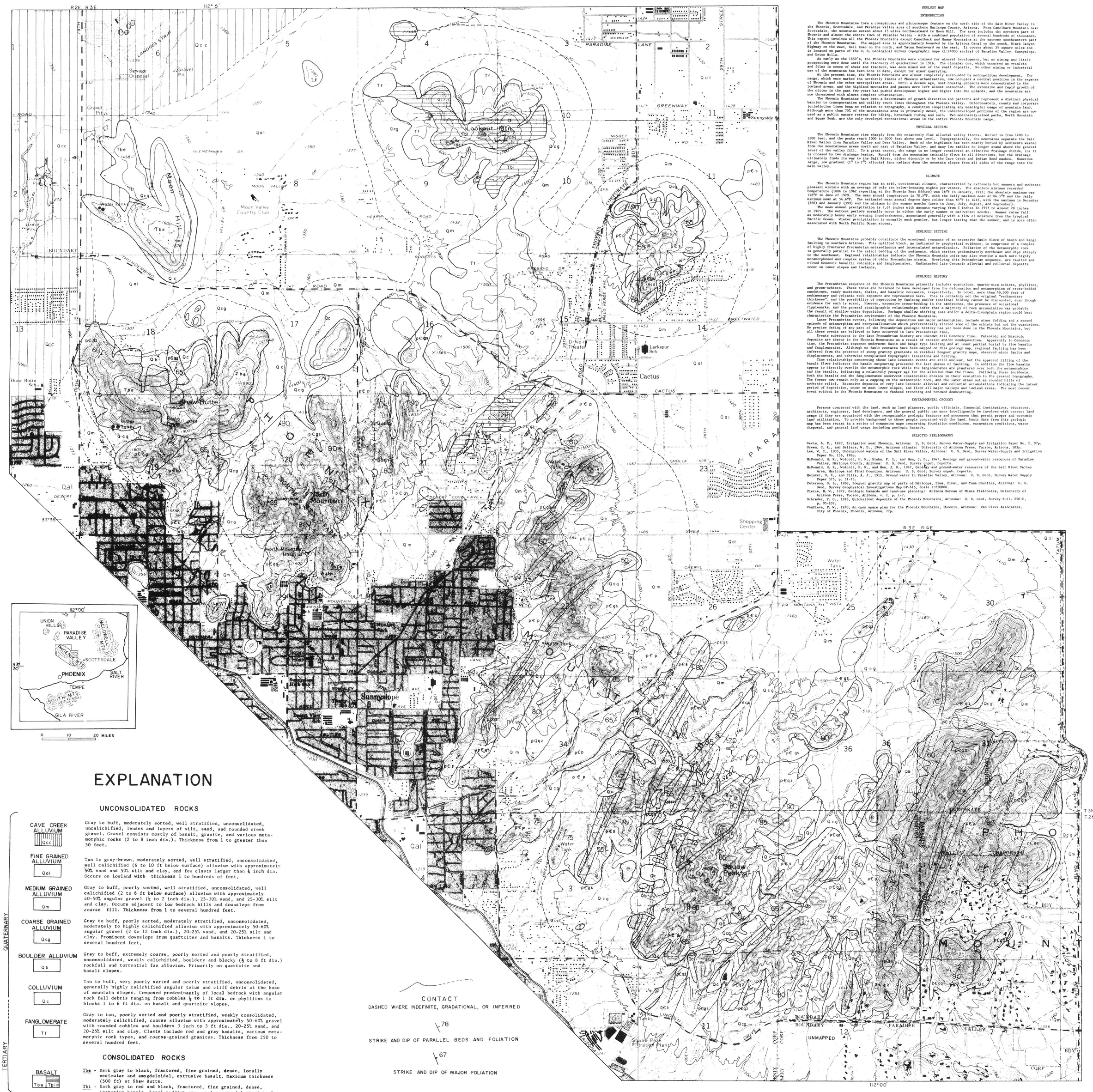
DEPARTMENT OF GEOLOGY
ARIZONA STATE UNIVERSITY



GEOLOGY MAP

INTRODUCTION

The Phoenix Mountains form a conspicuous and picturesque feature on the north side of the Salt River Valley in the Phoenix, Scottsdale, and Paradise Valley area of southern Maricopa County, Arizona. From Camelback Mountain near Scottsdale, the mountains extend about 15 miles northwestward to Moon Hill. The area includes the northern part of Phoenix and almost the entire town of Paradise Valley - with a combined population of several hundreds of thousands. This report involves all the Phoenix Mountains except Camelback and Mummy Mountains at the extreme southeastern part of the Phoenix Mountains. The mapped area is approximately bounded by the Arizona Canal on the south, Black Canyon Highway on the west, Bell Road on the north, and Tatum Boulevard on the east. It covers about 35 square miles and is located on parts of the U. S. Geological Survey topographic maps (1:24000 series) of Paradise Valley, Sunnyslope, and Union Hills.

As early as the 1850's, the Phoenix Mountains were claimed for mineral development, but no mining and little prospecting were done until the discovery of quicksilver in 1916. The cinnabar ore, which occurred as veinlets and films in zones of shear and fracture, was soon mined out of the small deposits. No other mining or industrial use of the mountains has been done to date, except for minor quarrying.

At the present time, the Phoenix Mountains are almost completely surrounded by metropolitan development. The range, which once marked the northerly limits of Phoenix urbanization, now occupies a central position in the expanse of Phoenix and the other metropolitan areas. Until a decade ago, most housing projects were concentrated in the lowland areas, and the highland mountains and passes were left almost untouched. The extensive and rapid growth of the cities in the past few years has pushed development higher and higher into the uplands, and the mountains are now threatened with almost complete urbanization.

The Phoenix Mountains have been a determinant of growth direction and patterns and represent a distinct physical barrier to transportation and utility trunk lines throughout the Phoenix Valley. Unfortunately, county and corporate jurisdiction lines bear no relation to topography, a condition complicating any meaningful usage of mountain land. Although more than 75% of the mountainous area is privately owned, the underdeveloped portions of the region are now used as a public nature retreat for hiking, horseback riding and such. Two moderately-sized parks, North Mountain and Squaw Peak, are the only developed recreational areas in the entire Phoenix Mountain range.

PHYSICAL SETTING

The Phoenix Mountains rise sharply from the relatively flat alluvial valley floors. Relief is from 1200 to 1500 feet, and the peaks reach 2000 to 3000 feet above sea level. Topographically, the mountains separate the Salt River Valley from Paradise Valley and have been nearly buried by sediments washed from the mountainous areas north and east of Paradise Valley, and many low saddles no longer stand above the general level of the valley fill. To a great extent, the range is no longer considered an effective drainage divide, for it is crossed by two drainage basins. Runoff from the mountains initially flows in all directions, but the drainage ultimately finds its way to the Salt River, either directly or by the Cave Creek and Indian Bend washes. Numerous large, low gradient (1° to 2°) alluvial fans radiate down the mountain slopes from all sides of the range into the main valley.

CLIMATE

The Phoenix Mountain region has an arid, continental climate, characterized by extremely hot summers and moderate pleasant winters with an average of only ten below-freezing nights per winter. The absolute minimum recorded temperature (1886 to 1962 reporting at the Phoenix Post Office) was 16°F in January, 1913; the absolute maximum was 118°F in June of 1929. The mean annual temperature is 70.5°F, with the daily maximum mean at 84.5°F and the daily minimum mean at 56.6°F. The estimated mean annual degree days colder than 65°F is 1413, with the maximum in December (368) and January (399) and the minimum in the summer months (zero in June, July, August, and September).

The mean annual precipitation is 7.67 inches with amounts varying from 3 inches in 1953 to almost 20 inches in 1905. The wettest periods normally occur in either the early summer or mid-winter months. Summer rains fall as moderately heavy early evening thundershowers, associated generally with a flow of moisture from the tropical Pacific Ocean. Winter precipitation is normally much gentler, but longer lasting than the summer, and is more often associated with North Pacific Ocean storms.

GEOLOGIC SETTING

The Phoenix Mountains probably constitute the erosional remnants of an extensive fault block of Basin and Range faulting in southern Arizona. This uplifted block, as indicated by geophysical evidence, is comprised of a complex of highly fractured Precambrian metasediments and intercalated metavolcanics. Foliation of the metamorphic rock is generally parallel to the relect bedding of the sediments, which strikes predominately northeast and dips steeply to the southeast. Regional relationships indicate the Phoenix Mountain units may also overlie a much more highly metamorphosed and complex system of older Precambrian strata. Overlying this Precambrian sequence, are faulted and tilted Cenozoic basaltic volcanics and fanglomerates. Undisturbed late Cenozoic alluvial and colluvial deposits occur on lower slopes and lowlands.

GEOLOGIC HISTORY

The Precambrian sequence of the Phoenix Mountains primarily includes quartzites, quartz-mica schists, phyllites, and green-schists. These rocks are believed to have developed from the deformation and metamorphism of cross-bedded sandstones, sandy mudstones, shales, and basaltic volcanics, respectively. In total, more than 40,000 feet of sedimentary and volcanic rock exposure are represented here. This is certainly not the original "sedimentary thickness", and the possibility of repetition by faulting and/or isoclinal folding cannot be discounted, even though evidence for such is scant. However, extensive cross-bedding in the sandstones, the presence of occasional ripplemarks, and the general stratigraphic relationships infer that a majority of rock accumulation was probably the result of shallow water deposition. Perhaps shallow shifting seas and/or a delta-floodplain region could best characterize the Precambrian environment of the Phoenix Mountains.

Later Precambrian events, following the deposition and major metamorphism, include minor folding and a second episode of metamorphism and recrystallization which preferentially altered some of the schists but not the quartzites. No precise dating of any part of the Precambrian geologic history has yet been done in the Phoenix Mountains, but all these events are believed to have occurred in late Precambrian time.

Events subsequent to the late Precambrian history are unknown till Cenozoic time. Paleozoic and Mesozoic deposits are absent in the Phoenix Mountains as a result of erosion and/or nondeposition. Apparently in Cenozoic time, the Precambrian sequence underwent basin and Range type faulting and at least partial burial by flow basalts and fanglomerates. Although no fault contacts have been mapped on this geology map, regional faulting has been inferred from the presence of steep gravity gradients on residual Bouguer gravity maps, observed minor faults and displacements, and otherwise unexplained topographic lineations and tilting.

Time relationships concerning these late Cenozoic events are still unclear, but the apparent tilting of the basalt flows indicates the basalt outpouring proceeded the last phases of faulting. In addition the flow basalts appear to directly overlie the metamorphic rock while the fanglomerates are plastered over both the metamorphics and the basalts, indicating a relatively younger age for the alluvium than the flows. Following these incidents, both the basalts and the fanglomerates underwent considerable erosion in their evolution to the present topography. The former now remain only as a capping on the metamorphic rock, and the later stand out as rounded hills of moderate relief. Extensive deposits of very late Cenozoic alluvial and colluvial accumulations indicating the latest period of deposition, occur on most lower slopes, and floor all major valleys and lowland areas. The most recent event evident in the Phoenix Mountains is fanhead trenching and renewed downcutting.

ENVIRONMENTAL GEOLOGY

Persons concerned with the land, such as land planners, public officials, financial institutions, educators, architects, engineers, land developers, and the general public can more intelligently be involved with correct land usage if they are acquainted with the recognizable geologic features and processes that permit proper and economic land utilization. To provide background to these people concerned with the land, basic date from this geologic map has been recast in a series of companion maps concerning foundation conditions, excavation conditions, waste disposal, and general land usage including geologic hazards.

SELECTED BIBLIOGRAPHY

Davis, A. P., 1897, Irrigation near Phoenix, Arizona: U. S. Geol. Survey Water-Supply and Irrigation Paper No. 2, 97p.
Green, C. R., and Sellers, W. D., 1964, Arizona climate: University of Arizona Press, Tucson, Arizona, 503p.
Lee, W. T., 1905, Underground waters of the Salt River Valley, Arizona: U. S. Geol. Survey Water-Supply and Irrigation Paper No. 136, 196p.
McDonald, H. R., Wolcott, H. N., Bluhm, F. I., and Hem, J. D., 1947, Geology and ground-water resources of Paradise Valley, Maricopa County, Arizona: U. S. Geol. Survey unpub. reports.
McDonald, H. R., Wolcott, H. N., and Hem, J. D., 1947, Geology and ground-water resources of the Salt River Valley Area, Maricopa and Pinal Counties, Arizona: U. S. Geol. Survey unpub. reports.
Meinzer, O. E., and Ellis, A. J., 1915, Ground water in Paradise Valley, Arizona: U. S. Geol. Survey Water Supply Paper 375, p. 51-75.
Peterson, D. L., 1968, Bouguer gravity map of parts of Maricopa, Pima, Pinal, and Yuma Counties, Arizona: U. S. Geol. Survey Geophysical Investigations Map GP-615, Scale 1:250000.
Pierce, H. W., 1972, Geologic hazards and land-use planning: Arizona Bureau of Mines Fieldnotes, University of Arizona Press, Tucson, Arizona, v. 2, p. 1-7.
Schrader, F. C., 1918, Quicksilver deposits of the Phoenix Mountains, Arizona: U. S. Geol. Survey Bull. 690-D, p. 95-107.
VanCleve, P. W., 1970, An open space plan for the Phoenix Mountains, Phoenix, Arizona: Van Cleve Associates, City of Phoenix, Phoenix, Arizona, 77p.

EXPLANATION

UNCONSOLIDATED ROCKS

QUATERNARY

CAVE CREEK ALLUVIUM (Qcc) — Gray to buff, moderately sorted, well stratified, unconsolidated, uncalichified, lenses and layers of silt, sand, and rounded creek gravel. Gravel consists mostly of basalt, granite, and various metamorphic rocks (2 to 8 inch dia.). Thickness from 1 to greater than 50 feet.

FINE GRAINED ALLUVIUM (Qal) — Tan to gray-brown, moderately sorted, well stratified, unconsolidated, well calichified (6 to 10 ft below surface) alluvium with approximately 50% sand and 50% silt and clay, and few clasts larger than ¼ inch dia. Occurs on lowland with thickness 1 to hundreds of feet.

MEDIUM GRAINED ALLUVIUM (Qm) — Gray to buff, poorly sorted, well stratified, unconsolidated, well calichified (2 to 6 ft below surface) alluvium with approximately 40-50% angular gravel (¼ to 2 inch dia.), 25-30% sand, and 25-30% silt and clay. Occurs adjacent to low bedrock hills and downslope from coarse fill. Thickness from 1 to several hundred feet.

COARSE GRAINED ALLUVIUM (Qcg) — Gray to buff, poorly sorted, moderately stratified, unconsolidated, moderately to highly calichified alluvium with approximately 50-60% angular gravel (2 to 12 inch dia.), 20-25% sand, and 20-25% silt and clay. Prominent downslope from quartzites and basalts. Thickness 1 to several hundred feet.

BOULDER ALLUVIUM (Qb) — Gray to buff, extremely coarse, poorly sorted and poorly stratified, unconsolidated, weakly calichified, bouldery and blocky (½ to 8 ft dia.) rockfall and torrential fan alluvium. Primarily on quartzite and basalt slopes.

COLLUVIUM (Qc) — Tan to buff, very poorly sorted and poorly stratified, unconsolidated, generally highly calichified angular talus and cliff debris at the base of mountain slopes. Composed predominantly of local bedrock with angular rock fall debris ranging from cobbles ½ to 1 ft dia. on phyllites to blocks 1 to 6 ft dia. on basalt and quartzite slopes.

TERTIARY

FANGLOMERATE (Tf) — Gray to tan, poorly sorted and poorly stratified, weakly consolidated, moderately calichified, coarse alluvium with approximately 50-60% gravel with rounded cobbles and boulders 3 inch to 3 ft dia., 20-25% sand, and 20-25% silt and clay. Clasts include red and gray basalts, various metamorphic rock types, and coarse-grained granites. Thickness from 250 to several hundred feet.

CONSOLIDATED ROCKS

BASALT (Tbe, Tbi)

Tbe - Dark gray to black, fractured, fine grained, dense, locally vesicular and amygdaloidal, extrusive basalt. Maximum thickness (500 ft) at Shaw Butte.

Tbi - Dark gray to red and black, fractured, fine grained, dense, intrusive basalt. Local reddish gray agglomerate (clasts ½ to 1 ft dia.) on Lookout Mountain.

PRECAMBRIAN

PHYLLITE (p€p) — Gray to tan, fractured, fine grained (less than 1/16 inch), laminated (0.1 to ½ inch), locally slaty and/or schistose phyllite with intercalated quartz-mica schists and basalt dikes. Maximum exposure from Dreamy Draw to Cave Creek Road (6600 ft).

QUARTZ-MICA SCHIST (p€s) — Buff to gray, fractured, fine to coarse grained (1/16 to 1/8 inch), thin to thick bedded (½ to 40 inch), locally massive, compositional group of highly siliceous, micaeous or quartz-rich schists with locally interbedded quartz-pebble (¼ to 2 inch dia.) conglomerates and local greenschist bodies and basalt dikes. Maximum exposure (2500 ft) south of Squaw Peak.

QUARTZITE (p€qz) — Light gray, fractured, medium to coarse grained (1/16 to 1/8 inch), crossbedded, thick bedded (5 to 50 inch), metaorthoquartzite with locally interbedded phyllite and quartz-mica schist. Maximum exposure (2600 ft) at Squaw Peak.

GREENSTONE (p€gs) — Blue to gray green, fractured, fine to medium grained (less than 1/16 to 1/16 inch), slightly schistose greenstone with local greenschist units and locally interbedded feldspathic quartz-biotite schists. Maximum exposure (4300 ft) at North Mountain.

GRANITE GNEISS (p€gg) — Gray to tan, fractured, medium to coarse grained (1/16 to 1/8 inch), quartz-feldspar-biotite gneiss with moderate foliation. Exposed west of Shaw Butte.

CONTACT
DASHED WHERE INDEFINITE, GRADATIONAL, OR INFERRED

78
STRIKE AND DIP OF PARALLEL BEDS AND FOLIATION

67
STRIKE AND DIP OF MAJOR FOLIATION

GEOLOGY OF THE PHOENIX MOUNTAINS, MARICOPA COUNTY, ARIZONA

DOUGLAS C. SHANK AND TROY L. PEWE

1973

BASE MAPS FROM U S GEOLOGICAL SURVEY TOPOGRAPHIC MAPS, 1:24000 SERIES: PARADISE VALLEY (1965), SUNNYSLOPE (1965), AND UNION HILLS (1964)

PREPARED IN COOPERATION WITH
DEPARTMENT OF GEOLOGY, ARIZONA STATE UNIVERSITY
DIVISION OF PARKS, CITY OF PHOENIX
AND ARIZONA STATE LAND DEPARTMENT

GN MN 0°35' 14° 10 MILS 249 MILS
UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:15000
1 ½ 0 1 MILE
1,000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

ARIZONA
LOCATION

ARIZONA GEOLOGICAL SURVEY
Contributed Report CM 94-D, plate 1 of 1