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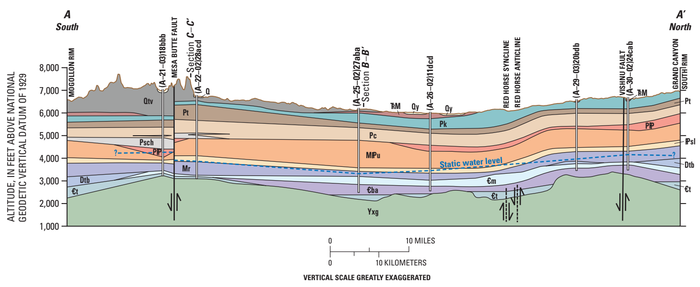
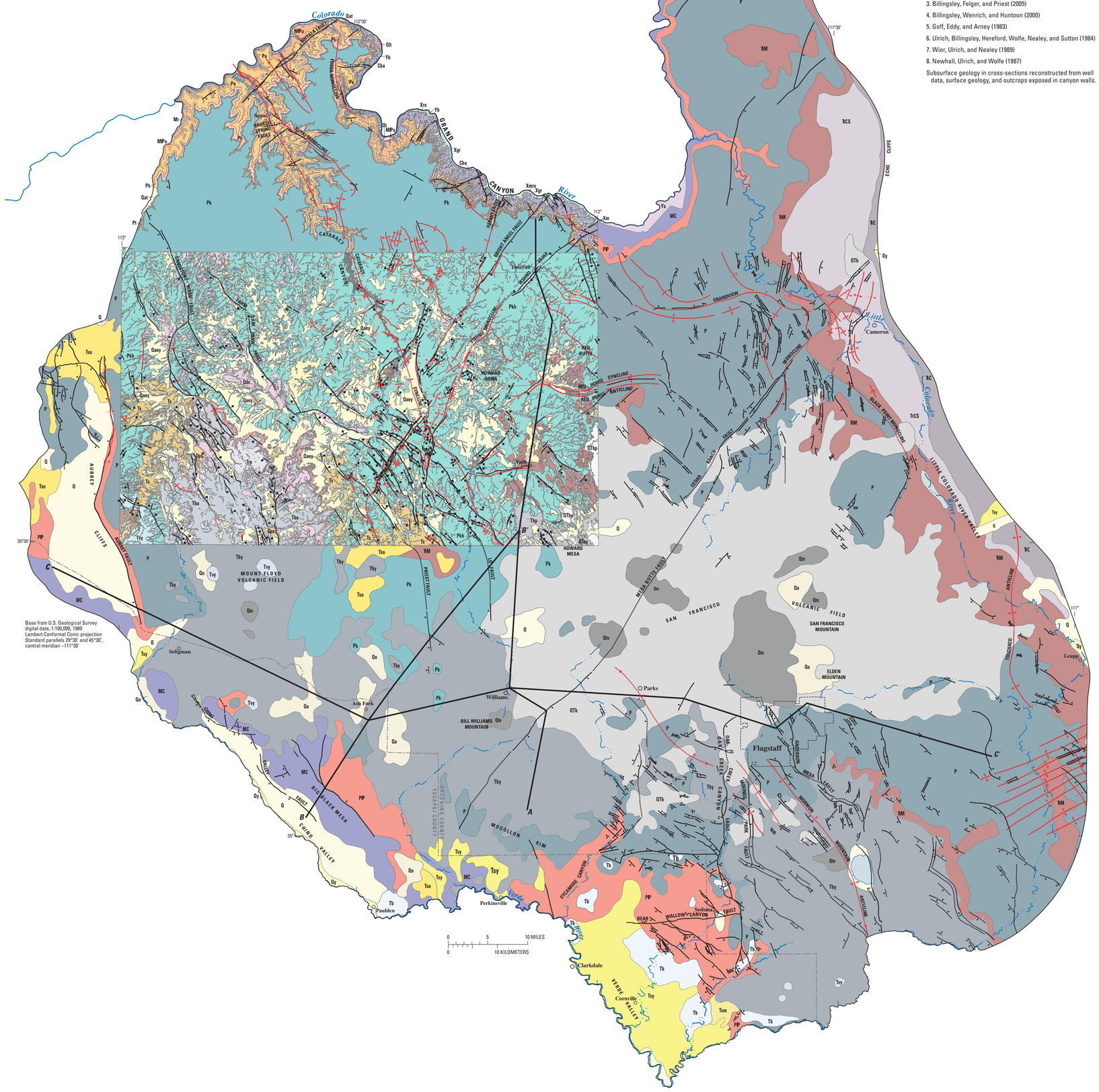
SCIENTIFIC INVESTIGATIONS REPORT 2005–5222
Surface geology, geologic structure, and sections of the Coconino Plateau and adjacent areas, Coconino and Yavapai Counties, Arizona—Plate 1 of 4
Donald J. Bills, Marilyn E. Flynn, and Stephen A. Monroe, 2007,
Hydrogeology of the Coconino Plateau and adjacent areas, Coconino and Yavapai Counties, Arizona

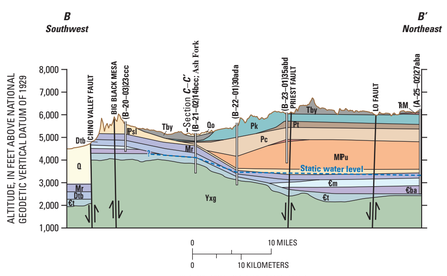


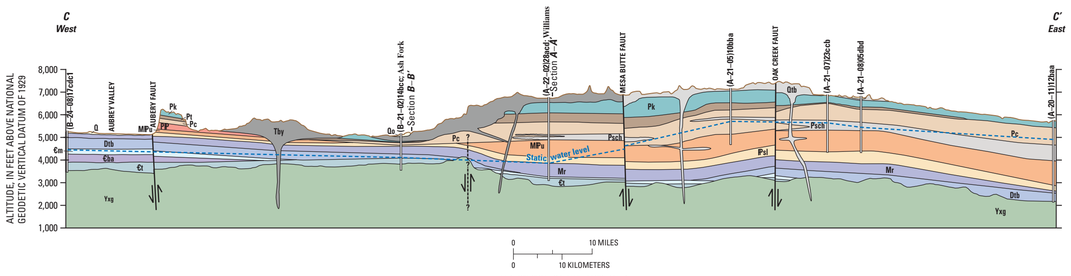
GEOLOGY, GEOLOGIC DESCRIPTIONS, AND GEOLOGIC STRUCTURE MODIFIED FROM:

1. Reynolds (1988), underlying surface geology for entire map. Additonal sources below are unhashed where used for both geology and structure, hashed where used for structure only.
2. Billingsley (2000)
3. Billingsley, Felger, and Priest (2005)
4. Billingsley, Wenrich, and Huntoon (2000)
5. Goff, Eddy, and Arney (1983)
6. Ulrich, Billingsley, Hereford, Wolfe, Nealey, and Sutton (1984)
7. Wier, Ulrich, and Nealey (1989)
8. Newhall, Ulrich, and Wolfe (1987)

Subsurface geology in cross-sections reconstructed from well data, surface geology, and outcrops exposed in canyon walls.







SURFACE GEOLOGY, GEOLOGIC STRUCTURE AND SECTIONS OF THE COCONINO PLATEAU AND ADJACENT AREAS, COCONINO AND YAVAPAI COUNTIES, ARIZONA

By
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2007

EXPLANATION

QUATERNARY

SURFICIAL DEPOSITS

- Q — UNCONSOLIDATED SEDIMENTS (HOLOCENE AND PLEISTOCENE)—Alluvium, colluvium, eolian, and glacial and glaciofluvial (on San Francisco Mountain) deposits, consisting of gravel, sand, cobbles, silt, and mud. Glacial and glaciofluvial deposits range from small boulders to silt. About 3 to 300 feet thick
- Qat — YOUNGER ALLUVIUM AND TERRACE GRAVELS (HOLOCENE)—Gravel, cobbles, and sand. About 3- to 300-feet thick
- Qaey — YOUNGER ALLUVIUM AND EOLIAN DEPOSITS (HOLOCENE)—Fine-grained sand, silt, and clay. About 1- to 25-feet thick
- Qy — YOUNGER ALLUVIUM (HOLOCENE AND PLEISTOCENE)—Sand, silt, and mud. About 1- to 100-feet thick
- Qfvr — FLOODPLAIN, FLUVIAL, VALLEY ALLUVIUM, AND RIVER GRAVEL DEPOSITS (HOLOCENE)—Gray, brown, and light red, clay, silt, sand, and gravel, poorly sorted. Stream channels subject to flash floods with little or no vegetation. Floodplains and fluvial deposits intertongue and overlap stream channel alluvium. About 3- to 20-feet thick
- Qo — OLDER ALLUVIUM (PLEISTOCENE AND PLIOCENE)—
  - Qoae — OLDER ALLUVIUM, EOLIAN, AND GRAVEL DEPOSITS (PLEISTOCENE AND PLIOCENE)—Sand, silt, clay, mud, and gravels lithologically similar to younger alluvium (Qy, Qat, and Qaey) with cobbles and boulders and capped by thin, poorly developed, calcrete soil. Forms flat mesa and terrace benches about 30- to 120-feet above modern drainage erosion. About 10- to 40-feet thick
- Qls — LANDSLIDE, TALUS, AND ROCKFALL DEPOSITS (HOLOCENE AND PLEISTOCENE)—Unsorted rock debris from house-sized boulders to cobbles, gravel, sand, and silt, mostly angular to subangular. Landslide masses are commonly found around the edges of the Mount Floyd Volcanic Field, Red Butte, and the San Francisco Volcanic Field. Talus deposits and rockfalls form debris slopes in steep canyons through the area. About 1- to 200-feet thick
- Qt — TRAVERTINE (HOLOCENE AND PLEISTOCENE)—Gray, white, and tan, massive, mounded or layered, chemical precipitate of calcium carbonate. Locally includes talus debris and stream gravels. Typically forms at the base of limestone cliffs at and near active and inactive springs. Thickest deposits are in the lower Little Colorado River, Havasu Creek, and the south rim of the Grand Canyon at the base of the Redwall and Muav Limestones. Older abandoned travertine deposits occur several hundred feet above the current level of spring discharge. About 30- to more than 100-feet thick
- Qds — DUNE SAND, SAND SHEETS, SILT DUNES AND SHEETS, AND FLUVIAL SILT DEPOSITS (HOLOCENE AND PLEISTOCENE?)—White to gray, fine to coarse wind blown sand, silt, and clay. Sand is mainly quartz and feldspar, silt and clay are mainly decomposed and weathered volcanic rocks. Dune sand and sand sheets occur as lumpy, poorly defined masses from 3- to 20-feet thick, some stabilized by sparse to moderate vegetation. Silt dunes, sheets, and fluvial deposits are more uniform and flat, occurring at the edges of dry lakes and ponds, and support little or no vegetation. About 6- to 80-feet thick
- Qps — PONDED SEDIMENTS (HOLOCENE AND PLEISTOCENE?)—Gray to brown clay, silt, and sand. Locally includes limestone fragments, pebbles, and gravel. Occurs in internal drainage depressions and sinkhole ponds mainly in the northwest quarter of the area. Supports little or no vegetation. About 5- to 30-feet thick

TERTIARY

- Tsm — SEDIMENTARY ROCKS (MIOCENE TO OLIGOCENE)—Light colored gray, orange, and pink, semi-consolidated to consolidated, bedded to interbedded, sandstone, siltstone, mudstone. Some limestone and gypsum beds. A few 10s to a few 100-feet thick
- Tsy — YOUNGER SEDIMENTARY ROCKS (PLIOCENE TO MIOCENE)—Light colored gray, green, orange, and pink, semi-consolidated to consolidated, bedded to interbedded, sandstone, siltstone, mudstone with interfingering limestone, gypsum, and volcanic debris. The Verde Formation southwest of the Mogollon Rim dominating the Verde Valley is the largest of these deposits. Also occurs to the north of the Verde Valley in Chino Valley. Maximum thickness more than 3,100 feet (Nations and others, 1981)
- Tso — OLDER SEDIMENTARY ROCKS (OLIGOCENE TO PALEOCENE)—Rim gravels and associated finer grained sediments of the Mogollon Rim region. Weakly consolidated, interbedded, sand, gravel, and silt containing clasts of Paleozoic rocks. Typically underlies Miocene basalts in drainages flowing south from the Mogollon Rim. A few to over 100-feet thick
- Ts — TERTIARY SEDIMENTS (EOCENE TO LATE PALEOCENE)—Light red, gray, and white interbedded siltstone, sandstone, gravel, conglomerate, and thin bedded freshwater limestone. Occurs mostly in the central and western parts of the area. About 60- to 180-feet thick

VOLCANIC ROCKS

- Qtv — VOLCANIC ROCKS (QUATERNARY TO LATE PLIOCENE)—Rhyolitic to andesitic rocks
- Qi — VOLCANIC AND INTRUSIVE ROCKS (PLEISTOCENE)—Dark gray basaltic dikes and necks. Dikes typically 1- to 3-feet thick
- QTsp — BASALTIC ANDESITE FLOWS, DIKES, AND NECKS, AND PYROCLASTIC FLOWS (PLEISTOCENE TO PLIOCENE)—Dark gray basalt, basaltic, andesite, and pyroclastic flows and deposits, with abundant clinopyroxene and plagioclase. About 20- to 300-feet thick
- QTb — BASALTIC ROCKS (PLEISTOCENE TO PLIOCENE)—
  - QTbp — BASALT AND PYROCLASTIC FLOWS (PLEISTOCENE TO PLIOCENE)—Dark gray to brown basalt with interbedded thick to thin pyroclastic deposits. Pyroclastic deposits are dark gray to red cinders, splatter, bombs and ribbon fragments that weather to brown and red brown. Overall thickness from 30- to 600-feet
- Tby — YOUNGER BASALTS (PLIOCENE TO MIOCENE)—
  - Tba — BASALT AND ANDESITE FLOWS (PLIOCENE TO EARLY MIOCENE)—Dark-gray to gray-black basalts and andesite flows. Basalt flows merge in several locations. Andesite flows in lobes from Howard Mesa. Thickness from 25 to more than 300 feet
- Tvy — YOUNGER VOLCANIC ROCKS (PLIOCENE TO EARLY MIOCENE)—
- Tb — BASALTS (LATE TO MIDDLE MIOCENE)—
  - Tbp — BASALT, PYROCLASTIC DEPOSITS, AND INTRUSIVE ROCKS (PLIOCENE TO MIOCENE)—Medium to dark-gray basalts and dark-gray to red pyroclastic rocks. Basalts are olivine to plagioclase rich occurring in massive flows, dikes, and vents. Dikes and vents from 4- to 20-feet thick. Pyroclastic deposits are cinders and splatter fragments that weather to brown and red brown. Thicknesses from 30 to 200 feet
  - Trp — RHYOLITE, RHYODACITE, OBSIDIAN FLOWS, DIKES, NECKS, AND PLUGS, VENT AREAS, AND PYROCLASTIC DEPOSITS (EARLY MIOCENE)—Red, gray, and black rhyolite, rhyodacite, and obsidian. Rhyolite and rhyodacite are in twisted thin flows, dikes, and vents. Obsidian flows are mostly black to gray-banded and red-black banded. Flows typically overlie one or more older (Tb) basalt flows. Pyroclastic deposits are red and reddish-gray cinders, scoria, ash, and glassy fragments of basalt, partly consolidated. Thicknesses from 30 to 200 feet
- Trb — RED BUTTE BASALT (EARLY MIOCENE)—Dark gray olivine basalt in massive flow. Weathers brown. Thickness 165 feet

SEDIMENTARY ROCKS

TRIASSIC

- TrC — CHINLE FORMATION UNDIFFERIENTATED (UPPER TRIASSIC)—Multi-colored interbedded siltstone, limestone, calcareous siltstone, medium to coarse-grained fluvial sandstone, and coarse-grained to conglomeratic, crossbedded sandstone. Occurs as continuous eroded beds along the Little Colorado River Valley. Less common in the rest of the area as paleo-valleys filled with fluvial deposits and protected by overlying volcanic rocks. Thickness from 4 to 700 feet
- TrCS — SHINARUMP MEMBER OF THE CHINLE FORMATION (UPPER? AND LOWER TRIASSIC)—White to pale-red, coarse-grained, crossbedded sandstone and pebble conglomerate. Forms small cliffs and ledges along the Little Colorado River Valley and weathers to a pavement of orange to red pebbles. In the central part of the area, the unit has been baked red to brick red by overlying basalt flows. Thickness from 5 to 85 feet
- TrM — MOENKOPI FORMATION (UPPER? AND LOWER TRIASSIC)—Reddish-brown mudstone, siltstone, silty sandstone, and sandstone with veins and stringers of gypsum. Typically thin bedded. Crops out as a continuous layer along the Little Colorado River Valley. Occurs as a discontinuous erosional remnant in the central northern and western part of the area, now buried by the volcanic rocks. Thickness from 0 to 1,000 feet

PERMIAN

- P — KAIBAB FORMATION, TOROWEAP FORMATION, AND COCONINO SANDSTONE UNDIFFERIENTATED (PERMIAN)—Gray limestone, gray, light-red, light-purple, and yellowish-red siltstone (Kaibab Formation); silty sandstone, fossiliferous limestone; thin-bedded dolomite, sandstone, and gypsum (Toroweap Formation); and tan to white, fine-grained, well sorted, crossbedded, quartz sandstone (Coconino Sandstone)
  - Pk — KAIBAB FORMATION (UPPER PERMIAN)—Thinly bedded, reddish-gray to brownish-gray, reddish-orange to white sandy to silty limestone, calcareous to silty sandstone, thin bedded limestone, and gypsum (Harrisburg Member, Pkh). Yellowish-gray to light gray, fine- to medium-grained, thin- to medium-bedded, fossiliferous, sandy cherty limestone, chert lenses, dolomite, dolomitic limestone, and minor sandstones and dolomitic sandstones (Fossil Mountain Member, Pkh). Dolomitic limestones and sandy limestones are commonly cherty making up at least 20 percent of the formation in the western half of the area. The whole formation is thickest to the southwest and thins to the east-northeast. The eroded top of the formation forms most of the land surface now exposed in the central and northern parts of the area or buried by the volcanic rocks of the Mount Floyd and San Francisco Volcanic Fields to the west and south. Dissolution of gypsum beds and limestone has resulted in the development of solution channels and fractures, sinkholes, and internal drainage through out the area. Total thickness of unit varies from 100 to 650 feet
  - Pt — TOROWEAP FORMATION (UPPER PERMIAN)—Gray to light-red, gypsiferous siltstone and silty sandstone with interbedded layers of gypsum and thin-bedded gray limestone. Gray, thin- to medium-bedded, fine- to coarse-grained fossiliferous limestone. Gray, light-purple, yellow-red, thin-bedded dolomite, limestone, sandstone, and gypsum. Gypsum beds can be up to 10 feet thick. White and gray chert nodules present in lower limestones. Collapse structures are common due to dissolution of gypsum. The formation thickens to the west and thins to extinction east of a northeast-southwest line through the middle of the area. In the western part of the area the lower part of the formation interfingers with the underlying Coconino Sandstone. Outcrops occur in steep canyons to the north on the south rim of Grand Canyon, in Havasu Canyon, at the base of the Aubrey Cliffs, and along the northwestern Mogollon Rim. Thickness of unit varies from 0 to 380 feet
  - Pc — COCONINO SANDSTONE (PERMIAN)—Tan to white to pale red, fine-grained, well sorted, cross-bedded quartz sandstone. Cross-bed sets can range up to 35 feet thick. Thickness decreases from east to west. To the north and northwest a sharp, unconformable, planar contact exists with the underlying Hermit Formation. To the south and southeast the Coconino Sandstone is interbedded and interfingered with the underlying Schnebly Hill Formation. Forms dramatic cliffs in outcrop areas. Outcrops occur in steep canyons to the north on the south rim of Grand Canyon, in Havasu Canyon, along the Aubrey Cliffs, and along the Mogollon Rim. Thickness varies from about 1,200 feet to about 150 feet at the western edge of the area
- Psch — SCHNEBLY HILL FORMATION (MIDDLE PERMIAN)—Orange to light-red, fine quartz sandstone and siltstone, cross-bedded to planar with interbedded gray limestone and dolomite. The upper units of the Schnebly Hill Formation alternate and interfinger with the lower Coconino Sandstone in the central and southern parts of the area. The Unit thins to extinction to the northwest. The only outcrops of the Schnebly Hill Formation in the area occur in Sycamore and Oak Creek Canyons and along the southeastern edge of the Mogollon Rim. Thickness of the unit varies from 0 to no more than 1,500 feet

PENNSYLVANIAN

- PP — HERMIT FORMATION AND SUPAI GROUP UNDIFFERENTIATED (LOWER PERMIAN, PENNSYLVANIAN, AND MISSISSIPPIAN)—Red, fine-grained, thin-bedded siltstone and sandstone (Hermit Formation); and light-red to pink sandstone, dark-red thin bedded siltstone, light-red to light-gray, fine-grained siltstone and mudstone interbedded with light-red coarse-grained, calcareous sandstone, light-red, white, and gray calcareous sandstone, dark-red siltstone with sandy limestone, and gray and purplish-red limestone, siltstone, mudstone, and conglomerate (Supai Group)
  - Ph — HERMIT FORMATION (LOWER PERMIAN)—Red, fine-grained, thin-bedded siltstone and sandstone. Upper part is mostly red and white massive, cross-bedded calcareous sandstones and siltstones. Siltstone beds fill shallow erosional channels on the underlying Esplanade Sandstone. Sandstone beds thicken and thin laterally as channel fill or shallow sand dunes. The formation thickens from east to west and thins to extinction to the south. Outcrops occur in steep canyons in the north and central parts of the area along the south rim of Grand Canyon and in Havasu Canyon. Thickness varies from 260 to 850 feet
  - MPu — SUPAI GROUP UNDIFFERENTIATED (LOWER PERMIAN, PENNSYLVANIAN, AND MISSISSIPPIAN)—Composed of upper, middle, and lower formations. The Upper Supai Formation is a reddish-brown, calcareous, planar to cross-stratified, fine-grained sandstone with subordinate siltstone and mudstone. The dominant sandstone member at the top of the formation is named the Esplanade Sandstone and forms a prominent bench and erosional surface in the western Grand Canyon. The Middle Supai Formation is a sequence of inter-bedded reddish-orange to reddish-brown, very fine-grained, calcareous and cherty sandstone, mudstone, and siltstone. The Lower Supai Formation is mainly bluish-gray to reddish-brown, mottled mudstone to claystone with an occasional basal conglomerate or breccia of chert clasts, cherty limestone, and reworked material from the underlying Redwall Limestone. The Supai Group is exposed in steep canyons to the north and south, to the west along the base of the Aubrey Cliffs, and in small areas east of Elden Mountain and north of San Francisco Mountain where the formation is brought to the surface by intruding volcanic rocks. The combined thickness of the unit varies from 1,230 to 2,380 feet
  - Pe — ESPLANADE SANDSTONE (LOWER PERMIAN)—Light-red to pinkish-gray, fine to medium-grained, well sorted calcareous sandstone with thin, interbedded, dark-red siltstone. Exposed in steep canyons along the south rim of Grand Canyon and as a broad erosional platform in the western Grand Canyon. Cataract Canyon. In the central part of the area has not eroded through the Esplanade. Along the Mogollon Rim the Esplanade Sandstone is undifferentiated from other upper Supai units. The Esplanade Sandstone is thickest in the western part of the area, thinning to the east. Thickness varies from less than 300 to 550 feet
  - IPsl — LOWER SUPAI FORMATION (LOWER PENNSYLVANIAN TO UPPER MISSISSIPPIAN)—Gray and purplish-red limestone, siltstone, mudstone, shale, and conglomerate. Watahomigi Formation of McKee (1982) in the Grand Canyon. Limestone contains gray and red, thin-bedded chert and chert lenses. Unconformable contact with underlying Redwall Limestone marked by small erosion channels filled with conglomerate of chert pebbles and limestone rubble. For most of the area, the lower purple shale and mudstone units directly overlie the Redwall Limestone and provide a sharp contrast. The unit thins from west to east. Thickness varies from 100 to 200 feet

MISSISSIPPIAN

- MC — REDWALL LIMESTONE, TEMPLE BUTTE FORMATION, AND TONTO GROUP (MUAV LIMESTONE, BRIGHT ANGEL SHALE, AND TAPEATS SANDSTONE) UNDIFFERENTIATED (MISSISSIPPIAN TO CAMBRIAN)—Gray limestone to light-gray limestone (Redwall Limestone); purple, reddish-purple, and dark to light-gray dolomite, sandy dolomite, sandstone, mudstone, and limestone (Temple Butte Formation); dark to light-gray, brown, and orange-red limestone, dolomite, and calcareous mudstone (Muav Limestone); green and purple-red siltstone and shale (Bright Angel Shale); and brown and red-brown, coarse sandstone and conglomerate (Tapeats Sandstone)
  - Mr — REDWALL LIMESTONE (MISSISSIPPIAN)—Massive light-gray limestone and dolomite. Limestone is fossiliferous and oolithic in places. Chert lenses and beds are common. Dolomite is dark-gray to brown and finely crystalline. The unit is exposed in steep canyons at the south rim of Grand Canyon, in Havasu Canyon, on Little Black Mesa, and in parts of the Verde Valley. A small area of the Redwall Limestone is exposed in the area east of Elden Mountain where the formation is brought to the surface by intruding volcanic rocks. The limestone thickens from east to west. Thickness varies from 450 to about 750 feet

DEVONIAN

- Dtb — TEMPLE BUTTE (MARTIN) FORMATION (UPPER AND MIDDLE DEVONIAN)—Purple, reddish-purple, dark-gray and light-gray dolomite, sandy dolomite, sandstone, mudstone, and limestone. Unconformable contact with channels eroded up to 100 feet into lower Cambrian units. Purple, reddish-purple, and light-gray, fine- to medium-grained sandstone, mudstone, dolomite, limestone, and conglomerate fill the channels. Unit thickens from east to west. In the central and southern part of the area and along the Mogollon Rim, equivalent Devonian rocks are recognized as the Martin Formation (Teichert, 1965). Exposures of the Temple Butte Formation occur in steep canyons on the south rim of the Grand Canyon. Exposures of the Martin Formation occur along the upper Verde River and at the north end of Little Black Mesa. Thickness of the Temple Butte varies from 50 to 250 feet excluding channel thickness. Martin Formation thickness varies from about 350 feet to more than 550 feet

CAMBRIAN

- €m — MUAV LIMESTONE (MIDDLE CAMBRIAN)—Dark-gray, brown, and orange-red, fine- to medium-grained, thin- to thick-bedded, fossiliferous limestone, silty limestone, dolomite, and calcareous mudstone. Unnamed green and purplish-red micaceous siltstone, mudstone, shale, and thin brown sandstone interfinger between limestones. Exposures of the unit occur in steep canyons of the south rim of Grand Canyon. Contact with the underlying Bright Angel Shale is gradational and lithology dependent. The Muav Limestone thickens from east to west and thins southward. Thickness varies from about 100 to about 600 feet
- €ba — BRIGHT ANGEL SHALE (MIDDLE CAMBRIAN)—Green and purplish-red siltstone and shale with interbeds of red-brown to brown sandstone. Siltstones can be micaceous and fossiliferous, and sandstones occasionally dark-green to purple-red and medium to coarse-grained. The upper part of the unit contains some gray thin-bedded micaceous, silty dolomite in the western part of the area. Red-brown sandstones are prominent ledge formers. Interfingering with the underlying Tapeats Sandstone produces a variable thickness and a gradational contact. Contact usually assigned to the most dominately brown, medium-grained sandstone. Exposures of the Bright Angel Shale occur in steep canyons of the south rim of Grand Canyon. The unit thins from west to east and thins to extinction southward. Thickness varies from about 450 feet in the west part of the study area to about 350 feet in the east part. Wells that penetrate Proterozoic granites in the southern parts of the area typically encounter no Bright Angel Shale between the Muav Limestone or Martin Formation and the Tapeats Sandstone
- €t — TAPEATS SANDSTONE (MIDDLE AND LOWER CAMBRIAN)—Brown and red-brown, thin-bedded, medium- to coarse-grained sandstone and conglomerate. Sandstones are planar to low-angle cross-bedded. Conglomeratic sandstone and comglomerate are typically found at the lower part of the unit. Unconformable contact with underlying Proterozoic rocks forms the Great Unconformity. The Tapeats Sandstone fills in lowlands on the Proterozoic surface and pinches out against Proterozoic highlands that can have several hundred feet of relief. Exposures of the Tapeats Sandstone occur in steep canyons of the south rim of Grand Canyon and as small outcrops on the western edge of Big Black Mesa. Thickness varies from 0 to about 400 feet

PRECAMBRIAN

- Ys — SEDIMENTARY ROCKS UNDIFFERENTIATED (MIDDLE PROTEROZOIC)—Grand Canyon Super Group, Apache Group, basalt flows and diabase
- Yb — GRAND CANYON SUPER GROUP (MIDDLE TO UPPER PROTEROZOIC)—In descending order: unnamed diabase sills and dikes, Dox Formation, Shinumo Quartzite, Hahatai Shale, Bass Formation, and Hotauta Conglomerate. The Grand Canyon Super Group is only exposed near the bottom of Grand Canyon and not all of the units are present. Borehole logs throughout the area that penetrate Proterozoic granites have not encountered the Grand Canyon Super Group south of the south rim. Thickness is about 4,500 feet where exposed in the Grand Canyon only

IGNEOUS ROCKS

- Yxg — GRANITOID ROCKS (MIDDLE TO LOWER PROTEROZOIC)—Typically gray to green-gray granite, plutons, stocks, dikes, pegmatites, and granite rubble. Granitoid rocks are exposed in the bottom of Grand Canyon and at the northern end of Chino Valley. Granite rubble it typically encountered at the top of the unit in boreholes in thickness of a few 10s of feet. Pink granites are encountered occasionally in borholes in the central and southern parts of the area. Overall thickness unknown
- Xgr — GRANITOID ROCKS (LOWER PROTEROZOIC)—Granite, granodiorite, quartz diorite, diorite, and gabbro, commonly foliated

METAMORPHIC ROCKS

- Xmro — SCHIST AND GNEISS (LOWER PROTEROZOIC)—Undifferentiated metasedimentary and metavolcanic rocks, quartz-mica schist (Vishnu Schist), amphibolite, hornblende-biotite, plagioclase schist, biotite-plagioclase schist, and metamorphosed sulfide deposits (Brahma Schist), massive fine-grained quartz-feldspathic schist and gneiss (Rama Schist), and orthoamphibole-bearing gneiss. Exposed only in Grand Canyon. As yet to be encountered in boreholes south of Grand Canyon. Thickness unknown

B — B′ TRACE OF SECTION

FAULT—Dashed where uncertain, dotted where concealed. On the map bar and ball on the downthrown side. On the sections arrows indicate direction of movement

ANTICLINE—Dotted where concealed

SYNCLINE—Dotted where concealed

MONOCLINE—Dotted where concealed

WELL