# Proterozoic rocks of Newlin Creek and Locke Park, San Isabel National Forest, Wet Mountains, Colorado

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## INTRODUCTION

The Wet Mountains, located in south central Colorado, are a part of a 500 km wide Proterozoic metamorphic terrane interpreted as accreted oceanic arcs along the south edge of the Archean province of Wyoming (Reed et al., 1987). Bounded by the Laramide Ilse fault to the west, the Arkansas River to the north, and the Great Plains to the East and South, the rocks of the Wet Mountains represent the highest metamorphic grade of any of the Colorado Plateau Proterozoic rocks (Reed et al., 1987; Bickford et al., 1989).

One of the purposes of the Summer 1996 Keck project was to map the units outcropping in the Newlin Creek and Locke Park area in detail (Figure 5). We were able to distinguish five mappable units which comprise the northern reaches of the Wet Mountains. Two of these units represent the country rock: a biotite-rich gneiss and an amphibolite. An alkaline granitic augen gneiss (G1), a biotite-poor granitic gneiss (G2), and a leuco-granite (G3), all represent later intrusive events.

The average foliation of the area is N60W, 30-40NE. Most of the lineations (stretched minerals of quartz and alkali-feldspar, biotite trains, and fold hinges) fall on a great circle with an orientation of N34W, 28NE. The variance of lineations along this great circle may be interpreted as a later broad folding of the area.

## BIOTITE-RICH GNEISS

In the field, biotite gneiss is distinguished by its gray color, migmatic layering, and distinct foliation. The mode is generally 15-35% biotite, 50-70% quartz, 5-10% plagioclase, 10-45% microcline, with accessory magnetite and garnet. The mineral percentages vary greatly among the leucosomes, mesosomes, and malinsomes. Migmatitic layers are on the order of 0.5-2.0 cm in thickness, but in some areas they can be several centimeters thick or form pockets of concentrated minerals. Weathering exploits the biotite rich layers, forming a texture of ridges and some overhangs in the outcrops. Very little garnet is present in the biotite gneisses in the northern portion of the map, and, if it is present, it is usually very small. While in the southernmost biotite gneiss outcrop on the map (Figure 5, #1), garnets are large and easily visible. In fact in one part of this outcrop, garnets the size of golf balls are weathering out.

The biotite gneisses are strongly foliated. The poles to foliation are plotted in Figure 1. The average foliation is N66W, 30 NE. Noses of folds in the biotite gneiss are rare. Where they are found, the limbs of the folds are parallel to the foliation, indicating that the biotite gneiss is isoclinally folded. The hinges to these folds are also plotted in Figure 1. Lineations of biotite and quartz minerals could also be found on the foliation surfaces of the biotite gneisses, and their orientations are included in Figure 1. They fall on a great circle with an orientation of N37W, 28NE. Because these lineations plot on a great circle and the poles to foliation slightly fan out, it appears that a second broad folding of the area has taken place. The timing of this event would be much later in the geologic time scale.

## AMPHIBOLITE

This rock type does not outcrop as much as the biotite gneiss. It usually is found as small blobs within G2; however, two extensive blocks, one boudinaged in G1, are found in the area (Figure 5 #2 and #3). The mineral composition is about 75% hornblende, 24% plagioclase, 1% quartz, and less than 1% pyroxene.

The amphibolites are also foliated. Due to the sparse number of outcrops, less structural data is available. Also, the larger blocks of this rock unit (Figure 5 #2) are found on a steep hillside where they are starting to slump, so the foliations are rotated. The poles to foliation did not cluster, so an average is indeterminable. The mineral lineations and hinge foliations are plotted in Figure 2 along with the poles to foliation.

## ALKALINE GRANITIC AUGEN GNEISS (G1)

Most of this rock type outcrops in the lower portion of Newlin Creek; however, a small outcrop is also found in the middle of the map (Figure 5 #4). This gneiss is coarser grained than all the other rocks of the area. Its overall composition is about 55% Quartz, 30% Microcline, 5% Biotite, 8% Plagioclase, and less than 1% hornblende and magnetite. The distinguishing feature of this rock is that it has centimeter- size augen of microcline within it.

These augen as well as the biotite define the foliation of the rock. Stretched quartz and microcline crystals also define a lineation within the rock. Both of these are plotted in Figure 3.

**BIOTITE-POOR GRANITIC GNEISS (G2)**

This rock is the most common rock in the Newlin Creek and Locke Park mapping area. Its distinguishing features are its low percentage of biotite and its lack of a strong foliation. It also tends to weather more rounded than the other gneisses and varies in color from salmon pink to yellow. The overall mineralogy of this rock is about 1-2% biotite, 18% plagioclase, 30% quartz, 50% microcline, and a trace of magnetite.

Although slightly foliated, this rock becomes more foliated in areas of shear where blocks of biotite and amphibole gneiss are present. The poles to foliation cluster fairly well as indicated in Figure 4. The average foliation is N65W, 35NE.

**LEUCO-GRANITE (G3)**

This rock lacks biotite and is light pink in color, helping distinguish it from the other granitoids. Also, this granite is not foliated. Even though it lacks biotite, which helps determine foliation in the field, thin sections of it do not show any planar orientation of the other minerals. Its approximate mode is 10% plagioclase, 40% quartz, 50% microcline, and less than 1% biotite. This granite is also associated with large pegmatitic dikes that cut across all of the rocks in the area and can be greater than a meter wide. These dikes consist solely of quartz and alkali-feldspar.

## DISCUSSION

Based on the field relationships and petrology work, the five rocks discussed above can be put into a relative chronology of events. The oldest rocks of the area are the biotite gneisses and amphibolites. The field relationships indicate this because these two units are contained as xenoliths within both the granitic gneisses (G1 and G2) and are cut by pegmatites associated with G3. The biotite gneisses were originally sedimentary rocks such as graywacke and quartz or arkosic sandstones that might have been deposited in a back-arc basin setting (Reed et al., 1987; Bickford et al., 1989). The high quartz content seen in the field and in thin sections supports these interpretations. The amphibolites were once basalt flows (Bickford et al., 1989). At some point, significant regional heating affected the units, leading to migmatitic segregation layering in the metasedimentary and metabasaltic rocks. The rocks were isoclinally folded during or after migmatization, with folds defined by the migmatitic layering. The isoclinal folding may have occurred during regional tectonic accretion events. This folding event imparted a foliation parallel to fold axial surfaces, which can be found in some outcrops.

Next, G1 was intruded. The G1 unit cuts foliation and folds in the biotitc gneisses and amphibolites. Our group interprets G1 to be associated with Boulder Creek intrusive bodies, dated at 1705 Ma in a nearby location (Noblett et al., 1987). G1 experienced deformation after it crystallized. The foliation imparted on it has a similar orientation as the foliation of the metaseds and metabasalts.

After G1 was emplaced and deformed, a larger magmatic event took place, resulting in the emplacement of G2. Our group interprets this event to be associated with the Silver Plume event, which took place around 1410±50 Ma (Noblett et al., 1987). Xenoliths of both the metasedimentary and metabasalts and G1 are found within G2. Also, in several outcrops G2 dikes cut across the foliation of the metaseds and metabasalts. However, the margins of G2 appear to parallel foliation in the area, so G2 forms a large sill. During its emplacement, G2 sheared and deformed several of the gneisses it injected into. Zones of G2 are intermixed with wispy pieces of melted gneisses, and mixed zones exist around the margin of this intrusion. The wispy material does not have distinct boundaries, so it differs from the xenolith blocks. G2 is foliated, but this foliation is weak.

The last Proterozoic rock of the area is of post tectonic origin. This rock is G3, the unfoliated granite of the area. G3 dikes may be related to the San Isbel batholith, located south of this mapping area, which was intruded 1360 million years ago (Noblett et al., 1987). Associated with this granite are large pegmatites which also cut through the rocks of the area.

## REFERENCES

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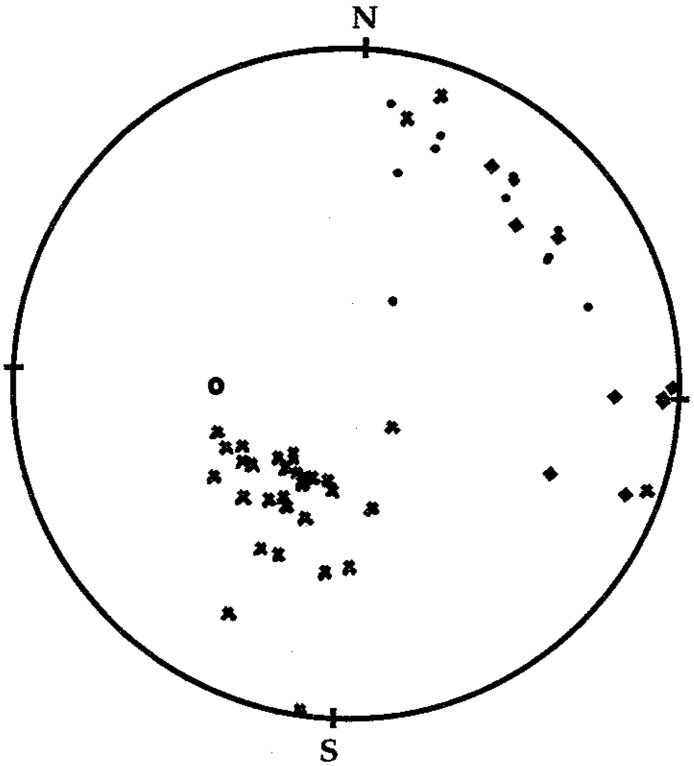


FIGURE 1: Biotite Gneiss Stereoplot

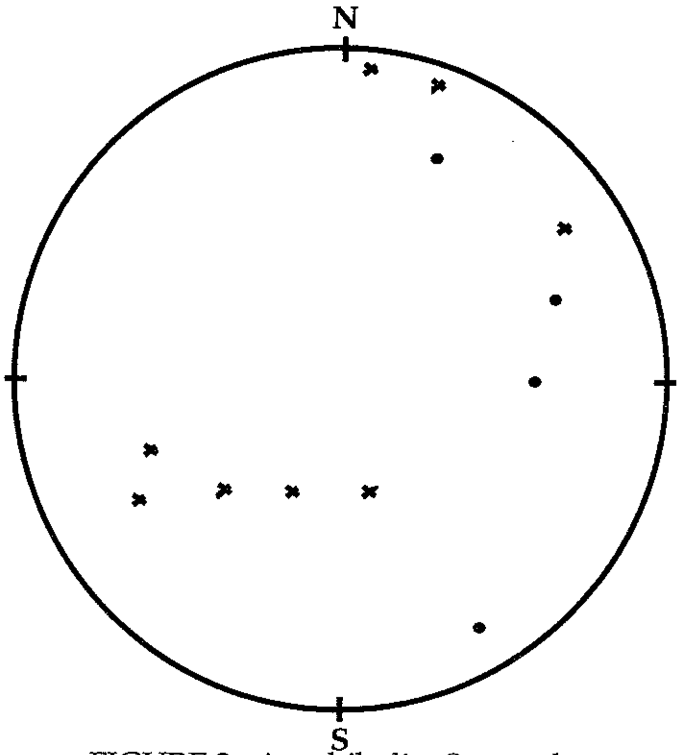


FIGURE 2: Amphibolite Stereoplot

× Poles to foliation
● Lineations
○ Pole to Shear Plane
◆ Fold hinges

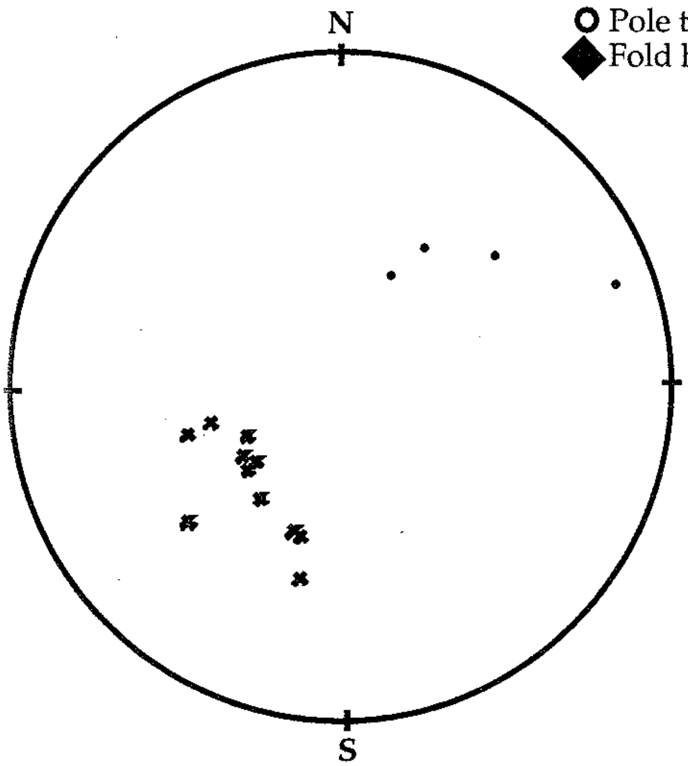


FIGURE 3: G1 Stereoplot

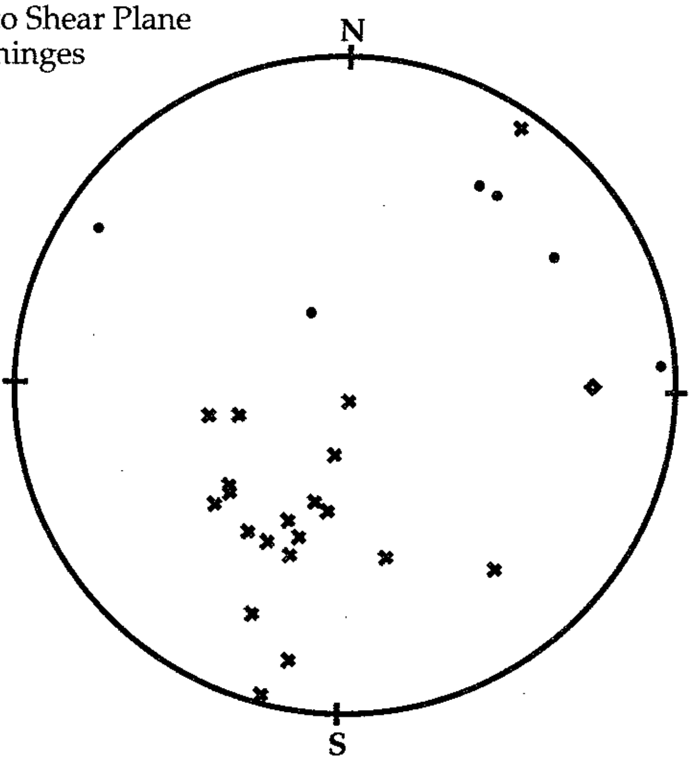


FIGURE 4: G2 Stereoplot

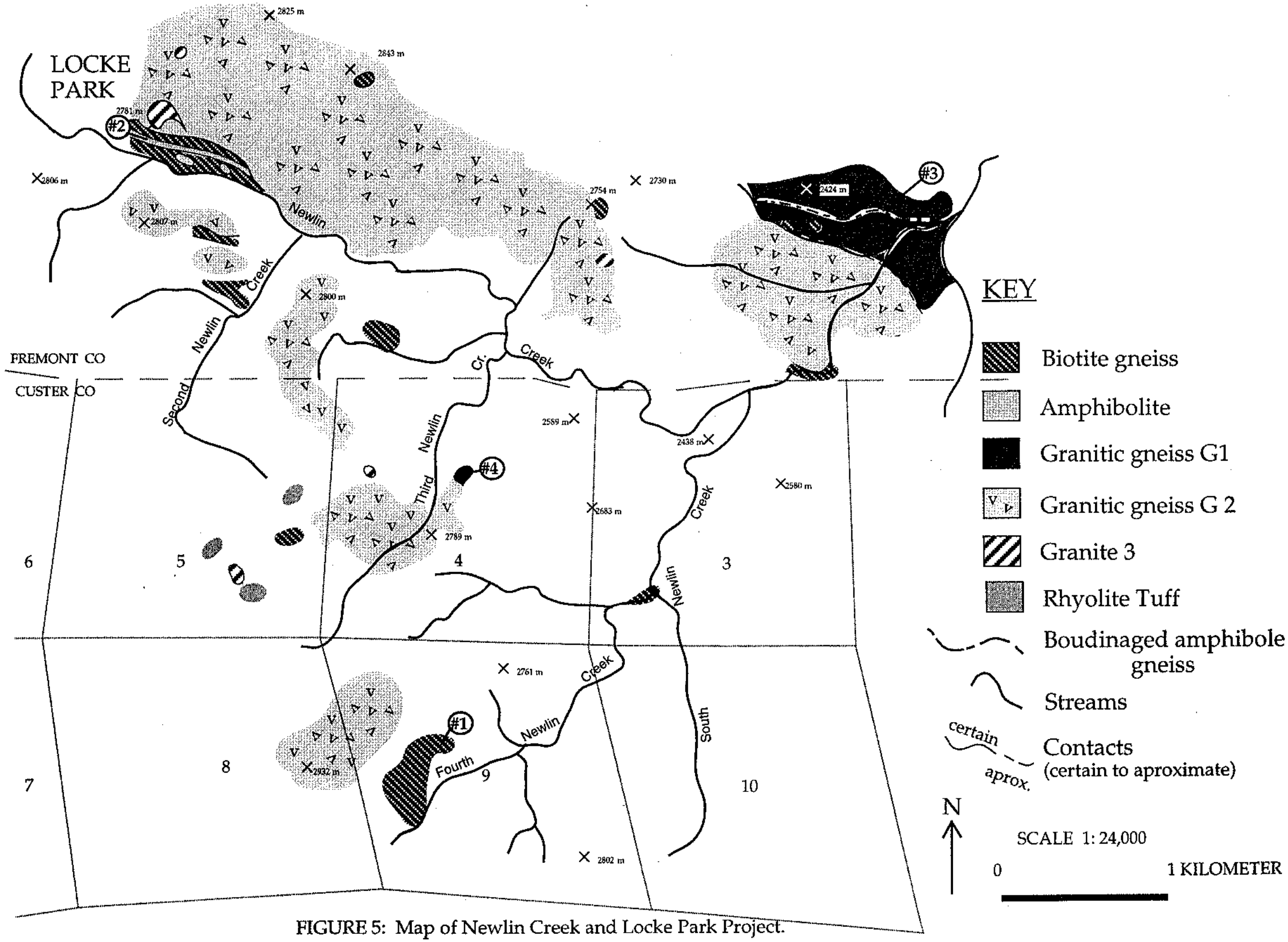


FIGURE 5: Map of Newlin Creek and Locke Park Project.