U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Preliminary geologic map of Chiricahua National Monument Cochise County, Arizona, with digital geologic map data

by

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DESCRIPTION OF MAP UNITS

[Ages for Tertiary igneous rocks are $^{40}Ar/^{39}Ar$ determinations by L.W. Snee (Pallister and others, 1990), except where otherwise noted. Plutonic and volcanic names are in accord with the IUGS system (Streckeisen, 1973; Le Bas and others, 1986), except the subalkaline-alkaline division of Irvine and Baragar (1971) is used. The terms accessory and trace, where referring to mineral abundances, indicate <1 percent and <0.1 percent by volume, respectively. SiO_2 based on the mean values given by du Bray and Pallister (1991)]

SURFICIAL DEPOSITS

Qal **Alluvium (Holocene and Pleistocene)**--Unconsolidated to poorly consolidated silt, sand, gravel, and peaty material in valley bottoms. Includes minor alluvial-fan and colluvial deposits at valley margins

Qaf **Alluvial-fan deposits (Holocene and Pleistocene)**--Poorly sorted, braided distributary deposits of silt- to boulder-size material; forms aprons adjacent to topographic highlands

Qc **Colluvium (Holocene and Pleistocene)**--Poorly sorted silt- to boulder-size material on slopes and in steep valleys. Locally includes small alluvial-fan, talus, and landslide deposits

QTls **Landslide deposits (Quaternary or Tertiary)**--Deposits formed by gravity sliding or flowage. Includes lobate accumulations of poorly sorted soil and rock debris (earthflow deposits) characterized by hummocky topography; occurs on slopes and as eroded outliers. Cuspate breakaway scarps (hachured on map) exposed at heads of some deposits. Degree of erosion and alteration, as well as proximity to Tertiary normal faults and to margin of Turkey Creek caldera suggest a Tertiary age for some deposits

Tcg **Conglomerate (Oligocene?)**--Weakly indurated, poorly sorted, very light gray to light-brownish-gray tuffaceous conglomerate and gritty sandstone. Clasts are principally derived from the underlying Rhyolite Canyon Tuff

ROCKS OF THE TURKEY CREEK CALDERA

Moat deposits

A sequence of crystal-poor rhyolite lava flows and tuffs and subordinate sedimentary rocks deposited in moat of Turkey Creek caldera. The tuff map units contain block-and-ash flows, probably derived from collapse of lava domes, as well as variably welded pumiceous ash-flow tuffs.

Aphyric or sparsely porphyritic high-silica rhyolite lava flows and tuffs are divided into three eruptive units on the basis of stratigraphic position, subtle petrographic differences, and distinct trace-element geochemistry (du Bray and Pallister, 1991).

Tmt_3 **Unit 3 (rhyolite tuff)**--Lavender to reddish-gray rhyolite (76-78 weight percent SiO_2) ash-flow tuff. Aphyric and lithic poor, except near base where quartz, sanidine, and plagioclase xenocrysts and rhyolitic lithic fragments are found. Thickness 20-80 m

Tmr_2 **Unit 2 (rhyolite lava)**--Light-gray to reddish-gray, phenocryst-poor rhyolite (76-78 weight percent SiO_2) lava. Flow layered and intricately flow folded, locally massive. Aphyric or sparsely (0-2 percent) porphyritic or microporphyritic with small (<1 mm) phenocrysts of sanidine, quartz, and opaque oxide minerals; accessory biotite and zircon present in some samples. Devitrified, except at basal flow contact where black or green glassy breccia or flow-layered perlite is locally exposed. Spherulitic and axiolitic (with respect to flow layers) devitrification and granophyric recrystallization common. Contains secondary (vapor-phase) quartz and feldspar crystals. Forms resistant ledges and massive cliffs in exhumed moat of Turkey Creek caldera. Maximum thickness approximately 300 m

Tmt_2 **Unit 2 (tuff)**--Ash-flow deposits and intercalated air-fall tuff and volcaniclastic sedimentary rocks. Mainly light-gray to orange or pink, poorly to densely welded, crystal-poor, rhyolite ash-flow tuff. Typically very sparsely porphyritic; phenocrysts (<1 percent) are quartz and sanidine (both <1 mm) and microphenocrysts of opaque oxide minerals. Similar in phenocryst assemblage and chemistry to overlying rhyolite lava (Tmr_2); however, some ash flows contain more abundant (about 1 percent) phenocrysts, including plagioclase, sanidine, opaque oxides, and accessory biotite. Pumice fragments show axiolitic devitrification and granophyric cores. Degree of welding variable within and between flows. Individual ash flows and intercalated volcaniclastic sedimentary beds range in thickness from <1 m to several tens of meters. Forms multiple low-relief cliffs or slopes below steeper cliffs of rhyolite lava (Tmr_2). Maximum thickness about 100 m

Tmr_1 **Unit 1 (rhyolite lava)**--Light-gray to reddish-gray or brown rhyolite (76-78 weight percent SiO_2) lava. Flow layered and intricately flow-folded but locally massive. Typically aphyric or crystal poor (<5 percent) with sanidine, quartz, and opaque oxide minerals; locally contains trace amounts of plagioclase, hornblende, and clinopyroxene. Some plagioclase and mafic silicates form resorbed crystal clots that are probably xenocrystic. Similar to rhyolite lava of eruptive unit 2 (Tmr_2), except for more variable phenocryst assemblage, less evolved trace-element composition (du Bray and Pallister, 1991), and stratigraphic position. Devitrified, except at basal flow contact where perlitic glass locally contains spherulitic zones and geodes. Carapace breccia locally exposed at margins of lava flows. Flow interiors recrystallized to granophyre and contain vapor-phase quartz and feldspar in amygdules. $^{40}Ar/^{39}Ar$ ages on sanidine: 26.64±0.13 Ma and 26.93±0.17 Ma. Maximum thickness 150 m

Tmt_1 **Unit 1 (tuff)**--Pyroclastic flow and surge deposits. Gray to dark-brown or purplish-brown, densely to poorly welded, typically aphyric or crystal-poor (<2 percent quartz and sanidine) rhyolite ash-flow tuff and light-gray surge beds. Basal vitrophyre passes upward into rheomorphic tuff with convoluted flow banding. Thickness 0-30 m

Dacite of Sugarloaf Mountain

Tdpl **Dacite porphyry lava (Oligocene)**--Isolated black to gray dacite (65 weight percent SiO_2) lava flow remnant atop Sugarloaf Mountain; equivalent of dacite that forms both lava flows at the base of the moat sequence and resurgent intrusion within the Turkey Creek caldera. Contains approximately 10 to 15 percent small (<2 mm) phenocrysts: mainly plagioclase, clinopyroxene, and minor orthopyroxene. Also contains glomerocrysts (to 1 cm across) of plagioclase, clinopyroxene, and opaque oxide minerals, and sparse, large (2-5 mm) alkali feldspar xenocrysts and small (<0.5

mm) quartz. Both plagioclase and alkali feldspars have thick dusty reaction rims; alkali feldspar xenocrysts are exsolved and recrystallized. Formerly glassy groundmass is variably devitrified, locally to fine-grained patchy granophyre. $^{40}Ar/^{39}Ar$ age on sanidine: 26.84±0.13. Thickness about 70 m

Outflow facies Rhyolite Canyon Tuff (Oligocene)

Light-gray, typically pumice-rich and lithic-poor, moderately crystal-rich (15 to 25 percent) quartz-sanidine rhyolite (76-78 weight percent SiO_2) ash-flow tuff erupted from the Turkey Creek caldera. Stratigraphic nomenclature of Fernandez and Enlows (1966) and Drewes (1982) revised and simplified following Latta (1983) and Pallister and others (1990). Divided into intracaldera and outflow facies; intracaldera facies exposed south of the map area, inside caldera. Outflow facies forms a compound cooling unit (Smith, 1960; Christiansen, 1979) consisting of lower, middle, and upper members (depositional units) separated by ash-fall and surge deposits. Phenocrysts composed almost entirely of sanidine and quartz; sanidine is typically more abundant (ratios vary from 2:1 to about 1:1). Sanidine is chatoyant cryptoperthite (approximately Ab_{50}-Or_{50}); forms subhedral, lath-shaped phenocrysts, typically 1-4 mm in length. Quartz is rounded and embayed; <1-3 mm in diameter. Also contains accessory opaque oxide minerals and trace clinopyroxene (augite), zircon, and apatite. Eutaxitic and vitroclastic; locally spherulitic. $^{40}Ar/^{39}Ar$ ages for sanidine samples from outflow facies are 26.94±0.16 Ma and 26.93±0.12 Ma for upper and lower members, respectively. Composite thickness of entire outflow facies in Chiricahua National Monument approximately 450 m. Great thickness, rising unconformity over Faraway Ranch Formation to west, and pinch-out of lower member of Rhyolite Canyon Tuff and underlying Jesse James Canyon Tuff to north, west, and east within the National Monument indicate deposition in a northerly trending paleobasin.

Trco **Outflow facies, undivided**--Most exposures probably equivalent to middle member

Trcu **Outflow facies, upper member**--White, ash-rich surge beds overlain by gray densely to moderately welded tuff. Top of surge beds indicated by dotted line. Surge beds cut by vertical fines-depleted pipes (fossil fumeroles) and overprinted by low-angle secondary Liesegang bands. Trace augite, zircon, and biotite more common than in lower and middle members. Welded tuff contains both white fiamme and dark-gray to maroon lensoidal masses of sanidine-megacrystic rhyolite, thought to represent poorly vesiculated magma blebs. Chemically equivalent to voluminous intracaldera facies Rhyolite Canyon Tuff, which contains similar megacrystic magma blebs at high stratigraphic levels. Uppermost 5 m is moderately to poorly welded and poorly exposed. Exposed principally as erosional outlier near top of Sugarloaf Mountain, although ash-rich zone and overlying tuff with sparse megacrystic magma blebs also exposed in northwest part of map area. Thickness 24 m at Sugarloaf Mountain

Trcm **Outflow facies, middle member**--Voluminous, gray, densely welded, pumiceous ash-flow tuff. Prominent vertical columns (hoodoos) produced by erosion along joint planes in this member. Jointing attributed primarily to contraction related to cooling; average erosional ages of columns inferred to be about 2.4 Ma (Hall, 1993). Internally homogeneous; however, slight variation in welding and weathering profile suggest member formed from multiple ash flows that were erupted in rapid succession and cooled together. Overlies white, ash-rich coignimbrite fall and surge deposits at top of lower member. Base locally marked by 1-m-thick, densely welded, pumiceous ash flow separated from main densely welded zone of middle member by 10-20 cm of white ash. Thickness 320 m at Sugarloaf Mountain where top exposed

Vitrophyre--Black perlitic vitrophyre present as indicated along the base of the middle member where it directly overlies basement rocks of Faraway Ranch Formation in western part of Monument. Not present in central part of outcrop area, where middle member is thick and overlies lower member. Vitrophyre typically <2 m thick

Trcl **Outflow facies, lower member**--Distinct red-brown basal zone composed of locally lithic-rich, densely welded tuff overlain by a light-gray, moderately to densely welded upper zone (contact, line composed of two short dashes followed by a long dash, shown on map). Finely dotted line indicates base of distinctive white ash-rich zone. Currently mapped only north of 32°N. lat. Believed to represent co-ignimbrite ash-fall and surge deposits, at top of lower member. Ash-rich zone is pumice-poor and locally contains ash-armored sanidine crystals and accretionary lapilli. Accretionary lapilli beds exposed in north wall of Rhyolite Canyon along Hailstone Trail. Thickness less than 10 m in most places

TERTIARY PRE-TURKEY CREEK CALDERA ROCKS

Tjj **Jesse James Canyon Tuff (Oligocene)**--Light-gray or pinkish-gray, typically lithic poor, moderately crystal poor (approximately 10 percent), biotite-bearing quartz-sanidine rhyolite (76-77 weight percent SiO_2) ash-flow tuff from undetermined source. Similar to middle and lower members of Rhyolite Canyon Tuff (Trcm, Trcl); distinguished by presence of trace biotite and sphene, less abundant, and typically smaller crystals, higher ratio of sanidine to quartz (3:1 or greater), less-evolved chemistry, and stratigraphic position. Forms a simple cooling unit; poorly welded upper zone grades downward into densely welded, eutaxitic lower zone; basal vitrophyre exposed locally. Thickness approximately 240 m near Jesse James Canyon, thins to north, northwest, and northeast

Faraway Ranch Formation (Oligocene)--An assemblage of interfingering mafic to silicic lava flows, near source pyroclastic rocks, and epiclastic sedimentary rocks that underlie Jesse James Canyon Tuff at Erickson Ridge and near Faraway Ranch, and Rhyolite Canyon Tuff elsewhere (Enlows, 1955; Fernandez and Enlows, 1966). K/Ar (biotite) ages 28.6±2.0 and 28.3±0.8 Ma (recalculated using IUGS constants--Steiger and Jäger, 1977) for samples of rhyolite lava from Erickson Ridge (Tfre) (Marjaniemi, 1969)

Tfre **Rhyolite of Erickson Ridge (Oligocene)**--Light-gray (devitrified) to black (glassy) biotite rhyolite (averages 73 weight percent SiO_2). Contains phenocrysts of oscillatory zoned, subhedral oligoclase-albite (3-7 percent) and biotite (1-2 percent). Accessory or trace sphene forms euhedral phenocrysts. Forms small lava domes and lobate flow-layered lava flows with black glassy carapace breccias. Prominent flow layering indicated by dotted trend lines. Equivalent to Faraway Ranch Formation member 7 of Fernandez and Enlows (1966). Thickness variable; as much as 150 m thick near Faraway Ranch

Tfpe **Pyroclastic flow deposits of Erickson Ridge (Oligocene)**--Light-gray to orange block-and-ash flow, ash-fall, surge deposits, and ash-rich lahars interbedded with Rhyolite of Erickson Ridge (Tfre). Bedding attitudes (indicated by dotted trend lines) vary widely as a result of steep constructional topography near vents. Partly equivalent to Faraway

Ranch Formation. Locally includes reworked volcaniclastic sedimentary deposits. Thickness 0-60 m

Tfrh **Rhyolite of Hands Pass (Oligocene)**--Light-gray, quartz-sanidine rhyolite (77-78 weight percent SiO_2). Contains subhedral sanidine (2-5 percent) and resorbed quartz (1-4 percent) phenocrysts and accessory or trace biotite and opaque oxide minerals, typically in a spherulitic to granophyric devitrified groundmass. Forms a prominent lava dome overlain by Rhyolite Canyon Tuff near Hands Pass. Thickness 0-130 m

Tfph **Pyroclastic flow deposits of Hands Pass (Oligocene)**--Light-gray to orange block-and-ash flow, ash-fall, ash-rich lahar, and volcaniclastic sedimentary deposits underlying and forming a pyroclastic apron adjacent to Rhyolite of Hands Pass (Tfrh). Thickness 0-70 m

Tft **Welded tuff of Riggs Spring (Oligocene)**--Gray to pink, lithic-poor (<10 percent) and moderately crystal-rich (15-25 percent) biotite-quartz-sanidine rhyolite (72-73 weight percent SiO_2) ash-flow tuff. Contains 10-15 percent sanidine, 5-7 percent quartz, 1-3 percent biotite, and about 1-2 percent plagioclase in a eutaxitic vitroclastic matrix. Forms moderately welded remnant of outflow sheet atop ridges southwest of Riggs Spring at Pinery Creek. Weathers to bouldery gruss-covered upper surface. May be correlative with Faraway Ranch Formation member 3 of Fernandez and Enlows (1966), which has a K/Ar (sanidine) age of 29.6±1.9 Ma, although locality for this age uncertain (see Marjaniemi, 1969; Drewes, 1982). Thickness approximately 130 m; top eroded

Tfbp **Sedimentary rocks of Bonita Park (Oligocene)**--Red-weathering, poorly sorted, clast-supported conglomerate, and interbedded volcanic lithic arenite, siltstone, and claystone; contains gypsum veinlets near Bonita Park. Graded beds (10-30 cm thick) and channel deposits common. Extensively altered to clay minerals and hematite. Clasts are mainly subangular fragments of mafic volcanic rock similar to those in the underlying lavas of the Faraway Ranch Formation. Initially interpreted as lakebed deposits by Waller (1952). Poor sorting, hematitic alteration, and channel-bedding more consistent with alluvial fan deposition (Hall, 1993). Faulted against pillow(?) lavas of Faraway Ranch Formation and overlain by Rhyolite Canyon Formation in road cuts southeast of

Bonita Park. Red clay-rich soil suggests that Quaternary-Tertiary colluvium and landslide deposits, mapped in Bonita Park and west of Whitetail Pass, are underlain by Bonita Park Formation. Stratigraphically interbedded between andesitic and rhyolitic lavas of Faraway Ranch Formation approximately 0.5 km west of map boundary, north of Arizona Highway 181. Thickness less than 50 m

Tfv **Intermediate to mafic lava flows of the Faraway Ranch Formation (Oligocene?)**--Assemblage of interfingering lava flows and near-source pyroclastic rocks. Red to brown, hornblende- and biotite-bearing plagioclase porphyritic dacite and dark-gray, locally glassy, clinopyroxene-bearing andesite and basalt. Spheroidal weathering and curvilinear vesicle trains in celadonitic plagioclase-clinopyroxene basalts southeast of Bonita Park are suggestive of pillow basalt (at locations indicated by "p?" symbols)

Tr **Rhyolite dikes (Oligocene?)**--Light-gray to pink or tan aphyric or quartz and (or) feldspar porphyritic rhyolite dikes. Intrude pre-Turkey Creek caldera rocks

Bisbee Group (Upper Jurassic-Lower Cretaceous)

A sequence of thin-bedded limestone, siltstone, and shale mapped as Lower Cretaceous Morita and Mural Formations by Drewes (1982), and metamorphosed graywacke, andesite, and basalt of uncertain age. Similar metavolcanic and metasedimentary rocks to the southeast, in the Rustler Park quadrangle (Pallister and others, in press), are believed to be Upper Jurassic on the basis of microfossil and pollen assemblages from interbedded siltstone and mudstone (Lawton and Olmsted, in press)

Kbvs **Volcanic and volcaniclastic rocks**--Dark-green to dark-gray metagraywacke, meta-andesite and metabasalt. Variably metamorphosed to greenschist-facies assemblages of chlorite, calcite, albite, epidote, and magnetite. Stratigraphic correlation and age uncertain. Thickness >300 m

Kbls **Mural Limestone**--Tan, thin-bedded, laminated silty limestone, interbedded with siltstone and shale

Km **Morita Formation**--Maroon-weathering siltstone, sandstone, shale, and conglomerate

Kg **Glance Conglomerate**--Cobble, pebble, and boulder conglomerate composed of subrounded to subangular clasts of Paleozoic limestone, sandstone, and quartzite. Thickness 0-200 m

Pcn **Concha Limestone (Lower Permian)**--Dark-gray, thick-bedded, fossiliferous, cherty limestone. Fossils include large productid brachiopods. Thickness 190-200 m

Ps **Scherrer Formation (Lower Permian)**--Light-gray to pinkish-gray, fine-grained, nearly massive sandstone and quartzite. Thickness >50 m

Pec **Epitaph Dolomite and Colina Limestone, undivided (Lower Permian)**-- Dark-gray, coarse-grained, sparsely fossiliferous, slightly cherty limestone, and local light-gray, fine-grained, limy dolomite. Fossils include large echinoid spines and gastropods. Thickness 164 m

Pea **Earp Formation (Lower Permian)**--Pale-red siltstone and argillaceous limestone; interbedded with light-gray to yellowish-gray limestone. Thickness >300 m

Phu **Horquilla Limestone, upper member (Lower Permian)**--Light-gray, thin- to thick-bedded, fine-grained calcilutite, coarse-grained bioclastic and fossiliferous cherty limestone, and interbedded pink siltstone. Thickness about 400 m

GEOLOGIC OVERVIEW

Chiricahua National Monument contains one of the thickest and most complete sections of the Rhyolite Canyon Tuff, an ash-flow tuff erupted from the Turkey Creek caldera. The caldera, whose northern margin is a few kilometers south of the Monument, is a mid-Tertiary (27 Ma) volcanic depression that formed during eruption of the Rhyolite Canyon Tuff and partial evacuation of an underlying rhyolitic to dacitic magma chamber (Marjaniemi, 1969; Pallister and others, 1990; du Bray and Pallister, 1991). The caldera is deeply eroded; volcanic and shallow plutonic levels are exposed. Shortly after eruption of the Rhyolite Canyon Tuff, the central part of the caldera was intruded and domed, and the structural margin was intruded by dacite porphyry. Dacite porphyry was erupted from a ring dike within the structural margin and accumulated as a series of thick lava flows within the caldera moat, between the central resurgent dome and the caldera wall. One of these lava flows either flowed over a low area of the caldera wall, or was erupted outside the wall, and flowed down a paleovalley into the area of the National Monument. An erosional remnant of this lava flow is now exposed atop Sugarloaf Mountain. A series of rhyolite lava flows, small-volume tuffs, and sedimentary rocks were then deposited in the caldera moat, along the southern margin of the map area.

Erosion has modified and partly inverted the topographic expression of the caldera. The topographically high caldera rim was located within what is now Pinery Canyon. Erosion-resistant moat lavas now form the high terrane south of Pinery Canyon. Similarly, the high terrane of the National Monument was formerly a paleobasin where outflow facies Rhyolite Canyon Tuff accumulated to great thickness and welded densely. The resulting basin-filling tuff is more resistent to erosion than surrounding basement rocks and now forms a high-standing block.

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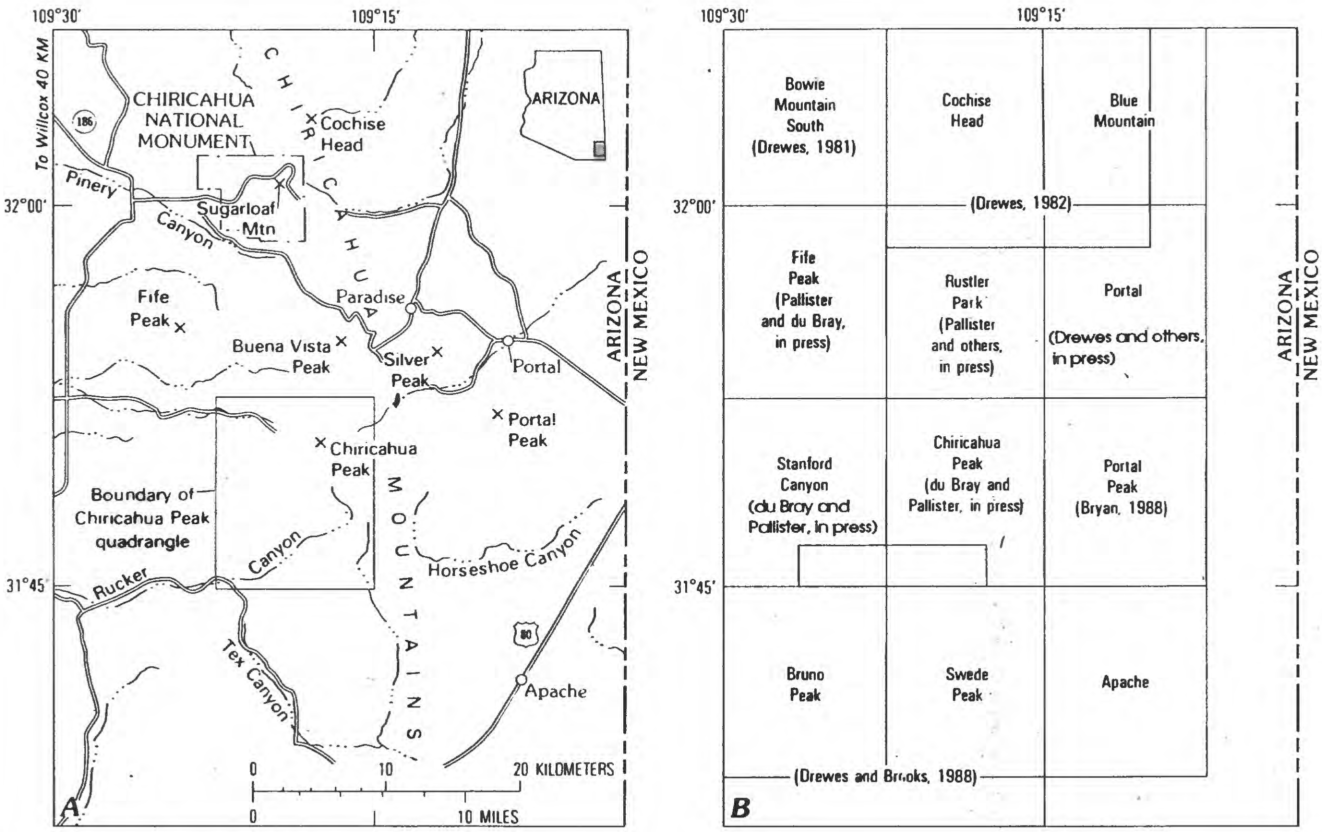


Figure 1. Location of Chiricahua National Monument and important geographic and geologic features in the Chiricahua Mountains area, Cochise County, Arizona

A, Quadrangle location, roads, and important geographic features.

B, U.S. Geological Survey quadrangle names in the area and existing geological maps (cited in parentheses).

C (on facing page), Generalized geology (adapted from Marjaniemi, 1969).

EXPLANATION FOR GEOLOGIC MAP ON FACING PAGE

Quaternary surficial deposits

OLIGOCENE ROCKS ASSOCIATED WITH THE TURKEY CREEK CALDERA

Moat deposits—Mainly rhyolite lavas and pyroclastic rocks

Resurgent intrusion, ring dike, and extrusive equivalents—Dacite and monzonite porphyry

Rhyolite Canyon Tuff

ROCKS THAT PRE-DATE THE TURKEY CREEK CALDERA

Volcanic rocks—Mainly Oligocene rhyolite and dacite

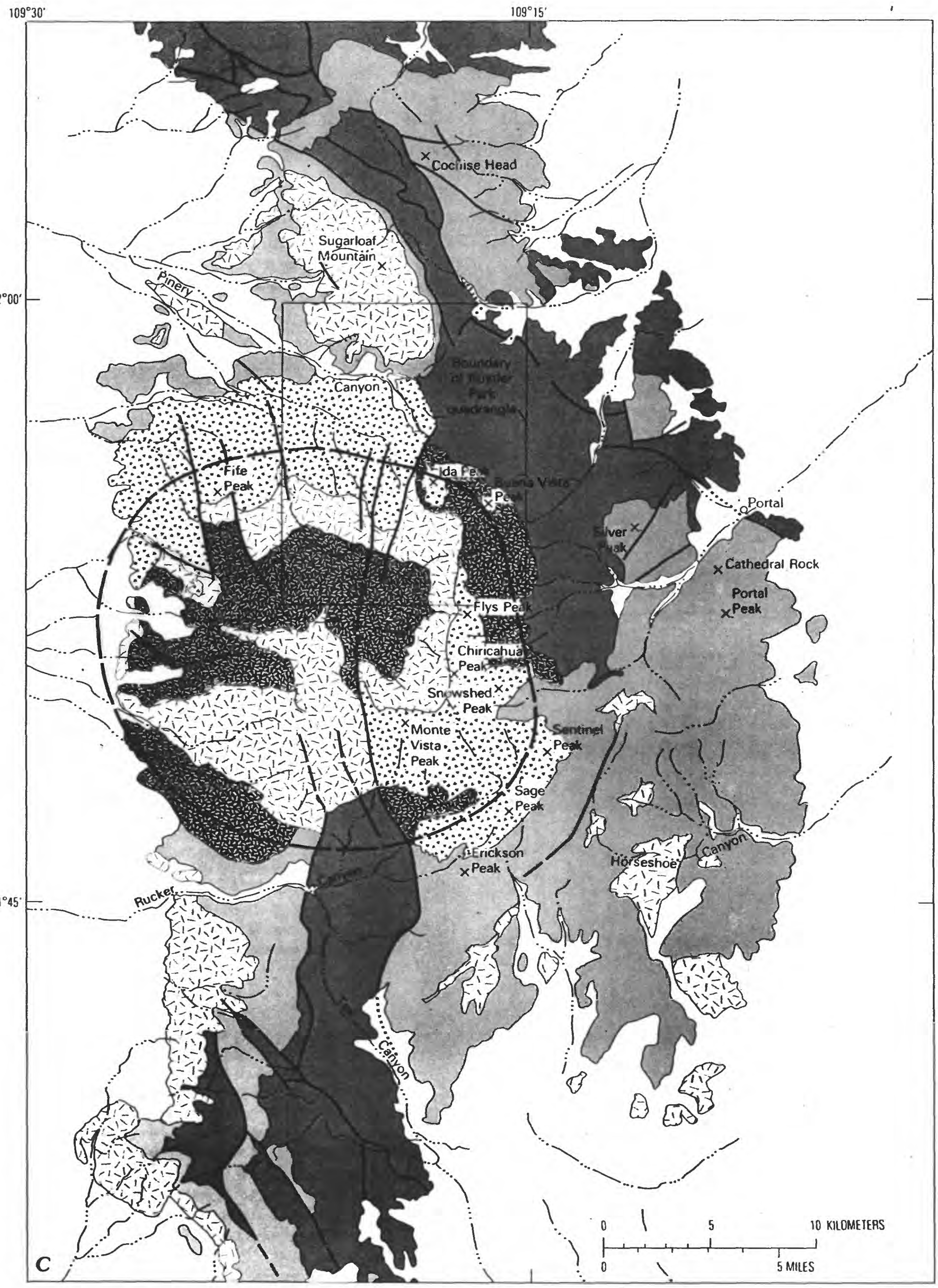
Basement rocks—Mainly Mesozoic and Paleozoic sedimentary rocks; includes some Precambrian granite

Contact

Structural margin of Turkey Creek caldera

Fault—Dashed where approximately located; dotted where concealed

Streams


109°30′
109°15′
32°00′
31°45′
Cochise Head
Sugarloaf Mountain
Pinery
Canyon
Boundary of Rustler Park quadrangle
Fife Peak
Ida Peak
Buena Vista Peak
Portal
Silver Peak
Cathedral Rock
Portal Peak
Flys Peak
Chiricahua Peak
Snowshed Peak
Monte Vista Peak
Sentinel Peak
Sage Peak
Erickson Peak
Horseshoe
Canyon
Rucker
Canyon
Cañyon
0
5
10 KILOMETERS
0
5 MILES
C