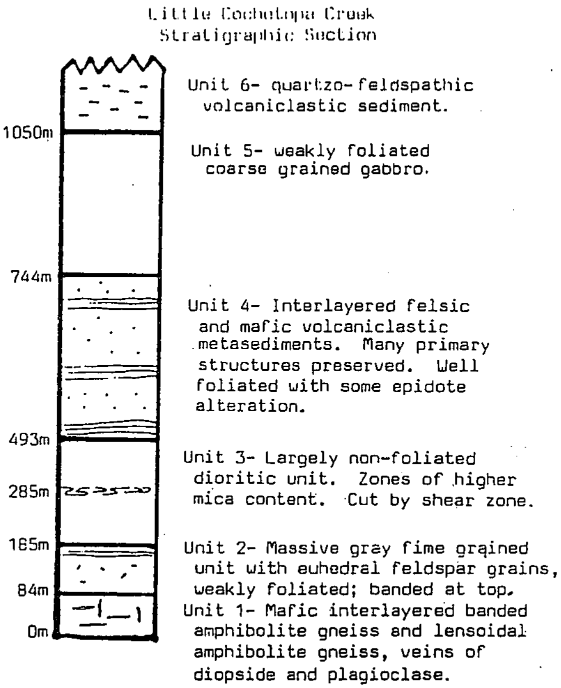

Figure 2

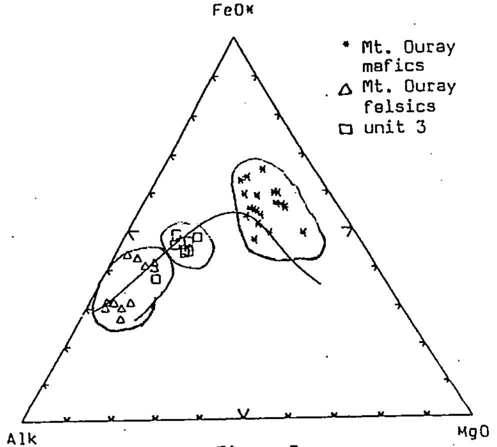

Figure 3.

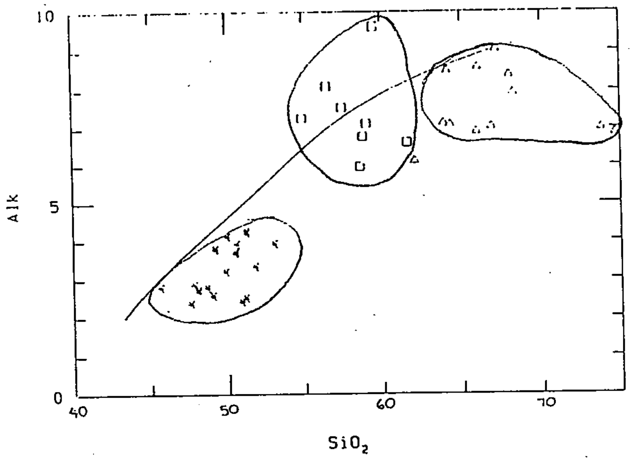

Figure 4

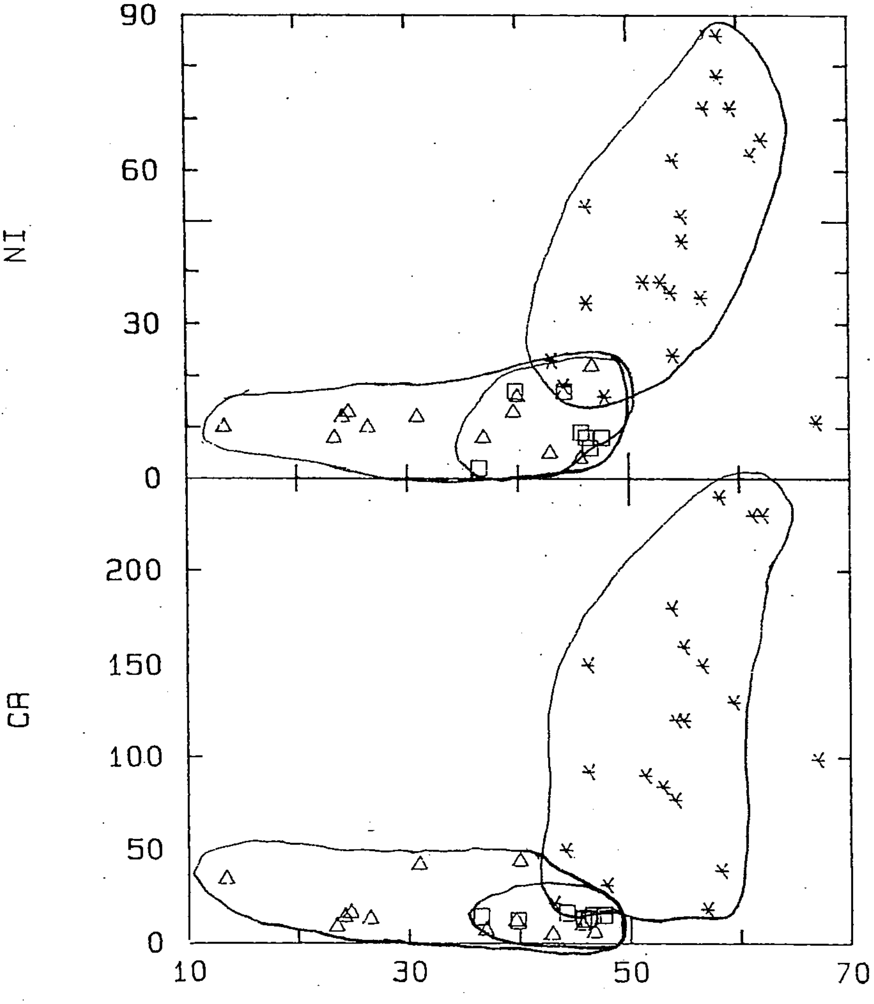

Figure 5