STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of geologic studies in the Sangre de Cristo Wilderness Study Area in the Rio Grande and San Isabel National Forests, south-central Colorado. The area was designated as a wilderness study area under Public Law 96-560 in 1980.

STRUCTURAL GEOLOGY

The Sangre de Cristo Range from Blanca Peak northward to the Arkansas River is composed mostly of Proterozoic crystalline rocks and Paleozoic clastic sedimentary rocks. The crystalline rocks consist of a wide variety of dominantly potassium-poor gneisses of probable volcanic and volcaniclastic protolith that are intruded by several large plutons and numerous smaller plugs, dikes, and sills, all of Proterozoic age. The clastic rocks comprise thick sequences of near-source conglomerate and conglomeratic sandstone red beds. These rocks have been folded and faulted by Laramide compressional forces from Late Cretaceous to Eocene time (Burbank and Goddard, 1937; Tweto, 1975) and subsequently intruded by mid-Tertiary stocks, sills, and dikes of mafic to felsic composition.

Laramide structures consist of large, arcuate thrust plates that intersect and overlap one another to form a northwesterly trending belt that extends across the mountains from Huerfano Park to Valley View Hot Springs. All of the thrust plates within the central part of the range are bounded by west-dipping faults, some of which extend into the basement of Proterozoic crystalline rocks. At the south end of the range, a sequence of three thrust plates is identifiable in several locations. The upper plate is Proterozoic gneiss, the middle plate is Paleozoic sedimentary rock, and the lower plate is Proterozoic gneiss. Along the east side of the range, the Alvarado fault is interpreted as an east-dipping thrust bringing Proterozoic crystalline rocks west over Paleozoic rocks. Thrust plates in both Paleozoic and Proterozoic rocks are internally folded; the folds tighten and decrease in amplitude toward the leading edge of the plate. Thrust faults are dominantly high- to medium-angle reverse faults along the leading edge of the thrust plates, but flatten at depth. Total shortening within the range is approximately 8 km at the latitude of Westcliffe and about 14 km near the latitude of the Great Sand Dunes.

During Neogene time the Sangre de Cristo Range was uplifted and the adjoining San Luis and Wet Mountain Valleys were down-dropped by extensional rift-related faulting. The principal range-front faults are the Sangre de Cristo and Alvarado normal faults, which in part follow the general zone of Laramide thrusting along the west and east margins of the range. Sediment eroded from the range, along with flows of mafic lava that were erupted from faults along the southwest side of the Wet Mountain Valley and in the southern San Luis Valley, partially filled the adjoining rift valleys. The floor of the Neogene sedimentary and volcanic fill of the San Luis Valley is 2,000-7,000 m below the top of the range; the floor of the Wet Mountain Valley fill is about 2,000 m below the top of the range. Rifting is still in progress in the San Luis Valley (Scott, 1970), west of the range, but may have ceased in the Wet Mountain Valley.

Post-Laramide structures consist of north-northwest-striking, high-angle faults that are apparently related to the Neogene-to-Holocene rifting and uplift. These faults generally follow the east and west range fronts north of the Great Sand Dunes National Monument but cut across the range south of the monument.

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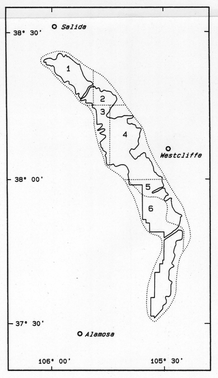

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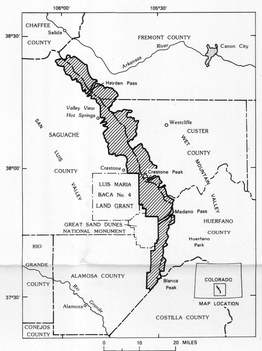
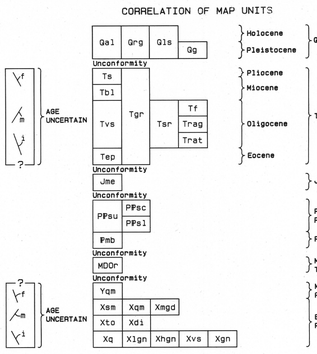


Figure 1.--Map showing location of Sangre de Cristo Wilderness Study Area (diagonally ruled), Colorado.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

[Names of plutonic rocks used in the following descriptions follow the classification of Streckeisen (1973) unless otherwise noted.]

Qal **ALLUVIUM (QUATERNARY)**—Sand, gravel, and clay deposited by streams; includes Holocene stream deposits, Pleistocene glacial outwash and alluvial fan deposits, and, locally, colluvium; also includes pediment deposits of Quaternary and possibly Tertiary age along east side of range south from South Colony Creek, composed of deeply weathered detritus derived mostly from Proterozoic and upper Paleozoic rocks. Thickness ranges from several meters to several hundred meters in alluvial fans

Qrg **ROCK GLACIERS (QUATERNARY)**—Deposits of angular blocks at base of steep slopes and floors of cirques. Flow morphology suggests formation by ice-cored flow. Thickness as much as 30 m

Qls **LANDSLIDE DEPOSITS (QUATERNARY)**—Deposits of angular rock debris at the base of steep slopes; includes Holocene landslide deposits along Huerfano River. Forms typically hummocky topography. Thickness as much as 30 m

Qg **GLACIAL DEPOSITS (PLEISTOCENE)**—Gray, unsorted till of Pinedale, Bull Lake, and pre-Bull Lake age; contains boulders as much as 3 m in diameter. Older moraines have more subdued topographic features and contain tillstones with thicker weathering rinds than those found in younger moraines (Taylor, Scott, Wobus, and Epis, 1975). Deposits as much as 10 m thick

Ts **SANTA FE (PLIOCENE AND MIOCENE) AND DRY UNION (MIOCENE) FORMATIONS UNDIVIDED**—Stratified gravel, sand, and clay in subsurface of Wet Mountain Valley (Scott and Taylor, 1975). Thickness as much as 400 m

Tbl **BASALTIC TO LATITIC VOLCANIC ROCKS (MIOCENE)**—From Crystal Creek to South Fork of Bruff Creek, along eastern side of range, flows of Miocene(?) olivine basalt more than 75 m thick (Burford, 1960, p. 105-115). From Goat Creek northward along northeastern side of range, in descending stratigraphic position, Miocene andesitic lahar, biotite latite, and dense hornblende-pyroxene andesite; about 200 m thick (Scott and Taylor, 1974; Taylor, Scott, Wobus, and Epis, 1975)

Tvs **VOLCANIC ROCKS AND INTERBEDDED SEDIMENTS (OLIGOCENE)**—In descending stratigraphic position, Gribbles Park Tuff, unnamed gravels, mudflows and andesite, Thorn Ranch Tuff, biotite latite, and Wall Mountain Tuff (Scott and Taylor, 1974; Taylor, Scott, Wobus, and Epis, 1975). Total thickness as much as 1,000 m in Goat Creek paleovalley (Scott and Taylor, 1975, p. 10)

Tep **ECHO PARK ALLUVIUM (EOCENE)**—Arkosic conglomerate, sandstone, and finer grained rocks. Overlies Paleozoic and Proterozoic rocks with pronounced angular unconformity. Possibly more than 400 m thick (Scott and Taylor, 1975)

Tgr **GRANITE AND GRANODIORITE (TERTIARY)**—Small irregularly shaped intrusions of tan to light-gray, leucocratic, medium- to coarse-grained, seriate granite and granodiorite; nonfoliated; composed of plagioclase, microcline, and quartz in subequal amounts with 1-5 percent biotite; plagioclase is zoned; accessory minerals include magnetite and apatite; local alteration to muscovite and chlorite; includes partially resorbed xenoliths of fine-grained, crystalline rocks

Tsr **SLIDE ROCK MOUNTAIN STOCK (OLIGOCENE)**—Tan to pink, fine-grained, homogeneous, leucocratic granite at Slide Rock Mountain; equigranular, nonfoliated; composed of subequal amounts of plagioclase, microcline, and quartz with trace amounts of muscovite, magnetite, and biotite; contains miarolitic cavities as much as 5 mm in diameter lined with hematite-coated quartz and feldspar crystals. Preliminary K-Ar age determination about same age as Rito Alto stock tonalite (Todd Ryerie, oral commun., 1983)

Tf **FELSIC IGNEOUS ROCKS (OLIGOCENE)**—Dikes and sills of light-gray to white, fine-grained, igneous rock; usually porphyritic; nonfoliated; composed of microphenocrysts as much as 2 mm in diameter of quartz, feldspar, and locally minor biotite in an aphanitic groundmass of the same minerals; commonly partly altered to quartz and sericite; mafic minerals generally less than 5 percent. Age based on one fission-track determination of 29.5 +1.1 m.y. on zircon in a dike approximately 3 km east of Eureka Mountain (C. W. Naeser, written commun., 1982). Thickness as much as 50 m

Trag **RITO ALTO STOCK (OLIGOCENE)**—Composite stock composed of a nonuniform, tonalite to quartz monzodiorite main phase (Trat) intruded by a later, more homogeneous, leucocratic, granite phase (Trag); both phases cut by several, generally 3- to 10-m-wide, white, porphyritic dikes (Tf); small amounts of molybdenum mineralization are associated with the stock; descriptions partially summarized from a petrographic study of Toulmin (1953)

Trag **Granite**—Tan to pink, medium- to coarse-grained, leucocratic, granite porphyry; subhedrally seriate with maximum grain size 9 mm to porphyritic with orthoclase phenocrysts as much as 3.5 cm in diameter; nonfoliated; composed of approximately 35 percent plagioclase, 35 percent orthoclase, 25 percent quartz, and 5 percent biotite; minor minerals include muscovite, magnetite, and hematite; sparse miarolitic cavities as much as 3 mm across locally lined with crystals; quartz-molybdenite greisens occur along contacts with tonalite (Trat)

Trat **Tonalite**—Medium-gray, medium-grained porphyry ranging in composition from tonalite to quartz monzodiorite; more mafic in core and more felsic near borders of stock; nonfoliated; pink to white plagioclase phenocrysts as much as 1 cm in diameter in a matrix of 1 mm grains; plagioclase averages 60 percent, quartz 15 percent, microcline 10 percent, and mafic minerals 15 percent; mafic minerals include biotite, commonly accompanied by hornblende and less commonly by augite; rare miarolitic cavities less than 1 mm in diameter contain moderately well developed crystal linings; includes xenoliths of sandstone and siltstone of the Sangre de Cristo and Minturn Formations (PFsu and Pmb). Sediments metamorphosed as much as 1 km from contact. Fission-track dates of 27.1 ±3.2 m.y. on zircon and 31.8 ±2.3 m.y. on sphene were reported by Marvin and others (1974) from a single tonalite sample

Jme **MORRISON FORMATION (UPPER TRIASSIC) AND ENTRADA SANDSTONE (MIDDLE JURASSIC) UNDIVIDED**—Description summarized from Volckmann (1965, p. 66-67); unconformably overlie Sangre de Cristo Formation (PFsu) and unconformably overlain by olivine basalt (Tbl) and pediment gravels (Qal)

Morrison Formation—Interbedded gray and brown shale, brown sandstone and minor gray limestone. Thickness about 75 m

Entrada Sandstone—Thin-bedded, white to light-gray, quartz sandstone. Thickness about 12 m

SANGRE DE CRISTO FORMATION (PERMIAN AND PENNSYLVANIAN)

PFsu **Undivided**—Red arkosic sandstone, conglomeratic sandstone, siltstone, shale, and minor limestone; located east of Spread Eagle Peak, Marble Mountain, and Huckleberry Mountain faults. Conformably overlies Middle Pennsylvanian Minturn Formation (mb); top eroded, unconformably overlain by Jurassic Entrada Sandstone (Jme) at Loco Hill. Thickness about 1,400 m below an eroded top at Horn Peak

PFsc **Crestone Conglomerate Member**—Red conglomerate, conglomeratic sandstone, sandstone, and minor siltstone and shale; located entirely west of Spread Eagle Peak, Marble Mountain, and Huckleberry Mountain faults. Coarse conglomerate contains boulders and cobbles of Early Proterozoic gneiss (Xgn and Xlgn), syenite, and quartz monzonite (Xqm); interfingers with lower member of Sangre de Cristo Formation northward from Mount Owen; unconformably overlies Middle Pennsylvanian Minturn Formation (Pmb) from Crestone Needle to Sand Creek; unconformably overlies Early Proterozoic gneiss (Xgn) at Spanish Creek, west of Medano Creek, and in Sand Creek. Thickness approximately 2,000 m

PFsl **Lower member**—Red arkosic sandstone, conglomeratic sandstone, siltstone, and shale; located entirely west of Spread Eagle Peak fault. Conformably overlies Middle Pennsylvanian Minturn Formation (Pmb) from Mount Owen northward; interfingers with overlying Crestone Conglomerate Member (PFsc) and thickens northward. Thickness about 600 m west of Rito Alto Peak

Pmb **MINTURN FORMATION (MIDDLE PENNSYLVANIAN) AND BELDEN FORMATION (MIDDLE AND LOWER PENNSYLVANIAN) UNDIVIDED**

Minturn Formation—Gray arkosic sandstone, conglomeratic sandstone, siltstone, shale, and minor limestone. Contains radioactive and copper-bearing siltstone and shale in upper part; marine limestone most abundant in upper part, where individual beds used as markers for contact with overlying Sangre de Cristo Formation (PFsu and PFsl); gypsum in upper part near Arkansas River Valley; contains fossils of marine invertebrates and land plants. Conformably overlies Belden Formation in northern part of range. Base faulted along east side of range; occurs in thrust plates west of Mosca Pass, at California Peak, and east of Blanca Peak. Maximum thickness about 2,000 m at Middle Fork of Taylor Creek

Belden Formation—Description summarized from Taylor, Scott, and Wobus (1975); occurs in Arkansas River Valley and along west side of range southward to Valley View Hot Springs. Dark-gray, carbonaceous shale, siltstone, and thin-bedded sandstone. Unconformably overlies lower Paleozoic sedimentary rocks (MDOr). Thickness 150 m

MDOr **MISSISSIPPIAN THROUGH ORDOVICIAN SEDIMENTARY ROCKS UNDIVIDED**—Unconformably overlie Proterozoic rocks and are overlain by same units in thrust contact. Description summarized from Taylor, Scott, and Wobus (1975), Karig (1964), and Koch (1963); in descending stratigraphic order:

Lower Mississippian Leadville Limestone—Dark-gray, massive limestone, locally contains limestone breccia. Thickness 70 m

Mississippian(?) to Upper Devonian Chaffee Group—Gyer Dolomite (yellow-gray, cherty dolomite, 30 m thick) and Parting Quartzite (gray, massive quartzite and dolomite, 15 m thick)

Upper Ordovician Fremont Dolomite—Dark-gray, coarsely crystalline dolomite, 70 m thick

Middle Ordovician Harding Sandstone—Pink-red, thin-bedded quartzite, 30 m thick

Lower Ordovician Manitou Limestone—Dark-gray, fine- grained, cherty, dolomitic limestone, 60 m thick

Yqm **QUARTZ MONZONITE (MIDDLE PROTEROZOIC)**—A large stock of gray to pink, medium-grained, equigranular, leucocratic, quartz monzonite (granite in classification of Streckeisen, 1973). Generally nonfoliated, local weak biotite alignment; composed of approximately 35 percent plagioclase, 30 percent microcline, 30 percent quartz, 2-5 percent biotite, and minor magnetite; extensively altered to chlorite, epidote, and muscovite; plagioclase sericitized; inclusions of mafic gabbroic sheets along western margin. Located along the Sangre de Cristo fault near Crestone. Correlated with the 1,435 b.y. Silver Plume Quartz Monzonite of central Colorado (Taylor, Scott, Wobus, and Epis, 1975) on the basis of petrology and texture

Xmgd **GRANODIORITE OF METHODIST MOUNTAIN (EARLY PROTEROZOIC)**—Several stocks of pinkish-tan to dark-gray, fine- to medium-grained, foliated granodiorite and quartz monzodiorite; appears porphyritic in hand specimen, but close examination reveals a subsidic of fine quartz and feldspar grains in clots surrounded by layers of fine-grained biotite. Generally composed of approximately 60 percent plagioclase, 15 percent microcline, 10 percent quartz, and 15 percent mafic minerals; mafic minerals consist of biotite and hornblende with biotite generally dominant and as much as 5 percent magnetite; moderately altered to chlorite, epidote, and sericite; includes common xenoliths of metadiorite (Xdi) and muscovite-bearing gneiss and schist (Xvs). Correlated with Boulder Creek Granodiorite of central Colorado on the basis of 1,700 m.y. Rb-Sr date (Taylor, Scott, and Wobus, 1975)

Xsm **SYENITE AND MONZONITE (EARLY PROTEROZOIC)**—A large stock of reddish-tan, medium- to coarse-grained porphyry of syenite and monzonite composition; nonfoliated to weakly foliated. Subhedral microcline phenocrysts (as much as 1.2 cm in diameter) with thin albite(?) rims; composed of 30-80 percent microcline, as much as 35 percent plagioclase, 1-5 percent quartz, and as much as 10 percent biotite with minor muscovite, zircon, and sphene; moderate alteration of plagioclase and biotite. Contact with Paleozoic sedimentary rocks faulted; contact with gneiss (Xgn) interlayered. Through-going fractures common in outcrop. Located along the Sangre de Cristo fault near the western edge of the range

Xto **TONALITE GNEISS (EARLY PROTEROZOIC)**—White to very light-gray-green, buff-weathering gneiss of tonalite composition. Porphyroblastic with aggregates of mafic minerals as much as 1.5 cm across; groundmass grain size generally 3-4 mm; composed of approximately 60 percent plagioclase, 30 percent quartz, 8 percent mafic minerals, 2 percent or less potassium feldspar; accessory minerals include magnetite, apatite, sphene, and rarely garnet; weak foliation formed by alignment of mafic mineral aggregates; weak to moderate cataclasis throughout unit becoming more intense near faults and shear zones; original mafic minerals thoroughly altered to epidote, chlorite, and muscovite with rare relict biotite preserved; potassium feldspar increases (to as much as 10 percent) near major faults. Contains numerous mafic dikes as much as several tens of meters thick; dikes shown on map are representative of mafic dike distribution, but not all dikes can be shown at this scale; dikes most abundant near contact with metadiorite (Xdi) where they make up 50 percent of outcrop; some mafic dikes indistinguishable from metadiorite; abundance of dikes decreases rapidly away from metadiorite to less than 1 percent of outcrop in most areas; dikes commonly foliated parallel to foliation of surrounding gneiss. Contact with metadiorite is interlayered and metadiorite xenoliths occur in tonalite gneiss near contact; tonalite gneiss restricted to a large body south end of study area. Protolith may have been a thick stack of dacitic volcanics, or an intrusive rock of tonalite composition; lack of compositional banding and homogeneity of composition over several kilometers suggest it was intrusive

Xdi **METADIORITE (EARLY PROTEROZOIC)**—Dark-gray to very dark green, meta-igneous rock of diorite composition; commonly porphyritic, 3-7 mm phenocrysts of dark-green hornblende and white to gray plagioclase in a finer grained matrix of dominantly plagioclase; consists of approximately 50 percent each of hornblende and plagioclase, trace to 4 percent opaque minerals (magnetite, pyrite, and locally copper sulfides), trace to 1 percent apatite, less than 1 percent quartz; weak foliation near contacts gives way to granoblastic interior; contains as much as 10 percent quartz near contacts; forms large and small intrusive bodies at north and south ends of range, and large dikes near Blanca Peak. Protolith may have been thick stacks of mafic extrusive rocks, or intrusive rocks of diorite or gabbro composition; large southern body at Blanca Peak commonly agmatitic with angular blocks of dark diorite up to several meters surrounded by light-colored, tonalitic matrix; weak compositional layering is visible in a few individual blocks of diorite. Body commonly cut by thin, white, aplite dikes and white, quartz-porphyry dikes (Tf). Contacts with tonalite gneiss (Xto) are interlayered dark quartz diorite gneiss and light tonalite gneiss over several tens of meters

Xq **QUARTZITE (EARLY PROTEROZOIC)**—Black and gray to purple and white, layered, quartzite breccia; blocks of layered quartzite range from several millimeters to tens of meters across; matrix is crushed quartzite with minor amounts of iron oxide and muscovite; blocks of layered quartzite have been completely recrystallized to interlocking grains and subsequently shattered; numerous fractures cross-cut source blocks; unit consists of 90-95 percent quartz, 3-8 percent opaque minerals, and minor muscovite and biotite; opaque minerals include magnetite, specular hematite, and earthy hematite; opaque minerals define layers in blocks which probably reflect original bedding. Unit occurs as a narrow, fault-bounded sliver between Crestone Conglomerate (PFsc) and quartz monzonite of Music Pass (Xqm) on the west, and gneiss (Xgn) on the east, and as scattered, poorly exposed xenoliths within the quartz monzonite; xenoliths within quartz monzonite have narrow rims of microcline and biotite replacing quartz

Xlgn **LEUCOCRATIC GNEISS (EARLY PROTEROZOIC)**—White to medium-gray, light-pink to light-gray weathering, leucocratic gneiss of granite to granodiorite composition; varies from massive, near summit of Mount Seven, to finely laminated on a millimeter scale to coarsely layered on a scale of several meters; locally migmatitic; generally seriate with grain size about 2 mm, locally porphyroblastic with crystals as much as 5 cm in diameter; leucocratic, massive and laminated gneiss and leucocratic layers of banded gneiss make up approximately 80 percent of unit and average about 35 percent plagioclase, 30 percent quartz, 30 percent microcline, and 4 percent biotite with rare traces of hornblende and muscovite; mafic layers in banded gneiss make up the remainder of unit and average about 40 percent plagioclase, 25 percent quartz, 20 percent microcline, and 15 percent mafic minerals; mafic minerals consist of subequal amounts of biotite and hornblende, as much as 2 percent magnetite, and as much as 1 percent sphene; original mafic minerals commonly altered to chlorite; moderate to strong foliation in laminated and banded gneiss consists of alignment of compositional bands and micaceous minerals; foliation dominantly steep and generally strikes parallel to north-northwest regional structural grain; compositional bands and laminations sharply bounded and locally pinch and swell; small-scale, open folds common; swirled, disharmonically folded migmatites and nebulites rare; quartz veins and pods and small pegmatites common; weak cataclasis pervasive. Protolith was probably a laminated to large bedded sequence of arkosic sediments and volcanic flows of rhyolite to dacite

Xhgn **HORNBLENDE GNEISS (EARLY PROTEROZOIC)**—Texturally varied from schistose to massive, but compositionally homogeneous, fine- to medium-grained, quartz-plagioclase-hornblende gneiss; dominantly well foliated, laminated gneiss with sharply bounded, 1-5 mm thick, continuous, mafic and leucocratic layers; locally, nonlaminated, medium-grained, massive rock; generally composed of subequal amounts of hornblende and plagioclase, approximately 5 percent quartz, and minor amounts of biotite and potassium feldspar. Contact with gneiss (Xgn) approximate and located where mafic, hornblende gneiss dominant over more felsic rocks; thus, numerous small bodies of hornblende gneiss occur within the gneiss unit (Xgn)

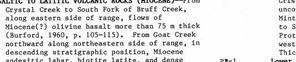
Xvs **MUSCOVITE-BEARING GNEISS AND SCHIST (EARLY PROTEROZOIC)**—Interlayered felsic and mafic, muscovite-bearing gneiss and schist; felsic gneiss is white to light gray, reddish tan weathering, fine to medium grained; biotite, muscovite, plagioclase, and quartz present in varied proportions with quartz generally 50 percent or more of the rock; quartz-augen porphyroblasts as large as 4 cm common; alkali feldspar scarce in fine-grained, well-foliated varieties and increases to a maximum of 10 percent in coarse-grained gneiss; minor cordierite, garnet, and sillimanite occur locally; felsic schists are more micaceous members of the assemblage; foliation generally well developed; mafic gneisses are medium to dark gray, medium grained, well foliated, and generally banded or laminated; hornblende and biotite make up 40-70 percent of the rock with hornblende dominant; quartz generally exceeds plagioclase, alkali feldspars are rare; minor mafic varieties include biotite gneiss, porphyroblastic biotite gneiss, actinolite-bearing hornblende gneiss, and garnet-biotite schist; layers of felsic and mafic units range from a meter to several hundred meters in thickness. Contact with gneiss unit (Xgn) interlayered and gradational and is identified on the basis of the dominance of muscovite-bearing versus muscovite-poor felsic layers

Xgn **GNEISS (EARLY PROTEROZOIC)**—An extremely variable complex of mafic and felsic gneiss, schist, and small bodies of nonfoliated intrusive rock; occurs along western side of Sangre de Cristo Range for most of its length; can be separated into two slightly different parts, structurally and lithologically, at Medano Pass; north of Medano Pass unit is more coherent structurally and less variable lithologically than south of the pass; both regions contain leucocratic, biotite-quartz-plagioclase-microcline gneiss and hornblende-bearing varieties of leucocratic gneiss interlayered with mafic quartz-plagioclase-hornblende gneiss; leucocratic gneiss variable in grain size, intensity of foliation, and thickness of compositional layers; hornblende gneiss is generally fine grained, well foliated, and thinly banded to laminated. All lithologies are altered to chlorite, epidote, and sericite; alteration increases in vicinity of Sangre de Cristo fault. North of Medano Pass these lithologies are interlayered on scales that consist of millimeters to several tens of meters; individual layers generally continuous and mappable; foliation patterns generally coherent over large areas. Contact with muscovite-bearing gneiss and schist (Xvs) interlayered and gradational and has been mapped on the basis of dominance of muscovite-poor versus muscovite-bearing felsic layers. South of Medano Pass a fine- to coarse-grained alaskitic gneiss is added to the lithologic variety; alaskite varies from weakly foliated to nonfoliated; continuous compositional layers are absent over distances larger than hundreds of meters; individual layers are not traceable over larger distances; minor lithologies in both areas include weakly foliated to massive granite of granite similar to quartz monzonite (Yqm) and irregular masses of foliated dioritic rock; a large variety of dikes and sills ranging from aplite and pegmatite to basalt cut the unit

f **FELSIC DIKES AND SILLS (AGE UNCERTAIN)**—A wide variety of light-colored, granitic dikes and sills intrusive into rocks of all ages; includes granite, aplite, pegmatite, quartz rock, and quartz-feldspar pegmatite; equigranular to porphyritic; aphanitic to pegmatitic; generally nonfoliated. Sharp contacts with all host rocks; some dikes mineralized, particularly in vicinity of Blanca Peak. Dominantly Tertiary in age, but may include Precambrian rocks as well. Thickness as much as 10 m

i **INTERMEDIATE DIKES AND SILLS (AGE UNCERTAIN)**—Medium-gray to gray-green, porphyritic dikes and sills of dacitic composition; phenocrysts of plagioclase, quartz, and hornblende as much as 1.5 cm in diameter in a groundmass of plagioclase, quartz, hornblende, and minor microcline; groundmass grain size 0.1-0.01 mm; sharp contacts with host rock; nonfoliated. Dominantly Tertiary in age. Thickness as much as 5 m

m **MAFIC DIKES AND SILLS (AGE UNCERTAIN)**—Dark gray-green to black, porphyritic to coarse-grained, holocrystalline, basaltic and gabbroic dikes and sills; generally massive, locally porphyritic; identifiable minerals include subequal amounts of plagioclase and hornblende with 5-10 percent opaque minerals; pyroxene- and olivine-bearing varieties occur locally; nonfoliated. Sharp contacts with host rocks; dominantly Tertiary in age, but may include Precambrian rocks. Thickness as much as 30 m



Base from U.S. Geological Survey, 1:50,000
Saguache, Custer, Alamosa, Huerfano, and Costilla Counties

APPROXIMATE BOUNDARY OF THE SANGRE DE CRISTO WILDERNESS STUDY AREA

CONTACT—Dashed where approximately located or inferred; dotted where concealed

U NORMAL OR REVERSE FAULT—U, upthrown side; D, downthrown side. Dashed where approximately located; queried where inferred; dotted where concealed

THRUST FAULT—Sawteeth on upper plate; dashed where approximately located; queried where inferred; dotted where concealed

STRIKE AND DIP OF BEDS
26 Inclined
Vertical
27 Overturned

STRIKE AND DIP OF FOLIATION
19 Inclined
Vertical

MONOCLINE—Showing crestline and direction of dip of limbs

SYNCLINE—Showing trough line and direction of dip of limbs
Upright
Overturned

ANTICLINE—Showing crestline, direction of dip of limbs, and direction of plunge
Upright
Overturned

DIKE
Single—Dashed where approximately located
Multiple—Areas where dikes are too numerous to show at map scale

MAP A.-NORTHERN HALF

RECONNAISSANCE GEOLOGIC MAP OF THE SANGRE DE CRISTO WILDERNESS STUDY AREA, SOUTH-CENTRAL COLORADO

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