Kinematic indicators and structural characteristics of the Road Gulch area, Colorado

David Gentry
Department of Geology, Washington and Lee University, Lexington, VA 24450
Faculty Sponsor: Edgar Spencer, Washington and Lee University

INTRODUCTION

The purpose of this project was to identify and map the rock units and record the structural characteristics of an area in the northern part of the Wet Mountains in Colorado. The area lies near the Arkansas River Canyon about sixty miles southwest of Colorado Springs, between Turkey and Rogers' Gulches (see figure 1.) It is bounded by the BLM/private land border to the East, and Texas Creek to the West. The Wet Mountains are part of a 1,500 km belt of Proterozoic crust affected by several periods of convergent tectonism with accompanying prograde metamorphism [Karlstrom, 1990.]. Peak metamorphism occurred during each tectonic pulse at 1.74, 1.70, and 1.65-1.60 Ga. The deformational fabrics resulting from these tectonic phases are compressional. Different metamorphic grades resulted from differential block uplifts [Karlstrom, 1990.] Condie, 1982, described the same accretion from Wyoming to Arizona as successive basin closures and Andean-type orogenies. He noted that in each province bimodal volcanic assemblages, a quartzite-shale assemblage, and granitic plutons are present [Condie, 1982.]

ROCK UNITS

The area of this study is underlain by a grey biotite gneiss, an amphibolite gneiss, and two metamorphosed plutonic formations. The grey, biotite gneiss consists of approximately 30% biotite, 60% quartz, and 10% K-feldspar. A layer of fining-upward feldspars in one outcrop of the grey gneiss appears to be a graded layer. If this interpretation is correct the grey gneiss is a meta-sedimentary gneiss. The amphibolite gneiss consists of roughly 70% hornblende and 30% plagioclase, with varying amounts of quartz and pyroxene. These amphibolite grade gneisses have been intruded by granitoid magmas during two phases of igneous activity.. The Boulder Creek formation, a well-foliated granodiorite gneiss covering most of the map area, intruded at 1.6 Ga. It can be characterized by its coarse grain size, big augens, and biotite laminations. The Silver Plume formation, a weakly foliated granitic gneiss, intruded the older gneisses around 1.4 Ga. Only a few scattered outcrops of the Silver Plume formation occur in this map area. Pegmatites which followed the intrusion of the Silver Plume formation are present throughout the map area. Especially large exposures of these pegmatites are present between Turkey and Road Gulches. Northwest of these gulches, in Howard County, bimodal volcanics are common, although not present in this map area.

FIELD RELATIONSHIPS

The grey gneiss and amphibolite are strongly foliated. The Boulder Creek has a slightly weaker foliation and the pegmatites have virtually none. The most prominent Boulder Creek foliation trends N50-60W and dips northeast (see figure 2.) The amphibolite and grey gneiss have similar trends (see figures 3 and 4.) The compositional layering and foliation of the gneisses was created by the same major deformation that led to isoclinal folding throughout the map area. The axial planes of most of these folds parallel the regional northwest-trending foliation. The axes of these folds plunge steeply, as shown by the plot of the hinge lines in figure 5. This suggests that they may have been formed as a result of a regional shear. A second set of folds trends N60-80E with varying plunge. Shear bands found in the Boulder Creek are all sinistral and trend N45-70E, at a high angle to the dominant foliation direction and the orientation of the earlier isoclinal folds. A third set of poorly developed folds in the foliation trend N10-20E and plunge 50-80 NE.

The rocks in this area have been metamorphosed to a high grade and have undergone at least two folding events. The amphibolites, which occur as elongate, boudin-shaped outcrops in map view, are mainly surrounded by larger fields of pegmatite and Boulder Creek granodiorite . The Boulder Creek

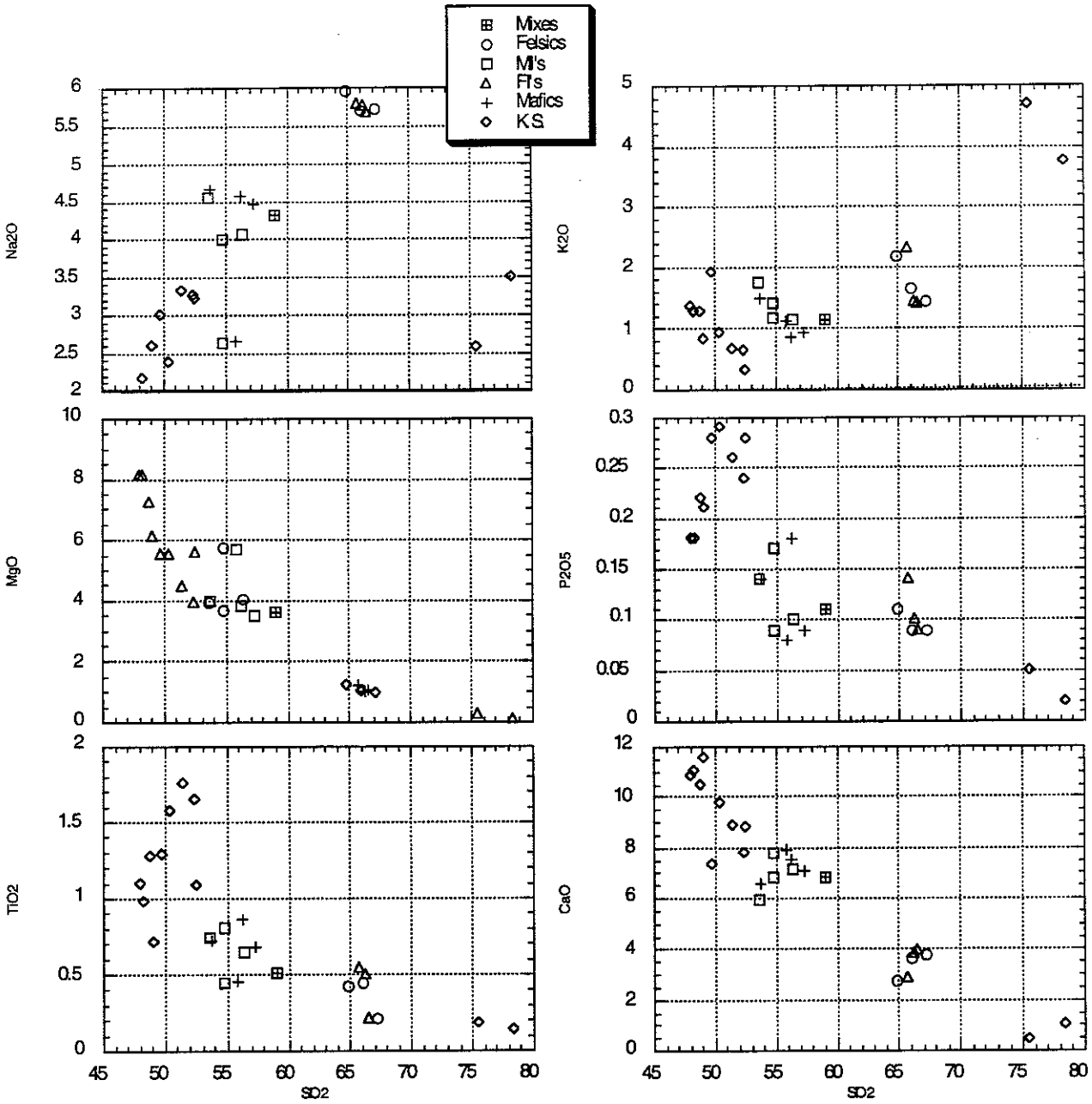


Figure 3. Harker diagrams for FEM, FCZ, MCZ, and MEM.

granodiorite, which covers the most area on the map, was part of a late-stage intrusion into metamorphic country rock, and shows both a strong foliation and, in some places, shear bands. The shear bands have a general trend of NE/SW; they cut across the foliation trend at an angle of 60-90°. The grey gneiss shows the most deformation, with tight, isoclinal folds commonly inside larger, coaxial open folds definitely indicating a second or possibly a third event. Pegmatites are widespread in the southern half of the map area. These occur both as large outcrops, and "intestinal"-looking injections within other outcrops. The pegmatites do not display foliations or folds.

The most prominent foliation is identified as an S1 surface. Sheared augens in some amphibolite bodies indicate a direction of shear parallel to the strike of the foliation. These sheared augens may be contemporaneous with the development of the steeply plunging isoclinal folds. Most of the contacts between the Boulder Creek and surrounding metamorphics parallel the trend of the foliation, NW/SE. Also, at certain granodiorite-grey gneiss and granodiorite-amphibolite contacts, close inspection reveals *lit-par-lit* injection into the metamorphics.

CONCLUSION

The dominant NW/SE foliation implies an initial compressional deformation from the Northeast and Southwest. The axial planes of the folds are in roughly the same direction as the foliation. These early folds plunge steeply. The steep nature of some of the grey gneiss folds (see figure 4) suggests a shearing event, with movement parallel to the dominant foliation. Post-isoclinal shear bands occur in some grey gneiss and Boulder Creek outcrops. These bands are perpendicular to the main foliation and axial planes of the isoclinal folds. A second, less common fold direction trends N60-80E, in the same direction as these post-isoclinal shear bands.

The sequence of events suggested by the field relationships and structural evidence is as follows: First, the grey gneiss and amphibolite were formed by high grade metamorphism of sedimentary rocks and possibly mafic volcanics. Next, these gneisses were folded. Third, the Boulder Creek intruded into the gneisses and became foliated. Then the Silver Plume intruded and a large-scale compressional event caused more foliation to form in the granodiorites, and refolded the older folds in the gneisses. Fourth, northwest-southeast trending shear bands developed in the Boulder Creek formation.

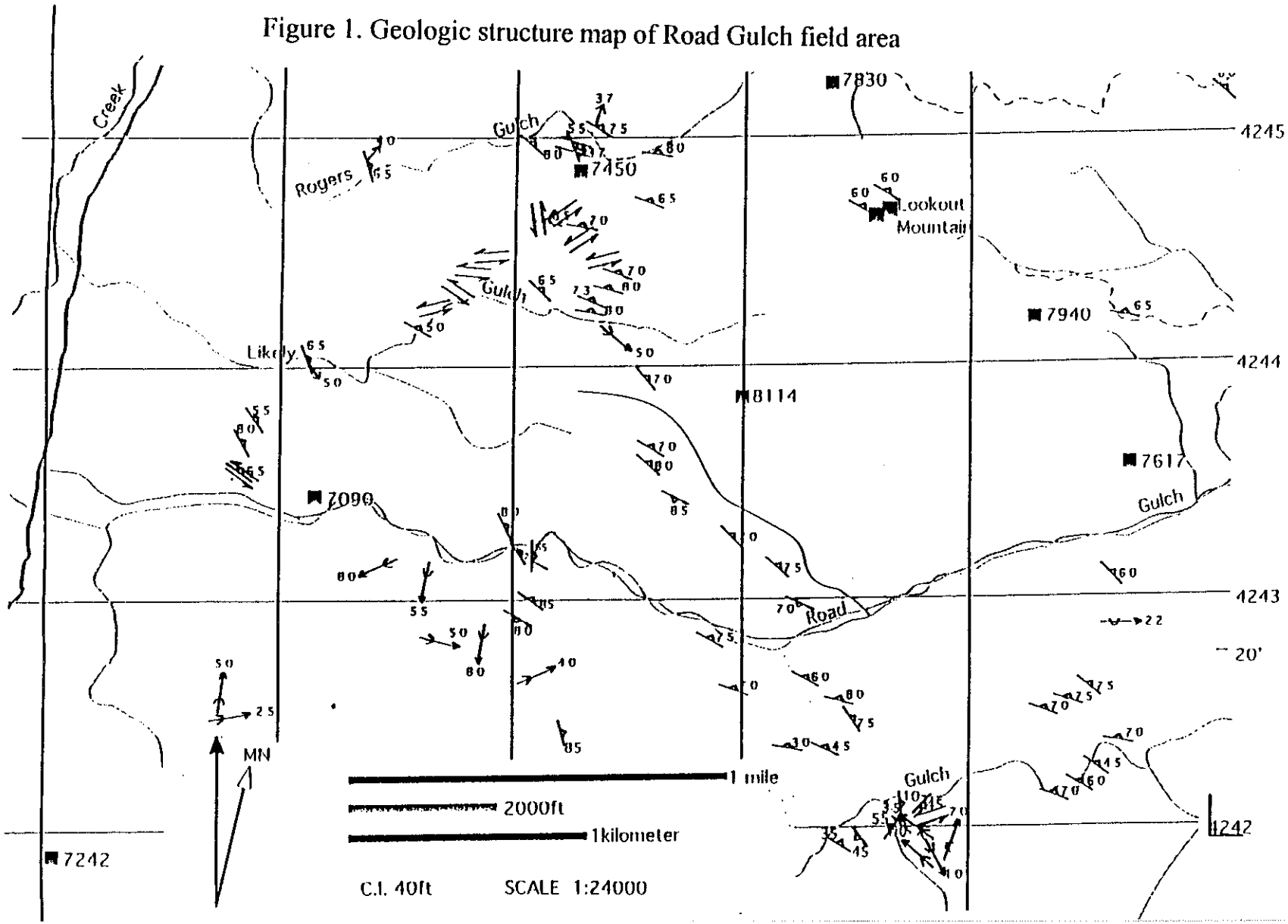
REFERENCES

Condie, K.C., 1982, Early and middle Proterozoic supracrustal successions and their tectonic settings: American Journal of Science.

Karlstrom, K.E., and Bowring, S.A., 1988, Early Proterozoic assembly of tecnostratigraphic terranes in Southwestern North America: Journal of Geology, v. 96, p. 561-576

Siddoway, 1997-1998, Personal communication.

Figure 1. Geologic structure map of Road Gulch field area



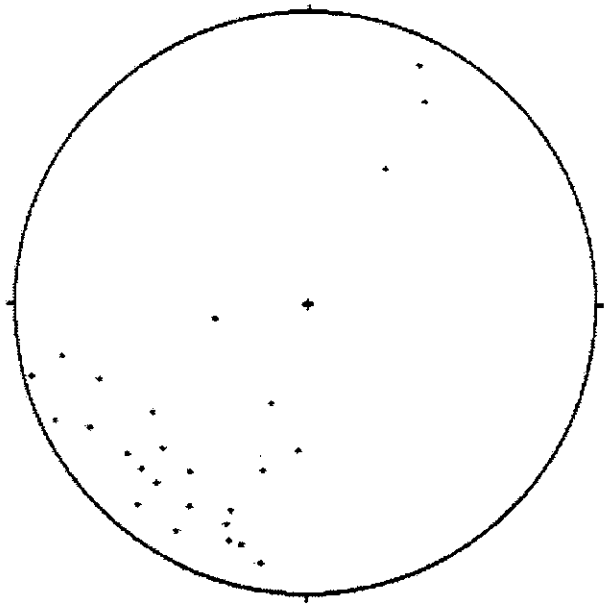


Fig.2 : Equal area projection of poles to planes of Boulder Creek foliation.

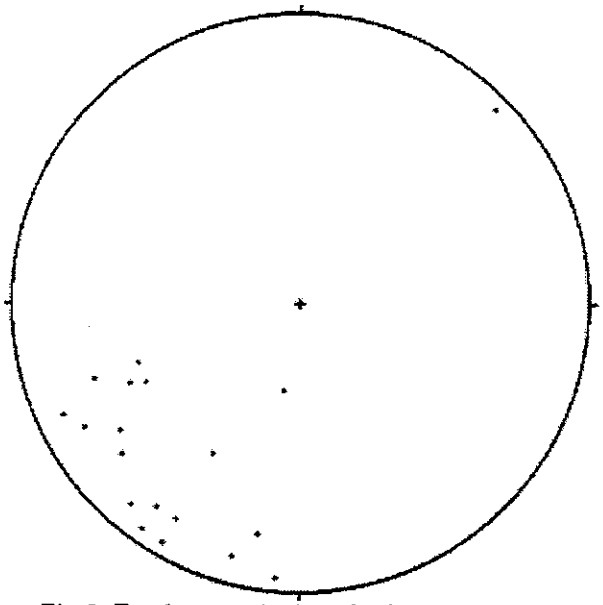


Fig. 3: Equal area projection of poles to planes of Amphibolite foliation.

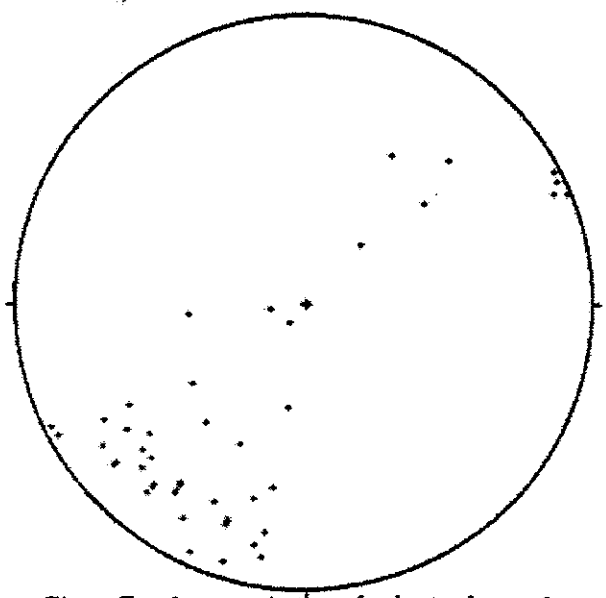


Fig.4: Equal area projection of poles to planes of grey gneiss foliation.

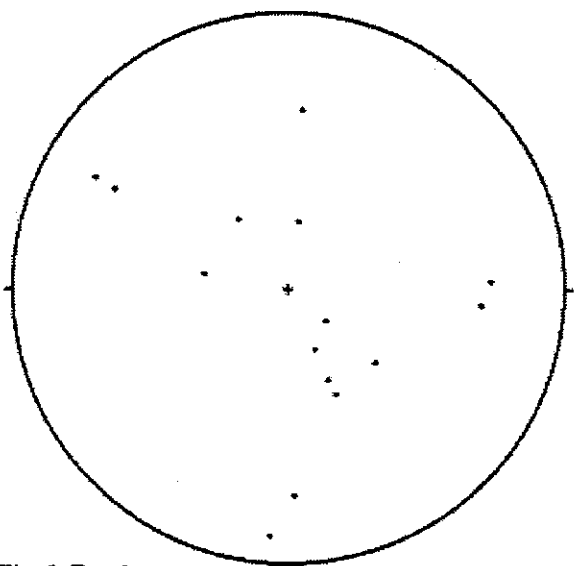


Fig. 5: Equal area projection of hinge line on folded grey gneiss.

Proterozoic Deformation and Metamorphism of Five Points Gulch, Colorado

Rima Givot
Department of Geology, The Colorado College, 902 N. Cascade Ave., Colorado Springs, CO 80946
Faculty Sponsor: Christine Siddoway, The Colorado College

INTRODUCTION

The Proterozoic felsic and mafic gneisses and schists of Five Points Gulch have experienced polyphase dynamic metamorphism in the amphibolite facies. Consistent penetrative fabrics developed in a broad, N-S striking ductile shear zone. In the eastern half of the field area shear zone rocks consist of sillimanite±garnet gneisses. The sequence west of the shear zone is made up of quartzose to quartzofeldspathic gneisses, amphibole gneisses, and cordierite schist, interpreted to be derived from predominantly metasedimentary protoliths, with some meta-igneous layers. This project focused on 1) mapping the Proterozoic lithologies and structures of an approximately 12 km^2 area that includes Five Points Gulch, a tributary of the Arkansas River in Colorado, and 2) interpreting the deformational and metamorphic history of the area. The metamorphic events recorded in Five Points Gulch likely correspond with broader regional events at approximately 1.7 and 1.4 Ga (Bickford *et al.*, 1987).

METHODS

Six major metamorphic units and a variety of granitic intrusions were distinguished in the field area. A total of ninety-six samples, over three-quarters of which were oriented, were collected. Criteria for sampling gave priority to the presence of mineral assemblages useful for P-T estimation or protolith interpretation, fabrics or textures containing potential kinematic indicators, and to samples representative of specific units. Thirty-seven samples were cut for thin sections, which were prepared by Wagner Petrographic in Provo, UT. Petrology, microscopic metamorphic textures, and kinematic indicators were examined in thin section. A total of 486 structural orientations of foliation planes, lineations, fold axial surfaces and hinge lines, and brittle joint surfaces were measured in the field using a Brunton compass. Structural data was recorded on a map and plotted on stereonet graphs using the Stereonet computer application. Maps and figures were created using the Canvas application, and empirical data was recorded on Microsoft Excel spread sheets.

LITHIC UNITS AND PETROLOGY

The Proterozoic metamorphic gneisses and schists in the Five Points Gulch field area were separated into six major lithologic units. The sequence west of the shear zone (western units) includes: quartz gneiss association (QGA), calc-silicate gneiss, cordierite schist, interlayered felsic and mafic gneisses (IFMG), and the amphibole gneiss association (AGA). The shear zone consists predominantly of sillimanite-quartz gneisses (SQG), with interlayered bands of the AGA. In general felsic gneisses are gray to pink, very hard and fine- to medium-grained with millimeter to centimeter compositional layering. Two intrusive units also crop out along the Arkansas River Canyon; Boulder Creek Granodiorite (1.7 Ga), which does not appear in the field area, and Silver Plume Granite (1.4 Ga) (Bickford *et al. 1987).* Felsic pegmatites associated with 1.4 Ga plutonism cut the lithologic units throughout the field area.

The mineral composition of the shear zone gneisses and the western units is very similar; however, no cordierite, staurolite, or andalusite is present to the east in the shear zone sequence. Within the western sequence, garnet, cordierite, staurolite, sillimanite, biotite, amphibole, plagioclase, quartz, muscovite, potassium feldspar, and epidote predate S_2 foliation (see following section). Compositional layering and aligned biotite, muscovite, or amphibole formed the foliation. In the shear zone-associated gneisses, sillimanite, biotite, quartz, plagioclase, potassium feldspar, and garnet formed before the S_3 foliation (see below). Aligned biotite and sillimanite defines the foliation, and muscovite crosscuts the fabric in thin section.