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PROTEROZOIC GEOLOGY OF THE RINCON RANGE NORTH OF GUADALUPITA, NEW MEXICO

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Abstract—Proterozoic rocks of the Vadito and Hondo Groups dominate the northern Rincon Range, where the Vadito Group includes metarhyolite, crossbedded quartzofeldspathic gneiss, amphibolite, fragmental silicic metatuff and pelitic schist. The stratigraphically highest beds in the Vadito Group consist of schist rich in kyanite, muscovite, hematite, quartz and manganese andalusite. They are interpreted to represent the metamorphosed equivalent of a lateritic soil that developed along an unconformity separating the Vadito Group from the overlying Hondo Group. Quartzite of the Ortega Formation (Hondo Group), with an exposed stratigraphic thickness of 900 m, overlies the unconformity. The quartzite is similar to but slightly poorer in aluminum silicate minerals than where it has been mapped elsewhere in northern New Mexico. Crossbeds found in both the Vadito and Hondo Groups show that the stratigraphy is everywhere overturned, a consequence of regional deformation. Large-scale, south-dipping ductile shear zones repeat the transition from Vadito to Hondo Groups six times in the mapped area. The shear zones have the geometry of north-verging ductile thrusts. The region experienced its thermal peak following deformation at metamorphic conditions near 500°C, 4 kb. These P-T conditions are common in the Proterozoic rocks of New Mexico, and they may have developed during a period of synmetamorphic extensional deformation.

INTRODUCTION

The Rincon Range offers one of the largest continuous exposures of Proterozoic rocks in New Mexico. Complexly deformed and metamorphosed rocks extend 35 km southward in the Rincon Range from Black Lake to Mora, then another 40 km south beyond Mora. Budding and Cepeda (1979) and Baltz and O'Neill (1980a, b) mapped the southern parts of the range. Grambling et al. (1989) published a map of Proterozoic rocks in the northern Rincon Range but did not discuss the area in detail. This study summarizes the results of detailed mapping of a 15 km^2 region in the northern Rincon Range, north of the village of Guadalupita, focusing exclusively on Precambrian rocks.

The mapped basement rocks crop out in a wedge-shaped area extending 8 km northwest from Guadalupita into the topographically highest parts of the range (Fig. 1). The area is rugged and lies mostly on private land, although all landowners contacted for this study readily allowed access. Topographic relief is extreme. Elevations vary from 7600 to 11,055 ft above sea level, with topography dominated by a single high ridge running north-northwest.

Precambrian rocks are bounded to the west by a steep fault, possibly Laramide, that juxtaposes them against unmetamorphosed sedimentary rocks of Paleozoic age (Dane and Bachman, 1965). Metamorphic rocks are overlain unconformably to the east by Tertiary(?) basaltic lavas that flowed down the trace of Coyote Creek; local outcrops of Proterozoic quartzite protrude from beneath the basalts along the creek at elevations near 7800 ft. To the north, the Proterozoic rocks are bounded by unconformably overlying Paleozoic sedimentary rocks.

PROTEROZOIC GEOLOGY

This report describes the rock types, deformation and metamorphic grade of Proterozoic rocks in the northern Rincon Range (Fig. 1). Proterozoic rocks can be assigned to two stratigraphic units, both of which are widely exposed in northern New Mexico: the Vadito and Hondo Groups (cf. Bauer and Williams, 1989). The Vadito Group in the mapped area includes mixed metasedimentary and metavolcanic lithologies, whereas the Hondo Group consists entirely of massive quartzite of the Ortega Formation.

Vadito Group

The most common rock type in the Vadito Group in the northern Rincon Range is quartzofeldspathic gneiss with quartz, plagioclase, K-feldspar, muscovite and FeTi oxide minerals. Some outcrops are foliated, show no primary bedding and contain apparent phenocrysts of quartz and feldspar. These rocks probably had a volcanic or volcaniclastic origin. Locally, the gneiss contains minor amounts of the mineral fuchsite, a green, chromium-bearing dioctahedral mica. Fuchsite-bearing samples have been collected at an elevation of 9600 ft along the main ridge of the Rincon Range; the origin of the chronium mineralization is uncertain. Other outcrops of quartzofeldspathic gneiss pre-

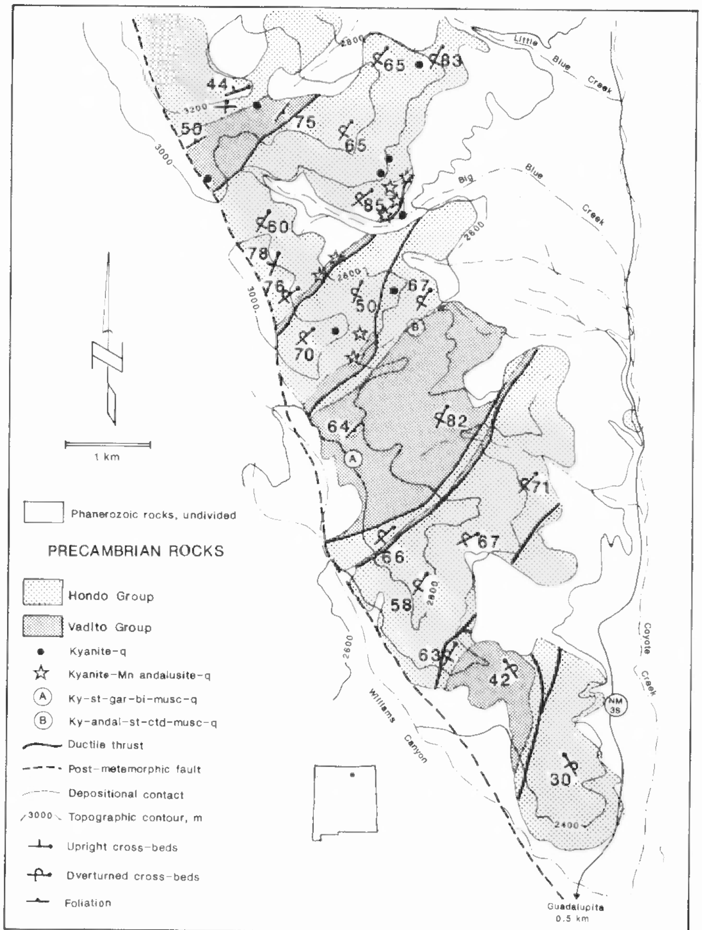

FIGURE 1. Simplified geologic map of Proterozoic rocks in the Rincon Range north of Guadalupita, New Mexico. Modified after Grambling et al. (1989).

serve festoon crossbedding outlined by 1–2-mm-thick concentrations of titaniferous hematite and rutile (Fig. 2). The crossbedding requires a sedimentary origin for at least part of the gneiss. The quartzofeldspathic gneiss has a maximum map thickness of 600 m, but abrupt local reversals in the facing directions of crossbeds require that some of this thickness is due to fold repetition. The actual thickness of the mapped unit may fall near 200 m.

Amphibolite layers up to 50 m thick are scattered throughout the Vadito Group. They typically lie parallel to bedding of adjacent rocks and contain blue-green hornblende, plagioclase, chlorite, quartz and minor FeTi oxides. Individual layers of amphibolite can be followed along strike for up to 3 km across the entire mountain range. They are considered to represent metamorphosed basalt, although no textures proving that interpretation have been found. In some outcrops the amphibolite grades into a schist with chlorite, hornblende and plagioclase. The protolith of this schist may have been a weathered basalt, or the schist may have been derived from amphibolite during ductile deformation.

Pelitic schist forms a minor but significant part of the Vadito Group in the study area. Pelites are characterized by mineral assemblages including kyanite-staurolite-Mg chlorite-garnet-biotite-magnetite-muscovite-quartz, kyanite-andalusite-staurolite-chloritoid-muscovite-quartz and kyanite-andalusite-chloritoid-magnesian chlorite-muscovite-quartz-hematite-rutile. Andalusite in pelitic schist shows optical properties consistent with it being nearly pure Al_2SiO_5 (cf. Grambling and Williams, 1985). Porphyroblasts of staurolite and andalusite reach up to 2 cm in length, whereas most kyanite, garnet, biotite and chloritoid crystals are 5–10 mm in length. Pelitic layers tend to be relatively thin (5–25 m thick) and laterally discontinuous. The pelitic rocks presumably represent metamorphosed shales.

A coarse-grained rock with subhedral to euhedral crystals of plagioclase and K-feldspar, 5–10 mm across in a matrix of much finer-grained plagioclase, K-feldspar, quartz, muscovite and chlorite, crops out near the northern edge of the thickest belt of Vadito rocks (Fig. 1). Outcrops of this unit are 50–100 m thick. A second, slightly thinner belt of identical texture crops out within the discontinuous band of Vadito rocks exposed just to the north. These rocks have the appearance of metamorphosed, fragmental volcanic tuffs; the two layers may represent tectonic repetition of a single volcanic bed.

Laterally continuous layers of aluminous schist have been found in two belts across the northern Rincon Range, located by the large stars in Figure 1. Both layers occur in the Vadito Group immediately adjacent to exposures of stratigraphically overlying quartzite of the Ortega Formation (Hondo Group). The layers, 1 to 30 m thick, contain kyanite, muscovite, quartz, bright-green, manganiferous andalusite, rutile, hematite and other accessory minerals. Kyanite and Mn-andalusite make up 30–50 modal percent of the rocks which are interpreted to be metalaterites that mark an unconformity between the Vadito and Hondo Groups (cf. Grambling and Williams, 1985).

FIGURE 2. Outcrop view of crossbedded quartzofeldspathic gneiss from the Vadito Group north of Guadalupita. Field of view is 2 m across. Crossbeds are outlined by concentrations of FeTi oxide minerals in the metasedimentry gneiss.

The metalaterites are assumed to correlate with a mineralogically similar layer found just below the base of the Ortega Formation elsewhere in northern New Mexico. Such manganiferous schists have been reported in Cedro Canyon in the northwestern Taos Range (Grambling et al., 1989), at Comanche Point in the north-central Taos Range (Grambling, 1990), across much of the Rio Mora uplift (Grambling and Williams, 1985), near Truchas Peak in the Truchas Range (Grambling, unpublished data), in the western Picuris Range (Grambling and Williams, 1985) and in the Tusas Mountains (Grambling and Williams, 1985; Williams, 1987). If, as seems likely, these rocks formed as metalaterite along a single major unconformity, and if structural disturbances have not disrupted the original distribution of the Proterozoic rocks, then the unconformity separating the Vadito and Hondo Groups extended over an area exceeding 15,000 km^2. This inferred regional unconformity may provide a useful time-line for stratigraphic syntheses.

Hondo Group

Massive, crossbedded quartzite of the Ortega Formation (Hondo Group) lies stratigraphically above the Vadito Group. The quartzite contains traces of muscovite, FeTi oxide minerals and zircon, but generally has well over 95 modal percent quartz. Scattered beds rich in kyanite and andalusite have been found locally, as has kyanite in crosscutting aluminous veins. However, in general the Al_2SiO_5 minerals are not common. This stands in marked contrast to the abundance of Al_2SiO_5 minerals in quartzite of the Ortega Formation elsewhere in northern New Mexico. The reason for the scarcity of aluminum-silicate minerals in quartzite of the Rincon Range is unknown.

Quartzite attains a maximum thickness of 900 m in the southern and northern parts of the mapped area (Fig. 1). In the southern exposures both the top and bottom of the quartzite are truncated by ductile shear zones. In the northern exposures the base of the Ortega Formation is exposed, but the top lies buried beneath unconformably overlying sedimentary cover. The 900 m thickness approaches the true thickness shown by the Ortega Formation elsewhere in northern New Mexico (Bauer and Williams, 1989), suggesting that rocks stratigraphically above the Ortega Formation might lie north of the mapped area but buried beneath overlying Paleozoic sedimentary cover.

PROTEROZOIC DEFORMATION

Deformation of Precambrian rocks in the northern Rincon Range is characterized by the development of both ductile shear zones and folds. Ductile shear zones are the dominant structures, repeating the contact between the Vadito and Hondo Groups six times across the mapped area (Fig. 1). Folds are preserved at a variety of scales. Small-scale folds are pervasive in rocks of the Vadito Group, whereas map-scale folds are rare but present.

Ductile shear zones

Ductile shear zones defined by intensely foliated and lineated rocks mark some contacts between the Vadito and Hondo Groups. Rocks in the shear zones exhibit a strong foliation that strikes northeast and dips southeast, with extension lineations plunging 60–80°S in the plane of foliation. Mineral asymmetries record a top-to-the-north sense of movement on the shear zones, giving them the geometry of north-directed, south-dipping ductile thrust faults. These features are similar to those reported by Bauer (1987), Williams (1987) and Grambling et al. (1988) elsewhere in northern New Mexico.

Most of the shear zones mapped in Figure 1 lie immediately south of exposures of the Vadito Group. Outcrops between shear zones expose structurally coherent stratigraphic transitions from the Vadito Group (to the south) to the Hondo Group (to the north). In each structurally coherent unit, bedding planes dip to the south, but crossbeds face to the north. This requires that all exposed transitions from the Vadito to the Hondo Groups are overturned; in other words, the region contains an imbricated series of thrust sheets, but the stratigraphy within each individual thrust sheet is upside-down. Figure 3 illustrates this relationship in cross-sectional view.

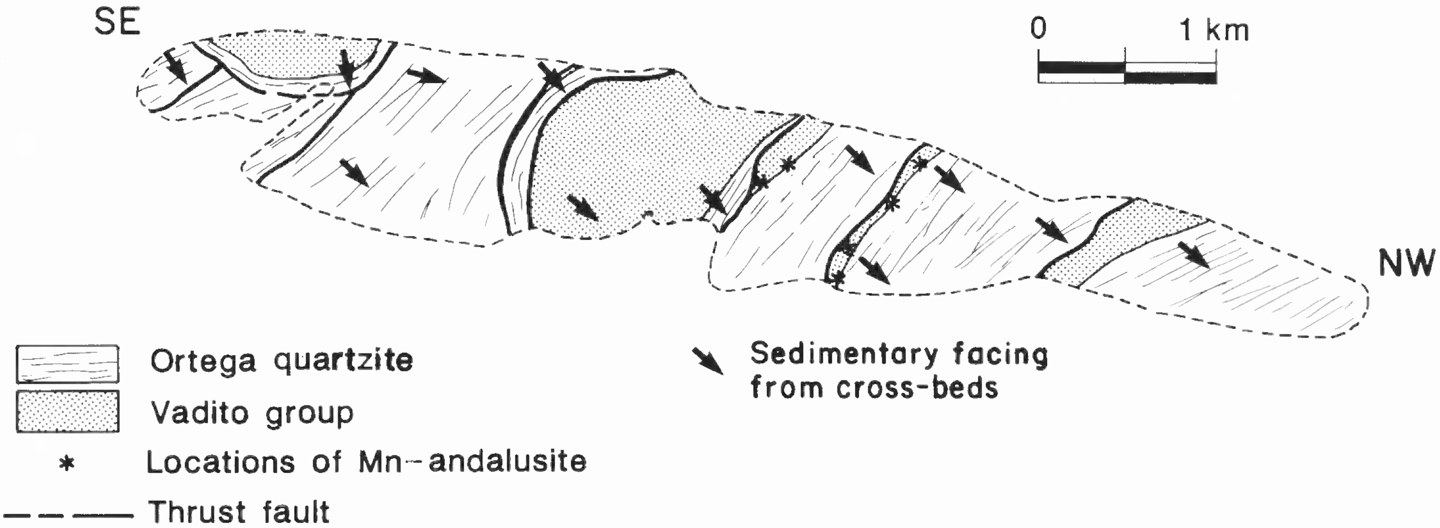

FIGURE 3. Cross section of Proterozoic rocks in the northern Rincon Range, New Mexico. The cross section approximates a down-plunge projection because rocks are exposed in steep mountain fronts with topographic relief exceeding 1000 m. Plane of projection is N50°W, 45°NE; northwest is to the right. Modified after Grambling et al. (1989).

The series of ductile thrusts repeating an inverted stratigraphy suggests that thrusting may have affected the overturned limb of a major, isoclinal, recumbent syncline. The axial trace of the inferred syncline, with overturned stratigraphy in its southern limb but upright stratigraphy in its hidden northern limb, might lie north of the region mapped for this study where Proterozoic rocks lie buried beneath Paleozoic sedimentary cover. Ductile thrusts developed on the overturned limbs of map-scale folds have been recognized elsewhere in northern New Mexico (Bauer, 1987; Williams, 1987; Grambling et al., 1988).

Folds

Although outcrops in the northern Rincon Range expose numerous small-scale folds, only one map-scale fold has been identified. It crops out in the southern part of the mapped area where quartzite of the Ortega Formation wraps around the Vadito Group in a synform (Figs. 1, 3) that plunges to the southwest. Crossbeds show that all units in the synform are upside-down, with the oldest rocks lying in the core of the fold. Hence, the synform has the geometry of a synformal anticline.

One might speculate that Proterozoic rocks south of the area treated in this study could preserve a major anticlinal fold relating to the overturning of units in the study area. If such an anticlinal fold is present, sedimentary structures such as crossbeds should be upright and south-dipping in its southern limb. Detailed mapping of the Rincon Range south of Guadalupita will be needed to find such a fold, if it exists.

METAMORPHISM

Mineral textures support the interpretation that the peak of regional metamorphism post-dated the northward-verging deformation. These textures consist of porphyroblasts of andalusite, garnet and staurolite that have grown across all observed tectonite fabrics.

Metamorphic rocks typically preserve considerable information about their peak pressure-temperature conditions, but in most cases one must obtain chemical analyses of minerals (e.g., garnet-biotite; Mn-andalusite-kyanite) to constrain those conditions. Fortunately, mineral assemblages in the northern Rincon Range place close constraints on the P-T conditions of metamorphism without knowledge of mineral chemistry. The minerals kyanite and andalusite show textures consistent with their having attained equilibrium, and sillimanite has not been found in the study area. These relations constrain peak metamorphic conditions to have been near the kyanite-andalusite boundary, at temperatures below the Al_2SiO_5 triple point but above the minimum thermal stability of aluminum silicate with quartz. This limits P-T conditions to a band extending from 400°C, 2.5 kb, to 500°C, 3.8 kb according to the experimental studies of Holdaway (1971) and Haas and Holdaway (1973).

Staurolite occurs with kyanite, andalusite, chloritoid and quartz in specimens from the study area, where all minerals appear to belong to the peak metamorphic assemblage. Richardson (1968) and Rao and Johannes (1979) studied the transition from choritoid + kyanite to staurolite + quartz, placing it at 500–520°C for conditions where $P(H_2O) = P(Total)$. The reaction is relatively insensitive to pressure although it is sensitive to variations in the composition of the metamorphic fluid phase. These constraints place peak metamorphic conditions near the upper limit of those consistent with the assemblage andalusite-kyanite, i.e., near 500°C, 3.8 kb.

Hornblende-plagioclase-chlorite forms a common assemblage in metabasalts of the northern Rincon Range. Hornblende and chlorite are stable with plagioclase in mafic rocks at temperatures between 475°C and 550°C (Apted and Liou, 1983; Moody et al., 1983), consistent with the P-T conditions estimated from pelitic assemblages of the northern Rincon Range.

Taken together, all constraints place metamorphic P-T conditions in the northern Rincon Range at 500 ± 20°C, 3.7 ± 0.3 kb. These conditions fall close to those of the Al_2SiO_5 triple point, suggesting that sillimanite might be present in the area, although it has not yet been found.

Metamorphic conditions close to 500°C, 3.7 kb are common in Proterozoic metamorphic rocks elsewhere in northern New Mexico (Grambling, 1986). Regional metamorphism at these P-T conditions has been interpreted to result from synmetamorphic crustal extension, with the 500°C rocks developed just above a major mid-crustal extensional decollement that is exposed in the northern parts of the state (Grambling et al., 1989). The surface exposures of the decollement nearest to the present study area lie in the western Cimarron Range, 30 km north of the northern Rincon Range (Grambling and Dallmeyer, 1990). If all metamorphism at P-T conditions near the Al_2SiO_5 triple point in New Mexico was related to the development of this decollement, one might predict it to lie in the subsurface, probably within several kilometers of the present erosional level, beneath the Rincon Range.

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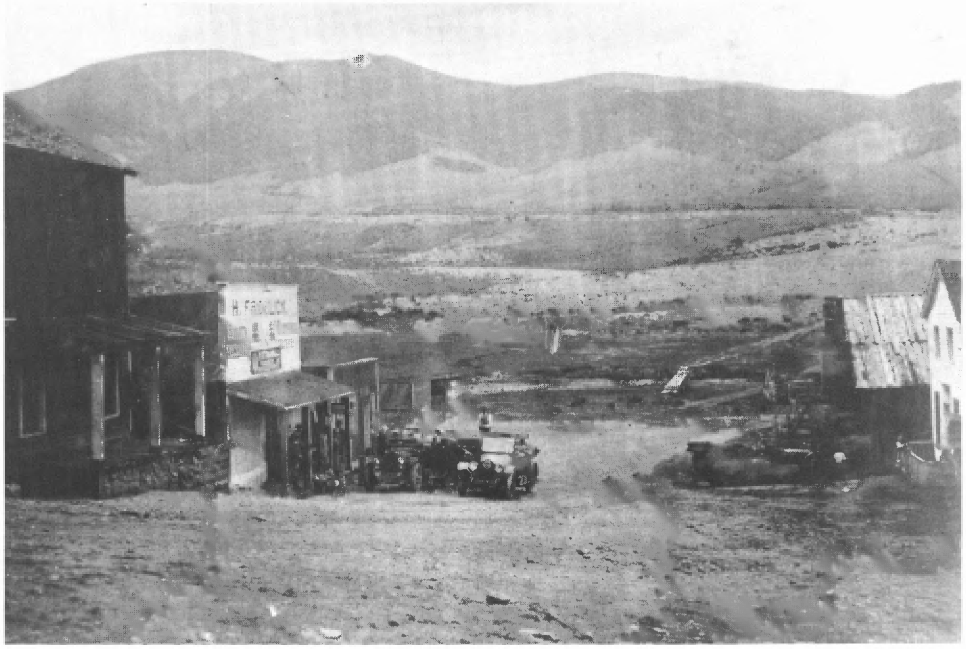

Touring cars in front of the Froelick Store, 1917, Elizabethtown. View east across Moreno Creek to abandoned placer fields and Baldy Mountain. Courtesy of New Mexico State Records Center and Archives, Collier Collection, album #32033.