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Stratigraphic nomenclature of Proterozoic rocks, northern New Mexico—revisions, redefinitions, and formalization

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Abstract

This paper proposes formal revisions of the lithostratigraphic nomenclature for some Early Proterozoic rocks in northern New Mexico. Mafic metavolcanic sequences older than ca 1,710 Ma, previously named the Moppin Metavolcanics, Pecos greenstone belt, and an unnamed Taos sequence, are renamed the Moppin Complex, Pecos Complex, and Gold Hill Complex respectively. The name Vadito Group is redefined to include the regionally exposed, felsic-dominated, metavolcanic–metasedimentary sequence that stratigraphically underlies the Ortega Formation. A Vadito Group principal reference section is chosen south of Kiowa Mountain in the Tusas Mountains. Several distinctive units are designated as formations: Big Rock Formation, Burned Mountain Formation, Marquenas Formation, Glenwoody Formation. The metasedimentary sequence previously called the Ortega Group is renamed the Hondo Group, and a principal reference section is proposed in the Hondo Canyon area of the northern Picuris Mountains. Formations in the unit include the Ortega Formation, Rinconada Formation, Pilar Formation, and Piedra Lumbre Formation. The name Embudo Granite is abandoned in the Picuris Mountains but provisionally retained in the Santa Fe Range. Nomenclature for all other plutonic rocks is provisionally retained pending further research. These proposals should provide a foundation for the development of a consistent, coherent, integrated nomenclature for the Precambrian rocks of New Mexico.

Introduction

The stratigraphic nomenclature of Proterozoic rocks in northern New Mexico has developed gradually over the past fifty years. Consequently, the literature is burdened with conflicting and obsolete stratigraphic names, most of which do not conform to the published rules of the North American Commission on Stratigraphic Nomenclature (1983) and are not officially recognized by the Geologic Names Committee of the U.S. Geological Survey. Recent detailed investigations of the stratigraphy, structure, geochronology, and geochemistry of Proterozoic rocks across northern New Mexico now make well-constrained regional correlations possible. The purpose of this paper is to propose a unified lithotectonic nomenclature for the supracrustal Precambrian rocks exposed in northern New Mexico.

The stratigraphic relationships presented here are based primarily on geological mapping and structural/metamorphic analyses in several Precambrian-cored uplifts: the Tusas Mountains (Brazos uplift), the Picuris Mountains, the Truchas Peaks area, the Rio Mora–Pecos area, and the southern Taos range of the southern Sangre de Cristo Mountains. Although the proposed nomenclature is rigorously applicable only in these ranges, reconnaissance and locally detailed mapping in a number of other areas suggest that some rock units may be correlable over wide areas of northern and central New Mexico, and perhaps in parts of Arizona and southern Colorado (Burns and Wobus, 1983; Wobus, 1985; Bauer and Williams, 1985; Grambling and Williams, 1985; Williams, 1987).

In the following sections, changes in nomenclature are proposed for many of the major and minor lithotectonic assemblages currently recognized in northern New Mexico, and a correlation chart containing both old and new nomenclature is provided. Although the proposed changes involve redefining and revising some names and abandoning others, the significance of most names and rankings has not been changed dramatically. Where the nomenclature is unchanged or where proposed changes are minor, appropriate references are given in lieu of details of unit descriptions. All proposed changes conform to the guidelines outlined by the North American Commission on Stratigraphic Nomenclature (1983).

Although most local stratigraphic relationships in the major mountain ranges have been resolved (Montgomery, 1953; Nielsen, 1972; Gresens and Stensrud, 1974; Holcombe and Callender, 1982; Wobus, 1985; Soegaard and Eriksson, 1986; Williams, 1987; Bauer, 1988), the nature of the contacts between many major stratigraphic packages is still controversial (Grambling et al., 1988; Grambling et al., 1989). It is not the purpose of this report to interpret the tectonic significance of contacts among the various major stratigraphic sequences. Rather, our intent is to offer a consistent yet flexible nomenclature that can serve as a common basis for further discussion and analysis.

Much of the exposed Proterozoic rock in northern New Mexico can be assigned to one of four major lithologic assemblages: 1) sequences dominated by metamorphosed mafic volcanic rocks, ca 1,765– 1,720 Ma in age; 2) sequences dominated by metamorphosed felsic volcanic rocks and immature clastic sedimentary rocks, ca 1,700 Ma and ca 1,600–1,650 Ma in age; 3) massive clean quartzite(s) and sequences of interlayered pelitic schist and quartzite, 1,700–1,650 Ma; and 4) intrusive rocks that range widely in age and composition (Robertson et al., in press). Each of these is discussed separately. Table 1 summarizes both existing and proposed new nomenclature for stratified units.

Mafic metavolcanic sequences

Extensive terrains dominated by amphibolite and mafic schist of igneous parentage and immature metasediments have been

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identified in several uplifts in northern New Mexico (Fig. 1). The three best-documented terrains are the Moppin Metavolcanics of the northern Tusas Mountains (Barker, 1958; Wobus, 1985), the Pecos greenstone belt of the Santa Fe Range (Robertson and Moench, 1979; Robertson and Condie, 1989), and a sequence of layered amphibolite ± biotite gneiss in the Taos Range (Condie and McCrink, 1982; Reed, 1984; Lipman and Reed, 1989) south of Questa. An assemblage of amphibolite and schist in the southern Picuris Mountains may represent a similar lithotectonic sequence (Bauer, 1988). Each of these mafic-dominated sequences is associated with a diverse suite of metaplutonic rocks. In all uplifts, the mafic-dominated rocks are interpreted to be the oldest exposed units. Preliminary U–Pb zircon isotopic age determinations suggest that although the individual sequences may be as old as 1,765 Ma, all are older than about 1,710 Ma (Williams, 1987). We suggest that they informally be designated mafic metavolcanic sequences.

Major- and trace-element analyses of the Moppin sequence (Barker and Friedman, 1974; Bingler, 1974; Boadi, 1986; Smith, 1986; Gabelman, 1988), the Pecos greenstone belt (Robertson and Moench, 1979; Klich, 1983; Robertson and Condie, 1989), and mafic rocks of the Taos Range (Condie and McCrink, 1982) suggest that these mafic suites are geochemically similar to modern tholeiitic and/or calc-alkaline rocks found in arc or back-arc volcanic assemblages.

TABLE 1—Stratigraphic nomenclature of supracrustal Proterozoic rocks in northern New Mexico.

Proposed nomenclature	Stratotype or reference section(s)	Previous nomenclature	Age (Ma)
HONDO GROUP	Picuris Mtns Hondo Canyon	Ortega Group (Long, 1976)	Younger than 1,700
Piedra Lumbre Formation	Picuris Mtns Hondo Canyon	Piedra Lumbre Formation (Long, 1976)	
Pilar Formation	Picuris Mtns Hondo Canyon	Pilar Formation (Long, 1976)	
Rinconada Formation	Picuris Mtns Hondo Canyon	Rinconada Formation (Nielsen, 1972)	
Ortega Formation	Picuris Mtns 1) Hondo Canyon 2) Pilar cliffs 3) Copper Hill Tusas Mtns 1) Ortega Mtns 2) Jawbone Syncline	Ortega Quartzite (Nielsen, 1972)	
VADITO GROUP	Tusas Mtns Mesa la Jarita	Vadito Group (Williams et al., 1986)	ca 1,700
Big Rock Formation	Tusas Mtns Mesa la Jarita	Big Rock Conglomerate (Barker, 1958)	
Burned Mtn Formation	Tusas Mtns Burned Mtn	Burned Mtn Metarhyolite (Barker, 1958)	
Marquenas Formation	Picuris Mtns Cerro de los Marquenas	Marquenas Quartzite (Long, 1976)	
Glenwoody Formation	Picuris Mtns Pilar cliffs	Felsic schist at Pilar (Bauer, 1988)	
	MAFIC METAVOLCANIC SEQUENCES		
PECOS COMPLEX	—	Pecos greenstone belt (Robertson and Moench, 1979)	ca 1,720
GOLD HILL COMPLEX	Taos Range Gold Hill	Unnamed (Reed, 1984)	ca 1,765
MOPPIN COMPLEX	Tusas Mtns 1) Brazos Box 2) Iron Mtn 3) Cleveland Gulch	Moppin Metavolcanics (Wobus, 1985)	older than 1,755

Moppin Complex (formerly Moppin Metavolcanics)—Tusas Mountains

The mafic metavolcanic sequence of the northern Tusas Mountains was named the Moppin metavolcanic series by Barker (1958) and renamed the Moppin Metavolcanics by Wobus (1985). The geographic name Moppin is appropriate for this succession of rocks and need not be changed. However, series designation (chronostratigraphic category) is inappropriate and Metavolcanics does not accurately reflect the diverse volcanic, volcaniclastic, and epiclastic lithologies present. Although this unit does contain local sequences of rock with distinctive characteristics that are individually mappable, these sequences are not regionally correlable. In addition, the unit is metamorphosed and multiply deformed and contains intrusive rocks. We therefore suggest the lithodemic rank of complex for the Moppin.

The Moppin Complex is exposed in the northern Tusas Mountains in a northwest-trending belt extending from American Creek (southwestern Mule Canyon 7½-min quadrangle, T28N, R8E) to Hopewell Lake and Placer Creek (northeastern East Gavilan Canyon 7½-min quadrangle, T29N, R6E), and along the eastern side of Jawbone Mountain. Its exposed primary thickness, though difficult to determine due to structural complexities, is probably at least several thousand feet (Barker, 1958).

The Moppin Complex is dominated by chlorite schist and/or amphibolite with lesser

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components of feldspathic schist and gneiss, muscovite (± biotite) schist, metaconglomerate, and banded iron formation. Locally exposed primary volcanic and sedimentary structures include pillows, graded beds, and relict phenocrysts. The Moppin Complex is associated with (intruded by?) several granodiorite bodies collectively called the Maquinita Granodiorite (Barker, 1958; Barker and Friedman, 1974; Wobus and Manley, 1982a) and with a 50+ km^2 (20+ mi^2) pluton of trondhjemite/granite informally called the trondhjemite of Rio Brazos (Barker et al., 1974). The trondhjemite has an Rb–Sr whole-rock isotopic age of 1,654±34 Ma recalculated from Barker et al. (1974) using the decay constant of Steiger and Jager (1977). Although contacts between mafic supracrustal rocks and most metaplutonic rocks are intensely deformed, trondhjemite appears to intrude the Moppin Complex in the Rio Brazos gorge area (Gabelman, 1988). Although rocks of the Moppin Complex have not been dated directly, Barker (1958) and Wobus and Hedge (1982) concluded that the Moppin Complex was intruded by the Maquinita Granodiorite (dated at 1,755 Ma by U–Pb zircon method by L. T. Silver, pers. comm. 1987). If the contact is not intrusive, then the Moppin Complex could be considerably younger.

Due to the lithologically complex nature of the Moppin Complex, we propose three different exposures as reference sections. Excellent exposures on Iron Mountain (informal name), southwest of Jawbone Mountain (Burned Mountain 7½-min quadrangle, sec. 30, T29N, R7E), are distinctive due to superbly preserved primary sedimentary and volcanic structures and to the occurrence of banded iron formation (Smith, 1986). The second reference section is in the Brazos Box area of the Rio Brazos (southwestern Lagunitas Creek 7½-min quadrangle, T29N, R5–6E). Relict volcanic textures and structures occur in the northern (lower?) portion of this thick (apparently up to 10,000 ft) exposure of the Moppin Complex (Gabelman, 1988). Although outcrop is more or less continuous in this area, Moppin Complex rocks are highly tectonized and primary thicknesses and stratigraphic relationships are complicated by folding. The third reference section is in Cleveland Gulch, south of Tusas Mountain (southeastern Burned Mountain 7½-min quadrangle, T28N, R7–8E). In this area, exposures of Moppin Complex consist of chlorite–hornblende phyllite, schist, and gneiss, plus subordinate hornblendite, metapelite, mafic breccia, hematite–quartz iron formation, and magnetite–quartz ironstone (Kent, 1980).

Pecos Complex (formerly Pecos greenstone belt)—Santa Fe Range

Robertson and Moench (1979) named this package of rocks after the nearby town of Pecos. The area of outcrop contains a significant amount (approximately 50%) of intrusive rock, is metamorphosed, multiply deformed, and poorly exposed, and may no longer conform entirely to the Law of Superposition. It is, therefore, best categorized as a lithodemic unit rather than a lithostratigraphic unit. Because this terrain consists of two or more genetic classes of rocks (volcanic, plutonic, sedimentary), it is proposed that the rank be designated as complex, thus Pecos Complex. At some future time, as mapping permits, this complex could be subdivided into supersuites and suites.

The Pecos Complex occupies approximately 650 km^2 (250 mi^2) in the headwaters of the Pecos River, northeast of Santa Fe. Robertson and Condie (1989) and Robertson and Moench (1979) distinguish four assemblages of Precambrian rock types within the complex: 1) metavolcanic rocks with minor interbedded volcaniclastic rocks and iron formation; 2) metasedimentary rocks including feldspathic sandstone, shale, volcaniclastic graywacke, carbonate, and distal iron formation; 3) intrusive felsic and mafic rocks of a subvolcanic complex; and 4) younger granitic rocks. An age of 1,720 Ma has been interpreted for the Pecos Complex based on U–Pb zircon dating of metavolcanic rocks and subvolcanic intrusive rocks (Bowring and Condie, 1982; Robertson and Condie, 1989) and on model lead ages of galenas from genetically related volcanogenic massive sulfide deposits (Stacy et al., 1976).

Gold Hill Complex—Taos Range

A mafic/felsic layered gneiss succession in the Taos Range south of Questa (Condie and McCrink, 1982; Reed, 1984; Lipman and Reed, 1989) has not previously been named formally. As in the Pecos Complex, these rocks contain a significant intrusive component, are metamorphosed and multiply deformed, and may be categorized best as a complex. We propose the name Gold Hill Complex after exposures at Gold Hill, 7 km (4 mi) north of Twining, New Mexico (southwestern Red River 7½-min quadrangle).

Reed (1984) described a layered gneiss sequence in the Gold Hill area as consisting of complexly interlayered feldspathic gneiss,

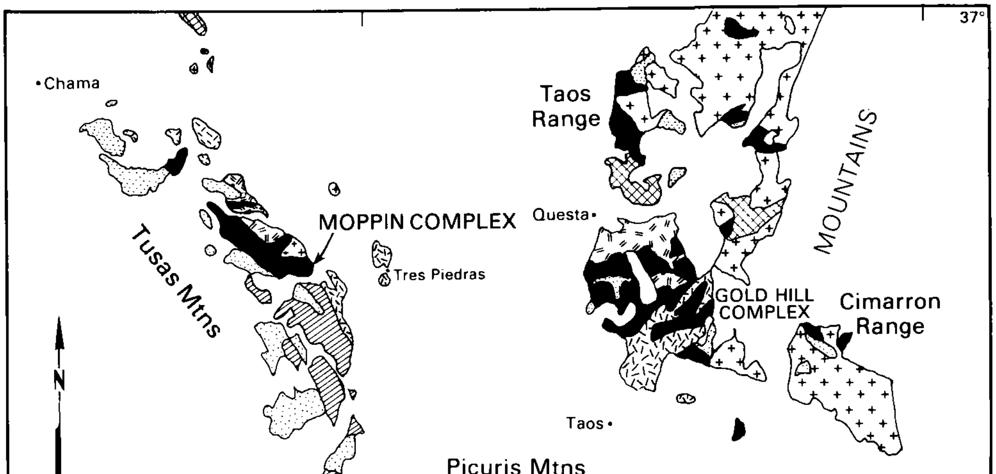

FIGURE 1—Generalized map showing the distribution of Precambrian rocks in north-central New Mexico. Modified from unpublished maps by J. M. Robertson and J. A. Grambling.

biotite–hornblende gneiss, hornblende gneiss, and amphibolite. He interpreted this sequence as metamorphosed volcaniclastic rocks interlayered with flows, tuffs, and sedimentary rocks. Geologic relationships within the layered gneiss sequence, and between it and adjacent felsic volcaniclastic rocks to the north, are unknown. Preliminary U–Pb zircon data from a felsic metatuff near Gold Hill have yielded an isotopic age of 1,765 Ma (S. A. Bowring, pers. comm. 1986).

Vadito Group

The names Vadito group and Vadito formation have been used in various ways in New Mexico during the past 30 years. Montgomery (1953) originally proposed the name Vadito formation for a sequence of mafic and felsic metavolcanic rocks in the southern Picuris Mountains. Long (1976) suggested raising its status to Vadito group. This sequence has been correlated with various metavolcanic and metasedimentary rocks in other uplifts (Robertson and Moench, 1979). Both felsic and mafic metavolcanic sequences have been included previously within the general group name (Soegaard and Eriksson, 1986).

Williams et al. (1986) informally proposed that the name Vadito Group be applied to a sequence of immature quartzofeldspathic metasediments and dominantly felsic metavolcanic rocks that stratigraphically underlie (Holcombe and Callender, 1982) the Ortega Formation in a number of places in northern New Mexico. These rocks are lithologically, geochemically, and tectonically distinct from the older (1,765–1,720 Ma) mafic metavolcanic sequences and can be correlated among isolated mountain ranges over much of northern New Mexico. We propose that the name Vadito Group be formally adopted under the definition of Williams et al. (1986). Although applying the name Vadito to this more broadly exposed package of rocks is in some ways unsatisfactory, as discussed below, the name is ingrained in the literature to the extent that, in our judgement, any redefinition would only further confuse the nomenclature.

Although the Vadito Formation (and subsequently, Group) was originally described in the southwestern Picuris Mountains (Montgomery, 1953) and that place therefore remains the original type locality, we believe that the southern Picuris Mountains is not the best place to characterize this newly defined, complex section of regionally exposed rock. Older mafic metavolcanic rocks in other areas have been included within the Vadito Group partly because the type locality near the Harding mine in the southwestern Picuris Mountains contains abundant amphibolites. Although the Vadito Group of the southern Picuris Mountains (as described by Long, 1976) differs in significant ways from the proposed Vadito Group of the Tusas Mountains and elsewhere, most of the differences can be attributed to a combination of original stratigraphic variation and superimposed structural complexities.

The southernmost part of the Vadito Group in the Picuris Mountains is dominated by large amphibolite bodies that host horizons of quartz–muscovite–biotite schist, cross-bedded impure quartzite, and metaconglomerate. Although relative proportions differ, all of these rock types can also be found in the Vadito Group reference section of the Tusas Mountains. At least some of the amphibolites are intruded by granitic plutons. Such intrusive relationships, however, are not found elsewhere in the Vadito Group. It is possible that bedding-parallel shear zones (Bauer, 1988) and/or unconformities (Bell, 1985) may exist within the original type section, such that some of these amphibolites may be related to the older mafic-dominated metavolcanic sequences, rather than to the Vadito Group proper.

The northern part of the Vadito Group in the southwestern Picuris Mountains consists of quartz–muscovite–biotite schists, metaconglomerates and impure quartzites of the Marquenas Formation, and subordinate feldspathic schists, calc-silicates, aluminous schists, and mafic schists and amphibolites. To the east, the Vadito Group also contains locally abundant feldspathic quartz-eye schists interpreted as metarhyolites (Bauer, 1988). All of these rock types are characteristic of the Vadito Group in the Tusas Mountains and elsewhere. However, what the original type locality in the southern Picuris Mountains appears to lack is the voluminous feldspathic schist (metarhyolite) commonly found elsewhere at the top of the Vadito Group just below the contact with the Ortega Formation. In the southern Picuris Mountains, a north-verging ductile fault separates Vadito Group from the younger Hondo Group rocks (Holcombe and Callender, 1982; McCarty, 1983; Holcombe et al., 1985; Bauer, 1988). This fault has removed an unknown amount of the upper part of the Vadito Group and juxtaposed an inverted Vadito Group against an upright Hondo Group. Possibly, the thick section of feldspathic schist below the Ortega Formation in the cliffs near Pilar is equivalent to part of the missing uppermost Vadito Group in the southern Picuris Mountains type locality (Bauer, 1988).

Until more is known about the southern Picuris Mountains section, we recommend continued application of the Vadito Group name for all of the supracrustal rocks exposed in the southernmost Picuris Mountains.

Because stratigraphic relationships within the redefined Vadito Group and between the redefined Vadito Group and younger rocks are clearly exposed and most easily accessible in the Tusas Mountains (Williams, 1987), we propose that a Vadito Group principal reference section be designated in the central Tusas Mountains, south of Kiowa Mountain between Mesa de la Jarita and Tusas Box (Las Tablas 7½-min quadrangle, all sections, T27N, R8E).

The Vadito Group, as defined herein, is a regionally extensive sequence of supracrustal rocks dominated by feldspathic schist, feldspathic gneiss, and metamorphosed clastic sediments. Rocks interpreted to belong to the Vadito Group have been identified in most of the major Precambrian-cored uplifts in northern New Mexico. In addition to the reference section in the central Tusas Mountains, Vadito Group rocks are exposed throughout the eastern half of La Madera quadrangle (Bingler, 1974), east of Ojo Caliente in the Ojo Caliente quadrangle (Treiman, 1977; Williams, 1987), and in the northern part of Cañon Plaza quadrangle (Barker and Friedman, 1974; Williams, 1987). In the Picuris Mountains, Vadito Group units crop out along the southern flank of the range (Montgomery, 1953; Long, 1974; McCarty, 1983; Bauer, 1988) and in the cliffs near Pilar in the northwestern part of the range (Gresens and Stensrud, 1974; Bauer, 1988). Vadito Group rocks have been found in the Truchas Range and Rio Mora area (Grambling, 1979; Grambling and Codding, 1982), in the Rincon Mountains and northern Taos Range at Cedro Canyon (Grambling et al., 1989), and in the northern Taos Range near Costilla Reservoir (J. A. Grambling, pers. comm. 1989) and along Costilla Creek (J. C. Reed, Jr., pers. comm. 1989). Although Vadito Group rocks have not yet been recognized in the Santa Fe Range, Cimarron Mountains, or southern Taos Range (J. A. Grambling, pers. comm. 1989), similar rock types have been reported in the Cimarron Mountains (Wobus, 1989).

The most distinctive component of the Vadito Group is quartz–muscovite–feldspar schist containing quartz megacrysts, interpreted to be phenocrystic felsic metatuff. These schists are interlayered with massive metarhyolite, vitreous quartzite, muscovitic quartzite, meta-arkose, biotite–muscovite schist, pelitic schist, amphibolite, and chlorite schist. Mafic lithologies make up only a small part (generally less than 10%) of the Vadito Group. Textural and compositional heterogeneity, characteristic of the Vadito Group at all scales, results from a combination of primary lithologic variation, local premetamorphic hydrothermal alteration, and the effects of metamorphism and deformation. Metavolcanic rocks from several localities within the Vadito Group have yielded U–Pb zircon isotopic ages of approximately 1,700 Ma (L. T. Silver, pers. comm. 1984).

Although it is not currently feasible to subdivide all of the Vadito Group, several units are sufficiently distinctive and/or laterally continuous to be formally designated as formations. These include the Big Rock and Burned Mountain Formations in the Tusas Mountains, and the Marquenas and Glenwoody Formations in the Picuris Mountains.

Vadito Group principal reference section near Kiowa Mountain

The Vadito Group in the central Tusas Mountains is dominated by felsic metavolcanic rocks and feldspathic metasediments. The most characteristic rocks are quartz–muscovite–feldspar schists, which contain large (to several mm in diameter) quartz and feldspar crystals interpreted as relict phenocrysts. These rocks range from highly schistose to massive both along and across strike, and are interlayered with amphibolite, crossbedded muscovitic quartzite, feldspathic quartzite, biotite–muscovite schist, conglomerate, and pelitic schist (Gresens and Stensrud, 1974; Wobus and Manley, 1982b; Williams, 1987).

The Vadito Group–Hondo Group contact at Kiowa Mountain (originally spelled Kiawa, but changed to Kiowa by the Forest Service in 1960's, according to F. Barker, pers. comm. 1989) is distinctive in that it may have been only minimally affected by the regional deformation. Apparently much of the regional shear and shortening was partitioned structurally above these rocks along a ductile thrust fault to the southwest (Williams, 1987). Because of their relatively low strain, rocks at Kiowa Mountain may preserve the primary character of the Vadito Group–Hondo Group contact. Here, feldspathic Vadito Group schists grade from impure feldspathic sediments and metarhyolite through impure metasediments (feldspathic schist and muscovitic quartzite) to the clean Ortega Formation quartzite of the Hondo Group (Williams, 1987). The upper contact of the Vadito Group is chosen as the lowermost exposure of the vitreous Ortega Formation. The lower stratigraphic boundary of the Vadito Group has not been formally recognized in the Tusas Mountains or elsewhere in northern New Mexico. However, the Burned Mountain Formation and associated metaconglomerates in the northern Tusas Mountains may be low in the original stratigraphy (Gibson, 1981; Gabelman, 1988). Ductile or brittle faults mark the presently exposed lower Vadito Group contact throughout the Tusas Mountains.

Just (1937) and Barker (1958) have distinguished a lithologic but not stratigraphic unit called Petaca schist, which occurs mainly in the southeastern part of the Vadito Group reference section at Kiowa Mountain. They interpreted these rocks to represent hydrothermally altered equivalents of several other units, including rocks now assigned to the Vadito Group and overlying Hondo Group. Wobus (1985) noted that many of the Petaca schist rocks are actually typical Vadito Group lithologies, and Williams (1987) concluded that the easternmost exposures of Petaca schist are actually Tres Piedras Granite. We support the suggestion of Wobus (1985) that the name Petaca schist be abandoned.

Big Rock Formation (formerly Big Rock Conglomerate)—Tusas Mountains

Barker (1958) originally mapped and named the Big Rock conglomerate as a member of the Kiowa Mountain formation of the central Tusas Mountains. The unit can be divided into a lower member dominated by conglomerate with minor interlayered micaceous quartzite and an upper member dominated by micaceous and feldspathic quartzite. Because of the lithological heterogeneity of these rocks, we propose the name Big Rock Formation for the composite package, and suggest a stratotype in the Las Tablas 7½-min quadrangle (secs. 22 and 29, T27N, R8E). The Big Rock Formation is the principal marker unit within the Vadito Group reference section south of Kiowa Mountain (Barker, 1958; Wobus, 1985; Williams, 1987) and has been traced along strike for more than 10 km (6 mi). Metaconglomerate layers are characterized by elongate cobbles, 1 to 20 cm in diameter, of vein quartz, quartzite, schist, and metarhyolite in a matrix of quartz–muscovite schist or quartzite. Locally, a thin impure quartzite is present below the main metaconglomerate horizon. Average thickness of the formation is approximately 60 m (200 ft).

Metaconglomerate layers of the Big Rock Formation are lithologically similar to those of the Marquenas Formation of the Picuris Mountains. The average clast size is greater, and the metaconglomerates are thicker in the Marquenas Formation. The most noteworthy difference between the two formations is the large volume of impure quartzite interlayered with metaconglomerate in the Marquenas Formation.

Burned Mountain Formation (formerly Burned Mountain Metarhyolite)—Tusas Mountains

The Burned Mountain metarhyolite (Barker, 1958), originally named the Vallecitos Rhyolite by Just (1937), is a massive, quartz–feldspar rock characterized by distinctive quartz and feldspar eyes in a fine-grained, laminated matrix. The quartz eyes range from gray to deep red and display remarkably well preserved primary features including hexagonal crystal shapes and resorption embayments. Wobus (1985) proposed that the entire Vadito Group of the central Tusas Mountains be included under the Burned Mountain Metarhyolite name. This suggestion is unsatisfactory because of the great variety of rock types within the Vadito Group, of which quartz-eye-bearing metamorphosed rhyolites are only a relatively minor part.

The metarhyolite can be followed along a northwest-trending belt for approximately 32 km (20 mi) in the northern Tusas Mountains, where it ranges in thickness from 4.5 to 30 m (15 to 100 ft) and represents a significant portion of the entire thickness of the Vadito Group there. We propose that this distinctive unit be formally designated as a formation of the Vadito Group and named Burned Mountain Formation for exposures on the northwest side of Burned Mountain (Barker, 1958). Detailed descriptions of the unit can be found in Just (1937), Barker (1958), Smith (1986), and Williams (1987).

The age of the Burned Mountain Formation, based on U/Pb ratios in zircon, is approximately 1,700 Ma (L. T. Silver, pers. comm. 1984). The Burned Mountain Formation is interpreted to be broadly equivalent to Vadito Group metarhyolites and feldspathic, quartz-eye schists exposed in the central and southern Tusas Mountains, the northern and southeastern Picuris Mountains, the Rincon Mountains, and the Rio Mora area. All of these sections contain appreciable thicknesses of well-layered, quartz–muscovite–feldspar schists with megacrysts of quartz.

Marquenas Formation (formerly Marquenas Quartzite)—Picuris Mountains

The Marquenas Formation of the southern Picuris Mountains was originally called the conglomerate member of the Vadito formation by Montgomery (1953). It was renamed the Marquenas quartzite of the Vadito Group by Long (1976), and subdivided into four informal members by Scott (1980). Because the Marquenas quartzite actually consists of approximately equal amounts of metaconglomerate and quartzite, the name Marquenas Formation is more appropriate than either Marquenas Conglomerate or Marquenas Quartzite. The proposed type section is in the southern Picuris Range at Cerro de las Marquenas in secs. 19 and 30, T23N, R11E. In this area the Marquenas Formation is approximately 500 m (1650 ft) thick and can be traced laterally for 14 km (9 mi). Crossbeds throughout the unit indicate that it lacks major internal folding and that stratigraphic tops are to the north.

Soegaard and Eriksson (1986) suggested that the Marquenas Formation is the youngest unit exposed in the Proterozoic of northern New Mexico, and that the quartzite clasts were derived from the Ortega Formation of the Hondo Group. We disagree with these conclusions. Although the Ortega Quartzite contains abundant aluminum silicate minerals, we have found no Marquenas Formation quartzite clasts that contain such minerals. Furthermore, even though the Ortega Formation is thoroughly crossbedded, less than 1 percent of quartzite clasts in the Marquenas Formation contain crossbed remnants (J. A. Grambling, pers. comm. 1987). If the Marquenas Formation is the youngest unit in the Picuris Mountains, then both contacts with the Hondo Group and Vadito Group must be faults or shear zones. Although the northern contact between the Marquenas Formation and the Hondo Group is a ductile shear zone (Bauer, 1988), there exists no field evidence to suggest that the southern Marquenas Formation contact with schist of the Vadito Group is a fault. Furthermore, discontinuous lenses of metaconglomerate and impure quartzite within the Vadito Group, south and east of the Marquenas Formation type section, consistently contain crossbeds indicating that stratigraphic tops are to the north. Thus, the Marquenas Formation is located stratigraphically within the upper part of the Vadito Group. Each of the clast lithologies found in the Marquenas Formation metaconglomerate could have been derived reasonably from units within the adjacent Vadito Group. Given its lithology and stratigraphic position, the Marquenas Formation is roughly equivalent to the Big Rock Formation of the Tusas Mountains.

Glenwoody Formation—northern Picuris Mountains

Approximately 300 m (1000 ft) of feldspathic schist containing quartz and feldspar megacrysts are exposed below the Ortega Formation in the cliffs near Pilar in the northern Picuris Mountains. The base of this unit is nowhere exposed. Although originally included as part of the Ortega Formation by Montgomery (1953), it is dominantly metavolcanic (Gresens and Stensrud, 1974; Grambling and Williams, 1985; Bauer, 1988) and is here treated separately from the metasedimentary quartzite. Previously, this schist was informally called the felsic schist at Pilar (Bauer, 1988). We propose that this unit be formally named the Glenwoody Formation and that it rank as a formation of the Vadito Group. The name Glenwoody comes from a turn-of-the-century mining camp that stood at the base of the cliffs.

Although the Glenwoody Formation is similar to the 1,700 Ma Vadito Group metarhyolites that underlie the Ortega Formation of the Hondo Group in the Tusas Mountains and to other feldspathic schists in the Rio Mora area, Truchas Peaks area, and Rincon Mountains, it is generally more schistose and homogeneous than these probable equivalents. This may be due to the relatively high, simple shearing strain that the Glenwoody Formation has experienced. The Glenwoody Formation also contains a regionally exposed Mn-rich horizon near its top, suggesting that it may occur high in the original Vadito stratigraphy.

Hondo Group (formerly Ortega Group)

The name Ortega was first used to describe a thick quartzite, quartzose schist, and minor metaconglomerate, feldspathic schist, and metarhyolite succession exposed in the Tusas and Picuris Mountains of the Brazos uplift (Just, 1937). Long (1976) proposed the name Ortega Group for a sequence of metasediments in the Picuris Range that included a thick orthoquartzite (Ortega Formation) and the overlying schists and quartzites of the Rinconada Formation. The presence of a group and a formation with the name Ortega is both confusing and unacceptable according to the North American Commission on Stratigraphic Nomenclature (1983). Furthermore, none of the schists or quartzites that overlie the Ortega Formation in the Picuris Mountains and elsewhere are present in the Tusas Mountains. Therefore, for these reasons, and because the name Ortega Quartzite is solidly entrenched in the literature, we propose a change of the group name to correspond with the geographical location of the new group reference section.

The name Hondo for exposures in the Hondo Canyon area of the northern Picuris Range is an appropriate geographic name for this important sequence of rocks. We propose that the name Hondo Group replace the name Ortega Group. The name Hondo was applied previously to the Hondo sandstone member of the San Andres Formation (Permian) in southeastern New Mexico (Lang, 1937). Kelley (1971) recommended that the term Hondo be dropped from usage because the Hondo sandstone member of Lang (1937) is clearly a tongue of the Glorieta sandstone, and the original terminology has been completely replaced by the name Glorieta sandstone. Just (1937) originally named a Precambrian, black, carbonaceous slate in the Picuris Mountains the Hondo slate. This unit was later renamed the Pilar Phyllite (Montgomery, 1953). The term Hondo slate has since been recommended for abandonment (Jicha and Lochman-Balk, 1958, p. 62) and is not currently used.

The stratigraphy of the Hondo Group is well established, but it lacks a designated type section. Therefore, we recommend designation of a principal reference section rather than a type locality. The most complete, well-exposed, easily accessible section of the Hondo Group occurs in the Hondo Canyon area of the north-central Picuris Mountains. The proposed reference section is located in the Taos SW 7½-min quadrangle in secs. 29–32, T24N, R12E. This nearly complete, upright section occurs on the north limb of a large overturned syncline, the Hondo syncline. A comparable, though less-accessible, section occurs to the south on the overturned limb of the syncline (Bauer, 1988). The lower boundary stratotype is set at the lowermost massive pure quartzite, as described above for the upper boundary of the Vadito Group in the Tusas Mountains.

A regionally extensive manganiferous marker layer, which occurs near the Vadito Group–Hondo Group boundary, aids in correlating Vadito–Hondo units across the discontinuously exposed Proterozoic terrain of northern New Mexico (Grambling and Williams, 1985; Williams, 1987). The layer, characterized by Mn–andalusite (viridine), piemontite (Mn–epidote), and other anomalous phases, is 1 to 100 m thick and can be traced almost continuously across individual uplifts. The exact stratigraphic position of the manganiferous zone varies from range to range. Although the actual geographic extent of the anomalous layer is unknown, it is exposed in every range in northern New Mexico in which the Vadito Group–Hondo Group contact is exposed and may correlate with similar Mn-rich rocks in Colorado and Arizona (Williams, 1987). The origin of the Mn-rich horizon is unknown. Williams (1987) concluded that most observations are consistent with a model involving syngenetic deposition from hydrothermal solutions or from a widespread manganese enrichment of basin waters at the end of Vadito Group volcanism. Alternately, manganese and associated elements may have been concentrated during weathering of Vadito Group schists. If either of these hypotheses is correct, the Mn-rich layer may represent a time marker in the Proterozoic section.

The Hondo Group is younger than ca 1,700 Ma, the age of the underlying Burned Mountain Formation and equivalent metarhyolites of the Vadito Group. The younger age is not well constrained because no unequivocal Precambrian igneous crosscutting relationships have been described. However, near Pecos Baldy in the Truchas Range, a felsic stock appears to intrude metapelites of the Hondo Group (Grambling, 1986). If this stock does intrude the metapelites, then its U–Pb zircon isotopic age of approximately 1,691 Ma provides a minimum age for deposition of the Hondo Group (J. A. Grambling and S. A. Bowring, pers. comm. 1986) in that place. In the northern Sangre de Cristo Mountains, pegmatite dikes spatially related to a 1,644 Ma quartz monzonite intrude an Ortega-like quartzite (Bowring et al., 1984; Reed, 1984). If the pegmatites and quartz monzonite are genetically related and if this quartzite is equivalent to the Ortega Formation, then the Ortega Formation must be older than 1,644 Ma. If these intrusive relationships are not genuine, then the Hondo Group is only constrained to be older than regional deformation and metamorphism, which by current evidence occurred between 1,650 and 1,450 Ma (Robertson et al., in press).

Ortega Formation (formerly Ortega Quartzite)

We propose to officially change the Ortega Quartzite of the Hondo Group to formation status. The lower boundary is at the lowermost massive quartzite, above the immature transitional metasediments of the Vadito Group. By this, the Ortega Formation then defines the lower boundary of the Hondo Group. The upper boundary of the Ortega Formation is defined by the uppermost massive pure quartzite occurrence below pelitic schist of the Rinconada Formation. We suggest the following supplemental reference sections for the Ortega Formation: 1) Ortega Mountains, Brazos uplift, where the Ortega Quartzite unit was originally described; 2) cliffs near Pilar, northern Picuris Mountains, where the base of the quartzite is superbly exposed; 3) Jawbone Syncline, northern Tusas Mountains, where original sedimentary structures are well preserved (Soegaard and Eriksson, 1985); and 4) Rattlesnake Canyon, south end of Copper Hill, south-central Picuris Mountains, where the uppermost quartzite, including the kyanite and andalusite schist/quartzite described by Williams (1982), is well exposed.

Rinconada, Pilar, and Piedra Lumbre Formations of the Hondo Group—Picuris Mountains, Truchas Peaks area, Rio Mora area, Taos Range

The remaining three formations of the Hondo Group have been thoroughly described elsewhere (Montgomery, 1953; Miller et al., 1963; Nielsen, 1972; Long, 1976; Grambling, 1979; Grambling and Codding, 1982; Bauer, 1988). We simply propose formal designation of the Rinconada Formation, the Pilar Formation, and the Piedra Lumbre Formation and their inclusion in the Hondo Group. Stratotypes are as described above for the Hondo Group with a supplemental reference section for the Rinconada Formation in the Trampas 7½-min quadrangle near the boundary between secs. 19 and 20, T23N, R11E, in Rattlesnake Canyon south of Copper Hill in the southern Picuris Mountains.

Felsic-dominated, ca 1,660–1,650 Ma rocks

The best-documented, ca 1,650 Ma, felsic-dominated sequence in northern New Mexico occurs in the Dalton Canyon–Glorieta Baldy–Thompson Peak area of the southern Sangre de Cristo Mountains. The rocks in that area were described first by Moench and Erickson (1980) in a reconnaissance study and in more detail by Fulp (1982), Renshaw (1984), and J. Wakefield (unpub. map). In general, the sequence consists of metamorphosed quartzo-feldspathic sedimentary and volcanic rocks intruded by pre- to syn-volcanic quartz porphyry bodies with U–Pb zircon isotopic ages determined by S.A. Bowring of 1,650 ± 10 Ma (Fulp, 1982) and 1,660 ± 10 Ma (Renshaw, 1984). These rocks, and similar units to the north, were informally named the Dalton Canyon succession by Robertson and Condie (1989). We suggest no changes to this nomenclature.

Plutonic rocks

Precambrian plutonic rocks in northern New Mexico range widely in composition and age (Condie, 1978). Most plutonic terrains contain more than one generation of intrusions, and in most areas of northern New Mexico detailed mapping, petrography, and geochemistry are insufficient for adequately delineating individual plutons or cogenetic phases of intrusion. Many plutonic bodies carry local names. At this time we suggest only a revision of plutonic nomenclature in the southern Picuris Mountains, where mapping and geochronology are excellent. All other nomenclature should be maintained until additional information is available.

Embudo Granite

We propose that the name Embudo Granite be abandoned for any and all plutonic rocks in the Picuris Mountains. It is now known that the granitic terrain of the southern Picuris Mountains, originally called the Embudo Granite or Embudo Granites (Montgomery, 1953), actually consists of four distinct plutons that range widely in chemistry, mineralogy, and U–Pb zircon isotopic age (Long, 1974, 1976; Bell, 1985; Bell and Nielsen, 1985). These are the Puntiagudo granite porphyry (1,684 ± 1 Ma), the Rana quartz monzonite (1,674 ± 5 Ma), the Cerro Alto metadacite, and the Peñasco quartz monzonite (ca 1,450 Ma). A fine-grained plutonic body exposed in the easternmost Picuris Mountains, on the east side of the Picuris–Pecos fault, is probably distinct and should be called the granite of Alamo Canyon, following the informal usage of Bauer (1988). The name Embudo is therefore obsolete in the Picuris Mountains.

The name Embudo has also been applied to plutonic rocks south of the Picuris Mountains in the complex granitic terrain of the Santa Fe Range by Miller et al. (1963). In much of this area, although mapping has not delineated individual plutons, reconnaissance work of Moench et al. (1988) suggests that the range may contain several different intrusive bodies. We suggest that, for now, the term Embudo granite complex be used to describe this complex granitic terrain.

Summary

Several revisions and redefinitions of stratigraphic nomenclature in the Proterozoic rocks of northern New Mexico are proposed. The two most significant suggestions are: 1) to adopt the name Vadito Group for the extensive ca 1,700 Ma, felsic metavolcanic/metasedimentary rock package exposed directly below the Ortega Formation of the Hondo Group, and to designate a reference section in the central Tusas Mountains; and 2) to propose the name Hondo Group for the regionally extensive, metasedimentary sequence beginning with the Ortega Formation that occurs directly above the Vadito Group. These rocks were previously called the Ortega Group.

Some workers may find these changes awkward at first, but we are convinced that both are necessary for a precise exchange of scientific information. The suggestions outlined in this paper are the first step toward this goal. We hope that, as investigation into the Precambrian history of New Mexico continues, the nomenclature proposed above will provide a consistent basis for further communication and will promote a more accurate and regionally compatible system of nomenclature.

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The New Mexico Geological Society will visit the eastern Sangre de Cristo–Moreno Valley–Cimarron Mountains area of northern New Mexico on Sept. 12–15 for its 41st fall field conference. Chris Mawer and Paul Bauer are general co-chairman for the trip; the theme is tectonic development of the southern Rocky Mountains, New Mexico. NMGS trips to this part of the state were held in 1956 and 1966, but some of the route had never been included in an NMGS roadlog.

We are soliciting peer-reviewed papers for the guidebook. Although we wish to emphasize original geologic research, we also encourage mini-paper contributions on mining history, archaeology, anthropology, and zoology–botany. If you would like to contribute or if you know of anyone who might be convinced to contribute, please contact us as soon as possible. The submittal deadline for reviewed papers will be February 15, 1990.

The guidebook editors are Chris Mawer, Paul Bauer, and Steve Hayden; managing editor is Spencer Lucas. For information and guidelines for authors, contact either Christopher K. Mawer, Dept. of Geology, Univ. of New Mexico, Albuquerque, NM 87131, (505) 277–4808 or Paul W. Bauer, NMBMMR, Campus Station, Socorro, NM 87801, (505) 835–5106.