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PRECAMBRIAN STRATIGRAPHY OF MANZANITA AND NORTH MANZANO MOUNTAINS, NEW MEXICO

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INTRODUCTION

The most complete Precambrian stratigraphic sequence in central New Mexico is present in the Manzano and Manzanita mountains. This sequence, however, is complicated because of intense penetrative deformation, unconformities, faults, and younger intrusions. These complications result in uncertainties concerning correlations of two major greenstone belts, one in Tijeras Canyon and the other in Hell Canyon (figs. 1 and 2), and correlations of metasedimentary units in the North Manzano Mountains. Reiche (1949) was the first to study the Precambrian geology of the entire North Manzano Mountains and to establish a stratigraphic sequence.

This paper is based on four University of New Mexico master's theses, from north to south, by Connolly (1981, Tijeras Canyon), Cavin (in progress, Kirtland Air Force Base), Parchman (1980, Hell Canyon area), and Edwards (1978, Bosque Peak area), that were supervised by L. A. Woodward. The New Mexico Geological Society provided partial financial support for the field work.

GEOLOGIC SETTING

The Manzano Mountains form an eastward-tilted fault block that developed in late Cenozoic time on the east side of the Rio Grande rift. Precambrian rocks are exposed along the western base of the mountains and are overlain unconformably by Paleozoic strata that cap the range. The western margin of Precambrian exposure is terminated by normal faults that mark the eastern limit of the Albuquerque basin, a graben filled with several thousand meters of late Cenozoic sediments.

Precambrian stratigraphic units in the North Manzano Mountains have been intensely deformed by northeast-trending folds and faults. True stratigraphic thicknesses are uncertain; the figures in this paper represent estimates based on outcrop width. Regional synkinematic metamorphism ranges from greenschist to amphibolite facies, with later local contact metamorphism and possibly metasomatism and remobilization adjacent to granitic intrusions.

Precambrian rocks of the North Manzano Mountains appear to be of Proterozoic age. The Ojito granodiorite has been dated at 1.53 b.y. (White, 1978), and the Sevilleta metarhyolite of the South Manzano Mountains has been assigned an age of 1.66 b.y. (Bolton, 1976). In the Los Pinos Mountains to the south, the Los Pinos granite was Rb-Sr dated at 1.38 b.y. by Bolton (1976). It thus seems likely that the rest of the Precambrian sequence in the North Manzano Mountains is also Proterozoic.

STRATIGRAPHIC UNITS

The stratigraphic units are briefly described in their suggested order of oldest to youngest, with a few exceptions where relative ages are uncertain. Unit relationships and stratigraphic nomenclature used by previous workers are depicted in Figure 3. The apparently oldest units are present in the Hell Canyon—Bosque Peak area and consist of, in ascending order: (1) Moyos metasediments, composed of 580 m of phyllite and quartzite with the base not exposed; (2) the Hell Canyon greenstone, a mafic metavolcanic unit about 1,500 m thick; (3) Bosque metasediments, which consist of at least 500 m of phyllite and quartzite with minor interbedded greenstone near the base; (4) Lacorocah metatuff, ranging from a wedge-edge to 630 m of dacite and rhyodacite, with abundant lithic inclusions; and (5) the Isleta metasediments, consisting of about 2,000 m of phyllite, metawacke, meta-arkose, and metaquartzite. A younger(?) sequence is present in the Coyote Canyon area of the Manzanita Mountains and consists of: (1) Coyote metasediments, which include 400 m of basal(?) Cerro Pelon quartzite overlain by up to 400 m of hematitic quartzite and phyllite, then by several meters of Coyote quartzite; (2) Coyote metarhyolite, a wedge of felsic metavolcanics up to 200 m thick; and (3) overlying Coyote greenstone of unknown thickness. The two contiguous metasedimentary terrains are separated by the Manzanita pluton (Condie and Budding, 1979), a coarse-grained granitic to quartz-monzonitic gneiss. The Tijeras greenstone is the subject of another paper (Connolly, this guidebook) and is not described here.

The following descriptions are abbreviated. Detailed descriptions, including thin-section petrography, are available in the master's theses by Connolly, Cavin, Edwards, and Parchman (fig. 1). Summary descriptions of most units are available in Woodward and others (1979).

Moyos Metasediments

This unit is overlain by the Hell Canyon greenstone, and its base is not seen. The Moyos metasediments consist mostly of phyllite and subordinate gritty, schistose metaquartzite with minor interlayered greenstone near the top. The Moyos metasediments were not recognized by previous workers (Reiche, 1949; Myers and McKay, 1970), nor did they recognize the base of the greenstone.

Phyllites are light green, whitish, and brownish gray with well-developed schistosity which generally parallels compositional layering. They are composed of 25-40 percent quartz and 7-10 percent sodic plagioclase in a matrix of well-aligned sericite, chlorite and green biotite. Metaquartzites are poorly sorted and consist of 65-75 percent quartz, 15-20 percent sericite, and about 10 percent sodic plagioclase with accessory alkali feldspar, muscovite, chlorite, and green biotite.

Near the top of the Moyos metasediments, seven graded beds, 2.32.5 m thick, fine toward the greenstone, grading from medium- and coarse-grained sand to silt- and clay-sized particles. They are interpreted as upward-fining sequences indicating that the top of the Moyos metasediments is the contact with the greenstone. The contact is gradational and is placed where greenstone becomes the dominant lithology.

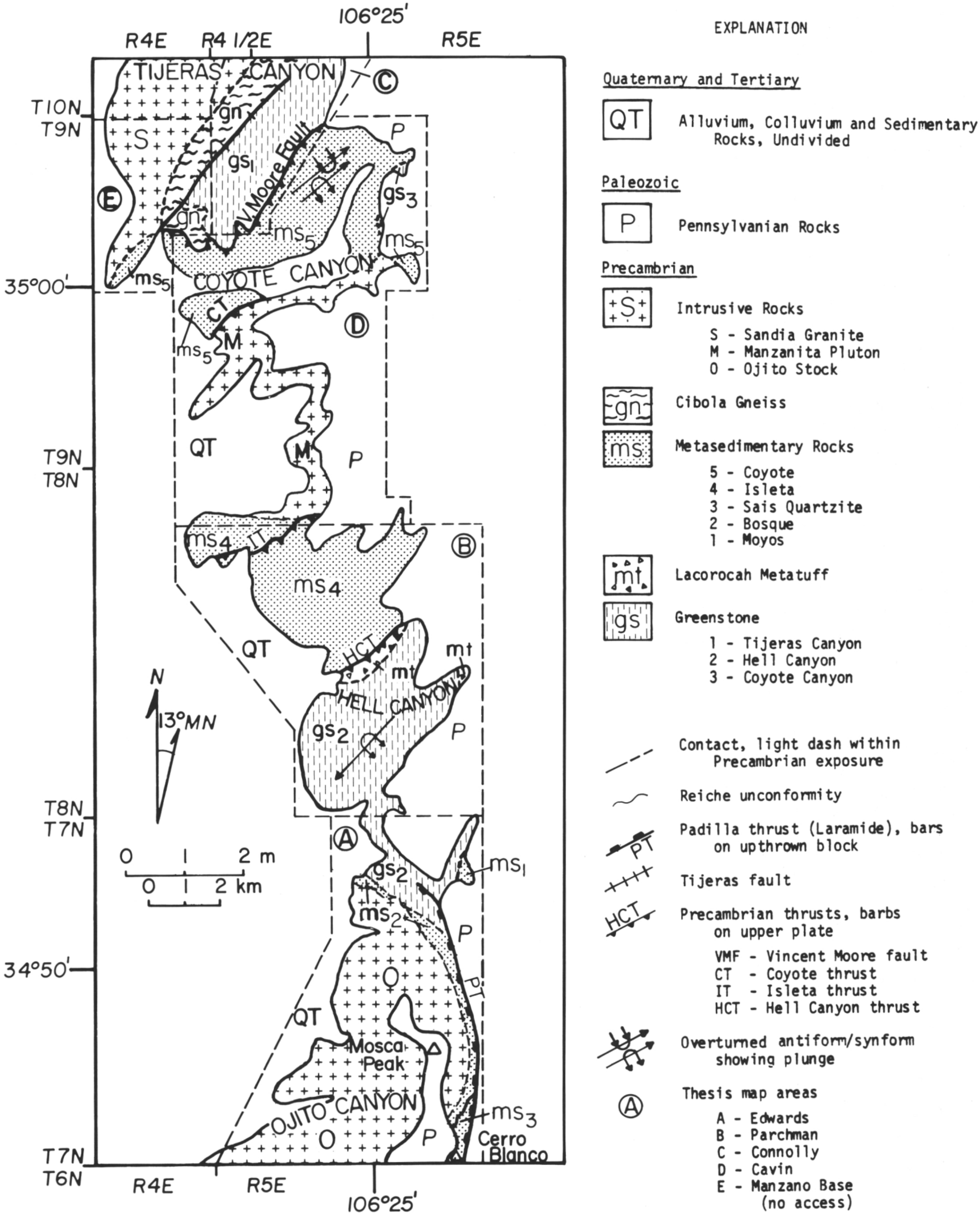

Figure 1. Generalized geologic map of the west front of the Manzanita and North Manzano mountains, showing Precambrian units (patterned) and major Precambrian structures.

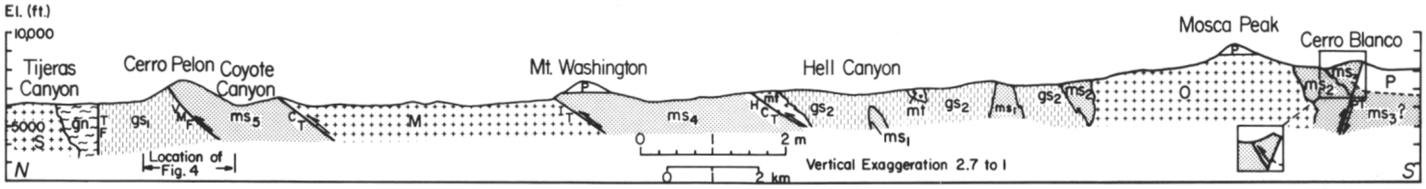

Figure 2. Diagrammatic north-south structure section through the Manzanita and North Manzano mountains from Tijeras Canyon to Cerro Blanco. Symbols correspond to Figure 1. Inset shows alternate interpretation of Reiche's unconformity as a thrust (see fig. 5).

Hell Canyon Greenstone

This unit is estimated to be about 1,500 m thick. The basal 500 m and the upper 300 m are well exposed and in good stratigraphic order, but post-Precambrian faults and cover by Paleozoic strata make it difficult to obtain a precise measurement of the middle part of the greenstone sequence. The dominant lithology is massive, fine-grained greenstone (albite-epidote-actinolite-hornblende hornfels) with subordinate monolithologic greenstone breccia, chlorite phyllite, quartz-mica phyllite, argillite, metasiltstone, leucocratic metavolcanic rocks, and minor talc. Interlayered metasediments occur mainly in the lower and upper parts of the unit.

Bosque Metasediments

This unit overlies and is transitional with the Hell Canyon greenstone through an interval of about 200 m, where metasedimentary rocks and greenstone are interlayered. The contact is placed at the base of where metasediments are the dominant lithology. Southeast of Mosca Peak, a possible correlative of the Sais metaquartzite overlies Bosque metasediments (Reiche, 1949). The top of the Bosque metasediments may be an unconformity that cuts stratigraphically lower to the north where this unit is missing. The maximum stratigraphic thickness of the Bosque metasediments cannot be determined, as the middle part is intruded by the Ojito stock (fig. 1). The lower 500 m is present between the greenstone and the Ojito stock, and the upper 500 m is present beneath Sais quartzite.

Light-gray to bluish- and greenish-gray, fine- to medium-grained metaquartzite and subordinate muscovite and chlorite phyllite with minor greenstone make up the lower part of the Bosque metasediments. Most metaquartzites are schistose and impure, containing clasts of quartz (40-50 percent), feldspar (up to 30 percent), and subordinate muscovite and chloritized biotite. The upper part consists of white and gray phyllite with subordinate micaceous metaquartzite and metasiltstone.

Lacorocah Metatuff

The Lacorocah metatuff was named by Reiche (1949) for exposures along Hell Canyon where it rests unconformably on Hell Canyon greenstone. Maximum thickness of the metatuff is 630 m in a measured section where the top is a fault. The fault is nearly parallel to compositional layering and foliation in the metatuff and the metasediments, but it probably has tectonically eliminated some of the Isleta metasediments. The metatuff thins southward and is absent at the southern end of the Hell Canyon greenstone exposure, probably as a result of having been deposited in a topographic low north of Hell Canyon.

Lacorocah metatuff is mostly dacite and rhyodacite with minor andesite. It is gray to light-greenish gray and contains abundant platy lithic fragments of phyllite, schist, greenstone, and hematitic quartzite. The matrix consists of blastoporphyritic sodic plagioclase (about 35 percent) and quartz (10-15 percent) in a groundmass of extremely fine-grained sericite, sodic plagioclase, and epidote with minor chlorite and opaque minerals. Schistosity is largely cataclastic and appears to be parallel to and superimposed on original primary igneous flow structure.

Isleta Metasediments

This unit consists of tan, light-gray and light-green phyllite, meta-arkose, and metaquartzite, in fault contact with the Lacorocah metatuff. Metavolcanics are present in the northernmost exposures. Reiche (1949) tentatively considered this unit to be correlative with the Bosque metasediments but noted that the correlation was tenuous.

The phyllites are composed of moderately to well-aligned, extremely fine-grained sericite arid chlorite with angular clasts of quartz and feldspar.

Coyote Canyon Sequence

The Coyote Canyon sequence consists of the Cerro Pelon quartzite, an overlying unit of quartzite and phyllite, a thin quartzite, a wedge of

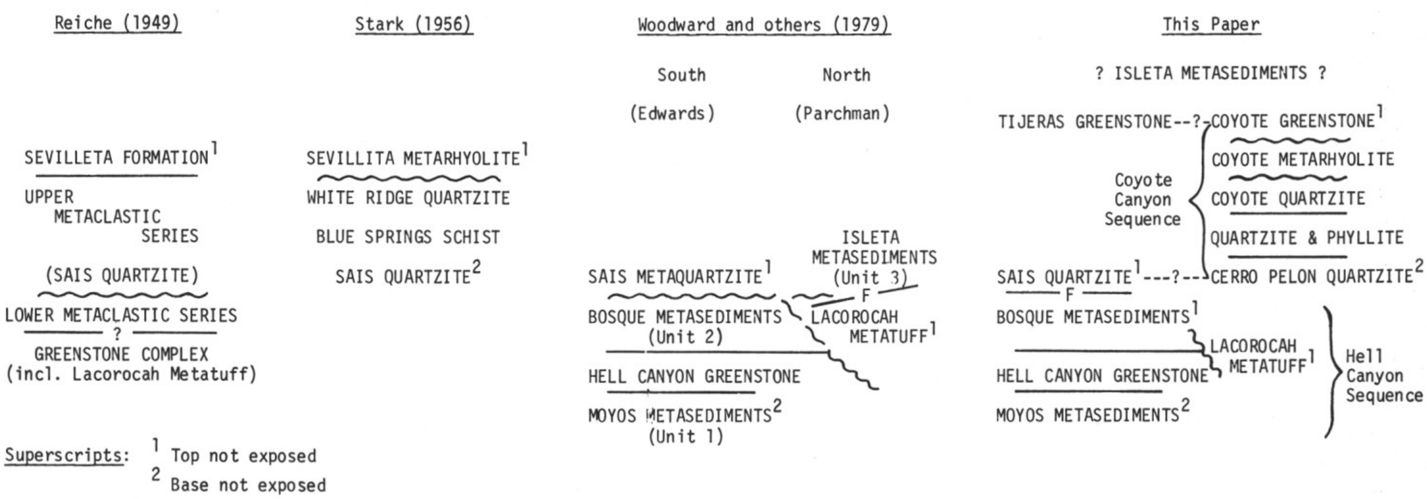

Figure 3. Stratigraphic nomenclature and relationships observed by previous workers in the Manzanita and North Manzano mountains. Symbols: ——— conformable, ∼∼∼∼ unconformable, ——F—— fault; inferred relationships are dashed.

felsic metavolcanic rock, and a unit of mafic to intermediate metavolcanics with interbedded metasediments. The Cerro Felon quartzite structurally overlies Tijeras greenstone along the Vincent Moore fault (fig. 1).

The quartzites are extremely pure, consisting of greater than 95 percent quartz, with minor muscovite and traces of detrital tourmaline, zircon, and sphene. Minor quartz-muscovite phyllite is interbedded in the lower part of the Cerro Felon quartzite. The intervening unit consists of dark red hematitic quartzite with minor muscovite, hematitic phyllite, and schistose grits. Mafic metavolcanics are primarily albite-actinolite-chlorite-epidote greenstone. Intermediate varieties contain appreciable quartz and potassium feldspar. Metarhyolites consist primarily of quartz, potassium feldspar, and muscovite, with subordinate plagioclase and rare sphene and zircon.

DISCUSSION

Factors Affecting Stratigraphic Correlation

Interrelated problems preclude firm stratigraphic correlations in the North Manzano and Manzanita mountains, as difficulties stem from both the character of the original sediments and their subsequent deformation and metamorphism. A comprehensive understanding will ultimately require an integrated solution of structure and stratigraphy in critical areas.

Repetitious metaclastic sequences

The metaclastic and metavolcanic units described above are complexly interbedded sequences characterized by subtle lithologic gradations. Distinctive marker horizons are rare, and regional metamorphism tends to mask compositional variations. Original sedimentary features which indicate the direction of younging within individual units are also rare, compounding the problem of deciphering the structure.

Precambrian structure

In the South Manzano Mountains, and probably throughout most of the area of this report, the most pervasive penetrative fabric in micaceous rocks is a well-developed S, schistosity which dips steeply southeastward. A less distinct S, foliation nearly always parallels original bedding (S_o), and S, usually cuts 80/81 at a low angle. Fold noses of the isoclinal F, event are difficult to identify since S_o is often strongly transposed. The large-scale overturned folds and southeast-dipping thrusts shown in Figures 1, 2 and 4 likely are F2 structures. The F2 event apparently involved northwest yielding in response to a horizontal compressional stress field.

Additionally, there is evidence for post-F, deformation. Map-scale refolded F2 folds have been identified by Grambling (this guidebook) within the Blue Springs schist in the Carlon del Trigo area, 12 km south of the area of this report. Farther south, Bauer (this guidebook) has mapped similar structures in the Blue Springs schist of the South Manzano Mountains.

Reiche's unconformity

The nature of the unconformity defined by Reiche (1949) as separating his upper and lower metaclastic series (see inset, fig. 2) has profound stratigraphic implications. There appears to be insufficient direct evidence to substantiate the age relations between the two series. Reiche based his relative ages on crossbedding observed in the Sais-equivalent quartzite, a method which is meaningful only if the quartzite has depositional contacts with the other units. If the contacts are tectonic, the younging direction is meaningful only for the quartzite itself. Recent work by J. F. Callender (personal commun. , 1982) and W. Blount (see first-day road log, this guidebook) indicates that structural discontinuities exist across the contact, and that the contact is discordant to the enveloping surfaces of original bedding on both sides of the contact. Thus, it is possible that the contact is tectonic, and that the direction of younging in the lower metaclastic series and its relative age relationship to the upper metaclastic series is completely independent of stratigraphic facing in the Sais metaquartzite. The resultant stratigraphic alternatives are discussed at the conclusion of this paper.

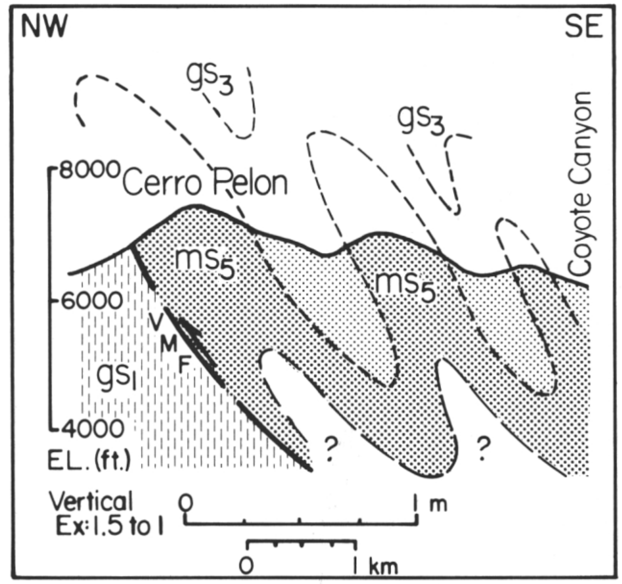

Figure 4. Possible structure of Vincent Moore fault, placing Coyote Canyon sequence over younger(?) Tijeras greenstone. Dark stipple represents Cerro Pelon quartzite. Folds (F_2) are projected above and below ground surface. Symbols correspond to Figure 1.

Intact Stratigraphic Sequences

Two apparently intact stratigraphic sequences have been identifies in the North Manzano and Manzanita mountains. Irrespective of strut tural complexities and uncertainties regarding the direction of younging the relative order of stratigraphic units within these sequences appear! valid because depositional contacts are preserved. Thus, these se quences represent first-order constraints governing current stratigraphic interpretations.

Hell Canyon sequence

The stratigraphy adjacent to the Hell Canyon greenstone terrain, at interpreted by Woodward and others (1979), is shown diagrammaticall) in Figure 3 and summarized in the section below.

South of Hell Canyon, the lithologically distinct Moyos and Bosqu(metasediments, respectively, are in conformable depositional contac below and above the Hell Canyon greenstone. The Moyos is interpreter as the oldest of the three units based on a series of graded beds whist fine upward toward the greenstone contact. Farther south, Bosque meta sediments are overlain by a massive quartzite along the contact Reich((1949) perceived as an unconformity separating his upper and 'owe] metaclastic series. Stark (1956) considered this quartzite correlativ(with the Sais quartzite of the Los Pinos Mountains, although the outcror is discontinuous due to intrusion and overlying Pennsylvanian sedi ments.

Bosque metasediments are missing north of Hell Canyon where La corocah metatuff, a local, unconformity-bounded unit, overlies Hel Canyon greenstone. The Lacorocah metatuff lies structurally abov(Isleta metasediments along the Hell Canyon thrust, a south-dippirq fault of unknown displacement.

Coyote Canyon sequence

The sedimentary succession along Coyote Canyon is clearly defined by distinct lithologic contacts which are continuous over several kilometers. The contact of Cerro Pelon quartzite with the structurally overlying red quartzite and schist conspicuously outlines the northeast-plunging isoclinal folds shown in Figures 1 and 4.

Direct evidence concerning the direction of younging is generally unreliable in the Coyote metasediments. Most crossbeds in the Cerro Pelon quartzite are structurally disturbed and yield contradictory stratigraphic facings, although a rigorous structural analysis using crossbed orientations and vergence relationships of small-scale folds has not been attempted. At present, only the relative stratigraphic order within the sequence is certain.

It is difficult to ignore comparison of the strikingly similar succession of lithologies in the Coyote Canyon sequence to the Sais quartzite through Sevilleta metarhyolite sequence described by Stark (1956) in the South Manzano Mountains. Previous interpretations of the Sais quartzite as a basal unit by Stark and Dapples (1946) and later by Reiche (1949) have been reconfirmed by Bauer (this guidebook). Crossbeds in the upper Sais quartzite consistently face toward the Blue Springs schist. Implications of a possible Sais quartzite—Cerro Pelon quartzite correlation are discussed below with the Tijeras greenstone.

Structurally Isolated Units

Isleta metasediments

The inability to correlate the Isleta metasediments with any other unit is a major problem which detailed mapping has failed to resolve. The exposure is structurally isolated by the south-dipping Isleta and Hell Canyon thrusts of unknown displacement (fig. 1).

Reiche (1949) was uncertain whether the Isleta exposures belonged in his lower or upper metaclastic series. Later workers (Woodward and others, 1979) considered these rocks younger than rocks of Reiche's lower metaclastic series, represented by Bosque metasediments south of Hell Canyon. Parchman (1981) speculated that the Isleta metasediments might represent Reiche's upper metaclastic series, with the basal quartzite eliminated along the Hell Canyon thrust. This scheme requires that the sediments be overturned adjacent to the thrust, since bedding parallels the southeast-dipping regional schistosity. There is no evidence indicating overturned beds along the Hell Canyon thrust; although Cavin (in preparation) has identified overturned bedding in metavolcanic rocks in the extreme northeast part of the Isleta exposure, where andesitic fragments are incorporated in the basal part of a basaltic flow which structurally underlies the adjacent andesite.

Parchman's idea relied on the assumption that the Isleta metasediments were depositionally overlain by Sevilleta-equivalent metarhyolite north of his map area. However, recent work by Cavin indicates that Isleta metasediments are faulted against coarse-grained granitic rocks of the Manzanita pluton. Reiche (1949) recognized the intrusive rocks but underestimated their abundance, and he included them with metarhyolite rather than separating them as a distinct map unit. The nearest occurrence of stratiform metarhyolite is nearly 6 km north, just south of Coyote Canyon, where metaclastic rocks lithologically similar to Isleta metasediments occur sparingly. Thus, there is no strong stratigraphic or lithologic correspondence to suggest the stratigraphic position of the Isleta metasediments, and it is possible that these rocks represent a unique stratigraphic unit.

Tijeras greenstone

The Tijeras greenstone (Connolly, this guidebook) also is isolated structurally. Depositional contacts with other stratigraphic units are not recognized, although the north-central part of the exposure is dominated by rocks of sedimentary origin. The greenstone is bounded on the north by the Tijeras fault, a vertical structure which places greenstone against meta-arkosic Cibola gneiss. The relative age of metasedimentary gneiss to greenstone (or any other Precambrian stratigraphic unit) is not known. The southern greenstone contact is poorly exposed in most places, and its interpretation is less straightforward.

Reiche (1949) and all later workers, including Kelley and Northrop (1975), mapped the southern contact as a south-dipping thrust, the Vincent Moore fault, which places Cerro Pelon quartzite over Tijeras greenstone. In addition to the abrupt lithologic change, the fault is characterized by extreme shear, brecciation, and abundant vein quartz. Recent work by Connolly (1981) and Cavin (in preparation) indirectly supports the fault interpretation based on structural discordance and a possible minor change in metamorphic grade across the contact. Classification of the fault as a thrust is consistent with its outcrop geometry, although minor post-fault deformation may have folded the fault surface slightly about north-trending axes (Reiche, 1949; Cavin, in preparation). Kinematically, the thrust is compatible with the northwest yielding indicated by the northeast-trending, overturned-to-the-north macroscopic folds which occur in Coyote Canyon rocks immediately south of the fault and with several similarly oriented thrusts to the south (figs. 1, 2).

Complex structural interactions involving the Vincent Moore fault and large-scale folding makes possible a multitude of interpretations. The most direct explanation compatible with the regional tectonic framework is that of a bedding-plane thrust along the limb of a large, overturned fold (fig. 4) that would likely place older rocks over younger rocks with elimination of the intervening strata. Such a scheme obviously suggests that Tijeras greenstone could be younger than the Coyote Canyon metasediments. Intercalated metabasalts and mafic metaclastics (Coyote greenstone) are present structurally above Coyote metasediments north of upper Coyote Canyon (Cavin, in preparation). Although contact relationships are obscure and exposures are limited by Paleozoic cover, the rocks clearly resemble the Tijeras greenstones. If these exposures indicate a greenstone terrain stratigraphically above Coyote metasediments, then they also represent the youngest stratigraphic unit based on traditional interpretations. Further, if the Cerro Pelon quartzite represents the basal quartzite of Reiche's (1949) upper metaclastic series, then the Tijeras greenstone must be younger than, and distinct from, the Hell Canyon greenstone.

Existence of the Vincent Moore fault is insufficient to rule out the possibility of correlative greenstone terrains. However, its presence increases the stratigraphic uncertainty, because the extent of tectonic elimination along the fault is unknown. Assuming the structure represents only an unconformity, an argument favoring correlative greenstone terrains could emerge. If Bosque metasediments are absent in the Coyote Canyon area due to the erosional unconformity postulated by Woodward and others (1979), then Sais-equivalent quartzite could unconformably overlie Hell Canyon—equivalent greenstone, and the Tijeras and Hell Canyon greenstone terrains might be considered correlative.

The above speculations emphasize the importance of deciphering the geometry surrounding the Vincent Moore fault and of determining the stratigraphic position of the Cerro Pelon quartzite. Until future work significantly reduces present uncertainties, the relationship of these two major greenstone terrains probably will not be resolved.

ALTERNATIVES AND CONCLUSIONS

A conservative view of the stratigraphy of the North Manzano and Manzanita mountains is presented in Figure 3. It does not contradict any of the evidence compiled by previous workers, but it is of course subject to the uncertainties discussed above.

When the evidence is viewed in the context of purely relative relationships, two stratigraphic packages emerge which at present represent the only major constraints governing interpretation of the overall Precambrian stratigraphy. These are the Hell Canyon sequence established by Edwards (1978) and the Sais to Sevilleta sequence established by Stark and Dapples (1946) and Stark (1956) in the Los Pinos and South Manzano mountains. If the Sais quartzite and the basal quartzite of Reiche's (1949) upper metaclastic series are correlative, and the contact with the underlying Bosque metasediments in the North Manzano Mountains is in fact depositional, then the only apparent alternative is a complete reversal of the previously established Precambrian stratigraphy (fig. 3). We consider this alternative remote.

A more reasonable approach is to examine the alternatives posed by assuming that the Bosque-Sais contact is tectonic, and that the younging criteria in the Sais quartzite (which have stood the test of several workers) are correct. Under these assumptions, the relative ages of Reiche's (1949) upper and lower metaclastic series would be suspect, yielding the four possibilities depicted in Figure 5. The alternatives envision a simple fault which would produce the observed contact relationship between the two series (fig. 2). Alternatives b, c, and d appear inconsistent with the regional tectonic style of northwest yielding indicated by the major Precambrian F2 folds and faults, in that they cannot produce the observed southeast-dipping contact geometry with a compressional structure. Alternatives b and c would require extremely large stratigraphic separations which are unlikely with a steep fault along steeply dipping units. None of these alternatives seem plausible. In addition, alternatives b and d contradict Edwards' (1978) younging criteria in the Moyos metasediments. Again, the traditional stratigraphy (alternative a) emerges as the most viable interpretation given our present knowledge.

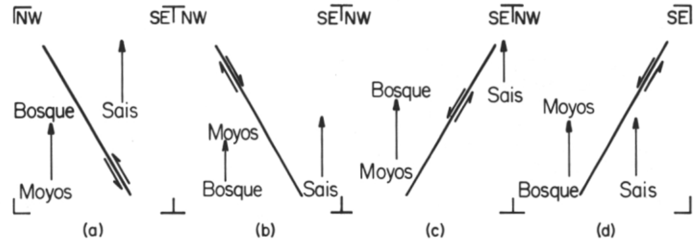

Figure 5. Alternatives posed by a faulted Bosque metasediments–Sais quartzite contact. Cross-section schematics show sense of fault movement and direction of stratigraphic facing.

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REFERENCES

Bolton, W. R., 1976, Precambrian geochronology of the Sevillita metarhyolite and the Los Pinos, Sepultera, and Priest plutons of the southern Sandia uplift, New Mexico (M.S. thesis): New Mexico Institute of Mining and Technology, Socorro, 45 p.

Cavin, W. J., 1982, Precambrian geology of the Manzanita Mountains, New Mexico (M.S. thesis): University of New Mexico, Albuquerque, in preparation.

Condie, K. C. and Budding, A. J., 1979, Geology and geochemistry of Precambrian rocks, central and south-central New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 35, 58 p.

Connolly, J. R., 1981, Geology of the Precambrian rocks of Tijeras Canyon, Bernalillo County, New Mexico (M.S. thesis): University of New Mexico, Albuquerque, 147 p.

Edwards, D. L., 1978, Petrology and structure of Precambrian rocks in the northern North Manzano Mountains and southern Manzanita Mountains, central New Mexico (M.S. thesis): University of New Mexico, Albuquerque, 87 p.

Kelley, V. C. and Northrop, S. A., 1975, Geology of Sandia Mountains and vicinity, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 29, 136 p.

Myers, D. A. and McKay, E. J., 1970, Geologic map of the Mount Washington quadrangle, Bernalillo and Valencia Counties, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-886.

Parchman, M. A., 1981, Precambrian geology of the Hell Canyon area, Manzano Mountains, New Mexico (M.S. thesis): University of New Mexico, Albuquerque, 108 p.

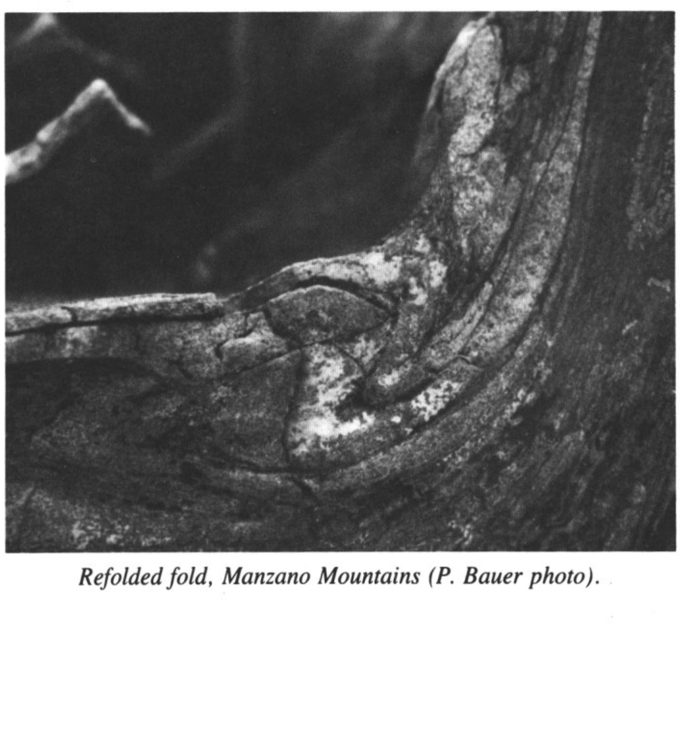
Reiche, P., 1949, Geology of the Manzanita and North Manzano Mountains, New Mexico: Geological Society of America Bulletin, v. 60, p. 1183-1212.

Stark, J. T., 1956, Geology of the South Manzano Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 34, 47 p.

Stark, J. T. and Dapples, E. C., 1946, Geology of the Los Pinos Mountains, New Mexico: Geological Society of America Bulletin, v. 57, p. 1121-1172.

White, D. L., 1978, Rb-Sr isochron ages of some Precambrian plutons in south-central New Mexico: 1sochron/West, n. 21, p. 8-14.

Woodward, L. A., Parchman, M. A., Edwards, D. L., and Husler, J. W., 1979, Stratigraphy and mineralization of Hell Canyon greenstone belt (Precambrian), New Mexico: New Mexico Geological Society Guidebook 30, p. 189-195.



Refolded fold, Manzano Mountains (P. Bauer photo).