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PROTEROZOIC GEOLOGY OF SUPRACRUSTAL AND GRANITIC ROCKS IN THE CABALLO MOUNTAINS, SOUTHERN NEW MEXICO

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Abstract—The western slope of the Caballo Mountains in southwestern New Mexico contains early Proterozoic supracrustal and plutonic rocks that are unconformably overlain by lower Paleozoic sedimentary rocks to the east, and are in fault contact with rift-related Cenozoic sediments to the west. Supracrustal rocks consist of biotite–hornblende–plagioclase amphibolites that probably represent metabasalts, and quartz–plagioclase–K-feldspar–biotite gneisses that may represent metamorphosed felsic volcanic rocks. No primary igneous textures are preserved. Amphibolitic and fine-grained metaigneous xenoliths in the felsic gneiss suggest that felsites postdate amphibolites. Plutonic rocks include an older, coarse-grained, porphyritic biotite granodiorite in the east-central map area, and a younger, medium-grained pink granite in the northern and southern map areas. Both granitic bodies intrude, but are separated by, the supracrustal sequence.

All Precambrian plutonic and supracrustal rocks are penetratively deformed and have sustained amphibolite-grade regional metamorphism. Excellent evidence for three fabric-forming deformational events is recorded in supracrustal rocks. The earliest recognized deformation is represented by a strong schistosity and gneissic layering (S_1) in felsites. The second event tightly folded this fabric around steep, approximately east-trending axial surfaces in felsites. S_1 and S_2 are parallel or subparallel throughout the area. The final event is a non-penetrative cross-folding that formed small crenulations in amphibolites. Although both plutonic bodies contain a penetrative foliation parallel to that in the country rock, and it is not known whether the granitic rocks preserve S_1, S_2, or both, several lines of evidence suggest pre-D_1 crystallization of the granodiorite.

Similar Proterozoic lithologies that have undergone similar deformational histories are exposed in nearby uplifts. Additional mapping and geochronology will be required to determine the manner in which these rocks relate to those of the Caballo Mountains.

INTRODUCTION

Proterozoic basement rocks of central and northern New Mexico have been the subject of increasingly intensive geological study during the last several years, but no detailed structural mapping in conjunction with U–Pb zircon geochronology has been attempted in the Proterozoic rocks of southern New Mexico. Although early workers described the various Precambrian-cored blocks in central and northern New Mexico, well-constrained regional correlations have been scarce. Based on stratigraphic, geochronologic, and structural criteria, Bauer & Williams (1985) suggested that rock packages mapped in northern New Mexico that belong to a single lithogenetic package called the Ortega Group may be correlative with Proterozoic sequences described in the Pedernal and Manzano Mountains in central New Mexico. The Ortega Group of northern New Mexico is a quartzite-dominated metasedimentary sequence that conformably overlies a 1,700 Ma felsic metavolcanic pile known as the Vadito Group (Williams et al. 1986). Precambrian supracrustal rocks younger than the Ortega Group appear to be rare in northern New Mexico. However, Fulp & Renshaw (1985) found metamorphic rocks as young as 1,650 Ma in the southern Sangre de Cristo Mountains near Santa Fe. In central New Mexico, a 1,650 Ma felsic volcanic pile appears to overlie a quartzitic metasedimentary sequence that may be equivalent to the Ortega Group. Although no metasedimentary rocks are exposed in the Caballo Mountains, it is feasible that metavolcanic rocks of the Caballos are time equivalents of either the 1,700 or 1,650 Ma terrane to the north. This paper is a first attempt at evaluating a possible southward extension of these terranes.

Early Proterozoic supracrustal and plutonic rocks are exposed along the western flank of the eastward-tilted, fault-bounded Caballo Mountains of southwestern New Mexico (Fig. 1). These rocks are unconformably overlain by Paleozoic sedimentary strata to the east and juxtaposed against Cenozoic sediments (mainly Santa Fe Group) by the Caballo fault to the west.

Access to the area is provided by an unimproved road that winds northward from Caballo Dam. This report describes the results of detailed mapping of a 20 km^2 area between Longbottom and Burbank Canyons, a region that includes most of the supracrustal rocks and a large area of the enclosing plutons (Fig. 2).

Previous geologic studies in the Caballo Mountains were regional in scope and did not emphasize Precambrian rocks. Doyle (1951), Kelley & Silver (1952), Silver (1955), and Mason (1976) each noted the general distribution and nature of Precambrian rocks in the Caballo Mountains without subdividing them on their accompanying maps. Condie & Budding (1979) examined Precambrian rocks in the Caballo Mountains and separated an amphibolite complex from the plutonic rocks.

Rb/Sr geochronology by Muehlberger et al. (1966) yielded an age of 1,304 ± 72 Ma (recalculated using new decay constant) for a granitic rock south of the present study area in the Caballo Mountains. Recent U–Pb zircon ages on metavolcanic and granitic rocks in the Socorro region indicate an age of about 1,650 ± 10 Ma for crystallization of supracrustal volcanic rocks and intrusive plutons (Bowring et al. 1983). Similar U–Pb zircon ages have been recorded in felsic metavolcanic rocks of the Manzano Mountains (Bowring & Condie unpubl.), and the Zuni Mountains (Bowring & Condie 1982). U–Pb zircon ages in southern New Mexico consist of a 1,655 ± 15 Ma granitic rock from the Black Range, and a 1,550 Ma biotite gneiss and 1,445 ± 15 Ma granite from the Big Burro Mountains (Stacey & Hedlund 1983).

As emphasized by Bowring et al. (1983), caution must be applied to proposed evolutionary models for the Proterozoic crust in New Mexico until detailed stratigraphic and structural studies are completed in conjunction with accurate U–Pb zircon geochronology. Zircon separates from samples of the felsic gneiss and both granitic bodies in the Caballo Mountains are currently being processed for U–Pb geochronology. Age constraints on these rocks will aid in future regional correlations.

SUPRACRUSTAL ROCKS

Field relations

Within the map area, Proterozoic rocks are bounded on the west by the Caballo fault and are nonconformably overlain to the east by Cambro-Ordovician sediments of the Bliss Formation. In the northern map area this unconformity is offset and downdropped to the west by an east-trending, high-angle fault. A splay of the Caballo fault cuts Proterozoic rocks in the western map area.

Supracrustal rocks compose approximately one-fourth of the Proterozoic rocks exposed in the Caballo Mountains. Within the map area these rocks are sandwiched between granitic plutons and form an ir-

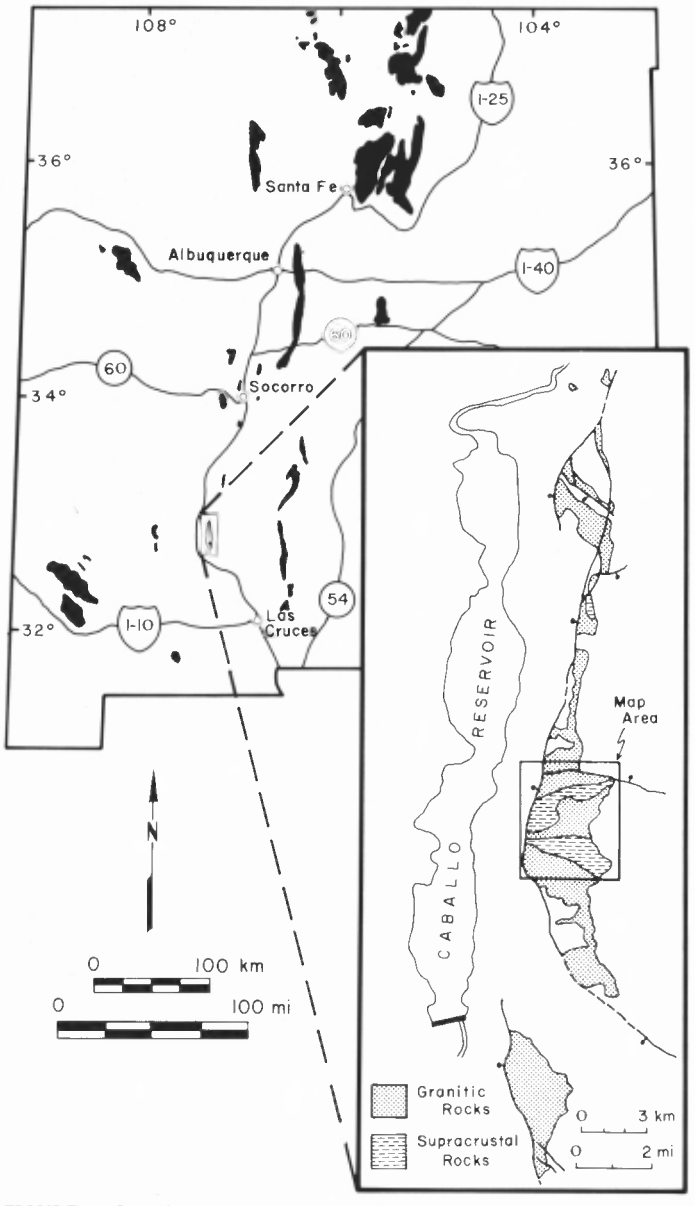


FIGURE 1—Location and generalized geologic maps (after Condie & Budding 1979) of the Caballo Mountains, showing Precambrian rock exposures and map area.

regular, roughly arcuate map pattern (Fig. 2). Supracrustal rocks are bordered to the east by a moderately coarse-grained porphyritic biotite granodiorite and to the west by a medium-grained pink granite. The contacts between intrusions and supracrustals are gradational and interfingering. Granitic veins have pervasively invaded country rock along contact zones. Bodies of amphibolite are isolated within the granitic porphyry in the central map area. Very fine-grained, gray, silicic metavolcanic(?) xenoliths exposed locally in felsic-gneiss units presumably represent fragments of older rock that were incorporated during emplacement of the felsic-gneiss protolith.

Exposed supracrustal rocks are approximately 60% mafic and 40% felsic. The only marker horizons within the supracrustal sequence are a series of distinctive felsic gneisses, but due to the highly tectonized nature of the supracrustal rocks it is unlikely that compositional layering truly represents the original geometry of stratigraphic layering. Mafic and felsic supracrustal rocks form complex, interfingering geometries (Fig. 2) that may be due to original stratigraphy, tectonic processes, or both.

Condie & Budding (1979) suggested that the supracrustal sequence may represent a roof pendant in a granitic pluton. If so, the roof pendant lies between two distinct plutonic bodies. They also noted that supracrustal rocks are very similar to three other major occurrences of dominantly amphibolite supracrustals they examined in central and south-central New Mexico (east of Salinas Peak in the central San Andres Mountains, the Tijeras Greenstone in the southern Sandia Mountains, and the Hell Canyon sequence in the southern Manzanita Mountains). Exposed within two ranges to the west of the Caballos, beyond the study area of Condie and Budding, are similar sequences of Proterozoic supracrustal rock. These areas are the northern Big Burro Mountains (Hewitt 1959) and the Black Range (Hedlund 1977) of southwestern New Mexico. More study is needed to evaluate geochronologic and structural similarities between all of these areas.

Mafic supracrustal rocks

Throughout the map area, elongate amphibolite horizons that range in length from meters to hundreds of meters sit isolated and aligned within the foliated plutonic rocks, and massive amphibolites interfinger with felsic-gneiss bodies. Mafic rocks range from fine-grained, weakly foliated black amphibolites (65% hornblende, 35% plagioclase) to well-foliated black biotite amphibolites (40% hornblende, 30% plagioclase, 20% biotite, 10% quartz). In thin section, amphibolites consist of equigranular mosaics of weakly lineated hornblende crystals, whereas biotite-rich amphibolites contain aligned, elongated crystals of hornblende and biotite. Locally, amphibolites contain white plagioclase–quartz pods and lenses flattened in the foliation. Quartz grains show domainal undulatory extinction.

No original volcanic or sedimentary features were found in the mafic rocks. Protoliths are presumably basaltic flows and/or sills. Isolated, aligned amphibolite bodies in granitic rocks are interpreted to be xenoliths that were incorporated in intrusions prior to deformation of granitic rocks.

Felsic gneiss

The most distinctive rock in the area is a felsic unit that contains alternating layers of light- and dark-colored mineralogy. In the southern map area, where the thickest gneiss section crops out, compositions and textures range widely, from well-foliated, dark, schistose rock to fine-grained, well-layered, light-colored, quartzose gneiss. In the west-central map area, the gneiss appears gradational with a fine-grained, light-gray, well-foliated rock that contains abundant euhedral crystals (possibly phenocrysts) of feldspar. Gneiss units typically contain nearly equigranular quartz (30–50%), sericitized plagioclase (35–40%), microcline (10–20%), biotite (0–20%), and lesser amounts of chlorite, sillimanite, opaques, and mats of folded fibrolite.

Compositional banding is due to segregation of quartz-rich and biotite-rich layers. Well-banded rocks exhibit a pervasive foliation defined by aligned micas. Muscovite is confined to biotite-rich layers and appears to have partially replaced biotite. Strain within the felsic gneiss is variable, with high strain characterized by thinly layered, fine-grained, well-foliated rock, and low-strain areas characterized by an aplitic or porphyritic texture. The presence of folded fibrolitic sillimanite in the gneiss implies a pre- or syn-kinematic peak metamorphic temperature of at least 500°C.

Xenoliths of amphibolite and fine-grained, gray, quartz-rich metavolcanic(?) rock, up to 60 cm in length, are found aligned and flattened in the dominant foliation plane of the felsic gneiss (Fig. 3). Pink granitic veins intrude gneiss, indicating that the felsic gneiss predates granitic intrusion. These gneissic units are interpreted as volcanic or hypabyssal felsic igneous rocks that were either coeval with, or slightly younger than, the mafic rocks.

PLUTONIC ROCKS

Field relations

Condie & Budding (1979) described three major types of granitic rocks in the Caballo Mountains: (1) gneissic granite in the northern Caballos; (2) brick-red syenites and granites intruded into the northern granite; and (3) the Caballo pluton, which is in fault contact with the

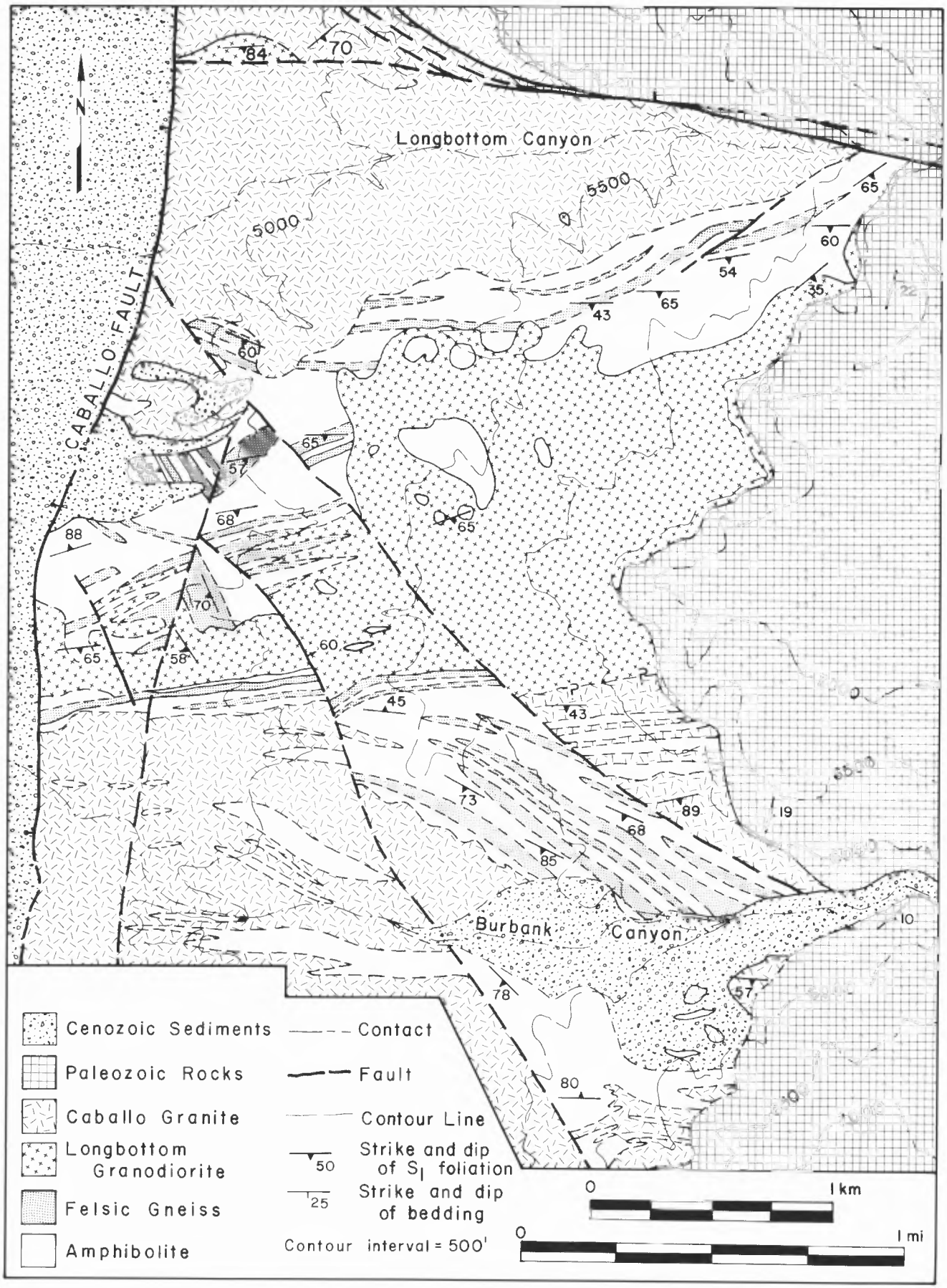


FIGURE 2—Generalized geologic map of Proterozoic rocks in southern Caballo Mountains.



FIGURE 3—Felsic gneiss containing amphibolite xenolith aligned in the dominant foliation (S_1). Knife is 10 cm long.

syenites and intrudes the supracrustal rocks of the southern Caballos. They described the average composition of the Caballo pluton as quartz monzonite. Based on field relations, textures, and whole-rock geochemistry, the Caballo pluton is here divided into two intrusive units, a biotite-rich granodiorite porphyry that crops out in the central map area, and a pink granite in the northern and southern map areas. Two small exposures of biotite-rich granitic rock within the pink granite in the northwestern map area appear to be phases of the biotite granodiorite. Although the syenites and red granites that Condie & Budding (1979) described lie north of the mapped area and are not included in this report, it should be noted that at least some of the red granitic rocks exhibit penetrative foliation consistent in orientation and style with that of the plutonic rocks examined in the study area. Furthermore, it is possible that the brick-red granitic rocks described to the north are equivalent to the pink granite in the present study area. We propose the informal names Caballo granite and Longbottom granodiorite for the pink-to-red true granite of the central and southern Caballos and the older, biotite-bearing pluton found only in the present map area, respectively. The relative proportions of these rocks in the map area are about 55% Caballo granite, 45% Longbottom granodiorite.

Minor occurrences of medium-grained, pink granitic rock or aplite form discordant dikes along northwest-trending faults. The thickest of these is about 10 m. In thin section, equant grains (average size = 1 mm) of microcline (45%), plagioclase (30%), and quartz (20%) form a granoblastic texture without any preferred orientation of minerals. Minor phases are biotite, chlorite, muscovite, and opaques. Quartz grains are strained and show crude 120° equilibrium boundaries. The age of these aplites is unknown, but their emplacement may have coincided with faulting.

Longbottom granodiorite

The Longbottom granodiorite is a dark to medium-gray, coarse-grained, weakly foliated rock containing abundant, large (up to 3 cm), euhedral to subhedral phenocrysts of microcline and plagioclase. The groundmass consists principally of quartz (about 15% of rock), plagioclase, microcline, biotite (about 10% of rock), and large, euhedral, wedge-shaped crystals of sphene. Feldspars are considerably sericitized and locally exhibit myrmekitic texture. Microperthite occurs locally. Quartz grains show zonal, undulatory extinction, suggesting postmetamorphic strain. This intrusion occurs as an irregularly shaped, massive body that is in generally gradational, somewhat discordant contact with the supracrustal rocks.

A small exposure of a very similar biotite-rich, sphene-bearing granitic body sits isolated within the pink granite in the north-central map area. This rock is host to a small mine explored for fluorite and lead. Although less porphyritic than the main body of granodiorite to the southeast, this exposure seemingly represents a xenolith or small roof pendant of that body. If so, the granodiorite crystallized prior to emplacement of the pink granite. The cause of the associated mineralization is unknown.

A third exposure of biotite–sphene-bearing granodiorite is present in the northwestern map area. Although this rock also lacks the very large feldspars of the main pluton and is well foliated, it is nonetheless similar in texture, mineralogy, and major-element chemistry to the Longbottom granodiorite. This exposure is in fault contact with the pink granite to the south and is in intrusive contact with an identical pink granite to the north. Cross-cutting relations suggest that the northern exposure of pink granite has intruded the granodiorite. Xenoliths of granodiorite are seen within granite, and near the contact granite dikes cut the granodiorite. These exposures are probably equivalents of the Caballo granite and Longbottom granodiorite mapped to the south, downdropped and offset laterally by the fault.

Caballo granite

The Caballo granite is a pink to red, nearly equigranular, medium-grained rock containing phenocrysts of plagioclase, microcline, and microperthite in a groundmass of feldspar, quartz, and minor chlorite. This rock is locally well foliated and in thin section shows quartz grains with undulatory extinction. Plagioclase crystals are highly sericitized.

The pink granite is massive and homogeneous over an irregularly shaped area of exposure. To the south and southwest, this unit is complexly interlayered with gneiss and amphibolite. The intrusion is generally concordant with compositional layering in supracrustal rocks. The concordance may be due both to primary intrusive relations and to postintrusive strain with reorientation of contacts and xenoliths. Along these contacts, extensive, thin, primary granitic veins have pervasively invaded mafic host rocks.

GEOCHEMISTRY

Several samples of granitic rock were analyzed for whole-rock chemistry. Major- and trace-element data were obtained by x-ray fluorescence techniques. Tab. 1 summarizes these results.

C.I.P.W. normative mineralogy, based on whole-rock chemistry, was used to classify these rocks according to normative feldspar ratios (O'Connor 1965). Both samples of pink granite plotted in the granite field. Both samples of biotite granodiorite plotted in the granodiorite field. According to the ternary diagram (Al_2O_3–CaO–$K_2O + Na_2O$) of Shand (1947), both granites are peraluminous, whereas both granodiorites are metaluminous. In both of these ternary diagrams, the biotite-rich granitic xenolith described above plots in an intermediate position between the granites and granodiorites, suggesting some degree of contamination or alteration of the xenolith by the granite.

TABLE 1—Whole-rock geochemical analyses of plutonic rocks, Caballo Mountains. (1) = biotite-granodiorite porphyry; (2) = biotite-granodiorite porphyry from NW map area; (3) = biotite "granite" from large xenolith in pink granite; (4) = pink granite; (5) = pink-granite sill in amphibolite.

Major Elements (Wt. %)	(1)	(2)	(3)	(4)	(5)
SiO_2	60.54	58.13	69.94	76.34	75.80
TiO_2	0.96	1.31	0.42	0.11	0.27
Al_2O_3	16.87	15.63	14.98	13.36	12.65
Fe_2O_3	6.33	6.99	3.47	1.29	2.13
MnO	0.06	0.07	0.03	-	-
MgO	2.75	3.15	1.48	0.32	0.53
CaO	3.90	4.43	2.35	0.13	0.68
Na_2O	3.99	3.72	4.05	3.69	2.77
K_2O	4.00	3.66	4.21	6.05	5.72
P_2O_5	0.31	0.40	0.11	0.04	0.05
H_2O+	1.35	3.65	1.12	0.47	0.99
Total	101.06	101.13	102.16	101.80	101.59

Minor Elements (ppm)	(1)	(2)	(3)	(4)	(5)
Sr	587	521	325	71	53
Rb	165	200	227	237	160
Nb	11	15	18	3	9
Zr	404	440	177	123	247
Pb	19	22	36	58	31
U	4	8	6	5	5
Th	10	26	23	32	25
Y	82	64	86	65	64

STRUCTURE

Fabrics

In spite of limited exposures of supracrustals and a lack of metasedimentary rocks containing porphyroblasts, the tectonite fabrics observed in the various rock types can be combined to provisionally reconstruct the Precambrian kinematic history of the area.

Well-developed foliations and minor folds are apparent in all supracrustal lithologies. Evidence indicates three deformational events. Compositional layering and the dominant cleavage (either S_1 or S_2) in all rocks (including granitic rocks) generally dip 40°–80° in a southerly direction. The earliest event (D_1) produced a layer-parallel foliation (S_1) defined by aligned micas in the felsic gneiss (Fig. 4). In the gneissic units, S_1 is contorted by small, tight, upright F_2 folds (Fig. 5) whose axial surfaces (S_2) parallel or are subparallel to S_1. Hinge lines of small F_2 folds plunge east or west at low angles. Although map patterns consisting of repetitions and terminations of units are suggestive of map-scale folding (Fig. 2), no definite evidence was found for such folds. Within the felsic gneiss, the S_2 axial-plane cleavage is only weakly and locally developed. The only potential D_1 fold was found in a float block of felsic gneiss. In this rock, both limbs of a small, asymmetric fold have been totally sheared off parallel to the S_1 cleavage. In the northern map area, the sense of shear during the D_1 event is suggested from the asymmetry of recrystallized "tails" around small xenoliths in the felsic gneiss. This feature indicates dextral shear as viewed toward the west.

The dominant cleavage in amphibolites is either S_1 or S_2. Microstructural evidence for two fabrics in amphibolites is lacking and the amphibolites do not display minor F_2 folds. Thus, if the cleavage is S_1, S_2 is absent, and if the cleavage is S_2, S_1 has been totally obliterated

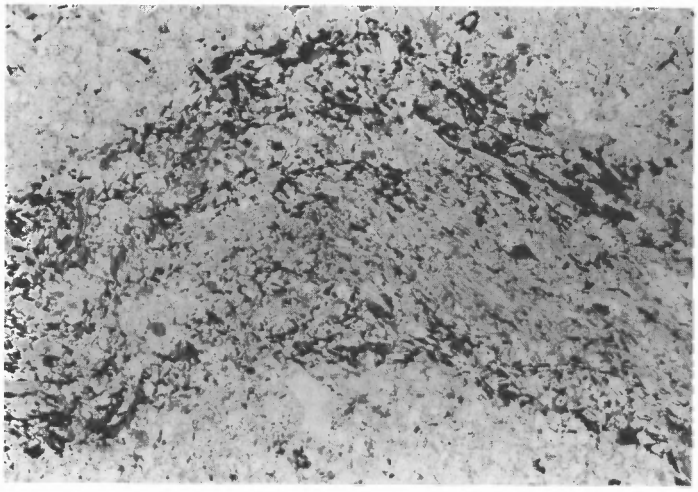


FIGURE 4—Photomicrograph of the hinge zone of a small F_2 fold in felsic gneiss. Note folded mica-rich layer containing biotite, muscovite, and opaques that defines S_1 foliation. Plane-polarized light. Photo is 15 mm across.



FIGURE 5—Small asymmetric F_2 fold in felsic gneiss, Caballo Mountains. Dime for scale.

by S_2. Most likely, the dominant cleavage in amphibolites is S_1. A third deformation (D_3) is characterized by small, nonpenetrative, crenulation folds seen locally in biotite amphibolite, and apparently does not represent a significant strain event.

All plutonic rocks within the area are penetratively deformed, with the finest grained, most biotite-rich rocks exhibiting the best developed foliation. Although the orientation of this foliation is consistent with either S_1 or S_2 in supracrustal rocks, several lines of evidence suggest that this foliation, especially in the granodiorite, may be S_1. First, many small granitic dikes intrude the mafic supracrustals along the granite–amphibolite contacts. These dikes are foliated, are generally aligned parallel to the dominant cleavage, and are commonly folded by D_2-style folds. Second, polyphase deformation in the granodiorite is suggested by the local presence of two cross-cutting, planar fabrics. However, these foliations may represent S–C surfaces that formed during a single shear strain. Third, evidence from the felsic gneiss suggests that the S_1 foliation-forming strain was greater than the S_2 foliation-forming strain. Thus, the strong intensity of the foliation of the granitic rocks may be best attributed to the D_1 rather than the D_2 event. Finally, granodiorite in the northwestern map area contains lens-shaped xenoliths of felsic gneiss elongate parallel to the dominant foliation. Gneissic layering in these felsites is aligned parallel to the foliation in the granodiorite, suggesting postintrusive generation of the S_1 fabric. Thus, based on these structural data, it is suggested that the granodiorite, and perhaps the granite, were emplaced pre- or syntectonically with respect to D_3, and that both D_1 and D_2 contributed to the strong flattening and alignment of xenoliths in an east–west direction. The effects of forceful emplacement of the plutons into supracrustal rocks are unknown, but the map pattern of supracrustal units wrapped around the granodiorite body suggests some manner of kinematic interaction.

Faults

Three generations of faults are recognized in the map area. The oldest are northwest-trending faults in the central map area that cut Precambrian units, but do not appear to cut either Cambrian rocks to the southeast or Cenozoic sediments and faults to the northwest. The fault zones are characterized by either breccia or pinkish, fine-grained, quartz-rich aplite veins. All of these faults dip approximately 60° northeast (Fig. 6). Both displacement sense and separation are unknown. These faults may be Precambrian in age.

A second generation of faults represented by an east-trending vertical fault zone in the northern map area is possibly Miocene or younger (Kelley & Silver 1952). Several fault splays to the west have isolated wedges of Paleozoic rock within Precambrian rock. Striated slickensides in granitic rocks within the fault zone document both strike–slip and dip–slip components of motion. This fault zone is vertical and is silicified and mineralized locally. No evidence within the map area precludes Laramide and younger movement along this fault zone. The youngest faults in the area are the Caballo and subsidiary, north-trending faults in the western map area which offset both Santa Fe Group sediments and the highest pediment level. The Caballo fault appears to truncate the east-trending Cenozoic fault.

In the west-central map area, where several faults converge, blocks of supracrustal rocks separated by these faults show large variations in attitudes of compositional layering, presumably reflecting individual block rotations.

PRECAMBRIAN GEOLOGIC HISTORY

Excellent evidence for three fabric-forming events is contained within the supracrustal rocks of the Caballo Mountains. D_1 was a relatively high-strain event characterized by gneissic layering in felsite units and probably by a strong foliation in amphibolites and granitic rocks. D_2 appears to have been less intense and resulted mainly in the formation of minor folds in gneiss. D_3 was a nonpenetrative, low-strain event characterized by small, local crenulation folds in amphibolites. Although both granitic plutons may have been emplaced before the major foliation-forming event (D_1), it is possible that intrusion of the pink granite postdated D_1. Tab. 2 outlines the proposed Precambrian geologic history of the rocks of the southern Caballo Mountains.

DISCUSSION

Major Proterozoic sequences of felsic metavolcanic rocks in northern and central New Mexico have U–Pb zircon ages of about 1,700 Ma (Williams et al. 1986) and 1,650 Ma, respectively. Bauer & Williams (1985) suggested that correlative stratigraphies may exist in both regions, and that the felsic volcanics exposed in the north may underlie the same quartzite-dominated sedimentary sequence that felsic volcanic apparently overlie in central New Mexico. It has yet to be demonstrated that supracrustal rocks older than about 1,660 Ma crop out south of Santa Fe. The presence of a granitic rock from the Black Range dated by a U–Pb zircon method at 1,655 ± 15 Ma (Stacey & Hedlund 1983) suggests that old supracrustal rocks may indeed exist in that part of southern New Mexico. If so, then the simple model according to which Precambrian crustal ages become progressively younger southward in New Mexico may not hold for at least one sequence of supracrustal

TABLE 2—Summary of Precambrian geologic history, from oldest to youngest, of the southern Caballo Mountains.

Event
Accumulation of mafic volcanic rocks.
Emplacement of felsic gneiss protolith into basalts.
Burial, followed by intrusion of granodiorite.
Intrusion of pink granite. (May post-date D1)
D_1: Relatively high strain event with development of strong schistosity in all rocks.
D_2: Possibly continuation of D_1, with modification of strain environment and development of folds in gneissic units.
D_3: Weak cross-folding event.
Faulting (timing uncertain).

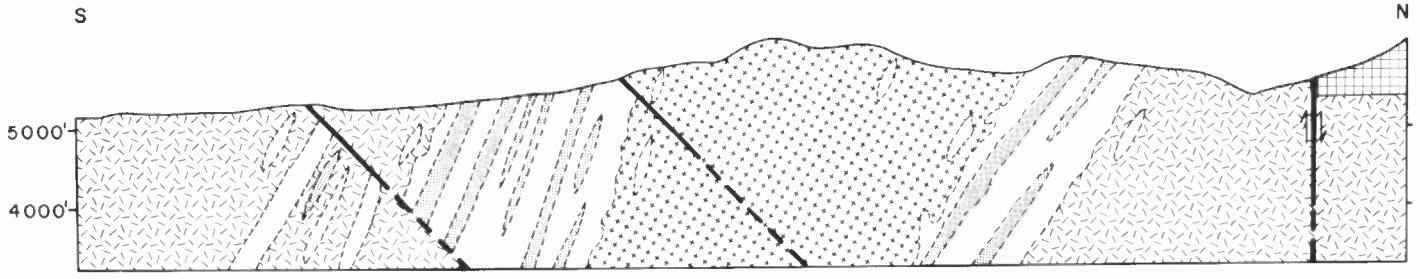


FIGURE 6—Generalized north–south structural cross section across area of supracrustal rocks exposed in the Caballo Mountains. No vertical exaggeration. Key to lithologies is the same as on geologic map (Fig. 2).

rocks. Our ongoing U–Pb zircon geochronologic study of rocks in the Caballo Mountains is the first step toward testing this possibility.

Most of the recent detailed studies of Proterozoic rocks exposed in northern New Mexico in the Tusas Range (M. Williams oral comm. 1986), Picuris Range (Bauer 1984, Holcombe et al. 1985), Taos Range (Grambling et al. 1986), and Truchas–Rio Mora areas (Grambling & Codding 1982, Grambling 1979), and in central New Mexico in the Manzano Mountains (Bauer 1983, Grambling 1982), Manzanita Mountains (Cavin 1985), Pedernal Hills (Armstrong & Holcombe 1982, Bauer & Williams 1985), and Lemitar, Magdalena, and Chupadera Mountains (Bowring et al. 1983) have described remarkably similar deformational histories of supracrustal rocks involving complex polyphase tectonism at intermediate-grade metamorphism. Furthermore, many of these areas contain one or more pre- to syntectonic granitic plutons. Rocks of the Caballo Mountains have experienced an analogous polyphase structural history in which an early episode of foliation-forming shear strain (D_1) is followed by a coaxial, upright-folding event (D_2), and late, weak, nonpenetrative cross-folding (D_3). Multiple granitic plutons may have been intruded pre- or syntectonically with respect to D_1 (or possibly D_2), and peak metamorphic conditions were within the amphibolite facies and followed D_2.

The general east-trending structural grain of the Caballo units is consistent with that of many of the other Proterozoic rocks exposed in isolated uplifts throughout New Mexico. In southern and central New Mexico, the northern San Andres, Chupadera, Magdalena, La Joyita Hills, Pedernal, Manzano, and Sandia areas are all dominated by east- to northeast-trending structural grains. In northern New Mexico, the Truchas, Picuris, and Tusas ranges all either exhibit general east–west striking fabrics or are overprinted by east–west striking structures.

The possibility that similar lithologies (of comparable ages?), which have experienced similar tectonic and intrusive histories, exist in most exposed uplifts from northern New Mexico to at least as far south as the Caballo Mountains suggests that in the early Proterozoic a very large, possibly continuous, tectonic province may have existed for the production and preservation of these rocks, and that during subsequent tectonism and crustal evolution the strain and metamorphic environments were remarkably similar over much of the state. Further work combining structural mapping and U–Pb geochronology in southern New Mexico is needed to better document the extent and nature of this possible tectonic province.

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