MAP GQ-1391

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

# GEOLOGIC MAP OF THE HAYDEN QUADRANGLE, PINAL AND GILA COUNTIES, ARIZONA

By Norman G. Banks
and Medora H. Krieger

GEOLOGIC QUADRANGLE MAP
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BANKS AND KRIEGER—HAYDEN, ARIZONA 1:24,000 MAP GQ-1391

# GEOLOGIC MAP SYMBOLS
## COMMONLY USED ON MAPS OF THE UNITED STATES GEOLOGICAL SURVEY
**(Special symbols are shown in explanation)**

Contact—Dashed where approximately located; short dashed where inferred; dotted where concealed

Contact—Showing dip; well exposed at triangle

Fault—Dashed where approximately located; short dashed where inferred; dotted where concealed

Fault, showing dip—Ball and bar on downthrown side

Normal fault—Hachured on downthrown side

Fault—Showing relative horizontal movement

Thrust fault—Sawteeth on upper plate

Anticline—Showing direction of plunge; dashed where approximately located; dotted where concealed

Asymmetric anticline—Short arrow indicates steeper limb

Overturned anticline—Showing direction of dip of limbs

Syncline—Showing direction of plunge; dashed where approximately located; dotted where concealed

Asymmetric syncline—Short arrow indicates steeper limb

Overturned syncline—Showing direction of dip of limbs

Monocline—Showing direction of plunge of axis

Minor anticline—Showing plunge of axis

Minor syncline—Showing plunge of axis

Strike and dip of beds—Ball indicates top of beds known from sedimentary structures

Inclined Horizontal
Vertical Overturned

Strike and dip of foliation

Inclined Vertical Horizontal

Strike and dip of cleavage

Inclined Vertical Horizontal

Bearing and plunge of lineation

Inclined Vertical Horizontal

Strike and dip of joints

Inclined Vertical Horizontal

Note: Planar symbols (strike and dip of beds, foliation or schistosity, and cleavage) may be combined with linear symbols to record data observed at same locality by superimposed symbols at point of observation. Coexisting planar symbols are shown intersecting at point of observation.

Shafts

Vertical Inclined

Adit, tunnel, or slope

Accessible Inaccessible

X Prospect

Quarry

Active Abandoned

Gravel pit

Active Abandoned

Oil wells

Drilling Shut-in Dry hole, abandoned
Gas Show of gas
Oil Show of oil

# GEOLOGIC MAP OF THE HAYDEN QUADRANGLE, PINAL AND GILA COUNTIES, ARIZONA

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## GENERAL GEOLOGY

The main physiographic feature of the Hayden quadrangle is the Dripping Spring Mountains, which trend northwest-southeast through the center of the map area and consist of Precambrian, Paleozoic, and Cretaceous rocks that are intruded by a wide variety of Cretaceous and Tertiary dikes and sills. The range is bounded on the north by the Dripping Spring Valley and on the south by the Gila River Valley. Both valleys were depositional basins for thick colluvial and lake sediments of Miocene age. Oligocene sediments have been exposed by faulting and erosion in the Gila River Valley but not in the Dripping Spring Valley. Complexly faulted Precambrian rocks crop out in the southwest corner of the quadrangle.

The oldest rock exposed in the quadrangle is the Ruin Granite of Precambrian Y age. It is unconformably overlain by Precambrian Y sedimentary and volcanic rocks of the Apache Group and the Troy Quartzite, which were deposited mainly in shallow marine environments; significant disconformities exist in this section. These Precambrian rocks are intruded by Precambrian Y diabase sills and dikes. Faulting accompanying intrusion of the sills did not appreciably tilt the large blocks of intruded sedimentary rock. Topographic relief developed by the intrusion and faulting during the Precambrian was greatly subdued but not entirely removed by erosion prior to Middle and Late Cambrian deposition of the Bolsa Quartzite and Abrigo Formation in shallow marine waters. Erosion and probable nondeposition during Ordovician, Silurian, and Early Devonian time removed only part of the relief remaining after deposition of the Cambrian sedimentary rocks; this resulted in a variable lithology and thickness for the Late Devonian Martin Formation. Slight tilting and faulting occurred during the long interval of early Paleozoic erosion. Dominance of stromatolitic structures and sublithographic dolomite in the Martin Formation suggests that it was deposited primarily near, or in, the intertidal zone. The overlying Upper Devonian Percha Shale (Schumacher and others, 1976) was deposited in a deeper marine environment.

The overlying Mississippian Escabrosa Limestone is locally slightly clastic and does not contain age-diagnostic fossils in its basal few meters, but above this interval, Osagean fossils have been identified (A. K. Armstrong, written commun., 1973), suggesting that a measurable period of erosion occurred in latest Devonian and earliest Mississippian time. Perceptible tilting did not occur during this erosional interval. Dominance of micritic and fine-grained limestone in the lower half of the Escabrosa Limestone suggests that it was deposited in relatively quiet, perhaps deep marine waters; bioclastic debris is much more abundant in the upper part of the formation, which suggests a comparatively more turbulent, perhaps shallower, marine environment during its deposition. Incomplete dolomitization occurs locally in both the basal and upper beds of the formation; dominance of saccharoidal dolomite and bleached and recrystallized chert in the basal dolomite beds suggests that the required magnesium solutions had a hydrothermal source, whereas sublithographic dolomite and pristine chert in the upper beds suggest that the upper incomplete dolomitization occurred by seepage reflux, perhaps from Pennsylvanian seawater. Silification and local solution brecciation of the uppermost beds (deposited in Meramecian time; A. K. Armstrong, written commun., 1973) occurred during late Mississippian or earliest Pennsylvanian erosion but was not accompanied by tilting or faulting.

The erosion produced topographic relief on the Escabrosa Limestone and a varied lithology and thickness in the basal parts of the overlying sedimentary rocks, which contain no age-diagnostic macrofossils or fusulinids. S. B. Keith (oral commun., 1975) reports Late Mississippian conodonts for these basal beds. Overlying beds of the Naco Limestone were deposited during Morrowan (A. K. Armstrong, written commun., 1973) and perhaps through earliest Permian (Peterson and Swanson, 1956) time in a marine environment that fluctuated between conditions favorable to shale deposition and conditions favorable to deposition of chert-bearing carbonates. The Permian parts of these sedimentary rocks, if deposited in the quadrangle, were removed by erosion prior to deposition of the Late Cretaceous basaltic Williamson Canyon Volcanics. During this erosional period or during eruption of the volcanic rocks, olivine basalt locally intruded the Paleozoic section, preferentially forming sills a few meters to tens of meters thick at specific horizons of the Abrigo and Martin Formations and the Escabrosa and Naco Limestones.

Eruption of the Williamson Canyon Volcanics was dominated by explosive activity. As indicated by megabreccia slides of Naco Limestone and older rocks in the volcanic pile in sec. 13, T. 4 S., R. 15 E., it also must have been accompanied or preceded by folding and faulting, perhaps along some of the major north-striking and north-west-striking faults used earlier for access by the Precambrian diabase. Deposition of the volcanic rocks was followed, and perhaps in part accompanied, by the development of a large number of generally east-striking faults, fissure faults, and generally northwest-oriented folds, by intrusion of dikes and sills of andesitic to quartz latitic rock, and only locally by development of intrusive breccias and pebble dikes. Field relations and correlation of petrologically identical rocks in this quadrangle with those in adjoining quadrangles suggest that deposition of the major sulfide ore bodies in the quadrangle occurred after most of these intrusive rocks were emplaced, or about 60 m.y. ago (Banks and others, 1972; Banks and Stuckless, 1973).

Tilting of the layered strata and movement on the major north-striking faults and on some of the east-west-striking faults recurred after deposition of ore but prior to deposition of the thick Oligocene and Miocene sedimentary formations—the San Manuel Formation, the Big Dome Formation, and the deposits in the Dripping Spring Valley. On some of these faults, movement and tilting of strata also occurred during, between, and after deposition of the Tertiary formations in the Gila River Valley.

Post-Miocene events recorded in the rocks of the quadrangle include erosion, faulting, development and then dissection of several pediment surfaces; deposition of several thin clastic units; deposition of travertine along some faults; and development of present drainage and accompanying older and younger alluvial deposits.

## STRUCTURE

Geologic structure in the Dripping Spring Mountains is dominated by an intricately patterned fault mosaic superimposed on a gently dipping sequence of rocks that have been arched into a broad, open anticline, plunging to the southeast (see also Eastlick, 1968). This general structure can be further classified into (1) the major northwest-southeast-oriented anticline, (2) minor folds with axial planes also oriented generally northwest-southeast, (3) four major north-south fault systems, (4) two major northwest-southeast-trending fault systems parallel to and near the Miocene sedimentary basins, and (5) many faults oriented 0°–35° north and south of east-west. Tilting of adjacent fault blocks during the faulting resulted in the extremely complex geologic relations of the range; the east-westerly faults provided the major channelways for emplacement of the Laramide igneous rocks.

From west to east across the quadrangle, the major north-south fault systems are the Cowboy, Kelly Springs, Keystone, and O'Carroll faults. The occurrence of Precambrian diabase sills at different stratigraphic horizons across the first three of these fault systems suggests that they were active during emplacement of the diabase, but data neither determine nor negate Precambrian movement on the O'Carroll fault. Combined Precambrian to post-Laramide normal displacement on these north-south fault systems locally is slightly more than 900 m, but individual strands typically show less normal displacement, and total displacement along each system varies along strike. For example, the greatest stratigraphic displacements on the Kelly Springs and O'Carroll faults occur near the north edge of the range, whereas those along the Keystone and Cowboy faults occur near the south edge. One or more strands of each fault system are cut by the Laramide dikes, whereas others cut the dikes, indicating that although major displacements occurred along the fault systems after deposition of the Williamson Canyon Volcanics and prior to intrusion of Laramide dikes, some strands had continued or recurrent activity after intrusion of the Laramide dikes. Some apparent strike-slip displacements along the fault systems are indicated by offset of individual dikes and dike sets, but their magnitudes are variable. For example, an intrusive breccia is offset in an apparent left-lateral direction by the Cowboy fault system near the north edge of the quadrangle. North of this breccia, a distinctive rhyodacite dike cropping out along the quadrangle boundary is also offset left laterally 600 m into the El Capitan Mountain quadrangle. Just south of the breccia, another distinctive dike is offset approximately 500 m, but in sec. 7, T. 4 S., R. 15 E., although Laramide dikes are cut by various fault strands, lateral offset is negligible. Apparent lateral offset of Laramide dikes also progressively decreased southward along the Kelly fault system and northward along the Keystone fault system. Although strands of the O'Carroll fault cut some of the dikes, lateral displacement is neither large nor consistent. At least part of the apparent lateral displacement along the north-south fault systems may reflect tilting of the blocks between them.

Faults are most closely spaced near the intersections between the major north-south fault systems and the two major northwest-southeast fault systems that bound the Dripping Spring Mountains on the northeast and southwest. The northwest-southeast range-front faults were active both prior to and after emplacement of the Laramide dikes, and in the Sonora quadrangle, at least one of the range-front faults moved during emplacement of the Precambrian diabase (Metz and Rose, 1966; Cornwall and others, 1971). These major fault zones may have resulted from a right-lateral shear couple along the range-front faults with complementary movement along the north-south faults. However, large lateral movement on the range-front faults is not compatible with slight offset of Laramide dikes and Precambrian contacts across the Gila River - Mineral Creek Valley (Cornwall, Brooks, and Phillips, 1971). East of the town of Hayden the range-front fault on the southwest side of the mountains displaces the Miocene Big Dome Formation, but significant post-Miocene displacement did not occur on this fault north of Keystone Canyon or along the range-front fault north of the mountains.

Displacement along the many faults oriented 0°–35° north and south of east-west are much smaller than the major north-south-striking and range-front faults discussed above, and many are fissure fractures with little or no displacement. Most of these east-westerly faults apparently developed during Laramide time because many are both parallel to and intruded by the Laramide dikes. Thus, both the major and minor fault systems, and the minor northwest-southeast-oriented folds whose hinge regions were intruded by Laramide dikes, had major development during Laramide time. These structures therefore provided ground preparation for fluid (magma and hydrothermal) access during the time that sulfide ore bodies developed in this and the adjacent quadrangles, and interpretation of the stress responsible for their formation is of potential economic interest.

The thin east-westerly dikes did not have enough thermal energy to stope their way through at least 600 m of carbonate rocks in the exposed section, and they do not show evidence of calcium-magnesium assimilation (no pyroxene). They likewise show only rare evidence of forceful intrusion. Thus, their abundance, lateral continuity, and narrowness suggest that they were most likely intruded in a tectonic environment involving northwest-southeast extension or tension. This condition could have resulted from generally northwest-southeast directed right-lateral tectonic shearing or approximately east-directed compression. However, the left lateral offset of the Laramide dikes on the major north-south faults is not compatiable with right lateral movement on the range-front faults, and east-west compression is supported by the observed northwesterly folds and the general anticlinal character of the Dripping Spring Mountains. It also is suggested on a more regional scale by similar orientation of dikes and sulfide veinlets in nearby quadrangles and elsewhere in Arizona (Cornwall and others, 1971; Cornwall and Krieger, 1975a, b; Krieger, 1974a, b; Willden, 1964; Rehrig and Heidrick, 1972) and by northwest-striking thrust faults to the southwest (Krieger, 1974c). This approximately east-directed compression might have originated in movement of lithospheric plates in Laramide time. Because each dike set in the Hayden quadrangle has its own particular northeast and northwest orientations that are not matched exactly by those of the next younger dike set, the orientation of regional stress probably fluctuated with time during Laramide igneous and structural activity. Thus, both dikes and sulfide veinlets may occupy tensional features, and exploration basinward along projections of the most extensive dike swarms, which indicate potentially favorable channelways for deep fluid sources, could be profitable. Alternatively, because the sulfide veinlets cut the Laramide rocks, the sulfide-bearing fluids might have traveled still another set of fractures oriented east-westerly but not necessarily on or parallel to the particular set of dikes on which a deposit might center. Thus, if all the Laramide sulfide deposits in the quadrangle developed at approximately the same time, the zone of major fluid access might have extended N. 80° W. from Christmas mine through the New Year, Chilito, and 79 mines, which suggests possible exploration ground N. 80° W. of 79 mine and N. 100° E. of Christmas mine. It is noteworthy that N. 80° W. of the 79 mine in Miocene alluvial deposits are manganese oxide-barite-jasperoid deposits (presumably hot springs deposits) that carry base metal anomalies and, as expected, that base metal anomalies in the bedrock parallel the zone occupied by the major known sulfide deposits rather than any particular dike swarm (N. G. Banks and R. D. Dockter, unpub. data).

Only a small part of the Tortilla Mountains occurs in the Hayden quadrangle (southwest corner). The structure of complexly faulted bedrock in this part of the quadrangle is discussed by Krieger (1974c).

## MINERAL DEPOSITS

Some of the metallization and alteration associated with the Christmas deposit, owned by Inspiration Consolidated Copper Co., occurs at the east-central edge of the quadrangle in secs. 19, and 30, T. 4 S., R. 15 E. (unsurveyed). From discovery through 1974, the deposit produced 279,250,300 pounds of copper (J. T. Eastlick, written commun., 1975), first in surface and underground mining of replacement beds in the Martin Formation, and the Escabrosa and Naco Limestones and later by open-pit mining, part of which includes stockwork mineralization. More detailed descriptions of the deposit are found in Eastlick (1968), Willden (1964), Peterson and Swanson (1956), and Ross (1925).

About 3 km northwest of the Christmas deposit in SW cor. sec. 13 and NW cor. sec. 24, T. 4 S., R. 15 E., is Santa Montica Camp (originally the Premier mining group reported by Ross, 1925). About 400 m of adits and drifts have been made in the area, and about $70,000 worth of gold was reportedly produced from one of the main workings (J. T. Eastlick, written commun., 1975). The gold occurs as native gold in thin seams with iron and manganese o[illegible]ides. The copper mineralization occurs as oxidized veins and replacement ore bodies immediately adjacent to the veins. At the surface, these veins are mostly jasper or spongy quartz, heavily stained with hematite, jarosite, and goethite; some veins show one or more of the following: manganese oxides, cerussite, anglesite, galena, copper carbonates, wulfenite, vanadinite, and hemimorphite.

The New Year mine, about 2.5 km N. 80° W. of Christmas mine, produced about 1,000 tons of lead ore and about 50 tons of zinc ore according to Ross (1925); there are four or more shafts including the Curtain shaft (reportedly 100 m deep, J. T. Eastlick, written commun., 1975), several adits, many prospect pits, and other surface workings. Alteration minerals in igneous rocks of the area include quartz-sericite, kaolinite, and propylitic minerals (epidote, chlorite, carbonate), and carbonate rocks have been variably converted to skarn. Eastlick (1968) reports galena, anglesite, cerussite, and hemimorphite as the major ore minerals.

About 1.5 km N. 80° W. of New Year mine is the Chilito mine (Kennecott Copper Corp.), a small- to medium-sized stockwork-vein-disseminated porphyry copper deposit presently (1975) worked under contract to provide silica flux for the Kennecott Copper Corp. smelter at Hayden. Alteration minerals include hydrothermal biotite, quartz-sericite, epidote, chlorite, and carbonate minerals. Hypogene chalcopyrite, pyrite, molybdenite, and anhydrite are present in the relatively unoxidized parts; at least $200,000 of supergene chalcocite ore was produced from the Schneider claims prior to 1913 (Ransome, 1923) in secondarily enriched pyrite in replaced beds of the Mescal Limestone west of the present open pit. Chilito produced about $1¼ million worth of ore during World War I (Eastlick, 1968).

Mineralization probably associated with Chilito encouraged development of small producing mines 1 km northeast (Apex or San Bernardo Jr. mine), and also east, southeast (Lavell mines), and south (London-Arizona mine) of Chilito along the east side of Schneider Canyon. Most of this mining activity focused on the upper beds of the Abrigo Formation and on the O'Carroll bed (local name) in the Martin Formation. The largest producer was the London-Arizona mine (about $1 million; Eastlick, 1968). The Lavell mines are said to have produced about $10,000 worth of gold ore (Ransome, 1923); the Apex mine produced about $20,000 worth of gold from oxidized lead ore and also some high-grade gold ore (Ross, 1925); and the London-Arizona produced at least 15,000 tons of ore averaging 4.5 percent copper. Minerals associated with these deposits include chalcopyrite, pyrite, pyrrhotite, copper carbonates, cuprite, chalcocite, cerussite, galena, wulfenite, native gold, andradite, specularite, quartz, idocrase, magnetite, serpentine, and anhydrite.

A few small adits and prospect pits that probably shipped no ore occur within 1 km to the northwest and southwest of Chilito mine. A little over 1 km southwest of London-Arizona mine, some workings in the upper Abrigo Formation and lower Martin Formation may have produced a few carloads of ore (probably gold) from oxidized veins and replacement bodies; the Hogvall prospect (Ross, 1925) is among these workings.

The 79 mine, in the approximate center of the quadrangle, was discovered in 1879 and worked intermittently through the 1950's. Production prior to 1947 was about 110,000 tons of mixed oxide and sulfide ore valued at between $3 million and $4 million (Kiersch, 1947). The ore came from vein and bedding replacement ore primarily in the Martin Formation and Naco Limestone (Eastlick, 1968; Keith, 1972). In addition to surface workings, the mine includes the main incline, seven levels, and over 3,000 m of tunnels and stopes (Keith, 1972). Near the surface is oxidized galena ore with cerussite, anglesite, sphalerite, chalcopyrite, descloizite, vanadinite, wulfenite, hematite, and some pyrite and copper carbonates. The zinc content of the ore increases with depth (Eastlick, 1968). The ore deposits at the mine are discussed in detail by Kiersch (1947), and a more complete list of minerals present in the mine is presented by Keith (1972). Many prospect pits, small shafts, and adits are scattered in sec. 21 and along its border with sec. 22, T. 4 S., R. 15 E., to the north of the main 79 mine workings.

Along Keystone Canyon, 1½ km south of 79 mine, are the Regan Camp prospects. Kiersch (1947) reported that several carloads of oxidized lead ore were produced from the irregular and scattered workings, mostly in replacement ore bodies and veins along a fault cutting Naco Limestone, south of Keystone Canyon. In addition to the oxidized galena ore, wulfenite, vanadinite, and copper carbonates occur on the prospect dumps. Similar minerals and also manganese oxides occur on the dump of the Overland mine near SE cor. sec. 28, T. 4 S., R. 15 E.; this mine consists of a main shaft and probably a few short tunnels that may have produced one or two carloads of oxidized lead ore.

Just north of the quadrangle is the Barbarosa mine, reported by Ransome (1923) to have produced $2,000–$3,000 worth of gold by dry washing alluvium deposited on Troy Quartzite on gully slopes. Associated workings occur in this quadrangle in and east of sec. 36, T. 3 S., R. 14 E. The gold most likely came from vein and replacement ore in the overlying Abrigo Formation and Martin Formation. Several prospects in Mescal Limestone, south of the Barbarosa mine in this quadrangle, show oxidized lead-zinc minerals.

Extensive jasperoid-barite reefs and associated cross-cutting manganese oxide and carbonate veins and bedding replacement bodies occur in the Miocene Big Dome Formation in an area of over a square mile centered in NW cor. sec. 19, T. 4 S., R. 15 E. Both the jasperoid-barite and manganese-carbonate mineralization extends into nearby older rocks. The strongest veining is oriented northwest-southeast. The mineralization carries base metal and vanadium-tungsten anomalies, and copper staining was observed at several localities (N. G. Banks and R. D. Dockter, unpub. data). Prospecting of the deposit has been extensive, but it is estimated that less than 1,000 tons of high-grade manganese ore has been shipped from the properties. High-grade manganese ore is better developed in the southeast part of the deposit relative to the northwest part. The geologic location, colloform banding of the jasperoid and manganese, mineralogy, open vugs, and a mercury-antimony anomaly favor a hot-spring origin for the deposit. Its position westward along the projection of a chain of Laramide sulfide deposits suggests that remobilized Laramide sulfides might account for the base metal anomaly.

About ½ km northeast of Kelly Springs are several prospects and minor shafts with oxidized galena, sphalerite, smithsonite, and minor amounts of copper carbonate. Silver concentrations of 1,100 ppm were detected in a sample of lead-rich rock from the dump of one prospect.

Scattered prospects on generally weak shows of mineralization are peripheral to each of the mining localities described above. Mineral showings in addition to those described above occur east of Hayden on the north and south sides of the Gila River and also along epidote alteration zones in the volcanic rocks southwest of the Christmas mine.

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Augustus K. Armstrong provided us with his unpublished fossil and stratigraphic data from the Escabrosa and Naco Limestones and also correlated several fossil collections from the Naco Limestone with his sections. Randolph A. Koski provided some thin sections from the Williamson Canyon Volcanics.

## DESCRIPTION OF MAP UNITS

### SURFICIAL DEPOSITS

Qd MINE DUMP – Waste from open-pit mining operations

Qal ALLUVIUM – Gravel, sand, and silt deposits in stream channels and on young low-lying terraces along streams

Qt TALUS – Accumulations of large to small angular blocks at or near the base of cliffs and steep slopes

Qls LANDSLIDE DEPOSITS – Several slides of Naco Limestone in sections 35 and 36, T. 4 S., R. 15 E., and one coherent slide block and accompanying debris along the Gila River (Sec. 12, T. 5 S., R. 15 E.)

Qtr TRAVERTINE – Calcium carbonate deposits occurring along faults in Steamboat Wash (secs. 1 and 12, T. 4 S., R. 14 E.) and east of Hayden townsite

Qp SOIL AND GRAVEL VENEER (0–8 m) – Reddish-brown soil and gravel with subangular to subrounded pebble to boulder clasts from older rocks. Deposited on terrace surfaces of several ages along the Gila River Valley, Dripping Spring Wash, and major drainages out of the Dripping Spring Mountains. Limestone clasts are rare even where deposits overlie carbonate rocks or limestone conglomerate

Qog OLDER GRAVELS (0–15 m) – Grayish to yellowish-white carbonate-cemented gravels and conglomerates deposited along but at higher levels than present channels, streams, and washes. Clasts are subrounded pebbles, cobbles, and small boulders of older rocks exposed along adjacent drainage. Includes deposits of several ages

QTv VEINS – Red jasperoid-barite-manganese oxide and manganese oxide-calcite veins and replacement bodies with local base metal anomalies

DEPOSITS IN DRIPPING SPRING VALLEY (0–>460 m) – Interfingering alluvial and lakebed deposits exposed in the Dripping Spring Valley; age unknown, tentatively correlated with Big Dome Formation on the basis of lithology but part might be as young as Quiburis Formation (Miocene or Pliocene age) of San Pedro Valley

Tgv CONGLOMERATE (0–>150 m) – Facies dominated by angular to subangular pebble- to boulder-size clasts of Williamson Canyon Volcanics and Cretaceous and Tertiary intrusive rocks. Matrix is greenish gray, sand size, and composed mainly of decomposed volcanic and intrusive rocks. Induration is poor to slight

Tg CONGLOMERATE (0–>460 m) – Conglomerate facies with subangular to subrounded clasts representing all pre-Miocene rocks in proportions and size that vary with proximity to and composition of the adjacent bedrock exposures. Matrix of silt- to small-pebble-size material (varying with composition of adjacent bedrock) is well cemented, particularly near bedrock, and is light olive gray to light tans and browns. Poorly sorted and bedded near bedrock; moderately well sorted and bedded in transitional facies with lakebed facies

Tl CLAY, SILT, AND SAND (0–unknown but at least 300 m) – Lakebed facies; interbedded clay, silt, and fine sand. Clay-rich beds, locally with lenses and veins of gypsum, are most abundant near and south of SE cor. sec. 35, T. 3 S., R. 15 E. The clay-rich beds, probably representing the center of the depositional basin, are orange pink to very pale brown and grade southwestward and northeastward into grayish beds containing progressively more silt and then progressively more sand; beds of freshwater limestone are present and become increasingly abundant on the east side of the basin. Interbedded tuffs (<3 m) are most apparent north of Dripping Spring Wash; alteration of the tuffs is variable; glass shards in one tuff have a refractive index slightly greater than 1.495

BIG DOME FORMATION (0–> 460 m) – An alluvial deposit having four facies in this quadrangle (see also Krieger and others, 1974; Cornwall and Krieger, 1975a) and two interbedded tuffs, one of which gives K-Ar ages of 14 m.y. (biotite) and 17 m.y. (hornblende) (Cornwall and others, 1971; Banks and others, 1972)

Tbg CONGLOMERATE (0–>300 m) – Facies dominated by subangular pebble- to boulder-size clasts of Ruin Granite and variable amounts of other pre-Miocene rocks; few clasts of Miocene Apache Leap Tuff (Peterson, 1969) and Paleozoic limestone except near boundary with sandstone and conglomerate facies. Matrix is pale-yellowish-brown to yellowish-gray sand-size material derived from decomposed and abraded granite. The clast/matrix ratio generally decreases northeastward. Beds are poorly indurated, bedded, and sorted. Shallow channeling is common. The main source area for this facies was to the west or south

Tbs SANDSTONE AND INTERBEDDED CONGLOMERATE (0–300 m) – Facies with arkosic, poorly indurated sandstone and interbedded conglomerate. The clasts consist of variable amounts of all pre-Miocene rocks. Matrix of the conglomerate is arkosic, calcareous, and sand sized. Large well-rounded clasts of Apache Leap Tuff (derived from northwest of the quadrangle) are common and locally abundant; conglomerate beds with limestone clasts dominant are abundant in basal beds. Facies occupies approximate center of the Big Dome Formation depositional basin

Tbl CONGLOMERATE (0–>460 m) – Facies dominated by subrounded pebble- to boulder-size clasts of Paleozoic limestone and variable, mostly minor, amounts of other pre-Miocene rocks. Matrix is light-gray, calcareous, and well-indurated sand- to granule-size material derived mostly from disintegration of Precambrian and Paleozoic sedimentary rocks

Tbv CONGLOMERATE (0–>400 m) – Facies dominated by angular to subangular pebble- to boulder-size clasts of Williamson Canyon Volcanics with locally abundant clasts of Cretaceous and Tertiary intrusive rocks. Clasts of Precambrian and Paleozoic sedimentary rocks are present but are subordinate in amount, especially close to bedrock outcrops. Clasts become smaller and less abundant relative to matrix southwestward from the bedrock contact. Matrix is greenish gray, sand size, and composed mainly of disintegrated volcanic and intrusive rocks. Induration is poor. Contains a few thin, highly altered white tuff beds that include clinoptilolite, a zeolite

Tblt LAPILLI TUFF (9 m) – Series of beds of thinly laminated to massive, white to tan, rhyolitic tuff, tuffaceous sandstone, and pumice lapilli tuff and interbedded sandstone and conglomerate lenses. Some shards and pumice lapilli are altered to clay minerals; glass in unaltered shards is rhyolitic (refractive index of 1.496). The lapilli are white (altered) or light gray (unaltered) and generally are 1–4 mm in diameter, although they are as much as 3 cm in diameter in middle bed where they are closely packed. Exposed in the SW¼ sec. 12, T. 4 S., R. 14 E.; widely exposed in adjacent Kearney quadrangle (Cornwall and Krieger, 1975a)

Tbq1 QUARTZ LATITE ASH-FLOW TUFF (6 m) – Nonwelded to partly welded ash-flow tuff; pinkish gray to pale red; basal 1 m is grayish white to grayish pink. Crops out in NW¼ sec. 1, T. 5 S., R. 14 E., and intersected in drill hole SE¼ sec. 12, T. 4 S., R. 14 E. (Neil Gambell, written commun., 1971). Phenocrysts and crystal fragments 0.5-1 mm in diameter are relatively abundant and, in order of decreasing relative abundance, they are sanidine, plagioclase ($An_{28}$), biotite, quartz, magnetite, hornblende, and sphene. Pumice lapilli, usually less than 5 mm long, are sparse. X-ray analysis of the groundmass in the upper pink part indicates only traces of cristobalite and sanidine, suggesting relatively little devitrification and alteration, whereas at least half of the glass in the lower white part and in 1-mm- to 1-cm-thick rinds surrounding lithophysae has been altered to clay minerals. Glass and much of the plagioclase in specimens from the drill hole have been altered to calcium-rich montmorillonite

SAN MANUEL FORMATION (0->600 m) – Alluvial and playa deposits with several facies (Krieger and others, 1974; Cornwall and Krieger, 1975a) and interbedded tuffs. Several K-Ar ages for samples in the upper part of the formation, 17 m.y. for biotite from one tuff, Cornwall and Krieger (1975a); 18 m.y. for biotite and 24 m.y. for sanidine from another (Krieger, 1974a) indicate a late Oligocene and early Miocene age for the formation. Overlain on an angular unconformity by the Big Dome Formation

Tsda DARK CONGLOMERATE (0->450 m) – Well-bedded and indurated conglomerate with subangular to subrounded pebble- to cobble-size (locally boulder) clasts of Williamson Canyon Volcanics, Late Cretaceous and Tertiary intrusive rocks, Precambrian sedimentary rocks and diabase, and, locally abundant, Paleozoic limestone; clasts of Ruin Granite are present but nowhere dominate. Matrix is calcareous, light olive gray to pale brown, and composed of silt- to granule-size material that varies in composition. Bedding ranges from about 1 cm to 2 m; a few thinner beds lack clasts. Channels with crossbedded sandstone are common

Tst RHYOLITE(?) TUFF (about 0.2 m) – White fine-grained tuff and medium- to coarse-grained tuffaceous sandstone and sandy tuff of probable rhyolitic composition; contains biotite, hornblende, plagioclase, sanidine(?), and quartz, with traces to 1 part in 10 of clay. Glass shards and matrix have been completely altered to clinoptilolite

LARAMIDE INTRUSIVE ROCKS – Laramide intrusive rocks in the area range in chemical composition from diorite to quartz monzonite. Because of their aphanitic to very fine grained groundmass they are termed herein andesite to quartz latite, but equally applicable terminology would be hornblende diorite porphyry, granodiorite porphyry, and quartz monzonite porphyry. The rock types and compositions were determined by counting from stained rock slabs and thin sections and by chemical analyses of petrologically identical rocks in adjacent quadrangles (Banks and others, 1972; Ransome, 1919). Potassium-argon and fission-track dating in the adjacent quadrangles (Banks and others, 1972; Banks and Stuckless, 1973; Damon and others, 1970; Creasey and Kistler, 1962; Damon and Bikerman, 1964) suggests ages of 63–60 m.y. for the Laramide rocks designated as Tertiary. All rock types are variable in composition and appearance, even along and across individual dikes, making classification of some of the dikes difficult. The dikes occupy fractures, faults, and, in places, fold hinges; some dikes terminate upward before traversing the entire geologic section, and some abut against other dikes without cutting them. In general, intrusion appears to have been passive; the exceptions are the intrusive breccia (Kb) in and adjoining sec. 31, T. 3 S., R. 15 E., parts of the contacts around the plug of Tr2, at Chilito, a breccia pipe (3–5 m across) just south of New Year mine (breccia also in drill core), and pebble dikes in the NW¼ sec. 7, T. 5 S., R. 16 E. Skarn occurs in limestone wallrock near some of the intrusive bodies, but it may locally also replace the igneous rock (endoskarn); it is better developed at sill bases than at sill tops. These observations and the variable, and in many places negligible, amount of skarn or calcium silicate metamorphism along the same dike suggest that the fluids involved did not directly evolve from the dikes or sills

Tha HORNBLENDE ANDESITE PORPHYRY – One dike exposed in two localities (northern parts of secs. 14 and 15, T. 4 S., R. 15 E.) oriented N. 80° W., cuts Tr2a. Phenocrysts make up about 43 percent of the rock as follows: subhedral to euhedral, lath and blocky plagioclase 1–3 mm long, with some plagioclase crystals totally altered to sericite (about 20 percent); euhedral 1–7 mm long laths of hornblende (about 20 percent), totally altered to chlorite, calcite, and hematite clots; subhedral magnetite, as much as 1/3 mm in diameter (about 2–3 percent). The hornblende occurs in pigeon-track-like arrangements. The aphanitic groundmass composes about 57 percent of the rock, is light brownish gray to greenish gray, and consists of 0.08 mm laths of highly altered plagioclase and opaque clots; sericite, calcite, clays, chlorite, and quartz are interstitial. The dike is foliated parallel to its margins

Tr3 RHYODACITE PORPHYRY – Four dikes (located in SW¼ sec. 6 and NE¼ sec. 7, T. 4 S., R. 15 E.; and northern and southern parts of sec. 12, T. 5 S., R. 14 E.) that are generally similar to Tr3 of Cornwall and others (1971). One dike (NE¼ sec. 7, T. 4 S., R. 15 E.) cuts Tr2a† dike; lacking crosscutting relations, the other three dikes might be equivalent to rhyodacite porphyry (TKr) of Cornwall and others (1971); all four dikes are cut by sulfide-lined fractures. Phenocrysts make up about 20 percent of the rock as follows: euhedral, blocky andesine ½–4 mm long with glomerocrysts to 7 mm in diameter (10–15 percent); euhedral blocky to acicular hornblende ½–3 mm in diameter (0–5 percent); subhedral and euhedral magnetite, as much as 1/3 mm in diameter (< 1 percent). Groundmass makes up about 80 percent of the rock, is gray to light tan, is aphanitic with trachytic to felty texture, and has an estimated composition relative to the whole rock of about 35–45 percent 0.5 mm-long andesine laths, 10–15 percent interstitial quartz, 30–35 percent interstitial clay minerals probably derived from K-feldspar. Accessory minerals are apatite and zircon. Plagioclase is largely altered to sericite, calcite, epidote, kaolinite, and montmorillonite; biotite and hornblende are totally converted to clay, sericite, and calcite.

Tql2 QUARTZ LATITE PORPHYRY – Four sets of en echelon dikes trending N. 50°-60° E.; one set exposed in sec. 17 and again in secs. 9 and 3, T. 4 S., R. 15 E.; one short set in the NW¼ sec. 20, T. 4 S., R. 15 E.; one set extending across the Dripping Spring Mountains parallel and 0.8 km north of Schneider Canyon; one set parallel and 0.8 km south of Schneider Canyon. The dikes usually are highly altered, forming crumbly outcrops and topographic depressions; disseminated and fracture-associated sulfides occur but are rare compared to older dikes. Best crosscutting relations with next older dike occur in centers of secs. 22 and 28, T. 4 S., R. 15 E.; dikes also crosscut TKrl and Tr2 rocks. Phenocrysts make up 45–55 percent of the rock as follows: euhedral to subhedral blocky andesine (some as stubby laths) ½–3 mm long with some glomerocrysts to 6 mm in diameter (25–40 percent); euhedral to resorbed and embayed quartz (2–8 percent); euhedral orthoclase, as much as 2 cm long (rare, to as much as 10 percent); euhedral biotite ½–2 mm in diameter (6–15 percent); euhedral to rounded magnetite up to 0.3 mm (< 1 percent); and laths and needles of euhedral hornblende (only in dike selvages). Groundmass composes 45–55 percent of the rock, is light to medium gray or brownish gray, is aphanitic with aplitic texture and grain size ranging from 0.03 to 0.06 mm in diameter, and has an approximate composition relative to the whole rock of about 10–12 percent plagioclase, 10–12 percent quartz, 25–30 percent orthoclase, and 2–4 percent biotite and opaques. Accessory minerals are apatite, allanite, and zircon. Plagioclase is partly to largely altered to sericite, montmorillonite, kaolinite, calcite, and K-feldspar; biotite is almost totally converted to chlorite, quartz, epidote, and titanium minerals; locally groundmass is totally converted to quartz-sericite. Includes some rhyodacite on basis of amount of K-feldspar phenocrysts present in some samples

Tql1 QUARTZ LATITE PORPHYRY – Spear-shaped (point to the southwest) dike swarm up to 2 km wide extending from west of the 79 mine, in the center of the quadrangle, to the east edge of the Dripping Spring Mountains; main dike orientations are N. 60° E., E-W±10°, and a few N. 30° E.; main orientation of the dike swarm changes from northeasterly to east-westerly in the approximate middle of the fault block between the Keystone and O'Carroll faults. Commonly cut by sulfide veinlets near major mining camps. Best exposed relations with next older rock (Tr2a) occur in the NE¼ sec. 15, T. 4 S., R. 15 E.; cuts rhyodacite porphyry (TKrl) at many localities. Phenocrysts compose 30–70 percent of the rock as follows: euhedral blocky oligoclase-andesine, ½–5 mm long, with some glomerocrysts to 12 mm (20–45 percent), euhedral to resorbed and embayed quartz dipyramids, ½–6 mm in diameter, with glomerocrysts to 10 mm in diameter (8–15 percent), euhedral orthoclase, 10–35 mm long (highly variable in amount across, along, and between dikes; relative to dikes 1–10 percent, relative to hand specimens 0–30 percent); euhedral biotite, ½–8 mm in diameter (5–15 percent); euhedral to resorbed magnetite (having sphene rims in some specimens) as much as 0.5 mm (usually less than 1 percent). Groundmass makes up 30–70 percent of the rock, is white to yellowish cream, is aphanitic with aplitic to felty texture and grain sizes of 0.02–0.03 mm, and has an approximate composition relative to the whole rock of 2–6 percent plagioclase, 8–20 percent quartz, 15–45 percent orthoclase, and 1–2 percent biotite and opaque minerals. Accessory minerals are apatite, zircon, and, locally, sphene. Plagioclase is moderately to highly altered to sericite, montmorillonite, kaolinite, calcite, K-feldspar, and epidote. Biotite is almost totally altered to chlorite, phengite, quartz, epidote, and titanium minerals. The orthoclase phenocrysts are intensely altered locally to kaolinite. This dike type is lithologically identical to and correlated with the Teapot Mountain Porphyry of Cornwall and others (1971) and Cornwall and Krieger (1975a). On the basis of geologic relations and fission-track and K–Ar dating of older and younger units (Banks and others, 1972; Banks and Stuckless, 1973), this rock type is probably younger than about 62 m.y. and older than about 60 m.y.

RHYODACITE PORPHYRIES – There are two main varieties of older rhyodacite porphyry. The first is a quartz-phenocryst-bearing variety that correlates with the rhyodacite porphyry in the Sonora quadrangle (unit TKr2) of Cornwall and others (1971) and the Kearny and Grayback quadrangles (unit Tr2) of Cornwall and Krieger (1975a, 1975b). The second is a quartz-phenocryst-poor or quartz-phenocryst-free variety (TKrl) that correlates with unit TKr1 of Cornwall and others (1971). In this report the first or quartz-bearing variety is further divided into four types (Tr2, Tr2a, Tr2b, and Tr2c), on the basis of restricted geographic occurrences of several petrologically distinguishable types. The differences between the four quartz-bearing rhyodacite porphyries include the number, size, and relative amounts of the main phenocryst minerals and the amount, color, grain size, and texture of the groundmass material

Crosscutting relations between the four quartz-bearing types are unknown because of their separate geographic locations, and most of the crosscutting relations indicated between the quartz-bearing type (Tr2) and the quartz-poor or quartz-free variety (TKr1) are questionable or interpretive because mutually similar facies (quartz-bearing TKr1, indicated by TKr1*), poor exposures, and moderate to intense alteration in areas of mineralization make identification of rock types and contacts difficult. Examples of questionable or interpretive crosscutting relations of TKr1 type by Tr2 type are north of Tornado Peak, in the New Year mine area, and in the area west of Christmas mine (unsurveyed sec. 30, T. 4 S., R. 16 E.). The southernmost Tr2 dike (flagged with a dagger – † –) crosscuts a sill of TKr1 type rock in sec. 26, T. 4 S., R. 15 E. The chilled selvages of this dike are thicker but otherwise similar to those of other Tr2 dikes, and the dike has comparatively fewer quartz phenocrysts, particularly in outcrops where the dike thins. Otherwise, it is petrologically similar to and is intruded parallel to the other Tr2 dikes

Some of the dikes of units Tr2a and Tr2b are also designated with a dagger (†), indicating lower than normal counts of quartz phenocrysts. Some of the Tr2a† dikes might be equally well classified as TKr1 dikes. Geologic relations between the various rhyodacite dikes and even the older hornblende andesite porphyry (Kha) dikes are not always clear cut because of mutually similar facies or alteration. Examples are found in the NE¼ sec. 12, T. 5 S., R. 15 E., where Tr2b cuts Tr2b†, and it is not certain whether the Tr2b† dike might not be a Kha dike. At another locality (sec. 7, T. 5 S., R. 16 E.), it is not certain that the Tr2b† dike cutting the hornblende andesite porphyry sill might not be a Tr2b dike in which quartz is present but was not observed. In addition, highly altered hornblende andesite porphyry is very similar to altered rhyodacite porphyry (unit TKr1), such as near New Year and Christmas mines

Tr2 RHYODACITE PORPHYRY – Four or more dikes composing a dike set located south of the Tql1 dike swarm and trending about N. 80° W. from the Christmas mine through the New Year mine area to the Chilito mine area; this rock makes up the Chilito intrusive and the Christmas intrusive; heavily mineralized by sulfides at the Christmas, New Year, and Chilito mines and also south of Schneider Canyon to the west of the Keystone fault. Like the Tql1 dike swarm, this dike set changes orientation in the approximate center of the fault block between the Keystone and O'Carroll faults. Phenocrysts make up 35–65 percent of the rock as follows: euhedral blocky andesine-labradorite, ¼–9 mm long with common glomerocrysts to 10 mm in diameter (20–50 percent; lower values in dike selvages): euhedral to embayed quartz dipyramids, ¼–9 mm in diameter (<1–15 percent; low values in Tr2†, and in dike selvages); euhedral to subhedral lathlike to acicular hornblende, ¼–4 mm long, sometimes glomerocrystic (5–20 percent; higher values in dike selvages); euhedral to subhedral biotite, ½–5 mm in diameter (<1–10 percent; lower values in dike selvages); euhedral to resorbed blocky magnetite, less than 1 mm in diameter (<1–2 percent); and a few large euhedral apatite grains. Groundmass makes up 35–65 percent of the rock; is light brownish or greenish gray or cream (chilled margins are medium gray to cream); is very fine grained to aphanitic with aplitic to hypidiomorphic texture and grain sizes of 0.01–0.04 mm; and has the approximate composition relative to the whole rock of 10–20 percent plagioclase, 15–20 percent K-feldspar, 10–15 percent quartz, and 1–10 percent mafic silicates and opaque minerals. Accessories are apatite, zircon, and rarely sphene and allanite. Plagioclase is variably altered to sericite, montmorillonite, K-feldspar, calcite, and epidote. Biotite usually is completely altered to chlorite, epidote, quartz, and titanium minerals. Near the Chilito deposit, the primary biotite and some of the groundmass is converted to intergrown aggregates of hydrothermal biotite and, locally, to phengite. Hornblende is usually less altered than primary biotite, being partially converted to epidote and carbonate, except near the Chilito deposit where it is converted to hydrothermal biotite. Magnetite usually is marginally oxidized to hematite. K-feldspar in the groundmass appears slightly altered, except in highly altered rock near the Chilito deposit where it is absent and possibly replaced by hydrothermal biotite. This rock has been dated in nearby quadrangles; the K–Ar method on biotite at 62 m.y. (Creasey and Kistler, 1962), 63.1 m.y. (Damon and others, 1970), and 62.1 m.y. (Banks and others, 1972). A representative chemical analysis of the rock is given in Ransome (p. 66, 1919)

Tr2a RHYODACITE PORPHYRY – One dike set trending about N. 80° E. across the Dripping Spring Mountain from just north of Steamboat Mountain and one 2.2-km-wide dike swarm located north of the Tql1 dike swarm and trending about N. 60°–65° E. in the fault block west of Keystone fault and about N. 60°–80° E. in the block east of Keystone fault. The dike type is locally cut by sulfide veinlets and is very similar to the Tr2 dike type but differs from it in having generally more abundant and smaller plagioclase phenocrysts. As exposed, these dikes do not crosscut older Laramide rocks, and their relations with Tql2 in sec. 17, T. 4 S., R. 15 E. are not exposed. Quartz-poor dikes are flagged with a dagger (†). Phenocrysts make up 45–70 percent of the rock as follows: euhedral blocky andesine, ¼–4 mm long with common glomerocrysts to 7 mm in diameter (35–55 percent); euhedral to embayed quartz dipyramids, ¼–5 mm in diameter (trace–15 percent); euhedral biotite, ¼–3 or 4 mm in diameter (2–15 percent); euhedral lathlike to acicular hornblende, ¼–3 mm (0–8 percent); euhedral magnetite, 0.1–0.2 mm in diameter (<1 percent); and a few large apatite grains. Groundmass makes up 30–55 percent of the rock; has various colors, such as very light tan to pale brown, pale yellowish white, pale yellowish green, pale to medium flesh, and light pinkish or greenish gray; is aphanitic to very fine grained with aplitic to felty texture and grain sizes of 0.01–0.03 mm; and has the approximate composition relative to the whole rock of 15–30 percent plagioclase (locally lathlike in dike selvages), 10–20 percent K-feldspar, 5–10 percent quartz, and variable, but small amounts of mafic and opaque minerals. Accessory minerals are apatite, zircon, and allanite. Plagioclase is moderately to heavily altered to sericite, montmorillonite, carbonate, and epidote. Biotite usually is completely altered to chlorite and titanium minerals. Hornblende usually is completely altered to carbonate, chlorite, iron oxides, and phengite. Magnetite is marginally altered to hematite, and K-feldspar is slightly altered to kaolinite

Tr2b RHYODACITE PORPHYRY – Dike swarm in southeast corner of quadrangle; dikes trend N. 50°–65° E., N. 30°–45° W., and N. 80° W.; dikes crosscut sills and dikes of hornblende andesite porphyry (unit Kha) at many localities, but as noted above, the rock is geographically juxtaposed with, and petrologically similar to, hornblende andesite porphyry. Quartz-poor varieties (flagged by †) are most similar to hornblende andesite porphyry. Dikes are cut by sulfide veinlets. Phenocrysts make up 30–60 percent of the rock as follows: euhedral to stubby laths of calcic andesine, ¼–5 mm long with abundant glomerocrysts to 8 mm in diameter (25–50 percent); rounded, embayed, and resorbed quartz dipyramids up to 6 mm in diameter (0–6 percent, usually only in center of dikes); euhedral acicular to stubby laths of hornblende, ¼–2 mm long (15–25 percent); euhedral biotite (0–2 percent; absent in many dikes and always absent in dike selvages); euhedral magnetite, up to 0.4 mm in diameter (<1–2 percent); and euhedral apatite up to 0.6 mm long (about 1 percent). Groundmass makes up 40–70 percent of the rock; has various colors, such as olive tan, dark to pale brown, with shades of pink to green, and pinkish medium to dark gray; is aphanitic but is more commonly fine grained with aplitic to hypidiomorphic granular textures (trachytic in dike selvages); has grain sizes of 0.03–0.06 mm; and has approximate composition relative to the whole rock of 15–25 percent plagioclase, 15–20 percent K-feldspar, 8–15 percent quartz, 4–7 percent mafic minerals, and 1–2 percent opaque minerals. Accessory minerals are apatite, zircon, and locally allanite. Plagioclase is slightly to heavily altered to sericite, carbonate, and montmorillonite. Hornblende is slightly to totally altered to carbonate, chlorite, iron oxides, and phengite. Biotite is heavily to totally altered to chlorite and titanium minerals. Magnetite is marginally altered to hematite

Tr2c RHYODACITE PORPHYRY – Several dikes trending N. 70°–80° E. occur in the northwest corner of the quadrangle north of the Tr2a dikes and one dike occurs in the southeast part of the quadrangle along the Gila River. Dikes are cut by sulfide veinlets and the dike along the Gila River cuts a hornblende andesite porphyry dike (Kha); relations with other Tertiary or Cretaceous igneous rocks are not exposed in the quadrangle. Phenocrysts make up 45–60 percent of the rock as follows: euhedral blocky andesine ¼–5 mm long, abundant glomerocrysts up to 10 mm in diameter (35–50 percent); euhedral to embayed quartz dipyramids, ½–6 mm in diameter (5–15 percent); stubby laths of euhedral hornblende, ¼–3 mm long (4–7 percent); euhedral biotite, ½–3 mm in diameter (3–15 percent); euhedral magnetite up to 0.3 mm in diameter (<1 percent); and a few euhedral apatite grains up to 0.4 mm long. Groundmass composes 50–65 percent of the rock, is light tan to light grayish brown or brownish gray, is aphanitic with aplitic texture and grain sizes of 0.01–0.02 mm, and has the approximate composition relative to the whole rock of 15–20 percent plagioclase, 15–20 percent K-feldspar, and 10–15 percent quartz. Accessory minerals are apatite and zircon. Plagioclase is heavily altered to carbonate, sericite, and montmorillonite. Hornblende is heavily altered to carbonate, chlorite, phengite, and iron oxides. Biotite is heavily altered to chlorite and titanium minerals

TKr1 RHYODACITE PORPHYRY – Sills and relatively few connecting and feeding dikes occurring in a 4-km-wide zone, trending N. 65°–70° E. in the center of the quadrangle; age relations with younger igneous rocks discussed above; relations with Cretaceous intrusive rocks not exposed in quadrangle; petrology and field relations allow correlation with the Rattler Granodiorite (of Late Cretaceous age) or with unit TKr1 of Cornwall and others (1971) which may be younger than the Rattler Granodiorite; cut by sulfide veinlets at many localities; sills most commonly occur 60–90 m above the base of the Escabrosa Limestone and at or near the contact between the Williamson Canyon Volcanics and Naco Limestone. Phenocrysts make up 45–55 percent of the rock as follows: euhedral blocky to stubby laths of andesine-labradorite ¼–7 mm long, abundant glomerocrysts as much as 12 mm in diameter (30–45 percent); rare embayed and rounded quartz dipyramids up to 1 mm in diameter (0–about 2 percent); euhedral to subhedral stubby laths of hornblende ¼–3 mm (rarely 7 mm) in length (6–22 percent); euhedral biotite ¼–3 mm in diameter (0–4 percent); euhedral magnetite up to 0.3 mm in diameter (1–2 percent); and sparse euhedral apatite up to 0.7 mm long. Groundmass makes up 45–55 percent of the rock; has various colors such as off white, pale greenish to grayish brown, and medium gray to olive medium gray; is aphanitic to fine grained, with aplitic texture and grain sizes of 0.02–0.05 mm; and has the approximate composition relative to the whole rock of 20–25 percent plagioclase, 20–35 percent K-feldspar, 10–12 percent quartz, 0–2 percent mafic minerals, and <1 percent magnetite. Accessory minerals are apatite, zircon, and, rarely, sphene. Plagioclase is moderately to heavily altered to sericite, kaolinite, carbonate, epidote, and montmorillonite; hornblende is moderately altered to carbonate, chlorite, and iron oxides; and biotite is heavily altered to chlorite, epidote, and titanium minerals

Kha HORNBLENDE ANDESITE PORPHYRY – Sills and feeder dikes in the south half of the Dripping Spring Mountains; the thickest sills occur in the Naco Limestone, here of Pennsylvanian age, and the dikes usually strike N. 55°–60° E. and N. 65° W.; cut by Tr2b and Tr2b† dikes and sulfide veinlets. Phenocrysts make up 20–55 percent of the rock (higher figure for dike and sill centers) as follows: subhedral stubby laths of labradorite ½–3 mm long, abundant glomerocrysts up to 4–5 mm in diameter (15–40 percent; more abundant toward centers of dikes and sills); rounded grains and aggregates of quartz that are in part vesicle fillings (0–2 percent); euhedral and glomerocrystic augite up to 1.5 cm long (0–20 percent, only at base of some sills); euhedral to subhedral needles and stubby laths of hornblende ½–4 mm long (locally, as much as 8 mm long, 10–20 percent; more abundant in center of dikes and sills); euhedral to glomerocrystic magnetite as much as 1 mm in diameter but usually less than 0.5 mm in diameter (1–2 percent); and euhedral apatite grains as much as 0.6 mm long (<1 percent). Groundmass makes up 45–80 percent of the rock; has various colors, such as dark to light gray, brownish light gray to light grayish brown; is fine grained to aphanitic with aplitic, hyalopilitic, and trachytic textures with grain sizes of the plagioclase laths ranging from 0.04 to 0.08 mm; and has variable composition. In dike and sill selvages, the groundmass has the approximate composition relative to the whole rock of about 15 percent plagioclase laths, 2–8 percent magnetite, and about 50 percent devitrified glass that stains with sodium cobaltinitrite solution. In thick dikes and away from selvages of thin dikes, the groundmass has the approximate composition relative to the whole rock of about 25 percent plagioclase laths, 5 percent hornblende laths, 2 percent magnetite, and 10–15 percent quartz, K-feldspar, and devitrified glass. Accessory minerals are apatite, and, rarely, allanite. Plagioclase is moderately to heavily altered to sericite, clinozoisite, epidote, carbonate, kaolinite, montmorillonite, and K-feldspar. Hornblende is slightly to totally altered to carbonate, chlorite, epidote or clinozoisite, and iron oxides. The interstitial glass is everywhere devitrified and in part chloritized. This rock is petrologically identical to, and is correlated with, hornblende andesite porphyry (Kha) in the Sonora and Crozier Peak quadrangles (Cornwall and others, 1971; Krieger, 1974a). Chemical analyses are presented by Banks and others (no. 1, Table 1, 1972) and Krieger (W-149, Table 2, 1974a). The reported hornblende K-Ar age of 128 m.y. (no. 1, Table 2; Banks and others, 1972) for this rock is, as suspected by Banks, Cornwall, Silberman, and Marvin of Banks and others (1972), anomalously old because the rock cuts the Upper Cretaceous Williamson Canyon Volcanics

Kb BASALT INTRUSIVE BRECCIA – A dike, sill, and a small, faulted, elongate plug in the center of the Dripping Spring Mountains at the north boundary of the quadrangle; offset of plug is apparently left lateral along the Cowboy fault. The plug is an intrusive breccia or breccia pipe with clasts ranging from crystal fragments to mappable blocks 30 m in diameter; the clasts include Devonian rocks derived from higher in the section than the present level of erosion. The dike, sill, and matrix of the plug are composed of grayish green to greenish purple devitrified glass (40–60 percent) and ¼–1 mm phenocrysts of anhedral to subhedral labradorite-bytownite laths (25–30 percent), anhedral augite (8–10 percent), and anhedral opaque minerals (4–5 percent). The rock and intrusive breccia are very similar to, and are tentatively correlated with, the Williamson Canyon Volcanics. Parts of the matrix of the plug are fine grained, and this variant is more properly called a pyroxene gabbro than a basalt. Apatite is the accessory mineral

Kw WILLIAMSON CANYON VOLCANICS – Medium- to dark-gray and greenish-gray flows, flow breccias, volcaniclastics, and minor tuffs. Flows, fragments, and matrix are porphyritic, feldspathic, hyalopilitic pyroxene basalt or, rarely, hornblende andesite. Phenocrysts compose 50–70 percent of the basalt as follows: euhedral stubby laths or blocky crystals of labradorite-bytownite, as much as 2 mm long (35–50 percent), either stubby subhedral laths of hornblende or, most commonly, subhedral to euhedral blocky augite, as much as 2 mm in maximum dimension (5–25 percent), euhedral to subhedral opaque minerals, as much as 1 mm in diameter (1–4 percent). The glass matrix is devitrified or heavily altered and locally is opaque from abundant disseminated opaque minerals. Plagioclase is moderately to heavily altered to sericite, kaolinite, calcite, and epidote; hornblende is commonly epidotized. Pyroxene is locally chloritized and uralitized. Quartz- and calcite-filled vesicles locally make up 10 percent of the rock. Locally the base of the formation is a sedimentary breccia or conglomerate, and at other localities it is coarse volcaniclastics. Thickness of the formation is 0 to at least 300 m; a 900-m section is reported by Willden (1964), a few miles east of the quadrangle. Age is uncertain but presumably Late Cretaceous; overlies Upper Cretaceous sedimentary rocks in the Christmas quadrangle (Willden, 1964); crosscutting intrusive rocks in the Crozier Peak and Winkelman quadrangles yield K–Ar ages that are Cretaceous but that are within analytical uncertainty of Paleocene age (Krieger, 1974a, b; Damon and others, 1964)

Mzb BASALT – Sills and a few dikes of dark-gray to olive-gray basalt in the Martin Formation and Escabrosa Limestone in sec. 36, T. 3 S., R. 14 E., on and near Steamboat Mountain, in the NE cor. sec. 12, T. 4 S., R. 14 E., and in N½ sec. 21, T. 4 S., R. 15 E. Subhedral ½ - 1 mm long laths of labradorite make up 55 - 60 percent of the rock; subhedral augite and minor pigeonite up to 2 mm in diameter make up 25 - 30 percent of the rock; euhedral to subhedral olivine as much as 2 mm in diameter makes up 10 - 15 percent of the rock. Subhedral to euhedral opaque minerals less than 1 mm in diameter make up about 5 percent of the rock, and biotite, mostly rimming the opaque minerals, locally composes 5 percent of the rock. Apatite is the accessory mineral. The plagioclase is partially sericitized and kaolinitized; the pyroxenes are slightly chloritized, and the olivine is variably altered to antigorite or talc, opaque minerals, and minor amounts of bowlingite and iddingsite. Limestone overlying the sills is commonly silicified and contains abundant hematite or goethite. On cursory examination this rock is similar to and was mistaken for Precambrian diabase in older publications on the area

IPn NACO LIMESTONE (180 to at least 260 m) – Higher figure is from drill hole information in the New Year mine area (J. T. Eastick, written commun., 1975) and from a composite section correlated with microfossil assemblages (A. K. Armstrong, written commun., 1975). Formation is characterized by fairly regularly spaced thin to medium (0.3–3.0 m) beds of resistant limestone and less resistant shale or shaly and silty limestone. The lithology of the basal unit varies in response to relief on the underlying Escabrosa Limestone. Most commonly, the basal unit (up to 3 m thick) is purple to reddish-purple shale with fragments or cobbles of black or red chert. Along the Gila River at the southern boundary of the quadrangle and south of Tornado Peak in Sec. 35, T. 4 S., R. 15 E., this basal unit is separated from the first white-weathering, fusilinid-bearing bed by 30 m of alternating 0.1- to 2-m-thick beds of purple shale and gray fine-grained dolomite. S. B. Keith (oral commun., 1975) reports upper Mississippian conodonts in these beds. At other localities, such as in the east center of sec. 16, T. 4 S., R. 15 E., less than 3 m of this dolomite and shale unit occurs, and in sec, 13, T. 4 S., R. 14 E., yellow dolomitic shale with reddish chert on bedding and fractures substitutes for the purple basal shale and the gray dolomite and shale unit. Above and including the first white-weathering, fusilinid-bearing, bioclastic limestone are about 70 m of 0.3–3.0 m beds of bioclastic to micritic to nodular, brown to flesh-colored (white-weathering) limestone (with variable, locally extremely abundant, amounts of red chert nodules, stringers, and layers) alternating with red to purple shale and siltstone. Intraformational disconformities and limestone and chert conglomerates are common in this interval, microfossils indicate that deposition occurred from Morrowan through Atokan time (A. K. Armstrong, written commun., 1973). Chert and shale in the upper 150 m of the formation tend to be black rather than red and purple, and the limestone tends to weather more to gray rather than white; the shale is less abundant than in the lower 110 m. Otherwise, similar to the rest of the formation, the limestone in upper 150 m is bioclastic, micritic, and nodular, is brown to gray, and contains intraformational breccias and a large variety of well-preserved silicified macrofossils, the microfossil assemblage indicates deposition in Desmoinesian and perhaps younger Pennsylvanian time (A. K. Armstrong, written commun., 1975). Peterson and Swanson (1956) report fusilinids in the uppermost beds, near the Christmas mine where the section is about 300 m thick, are characteristic of uppermost Pennsylvanian or lowermost Permian, but farther east, in the Mescal Mountains, Willden (1964) reports Pennsylvanian fusilinids occur to at least 450 m above the base of the formation

Me ESCABROSA LIMESTONE (120 m in northwestern part of quadrangle, 160–170 m on and south of Tornado Peak)–Lowermost 5 m of limestone or dolomite, locally with basal 5–10 cm of sandstone, is yellowish and contains silt and clay reworked from disconformably underlying Percha Shale. Overlying 65 m consists of medium- to dark-gray, laminated, thick-splitting, fossiliferous, micritic limestone, locally partly to completely converted to saccharoidal dolomite; chert nodules occur in this unit but are not abundant except for 3 m about 45 m above the base; uppermost 1 m is locally sandy or contains a quartzite. The overlying unit is 30 m of laminated, thick-splitting bioclastic (encrinite) limestone, which forms a distinct white marker unit. The uppermost beds (remaining 20–70 m of the formation) form two to three massive splitting units of thin-bedded to laminated micritic to bioclastic, gray and brown fossiliferous limestone that is locally progressively dolomitized upward; chert occurs throughout, but chert-rich units occur 20–35 m and 45 m above the white marker unit. The contact with the Naco Limestone has considerable relief (50 m) throughout the quadrangle (local relief of 1–3 m), and the uppermost beds are locally silicified 1–2 m down from the contact. Fossils include crinoids, brachiopods, corals, and ostracods. The fossil assemblage indicates that most of the formation was deposited in Osagean time, but the upper 40 m may have been deposited in Meramecian time (A. K. Armstrong, written commun., 1973).

Dpm PERCHA SHALE AND MARTIN FORMATION (60–115 m)—Thicknesses of the formations and the lithology of individual mappable units in each formation vary, presumably in response to relief on the erosional surface on which the Martin Formation was deposited and subsequent erosion of the Percha Shale. Percha Shale is everywhere present but was not mapped separately. In the NE¼ sec. 23, T. 4 S., R. 15 E., where the Martin Formation lies on Abrigo Formation, local relief on the pre-Martin surface is very small and the basal unit is sparsely sandy dolomite (<1 m thick), whereas in the NW¼ sec. 2, T. 5 S., R. 15 E., a basal sandstone channels 3–12 m into the underlying Abrigo Formation, and the SE¼ sec. 12, T. 4 S., R. 14 E., it channels the Abrigo Formation as much as 6 m. In sec. 1, T. 4 S., R. 14 E., the Martin Formation locally rests on Troy Quartzite. A 100-m-thick measured section of the two Devonian formations in the SW¼ sec. 6, T. 4 S., R. 15 E., is as follows: (a) Martin Formation; basal 4 m of tan to light-brown medium-grained dolomitic quartzite with bedding of 2–10 mm and vague crossbedding; overlain by 3.3 m of light-tan sandy dolomite with poorly sorted sand grains and rounded quartzite pebbles as much as 1.5 cm in diameter, grades less sandy upward; overlain by 6.7 m of dark- and light-gray laminated (2–20 mm) dolomite, splitting 2–4 cm, with stromatolitic and slump contortions of laminae and several 1–2 cm horizons of nodular and layer black chert, locally known as the O'Carroll bed; overlain by 47 m of alternating yellow-gray and medium-gray, fine-grained dolomite units, 2 cm-1 m thick; overlain by a 1.5-m-thick, red-brown to buff, fine-grained dolomitic quartzite with fucoid-like molds; overlain by a distinctive cliff-forming, 4.5-m-thick, fossiliferous, bioclastic, fine-grained, laminated, gray to medium-olive-gray-limestone with wavy clay partings that weather grayish orange (fossils including *Cyrtospirifer, Stropheodonta, Atrypa,* small spiriferoids, crinoid stems, and bryozoa occur primarily in this and the overlying units); (b) Percha Shale, divided into a basal 18 m of thin-bedded orange-yellow, marly dolomite that weathers to rounded pebble- and cobble-sized blocks and an overlying 15 m of olive to yellow-olive fissile shale. In the NE¼ sec. 8, T. 4 S., R. 15 E., the total thickness of the two formations is about 60 m and the basal sandy units, and the distinctive limestone unit of the Martin Formation are very thin. In the NW¼ sec. 2, T. 5 S., R. 15 E., a basal 3- to 12-m-thick sandstone of the Martin Formation is overlain by a 7-m-thick yellow-gray dolomite; the distinctive limestone unit is missing, and the quartzite that elsewhere underlies the limestone is thickened to a 6-m unit of sandy dolomite and interbedded quartzite which is directly overlain by 25 m of Percha Shale. The formations are locally intruded by one or more <1 m thick sills of andesite or basalt (unmapped).

Ꞓa ABRIGO FORMATION (0–60m)—Like the Martin Formation, the thickness and lithology of this formation varies from locality to locality in the quadrangle. It is absent locally in sec. 1, T. 4 S., R. 14 E., is thickest on the north slope of Tornado Peak, and is most clastic in the NW¼ sec. 2, T. 5 S., R. 15 E., where it consists wholly of thin-bedded brown quartzite. In sec. 12, T. 4 S., R. 14 E., in a 26-m-thick measured section, the formation may be divided into a basal 15 m of paper-thin yellow-brown siltstone, interbedded with 6- to 10-mm-thick dark-reddish-brown arkosic quartzite lenses and beds, and an upper 11 m of 6- to 20-mm-thick beds of brown arenaceous to argillaceous dolomite with phosphatic brachiopod fragments, and interbedded paper-thin yellow-brown siltstone and rare quartzite beds that are similar to those of the lower unit. In the NW¼ sec. 7, T. 4 S., R. 15 E., the section is similar, but the lower unit contains an additional 12 m of coarse hematitic dirty sandstone, and in the north-central part of sec. 12, T. 4 S., R. 14 E., a 1- to 3-m-thick chocolate-brown sandy dolomite occurs in the approximate middle of the formation. In the east-central edge of sec. 20, T. 4 S., R. 15 E., the formation consists of a basal 30 m of thin-bedded, brownish, dirty sandstone and quartzite, and an upper 25 m of yellow-brown mudstone. Many of the siltstone and mudstone beds have fucoids and other evidence of biogenic reworking of the beds. Unmapped basalt and andesite sills (<1 m thick) locally intrude the formation

Ꞓb BOLSA QUARTZITE (0–55 m)—Variable thickness and locally absent throughout the quadrangle. In a 15-m-thick measured section in the SW cor. sec. 6, T. 4 S., R. 15 E., the formation may be divided into two units: a basal 7.5 m of 0.2- to 1-mm-bedded, massive-splitting, white to light-tan quartzite with abundant liesegang banding in the basal 3 m and abundant *Scolithus* at the top; and an upper 7.5-m unit very similar to the lower unit except for the presence of low-angle crossbedding recurring on about 3-cm intervals. In the SE¼ sec. 17, T. 4 S., R. 15 E., the formation is an estimated 50 m thick, channels the underlying Troy Quartzite, and consists in ascending order of 3 m of drab, red pebble-conglomerate with a coarse sand matrix, followed by 15 m of medium-grained white quartzite with maroon spots up to 8 mm in diameter, and then 11 m of lavender, medium-grained, laminated to crossbedded quartzite, and finally 25 m of thin-bedded, white to buff, medium-grained quartzitic sandstone

Ydb DIABASE—Dikes and sills, <1 m to 180 m thick where exposed (composite of all the sills in drill core near Chilito mine is 410 m (D. S. Fountain, oral commun., 1970); intrudes all other Precambrian rocks, but in particular the Mescal Limestone and Dripping Spring Quartzite. Fresh diabase is dark- to very-dark gray, holocrystalline, fine- to coarse-grained, with diabasic to ophitic texture, and composed of plagioclase $An_{35-70}$), faintly brownish augite (up to 2 cm in diameter) that is sometimes rimmed or substituted by a blue-green hornblende, olivine, and opaque minerals such as magnetite and ilmenite, and lesser amounts of pyrite, chalcopyrite, pyrrhotite, and rarely marcasite. Apatite is locally abundant and red-brown biotite or sphene are local accessory minerals. Some specimens have interstitial micrographic quartz and K-feldspar. Associated pegmatitic schlieren and irregular masses cut some of the sills. Chemical analyses of samples collected near the quadrangle are reported by Ransome (1919, p. 54) and Krieger (1974a, b); radiometric dating of samples from other localities suggests a general 1.15 billion year age for the diabase (Silver, 1963; Damon and others, 1962). The rock weathers to a greenish to olive-gray, granular material with pea- to boulder-sized masses of resistant rock with nodular surfaces. Metamorphism of the surrounding host rocks is most obvious in the Mescal Limestone where tremolite, forsterite, talc, and diopside occur; the Pioneer Formation becomes hornfelsed near the sills. The plagioclase is commonly sericiticized or kaolinitized and locally contains carbonate, epidote, and clinozoisite; ferromagnesium minerals alter to serpentine, talc, chlorite, bowlingite, iddingsite, opaque minerals, and fibrous to massive or aggregate greenish hornblende; at the Chilito mine area, hydrothermal biotite replaces the primary ferromagnesiam minerals

Yt TROY QUARTZITE (0–300 m)—Formation is thickest in the northwest part of quadrangle; thins southward, both by depositional thinning of the lowermost units and by erosion of the upper units prior to Cambrian time; locally absent beneath Cambrian in NE¼ sec. 22, T. 4 S., R. 15 E. In the NW¼ sec. 8, T. 4 S., R. 15 E., the formation is 220 m thick, is typical of exposures throughout the quadrangle, and in ascending order consists of 10 m of cliff-forming poorly sorted cobble to pebble conglomerate with subrounded to subangular clasts of basalt, quartzite, red jasper, black chert, and white chert in a dark-purple to dusky-maroon quartzite matrix (½–2 mm grain size); disconformably overlain by 5.5 m of slope-forming, light-rose to tan, 2–4 cm alternating beds of coarse-grained quartzite and pebble conglomerate (splitting ½–1 m); 12 m of cliff-forming interbedded (0.15–1 m) yellowish-white poorly sorted pebble-bearing convoluted sandstone, and yellow to rose-gray poorly sorted coarse-grained quartzite with locally abundant pebbles; 22 m of slope-forming 0.3–1.3 m beds of reddish pebbly quartzite and pebble conglomerate, upper 10 m with better rounding of pebbles and more yellow and buff colors; 1 m of coarse pebble to cobble conglomerate; 25 m of ledge-forming interbedded (5–20 cm) greenish to yellowish-white medium-grained quartzite and light-yellowish buff poorly sorted coarse quartzite with locally abundant pebbles, paper-thin shale on bedding surfaces and convolution in many beds; 7 m of cliff-forming 1–3 cm beds (3 m splitting) of granule to fine-grained gray-white crossbedded (low angle) quartzite with a basal 1/3 m cobble conglomerate (sparse 1- to 2 cm clasts of white quartz); 20 m of ledge-forming, thin- to medium-bedded (1–8 cm), coarse-grained white convoluted quartzite; 2.5 m cliff of lavender, crossbedded (low angle), fine-grained to granule quartzite with an upper conglomerate; 61 m of slope-forming, interbedded (4 cm–3 m), white, fine- to medium-grained, convoluted quartzite and reddish-brown, medium-grained to granule, crossbedded (low angle) quartzite, a distinctive, red gritty sandstone to pebble conglomerate occurs 40 m above the base; 12 m of slope-forming, yellowish, pebbly, medium-grained quartzite beds (6–12 cm thick); and 42 m of clean white crossbedded (low angle) fine-grained quartzite with some pebbles and granules

APACHE GROUP

Yb BASALT (0–12 m)—One or more flows of porphyritic basalt, dusky-dark-brown to reddish-black, abundant flattened vesicles filled with sericite, calcite, or epidote. Sodic labradorite phenocrysts, 2–8 mm long, are set in very fine grained, highly altered groundmass of labradorite laths and interstitial pyroxene, olivine, and opaque minerals

Ym MESCAL LIMESTONE (25–60 m)—Variations in thickness, caused by erosion after deposition of the basalt but prior to deposition of Troy Quartzite; upper beds are locally silicified and have solution collapse breccias formed during this weathering. Formation consists of light- to pinkish-brown and grayish-white, laminated to thin-bedded, partly calcareous, sublithographic to fine-grained and locally coarse-grained dolomite. Generally black chert forms 5- to 20-mm-thick layers and lenses, locally in great abundance, throughout the formation. Algal stromatolitic structures occur only in the uppermost parts of the thicker sections

Ybm BASALT AND UNDERLYING MESCAL LIMESTONE

Ymd MESCAL LIMESTONE AND DIABASE SILLS

Yds DRIPPING SPRING QUARTZITE (about 220 m, from composite in drill hole near Chilito mine, corrected for dip)—The formation is everywhere too intensely faulted and intruded by diabase to provide a satisfactory locality for a continuous measured section, but one or more of four units comprising the formation (described below in descending order) were recognized in individual fault blocks:

Siltstone unit (about 120 m)—Siltstone and fine- to very-fine-grained sandstone and quartzite, feldspathic to arkosic, thin-bedded to laminated, locally with thin cross-laminated sets; thin-splitting, ledge- or slope-forming; light- to dark-gray, olive-green, dusky-brown, yellowish-brown, and grayish-red colors, often in irregular patterns associated with joints; subrounded feldspar and quartz with mafic or clay minerals in siliceous cement, locally abundant pyrite; more quartzitic upward; grades into underlying shale unit

Shale unit (as much as 30 m)—Thin to medium interbeds of gray to buff, medium- to fine-grained quartzite and red to dark-purplish micaceous shale; slope-forming; common ripple marks and mudcracks; grades into underlying arkose unit

Arkose unit (about 55 m)—Arkosic to feldspathic quartzite; thin-bedded to laminated with local low-angle thin- to medium-sets of cross laminae, cliff- or ledge-forming; thick- to massive-splitting; medium- to fine-grained; light-buff, off-white to grayish-pale colors; grades into underlying Barnes Conglomerate Member

Barnes Conglomerate Member (variable thickness, 1–15 m)—Pebble and cobble conglomerate; well-rounded, ellipsoidal, closely to loosely packed clasts of white, gray, and black quartzite, schist, quartz, and red jasper; light-gray to brown feldspathic medium- to coarse-grained matrix; medium- to thick-bedding and splitting, forms cliff or ledges

Yp PIONEER FORMATION (30–55 m)—Formation consists of the basal Scanlan Conglomerate Member, overlain by a tuffaceous siltstone and interbedded arkosic sandstone unit

Tuffaceous siltstone and arkosic sandstone unit (30–50 m)—Tuffaceous siltstone and very fine grained sandstone; laminated with local thin sets of cross laminae, slope-forming, dark- to orange-red to dark-purple; ovoid to round grayish-green and white spots common; subrounded K-feldspar, quartz, plagioclase, and dark minerals with hematitic devitrified glass shards. Interbedded 1-cm- to 1-m-thick sandstone is tuffaceous, reddish gray to buff, arkosic to feldspathic, and locally cross laminated

Scanlan Conglomerate Member (0.1–3 m)—Conglomerate, well-rounded, ellipsoidal, large pebbles and cobbles of white to gray quartz, schist, and jasper with subangular to angular smaller pebbles and granules of quartz, schist, and mineral fragments in medium- to very-coarse-grained, arkosic quartzite or sandstone matrix; locally only the matrix material and crystal fragments from underlying Ruin Granite make up the member

Yr RUIN GRANITE—Very coarse and coarse-grained (southwest of Gila River) to coarse- and medium-grained (in Dripping Spring Mountains), porphyritic to seriate porphyritic quartz monzonite. Pink, poikilitic orthoclase and perthitic microcline are largest (1–2 cm) of the constituent minerals (25–35 percent); oligoclase-andesine is as much as 1.5 cm across (30–45 percent); quartz is less than 1 cm in diameter (25–35 percent). Biotite and magnetite (3–8 percent) are the dark minerals; and sphene, apatite, and zircon are accessory minerals. Plagioclase is always partially altered to sericite; biotite is partly chloritized

Xp PINAL SCHIST—Not exposed but reported as a 150-m-thick slab penetrated by two drill holes in the Chilito mine area (D. S. Fountain, oral commun., 1970; Neil Gambell, written commun., 1975) as shown in cross section D–D′ only

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