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**Structural mapping of the Uncompahgre Front near Gateway, Colorado,
With emphasis on Ancestral Rocky Mountain fabrics**

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The Uncompahgre Plateau is a northwest trending physiographic high located in southwest Colorado. The plateau was uplifted most recently during the Laramide Orogeny. It was also a major high (with a similar, relative orientation) during the Pennsylvanian and Permian, when it was part of the Ancestral Rocky Mountains (ARM) uplift. At that time, it served as a major source area for sediments deposited in the Paradox Basin including the Pennsylvanian-Permian aged Cutler Formation (up to 14,000 feet thick). To date, most information about the structural evolution of the Uncompahgre Uplift during the ARM Orogeny has been inferred from sedimentological, geophysical and well data. Frahme and Vaughn [Field Conference- RMAG v. 1983, p. 201-211] published a structural interpretation based on the Mobil No. 1 McCormick well and a related seismic study that was conducted along the southwest flank of the Uncompahgre. The well reportedly drilled 12,000+ feet of Precambrian basement before bottoming out in the Pennsylvanian Paradox Formation. They interpreted the seismic data to show a southwest verging thrust which did not affect the overlying Triassic-aged Chinle Formation. Their results renewed debate over the mechanism responsible for uplift in this portion of the ARM Orogeny.

Laramide deformation has presented a major barrier to studies of ARM fault kinematics, because most ARM faults have been assumed to have been reactivated during the Laramide Orogeny. We question this assumption and conducted this study in an area that suggested Laramide overprinting might be relatively minimal. This study provides kinematic structural data that can be used to test geophysical, quantitative and theoretical models of the tectonic evolution of the Uncompahgre Uplift during its ARM rise, and to test models seeking to explain the formation of the greater Ancestral Rockies.

In this study, we used GPS and compass and pace methods to map a portion of the Gateway, Pine Mountain and Two V Basin 7.5' quadrangles, northeast of Gateway, Colorado (Figure 1). Mapping in this location is advantageous because there is good exposure of the unconformity that separates basement from the alluvial deposits of the Cutler Formation. Within the region, the Tr-1 unconformity is well exposed, and besides flexure, only normal fault related offsets are observed. These normal offsets affect all Mesozoic rocks outcropping in the area. Mesozoic strata show only minor flexure as they cross the southwest boundary of the plateau, as opposed to many areas along its flanks where the Mesozoic section is sharply folded along monoclines. This suggests that Laramide structures may be less penetrative and/or severe here. In addition to mapping, oriented samples were obtained for thin section and X-ray diffraction analysis. K-Ar and Ar-Ar dates from selected fault zones that show sufficient secondary mineralization are being obtained.

Figure 1 presents a simplified version of our preliminary results. It does not include all field data, and should be considered schematic. It does show the basic structures found near Gateway and their relative chronologies, although the lack of good stratigraphic control within the Permian rocks in the region makes it difficult to determine the magnitude of fault offsets. From youngest to oldest the major structures are:

1. A series of normal faults that cut all Mesozoic rocks, and in some instances Tertiary channel conglomerates and terraces deposited by the ancestral Gunnison [Lohman, NM Geo. Soc. Guidebook, 32nd Field Conf., Western Slope, CO, 1981, 137-143]. This is

consistent with the suggested extensional collapse of the periphery of the Colorado Plateau presented by Blank, et al. [USGS Bull. 2158 (1998), 9-32]. Vitreous, down-dip plunging slickensides of calcite, hematite, quartz and gypsum are associated with these faults.

2. Coarse, crystalline calcite veins occur in portions of the Cutler Formation most proximal to the Uncompahgre. These dip steeply to the northeast and strike on average N30W, subparallel to the Uncompahgre's axis. Jurassic sandstone float contains similar veins. Where these veins occur in Precambrian rocks, they accompany a gray to red, calcic gouge. Brecciated epidote is occasionally associated with these veins, but the epidote likely pre-dates calcite and gouge formation. These gouges and veins are inferred to be primarily of Laramide age and origin. They may, in some instances, represent overprinted ARM faults, which is the subject of ongoing thin section analysis.
3. A mylonite found in the Pickett Trail Wash marks a low-angle fault that dips 13° SW and cuts sharply across bedding (dips 11°, SW) within a locally fine-grained, planar-bedded Cutler succession. A *mélange* overlies this mylonite. Together the mylonite, *mélange* and a capping upper portion, which shows cataclasite texture and secondary quartz mineralization, constitute the informal Pickett Trail *Mélange* (PTM) shown in Figure 1. The *mélange* contains resistant quartzite blocks with veins of epidote and calcite in them. These lensoidal blocks are intercalated with matrix-supported breccias. Breccia clasts are dominantly composed of Precambrian schists and amphibolites. Fine-grained, steeply dipping, hematite-rich zones which show little other secondary mineralization, are ubiquitous and have many different orientations. The upper portions of the PTM at this location contain metamorphosed debris flows and talus-like deposits. A quartz filled tension crack plunges shallowly to the southwest and is interpreted to indicate southwest vergence of the hanging wall. Secondary mineralization in the upper portions of the PTM is dominated by quartz and minor calcite. In addition, aplite clasts show P-T conditions produced quartz and K-spar instability. Haloes of biotite surround these round aplite clasts. The exposure in Pickett Trail Wash suggests that the *mélange* (syntectonic) formed in a high heat regime, caused by superposition of older and deeply buried Cutler deposits atop younger Cutler and/or coeval upward migration of deep seated fluids. This outcrop suggests that crustal loading and shortening, to some as yet unquantified extent, occurred via décollement structures, as suggested by Huffman and Potter [GSA abs. V.25(5), 55]. In addition, Figure 1 shows that the PTM covers an extensive map area. It becomes a catclasite to the east (where the base of the section is not exposed) and basement involvement appears likely due to extensive granitic veins (up to 8 meters in length) in essentially homolithic exposures of brecciated gneiss.

The PTM shows evidence of a later remobilization. Rigid quartzite lenses within the *mélange* show northeast verging, overturned folds. Some epidote veins also show evidence of shearing suggestive of northeastward mobilization of the hanging wall. These trends are opposite those previously inferred from rotated grains and the tension crack, for the direction of vergence in the hanging wall. The seemingly contradictory orientation of those folds and sheared epidote veins are reconciled as a second, younger deformational event. In Wright Draw, thinly bedded silty sandstones show sporadic kink banding (but no cleavage development) that in some instances is also overturned (rarely recumbent) and northeast verging. These northeast verging shear indicators may be of Laramide, or possibly even Sevier origin. However, In distal and more extensive, fine-grained units of the Cutler, as well as in the overlying Mesozoic units where such sliding and kinks might be more likely to develop from a Sevier or Laramide cause, no such structures have been reported. Perhaps northeast vergent thrusting (back thrust?) occurred near the close of the ARM Orogeny.

4. Fine-grained, red gouges containing epidote as veins and breccia occur in association with both reverse and thrust faults. These faults typically dip to the east-northeast and polished

sections show pseudotachylite formation. Exposures along Casto Draw, constrain these faults to Cutler time. A fine-grained, onlapping unit of the Cutler is tilted up to 44° (dipping to the southwest). The folding begins abruptly. Most of the Cutler dips consistently $20\text{--}25^{\circ}$ to the southwest and this dip is continued to within less than 20 feet of this folded layer. Precambrian granites are thrust over the folded Cutler units, and an unconformity cuts through them. The unconformity appears to be overlain by younger Cutler deposits (thin section analysis will confirm or disprove this interpretation). A second unconformity within the Cutler is present in Texas Draw. There, fine-grained Cutler deposits are steeply incised and filled by coarse fluvial conglomerates and debris flow deposits. The presence of unconformities within the Cutler support the interpretations of Mack and Rasmussen [GSA Bull., v. 95 (1984), 109-116], who indicated that the overall grainsize distribution within the Cutler required three separate, faulting events.

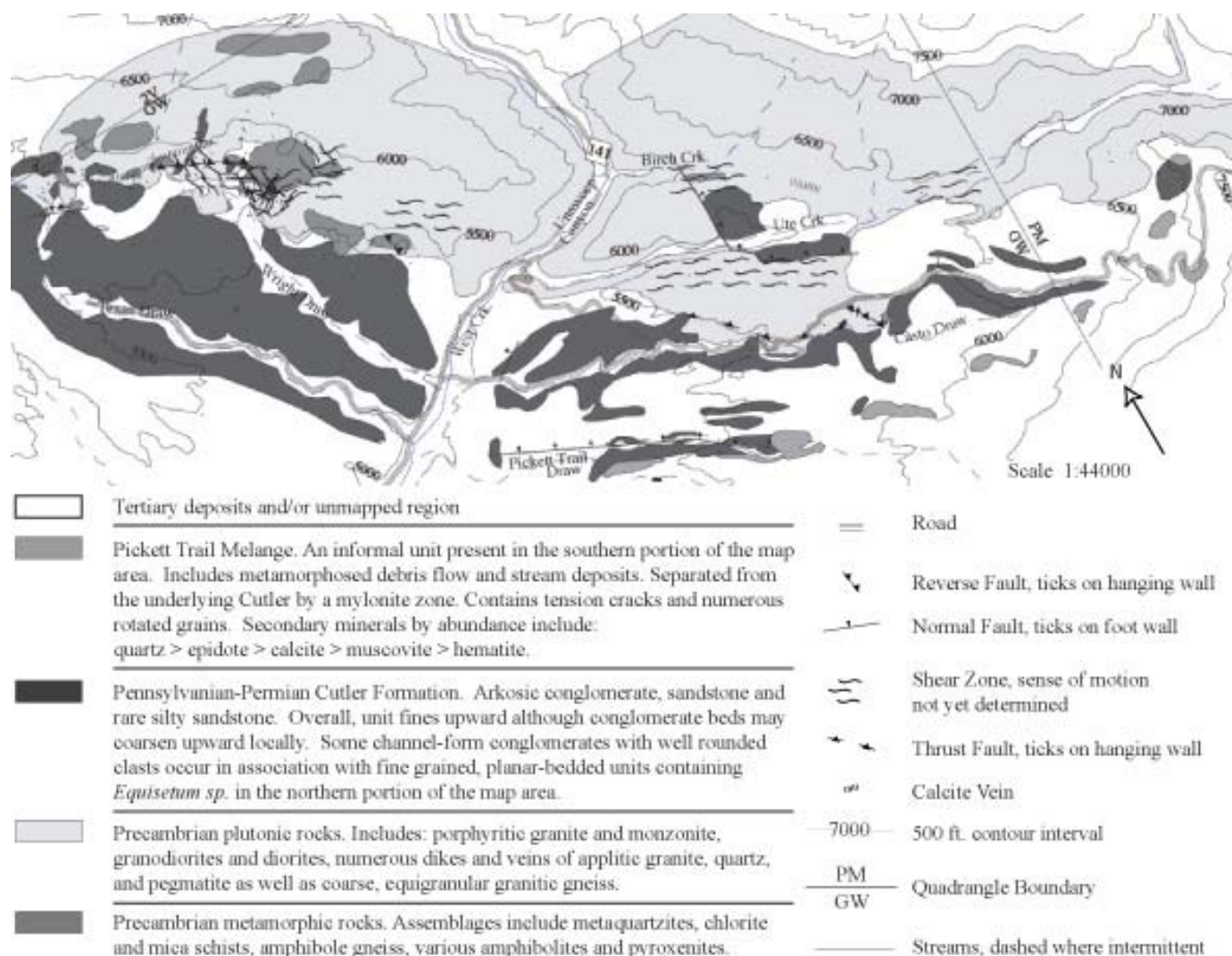


Figure 1. Preliminary outcrop map along the southwest flank of the Uncompahgre Plateau, near Gateway, Colorado. See text for description of inferred tectonic history. This map should be considered schematic as not all field data and thin section lithologic distinctions have been included in this simplified presentation. Contours were derived using 7.5' USGS DEM data from the Gateway (GW), Pine Mountain (PM), Two V Basin (2V) and Fish Creek quadrangles. Funding for this project was provided through a USGS EDMAP grant.

Our preliminary results suggest at least two styles of deformation occurred during the ARM orogeny in the vicinity of Gateway. At some time after the initial formation of the Uncompahgre Uplift, motion along the Uncompahgre front near Gateway was dominated by reverse faults and subsidiary, low-angle thrusts. Later, shortening occurred on a décollement; whether significant lateral transport and ramping occurred, or whether the mélange was actually associated with rupturing of a reverse or thrust fault, remains unclear. Thus far, results suggest that décollement sliding constitutes the final ARM motion in this area. There may, however, exist other unmapped faults present within the Precambrian rocks to the east or buried basinward. Thin section analysis may yet distinguish additional ARM fabrics in some structures that we have attributed to the Laramide Orogeny. At Gateway epidote seems to be the most distinctive secondary mineral associated with ARM evolution. It is important to note that epidote is the most common heavy mineral in the Cutler [Werner, J. Sed. Pet., v. 44(2) (1974), 292-298]. This suggests that, locally, erosion and tectonics contributed to the exposure of fault structures during much of Cutler deposition.