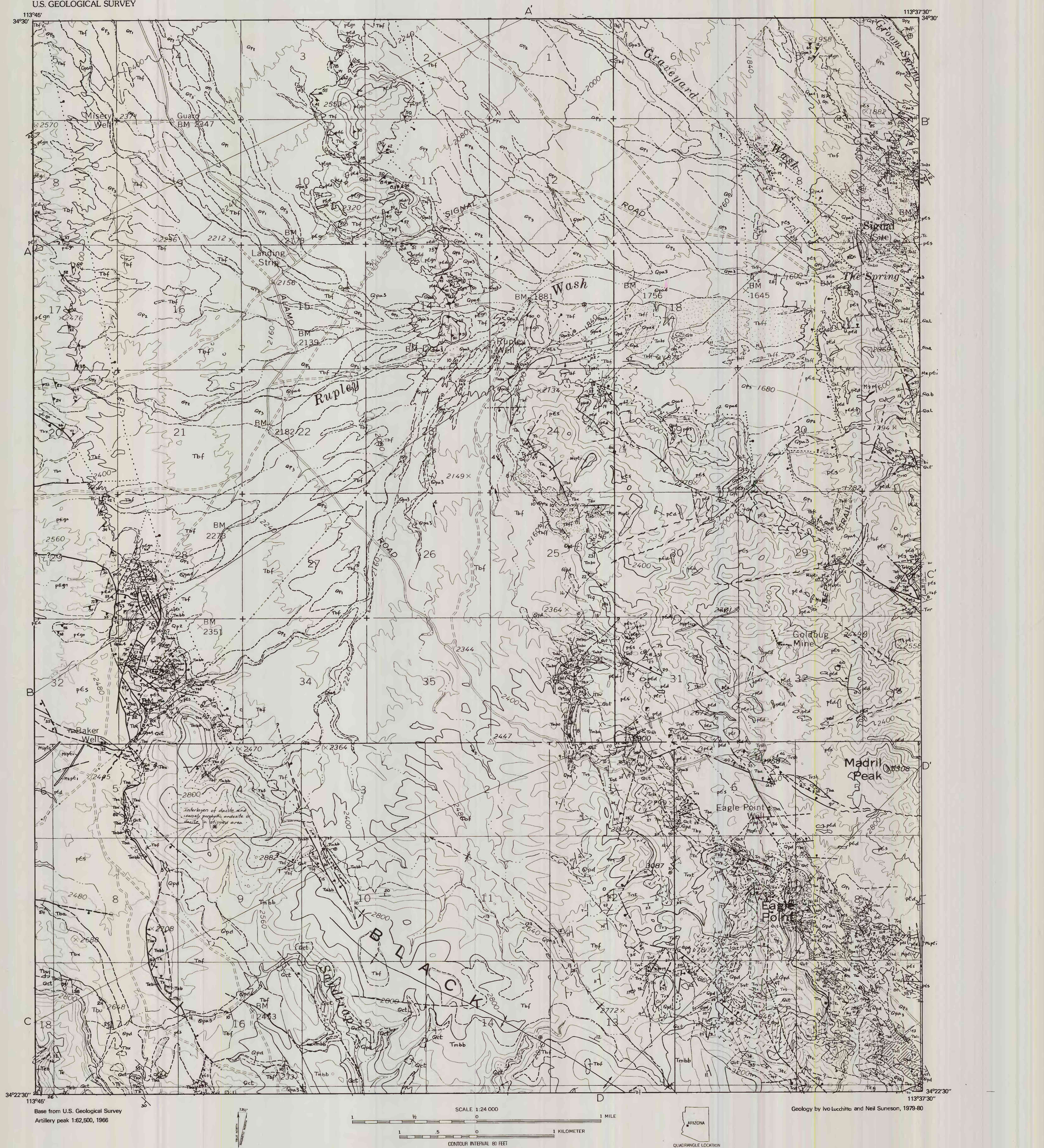
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT 85-277
PLATE 1



Base from U.S. Geological Survey
Artillery peak 1:62,500, 1966

Geology by Ivo Lucchitta and Neil Suneson, 1979-80

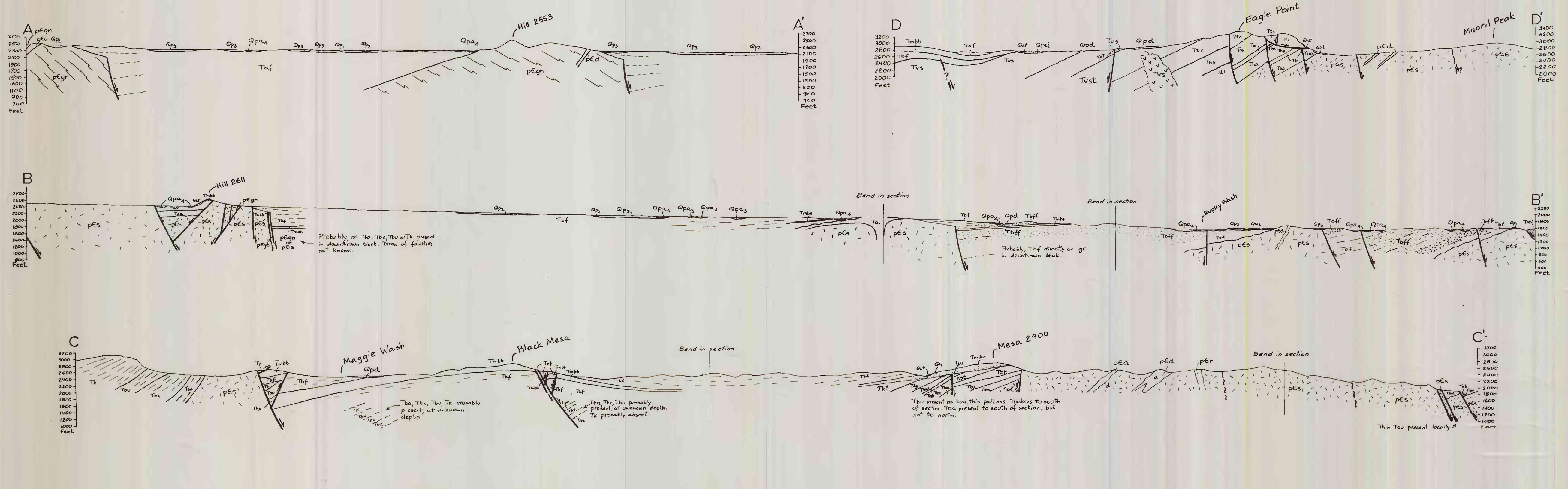
GEOLOGIC MAP OF THE ARTILLERY PEAK NORTHWEST QUADRANGLE, MOHAVE COUNTY, ARIZONA

By

Ivo Lucchitta and Neil Suneson

1985

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.



LIST OF MAP UNITS

BEDS REFLECTING THROUGH-FLOWING DRAINAGE

	ALLUVIUM OF THE BIG SANDY RIVER
Qal	Sand and gravel of present channel
Qaa	Lower terrace gravels
Qab	Intermediate terrace gravels
Qac	Upper terrace gravels
	PIEDMONT SLOPE DEPOSITS
Qpa_4	Alluvium of active channels
Qpa_3	Alluvium of inactive channels
Qpd	Pediment gravels with desert varnish
Qpc	Calcrete unit
Qp_3	Undissected pediment
Qp_2	Moderately dissected pediment
Qp_1	Dissected pediment
Qct	COLLUVIUM AND TALUS
Qls	LANDSLIDE DEPOSITS

INTERIOR-BASIN DEPOSITS LAID DOWN IN PRESENT BASINS

	BASIN-FILL DEPOSITS
Tbf	Basin fill, undifferentiated
Tbfc	Coarse-grained facies
Tbff	Fine-grained facies
Tbft	Tuffaceous facies
	MESA-FORMING MAFIC LAVA FLOWS
Tmbs	Basalt near Signal
Tmbb	Basaltic andesite of Black Mesa
Tmbo	Basalt of Mesa 2900

ROCKS DEPOSITED IN BASINS NOT RELATED TO PRESENT TOPOGRAPHY

Tss	TUFFACEOUS SANDSTONE
Tvs	RHYOLITE LAVA FLOWS, DOMES, PLUGS AND DIKES
Tvsh	HORNBLENDE RHYOLITE
Tvst	PYROCLASTIC AND EPICLASTIC ROCKS
Ttc	TUFFACEOUS CONGLOMERATE
Tk	ARKOSE OF KEENAN CAMP
Tcg	BOULDER CONGLOMERATE
	OLDER BASALT SEQUENCE
Tbp	Porphyritic plagioclase basalt
Tbpi	Intrusive facies of porphyritic plagioclase basalt
Teb	Early basalt
Tob	Porphyritic olivine basalt
Tbu	UPPER BASIN BEDS
Tbx	BRECCIA
	LOWER BASIN BEDS
Tbl	Lower basin beds, undifferentiated
Tbll	Limy facies
Tblc	Clastic facies
Tba	BASAL ARKOSE

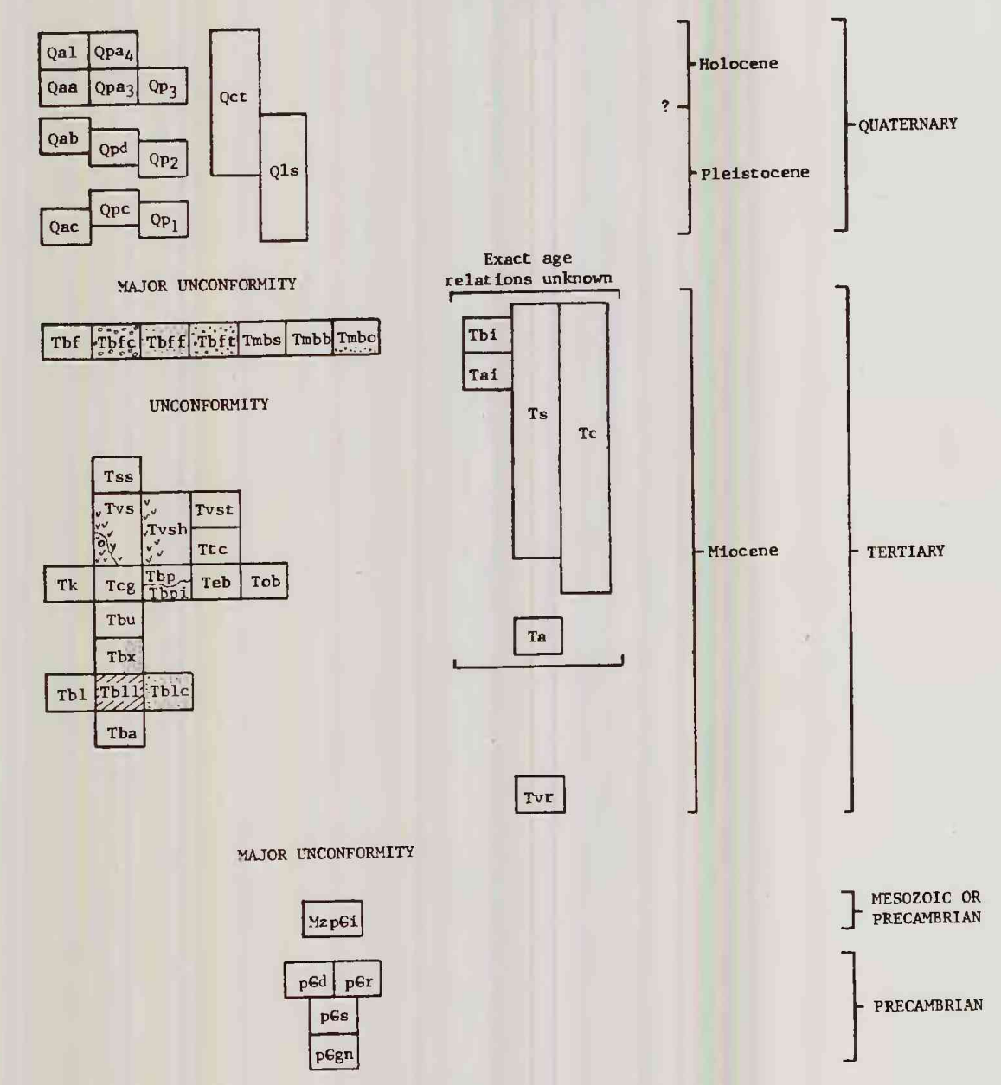
ROCKS OF INDETERMINATE STRATIGRAPHIC POSITION

Tbi	INTRUSIVE BASALTIC ROCKS
Tai	HORNBLENDE ANDESITE DIKE
Ts	TUFFACEOUS SEDIMENTARY ROCKS
Ta	HORNBLENDE ANDESITE
Tc	CONGLOMERATE
Tvr	RHYODACITE

BASEMENT ROCKS

Mzp€i	SILICIC AND INTERMEDIATE INTRUSIVE ROCKS
p€d	DIABASE
p€r	METARHYOLITE PORPHYRY
p€s	SIGNAL GRANITE
p€gn	GNEISS

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Surficial deposits are mostly 1 m or more in thickness where mapped. Qp units were delineated using photointerpretation techniques augmented by local field checks.

BEDS REFLECTING THROUGH-FLOWING DRAINAGE

Alluvium of the Big Sandy River (Holocene and Pleistocene)—Material that includes non-local lithologies and deposited by the Big Sandy River. Consists of rounded to subangular, well- to moderately well-sorted, unconsolidated sand and gravel. Clasts, up to 50 cm in diameter but mostly 1-10 cm, consist of a wide variety of rock types, including basalt, granitic rocks, biotite dacite, granitic gneiss, and aplite

Qal **Sand and gravel of present channel (Holocene)**—Good source of sand and gravel. Thickness unknown

Qaa **Lower terrace gravels (Holocene)**—Sand and gravel forming moderately continuous terraces 2-5 m above present river level. Good source of sand and gravel. Thickness 2-5 m

Qab **Intermediate terrace gravels (Holocene or upper Pleistocene)**—Form moderately continuous terraces 5-10 m above present river level. Moderately good source of sand and gravel. Thickness 7 m

Qac **Upper terrace gravels (Pleistocene)**—Discontinuous remnants 50-60 m above present river level. Too small and discontinuous to be a good source of sand and gravel. Thickness 5 m

Piedmont slope deposits (Holocene and Pleistocene)—Unit consists of locally derived pediment deposits and channel deposits of arroyos that dissect the pediments. Differs from alluvial deposits of Big Sandy River in degree of rounding, composition, source, and environment of deposition. Composed of poorly sorted, angular to subangular silt, sand, and gravel with varying degrees of cementation and dissection

Qpa_4 **Alluvium of active channels (Holocene)**—Sand and pebble- and cobble-size gravel in channels affected by modern floods. Channels unvegetated, except for scattered trees of substantial dimensions. Within quadrangle, areas underlain by this unit are in greatest danger of flooding. Grades into unit Qal at confluences with Big Sandy River. Thickness unknown

Qpa_3 **Alluvium of inactive channels (Holocene and upper Pleistocene)**—Poorly sorted sand, pebble- and cobble-size gravel, and local boulder-size gravel, in those parts of arroyos not reached, or seldom reached, by modern flood waters. Typically 0.5-1 m above active channels. Extensive vegetation, including grasses, forbes, cacti, bushes, and trees. Grades laterally into undissected pediment gravels (Qp_3). Thickness unknown

Qpd **Pediment gravels with desert varnish (Pleistocene)**—Unconsolidated to poorly consolidated silt, sand, and gravel forming a veneer, from several tens of centimeters to a few meters thick, on weathering regolith developed on older rocks. Forms smooth, flat to gently sloping surfaces characterized by well-developed desert pavement consisting of moderately well-sorted, angular pebbles typically 1-10 cm in size. Most pebbles are heavily coated with black desert varnish, giving the surface of unit a grayish-brown to grayish-red color. Buried parts of pebbles and cobbles are lightly coated with caliche. Beneath the desert pavement, the unit consists of loose, porous, pebbly sand and silt. Where exposed in cross section, the lower and middle parts of the unit are characterized by caliche veins that are in part subparallel and in part at a high angle to the topographic surface. Dissected to depths as great as 25 m by modern arroyos. Subject to sheet flow but not to flash flooding. Excellent location for roads and other construction. Present chiefly where clast lithology is suitable for formation of desert varnish. Grades laterally into moderately dissected pediment gravels (Qp_2). Thickness <3 m

Qpc **Calcrete unit (Pleistocene)**—Pale-yellowish-brown to light-olive-gray, poorly to moderately sorted, massive to poorly bedded, strongly caliche-cemented pebble-, cobble-, and boulder conglomerate and breccia containing angular to subangular clasts heavily coated with caliche. Typically, little or no soil or unconsolidated material is present on the surface of the unit, which is conspicuously light toned on aerial photographs. Unit generally occurs as erosional remnants of small extent that form flat to gently sloping mesa-like surfaces. Although dissection is variable, unit typically occurs at a considerable altitude above present arroyos. Subject to little sheet flow and no flooding. Probably correlative in part with dissected pediment gravels (Qp_1), from which it is distinguished by stronger calichification, smaller areal extent, and less dissection. Thickness <5 m

Qp_3 **Undissected pediment gravels (Holocene and upper Pleistocene)**—Angular, poorly sorted gravel and sand, forming thin veneer on gently sloping pediment surfaces. Top of unit forms extensive, gently rolling, vegetated surfaces with local dissection of less than 1 m but up to 25 m above major washes. Subject to sheet flow but not to flash flooding. Excellent sites for roads and other construction. Thickness <5 m

Qp_2 **Moderately dissected pediment gravels (Pleistocene)**—Angular, poorly sorted gravel and sand, forming thin veneer on gently sloping pediment surfaces. Top of unit forms rolling, vegetated surfaces with local dissection of about 1 m but up to 25 m above major washes. Parts of unit that are more dissected show some caliche development and are lighter toned than parts that are less dissected. Subject to sheet flow but not to flash flooding. Moderately suitable sites for roads and other construction. Thickness <5 m

Qp_1 **Dissected pediment gravels (Pleistocene)**—Angular, poorly sorted gravel and sand, forming thin veneer on gently sloping pediment surfaces. Top of unit forms ragged surfaces that typically are dissected to about a 3-m depth. Considerable caliche. Considerably lighter toned than other pediment units on aerial photographs. Subject to little sheet flow, but potentially some flash flooding in drainages. Poorly suited for road construction. Thickness <5 m

Qct **Colluvium and Talus (Holocene and Pleistocene)**—Locally derived, unconsolidated slope wash, talus, and rockfall material. Moderately stable to stable

Qls **Landslide deposits (Holocene and Pleistocene)**—Several small toreva blocks of basalt (Tmbo, Tmbs), and tuffaceous conglomerate (Ttc). One large (500 m wide) mass of tuffaceous conglomerate (Ttc) near Eagle Point may be of tectonic origin formed along a low-angle normal fault (as mapped) or a landslide block

INTERIOR-BASIN DEPOSITS LAID DOWN IN PRESENT BASINS

Basin-fill deposits (Miocene)—Heterogeneous assemblage of clastic strata filling present basins

Tbf **Basin fill, undifferentiated**—Typically grayish-orange, yellowish-gray, and pale-yellowish-brown, moderately to poorly sorted, moderately to poorly bedded, moderately to poorly consolidated pebble- and cobble fanglomerate. Clasts typically angular, 0.5-50 cm in diameter, and locally derived. Clasts are unsupported in a matrix of coarse sand. At northeast corner of quadrangle, unit includes a sandy pebble- and cobble conglomerate containing subrounded heterogeneous clasts interbedded with granule conglomerate and coarse sandstone. These rocks may be equivalent to the Big Sandy Formation of Sheppard and Gude (1972), now considered to be Miocene. In southwest part of quadrangle, unit includes Pliocene and Miocene Sandtrap Conglomerate of Lasky and Webber (1949). Maximum thickness unknown; probably reaches several hundred to a few thousand meters

Tbfc **Coarse-grained facies**—Poorly consolidated, poorly bedded cobble- to boulder fanglomerate composed chiefly of large (0.25-2 m) subangular boulders of coarse-grained granitic rocks. Typically a lag deposit of boulders

Tbff **Fine-grained facies**—Very pale yellowish-brown, very pale-brown, and grayish-orange-pink, unconsolidated to poorly consolidated, locally derived siltstone, fine-grained sandstone, claystone, and less abundant pebbly sandstone. Pebbles unsupported in a matrix of sand and silt. Pebbles and sand grains subangular to subrounded. Mostly moderately bedded to well-bedded. Locally tuffaceous. Forms badlands in places. May be equivalent to sedimentary rocks included within the basalt of Mesa 2900 (Tmbo). Thickness probably 200 m or more in places

Tbft **Tuffaceous facies**—Well-bedded tuffaceous sandstone, pumice-rich tuff and unbedded, ash-flow(?) tuff. The pumice-rich tuff includes pumice fragments 2-7 mm long and less abundant lithic fragments. Maximum thickness about 100 m

Mesa-forming mafic lava flows (Miocene)—Basalt and basaltic andesite lava flows occurring as subhorizontal to gently tilted erosional remnants that typically form mesas. All flows are interbedded with basin-fill deposits (Tbf) and probably are of similar age. Includes Quaternary basalt of Manganese Mesa, basalt near Sandtrap Wash, and Cobwebb Basalt of Lasky and Webber (1949)

Tmbs **Basalt near Signal**—Dark-gray to black basalt lava flows, typically dense but commonly containing vesicular tops, rubble bases, and granite xenoliths. Platy jointing common. Phenocrysts less than 5 percent; most are 1-3 mm-long olivine partly altered to iddingsite; 1-mm-long corroded plagioclase is much less common; glomerocrysts of plagioclase, and plagioclase and olivine are present but rare. Groundmass is diktytaxitic to ophitic in thin section, with 1-2 mm-long optically continuous clinopyroxene crystals surrounding smaller plagioclase laths. Groundmass pyroxene crystals are separated by a matrix of small olivine crystals in network of plagioclase. Maximum thickness 15-20 m

Tmbb **Basaltic andesite of Black Mesa**—Medium-gray, highly vesicular to dense, fine-grained equigranular to porphyritic, diktytaxitic to intersertal basaltic andesite lava flows. Phenocrysts include about 3 percent highly corroded and zoned plagioclase as much as 12 mm long; microphenocrysts of clinopyroxene and olivine altered to iddingsite and local 1-2 mm-long quartz crystals are present but rare. Plagioclase phenocrysts, as much as 10 mm long, locally constitute as much as 15 percent of the rock. Many vesicles are filled with calcite. Many flows occur in areas of greatest thickness. Thickness ranges from 0 to 150 m. K-Ar dated at 9.6 ± 0.3 m.y. (Shackelford, 1980)

Tmbo **Basalt of Mesa 2900**—Medium- to dark-gray basalt lava flows, mottled brownish-gray. Weathers light gray, pale red, and dark reddish brown. Vesicular to dense, locally occurs as flow breccia. Seriate diktytaxitic to hyalophitic texture. Small plagioclase, olivine, and orthopyroxene phenocrysts in a groundmass of plagioclase, olivine, clinopyroxene, and orthopyroxene. Plagioclase phenocrysts typically zoned; cores of olivine phenocrysts altered to iddingsite. Two lithologically similar flow units are present: a lower unit that blankets irregular topography and is 0-30 m thick; and an upper unit that has a consistent thickness of about 4 m. Poorly exposed, poorly consolidated, grayish-orange-pink, very pale orange, and very pale-yellowish-brown tuffaceous siltstone, sandstone, and conglomerate at base of basalt and possibly interbedded with it; these rocks are shown by stippled pattern. The rocks may be equivalent to the tuffaceous facies or the fine-grained facies of the basin-fill deposits (Tbft, Tbff) or the tuffaceous sedimentary rocks (Ts). K-Ar age of basalt is 9.2 ± 0.3 m.y. (Suneson, 1980)

ROCKS DEPOSITED IN BASINS NOT RELATED TO PRESENT TOPOGRAPHY

Tss **Tuffaceous sandstone (Miocene)**—Tan, well-bedded, cross-bedded, tuffaceous and conglomeratic sandstone in scattered outcrops overlying rhyolite units. May correlate with tuffaceous sedimentary rocks (Ts). Thickness 0-20 m

Tvs **Rhyolite lava flows, domes, plugs and dikes (Miocene)**—Very pale-gray to very pale-orange aphyric to porphyritic (with approximately 25 percent phenocrysts) rhyolites, light-colored where devitrified, and commonly flow-banded. Domes, plugs, and dikes (shown on map by check pattern) are characterized by black to gray glassy selvages. Flows have brecciated bases. Miarolitic cavities present but scarce. Nearly aphyric varieties generally contain very small amounts of highly embayed quartz phenocrysts. Porphyritic varieties contain variable amounts of quartz, sanidine, and (or) plagioclase and, in places, small amounts of biotite. Maximum size of phenocrysts: quartz and sanidine, 1.5 mm; plagioclase, 3.5 mm; biotite, 1 mm. Ferromagnesian minerals are partly to wholly oxidized. Groundmass generally is devitrified, microcrystalline, flow banded, and locally spherulitic. Some rhyolites are largely composed of glass. Contact within map unit separates intrusive masses of slightly different ages (y = younger, o = older), differentiated on the basis of intrusive relations. K-Ar ages of similar rhyolites in the same stratigraphic position in adjacent quadrangles range from 15.1 ± 0.1 to 10.3 ± 0.1 m.y. Most ages are between 13 and 12 m.y. (Suneson and Lucchitta, 1979)

Tvsh **Hornblende rhyolite (Miocene)**—Light-gray to very pale-orange, fine-grained, porphyritic, banded rhyolite characterized by 1-3 mm-long needle-like hornblende phenocrysts. Forms one dome and an associated flow, and several dikes north of Eagle Point well (sec. 6, T. 12 N., R. 13 W.). Intrusive rocks shown by check pattern

Tvst **Pyroclastic and epiclastic rocks (Miocene)**—Very pale-orange, pale-greenish-yellow, and yellowish-gray, well-bedded to massive vitric-lithic tuff, tuffaceous sandstone, and tuffaceous conglomerate. Pumice lapilli and angular xenoliths of rhyolite, coarse-grained granite, and metavolcanic rocks are common in the ashy groundmass of the fine-grained rocks of the unit. Thin air-fall tuff and reworked tuff are interbedded with thicker, more massive, and coarser grained air-fall and ash-flow tuffs. Locally, tuff units of probable ash-flow or block-flow origin contain rhyolite clasts as much as 0.5 m long. In places, the tuff has a pinkish cast because of weathering or because of oxidation related to post-depositional cooling. Thickness 0-600 m

Ttc **Tuffaceous conglomerate (Miocene)**—Pale-reddish-brown to moderate-reddish-orange, poorly bedded to well-bedded, pumiceous conglomerate and sandstone. Sandstone is medium- to coarse-grained. Both sandstone and conglomerate are arkosic and are characterized by abundant pumice lapilli. Locally interbedded with tuff and tuffaceous sandstone, especially toward the top of unit. Cobble-sized clasts, commonly subrounded but locally angular, are common. Clast lithologies include granitic rocks, rhyolite, and metavolcanic rocks. Interbeds of boulder conglomerate containing clasts of coarse-grained granite, as much as 50 cm in diameter, occur locally. In places, the unit is calichified or strongly stained with manganese. Thickness 0 to about 365 m

Tk **Arkose of Keenan Camp (Miocene)**—Pale-red to pale-grayish-red, well-indurated to unconsolidated, interbedded boulder- and cobble conglomerate and coarse sandstone, all arkosic in composition. Bedding moderate to poor; crossbedding common. Clasts include porphyritic granitic rocks, various kinds of gneiss, aplite, leucogranite, diabase, amphibolite, metarhyolite, quartzite, other metavolcanic and metasedimentary rocks, dacite porphyry, and olivine basalt. Clasts are as much as 2.5 m in diameter, typically 1-10 cm, and are rounded to subangular. Manganese stain common locally. Unit distinguished from the basal arkose (Tba) by the presence of metasedimentary and metavolcanic rocks of the type found in the breccia (Tbx), and by the abundance of olivine-basalt clasts. Thickness 0 to about 190 m

Tcg **Boulder conglomerate (Miocene)**—Boulder conglomerate, coarse sandstone, and siltstone, in discontinuous outcrops. Mostly poorly bedded, well-consolidated to unconsolidated, arkosic conglomerate containing thin interbeds of sandstone and siltstone. Sandy matrix is moderate orange-pink to moderate reddish-orange. Weathers into light-toned boulder-strewn slopes that have few outcrops; on casual inspection can be mistaken for spheroidally weathered Signal Granite (p€s). Characterized by rounded clasts as much as 2 m in diameter, commonly 1 m, typically 10-15 cm. These clasts are composed of granitic rocks, augen gneiss, banded gneiss, aplite, amphibolite, metarhyolite, metavolcanic rocks, gray limestone, quartzite, andesite or dacite porphyry, and olivine basalt. Thickness 0-50 m

Older basalt sequence (Miocene)—Highly altered, generally coarse-grained and amygdaloidal basalt flows. Probably correlates with the basalt member of the Artillery Formation of Lasky and Webber (1949), mapped in the area just south of this quadrangle. The basalt member most likely consists of several distinct flows in slightly different stratigraphic positions, rather than a single, widespread basalt member whose characteristics change laterally, as suggested by Lasky and Webber (1949)

Tbp **Porphyritic plagioclase basalt**—Porphyritic basalt lava flows containing conspicuous phenocrysts of plagioclase and less abundant olivine and pyroxene. Plagioclase phenocrysts are as much as 2.5 mm long, range from highly corroded and embayed to fresh, and commonly show oscillatory zonation. Olivine phenocrysts are as much as 2.5 mm in diameter, and generally are completely altered to iron oxide and (or) bowlingite. Clinopyroxene phenocrysts are as much as 1 mm long, are completely uralitized, and grade in size to microphenocrysts and groundmass crystals. Groundmass consists of plagioclase, clinopyroxene, olivine, and opaque minerals and makes up approximately 85 percent of the rock. Thickness about 10 m

Tbpi **Intrusive facies of porphyritic plagioclase basalt**—Thin irregular dikes identical in lithology to the porphyritic plagioclase basalt flows (Tbp)

Teb **Early basalt**—Highly altered, coarse-grained basalt lava flows containing conspicuous plagioclase and olivine phenocrysts. Plagioclase phenocrysts are as much as 5 mm in length, and range from fresh to highly corroded epidote and clay, but typically have fresh rims. Rare olivine phenocrysts as much as 1 mm in diameter are altered to iron oxide. Plagioclase and olivine phenocrysts grade in size to microphenocrysts and groundmass crystals. Groundmass consists of plagioclase laths altered to epidote and calcite, pyroxene crystals altered to opaque minerals, possibly olivine, opaque minerals, and interstitial glass altered to brown clays. Rock is highly vesicular and amygdaloidal. Thickness varies from 0 to about 25 m

Tob **Porphyritic olivine basalt**—Medium- to dark-gray basalt flows, generally highly altered, weathering into rubbly, medium- to light-gray outcrops. Contains 2-5 percent olivine phenocrysts altered to iddingsite or bowlingite that are as much as 15 mm long, though typically 1-3 mm, locally in glomerocrysts; 5-10 percent plagioclase phenocrysts that are as much as 5 mm long, but typically less than 1 mm, of which the larger crystals commonly are corroded; and rare uralitized pyroxene phenocrysts approximately 1 mm long. Groundmass consists of plagioclase, clinopyroxene, olivine, and opaques. Iddingsitized-olivine phenocrysts are characteristic of unit. The unit may include several flows. Thickness 0-20 m

Tbu **Upper basin beds (Miocene)**—Heterogeneous unit composed of white, wavy-bedded limestone; white limestone; reddish chert; very pale green, poorly consolidated, well-bedded, gypsiferous limy siltstone; and poorly consolidated gray sandstone. Commonly well-bedded. Thickness 0-40 m

Tbx **Breccia (Miocene)**—Medium- to light-gray, light-brownish-gray, pale-brown, and pale-red, unstratified, moderately to poorly indurated, unsorted breccia with chaotic structure and composed of angular fragments a few centimeters to several meters in diameter. Clasts chiefly composed of weakly foliated metasedimentary and metavolcanic rocks; fine-grained plutonic rocks not found within the basement rocks exposed in the area; and well-foliated quartz-eye metavolcanic rocks (metatuff?). Metasedimentary rocks consist chiefly of poorly sorted coarse-grained graywacke sandstone and granule conglomerate. Less common, but conspicuous, are quartzite and a conglomerate that contains well-rounded clasts, as much as several centimeters in diameter, of fine-grained plutonic rocks and dacite(?) porphyry with feldspar phenocrysts as long as 2 cm. This conglomerate is sufficiently indurated to break across clasts. Unit locally includes an alluvial facies (stippled pattern) that shows much evidence of reworking by water and is characterized by subangular clasts, weak stratification, and interbedded coarse-sandstone layers. The breccia typically is not exposed and occurs as a greenish lag of angular clasts, some very large. Unit is a regional marker bed. Thickness very variable, ranging from zero in northern part of quadrangle to about 150 m in southern part

Lower basin beds (Miocene)—Clastic to limy beds, poorly to well-indurated, well-bedded. Locally includes tuffaceous material. Thickness zero in northern part of quadrangle to about 180 m in southern part

Tbl **Lower basin beds, undifferentiated**

Tbll **Limy facies**—Gray and yellowish-gray limestone, and yellowish-gray limy siltstone and sandstone. Generally well-consolidated, wavy-bedded, and contorted. Has yielded a Miocene microflora (R. F. Hevly, written communication, 1979). Thickness increases from zero in northern part of quadrangle to about 260 m at southern boundary

Tblc **Clastic facies**—Grayish-yellow-green, moderate-greenish-yellow, light-bluish-gray, grayish-orange-pink, and very light-gray, moderately consolidated to unconsolidated siltstone, sandstone, granule conglomerate, pebble conglomerate, and subordinate air-fall biotite tuff. Grains and clasts are angular to subrounded. Sand fraction is arkosic. Clasts, typically 1-2 cm in diameter, with a maximum of 15 cm, are composed of porphyritic granitic rocks, diabase, quartzite, chloritized mafic plutonic rocks, leucogranite, metarhyolite, quartzite, and metasedimentary and metavolcanic rocks. Bedding moderate to good; beds typically 3-8 cm thick. Gradational into the basal arkose (Tba) and interfingers with the limy facies (Tbll). Thickness increases from zero in northern part of quadrangle to about 170 m near southern boundary

Tba **Basal arkose (Miocene)**—Pale-reddish-brown to light-red, moderately to poorly sorted, moderately well-stratified, medium- to coarse-grained, moderately to poorly indurated arkosic conglomerate. Sand fraction subangular to subrounded. Clasts subrounded to rounded, typically less than 10 cm in diameter. Clasts are from Precambrian units and include quartz, porphyritic granitic rocks, leucogranite, aplite, and metarhyolite porphyry. Beds 1-50 cm thick, typically defined by color and grain-size variation. Parallel bedding, cross bedding, and channeling are all common. Unit tends to underlie low areas and forms poor exposures. Thickness highly variable, from zero in northern part of quadrangle to about 150 m in southern part

ROCKS OF INDETERMINATE STRATIGRAPHIC POSITION

Rocks whose stratigraphic position cannot be determined because they are of nondiagnostic lithology, are present in isolated exposures, are not associated with rocks of known stratigraphic position, and (or) could be correlated with any one of several similar stratigraphic units.

Tbi **Intrusive basaltic rocks (Miocene)**—Small dikes and irregular intrusive masses of indeterminate age. Includes olivine basalt, containing 1-mm-diameter olivine phenocrysts altered to iddingsite; and porphyritic hornblende andesite, containing about 5 percent hornblende needles as much as 10 mm long, but typically 3-4 mm long, as well as corroded plagioclase laths 8-10 mm long. Intrudes Precambrian basement rocks and arkose of Keenan Camp

Tai **Hornblende andesite dike (Miocene)**—Greenish-gray porphyritic hornblende andesite dike, weathers reddish-gray. Distinguished by conspicuous needle- to lath-shaped phenocrysts of hornblende, as much as 8 mm long, although typically 3-4 mm long, that form 5-10 percent of rock, intergrown with abundant plagioclase needles, as much as 10 mm long, forming a felty texture. Intrudes Precambrian gneiss, but is in contact with no other rock. Northerly trend parallels that of latest Miocene to Pliocene megacryst-basalt dikes in adjacent quadrangles. The hornblende andesite dike may be of similar age

Ts **Tuffaceous sedimentary rocks (Miocene)**—Heterogenous tuffaceous clastic rocks. Includes the following units: (a) Light-brown to grayish-orange-pink, moderately to poorly bedded, moderately to poorly indurated conglomerate composed of angular pebbles and cobbles derived from underlying Precambrian rocks, in a tuffaceous matrix; grades upward into pebbly sandstone of the same composition. (b) White to very light-gray, well-bedded, parallel-bedded pumiceous and tuffaceous sandstone, showing open texture and beds 2-20 cm thick. Pumice fragments are as much as 15 mm in diameter. Quartz grains and scattered biotite crystals are most conspicuous components. Includes a 1-m-thick bed of tan, massive, structureless, tuffaceous sandstone with floating clasts of Precambrian Signal Granite (p€s), possibly a lahar deposit. (c) Very light-gray to white, limy sandstone containing unsupported 1 to 3 cm-long clasts of granite interbedded with light-brown, well-bedded sandstone that locally contains abundant granite fragments. The tuffaceous sedimentary rocks occur in isolated exposures and, in the northeastern part of the area, isolated fault-bounded troughs. The presence of silicic tuffaceous and pumiceous material suggests that much of the unit is coeval with the silicic rocks. In general, the less tilted rocks of this unit probably correlate with the fine-grained facies of the basin-fill deposits (Tbff), the tuffaceous facies of the basin-fill deposits (Tbft), and the tuffaceous sediments associated with the basalt of Mesa 2900 (Tmbo); the more tilted rocks probably correlate with the tuffaceous sandstone (Tss), the pyroclastic and epiclastic rocks (Tvst), and the tuffaceous conglomerate (Ttc). Thickness not known with certainty because of poor exposures, but probably from 0 to about 50 m

Ta **Hornblende andesite (Miocene)**—Purplish-brown to medium gray, andesite lava flow, flow breccia, and intrusive breccia. Phenocrysts (5-6 percent of rock volume), typically about 1 mm long but some as much as 5 mm long, consist of 5 percent hornblende needles, and 1 percent plagioclase. Groundmass locally partly glassy. Phenocrysts and groundmass generally are altered, but are relatively fresh locally. Rock overlies and intrudes Precambrian Signal Granite (p€s) and is overlain by basin-fill deposits (Tbf). Locally, flow and flow breccia of this unit are associated in unclear contact with sandstone that interfingers with breccia (Tbx) and boulder conglomerate (Tcg). The andesite thus may be as old as these units. Thickness from 0 to about 60 m

Tc **Conglomerate (Miocene)**—Pebble-, cobble-, and boulder conglomerate containing sandstone interlayers. Moderately to poorly consolidated, typically brown to reddish-orange, weathering into light-toned, boulder-strewn slopes with few outcrops. Coarse-grained porphyritic granite (p€s) is a conspicuous clast type that in places unit can be mistaken for spheroidally weathered granite. Typically occurs as isolated patches mantling the granite. May correlate with Tbfc, Ttc, and Tcg. Thickness unknown

Tvr **Rhyodacite (Miocene?)**—Intrusive mass of light-gray to pale-pink porphyritic hornblende-biotite rhyodacite. Phenocrysts, which comprise about 30 percent of rock, consist of euhedral uncorroded plagioclase typically 1 mm long, with thin rims of iron oxide; hornblende as much as 4 mm long, fresh to completely altered to calcite and brown clays; biotite, about 1 mm in size, fresh to moderately altered; and rounded and embayed quartz as much as 2 mm in diameter. Groundmass consists of plagioclase laths, minor biotite and hornblende in a brown, dusty, relatively altered microcrystalline matrix. Unit intrudes Precambrian Signal Granite (p€s) and is overlain by basin-fill deposits (Tbf)

BASEMENT ROCKS

Mzp€i **Silicic and intermediate intrusive rocks (Mesozoic or Precambrian)**—Pinkish-gray, grayish-orange-pink and very pale-orange, fine- to coarse-grained, equigranular leucogranite; fine-grained aplite; medium- to coarse-grained pegmatite; and leucocratic to mesocratic medium- to fine-grained biotite granodiorite. Typically fresh. Occurs as a subequant stock measuring about 250 by 450 m; as thick dike-like bodies 50-70 m wide and about 500 m long; as numerous dikes a few meters thick and as much as 900 m long; and as abundant dikes and veins too small to map. Tabular bodies typically trend northeast

p€d **Diabase (Precambrian?)**—Medium-gray to dark-greenish-gray, fine- to medium-grained diabase dikes, mostly with well-developed ophitic texture. Diabase in many places forms tabular bodies that intrude granite and gneiss and trend northwest to north-northwest. Typically weathers to rubble and forms few good exposures

p€r **Metarhyolite porphyry (Precambrian?)**—Light-gray to pinkish-gray rhyolite porphyry dikes. Contains 1 to 1.5-mm-long rounded quartz phenocrysts in altered felsic groundmass. No flow banding visible. Very hard. Weathers into angular fragments that litter slopes

p€s **Signal Granite (Precambrian)**—Light-gray to medium-brownish-gray leucocratic to mesocratic, unfoliated to weakly foliated, typically massive, locally jointed and spheroidally-weathered, medium- to coarse-grained porphyritic biotite granite or monzogranite. Phenocrysts are subequant, typically 2-3 cm long, maximum 5 cm, composed of twinned potassium feldspar. A coarse-grained equigranular phase occurs locally. In places, contains sparse xenoliths of melanocratic diorite and biotite schist, and xenoliths of leucocratic to mesocratic gneiss. Also contains local zones of closely spaced subparallel joints in areas of structural disturbance. Intruded by quartz, aplite, pegmatite, leucogranite, metarhyolite porphyry, and diabase. Leucocratic and mesocratic phases form coherent bodies measuring hundreds of meters. Cut by numerous shear zones, locally mineralized, showing evidence of weak recrystallization. The age assignment is based on lithologic and structural similarity with Precambrian granite on Colorado Plateau to east and Hualapai Mountains to north. Best exposed in the Artillery Mountains, in the northern part of the Artillery Peak quadrangle, between the ghost town of Signal (SW 1/4 sec. 9, T. 13 N., R. 13 W.), and Eagle Point (E 1/2 sec. 7, T. 12 N., R. 14 W.). New name, proposed by Lucchitta and Suneson (1982)

p€gn **Gneiss (Precambrian)**—Includes a variety of gneissic rocks that are predominantly orthogneisses, are affected by open to isoclinal folding, and locally are migmatitic. Chief lithologies are: (a) Light- to medium-gray, leucocratic to mesocratic equigranular gneissic granite, locally porphyritic. Where porphyritic, includes 2-5 cm subequant crystals of potassium feldspar. Probably a marginal facies of the Signal Granite (p€s). (b) Coarse-grained, equigranular leucocratic to mesocratic, weakly to moderately foliated biotite granite gneiss. (c) Dark-gray, medium- to fine-grained, equigranular, mesocratic to melanocratic, well-foliated biotite granite gneiss. Locally contains bands of well-defined augen composed of potassium feldspar, and has a mylonitic fabric. Locally contains garnet.

The unit is intruded by quartz, pegmatite, and aplite veins, and by diabase, metarhyolite and leucogranite dikes. Locally it is cut by shear zones that are marked by crushing, mylonitization, and alteration, and are intruded by pegmatite, aplite, and quartz veins. Similar to and continuous with Precambrian rocks in Hualapai Mountains to north and Colorado Plateau to east.

Contact—Dashed where approximately located or gradational. In silicic volcanic rocks (Tvs), contacts separate intrusions of slightly different ages and y/o indicates younger/older where determined

Fault—Dashed where approximately located, dotted where concealed, queried where inferred. Arrow shows direction and amount of dip. Crossbar denotes vertical fault. Bar and ball on downthrown side, where determined

Shear zone—Zone of crushing, brecciation, mineralization, and bleaching, for which no displacement can be determined

Mineralized vein

Area of intense brecciation

Vent area

Anticline—Showing crestline and direction and amount of plunge

Syncline—Showing troughline and direction of plunge. Dashed where approximately located

Strike and dip
Dot at end of leader shows location of measurement

Beds

- **Inclined**
- **Horizontal**
- **Approximate**
- **Apparent** (in areas of low dip and poor exposure)
- **Generalized** (crumpled, plicated, or indulating beds)

Foliation

- **Inclined**
- **Vertical**

Joints

- **Inclined**
- **Inclined showing range of dips**

GEOLOGIC SETTING

The Artillery Peak NW quadrangle is one of a series of quadrangles being mapped in a northeast-trending belt extending from the metamorphic-core-complex terrane of the Rawhide, Buckskin, and Whipple Mountains to the Colorado Plateau near Wikieup, Arizona.

Four major sequences of rocks are present. From oldest to youngest they are:

(1) Basement rocks, which consist of: (a) Banded gneiss, augen gneiss, granite gneiss, and medium-grained equigranular granitic rocks, all indistinguishable from similar rocks of Precambrian age in the Hualapai Mountains to the north and the Colorado Plateau to the east. (b) Coarsely porphyritic granite or monzogranite forming a large pluton. Age unknown, but thought to be Precambrian because of lithologic similarity with known Precambrian granites (the Prescott Granodiorite, Oracle (of Peterson, 1938), and Ruin Granites, all in Arizona). (c) Metarhyolite and diabase dikes trending northeast and dipping southwest. Age unknown, but probably Precambrian. (d) Aplite, pegmatite, and leucogranite dikes trending northeast, and one small leucogranite stock. Age unknown, most likely Precambrian or Laramide.

(2) Fluvio-lacustrine rocks, with interlayered basaltic and rhyolitic rocks, that were deposited in basins not related to the present topography and that now are highly deformed. The lower part of the sequence reflects drainage chiefly from the northeast, whereas the upper part reflects drainage chiefly from the southwest. Because of the several basins of deposition, marked lateral changes in facies and thickness are the norm. These rocks are analogous to the Miocene Horse Spring Formation and related deposits in the Lake Mead area (Longwell, 1921, 1922; Bohannon, 1980). The Artillery Peak NW quadrangle is near the northeastern limit of deposition of fluvio-lacustrine rocks of the Bill Williams River area.

(3) Interior-basin deposits filling the present basins, which were formed by basin-range tectonism. Basaltic lava flows associated with these deposits typically form conspicuous mesas or gently sloping cuestas. All these basin-filling deposits are analogous to the Muddy Creek Formation, the Big Sandy Formation of Sheppard and Gude (1972), the fanglomerate of Metzger and others (1973), and the fanglomerate of Osborne Wash of Dickey and others (1980).

(4) Deposits related to through-flowing drainage. Chiefly piedmont-slope deposits, alluvial deposits, and basaltic lava flows that have followed present drainages. Probably younger than 5.5 m.y. (Lucchitta, 1972, 1979).

Rocks of the second, or fluvio-lacustrine, sequence are tilted southwest and cut by faults trending northwest and dipping northeast. Based on exposures in adjacent quadrangles to the southwest, these faults are believed to be listric and associated with an episode of low-angle detachment faulting and intense extension.

Interior-basin deposits are much less deformed than older rocks, but nevertheless are affected by basin-range faulting and mild warping. Faulting and deposition were largely synchronous, but faulting ceased before the end of deposition so that fault traces are buried by the youngest interior-basin deposits.

The fourth, or youngest, group of deposits is not cut by faults in this quadrangle.

None of the rocks of sequence 2 are Eocene(?) or Oligocene in age, as had previously been believed (Lasky and Webber, 1949; Gassaway, 1977, 1978; Otton, 1977; Eberly and Stanley, 1978; Shackelford, 1980). Our work in this and four quadrangles adjacent to the west indicates that these rocks are Miocene because: (a) K-Ar age determinations on basalts of the older basalt sequence range from about 16.5 to about 18.7 m.y. (Suneson and Lucchitta, 1979); (b) These basalts are interbedded with the Miocene Peach Springs Tuff of Young and Brennan (1974); (c) K-Ar age determinations on the silicic volcanic rocks are mostly in the 12 to 13 m.y. range (Suneson and Lucchitta, 1979); and (d) Rocks from the lower part of the sequence have yielded Miocene microfossils (R. F. Hevly, written communication, 1979).

Basalts that are part of sequence 3 (interior-basin deposits) have yielded K-Ar ages ranging from 9 to 13 m.y. (Suneson and Lucchitta, 1979).

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