DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

STRUCTURE

Lower Precambrian schist exposed in the western part of the quadrangle is overlain by a sequence of chiefly sedimentary upper Precambrian and Paleozoic rocks that dip east. Diabase intrudes the Precambrian rocks and dioritic plutonic and hypabyssal rocks intrude the entire sequence. Conglomerate and lava and ash flows of Cenozoic age blanket the older rocks in the eastern part of the quadrangle.

A complex network of faults belonging to two principal systems is best developed in the southwest quarter of the area. One system of faults striking east to northeast cuts the Precambrian and Paleozoic rocks and is pre-Cenozoic. Some of these faults are mineralized, with the most important being the Magma vein, site of the largest mine in the quadrangle. The second system of faults, not appreciably mineralized, strikes north to northwest and cuts Cenozoic as well as older rocks. The most prominent of these, the Concentrator fault, forms the eastern border of the flat basin in the southwest part of the quadrangle. Several other faults in this system have displacement of a few hundred feet.

The structure of the area is discussed in greater detail by Hammer and Peterson (1968).

ORE DEPOSITS

The most productive ore deposits of the quadrangle are those of the Magma mine. In its 90-year history it has yielded more than 13 million tons of ore, which have provided nearly 1.5 billion pounds of copper and smaller amounts of gold, silver, zinc, and lead. The Magma quartz-sulfide vein has provided most of the ore, but in recent years replacement deposits in limestone have been the principal source of ore.

Most of the ore in the Magma and related veins occurs in large shoots that plunge steeply westward. Ore has been mined from the surface to a depth of 4,900 feet and through a length of more than 7,000 feet. The Magma vein has an average productive width of 12–15 feet. In limestone replacement deposits in the eastern part of the mine, ore occurs as tabular masses of irregular outline dipping eastward about 30°, parallel to the bedding. The host rock is a bed 10–30 feet thick of dark-gray crystalline limestone that lies 10–20 feet above the base of the Martin Limestone. Additional replacement deposits have been discovered in the Escabrosa Limestone.

Chief ore minerals are chalcopyrite, bornite, enargite, tennantite, chalcocite, digenite, and sphalerite. Principal gangue minerals are pyrite and quartz, and less common are carbonate minerals and hematite. The Magma mine is discussed in greater detail by Short and others (1943) and Hammer and Peterson (1968).

The Silver King mine produced silver for about 15 years prior to 1890, but subsequent efforts to re-establish the mine have not been successful. The ore body was a stockwork of intersecting veinlets within a plug of diorite porphyry that intrudes a quartz diorite stock. Although the mine was worked for silver, the ore consisted chiefly of zinc, lead, and copper sulfides. The mine history, production, geology, and literature are summarized by Short and others (1943, p. 139–154).

Several other formerly productive mines in the quadrangle are described by Short and others (1943). Included are the Lake Superior and Arizona (p. 135–139), Belmont (p. 154–158), Grand Pacific (p. 158), and Queen Creek (p. 158–159). The entire area has been extensively prospected, and the chief targets have been the mineralized east-striking faults and the beds near the base of the Martin Limestone.

Manganese oxides fill fractures, chiefly in the Escabrosa Limestone. Several of these deposits have been mined, particularly in Queen Creek Canyon just east of Superior.

Perlite has been mined from several pits in rhyolitic rocks in the southwestern part of the quadrangle, though the major perlite production of the Superior area has been beyond the western quadrangle boundary.

Asbestos deposits in the Mescal Limestone in the southern part of the quadrangle have sporadically supported small operations.

ACKNOWLEDGMENTS

This work has greatly benefited from the experience and guidance of N. P. Peterson, and his contributions are gratefully acknowledged. Stratigraphic studies by Krieger (1961) and Shride (1967) in nearby areas have provided evidence enabling the Troy and Bolsa Quartzites of this quadrangle to be separately identified and mapped. The management and staff of the Magma Copper Company have provided cordial cooperation and important information throughout the course of the project. Particular thanks are extended to members of the geological and engineering staff, who at the time of the fieldwork included B. VanVoorhis, chief engineer, R. N. Webster, chief geologist, and J. D. Sell, D. F. Hammer, and Locke Yut, geologists.

SELECTED BIBLIOGRAPHY

Creasey, S. C., and Kistler, R. W., 1962, Age of some copper-bearing porphyries and other igneous rocks in southeastern Arizona, *in* Geological Survey research 1962: U.S. Geol. Survey Prof. Paper 450–D, p. D1–D5.

Granger, H. C., and Raup, R. B., 1964, Stratigraphy of the Dripping Spring Quartzite, southeastern Arizona: U.S. Geol. Survey Bull. 1168, 119 p.

Hammer, D. F., and Peterson, D. W., 1968, Geology of the Magma mine area, Arizona, *in* Ridge, J. P., ed., Ore deposits of the United States, 1933–1967: A.I.M.E. Graton-Sales volume. p. 1282–1310.

Hammer, D. F., and Webster, R. N., 1962, Some geologic features of the Superior area, Pinal County, Arizona, with a section by D. C. Lamb, Jr., *in* Guidebook of the Mogollon Rim region, east-central Arizona: New Mexico Geol. Soc., 13th Field Conf., 1962, p. 148–152.

Krieger, M. H., 1961, Troy Quartzite (Younger Precambrian) and Bolsa and Abrigo Formations (Cambrian), northern Galiuro Mountains, southeastern Arizona, *in* Geological Survey research 1961: U.S. Geol. Survey Prof. Paper 424–C, p. C160–C164.

Peterson, D. W., 1960, Geologic map of the Haunted Canyon quadrangle, Arizona: U.S. Geol. Survey Quad. Map GQ–128, scale 1:24,000.

——— 1962, Preliminary geologic map of the western part of the Superior quadrangle, Pinal County, Arizona: U.S. Geol. Survey Mineral Inv. Studies Map MF–253, scale 1:12,000.

——— 1968, Zoned ash-flow sheet in the region around Superior, Arizona, *in* Titley, S. R., ed., Southern Arizona Guidebook III: Tucson, Ariz., Arizona Geol. Soc., p. 215–222.

Peterson, N. P., 1962, Geology and ore deposits of the Globe-Miami district, Arizona: U.S. Geol. Survey Prof. Paper 342, 151 p.

——— 1963, Geology of the Pinal Ranch quadrangle, Arizona: U.S. Geol. Survey Bull. 1141–H, 18 p.

Ransome, F. L., 1903, Geology of the Globe copper district, Arizona: U.S. Geol. Survey Prof. Paper 12, 168 p.

——— 1914, Copper deposits near Superior, Arizona: U.S. Geol. Survey Bull. 540–D, p. 139–158.

——— 1919, The copper deposits of Ray and Miami, Arizona: U.S. Geol. Survey Prof. Paper 115, 192 p.

Short, M. N., Galbraith, F. W., Harshman, E. N., Kuhn, T. H., and Wilson, E. D., 1943, Geology and ore deposits of the Superior mining area, Arizona: Arizona Bur. Mines Bull. 151, geol. ser. 16, 159 p.

Shride, A. F., 1967, Younger Precambrian geology in southern Arizona: U.S. Geol. Survey Prof. Paper 566, 89 p.

Wilson, E. D., and Moore, R. T., 1959, Geologic map of Pinal County, Arizona: Tucson, Arizona Bur. Mines, scale 1:375,000.

DESCRIPTIONS OF MAP UNITS

TALUS AND LANDSLIDE—Accumulations of loose, angular blocks from nearby outcrops. Common throughout quadrangle but shown only where especially prominent.

ALLUVIUM—Sand and gravel deposits in partly enclosed basins or along streambeds. Generally unconsolidated.

BASALT—Gray aphanitic basalt. Groundmass chiefly plagioclase and pyroxene; may contain small olivine phenocrysts, some of which are altered to iddingsite. Locally vesicular. Occurs as small, irregular, intrusive bodies, commonly along faults.

GRAVEL AND CONGLOMERATE—Stream deposits derived from older rocks. Contains pebbles, cobbles, and boulders, which range from angular to subrounded. Matrix is coarse, poorly sorted arkosic sandstone that varies from well consolidated to poorly consolidated. Crude to well-defined bedding.

VOLCANIC ROCKS (0–250 FT)

Lava—Flows of rhyolite with aphanitic centers and glassy to pumiceous outer envelopes; rock contains sparse phenocrysts of quartz, feldspar, and biotite. Aphanitic rhyolite is gray and varies from massive to strongly flow laminated; laminations vary from planar to contorted. Spheroidal structures locally abundant along contacts between aphanitic and glass phases. Glass phase, generally light gray, is locally perlite of commercial quality.

Tuff—Light-yellow, white, and light-brown air-fall and water-laid tuff. Crudely bedded to well-bedded, with beds ranging from about 1 to 4 feet in thickness. Generally poorly sorted, composed of coarse and medium grains of quartz and feldspar, pumice and rhyolite chips, xenoliths, and volcanic dust. Some beds separated by partings of ash.

QUARTZ MONZONITE PORPHYRY

Porphyritic facies—Phenocrysts of quartz, K-feldspar, and plagioclase, 1–3 mm in diameter, make up 10–15 percent of the rock. Finely crystalline groundmass is composed of quartz, feldspar, and mafic minerals. Cavities with quartz filling or druses common. Forms a small, irregular stock, probably intruded at shallow depth.

Aphanitic border facies—Border of quartz monzonite porphyry body. Similar to porphyritic facies except phenocrysts are small or absent, and groundmass grades from finely crystalline to aphanitic. Transition to porphyritic facies is gradational to abrupt.

APACHE LEAP TUFF (NEW) (2,000 FT AT TYPE SEC.; AVERAGES ABOUT 500 FT)—This formation is here named for Apache Leap, a prominent west-facing cliff that trends southward through the central part of quadrangle. Type section is in Queen Creek Canyon and Oak Flat (sec. 36, T. 1 S., R. 12 E., and secs. 28, 29, 30, and 31, T. 1 S., R. 13 E.). In earlier reports this formation was informally termed "dacite." The Apache Leap Tuff is an ash-flow sheet which, at type section, constitutes a simple cooling unit. Nonwelded light-gray tuff at base grades upward to densely welded black vitrophyre that is overlain by densely welded tuff with cryptocrystalline groundmass. Farther up, degree of welding gradually decreases and degree of devitrification and vapor-phase crystallization increase. Color progressively changes upward from light brown just above vitrophyre through moderate red to very light gray near top. Abundant pumice fragments progressively less flattened toward top. Phenocrysts constitute about 40 percent of the rock, and consist of about three-fourths plagioclase, one-tenth each quartz and biotite, trace to one-tenth sanidine, minor hornblende, magnetite, sphene, zircon, and apatite.

Tertiary in age, on basis of 20-m.y. K-Ar date (Creasey and Kistler, 1962, p. D1).

Lower contact—Rests on Whitetail Conglomerate at type locality; contact designated as basal surface of ash-flow material; below this surface, clastic sedimentary rock is interbedded with water-laid tuff. Apache Leap Tuff may also rest on Tertiary rhyolitic lava flows, Paleozoic, or Precambrian rocks.

Upper contact—Overlain unconformably by water-laid gravel and conglomerate.

RHYOLITE (0–2,000 FT)—Lava flows of rhyolite and perlitic obsidian. Light- to medium-gray rhyolite with 1 to 5 percent phenocrysts of plagioclase, quartz, sanidine, and biotite in aphanitic groundmass. Flow laminations generally prominent, locally contorted; laminations locally absent resulting in massive structure. Tops and bottoms of flows generally composed of black to brown obsidian with well-developed perlitic cracks. Obsidian slightly to completely devitrified and grades to grayish-yellow felsite. Unit includes local deposits of tuff and tuff breccia, and flows of andesite and trachyte.

WHITETAIL CONGLOMERATE (OUTCROPS, 0–350 FT; SUBSURFACE, 500–>2,000 FT)—Stream deposits derived from all older rocks. Fragments are angular to subrounded, pebble to boulder size, and coarsest near base. Fragment composition generally is like nearby bedrock. Matrix typically coarse-grained, poorly sorted, arkosic to lithic sandstone, but matrix of some beds is fine grained. Moderately to well cemented. Bedding planes generally poorly defined, locally absent, become distinct upward. Upper part locally interstratified with water-laid tuff.

Age is here changed from Tertiary(?) (Ransome, 1903, p. 47; Peterson, N. P., 1962, p. 36) to Tertiary on basis of 20-m.y. K–Ar date for overlying Apache Leap Tuff (Creasey and Kistler, 1962, p. D1), and on basis of alternating sedimentary and tuffaceous beds in upper part of Whitetail. The tuff in the Whitetail is from pyroclastic eruptions that immediately preceded the ash-flow eruptions of the Apache Leap Tuff.

FELSITE DIKE—Known locally as "Grandfather lead." Light-gray aphanitic rock largely altered to clay, mica, and calcite. Relict phenocrysts of plagioclase discernible. Forms prominent outcrops.

VEIN QUARTZ—White "bull" quartz forming prominent outcrops. No metallic minerals detected.

DIORITE PORPHYRY—Sills, dikes, and small irregular hypabyssal bodies of light- to medium-gray porphyritic altered rock. Phenocrysts that constitute 20–60 percent of rock consist chiefly of euhedral and subhedral plagioclase, 1–10 mm in diameter, and euhedral hornblende prisms 1/2–15 mm long. Groundmass aphanitic to very fine grained; chiefly plagioclase, K-feldspar, hornblende, biotite, locally pyroxene; quartz generally absent but locally abundant. Partly to completely altered to sericite, clay, calcite, and chlorite. Contains disseminated pyrite near Silver King mine.

QUARTZ DIORITE—Small stock intrusive into Precambrian and Paleozoic rocks. Medium- to fine-grained, generally hypidiomorphic granular, locally grades to panidiomorphic granular. Consists mostly of euhedral to subhedral plagioclase and variable amounts of euhedral hornblende, pyroxene, and biotite; interstitial quartz ranges from trace to 15 percent.

There are two major but intergradational rock types: one is medium grained and contains 10–20 percent mafic minerals and 10–15 percent quartz; the other is fine grained and contains 20–40 percent mafic minerals and trace to 10 percent quartz. Common in both types are irregular masses of coarse-grained rock containing euhedral hornblende as much as 4 cm long or euhedral pyroxene as much as 2 cm wide. Plagioclase shows slight to moderate alteration to sericite and clay, and mafic minerals are altered to uralite, epidote, biotite, and chlorite.

NACO LIMESTONE (0–1,000 FT)—Medium- to thin-bedded, light-gray, white, pale-blue, and pink limestone that locally contains irregular light-brown chert nodules and layers. Bedding planes distinct and most are flat, though some are wavy. Fossils that are common and locally abundant include fusulinids, brachiopods, corals, bryozoa. Base of formation generally marked by 15-foot bed of very dusky red to dusky-purple fissile shale; similar shale is sporadically interbedded with limestone higher in section. Thin discontinuous beds of chert conglomerate crop out locally below the shale and mark the base.

Variability of thickness due to post-Naco erosion that occurred before deposition of overlying Tertiary rocks.

ESCABROSA LIMESTONE (400–500 FT)—Thick- to thin-bedded, very light gray to dark-gray limestone. Lowest beds are dark gray, thick to medium bedded, and overlain by very light gray thick-bedded limestone that forms one or more prominent cliffs. Upper part is light- to medium-gray, medium- to thin-bedded limestone that contains abundant chert and interbedded shale partings. Moderately fossiliferous; crinoid stems, brachiopods, and corals most abundant forms.

MARTIN LIMESTONE (350–450 FT)—In ascending order: 15–20 feet of grayish-yellow limestone containing abundant frosted quartz grains and dusky-red spheroidal spots. 10–30 feet of medium-bedded dark-gray crystalline limestone that is the host rock for replacement ore bodies in Magma mine and is locally mineralized elsewhere. 150–200 feet of dark- to light-gray to grayish-yellow, thin-bedded, unfossiliferous dolomite with dense texture; one or more thin beds of medium-grained quartzite or sandstone may be interbedded. 160–200 feet of alternating thin to medium beds of limestone, dolomite, and a little sandstone and gray to grayish-yellow to grayish-red shale; some of the limestone is crowded with brachiopods and crinoid stems. 10–30 feet of gray to grayish-yellow, highly fissile, calcareous shale.

BOLSA QUARTZITE (0–430 FT)

Lower part—Heterogeneous clastic lithologies with abrupt changes both laterally and vertically. Includes poorly sorted pebble conglomerate, arkosic sandstone, graywacke, and wavy bedded mudstone; most rocks deeply iron stained and are dark shades of grayish to reddish brown. This material is largely derived from nearby older rocks and fills irregularities on an eroded surface of moderate relief.

Upper part—Medium- to fine-grained quartzite, feldspathic quartzite that locally may grade to sandstone, and some beds of grit. White to light gray where fresh, grayish yellow to light brown where weathered; red and brown color laminations are common and locally prominent. Bedding distinct, medium to thick, generally even, locally undulating; crossbedding common. Locally forms cliffs.

Changes in thickness chiefly due to pre-Paleozoic relief.

DIABASE—Sills and dikes. Chiefly subhedral and euhedral plagioclase and pyroxene, with lesser amounts of amphibole, biotite, and opaque oxides; minerals commonly moderately altered. Freshly broken surfaces dark gray to greenish black; weathered surfaces dark shades of brown, green, and gray. Texture ophitic and subophitic; generally medium grained, locally coarse grained, aphanitic at chilled borders. Intrudes Troy Quartzite and older formations, and is depositionally overlain by Bolsa Quartzite.

TROY QUARTZITE (730 FT)

Lower member (185 ft)—Alternating beds of conglomerate, poorly sorted coarse-grained feldspathic quartzite and arkose, and siltstone; conglomerate beds most abundant near base; beds are lenticular and have highly variable thicknesses. Crossbedding and local Liesegang banding are common. In upper part, a medium-grained feldspathic sandstone bed as much as 50 feet thick shows well-developed convolute laminations.

Upper member (545 ft)—Chiefly fine-grained, locally medium- to coarse-grained quartzite and arkosic quartzite. Weathers to resistant, blocky ledges. Bedding medium, generally even but locally wavy. White to light gray where fresh, light gray to light brownish gray where weathered. Chiefly rounded to subrounded, well-sorted grains; beds locally contain scattered quartz granules and small pebbles, which in some places stud surface just below parting plane. Many beds contain clots of powdery hematite interstitial to grains, giving rock a spotted appearance.

BASALT (MAXIMUM 320 FT)—Dark-gray to dark-brown aphanitic rock composed of microscopic plagioclase tablets partly altered to clay and calcite, and pyroxene and olivine largely altered to opaque oxides, serpentine, calcite, iddingsite, and other products. Locally vesicular and amygdaloidal. Some layers are volcanic breccia consisting of angular basalt blocks in a matrix of basaltic lava.

MESCAL LIMESTONE (350 FT)—Medium-gray to light-brown to white dolomite and limestone; generally thin-bedded with undulating to even bedding planes. Texture generally aphanitic or fine grained, locally medium or coarse grained, crystalline. Black to light-brown variegated chert abundant in some beds as uneven layers alternating with carbonate or as irregular nodules. Near base is layer of poorly exposed breccia of angular cherty dolomite fragments in a matrix of silty, locally calcareous, dolomite. Near top an algal member contains abundant wavy concentric structures characteristic of stromatolites. Locally near intrusive bodies of diabase in southern part of quadrangle, seams of chrysotile asbestos occur parallel to bedding.

DRIPPING SPRING QUARTZITE (720 FT)—In ascending order:

Barnes Conglomerate Member (6–15 ft)—Well-rounded, ellipsoidal pebbles and cobbles of gray and brown quartzite, white quartz, and minor red jasper in a matrix of medium- to coarse-grained, poorly sorted, arkosic quartzite. Ledge-forming.

Arkose member (220 ft)—Light-brown, yellowish-gray, and pale-reddish-brown, medium- to coarse-grained, feldspathic quartzite and arkose, medium- to thick-bedded, locally crossbedded, some beds separated by siltstone partings. Commonly forms ledges and cliffs.

Siltstone member (490 ft)—Alternating thin layers of very fine grained feldspathic quartzite, arkose, and siltstone. Fresh surfaces light gray to light brown; weathered surfaces strong shades of brown, red, and yellow; color laminations common, locally spotted. Weathers to slabs and blocks; generally forms slopes with intermittent low ledges. Generally intruded by several diabase sills.

PIONEER FORMATION (305 FT)—In ascending order:

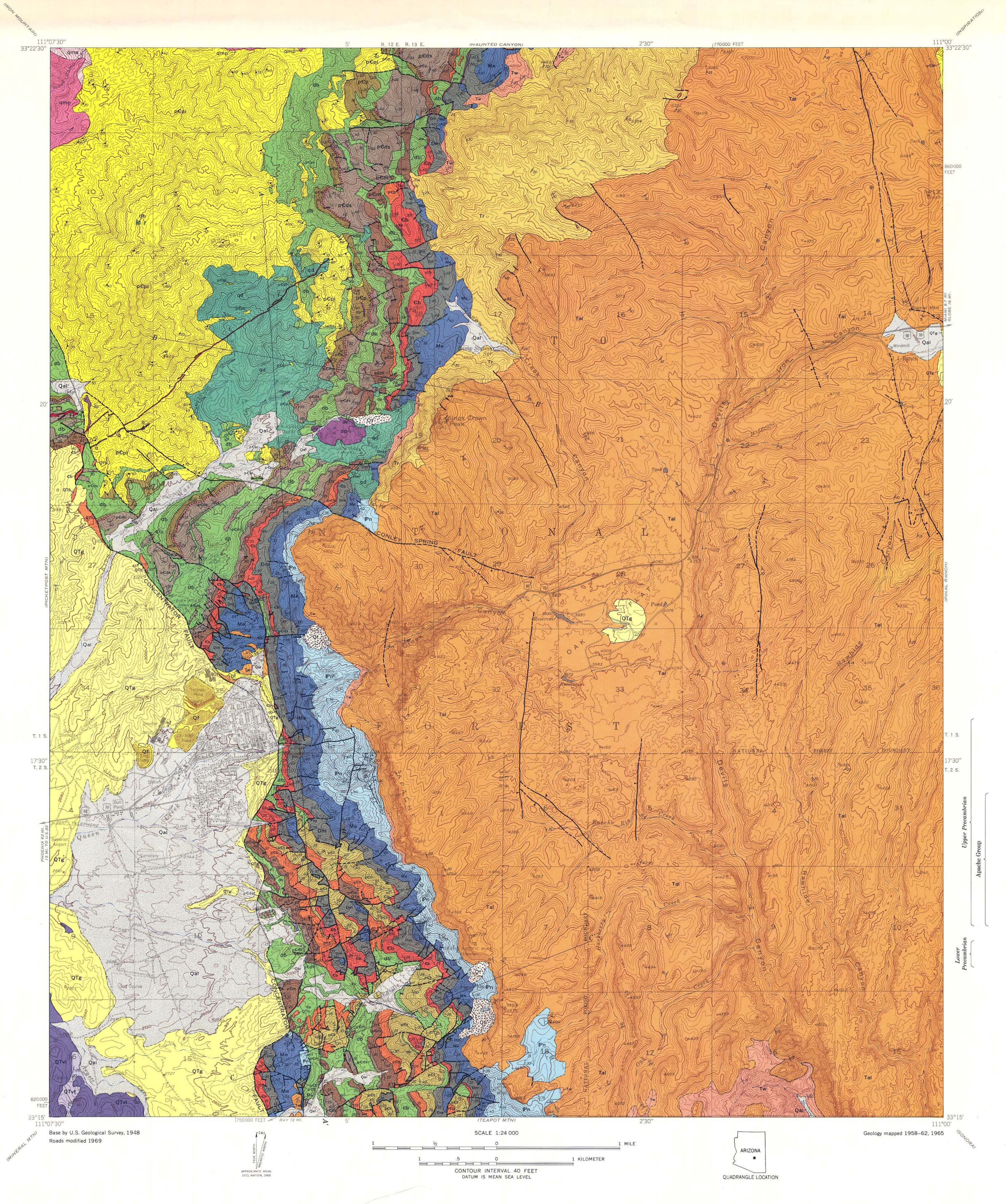
Scanlan Conglomerate Member (generally 1–4 ft, locally as much as 18 ft)—Well-rounded to subangular pebbles of white quartz, locally abundant, and angular pebbles and granules of schist in a matrix of grayish-red-purple, very coarse grained, poorly sorted rock chips and arkosic sandstone.

Arkose member (155 ft)—Arkose and feldspathic quartzite and sandstone, light-brown to dark-brown to dusky-red-purple, medium- to thin-bedded. Sandy beds separated by thin beds of siltstone and shale. Number and thickness of siltstone beds increase upward so that upper part of member contains equal amounts of arkose and siltstone.

Siltstone member (135 ft)—Thin-bedded siltstone, shale, and fine-grained arkose, dusky-purple and dusky-red, speckled by light-brown to greenish-yellow spots. Siltstone and shale are tuffaceous. Typically weathers to small, flat, angular flakes.

PINAL SCHIST—Quartz-muscovite schist and quartz-muscovite-chlorite schist, with some feldspar, and locally andalusite and sillimanite. Well-developed to indistinct foliation that is slightly to intensely contorted. Fresh and weathered surfaces light to dark gray and locally pale blue; in some places weathered surfaces brown. Pods, veinlets, and veins of white quartz locally abundant. Hornfels and granulite locally abundant.

Note: Additional information on these rocks may be obtained from reports listed in the selected bibliography.

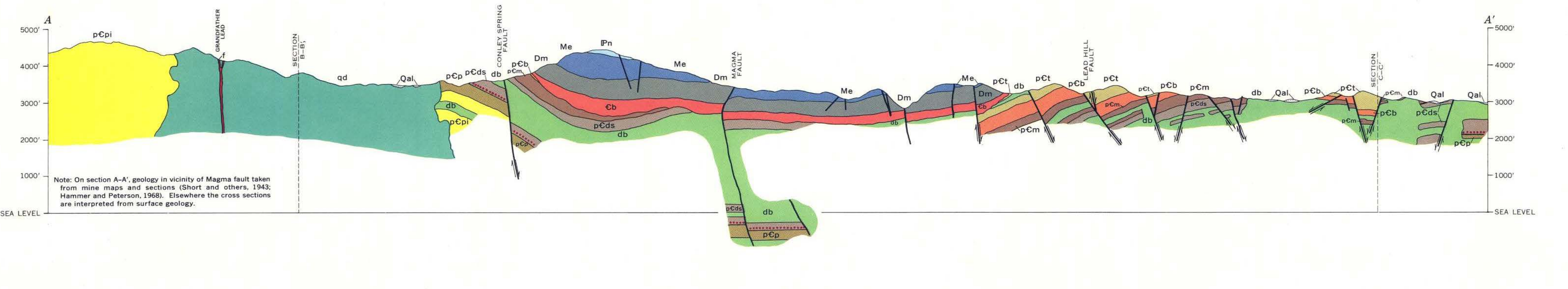


Base by U.S. Geological Survey, 1948
Roads modified 1969

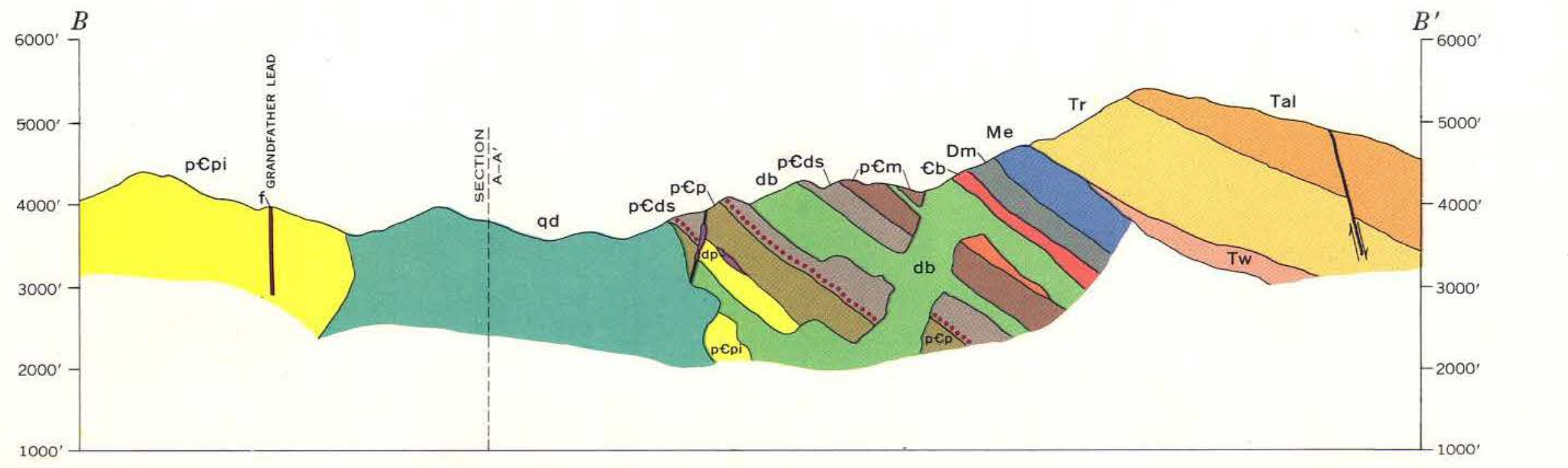
SCALE 1:24 000

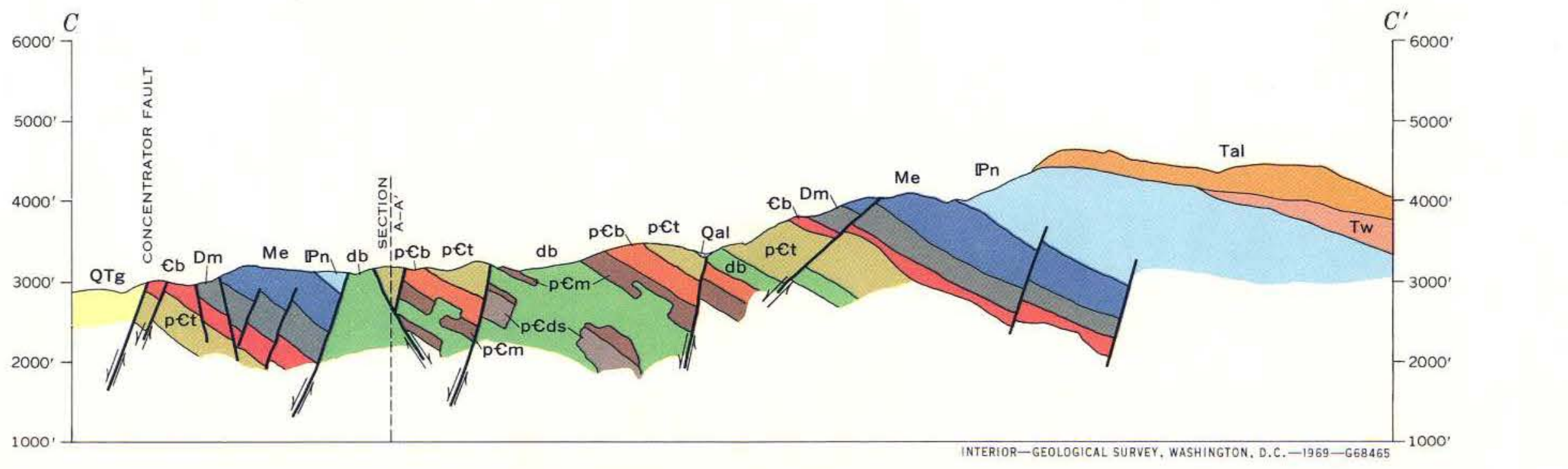
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

Geology mapped 1958–62, 1965



Note: On section A–A', geology in vicinity of Magma fault taken from mine maps and sections (Short and others, 1943; Hammer and Peterson, 1968). Elsewhere the cross sections are interpreted from surface geology.





INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1969—G68465

GEOLOGIC QUADRANGLE MAP
SUPERIOR QUADRANGLE, ARIZONA
GQ–818

EXPLANATION

QUATERNARY
- Qf Tailing and slag piles, and fill
- Qt Talus and landslide material
- Qal Alluvium

UNCONFORMITY

TERTIARY AND QUATERNARY
- QTb Basalt
- QTg Gravel and conglomerate

UNCONFORMITY

- QTvl QTvt Volcanic rocks
  - QTvl, *lava*
  - QTvt, *tuff*

UNCONFORMITY

TERTIARY
- qmp qma Quartz monzonite porphyry
  - qmp, *porphyritic facies*
  - qma, *aphanitic border facies*
- Tal Apache Leap Tuff
- Tr Rhyolite
- Tw Whitetail Conglomerate

UNCONFORMITY

CRETACEOUS OR TERTIARY
- f Felsite dike
- q Vein quartz
- dp Diorite porphyry
- qd Quartz diorite

UNCONFORMITY

CARBONIFEROUS
- PENNSYLVANIAN: Pn Naco Limestone
- MISSISSIPPIAN: Me Escabrosa Limestone

DEVONIAN
- Dm Martin Limestone

DISCONFORMITY

CAMBRIAN
- €b Bolsa Quartzite

UNCONFORMITY

PRECAMBRIAN

Upper Precambrian
- db Diabase
- p€t Troy Quartzite

DISCONFORMITY

Apache Group
- p€b Basalt
- p€m Mescal Limestone
- p€ds Dripping Spring Quartzite
  Dots indicate Barnes Conglomerate Member
- p€p Pioneer Formation

UNCONFORMITY

Lower Precambrian
- p€pi Pinal Schist

Contact showing dip
Dashed where approximately located

Fault, showing dip
Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side

Overturned anticline   Overturned syncline
Fold axes
Dashed where approximately located

Inclined   Overturned
Strike and dip of beds

Horizontal beds

Strike and dip of foliation

Strike and dip of layered structures in volcanic rocks

Shaft

Adit

Prospect pit

GEOLOGIC MAP OF THE SUPERIOR QUADRANGLE, PINAL COUNTY, ARIZONA

By

Donald W. Peterson

1969

For sale by U.S. Geological Survey, price $1.00