RECONNAISSANCE ENVIRONMENTAL GEOLOGY OF NORTHERN SCOTTSDALE

MARICOPA COUNTY, ARIZONA

by Troy L. Péwé, Jim Bales and Melissa Montz
1983

GEOLOGY

Prepared in cooperation with
Department of Geology, Arizona State University
Long Range Planning Department, City of Scottsdale
Arizona State Land Department

INTRODUCTION*

The north part of the City of Scottsdale lies along the northeast edge of the broad northwest-trending Paradise Valley Basin in which parts of the cities of Paradise Valley and Phoenix are also located. There, the high peaks of the McDowell Mountains reach elevations of 4,000 ft (1,330m), forming a picturesque northeast border for the Phoenix-Scottsdale metropolitan area.

In the past few years, urbanization has encroached upon this area with the rapid expansion of the metropolitan area. Residential and commercial developments are being constructed, and complete development of the northern part of Scottsdale, including the alluvial slopes of the McDowell Mountains and the Pinnacle Peak Pediment, can be foreseen in the not-too-distant future. To aid in proper land use planning prior to such development, maps depicting environmental geological information as well as delineation of hazardous areas due to unstable slopes, subsidence and fissuring potential, and information on conditions for waste disposal based on an analysis of permeability of the sediments, development of caliche, flooding, and depth to groundwater and bedrock, are needed.

Geographic setting

The northern Scottsdale study area is in south-central Arizona about 14 mi (22km) north of the Salt River. The area mapped includes parts of the Curry's Corner, McDowell Peak, Wildcat Hill, Sawik Mountain, and Cave Creek Quadrangles (U.S. Geological Survey topographic map series, 1:24,000). It extends north of the Central Arizona Project (CAP) canal to Dove Valley Road and east from Scottsdale Road to 136th Street, and comprises 88 square miles ($230km^2$), including parts of the McDowell Mountains, Pinnacle Peak Pediment, and Paradise Valley.

Regional geology

Southern Arizona, south of the Mogollon Rim, is generally referred to as the Basin and Range Physiographic Province. As the name implies, this province is characterized by alternating broad, elongate basins and long, narrow mountain ranges which trend generally northwest. This unique physiography resulted from a period of extensive faulting which began about 18 million years ago when large blocks of the earth's crust were uplifted along faults which locally trend northwest (Damon and others, 1983). The present mountain ranges, including the McDowell and Phoenix Mountains, were formed at about this time. They occur on the upthrown (relative motion) sides of these large faults, whereas the basins (Paradise Valley, Phoenix Basin) occur on the downdropped sides of the faults. Erosion and downwasting occurred continuously as these large rock masses elevated; and up to 5,000 ft (1,525m) or more of alluvium and other sediments accumulated in the adjoining basins.

Geologic history

The McDowell Mountains and Pinnacle Peak Pediment are composed principally of rock of Precambrian age. Two distinct ages of Precambrian rocks are present. The earlier Precambrian rocks are quartzites, phyllites, greenschists, and metavolcanic rocks of various types. These rocks form the high peaks of the McDowell Mountains with the predominant metamorphic rock type being a northeast-trending, southerly dipping, foliated metarhyolite and metatuff unit. This is underlain by quartz-mica schist (probably metavolcanic rocks of dacite and andesite composition) and greenschists (metabasalts), which are in turn underlain by variously colored quartzites. These quartzites range from massive and structureless to intricately cross-bedded and ripple-marked. A phyllite-argillite of extreme variability occurs interbedded with these quartzites and both rock types are interpreted to be metasedimentary rocks. The entire sequence of sediments and volcanics has undergone at least one episode of metamorphism and folding which resulted in the formation of a series of folds with axes trending northeast, parallel to the foliation in the rocks. These folds include a gentle, broad syncline in the northern section and a very steep isoclinal anticline in the central section of the McDowells.

Intrusion of igneous rocks occurred in later Precambrian time; their composition ranges from diorite to granite. Altered metamorphic rocks occurring within and around these intrusives retain the consistent northeast strike and southerly dip common to the other metamorphic rocks of the McDowell Mountain Range. Contact relationships indicate a post-metamorphic age for the granitic intrusions. In the Pinnacle Peak Pediment of the northern part of the area, most of the hills have a core of quartzite that was slightly to almost completely altered as it was surrounded by the granite.

A large gap in the geologic record exists between Precambrian rocks and the Tertiary volcanics which occur in the northern part of the area. No record of Paleozoic or Mesozoic history has been found in this region. The late Tertiary volcanic rocks include tuffs and basalt flows. Considerable erosion of the fault block mountains and lava flows occurred in late Tertiary and Quaternary time, forming large alluvial fans and pediments and depositing sediments in the basins. As the granitic mountain block eroded more rapidly in the northern part of the map area than in the southern part, a pediment surface sloping toward both Paradise Valley and the Verde Valley was produced. The pediment is gently sloping bedrock erosional landform with a veneer of granitic alluvium 1 to 5 ft (0.9 to 1.6m) thick, locally up to 15 ft (4.6m). The edges of the pediment extending into the basins are buried by an ever thickening wedge of alluvium worn from the pediment and the mountains. Only "roots" of the original mountains remain, preserved as altered metamorphic rocks on the crests of small hills and mountains projecting 400 to 500 ft (122 to 152m) above the Pinnacle Peak Pediment. Erosion has continuously lowered the pediment surface since the time of deposition of the Tertiary volcanics and only a few remnants of basalt cap the granite knobs in the northern part of the area.

Environmental geology

From the basic geologic data, derivative environmental geology maps have been constructed. Data used to supplement the geologic map in constructing these derivative maps include: (1) engineering tests of consolidated rocks for crushing strength and resistance to abrasion; (2) tests on unconsolidated materials to determine grain size distribution and Atterberg limits; (3) numerous field observations of caliche development, rock jointing fracture patterns, and (4) other data pertinent to environmental considerations, such as subsurface information from water well-logs, dry well borings, and sewer and other utility trenches.

Maps have been prepared depicting hazards to development, such as slope instability, earthquake problems, land subsidence and fissure development, and presenting waste disposal evaluation involving the geologic parameters limiting the location of septic tanks, waste stabilization ponds, and sanitary landfills, and sources of cover for sanitary landfills. These maps may be utilized by planners, engineers, public officials, or anyone interested or involved in land use, to assist in evaluating the suitability of the area for development.

SELECTED REFERENCES

Christenson, G. E., Welsch, D. G., and Péwé, T. L., 1978, Environmental geology of the McDowell Mountains Area, Maricopa County, Arizona: University of Arizona, Bureau of Geology and Mineral Technology, Folio Series, Map GI-1-A (Geology) 1:24,000.

_____, 1978, Environmental geology of the McDowell Mountains Area, Maricopa County, Arizona: University of Arizona, Bureau of Geology and Mineral Technology, Folio Series, Map GI-1-B (Landform) 1:24,000.

_____, 1979, Environmental geology of the McDowell Mountains Area, Maricopa County, Arizona: University of Arizona, Bureau of Geology and Mineral Technology, Folio Series, Map GI-1-G (Geologic Hazards) 1:24,000.

Cordy, G. E., Holway, J. V., and Péwé, T. L., 1978, Environmental geology of the Paradise Valley Quadrangle, Arizona: unpublished report, City of Scottsdale, Arizona, 14 maps.

Couch, N. P., 1981, Metamorphism and reconnaissance geology of the eastern McDowell Mountains, Maricopa County, Arizona: Arizona State University unpublished Masters Thesis, 57 p.

Damon, P. E., Shafiqullah, M., and Lynch, D. J., 1983, Late Cenozoic landscape development in the Basin and Range Province in Arizona: in Landscapes of Arizona: the geological story: Eds., Smiley, T., Péwé, T. L., Nations, D. K., and Schaffer, P., (in press) 54 manuscript pages.

Green, C. R., and Sellers, W. D., 1964, Arizona climate: Tucson, Arizona, University of Arizona Press, 503 p.

Little, L. A., 1975, Geology and land-use investigation in the Pinnacle Peak Area, Maricopa County, Arizona: Arizona State University unpublished Masters Thesis, 102 p.

Manera, P. A., 1982, Impact of the ground water supply on the population of the Cave Creek Area, Maricopa County, Arizona: Arizona State University unpublished Doctoral Dissertation, 176 p.

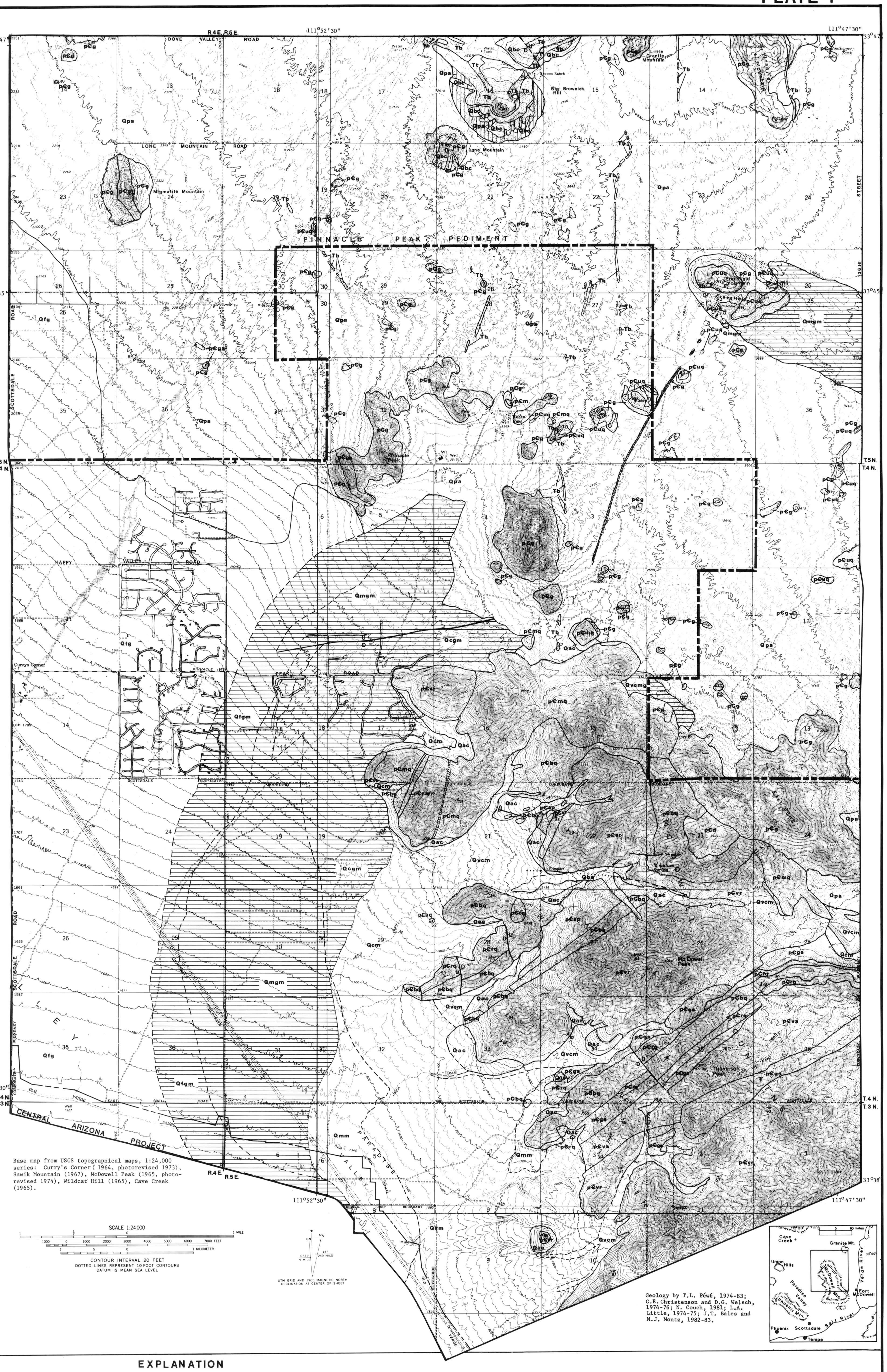
McDonald, H. R., Wolcott, H. N., and Bluhm, F. I., 1947, Geology and ground water resources of Paradise Valley, Maricopa County, Arizona: U. S. Geological Survey Miscellaneous Investigation Map I-845-I, 1:250,000.

Peirce, H. W., 1983, Late Cenozoic basins and basin deposits of southern and western Arizona: in Landscapes of Arizona: the geological story: Eds., Smiley, T., Péwé, T. L., Nations, D. K., and Schaffer, P., (in press) 27 manuscript pages.

Péwé, T. L., and Larson, M. K., 1982, Origin of ground subsidence and earth fissures, northeast Phoenix, Arizona: City of Phoenix, Arizona, 98 p., 8 appendices.

Péwé, T. L., 1982, Geology of the Highlands of Pinnacle Peak, Scottsdale, Arizona: unpublished report, 5 sheets, 1:1200.

Wilson, E. D., Moore, R. T., and Peirce, H. W., 1957, Geologic map of Maricopa County, Arizona: Arizona Bureau of Mines, University of Arizona, Tucson.



Base map from USGS topographical maps, 1:24,000 series: Curry's Corner (1964, photorevised 1973), Sawik Mountain (1967), McDowell Peak (1965, photorevised 1974), Wildcat Hill (1965), Cave Creek (1965).

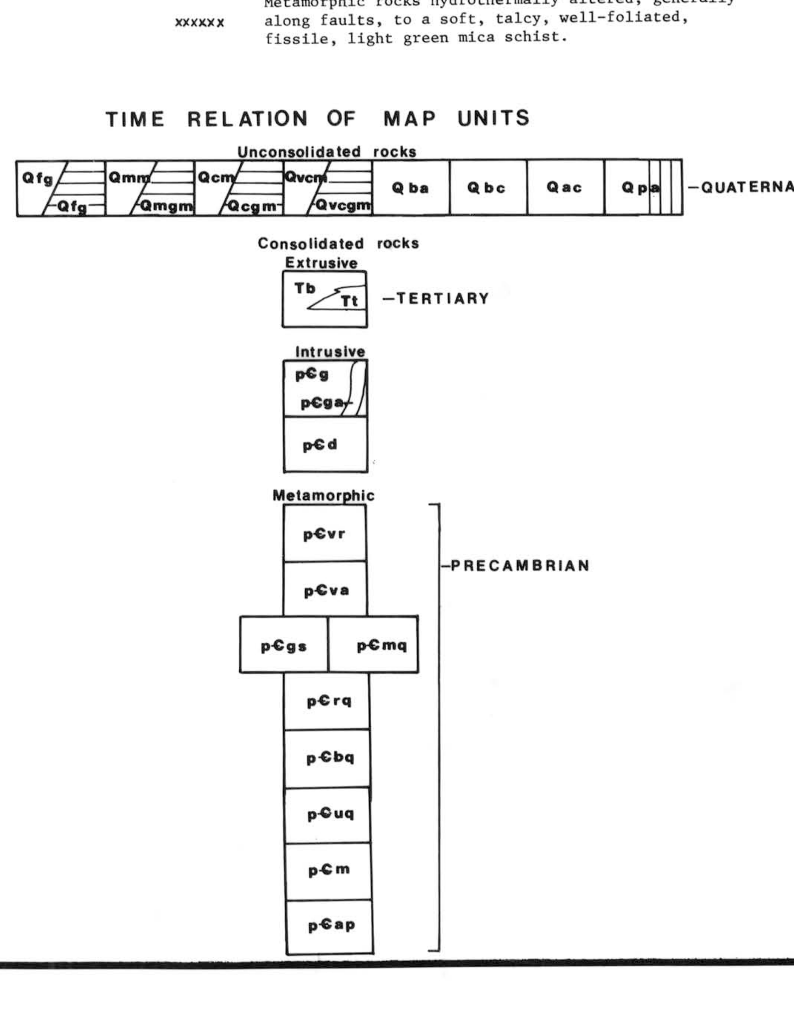
Geology by T.L. Péwé, 1974-83; G.E. Christenson and D.G. Welsch, 1974-76; N. Couch, 1981; L.A. Little, 1974-75; J.T. Bales and M.J. Montz, 1982-83.

*This map involves a general investigation on a broad scale and does not preclude the necessity of individual site analysis.

MAP SYMBOLS

- Contact, dashed where gradational
- Fault, dashed where inferred, dotted where buried.
- Dip and strike of beds.
- Dip and strike of foliation.
- Veins of milky quartz, generally less than 5 ft (1.5m) wide
- Mineralized brecciated fault zones less than 10 ft (3.0m) wide.
- Metamorphic rocks hydrothermally altered, generally along faults, to a soft, talcy, well-foliated, fissile, light green mica schist.

TIME RELATION OF MAP UNITS



EXPLANATION

UNCONSOLIDATED ROCKS[1]

Fine Alluvium (Qfg, Qfgm): Tan to buff, moderately sorted, moderately stratified, weakly to moderately calichified alluvium averaging 15% subrounded gravel with clasts generally not exceeding 1½ in (3.8cm), 50% sand, and 35% silt and clay. Qfg, composed of grus and clasts of granite with 23% gravel, 50% sand, and 27% silt and clay. Qfgm, composed of grus and clasts of granite and metamorphic rocks.

Medium Alluvium (Qmm, Qmgm): Gray to buff, poorly sorted, moderately stratified, weakly to very strongly calichified alluvium averaging 30% subangular gravel with clasts generally not exceeding 1 ft (30cm), 50% sand, and 20% silt and clay. Qmm, clasts composed of platy metamorphic rocks. Qmgm, composed of grus and clasts of granite and metamorphic rocks.

Coarse Alluvium (Qcm, Qcgm): Gray to buff, poorly sorted, poorly stratified, weakly to very strongly calichified alluvium averaging 50% subangular gravel with clasts generally less than 2 ft (61cm), 30% sand, and 20% silt and clay. Qcm clasts composed of platy metamorphic rocks. Qcgm, composed of grus and clasts of granite and metamorphic rocks.

Very Coarse Alluvium (Qvcm, Qvcgm): Gray to buff, poorly sorted, poorly stratified, strongly calichified (non-calichified in dry washes) alluvium averaging 55% angular gravel with clasts generally less than 3 ft (91cm), 30% sand, and 15% silt and clay. Qvcm, clasts composed of platy metamorphic rocks. Qvcgm, composed of grus and clasts of granite and metamorphic rocks.

Boulder Alluvium (Qba): Color varies with parent rock type, poorly sorted, poorly stratified, non-calichified alluvium composed of boulders commonly exceeding 3 ft (91cm) with minor amounts of silt and clay. Occurs at heads of fans in steep mountain stream channels. Composed of local rock types.

Basalt Colluvium (Qbc): Black, poorly sorted, poorly stratified, moderately to strongly calichified angular talus debris on the side and at the foot of basalt hills. Contains boulders up to 5 ft (152cm), locally with only boulders at the surface.

Alluvium-Colluvium (Qac): Color varies with rock type, poorly sorted, poorly stratified, strongly calichified angular talus debris on fan surfaces and bedrock slopes averaging 55% angular gravel less than 3 ft (91cm), 25% sand, and 20% silt and clay. Composed of local bedrock types.

Pediment Alluvium (Qpa): Gray to buff, poorly sorted, moderately stratified, moderately to very strongly calichified, fine to medium alluvium composed of grus averaging 20% to 35% subangular gravel with clasts generally 1 to 2 in (2.5 to 5.1cm), locally 6 to 12 in (15.2 to 30.5cm) near bedrock outcrops, 50% to 70% sand and 10 to 15% silt and clay. Alluvium in washes is well-stratified, moderately sorted grus with few large clasts. Alluvium forms a thin blanket 1 to 5 ft (0.3 to 1.6m) thick over the irregular surface of the granite pediment; local thicknesses to 15 ft (4.6m). Rounded, widespread clusters and isolated protuberances of yellow to reddish brown, coarse grained, massive, Precambrian granite, 1 to 20 ft (0.3 to 6.1m) high project above the alluvium. Vertically patterned area indicates grus thickness of 5 to more than 30 ft (1.6 to more than 9.1m).

CONSOLIDATED ROCKS

Extrusive

Basalt (Tb): Dark gray to black, fine-grained, blocky to scoriaceous to massive, locally finely fractured, locally with calcite-filled amygdules, basalt flows. Local basalt dikes, generally 2 to 10 ft (0.6 to 3m) wide.

Tuff (Tt): Buff to cream, massive, cliff-forming tuff with pumice and other rock clasts up to ¼ in (.6cm). Locally, upper 1 to 10 ft (0.3 to 3.1m) light brown to tan, dense, massive, cliff-forming fine-grained welded tuff with rock clasts and quartz crystals 1/16 in (2mm); some rock clasts 3/4 in (1.9cm). Locally, lower 1 to 10 ft (0.3 to 3m) lahar(?), gray to brown, medium fine grained, friable, containing basalt fragments and blocks up to 6 in (15.2cm).

Intrusive

Granite (p€g, p€ga): Yellow to reddish brown, coarse-grained, massive granite, locally fine- to medium-grained, characteristically weathers spheroidally. P€ga, fine-grained aplite dikes up to 50 ft (15.2m) thick which weather into vertical cliffs and pinnacles.

Diorite (p€d): Dark gray to black, fine- to coarse-grained, blocky diorite, locally highly fractured and highly sheared.

Metamorphic

Taliesin Quartzite (p€vr): Light green to black, very fine-grained, platy to blocky, foliated quartzite, probably metamorphosed rhyolite and dacite flows and units, locally cut by greenstone dikes. Weathers orange to grayish-red. Highly fractured and weathers to a sugary texture near intrusive rocks.

Quartz-mica Schist (p€va): Gray to dark green, fine-grained, platy and locally fissile, moderately to highly foliated quartz-mica schist, probably metamorphosed dacite and andesite flows and tuffs.

Greenschist (p€gs): Gray to dark green, fine-grained, platy to fissile to massive, moderately to highly foliated, chlorite-rich greenstones and greenschists, probably metamorphosed basalt flows and mafic pyroclastics.

Micaceous Quartzite (p€mq): Silver to gray, fine- to medium-grained, platy, micaceous metamorphosed argillaceous sandstone, locally jointed to form thick rectangular blocks.

Red Quartzite (p€rq): Red to white, medium- to coarse-grained, massive metamorphosed orthoquartzite, locally conglomeratic.

Blue Quartzite (p€bq): Blue to black, medium- to coarse-grained, locally cross-bedded and conglomeratic, massive metamorphosed orthoquartzite with minor interbedded silver mica schists, green quartzites, and greenstone.

Undifferentiated Quartzite (p€uq): Undifferentiated, massive, blocky, metamorphosed red or blue orthoquartzite with minor interbedded mica schist, green schist and greenstone.

Migmatite (p€m): Veined, folded gneisses with some igneous intrusive breccia. Medium to coarse-grained, mica-rich, streaky rocks with sillimanite and kyanite, formed from alteration of quartzites by intruding granite.

Argillite-Phyllite (p€ap): Red-brown to black, fine-grained, slaty to massive (locally fissile) argillite and phyllite, probably metamorphosed shales and siltstones.

1. Classification of unconsolidated units is based on the unified soil classification system: Gravel---greater than 4.76mm; sand---4.76 to .074mm; silt and clay---less than .074mm.