# Early To Mid-Proterozoic Volcaniclastic Sediments, Tuffaceous flows, and Basaltic Komatiite Flows From the Cochetopa Accretionary Terrane, Little Cochetopa Creek, Central Colorado.

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## INTRODUCTION

The Colorado Group conducted a study of a previously undescribed package of mid-Proterozoic metamorphic rocks in the Little Cochetopa Creek valley located in the volcanogenic Cochetopa terrane in central Colorado. The Cochetopa terrane is one of three proposed volcanogenic terranes in central Colorado that accreted onto the Wyoming craton during the mid-Proterozoic. A bimodal suite of volcaniclastic sediments and volcanic flows are the typical rock types associated with the Cochetopa terrane. This terrane is hypothesized to have formed in a back-arc basin tectonic setting (Bickford and Boardman 1984, Boardman and Condie 1986, and Boardman 1986)

The Little Cochetopa Creek valley is located on the southern flank of Chapeta mountain (13,470 ft.) in the southern Sawatch range. Mount Ouray (13,947 ft.) lies directly south. The north side of the valley was divided into six lithologically distinct units for mapping (figure 1). One of the major map units (unit I) was chosen for a detailed geochemical and petrographical investigation (figure 2).

## FIELD AND PETROGRAPHIC DESCRIPTION

Based on geochemical and petrographic results, unit I can be divided into three major sub-units. These sub-units are: 1). Volcaniclastic sediments that contain felsic clasts embedded in a biotite-amphibole-quartz-feldspar matrix; 2). tuffaceous or brecciated material with extensive epidote and diopside alteration; and 3). basaltic komatiite flows.

The presence of sillimanite in near by schists suggests the entire region has been subjected to amphibolite grade metamorphism. However, the rocks from unit I contain minerals such as epidote, calcite, and actinolite typically associated with greenschist facies. The high Mg content of these rocks may have prevented the formation of expected hornblende. This mineral assemblage could also be the result of extensive pre-metamorphic ocean floor alteration due to the percolation of sea water onto the molten rocks at the time of eruption. Each sub-unit displays different degrees of alteration involving epidote and calcite which could be a reflection of the permeability of the rocks.

The rocks in the region have been subjected to at least two separate deformational events which have produced a strong foliation (Carey 1987). This however does not appear to have destroyed some of the sedimentary structures present.

Thin sections from the first sub-unit have a matrix rich in both felsic and mafic material. This suggests a continental source of sand existed near the eruptive source. The arrangement of the felsic clasts into a graded sequence suggests a sub-aqueous depositional environment. Epidote alteration is not as prevalent as in the second sub-unit.

Sub-unit number 2 is interpreted as a tuffaceous or brecciated deposit. No clasts are apparent in either thin section or hand sample. The relatively uncompacted depositional state of this rock has enabled extensive Calcite alteration to occur. These rocks could have been hyaloclastites or tuffs. Orthopyroxene, epidote, and diopside with minor amounts of background quartz, are the major constituents of this sub-unit.

The basaltic komatiite volcanic sub-unit is composed mainly of actinolite, phlogopite, and minor amounts of talc. A very small amount of background quartz does exist but in such a manner that it appears to be secondary. The texture of this unit in both thin section and hand sample is very massive which suggests a volcanic flow.

## GEOCHEMISTRY

Analyses for major oxides and trace elements were obtained by x-ray fluorescence on a Rigaku 3070 mass spectrometer for eighteen samples. Four of these samples were also chosen for instrumental neutron activation analysis. INAA results from five other samples are still in progress.

Geochemistry for the volcaniclastic sub-unit, number 1, shows average SiO2 values of 57 wt.%. K is on the order of 4 wt.%. When these samples are plotted on igneous vs sedimentary protolith diagrams they tend to favor a sedimentary origin. Classification diagrams generally place these rocks in the graywacke to sub-graywacke fields.

Rocks from the tuffaceous sub-unit, number 2, have SiO2 values of 43 wt.%. The Magnesium-numbers (Mg/Mg+Fe+Ti) range from 44 to 53. Calculations of CIPW norms show these rocks as nepheline normative. This sub-unit generally plots both in fields with the volcaniclastic sub-unit and also with the volcanic flows depending upon the diagram.

The basaltic komatiite volcanic flows show SiO2 values ranging from 28 to 44 wt.%. Mg-numbers are on the order of 63 to 76. CIPW norms show these rocks also as nepheline normative. These rocks plot well within the basaltic komatiite field on the Jenson Cation ternary diagram (figure 3) and other plots such as Al2O3 vs FeO/FeO+MgO and MgO vs FeO. Plots on discriminant diagrams place these rocks in the overlap area of MORB and island arc basalt (IAB) (figure 4) which is typical of modern day back-arc basin basalts.

## DISCUSSION

There is much controversy over the interpretation of the Southwestern United States as being a series of volcanic arcs and back-arc basins that accreted onto the Wyoming Craton. Inconsistencies found in some of the geochemical data include plots that show back-arc basin basalts as well as plots that show within-plate, rifting basalts. These are two distinctly different tectonic settings yet we see them occurring with rocks collected from one geographical location. The rocks from Little Cochetopa Creek plot consistently as back-arc basin basalts and are also similar to the basalts and gabbros from the surrounding volcanogenic terrane. Therefore the interpretation best suited for Little Cochetopa Creek is a back-arc basin tectonic setting.

Mid-proterozoic komatiites are relatively unusual in the world of geology. Until recently, high-temperature and high-Mg volcanic flows were thought only to have occurred under conditions found exclusively in the Archean. Rocks of kommatiite composition were found in the Pass Creek area one drainage north of Little Cochetopa Creek. The composition of the Pass Creek basaltic komatiites coincide reasonably well, though slightly less Fe-rich, with the basaltic komatiite volcanic flow sub-unit from unit I (figure 3). The presence of komatiite lavas in the mid-proterozoic in and of itself are unusual and these lavas may therefore represent a parental magma to the gabbros common in this terrane.

## CONCLUSIONS

1). The rocks present include felsic and mafic volcaniclastic sediments, brecciated/tuffaceous "hyalloclastic" material, and komatiitic volcanic flows.

2). The influx of felsic material to produce the quartz-rich matrix found in the sediments suggests a near continent environment.

3). Plots on discriminant diagrams consistently favor a back-arc basin tectonic setting.

4). Geochemical results obtained from unit I are consistent with surrounding areas in the Cochetopa terrane.

5). Mid-Proterozoic komatiitic flows are unusual and possibly the parent melt to the gabbros

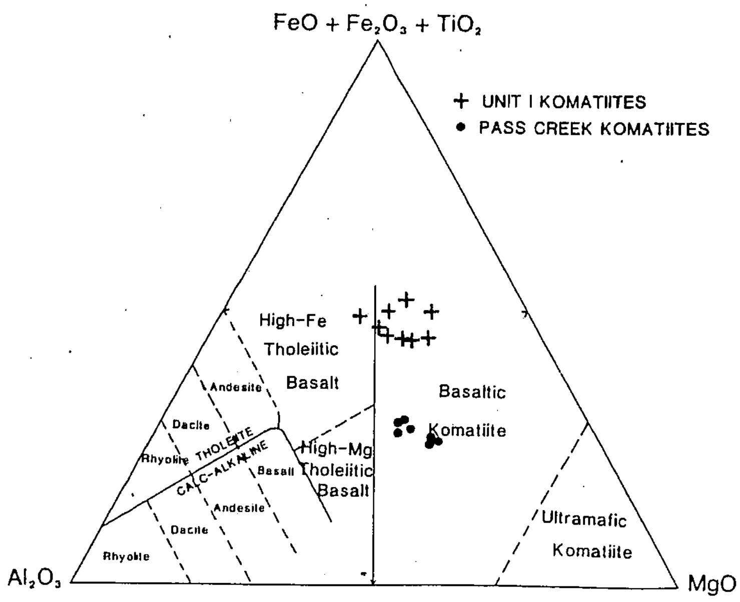


Figure 3: Jenson Cation Diagram showing the relationship between the Little Cochetopa Creek komatiites and the Pass Creek komatiites.

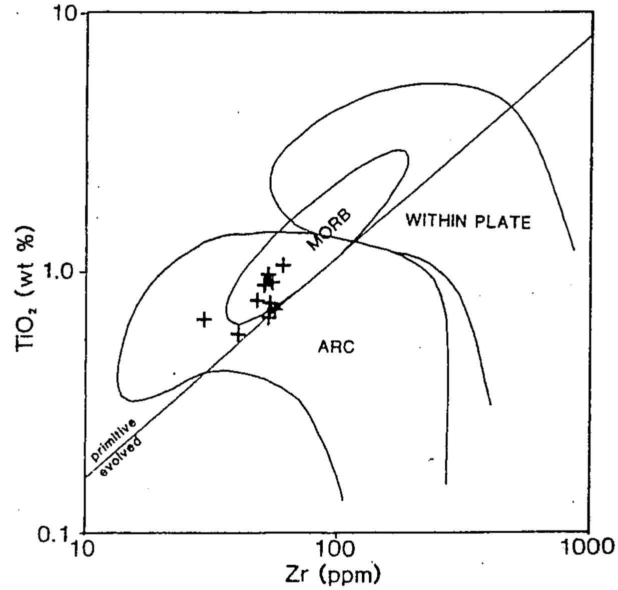


Figure 4: Discriminant diagram showing a typical back-arc basin plot.

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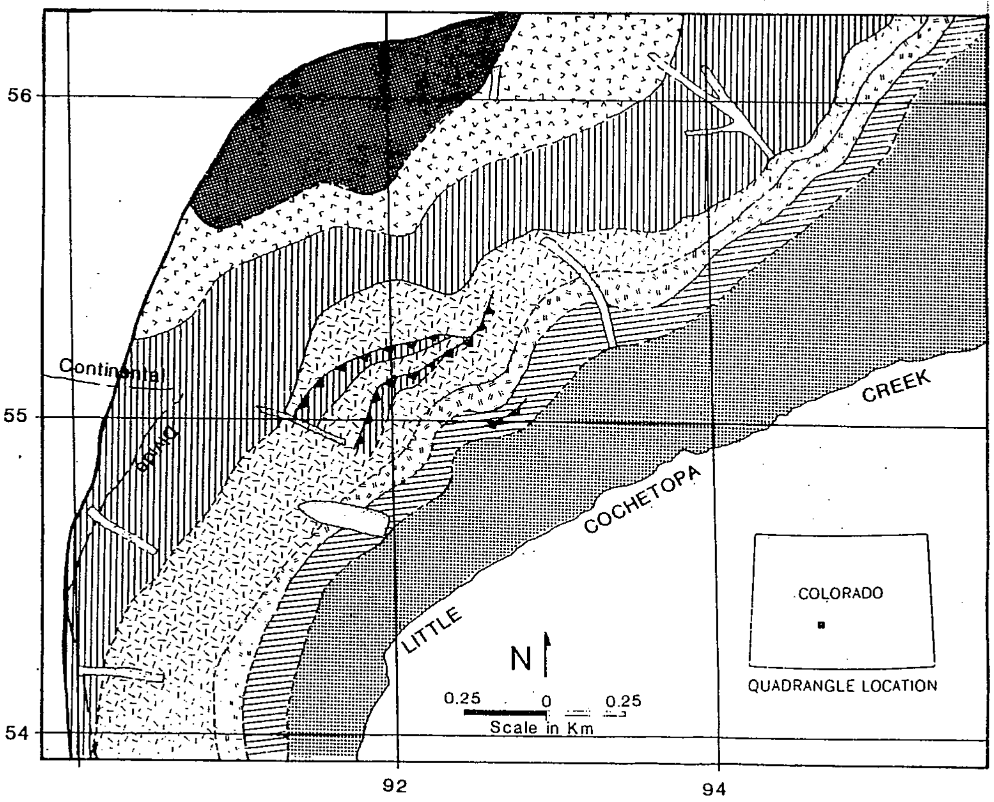


Figure 1: Geologic Skeich Map of the north side of Little Cochetopa Creek. See figure 2 for description of individual units (the light stippled area is quaternary glacial deposits).

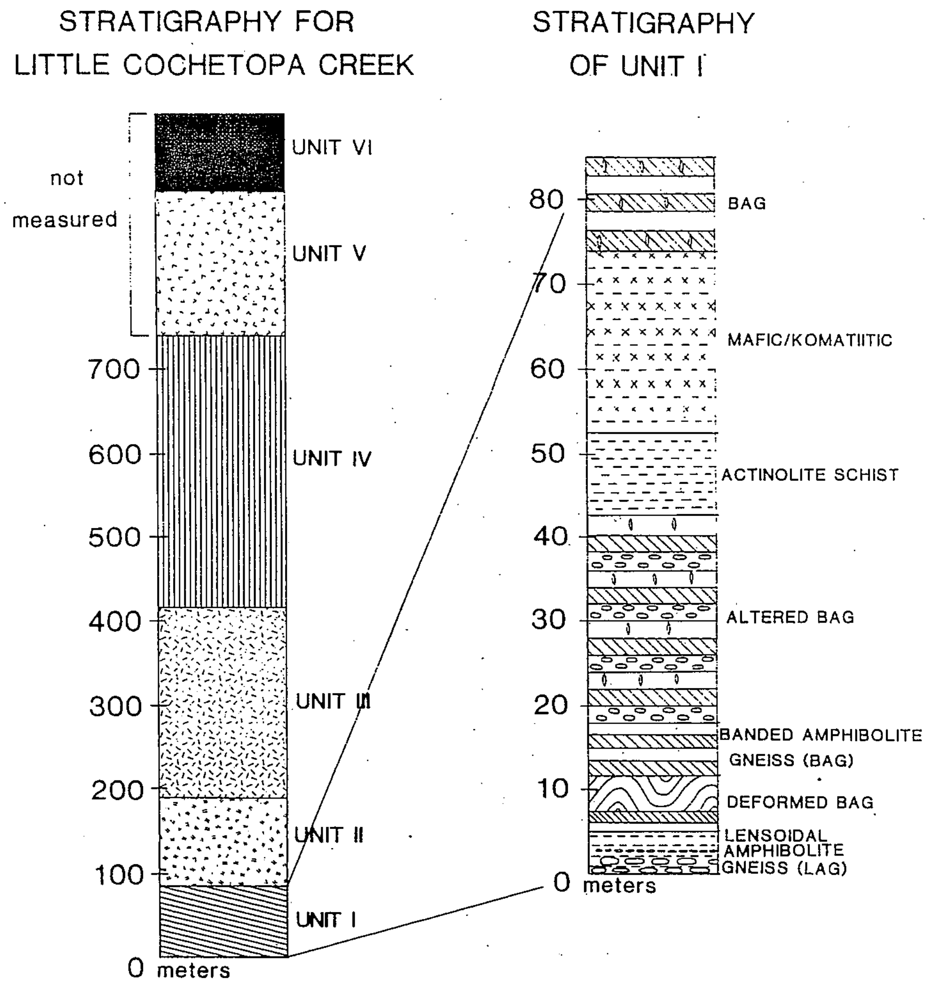


Figure 2: Stratigraphic column of Little Cochetopa Creek. Unit I is a package of lensoidal amphibolote gneiss, banded amphibolite gneiss, and komatiite flows. Unit II is a massive quartzo-felspathic, relatively uniform unit. Unit III is a massive dioritic appearing unit. Unit IV is a feldspathic volcaniclastic unit. Unit v is a meta-gabbro. Unit VI is a felsic volcanic rock. A detailed stratigraphic column of unit I is shown on the right.