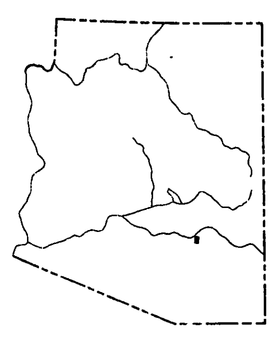
MAP GQ-668

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

GEOLOGIC QUADRANGLE MAPS OF THE UNITED STATES

GEOLOGIC MAP OF THE BRANDENBURG MOUNTAIN QUADRANGLE PINAL COUNTY, ARIZONA

By
Medora H. Krieger



QUADRANGLE LOCATION

PUBLISHED BY THE U. S. GEOLOGICAL SURVEY
WASHINGTON, D. C.
1968

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DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Alluvium (0- about 15 ft).—Unconsolidated gravel, sand, silt, and clay.

Landslides (0-100? ft).—Consist largely of Galiuro Volcanics, locally cemented with caliche.

Talus (0- about 50 ft).—Rock debris consisting of large angular blocks to silt-sized particles, locally cemented with caliche.

Gravel veneer on pediments and lower terraces (0-25 ft).—Largely subangular pebbles and cobbles of Paleozoic and younger Precambrian sedimentary rocks in a generally reddish-brown, fine- to coarse-grained matrix. Reddish-brown color less pronounced on younger terraces and generally lacking on higher level (about 4,000 ft), older(?) surfaces where the gravels are composed largely of Galiuro Volcanics. Locally includes some pediments and terraces stripped of gravels.

Surficial deposits, undivided (0-20 ft).—Include fine-grained colluvium and alluvium, and some pediment and terrace gravels.

GILA CONGLOMERATE (0-400 ft)

Fanglomerate consisting of subangular to subrounded pebbles, cobbles, and small boulders of Paleozoic rocks, and lesser amounts of Galiuro Volcanics and Precambrian rocks. Matrix is light shades of gray, green, and brown, generally well cemented, and composed of small pebbles to silt-sized particles. Pliocene age of Gila in this area indicated by pre-Blancan fossils (J. F. Lance, oral communications, 1964) in presumably equivalent beds southeast of Mammoth.

GALIURO VOLCANICS

Includes Apsey Conglomerate Member, Hells Half Acre Tuff Member, rhyolite-obsidian member, andesite and conglomerate of Virgus Canyon, Aravaipa Member, tuff and conglomerate of Bear Springs Canyon, andesite and conglomerate of Depression Canyon, tuff of Oak Springs Canyon, and Holy Joe Member. K-Ar determinations on biotite and sanidine from the Hells Half Acre Tuff, Aravaipa, and Holy Joe Members, and from the tuff of Bear Springs Canyon yielded ages of 22.4 to 25.9 million years (S. C. Creasey, oral communication, 1965).

APSEY CONGLOMERATE MEMBER[1] AND[2] (0-400 ft)

Here named Apsey Conglomerate Member. Type locality in vicinity of Apsey Camp, Ash Creek, sec. 25, T. 5 S., R. 17 E. Reference sections, showing relations to underlying rhyolite-obsidian or intervening Hells Half Acre Tuff Members, are north of Aravaipa Canyon in secs. 5, 6, 7, and 8, T. 6 S., R. 18 E.; and along Ash Creek, secs. 19, 20, 29, and 30, T. 5 S., R. 18 E. Overlain by andesite of Table Mountain only in the Holy Joe Peak quadrangle (Krieger, 1967b). Cliff-forming, thin-bedded, yellowish- to light-gray conglomerate and some conglomeratic tuff composed of pebbles, cobbles, and scattered boulders, largely derived from the rhyolite-obsidian member. It also contains sparse to abundant fragments of older rocks, including older members of the Galiuro Volcanics. The well-indurated, sandy, mostly noncalcareous matrix consists of quartz, feldspar, and many small rock and crystal fragments. Pumice shards and lapilli are common in some of the conglomerate, especially in the lower part. The member is well jointed and locally it erodes to conical forms and weird columnar shapes; many cliff faces are cavernous. The conglomerate conformably and gradationally overlies the Hells Half Acre Tuff Member.

[1]Upper tuff unit of Simons (1964) includes Apsey Conglomerate and Hells Half Acre Tuff Members.

[2]Tertiary tuff and rhyolite of Willden (1964) includes Apsey Conglomerate, Hells Half Acre Tuff, and rhyolite-obsidian members.

HELLS HALF ACRE TUFF MEMBER[1] AND[2] (0-500 ft)

Here named Hells Half Acre Tuff Member for exposures on Hells Half Acre, sec. 19, T. 6 S., R. 18 E. Type locality in Aravaipa Canyon upstream from Javalina Canyon, sec. 7, T. 6 S., R. 18 E., where the member is completely exposed in inaccessible cliffs. Consists of three units, from top to bottom: (1) (0-100 ft or more). Cliff- and slope-forming, white, air-fall and partly reworked vitric, lithic (rhyolite and pumice lapilli), and crystal tuff. Narrow, deep crevices have developed along prominent northeast- and northwest-trending joints, especially on Hells Half Acre. (2) (0-400 ft, maximum thickness between Javalina and Cave Canyons). Massive, cliff-forming, white, vitric tuff, possibly one or more nonwelded to slightly welded ash-flow tuffs[3]. Composed of white to yellowish-brown pumice lapilli, some obsidian and rhyolite lapilli, and grains of quartz, feldspar and minor biotite. (3) (0-50 ft). Well-bedded, cliff-forming, porous, yellowish-brown to brown, finely crystalline rhyolite tuff with pumice lapilli, grains of quartz, feldspar, and biotite, and scattered accidental fragments. The base in Horse Camp Canyon is a thin wedge of crossbedded, tuffaceous sandstone. Rhyolite tuff in the northeast corner of the quadrangle is tentatively included in this member, although some of it is overlain by the rhyolite-obsidian member. Pumice lapilli and groundmass of the member have been extensively zeolitized (heulandite or clinoptilolite).

RHYOLITE-OBSIDIAN MEMBER[2] (0-1,000? ft)

Gray and black, flow-banded to massive, perlitic to lithophysal obsidian, finely laminated to contorted, gray, stony (devitrified), locally lithophysal rhyolite, flow breccias. Some breccias are composed of angular fragments of very vesicular, vitric rhyolite. Rhyolite and obsidian contain small amounts of sanidine, quartz, plagioclase, pyroxene, hornblende, iron oxide, and sphene, and scattered accidental fragments. Lithophysae, generally 1-3 cm in diameter, in places are strung out, giving large outcrops a steeply dipping, bedded appearance. Chalcedony-lined geodes are as much as 10 cm in diameter. The member probably was extruded as domes and stubby flows. Cinder cones, some unmapped, consist of steeply dipping, well-bedded material, associated with tuff, conglomerate, and breccia. They contain variable amounts of older rocks.

ANDESITE AND CONGLOMERATE OF VIRGUS CANYON

Upper andesite (0-100 ft).—Dark-colored, fine-grained, amygdaloidal andesite with small phenocrysts of plagioclase, altered olivine, and pyroxene. Exposed only as thin flows along Aravaipa and Virgus Canyons upstream from their junction, and as a thin remnant (?) south-southwest of the mouth of Javalina Canyon. Overlain by the rhyolite-obsidian member in Horse Camp Canyon. Mapped as upper andesite unit by Simons (1964), who correlated it with andesite that overlies rhyolite-obsidian north of Aravaipa Canyon, in an area where his upper tuff unit (Hells Half Acre Tuff Member of this report) is absent.

Conglomerate (0-100 ft).—Pebbles and cobbles derived from lower andesite of Virgus Canyon and older rocks in a sandy matrix. Along Whitewash, Bear Springs, and lower Aravaipa Canyons, 0-25 ft of unmapped conglomerate composed largely of the lower andesite separates the Aravaipa Member from the Hells Half Acre Tuff Member. A few feet of unmapped conglomerate locally underlies the lower andesite.

[3]Terminology for pyroclastic rocks from Ross and Smith (1961) and Smith (1960).

Lower andesite (intermediate andesite unit of Simons, 1964) (0-100 ft).—Medium-gray, light-brown-weathering, very coarsely porphyritic andesite (the so-called turkey-track porphyry of Cooper, 1961) with platelike plagioclase as much as 2 cm long and 0.2 cm thick; small (mostly less than 1 mm) olivine(?) altered to orange iddingsite (bowlingite?), and minor clinopyroxene in a groundmass of plagioclase laths, clinopyroxene, iron ore, altered olivine, and apatite needles. Some andesite has only small olivine and 2-3 mm plagioclase phenocrysts. Staining with cobaltinitrite reveals some potassium feldspar in the groundmass.

ARAVAIPA MEMBER (WHITE TUFF AND UPPER WELDED TUFF UNITS OF SIMONS, 1964) (200-300 FT, THIN TO ABSENT WHERE IT LAPS AGAINST HILLS OF OLDER ROCKS)

Here named Aravaipa Member for exposures in its type locality, Aravaipa Canyon, NE¼ sec. 17, T. 6 S., R. 18 E., where the thickest and most complete section is exposed, except for basal vitrophyre, which is below the floor of the canyon. Reference sections in Holy Joe Peak quadrangle (Krieger, 1967b) on north side of Table Mountain, sec. 8, T. 7 S., R. 18 E.; along unnamed gulch in sec. 5, T. 7 S., R. 18 E.; and along Bear Springs Canyon, sec. 32, T. 6 S., R. 18 E. Rhyolitic ash-flow tuff, a simple cooling unit and possibly a single flow unit, with a well-developed zonal pattern. Contacts between most zones are abrupt. Composed of pumice shards and lapilli, crystal fragments (not abundant) of quartz, sanidine, plagioclase, biotite, and minor accidental fragments; some rhyolite lapilli in upper nonwelded zone.

Upper nonwelded zone (0-100 ft).—Massive, slope-forming white tuff, characterized by devitrification and vapor-phase crystallization.

Partly welded, welded, and lower nonwelded zones (200-250 ft in most places).—Largely cliff-forming and consisting of, from top to bottom: (1) Columnar-jointed, vapor-phase zone (0-80 ft, thickest in Aravaipa Canyon). Very light shades of gray and brownish-gray, slightly welded, devitrified tuff with vapor-phase crystallization pronounced in pumice lapilli. (2) Welded, devitrified zone (0-160 ft). Light shades of brown and red, mostly dark-weathering tuff that becomes darker colored and densely welded downward. Some vapor-phase crystallization in pumice lapilli in upper part. Thoroughly devitrified, becoming less so near base. The lower two-thirds is characterized by large vugs and silica-lined or filled lithophysae (the "vuggy" zone). (3) Thoroughly welded zone (0-30 ft). Black and dark-brownish-gray vitrophyre with local brown oxidized lenses and devitrified spots. (4) Lower nonwelded zone (0-10 ft). Grayish-orange-pink vitric tuff, becoming lighter colored to nearly white at base. The distal end of the flow is exposed intermittently in canyon walls from Bear Springs to Cave Canyons and the change from welded to nonwelded tuff completely exposed along lower White Wash Canyon.

TUFF AND CONGLOMERATE OF BEAR SPRINGS CANYON

Conglomerate (0-50 ft).—Includes conglomerate above and below the tuff (Ttb). Above the tuff (0-25 ft), fragments are Paleozoic rocks and older members of the Galiuro Volcanics. Below the tuff, fragments are largely andesite and diabase.

Tuff (0-100 ft).—Rhyolitic ash-flow tuff composed of pumice lapilli, crystal and some accidental fragments. Upper part, where remnant, is columnar-jointed to very light-olive- and brownish-gray, partly welded tuff showing vapor-phase crystallization and containing local lithophysae near base. Lower part is moderate-orange-pink poorly welded tuff, grading down into light-colored nonwelded vitric tuff with slight clay alteration.

ANDESITE AND CONGLOMERATE OF DEPRESSION CANYON

Conglomerate (0-50 ft).—Composed of older rocks, including older members of the Galiuro Volcanics. In the northwest part it includes material from the Late Cretaceous and (or) early Tertiary volcanic and intrusive rocks (Krieger, 1967a).

Andesite(Tertiary basalt and andesite of Willden, 1964)[4] *(0-600 ft).* Massive, flow-banded, to agglomeratic, gray, brown, and olive andesite that weathers to lighter shades of brown. Local tuff and breccia beds are at base and between flows. The vesicular, nonvesicular, or amygdaloidal andesite contains a few to abundant, mostly small phenocrysts of plagioclase, olivine (altered or partly altered to iddingsite, rarely to serpentine), pyroxene, and magnetite. The groundmass consists of plagioclase microlites, pyroxene, iddingsite, magnetite, and some K-feldspar. The presence of isolated thin beds of rhyolite tuff suggests that thicker sections may include upper andesite of Virgus Canyon, or younger andesites.

TUFF OF OAK SPRINGS CANYON (0-100? FT)

White to grayish-orange-pink, partly welded(?) rhyolitic tuff with crystal fragments (quartz, feldspar, and biotite), pumice lapilli, and accidental fragments. Shown only on sections A-A′, C-C′, and F-F′. Exposed in Holy Joe Peak quadrangle (Krieger, 1967b).

HOLY JOE MEMBER (LOWER WELDED TUFF UNIT OF SIMONS, 1964) (0-40 FT)

Quartz-latite ash-flow tuff. Largely black and brown vitrophyre, composed of abundant crystal fragments (quartz, plagioclase, biotite, and sanidine), pumice lapilli, and accidental fragments in a firmly welded shard matrix; nonwelded at base, upper part slightly devitrified, except where overlain by a thin vitrophyre. South of the quadrangle (Krieger, 1967b) the member is 200-300 ft thick and forms a single cooling unit composed of several flows, the top flow being a vitrophyre.

WHITETAIL(?) CONGLOMERATE (0-200 FT)

Composed of pebbles and cobbles of Precambrian and Paleozoic rocks, largely diabase, quartzite, and limestone. It includes a bed of white rhyolite tuff (0-25 ft thick) in Aravaipa Canyon and below the tuff a small mass of andesite (unmapped) on the north side of the creek about 0.7 mile northeast of Wagner Ranch.

NACO LIMESTONE (0-250 FT)

A slope-forming unit with characteristic grain due to evenly spaced resistant and less resistant beds. Most of the limestone is medium to thin bedded, fine grained, and brownish to light gray, and weathers nearly white; some is mottled red. It contains interbeds of coarse-grained limestone, dolomitic to silty or marly limestone, thin beds or seams of pink to yellow calcareous shale and siltstone, and local chert nodules and layers. Low relief on the pre-Naco surface can locally be recognized, but in many places the contact with the Escabrosa Limestone is arbitrarily located because the lower 50 ft of the Naco lacks fusulinids and contains brown dolomitic and silty limestone beds that resemble some beds in the Escabrosa. Fossils include fusulinids, brachiopods, corals, crinoids, bryozoans, and ostracodes. The Naco here probably is largely equivalent in age and lithology to the Horquilla Limestone, the lowest of the six formations into which the Naco Group, farther south, has been divided (Gilluly and others, 1954, p. 6).

ESCABROSA LIMESTONE (0- ABOUT 400 FT)

Massive, cliff-forming, thick-bedded, mostly coarse-grained, limestone in shades of gray and yellowish to greenish gray. The cliffs, as much as 50 ft high, are separated by narrow slopes of thin-bedded, medium- to fine-grained gray limestone and brown silty and dolomitic limestone. Chert nodules are common in some beds, especially in upper part. The basal part is crossbedded, coarse-grained brown sandstone and dolomitic sandstone (0-10 ft) overlain by limestone that resembles beds near the top of the Martin Formation. Fossils are abundant and include crinoids, brachiopods, and corals, and in the upper part many ostracodes. Dark-brown chert breccia, common in some areas, may represent pre-Naco solution and erosion.

MARTIN FORMATION (150-250 FT)

A slope-forming shale unit generally with overlying and thinner underlying carbonate beds. The shale is olive to reddish brown, with interbedded reddish-brown and light-brownish-gray limestone beds (2 in. to 4 ft thick) in the upper part. These limestone beds weather to rounded surfaces that are light shades of brown and red. The top in thicker sections consists of coarse-grained, light-gray Escabrosa-like limestone. Brachiopods, bryozoa, and crinoids are common in the limestone beds. The shale may rest directly on the Abrigo Formation, or be separated from it by as much as 25 ft of very fine grained, pale-reddish-brown or light-gray, medium-grained limestone. The base is generally a few inches of hematite-rich sandstone with granules and small pebbles of quartz and abundant shark teeth and arthrodiran fish fragments (F. C. Whitmore, Jr., and D. H. Dunkle, written communications, 1961 and 1962). The hematitic beds

[4]Lower tuff unit of Simons (1964) includes tuff of Bear Springs Canyon and andesite of Depression Canyon.

occur at the same horizon as the oolitic hematite bed on the Christmas quadrangle (Willden, 1960, 1964).

ABRIGO FORMATION[5] (165–600 FT)

Upper (or brown sandy) member (116-165 ft).—The upper part (70-100 ft) is slope-forming, thin-bedded (½-1 ft, locally 2 ft), medium- to coarse-grained dolomite and dolomitic sandstone in light shades of brown. It contains some argillaceous and glauconitic beds, intraformational conglomerate, irregular surficial chert, and a few thin chert beds and lenses. Silicified specimens of the brachiopod *Billingsella* (A. R. Palmer, oral communication, 1960) occur in a narrow horizon near the middle of thicker sections. The lower part (75-95 ft) is cliff-forming, dark-brown-weathering, thin- to thick-bedded (8 in. to 8 ft, mostly 3 ft), mostly poorly sorted and crossbedded, dolomitic and glauconitic sandstone; some dolomite, sandy and glauconitic dolomite, light-colored sandstone and quartzite, intraformational conglomerate, and siltstone; local granule and small-pebble conglomerate beds. Phosphatic brachiopod scraps are generally abundant in the dark-brown-weathering beds. Fucoids and *Scolithus* occur in light-colored sandstones.

Middle (sandstone) member (0- about 280 ft).—Predominantly cliff-forming, yellowish-gray, thin- to thick-bedded (3 in. to 3 ft), mostly poorly sorted sandstone and argillaceous sandstone; some granule conglomerate and thin to very thin silty or shaly partings. Most bedding surfaces are irregular due largely to abundant fucoids. *Scolithus* also are generally abundant. The upper part contains local beds of pronounced, steep crossbedding and 2- to 6-in. beds of white quartzite. Locally in the lower part a 40-ft massive unit has smooth bedding surface, no fossils, and only sparse shaly partings; it is overlain by 2-30 ft of mudstone-siltstone beds like those in the lower member. Contact with the lower member is arbitrarily located in some places and is not everywhere at the same horizon, partly because of variations in the influx of sand in the upper part of the lower member.

Lower (mudstone) member (0- about 155 ft).—A thin-bedded, slope-forming, poorly sorted, argillaceous and sandy unit that weathers to shades of brown and yellowish to reddish brown. It consists of massive to very thin bedded (½-2 in.), in part thinly laminated, olive- to greenish-gray, and grayish-red mudstone, siltstone, and sandy mudstone; interbedded argillaceous sandstone beds (1 in. to 1 and locally 3 ft) and thin (mostly about 1 in.), well-sorted, light-colored quartzite and sandstone beds, paper-thin shale, and local beds and lenses of granule to small-pebble conglomerate. The member becomes more sandy and lighter colored upward. Most bedding surfaces are extremely irregular and pellety. Phosphatic brachiopod scraps are generally abundant; fucoids and *Scolithus* are present, but are mostly smaller and less abundant than in the middle member. Where the formation rests on diabase the base generally is a conglomerate (0-50 ft) composed of cobbles to small boulders (largely Troy Quartzite) in a grayish-red, sandy, diabasic matrix. Overlying beds commonly contain dolomite as cement, or as layers, lenses, nodules, and detrital pebbles.

DIABASE

Dark-gray to dark-greenish- or olive gray, medium-grained diabase occurring mostly as sills and multiple sills (totaling more than 1,000 ft in places). The texture is diabasic, ophitic, or poikilitic. The rock contains plagioclase (mostly about 5 mm, locally 2 cm), smaller pyroxene (poikilitic crystals are as much as 2 cm across), magnetite, ilmenite, and minor olivine. Some thicker sills contain aplitic and pegmatitic differentiates. The chilled contact of diabase against older rocks (including earlier sills) contrasts with the weathered appearance of diabase beneath Paleozoic rocks, where, within a zone as much as 20 ft thick, diabase grades upward from the fresh, massive, dark-gray rock into crumbly, red to purple rock with a pronounced platy structure.

TROY QUARTZITE[5] (0–280 FT)

Upper unit (0-120 ft).—White to yellowish-gray, somewhat lenticular, thin- to thick-bedded (mostly 1-3 ft), feldspathic (white feldspar or clay alteration) to nonfeldspathic sandstone and granule to small-pebble (less than ½ in.) conglomerate. Pebbles are composed largely of quartz; some are concentrated on tops of beds. The unit contains local slump structures and large-scale crossbedding. Surficial silicification obscures some bedding features.

Lower unit (0-160 ft).—Dark-brownish-gray outcrops of medium-gray and pale-red conglomerate and sandstone that are mostly thin bedded (many are 6 in. or less), lenticular, and channeled. The upper part consists of light-colored sandstone and quartzite interbedded with and replaced downward by dark sandstone, granule to small-pebble conglomerate, and thin beds of greenish-gray argillite. Much of the conglomerate contains abundant pink to orange fragments of feldspar and quartz porphyry or rhyolite. The basal 30-50 ft consists of pale-red sandstone and conglomeratic sandstone, in places metamorphosed (by diabase) to light bluish-gray, underlain by pebble to small-cobble conglomerate that locally contains sparse to closely packed, well-rounded pebbles derived from the Barnes Conglomerate Member of the Dripping Spring Quartzite.

APACHE GROUP

Only part of the middle of the three formations that make up the Apache Group is present in the quadrangle.

DRIPPING SPRING QUARTZITE (MAXIMUM OF 250 FT EXPOSED, DUE TO INTRUSION BY DIABASE)

The upper member (20-50 ft) is thin-bedded (¼-12 in.), very fine grained, feldspathic to arkosic quartzite and siltstone that are shades of gray, brown, red, and yellow. Some beds are ripple marked; others contain shallow crossbeds. The middle member (200 ft) is medium-grained, locally fine- to coarse-grained, red to pink, feldspathic to arkosic quartzite, with a little nonfeldspathic quartzite. It is thin to very thick bedded (2-12 ft) and crossbedded. The Barnes Conglomerate Member is not present in this area.

PORPHYRY

Massive to slightly foliated, fine-grained porphyritic rock in shades of red, brown, and gray. Sparse to abundant phenocrysts of quartz and plagioclase (1 to rarely 3 mm) and scattered lithic fragments (2 cm long or more) are in a dense groundmass of quartz, alkalic feldspar, variable amounts of sericite, and some epidote, biotite, magnetite, and chlorite. The phorphyry is locally cut by minute quartz veins, or by larger gash or ladderlike veins of milky quartz.

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[5] For discussion of the Troy and Cambrian formations see Krieger (1961).