Geologic map and digital database of the San Bernardino Wash 7.5 minute quadrangle, Riverside County, California

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For database limitations, see following page

DATABASE LIMITATIONS

Content

This database is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards or with the North American Stratigraphic Code. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

This database, identified as "Geologic map and digital database of the San Bernardino Wash 7.5 minute quadrangle, Riverside County, California," has been approved for release and publication by the Director of the U.S. Geological Survey. Although this database has been subjected to rigorous review and is substantially complete, the USGS reserves the right to revise the data pursuant to further analysis and review. Furthermore, it is released on the condition that neither the USGS nor the United States Government may be held responsible for any damages resulting from its authorized or unauthorized use.

Spatial Resolution

Use of this digital geologic map should not violate the spatial resolution of the data. The San Bernardino Wash database was developed using digital orthophotograph quarter quadrangles (DOQQs) as a base. DOQQs have a pixel resolution of 1 m and are accurate to a scale of 1:12,000 (1 in = 1,000 ft). Any enlargement beyond 1:12,000 exceeds the spatial resolution of the geologic data and should not be used in lieu of a more detailed site-specific geologic evaluation. Similarly, the digital topographic base map is derived from the U.S. Geological Survey, 1:24,000-scale San Bernardino Wash 7.5 minute quadrangle (provisional edition, 1986); any enlargement beyond 1:24,000 exceeds the spatial resolution of the topographic data. Where the geologic data is used in combination with the topographic data, the resolution of the combined output is limited by the lower resolution of the topographic data. Where this database is used in combination with other data of higher resolution, the resolution of the combined output will be limited by the lower resolution of these data.

INTRODUCTION

The geologic map and digital database of the San Bernardino Wash quadrangle are products of a regional geologic mapping effort undertaken in the eastern Transverse Ranges in and around Joshua Tree National Park. This investigation, part of the Southern California Areal Mapping Project (SCAMP), is conducted in cooperation with the California Geologic Survey and the National Park Service. In line with the goals of the National Cooperative Geologic Mapping Program (NCGMP), mapping of the San Bernardino Wash and other quadrangles has been directed toward generating a multipurpose digital geologic map database that is applicable to land-related investigations in the earth and biological sciences. This mapping is conducted to further understanding of bedrock geology and surficial processes in the region and to document evidence for seismotectonic activity in the eastern Transverse Ranges. It is also intended to serve as a base layer suitable for ecosystem and mineral resource assessment and for building a hydrogeologic framework for Pinto Basin.

Initial investigations span Pinto Basin from the Hexie and Eagle Mountains northward into the Pinto Mountains (fig. 1). Quadrangles mapped include the Conejo Well 7.5-minute quadrangle (Powell, 2001a), the Porcupine Wash 7.5-minute quadrangle (Powell, 2001b), the Pinto Mountain 7.5-minute quadrangle (Powell, 2002), and the San Bernardino Wash 7.5-minute quadrangle. Parts of the San Bernardino Wash quadrangle had been mapped previously at a variety of scales (Weir, and Bader, 1963; Hope, 1966, 1969; Jennings, 1967; Powell, 1981, 1993).

Approach to assembling the database

The geologic map and digital database of the San Bernardino Wash quadrangle stores geologic information about the quadrangle in four distinct digital products: (1) an ArcInfo geospatial database, (2) a PostScript (.ps) plot-file of a geologic map, (3) a Portable Document Format (pdf) file of the geologic map, and (4) this summary pamphlet. Each of these products serves different purposes and each contains data not found in the other three. The PostScript (.ps) plot-file and Portable Document Format (pdf) file display a conventional, full-color geologic map on a 1:24,000-scale topographic base. A paper map can be plotted using either of these files. The map is accompanied by a marginal explanation that includes a Description of Map Units (DMU), a Correlation of Map Units (CMU), and a detailed index map. In addition, the pdf file enables a digital map display that provides a full-resolution, navigable image for viewing on-screen. The geospatial database stores the data necessary to generate the geologic map represented in the plot- and pdf files, but not the map-margin explanation, which is imported from a graphics application. The geospatial database can be displayed, queried, and analyzed in GIS applications such as ArcInfo, ArcMap, and ArcView.

The geospatial database is designed not only to generate the geologic map contained in the plot file, but also to facilitate representation of geologic data not readily shown on a single, conventional, hand-drafted geologic map. This versatility is achieved by implementing various GIS capabilities. Instead of using only polygons and arcs to attribute areal and linear geologic features, the database also utilizes groups of polygons (*regions* in ArcInfo) to represent rock units and landforms and utilizes groups of arcs (*routes* in ArcInfo) to represent faults. Regions and routes are stored as subclasses of the polygon and arc feature classes, respectively. Each region or route subclass has its own feature attribute table that is independent from the polygon or arc attribute table and from the attribute tables of other regions or routes in the same coverage. Regions and routes allow the database to store and display more than one representation of the geology of the quadrangle. In addition, the descriptive and classification attributes (lithology, composition, texture, age, etc.) that define a map feature are identified in relational tables. These tables can be searched to identify and display geospatial features by shared attributes.

Regions are used in three ways in the San Bernardino Wash database. (1) First-order rock units are stored in the rockunit region subclass by grouping related polygons to associate sets of non-contiguous polygons that make up a single rock unit. The units stored in this region subclass are the ones shown on the plot-file map. (2) Higher-order rock units comprising an array of stratigraphic parents to the rock units shown on the plot-file map are grouped by architectural level (crystalline basement, cover, surficial) and stored in additional region subclasses. These subclasses allow the database user to display the geology at his or her desired level of generalization. The array of rock units and their

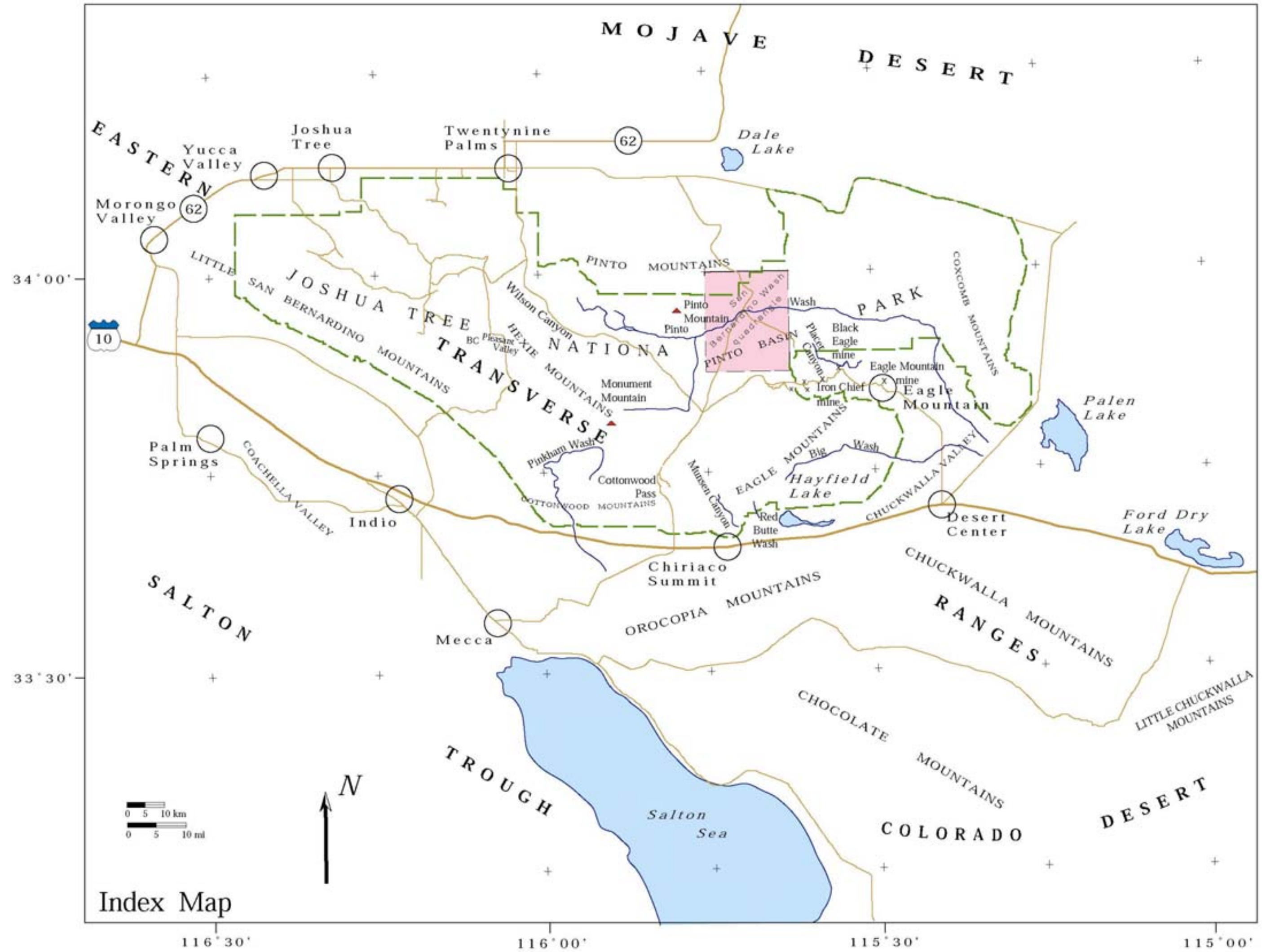


Figure 1.—Index map showing location of San Bernardino Wash 7.5-minute quadrangle. BC, Blue Cut

stratigraphic parents that are incorporated in version 1.0 of the San Bernardino Wash database are shown in Figures 2 to 5 and are described in the Appendix. (3) Region subclasses are utilized to represent surficial units or areal geomorphic features that overlap other rock units. These subclasses permit the user to represent units that are concealed beneath other units, units that form surface veneers on other units, and landforms superimposed on lithologic units. Using the various region subclasses that are built into the database, the user can display (in ArcView or ArcMap) different arrays of units and emphasize other aspects of the geology of the quadrangle than those displayed and emphasized in the plot-file map.

Routes are used to group and further define fault arcs. Information about faults is entered into the database in two route subclasses: fault segments and faults. The segments route subclass characterizes fault segments (groups of arcs) that have geological significance. It is used, for example, to distinguish segments of a fault that break alluvium or that are brecciated or that have differing separations, such as the bounding segments of a fault horse. The fault route subclass is used to attribute entire faults or groups of faults. In version 1.0 of the San Bernardino Wash database, fault routes are used to distinguish groups of faults by orientation and by named fault zone or fault system. For example, northwest-trending faults are distinguished from east-west trending faults. Similarly, the various groups of fault arcs that constitute named faults zones (Eagle Mountain and East Pinto Basin faults) in the left-lateral Pleasant Valley-Pinto Basin fault system are distinguished from one another.

Geologic setting

The San Bernardino Wash 7.5-minute quadrangle is located in the Transverse Ranges physioghraphic and structural province east of the San Andreas fault (fig. 1). The quadrangle straddles the central part of Pinto Basin between the Eagle Mountains to the south and the Pinto Mountains to the north.

Crystalline basement rocks in these mountain ranges include parts both of regionally defined assemblages of metamorphosed Proterozoic rocks and of belts of Mesozoic batholithic rocks. The Pinto Gneiss of Miller (1938) occurs west and southwest of the quadrangle in the Hexie and Pinto Mountains. Ortho- and paragneissic subdivisions of this unit are distinguished in the database and on the plot-file geologic map. The quartzite of Pinto Mountain underlies parts of the northwestern Eagle Mountains and south-central Pinto Mountains in the quadrangle. In the Pinto Mountain massif west of the quadrangle, the quartzite unconformably overlies the porphyritic granite and granite gneiss of Joshua Tree. Prior to deposition of the quartzite, a Proterozoic weathering regolith formed atop the granite; subsequent to deposition, the quartzite, regolith, and granite were metamorphosed and deformed. Mesozoic rocks in the San Bernardino Wash quadrangle consist of Jurassic plutonic rocks including a mafic and mafic intermediate suite of gabbroic and dioritic rocks and parts of a very large batholith of porphyritic granitoid rocks spanning a compositional range that includes quartz monzodiorite, quartz monzonite, granodiorite, and monzogranite. Regionally, these basement assemblages have proven to be important in demonstrating overall displacement on the sinistral faults of the eastern Transverse Ranges and on the dextral faults of the San Andreas system (Hope, 1966, 1969; Powell, 1981, 1982, 1993; Powell and Weldon, 1992).

During the Miocene, a widespread regional erosion surface developed on the bedrock of the Mojave Desert and eastern Transverse Ranges. As the crust was flexed and faulted during the evolution of the eastern Transverse Ranges, the Miocene erosion surface was deformed. Where upwarped, the surface has undergone erosion in the highlands that surround the basins and played a role in the development of Quaternary pediments. Late(?) and middle Miocene, reddish, arkosic sedimentary deposits that crop out beneath Miocene basalt probably represents detritus derived from stripping of a Miocene weathering regolith. The unit is deposited on weathered granitic rock and, as mapped, may include weathering regolith. Basalt flows in the region commonly overlap reddish, arkosic sedimentary strata and saprolitic granitic basement rock.

In the center of Pinto Basin, surficial deposits are underlain by the tilted and folded sedimentary strata. These strata, which crop out west of the quadrangle, include clay, siltstone, sandstone, and rare freshwater limestone that are interpreted as lacustrine and are probably Pliocene in age. Fluvial boulder conglomerate debris flow deposits that overlie the lake beds may be Pliocene or Pleistocene in age.

The east-trending structural and geomorphic grain of the province is controlled by a family of throughgoing left-oblique transcurrent fault systems. Pinto Basin has evolved in conjunction with uplift of the Eagle, Pinto, and Hexie Mountains and with displacement on the left-oblique fault systems. The basin developed as a segmented basin along one of these, the Pleasant Valley-Pinto Basin fault system, which consists of a left-stepping sequence of fault zones, including the Blue Cut, Hexie Mountains, Eagle Mountains, and East Pinto Basin faults. Climatic fluctuations and tectonism have led to an evolving landscape and have generated a wide variety of Quaternary surficial deposits associated with various landforms in and around Pinto Basin.

Geomorphically, the Pinto Basin is a broad intermontane valley having a central wash bounded by alluvial fans emanating from the flanking bedrock mountain ranges. The basin is flanked by steep fault-controlled escarpments along the Pinto Mountains to the north and the Hexie and Eagle Mountains to the south. Alluvial fans along these escarpments form prominent bajadas. The southwestern quarter of the quadrangle is underlain by the distal part of an extensive pediment surface beveled across tilted Pliocene and early Pleistocene sedimentary strata onto underlying Cretaceous granitoids that crop out south of the quadrangle. Intervening between the major fans that have debouched onto the pediment from large canyons are broad piedmont slopes where the pediment is mantled by slopewash, sheet wash, and small alluvial-fan deposits.

CRYSTALLINE BASEMENT ROCKS

PROTEROZOIC ROCKS

Proterozoic rocks in the San Bernardino Wash quadrangle constitute part of a cratonic inlier caught up in the Mesozoic magmatic arc of southern California. Regionally, the rocks in this inlier include Early and Middle Proterozoic plutonic and metamorphic rocks that are grouped into three assemblages based on stratigraphic and structural relations (Powell, 1981, 1993). These assemblages are widespread in the Transverse Ranges province and vicinity. Proterozoic rocks exposed in the San Bernardino Wash quadrangle, comprise parts of one of these assemblages.

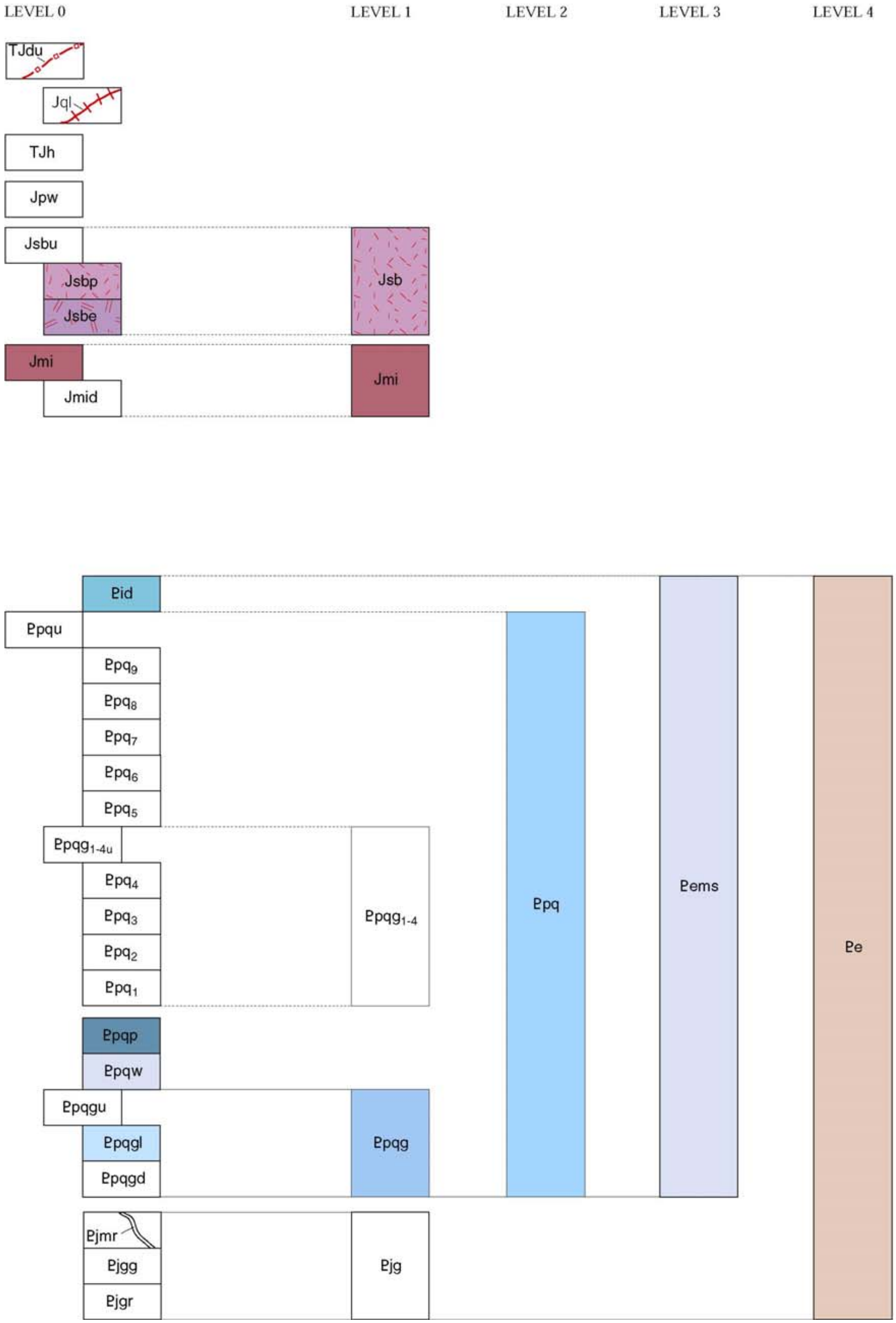
Eagle Mountains assemblage

In the San Bernardino Wash quadrangle, the Eagle Mountains assemblage (Ꝑe) crops out in the northwestern Eagle Mountains and in the southern Pinto Mountains. These exposures lie near the northern end of a belt that extends south-southeast from the Pinto Mountains through the Eagle and Chuckwalla Mountains (fig. 1). This assemblage of crystalline basement units is named for extensive exposures in the Eagle Mountains, and consists of two groupings of rock units. Units of the older grouping evolved from the weathering, metamorphism, and penetrative deformation of a batholith of porphyritic granite. Units of the younger grouping constitute a metamorphosed sedimentary section that was deposited on the granite. The assemblage developed in the Early and Middle(?) Proterozoic as the porphyritic granite was exhumed, weathered, and nonconformably overlain by a platform sequence of quartz sandstone, shale, and dolomite. Subsequently, the infracrustal granite basement and its supracrustal sedimentary cover both were overprinted by a regional metamorphic event that ranged from thermal in the north-central Pinto Mountains to dynamothermal in the south-central Pinto, Eagle, and Chuckwalla Mountains. These rocks were metamorphosed along an andalusite-sillimanite P-T trajectory, reaching peak conditions of about P = 4 kbar and T = 600°C (Powell, 1981, 1982, 1993). In the San Bernardino Wash quadrangle, exposures of the Eagle Mountains assemblage are restricted to the metamorphosed platform sequence.

Metasedimentary rocks of the Eagle Mountains assemblage

The metasedimentary rocks of the Eagle Mountains assemblage (Ꝑems) are well exposed in a belt that extends from Pinto Mountain and vicinity in the central Pinto Mountains southeastward through the northeastern Eagle Mountains. Parts of this belt occur in the San Bernardino Wash quadrangle. In order of decreasing abundance, the metamorphosed strata include quartzite, pelitic schist and granofels, dolomite marble, and limestone marble. These rocks were metamorphosed from a platform section of sandstone, shale, and subordinate carbonate rocks. Identical strata crop out in the northeasternmost Mojave Desert about 15 km north of Baker, providing a tentative stratigraphic link between Proterozoic rocks of the Transverse Ranges cratonic inlier and the North American craton (Powell, 1993).

Figure 2.—Stratigraphic parent units for crystalline basement rocks. Symbols shown in open boxes indicate units mapped in the vicinity of the San Bernardino Wash quadrangle but not exposed within the quadrangle (see Powell 2001a,b; Powell, 2002).



Quartzite of Pinto Mountain

The quartzite of Pinto Mountain (Ꝑpq) consists of three interfingering lithofacies: (1) gray to bluish gray quartzite, coarse- to very coarse-grained, vitreous, thin-bedded to massive, containing granule and pebble conglomerate beds; (2) white quartzite, coarse- to very coarse-grained, vitreous, massive; and (3) pelitic rocks. These strata form a stratigraphic parent unit that is subdivided into lithofacies units in one of two ways in the database. Exposures of quartzite in the quadrangle are mapped as one of the three lithofacies based on color and composition: light gray quartzite unit (Ꝑpqgl), white quartzite unit (Ꝑpqw), or pelitic unit (Ꝑpqp).

Quartzite lithosomes in this unit are characteristically coarse- to very coarse-grained and vitreous. The gray quartzite lithofacies is typically mottled light to dark gray to dark bluish gray, medium-bedded to massive, and compositionally mature (> 95 percent quartz). The quartzite contains andalusite, sillimanite, and, locally, viridine, which gives the quartzite a greenish cast. Opaque minerals occur in sporadic thin black laminae (≤ 1 mm). West of the northern part of the quadrangle, where the quartzite is undeformed, cross-bedding is abundant; in and south of the quadrangle in the Eagle Mountains, cross-bedding has been obscured by deformation. Conglomerate is abundant near the unconformity at the base of the quartzite unit, where it occurs in layers and lenses as thick as 3 m, and sporadically higher in the section. Clasts, constituting 75-85 percent of the conglomerate, consist of pebbles and cobbles of very coarse-grained white quartzite or quartz (85-95 percent), tabular clasts of fine-grained, black, specular hematite-rich quartzite (5-15 percent), and rare fine-grained jasper. The matrix is mottled light- to dark-gray quartzite. In the Pinto Mountains west of the quadrangle, the clasts are undeformed and roughly equidimensional; in the Eagle Mountains to the south of the quadrangle, deformation of the conglomerate has stretched the pebbles and cobbles to aspect ratios as great as 10:2:1. Hematite imparts a characteristic rusty brown stain.

The white quartzite lithofacies is compositionally supermature (98-99 percent quartz) and consists of very coarse-grained vitreous white to light-gray quartzite having interlocking grains as large as 1 cm. Grains are strongly recrystallized, have sutured boundaries, and show no evidence of relict rounded sedimentary grains. The quartzite is massive and bedding is obscure or obliterated except where it contains thin seams of reddish black hematite, aluminosilicate, and quartz. Rocks mapped as the white quartzite lithofacies may include large domains of remobilized quartz. The unit is a ledge-former and is intensely jointed.

Pelitic rocks in the quartzite of Pinto Mountain typically contain quartz, muscovite, sillimanite and (or) andalusite, and in places biotite. In the Pinto Mountains, rocks of this unit contain abundant aluminosilicate minerals and are usually porphyroblastic to granoblastic showing little or no pervasive deformation; in the Eagle Mountains, they are schistose and muscovite-rich. In the San Bernardino Wash quadrangle, rocks of the pelitic lithofacies appear dark-colored on aerial photographs, exhibit a well developed patina of desert varnish, and contain dark-colored quartzite.

Dolomite of Iron Chief mine

The dolomite of Iron Chief mine (Ꝑid) consists predominantly of very coarse-grained dolomite marble with interlocking recrystallized grains. Fresh rock is white to light gray; weathered rock grayish orange (10YR 7/4) to very pale brown. Typically massive and pure, the dolomite contains thin to thick-layered intervals rich in dark-brown weathering siliceous nodules, pods, and lenses probably derived from chert. Scattered calc-silicate minerals, including garnet, diopside, and phlogopite, are present in the dolomite. The dolomite also contains sporadic layers of very coarse-grained white calcite marble (≤ 10 ft), quartzite, and dark-brown-weathering hematite-dolomite (iron ore). Only two small bodies of dolomite and limestone have been mapped in the quadrangle in the Eagle Mountains. Where it is more abundant just southeast of the quadrangle, dolomite forms bold, light-colored ridges that stand out in stark contrast to the darker Jurassic plutonic rocks that have intruded it.

MESOZOIC ROCKS

Voluminous plutonic rocks of the Cordilleran system of Mesozoic batholiths intrude Proterozoic and Phanerozoic host rocks in the eastern Transverse Ranges and adjoining parts of the Mojave and Colorado Deserts. These Mesozoic plutonic rocks define three broad northwest-trending belts (Powell, 1993). Distribution of plutons of the central belt roughly coincide with the Proterozoic and Paleozoic rocks. Plutons of the eastern belt intrude the eastern margin of the domain of Proterozoic and

Paleozoic rocks and the domain of metamorphosed Mesozoic strata that lies to the east. Plutons of the western belt intrude the western margin of the domain of Proterozoic and Paleozoic rocks and the domain of metamorphosed Mesozoic strata that lies to the west. Mesozoic plutonic rocks exposed in the San Bernardino Wash quadrangle all fall within the eastern belt.

Eastern plutonic belt

In the eastern Transverse Ranges, the eastern plutonic belt consists of a suite of Jurassic hornblende-bearing mafic to intermediate intrusive rocks that is intruded by a Jurassic calc-alkaline to alkaline suite of porphyritic hornblende-biotite quartz monzonite, monzodiorite, granodiorite, and quartz diorite. These intermediate porphyritic rocks are characterized by a paucity of quartz and by phenocrysts of alkali feldspar having a distinct lavender cast. Chlorite and epidote, occurring as alteration products of hornblende and biotite, are ubiquitous and abundant. These plutonic rocks yield Middle and Late Jurassic K-Ar and U-Pb ages (about 165 to 150 Ma) in the Transverse Ranges (Bishop, 1963; L.T. Silver, 1978, oral communication) and the Mojave and Sonoran Deserts (Miller and Morton, 1980; Anderson and Silver, 1986; Tosdal, 1986; Karish and others, 1987; Tosdal and others, 1989), where they form part of a belt of Jurassic magmatic rocks along the Pacific margin of the North American continent (Kistler, 1974; Anderson and others, 1979; Burchfiel and Davis, 1981; Gastil, 1985; Tosdal and others, 1989).

In the Mojave Desert east of the Transverse Ranges, Jurassic plutons are intruded by Cretaceous plutons of leucocratic, biotite monzogranite and granodiorite, some of which also contain hornblende or muscovite. These plutonic rocks range from equigranular to porphyritic with phenocrysts of alkali feldspar, and locally are foliated to mylonitic (Miller and others, 1982; Howard and others, 1982). Granodiorite in the Coxcomb Mountains yields a zircon U-Pb age of 70 Ma (Calzia and others, 1986).

Mafic and intermediate plutonic rocks

The mafic and intermediate suite (Jmi) consists of intermingled mafic and mafic intermediate rocks of varied composition and texture. Color index ranges from 50 to > 95. Coarse- to very coarse-grained hornblendite and hornblende gabbro are characterized by stubby, equant hornblende ranging in size between 3-5 mm and 3-4 cm. Clinopyroxene and rare olivine occur as inclusions in poikilitic hornblende; biotite is present in some rocks. Plagioclase occurs as subhedral to euhedral zoned crystals of labradorite with calcic cores saussuritized to epidote, chlorite, and sericite. Interstitial quartz is common. In lighter-colored, medium- to coarse-grained biotite-hornblende dioritic rocks, scattered stubby hornblende crystals result in a spotted appearance. Fine-grained, dark-colored dioritic to quartz dioritc rocks contain hornblende and biotite. Medium-grained diorite and quartz diorite contain biotite and prismatic hornblende. Sporadic cumulate(?) layering in biotite-hornblende gabbro-diorite is defined by mafic-rich laminations in the plane of which acicular hornblende crystals are randomly oriented. Coarse- to extremely coarse-grained gabbro-dioritic pegmatite is characterized by radiating clusters of prismatic hornblende, and less commonly by hornblende comb-structures. Subhedral to euhedral zoned crystals of plagioclase range from labradorite to oligoclase; alkali feldspar and quartz are interstitial; sphene, apatite, and secondary epidote and chlorite are ubiquitous; zircon is usually present. Rocks of this unit are intruded by the quartz monzonite, monzogranite, and granodiorite of San Bernardino Wash (Jsb).

Quartz monzonite, monzogranite, and granodiorite of San Bernardino Wash

The quartz monzonite, monzogranite, and granodiorite of San Bernardino Wash (Jsb) is extensively exposed in the eastern Pinto Mountains and southeast of the quadrangle in the northeastern Eagle Mountains (fig. 1). In addition to the compositional range indicated by the rock unit name, the unit contains subordinate diorite and quartz monzodiorite. The unit typically contains less than 25 percent quartz and abundant sphene; porphyritic rocks are characterized by lavender-tinted phenocrysts of alkali feldspar. Mafic minerals consist of hornblende, biotite, and locally clinopyroxene. Rocks of this unit show widespread propylitic alteration. This unit consists chiefly of a porphyritic facies (Jsbp) and subordinately of an equigranular facies (Jsbe) that crops out in the Eagle Mountains along the south margin of the quadrangle.

Porphyritic quartz monzonite, monzogranite, and granodiorite of San Bernardino Wash

The porphyritic quartz monzonite, monzogranite, and granodiorite (Jsbp) consists of medium- to coarse- to very coarse-grained porphyritic rock having phenocrysts of alkali feldspar set in a biotite-hornblende-quartz-microcline-plagioclase groundmass. Alkali feldspar phenocrysts are pink and have a distinctive lavendar cast; they are euhedral, tabular, and 1- to 4-cm-long; Carlsbad twinning is common. Alkali feldspar (30-35 percent) is microcline and microperthitic microcline; plagioclase (25-40 percent) is twinned and zoned oligoclase to andesine; quartz (10-25 percent) is interstitial; hornblende (4-10 percent) is subhedral to eudhedral and pleochroic green to yellowish brown; biotite (0-6 percent) is pleochroic green to brown; sphene (0.5-1 percent) occurs as large euhedral to subhedral crystals and as rims around magnetite-ilmenite; accessory minerals include zircon, apatite, and allanite. Phenocrysts typically constitute from 20 to 40 percent of the rock. The porphyritic rock is locally quartz monzodiorite, and the unit grades transitionally into local domains of more mafic-rich and quartz-poor monzonite and monzodiorite lacking phenocrysts. The unit has undergone pervasive propylitic alteration and secondary chlorite, epidote, and carbonate are ubiquitous, abundant, and impart a greenish cast to the rock. Weathered surfaces exhibit a dark patina of desert varnish. The unit is foliated locally. Biotite from the unit in the Pinto Mountains north of the quadrangle yields a conventional K-Ar age of 167 Ma (Bishop, 1963), and zircon from the unit in the Pinto Mountains northwest of the quadrangle and in the Eagle Mountains southeast of the quadrangle yields U-Pb ages of about 165 Ma (Silver, 1978, oral communication; Wooden and others, 1994).

Equigranular quartz monzonite, monzogranite, and granodiorite of San Bernardino Wash

The equigranular facies of the quartz monzonite, quartz monzodiorite, monzogranite, and granodiorite (Jsbe) is mineralogically similar to the porphyritic facies, but is nonporphyritic and ranges in composition to quartz monzodiorite. The equigranular facies is typically mafic-rich and grades into the porphyritic facies.

MESOZOIC AND CENOZOIC(?) ROCKS

Dike rocks

Dike rocks (TJdu) are widespread in the San Bernardino Wash quadrangle and have a variety of compositions that are not distinguished from one another on the geologic map; they include dacite porphyry, microdiorite, and quartz latite or rhyodacite. Rock names are based on phenocryst percentages. Dacite dikes are gray hornblende-feldspar porphyry containing abundant to sparse phenocrysts of zoned euhedral plagioclase (labradorite to andesine) as large as 1 cm, subordinate euhedral brown hornblende and brown biotite, and rare embayed quartz set in a gray microcrystalline groundmass of plagioclase, alkali feldspar, quartz, sphene, apatite, and zircon. Dacite dikes trend northeast and are typically a few meters thick, several hundred meters long, and dip steeply. They form resistant ribs, and exhibit a dark brown patina of desert varnish. Similar dacite dikes intrude Cretaceous granodiorite and monzogranite in the Eagle Mountains southeast of the quadrangle. Microdiorite dikes are medium- to dark-greenish gray, fine- to very fine-grained, and composed primarily of hornblende and plagioclase; typically, they are altered propylitically to epidote, chlorite, and calcite. Quartz latite dikes (Jql), distinguished locally along the southern boundary of the quadrangle, typically trend north and are light- to medium-gray, siliceous, aphanitic rocks containing microphenocrysts of quartz, microcline, plagioclase, and biotite. A quartz latite dike in Big Wash in east-central Eagle Mountains southeast of the quadrangle yields a zircon U-Pb intercept age of 145 Ma and a sphene U-Pb age of 142 Ma (James, 1989).

TERTIARY ROCKS

Erosion surface

During the Miocene, a widespread regional erosion surface developed on the bedrock of the Mojave Desert and eastern Transverse Ranges (Oberlander, 1972, 1974; Trent, 1984), although this surface may represent multiple cycles of weathering and erosion, perhaps extending as far back in time as the Cretaceous (Vaughan, 1922; Dibblee, 1967b; Meisling and Weldon, 1982, 1989). Granitic rocks were deeply weathered beneath the erosion surface; metamorphic rocks were not as deeply weathered and uphold some of the inselbergs in the region. Remnants of the granite regolith developed with the erosion surface are present in the Pinto and Eagle Mountains in the vicinity of the San Bernardino Wash quadrangle. The erosion surface was broadly planar, especially where developed on granitoid rocks.

As the crust was flexed and faulted during the evolution of the eastern Transverse Ranges, the Miocene erosion surface was deformed. Where downwarped, the surface lies buried beneath younger basinal deposits; where upwarped it has undergone erosion in the highlands that surround the basins and played a role in the development of Quaternary pediments (Powell and Matti, 2000). The erosion surface and regolith are buried beneath Pinto Basin, whereas in the bedrock highlands around the basin, subsequent erosion largely has stripped the regolith and dissected the upwarped parts of the erosion surface.

COVER ROCKS

TERTIARY ROCKS

Sedimentary deposits

Late(?) and middle Miocene, reddish, arkosic sedimentary deposits (Ts) that crop out beneath Miocene basalt probably represents detritus derived from stripping of the Miocene weathering regolith. The unit is deposited on weathered granitic rock and, as mapped in the San Bernardino Wash quadrangle, may include the weathering regolith.

Basalt

Middle and late Miocene basalt (Tb) centers are scattered throughout the eastern Transverse Ranges province and adjacent parts of the Mojave and Colorado Deserts. The centers consist of small near-vent flows and the pipes that fed the flows. The basalt is olivine-bearing, massive, and black. Microphenocrysts include euhedral laths of labradorite, euhedral olivine partially altered to iddingsite, and clinopyroxene. In and around the Pinto Basin, basalt occurs in flows in the northern Eagle and southern Pinto Mountains and in pipes and (or) near-vent flows on small inselbergs that rise above the pediment forming the south slope of the basin. Basalt flows in the region commonly overlap reddish arkosic sedimentary strata (Ts) and saprolitic granitic basement rock and underlie old alluvial deposits. Basalt centers are spatially associated with high-angle faults; this association is consistent with crustal flexing. Similar basalt flows in Eagle Mountains east and southeast of the quadrangle yield whole-rock conventional K-Ar ages of 7.8 and 10.2 Ma (Carter and others, 1987). Olivine basalt flows are widely distributed in the western Mojave Desert and eastern Transverse Ranges and yield whole-rock conventional K-Ar dates that range in age chiefly between about 15 and 6 Ma, but are as old as 23 Ma (Oberlander, 1972; F.K. Miller, in Woodburne, 1975, p. 83; Neville and Chambers, 1982; Carter and others, 1987; J.K. Nakata, in Howard and others, in press).

TERTIARY AND (0R) QUATERNARY DEPOSITS

Sedimentary strata of Pinto Basin

West of the San Bernardino Wash quadrangle, in the center of the Pinto Mountain quadrangle, surficial deposits overlie the tilted and folded sedimentary strata of Pinto Basin that crop out in the low hills south of Pinto Wash. In the center of the Pinto Basin, these strata include clay, siltstone, fine-grained sand, and rare freshwater limestone that are interpreted as lacustrine (QTpbl) and are probably Pliocene in age. Cross-bedded arkosic sandstone (QTpbs) that crops out just north of the Hexie Mountains and is similar to sandstone interbedded with the lake beds may be Pliocene or Pleistocene in age. The lake beds are overlain by, and perhaps interfinger with, boulder conglomerate that form coarse fluvial deposits derived from Proterozoic rocks in the Hexie Mountains. Proximal to the Hexie Mountains, very similar boulder conglomerate mapped as old alluvial deposits, middle unit 1 (Qoa_{m1}) overlies arkosic sandstone beds (QTpbs). In the San Bernardino Wash quadrangle, part of the sedimentary deposits, undivided (QTsu) exposed along the south edge of the quadrangle may be equivalent to the basin-margin arkosic sandstone on the Hexie Mountains piedmont. The basinal facies of the sedimentary strata of Pinto Basin are not exposed of the San Bernardino Wash quadrangle, but are likely present in the subsurface.

Sedimentary deposits, undivided

Undivided sedimentary deposits (QTsu) lie on the Miocene erosion surface in the northwestern part of the quadrangle. The unit is mapped chiefly by interpreting aerial photographs and may include Tertiary sedimentary deposits (Ts), part of the sedimentary strata of Pinto Basin (QTpb) exposed to the west in the Pinto Mountain quadrangle (Powell, 2002), Quaternary or Tertiary quartzite-clast conglomerate (QTcq), and very old alluvial deposits (Qvoa). In the

Figure 3.—Stratigraphic parent units for late Cenozoic cover rocks. Symbols shown in open boxes indicate units mapped in the vicinity of the San Bernardino Wash quadrangle but not exposed within the quadrangle (see Powell 2001a,b; Powell, 2002).

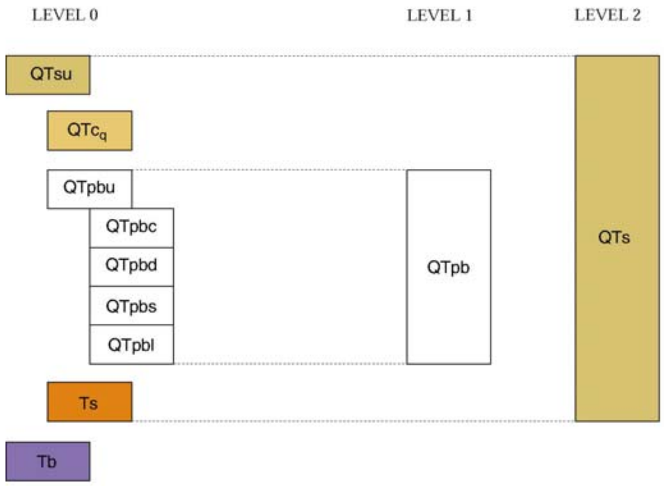
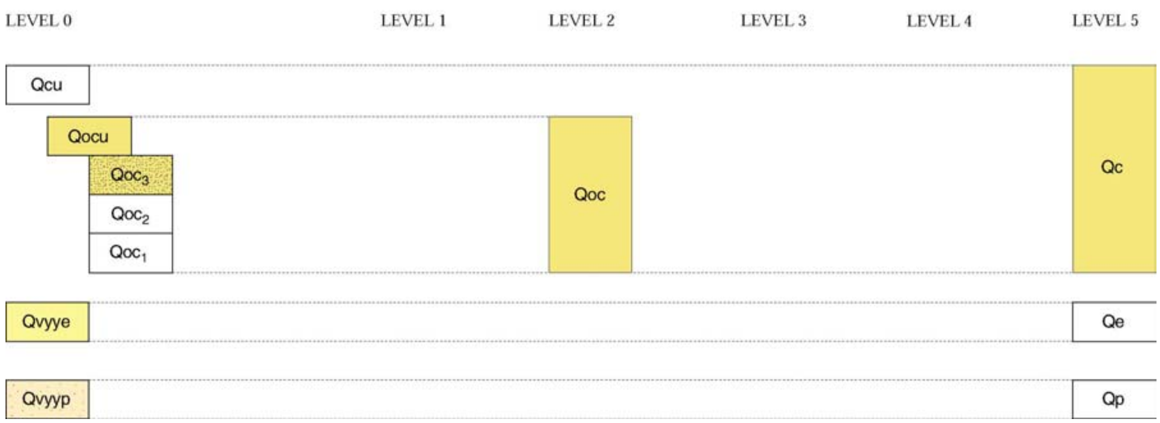


Figure 4.—Stratigraphic parent units for non-alluvial surficial deposits. Symbols shown in open boxes indicate units mapped in the vicinity of the San Bernardino Wash quadrangle but not exposed within the quadrangle (see Powell 2001a,b; Powell, 2002).



digital database, these deposits are included both in a parent unit that includes all Quaternary and (or) Tertiary sedimentary deposits (QTs) and in a parent unit that includes Quaternary and (or) Tertiary alluvial deposits (QTa).

Conglomerate, quartzite-clast

Quaternary and (or) Tertiary quartzite-clast conglomerate (QTcq) consists of cobble and boulder conglomerate shed in an alluvial apron from quartzite outcrops on Pinto Mountain onto an old erosion surface. In the digital database, these deposits are included both in a parent unit that includes all Quaternary and (or) Tertiary sedimentary deposits (QTs) and in a parent unit that includes Quaternary and (or) Tertiary alluvial deposits (QTa).

SURFICIAL DEPOSITS

ALLUVIAL DEPOSITS

Quaternary alluvial deposits in the San Bernardino Wash quadrangle form extensive aprons on mountain piedmonts, fill broad braided-channel washes along intra- and intermontane valley floors, and occupy intramontane canyon bottoms. The alluvial sediment originated from bedrock units in the Pinto, Hexie, and Eagle Mountains and accumulated in various deposits shaped by processes of weathering, erosion, transportation, and deposition. Variations in the textural and morphological characteristics of the alluvial deposits reflect differences in bedrock provenance, climate, tectonic activity, and geomorphic setting.

The piedmont deposits comprise the greatest volume of surficial sediment found in the quadrangle, where two geomorphically distinct classes of alluviated piedmonts are present. Class 1 piedmonts consist of deposits forming alluvial aprons characterized by prominently cone-shaped, multi-lobed fans that coalesce down-piedmont into bajadas. These deposits typically occur along the base of steep, fault-controlled mountain escarpments developed in resistant rocks having weathering and denudation characteristics that are relatively insensitive to climatic change (see Bull, 1991, p. 161-167). The south piedmont of the Pinto Mountains and the north piedmont of the Hexie Mountains are class 1 bajadas.

Class 2 piedmonts consist of deposits that accumulated on broad piedmont slopes developed on less resistant rocks along deeply embayed mountain fronts. Weathering and denudation of these less resistant rocks are relatively sensitive to climatic change. Piedmonts are punctuated with inselbergs, rimmed with pediments, and exhibit broad, multi-faceted slopes that drain via small intra-piedmont valleys between slope facets. At least in part, alluvial deposits in class 2 piedmonts occur as veneers on pediments. Alluvium on slope facets originates as fans distributed from feeder drainage-channels and as sheet wash on slopes between drainage channels. Fans in class 2 piedmont settings are characterized by low-convexity transverse profiles, and by surfaces having low-relief morphology. Fans and sheetwash on slopes between fans commonly merge imperceptibly. Down-piedmont, distributary slope drainage re-collects into intra-piedmont tributary valleys that, in turn, debouch onto fans farther down-piedmont. Deposits are formed by channelized flow and by unconfined overland flow in a distributed network of branching and coalescing washes, fans, and thin slope-blanketing sheets.

Alluvium has been deposited on piedmonts in distinct aggradational pulses. These pulses result in similar-appearing deposits that have been preliminarily mapped for this open-file report; they are distinguished mainly by interpreting aerial photographs and not all have been checked systematically in the field. Alluvial deposits are grouped hierarchically in the database as shown in Figure 5. Quaternary alluvial deposits (Qa) are divided into old and very old deposits (Qovoa) that are chiefly Pleistocene in age and very young and young deposits (Qvyya) that are mostly Holocene in age. These two parent units are in turn subdivided into very old (Qvoa) and old (Qoa) alluvial deposits and into young (Qya) and very young (Qvya) alluvial deposits, respectively.

Very old alluvial deposits

Very old alluvial deposits (Qvoa) consist of moderately to well-cemented boulder gravel. The unit exhibits strongly dissected geomorphic surfaces characterized by ridge-and-ravine (ballena) morphology and by truncated Av/K soil profiles. Ridges are rounded, littered with calcrete fragments, and have no remaining pavement. Carbonate morphology in the K horizon is consistent with pedogenesis in the range of Stage IV-VI. Pervasive hard to very hard chalky cementation is typically accompanied by abundant veins of laminar calcrete. These deposits are probably early Pleistocene in age.

Old alluvial deposits

Old alluvial deposits (Qoa) consist of consolidated sand and gravel deposited in canyon and arroyo bottoms and on piedmont slopes; granitic debris characterized by Av/Bt/Bk/Cox soil profiles; Stage III-IV carbonate morphology. Unit surfaces consist of very well-developed dark and smooth pavements of strongly varnished pebbles and cobbles. Pavements are underlain by pedogenic Av horizon of very pale brown (10YR 7/3), loess-like, vesicular silt. On class 1 piedmonts, old deposits exhibit slightly to strongly dissected geomorphic surfaces. Relict pavements and the underlying old alluvial deposits are more deeply dissected with increasing age. On class 2 piedmonts in the San Bernardino Wash quadrangle, old alluvial deposits consist of consolidated deposits of alluvium and slope wash that accumulated as thin aprons on pediments beveled onto Mesozoic granitic rocks, Proterozoic granite gneiss of Joshua Tree, and tilted Quaternary and (or) Tertiary strata. The underlying crystalline rocks are exposed south of quadrangle, where alluvial deposits are buttressed against bases of inselbergs in the Eagle Mountains (see Figure 1). Much of mapping of these deposits is based on aerial photograph interpretation and has not been field checked; age assignments are tentative. The old alluvial deposits unit is a stratigraphic parent unit that groups a sequence of old, middle, and young subunits (Qoa_o, Qoa_m, Qoa_y). Only the latter two subunits occur in the San Bernardino Wash quadrangle.

Old alluvial deposits, middle unit

Pleistocene alluvial deposits of the middle unit (Qoa_m) debouch from channels incised into bedrock and fan out onto piedmonts in a sequence of three aggradational events separated by erosional intervals. Each successive aggradational subunit is inset into the preceding subunits as well as older units. Surfaces consist of very well-developed pavements of strongly varnished pebbles and cobbles. The late Pleistocene youngest subunit (Qoa_{m3}) is characterized by pavements that are generally continuous over broad relict surfaces and slightly to moderately incised by a dendritic network of scattered to closely spaced gullies that originate on the fan surface. Pavements on deposits of the middle subunit (Qoa_{m2}) are extremely dark and moderately to deeply incised by a dendritic network of gullies. The pavement and Av horizon are underlain by a reddened pedogenic B-horizon, in turn underlain by pervasively chalky-cemented sand and gravel. On the oldest subunit (Qoa_{m1}), middle and early Pleistocene pavements are extremely dark and deeply incised by a dendritic network of ravines. Where the pavement has been completely removed, erosional ridges are rounded and surface is littered with calcrete fragments.

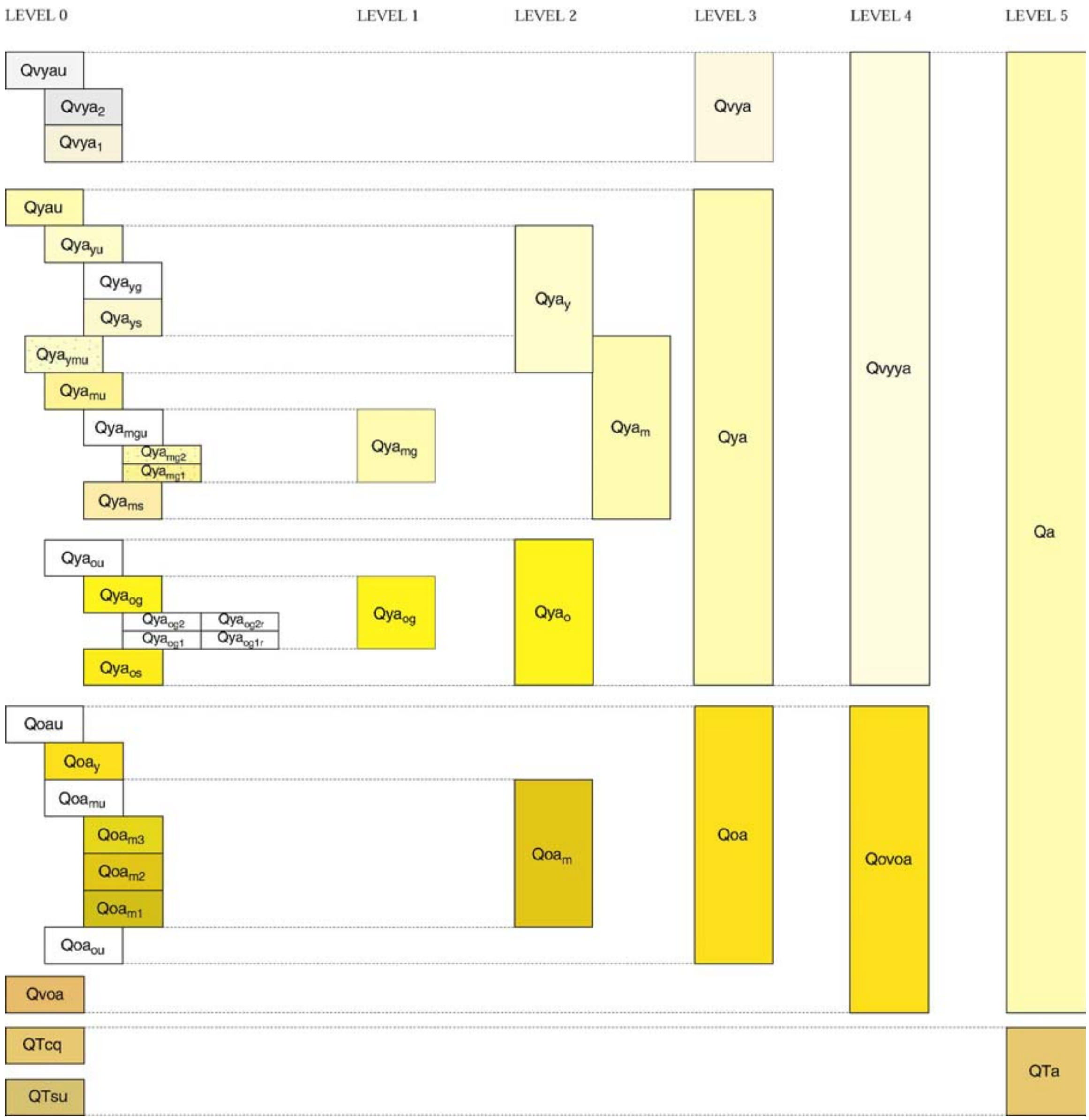
Old alluvial deposits, young unit

In the San Bernardino Wash quadrangle, the youngest of the old alluvial deposits (Qoa_y) comprise sand and pebbly to cobbly sand deposited as distal fan deposits on the north piedmont of the Hexie and Eagle Mountains. Deposits are derived chiefly from exposures of granite gneiss of Joshua Tree (Ꝑjgg) and monzodiorite of Munsen Canyon (ŦPmc) south of quadrangle (see Powell, 2001a, 2001b). Pavements are light-colored, smooth, and moderately incised by dendritic networks of closely spaced gullies generated by surface run-off. Young unit deposits (Qoa_y) are inset into the middle unit. As mapped, this unit may include older middle unit subunits having an atypically light-colored pavement or may include younger pavemented distal fan deposits.

Young alluvial deposits

Young alluvial deposits (Qya_y, Qya_m, Qya_o) consist of loose to moderately consolidated sand and gravel deposited in canyon bottoms and on piedmont slopes. Fans spread out across the piedmont as aggradational aprons, back-filled the drainage washes from which they emanated, and grew progressively down-piedmont in nested complexes; oldest fans are proximal to range-front and youngest fans occur on lower piedmont. Successively younger fans are inset into older fans at their apices and either bury or feather out onto older fans distally. Abandoned surfaces are characterized by pedogenic Av horizon of loess-like, vesicular light brown (10YR 6/4) calcareous silt. Fan surfaces are not dissected by streams that originate on the surfaces. Alluvial deposits exhibit slightly to strongly incised geomorphic surfaces characterized by Av/Cox or Av/Bw/Cox soil profiles typical of Holocene surfaces (McFadden, 1988; Bull, 1991). Young alluvial deposits form a thin, Holocene mantle that tapers basinward on a landscape inherited from Pleistocene.

Figure 5.—Stratigraphic parent units for alluvial surficial deposits. Symbols shown in open boxes indicate units mapped in the vicinity of the San Bernardino Wash quadrangle but not exposed within the quadrangle (see Powell 2001a,b; Powell, 2002).



Young alluvial deposits, old unit

The oldest young alluvial deposits consist of consolidated coarse gravel and sand forming fans adjacent to mountain-front escarpments on class 1 piedmonts along the Pinto and Hexie Mountains and sandy deposits on the distal class 2 piedmont of the Eagle Mountains in the southeastern part of the quadrangle. These proximal fan deposits and surfaces extend into the mountains as canyon-bottom feeder-channel deposits. The surfaces are characterized by plumose anastomosing channels indicative of bar and swale morphology. Locally, the oldest young alluvial deposits include cobbly and bouldery debris flow deposits. Rocky surfaces exhibit moderate to strong varnish and, on color aerial photographs, the gravelly facies unit (Qya_{og}) shows as dark brownish gray to dark gray to black surfaces. Proximally, the gravelly facies unit is inset into Pleistocene deposits (Qoa_{m3}; Qoa_{y}); distally, it overlaps them. Inferred stratigraphic position, strong desert varnish, and bar and swale morphology suggest an early to middle? Holocene age. Surfaces are at least in part correlative with Q3a surfaces of Bull (1991). The extent of the unit is interpreted largely from aerial photographs.

Young alluvial deposits, old oxidized sandy unit

The old oxidized sandy unit of the young alluvial deposits consist of arkosic sand and pebbly to cobbly sand forming part of the lower piedmont alluvial apron in the southeast quarter of the quadrangle. South of the quadrangle, this unit extends up-piedmont, where it is buttressed against Cretaceous granitic rocks exposed in inselbergs and along escarpments in the Eagle and Hexie Mountains. The unit is deposited on a pediment beveled across tilted Pliocene and Pleistocene sedimentary strata of Pinto Basin (QTpb) and Cretaceous granitic rocks. It is thickest where buttressed against basement rock, tapering down-piedmont into thin veneers on Pleistocene and older deposits. The unit occurs as thin alluvial aprons deposited on weathered granitic basement high on piedmont slopes and spread down-slope across older surficial deposits. Where unit is exposed in arroyo walls high on piedmont slopes, loose surficial sediment passes down-section into firmer slope wash and alluvial deposits. Deposits of this unit redden with depth and probably contain one or more buried soil horizons. In places, reddened sediment contains scattered equant blebs of filamentous calcite, indicating an incipient (Stage I) calcic soil.

Unit surfaces are smooth, sandy, and characterized by oxidized grains of potassium feldspar that range in color from reddish yellow (5YR 6/6 to 7/6) to yellowish red (5YR 5/6) to pink (5YR 7/4); unit appears orange to reddish orange on color aerial photographs. These grains occur as a veneer underlain by pedogenic Av horizon of loess-like, vesicular very pale brown (10YR 7/3) calcareous silt, typically 1 to 4 cm thick. Av horizon underlain by pale-brown (10YR 6/3 to 6.5/3) to light yellowish-brown (10YR 6/4) sand.

Exposed to rain and sheet wash, the surfaces of the aprons formed by the unit continued to be sites of active sediment transport and accumulation of arkosic sand reworked from the underlying unit and perhaps in part newly eroded from granitic basement. Because unit surfaces appear to have been active from the latest Pleistocene into the late Holocene, assignment of sandy deposits to the old oxidized sandy unit or to a younger alluvial or slopewash unit is in places subjective.

The unit is inferred to include latest Pleistocene and (or) early to middle Holocene aggradational alluvial deposits as well as younger alluvial deposits that have accumulated as a result of sheet floods originating either as drainage basin discharge or as surface run-off across the older deposits. Proximal parts of unit are incised by channels in which more recent young (Qya_{m} units and Qya_{y} units) and very young (Qvya units) alluvial deposits have accumulated. Down-piedmont, where more recent young alluvial deposits feather out onto Qya_{os}, Qya_{os} surfaces are slightly dissected by anastomosing network of braided channels surrounding small islands of Qya_{os}.

Young alluvial deposits, middle unit

The middle unit consists of middle Holocene sand and gravel deposits (Qya_{m}) that range from unconsolidated to consolidated and are poorly to moderately sorted. On class 1 piedmonts, gravelly facies units (Qya_{mgu}, Qya_{mg1}, Qya_{mg2}) form the proximal parts of fans and extend into the mountains as canyon-bottom feeder-channel deposits. Surfaces of the gravelly proximal parts of these units are moderately varnished and show as gray on color aerial photographs. Gravelly and sandy medial parts are mottled gray and pale brownish gray; sandy distal parts are pale to medium brownish gray. Surfaces on gravelly parts of fans exhibit plumose bar and swale morphology; surfaces on sandy parts of fans exhibit braided bar and swale morphology generated by anastomosing channels. Swales exhibit pebbly pavements underlain by Av horizon. Surfaces are correlative with Q3b surfaces of Bull (1991). Unconsolidated sand and gravel (Qya_{mu}) and sand (Qya_{ms}) occur as fan deposits on the class 2 piedmont of the Eagle Mountains, as distal fan and fan-skirt deposits Hexie and Pinto Mountains piedmonts, and as valley-bottom wash deposits in Pinto Basin. Surfaces are tentatively correlated with Q3b surfaces of Bull (1991).

Young alluvial deposits, young unit

The young unit (Qya_y) consists of late and (or) middle Holocene sand and gravel deposits. On class 1 piedmonts, this unit shows pale brownish gray to pale gray on color aerial photographs. Surfaces exhibit braided bar and swale morphology generated by anastomosing channels. The sand and gravel deposits are unconsolidated, poorly to moderately sorted, and contain more sand and less gravel than older Qya units. Surfaces have little or no desert varnish and are correlative with the Q3c and (or) Q4b surfaces of Bull (1991). On class 2 piedmonts, sand and pebbly sand deposits are unconsolidated and poorly to moderately sorted. Proximally, deposits of this unit are inset into older Qya units; distally, they feather out onto surfaces of Qya_m units. On class 1 piedmonts, the unit includes a gravelly facies (Qya_{yg}) that forms feeder-channel deposits in canyon-bottoms and fans proximal to steep range fronts in the Pinto and Hexie Mountains. The unit also includes a sandy facies (Qya_{ys}) that forms valley-bottom deposits, fan and fan-skirt deposits distal to steep range fronts on class 1 piedmonts, and alluvial-apron deposits on class 2 piedmonts.

Very young alluvial deposits

Very young alluvial deposits (Qvyau, $Qvya_1$, $Qvya_2$) consist of loose to slightly consolidated, medium- to coarse-grained sand and gravel and subordinate fine sand and silt. These sediments form channel-fill in washes incised both into bedrock and into other Quaternary units. Very young detritus is transported and deposited in erosional channels graded to base-level playa deposits in Chuckwalla Valley (fig. 1) and is inset into young alluvial deposits (Qya) and older units. Geomorphic surfaces are undissected to slightly dissected and characterized by active or recently active sediment accumulation. Unit surfaces have a bar and swale morphology, exhibit little or no soil profile development, and are correlative with late Holocene with Q4a and Q4b surfaces of Bull (1991). Surface clasts are unvarnished. Washes are sparsely to moderately vegetated and commonly have prominent riparian shrub lines.

EOLIAN DEPOSITS

Quaternary eolian deposits in the San Bernardino Wash quadrangle occur as loose windblown in central part of quadrangle. The deposits are chiefly Holocene in age and mapped as very young and (or) young eolian deposits (Qvyye). Where it occurs in discontinuous surficial veneers, Qvyye is represented by a red-dot overlay pattern on the map. In the database, these deposits are also included within a stratigraphic parent unit of all Quaternary eolian deposits (Qe).

PLAYA DEPOSITS

Quaternary playa deposits in the San Bernardino Wash quadrangle occur in two small areas of mudstone ponded against the Pinto Mountains along Pinto Wash, one on the west-central edge of the quadrangle and one in the center of the quadrangle. The deposits are Holocene in age and mapped as very young and (or) young playa deposits (Qvyyp). In the database, these deposits are also included within a stratigraphic parent unit of all Quaternary playa deposits (Qp).

COLLUVIAL DEPOSITS

Quaternary colluvial deposits in the San Bernardino Wash quadrangle occur in two principal settings. First, Pleistocene colluvium occurs as small aprons shed from granitoid inselbergs north of Pinto Wash. The surfaces of these old deposits have well-developed, varnished pavements.

Second, in the southeastern corner of quadrangle, varnished aprons of colluvial debris have been shed from flat-topped, pavemented surfaces of Qoa_{m1} and Qoa_{m2} down steep banks eroded into the underlying deposits.

In the digital database, these colluvial deposits are grouped into stratigraphic parent units. Mapped old colluvial deposits (Qocu, Qoc_3) are grouped into the parent unit of old colluvial deposits (Qoc). In turn, Qoc is included into the parent unit of all Quaternary colluvial deposits (Qc).

FAULTS

Pleasant Valley west of the San Bernardino Wash quadrangle and the Pinto Basin developed along a throughgoing, left-oblique, transcurrent fault system that extends across the eastern Transverse Ranges province. From the east end of the Pinto Basin east of the quadrangle, the fault system extends westward into the Little San Bernardino Mountains west of the quadrangle. Pleasant Valley and sub-basins of the composite Pinto Basin occur between left-stepping fault zones within this system. The south frontal escarpments of the Pinto Mountains and the north frontal escarpments of the Eagle and Hexie Mountains as well as the uplift of the low hills underlain by the sedimentary strata of Pinto Basin (QTpb) in the Pinto Mountain quadrangle also are controlled by these faults. This fault system has been called the Blue Cut fault after fault exposures in the Blue Cut in the Little San Bernardino Mountains (Hope, 1966, 1969; Powell, 1993). The fault zone exposed in the Blue Cut, however, is only one of several left-stepping fault zones that make up the Pleasant Valley-Pinto Basin system. Fault zones mapped in the San Bernardino Wash quadrangle include parts of fault zones herein called the Hexie Mountain and Eagle Mountain faults.

The Pinto and Hexie Mountains contain numerous late Cenozoic faults, some of which are probably related to the Pleasant Valley-Pinto Basin system and others of which may be older. In addition to the east-trending group of faults, northwest- and northeast-trending faults also are common.

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APPENDIX

This appendix contains a description of map units contained in the geospatial database of the San Bernardino Wash 7.5-minute quadrangle. Unit descriptions are categorized under the headings SURFICIAL DEPOSITS, COVER ROCKS, and CRYSTALLINE BASEMENT ROCKS. The units described include (1) the first-order units that are shown on the geologic map in the plot- and pdf-files and stored in the *rockunit* region attribute table, and (2) the higher-order stratigraphic parent units available for GIS display and stored in the various region attribute tables (see Figures 2 to 5). In the description of map units below, the higher-order unit symbols are shown in bold text and aligned with the left margin; the first-order map unit symbols are shown in normal font and indented into the page.

SURFICIAL DEPOSITS

ALLUVIAL DEPOSITS

Qa **Alluvial deposits (Quaternary)**—Loose to well consolidated sand and gravel that form bajadas, underlie valley-floors, and fill intramontane canyon bottoms. Stratigraphic parent unit that includes all Holocene and Pleistocene alluvial deposits

Qvyya **Very young and young alluvial deposits (Holocene and latest Pleistocene)**—Loose to moderately consolidated sand and gravel. Stratigraphic parent unit that includes all Holocene alluvial deposits and may include some latest Pleistocene deposits

Qvya **Very young alluvial deposits (late Holocene)**—Loose to slightly consolidated alluvial deposits in washes incised both into bedrock and into other Quaternary units and graded to base-level playa deposits in Chuckwalla Valley (fig. 1). Geomorphic surfaces undissected to slightly dissected and characterized by active or recently active sediment accumulation. Stratigraphic parent unit that consists of:

Qvyau **Very young alluvial deposits, undivided**—Medium- to coarse-grained sand and sandy gravel, including subordinate fine sand and silt; bar and swale morphology; unvarnished clasts. Sparsely to moderately vegetated; prominent riparian shrub lines. Chiefly degradational.

$Qvya_2$ **Very young alluvial deposits, Unit 2**—White on color aerial photographs, no soil profile development. Mostly sand in washes developed on slopes flanking granite inselbergs. Transported and deposited in most recently active channels; inset into $Qvya_1$ and older deposits. Unit surfaces correlative with Q4b surfaces of Bull (1991)

$Qvya_1$ **Very young alluvial deposits, Unit 1**—Light gray (2.5YR 7/2) to pale yellow; gray on color aerial photographs; little or no soil profile development. Transported and deposited in channels or parts of channels less recently active than those in which unit $Qvya_2$ deposited; incised into young alluvial and older deposits. Unit surfaces correlative with Q4a and (or) Q4b surfaces of Bull (1991)

Qya **Young alluvial deposits (Holocene and latest Pleistocene)**—Loose to moderately consolidated alluvial deposits on piedmont slopes. Alluvial deposits exhibit slightly to strongly dissected geomorphic surfaces characterized by Av/Cox or Av/Bw/Cox soil profiles typical of Holocene surfaces (McFadden, 1988; Bull, 1991). Deposits form a thin mantle spread across landscape inherited from Pleistocene. Stratigraphic parent unit that consists of:

Qyau **Young alluvial deposits, undivided**—Loose to moderately consolidated alluvium deposited in canyon bottoms and on piedmont slopes. Fans spread out as aggradational aprons across inherited Pleistocene, back-filled drainage washes from which they emanated, and grew progressively down-piedmont in nested complexes; oldest fans are proximal to range-front and youngest fans occur on lower piedmont. Successively younger fans are inset into older fans at their apices and either bury or feather out onto older fans distally. Abandoned surfaces are characterized by pedogenic Av horizon of loess-like, vesicular light brown (10YR 6/4) calcareous silt. Fan surfaces are not dissected by streams that originate on the surfaces. Piedmont alluvial deposits comprise two classes associated with geomorphically distinct piedmont settings: Class 1—Deposits forming alluvial aprons characterized by prominently cone-shaped, multi-lobed fans that coalesce into bajadas down-piedmont. Typically occur along base of steep, fault-controlled mountain escarpments developed in resistant rocks having weathering and denudation characteristics that are relatively insensitive to climatic change (see Bull, 1991, p. 161-167). Class 2—Deposits that accumulated on broad piedmont slopes developed on less resistant rocks along deeply embayed mountain fronts. Weathering and denudation of these less resistant rocks are relatively sensitive to climatic change. Piedmonts are punctuated with inselbergs, rimmed with pediments, and exhibit broad, multi-faceted slopes that drain via small intra-piedmont valleys between slope facets. Alluvium on slope facets originates as fans distributed from feeder drainage-channels and as sheet wash on slopes between drainage channels. Fans in class 2 piedmont settings are characterized by low-convexity transverse profiles, and by surfaces having low-relief morphology. Fans and sheetwash on slopes between fans commonly merge imperceptibly. Down-piedmont, distributary slope drainage re-collects into intra-piedmont tributary valleys that, in turn, debouch onto fans farther down-piedmont. Deposits are formed by channelized flow and by unconfined overland flow in distributed network of branching and coalescing washes, fans, and thin slope-blanketing sheets. Young alluvial deposits are divided into old, middle, and young subunits roughly equivalent to Q3a,b,c units of Bull (1991). These units are further subdivided as needed. Consists of:

Qya_{ymu} **Young alluvial deposits, young and middle units, undivided (Holocene)**—Unconsolidated to slightly consolidated aggradational piedmont alluvial deposits; medium- to coarse-grained sand and pebbly sand, poorly to moderately sorted. Light to very light gray on color aerial photographs. Comprise class 2 piedmont deposits that occur in: (1) small fans that debouch from small canyons in mountains or inselbergs, are inset proximally into Qyaos, and spread out distally to merge with the surface of Qya_{os}; proximal surfaces exhibit braided bar and swale micromorphology; (2) pediment veneer over saprolite. Little or no desert varnish. Includes:

Qya_y **Young alluvial deposits, young unit (late and (or) middle Holocene)**—On class 1 piedmonts, unit shows pale brownish gray to pale gray on color aerial photographs; surfaces exhibit braided bar and swale morphology generated by anastomosing channels. Unconsolidated sand and gravel, poorly to moderately sorted; more sand and less gravel than older Qya units. Little or no desert varnish. Surfaces correlative with Q3c and (or) Q4b surfaces of Bull (1991). On class 2 piedmonts, unconsolidated sand and pebbly sand, poorly to moderately sorted. Proximally, deposits are inset into older Qya units; distally, they feather out onto surfaces of Qya_m units. Surfaces correlated with Q3c surfaces of Bull (1991). Stratigraphic parent unit that consists of:

Qya_{yu} **Young alluvial deposits, young unit, undivided (late and (or) middle Holocene)**—Same as in parent unit

Qya_{ys} **Young alluvial deposits, young unit, sandy facies**—Sandy alluvium forming valley-bottom deposits, fan and fan-skirt deposits distal to steep range fronts on class 1 piedmonts, and alluvial-apron deposits on class 2 piedmonts deeply embayed into mountain fronts

Qya_m **Young alluvial deposits, middle unit (middle Holocene)**—On class 1 piedmonts, Qya_{mu} forming gravelly proximal parts of fans is gray on color aerial photographs; gravelly and sandy medial parts are mottled gray and pale brownish gray; sandy distal parts are pale to medium brownish gray. Surfaces on gravelly parts of fans exhibit plumose bar and swale morphology; surfaces on sandy parts of fans exhibit braided bar and swale morphology generated by anastomosing channels. Unconsolidated to consolidated sand and gravel, poorly to moderately sorted. Moderate varnish on gravelly proximal parts of fans; swales exhibit pebbly pavements underlain by Av horizon. Surfaces correlative with Q3b surfaces of Bull (1991). On class 2 piedmonts, unconsolidated sand and gravel, poorly to moderately sorted. Surfaces tentatively correlated with Q3b surfaces of Bull (1991). Stratigraphic parent unit that consists of:

Qya_{mu} **Young alluvial deposits, middle unit, undivided (middle Holocene)**—Light gray (2.5YR 7/2) to pale yellow; gray on color aerial photographs; little or no soil profile development. Transported and deposited in channels or parts of channels less recently active than those in which unit $Qvya_2$ deposited; incised into young alluvial and older deposits. Unit surfaces correlative with Q4a and (or) Q4b surfaces of Bull (1991)

Qya_{mg} **Young alluvial deposits, middle unit, gravelly facies**—Gravelly alluvium forming feeder-channel deposits in canyon-bottoms and fans proximal to steep range fronts. On class 1 piedmonts, gravelly proximal parts of fans are gray on color aerial photographs; gravelly and sandy medial parts are mottled gray and pale brownish gray; sandy distal parts are pale to medium brownish gray. Surfaces on gravelly parts of fans exhibit plumose bar and swale morphology; surfaces on sandy parts of fans exhibit braided bar and swale morphology generated by anastomosing channels. Unconsolidated to consolidated sand and gravel, poorly to moderately sorted. Moderate varnish on gravelly proximal parts of fans; swales exhibit pebbly pavements underlain by Av horizon. Surfaces correlative with Q3b surfaces of Bull (1991). On class 2 piedmonts, unconsolidated sand and gravel, poorly to moderately sorted. Surfaces tentatively correlated with Q3b surfaces of Bull (1991). In San Bernardino Wash quadrangle, fan deposits occur only in class 1 piedmont setting. Stratigraphic parent unit that consists of:

Qya_{mg2} **Young alluvial deposits, middle unit, gravelly facies 2**—Younger gravelly alluvial deposits of middle unit; form fans that debouch from channels incised into older gravelly deposits of middle unit

Qya_{mg1} **Young alluvial deposits, middle unit, gravelly facies 1**—Older gravelly alluvial deposits of middle unit

Qya_{ms} **Young alluvial deposits, middle unit, sandy facies**—Sandy alluvium forming valley-bottom deposits, fan and fan-skirt deposits distal to steep range fronts on class 1 piedmonts, and alluvial-apron deposits on class 2 piedmonts deeply embayed into mountain fronts

Qya_o **Young alluvial deposits, old unit (Holocene)**—Consolidated coarse gravel and sand forming fans adjacent to mountain-front escarpments. Proximally, unit is inset into Pleistocene deposits (Qoa_{m3}; Qoa_y); distally, it overlaps them. Inferred stratigraphic position, strong desert varnish, and bar and swale morphology suggest early Holocene age. Surfaces correlative with Q3a surfaces of Bull (1991). Extent of unit is interpreted largely from aerial photographs. Stratigraphic parent unit that consists of:

Qya_{og} **Young alluvial deposits, old unit, gravelly facies**—Gravelly alluvial deposits in fan deposits proximal to steep range fronts and in canyon-bottom feeder-channel deposits along class 1 piedmonts. On color aerial photographs, unit shows as dark brownish gray to dark gray to black surfaces characterized by plumose anastomosing channels indicative of bar and swale morphology. Locally, unit includes cobbly and bouldery debris flow deposits. Moderate to strong varnish on rocky surfaces. On some fans west of quadrangle, two sequences can be distinguished morphologically on aerial photographs (Powell, 2002)

Qya_{os} **Young alluvial deposits, old oxidized sandy unit (middle and (or) early Holocene and late Pleistocene?)**—Sand and pebbly to cobbly sand forming aprons on class 2 mountain-front and inselberg piedmonts where source terrane consists of Cretaceous granitic rocks. Thickest where buttressed against inselbergs or range-front; tapers down-piedmont into thin veneers on Pleistocene deposits. Where unit is exposed in arroyo walls high on piedmont slopes, loose surficial sediment passes down-section into firmer slope wash and alluvial deposits. Deposits of this unit redden with depth and probably contain one or more buried soil horizons. In places, reddened sediment contains scattered equant blebs of filamentous calcite, indicating an incipient (Stage I) calcic soil. Unit surfaces are smooth, sandy, and characterized by oxidized grains of potassium feldspar that range in color from reddish yellow (5YR 6/6 to 7/6) to yellowish red (5YR 5/6) to pink (5YR 7/4); appear orange on color aerial photographs. These grains occur as veneer underlain by pedogenic Av horizon of loess-like, vesicular very pale brown (10YR 7/3) calcareous silt, typically 1 to 4 cm thick. Av horizon underlain by pale-brown (10YR 6/3 to 6.5/3) to light yellowish-brown (10YR 6/4) sand. Unit inferred to include latest Pleistocene and (or) early to middle Holocene aggradational alluvial deposits as well as younger alluvial deposits that have accumulated as a result of sheet floods originating either as drainage basin discharge or as surface run-off across the older deposits. Proximal parts of unit are incised by channels in which more recent young (Qya_m units and Qya_y units) and very young (Qvya units) alluvial deposits have accumulated. Down-piedmont, where more recent young alluvial deposits feather out onto Qya_{os}, Qya_{os} surfaces are slightly dissected by anastomosing network of braided channels surrounding small islands of Qya_{os}. Unit typically occurs as thin alluvial apron deposited on weathered granitic basement high on piedmont slopes and spread down-slope across older surficial deposits. As mapped, unit may include more recent young alluvial deposits

Qovoa **Old and very old alluvial deposits (Pleistocene)**—Consolidated to very well consolidated sand and gravel. Stratigraphic parent unit that includes all Pleistocene alluvial deposits and may include some earliest Holocene deposits

Qoa **Old alluvial deposits (Holocene? and late and middle? Pleistocene)**—Consolidated alluvium deposited in canyon and arroyo bottoms and on piedmont slopes; granitic debris characterized by Av/Bt/Bk/Cox soil profiles; Stage III-IV carbonate morphology. As with young alluvial deposits (Qya units), old piedmont alluvial deposits comprise two classes: (1) Deposits that occur in alluvial aprons characterized by prominently cone-shaped, multi-lobed fans that coalesce into bajadas down-piedmont. Sediments generally have a source in resistant rocks having weathering and denudation characteristics that are relatively insensitive to climatic change (see Bull, 1991, p. 161-167). Sand and gravel. Unit surfaces consist of very well-developed pavements of strongly varnished pebbles and cobbles; dark and smooth. Pavements underlain by pedogenic Av horizon of very pale brown (10YR 7/3), loess-like, vesicular silt. Old deposits exhibit slightly to strongly dissected geomorphic surfaces. Relict pavements and underlying old alluvial deposits are more deeply dissected with increasing age. (2) Deposits that occur on broad piedmont slopes developed on less resistant rocks along deeply embayed mountain fronts. Weathering and denudation characteristics of these less resistant rocks are relatively sensitive toclimatic change. In southwestern San Bernardino Wash quadrangle and in adjoining quadrangles to south and west, class 2 piedmont deposits consist of consolidated deposits of alluvium and slope wash that accumulated as thin aprons on pediments beveled onto Mesozoic granitic rocks, Proterozoic granite gneiss of Joshua Tree, and older Quaternary and (or) Tertiary strata. The underlying crystalline rocks are exposed south of quadrangle, where alluvial deposits are buttressed against bases of inselbergs in the Eagle Mountains (see fig. 1). Mapping of these deposits is based largely on aerial photograph interpretation and has not been field checked; age assignments are tentative. Stratigraphic parent unit that consists of:

Qoa_y **Old alluvial deposits, young unit (Holocene? and late Pleistocene)**—Sand and pebbly to cobbly sand deposited as alluvial fill in canyons and arroyos and in aprons buttressed against bases of inselbergs and mountain massifs. Deposits chiefly derived from older Qoa units and from exposures of granite gneiss of Joshua Tree (Ꝑjgg) and monzodiorite of Munsen Canyon (ꞦPmc) south of quadrangle (see Powell, 2001a, 2001b). Pavements are light-colored, smooth, and moderately incised by dendritic networks of closely spaced gullies generated by surface run-off. Deposits partially bury older erosional landscape on which pediment flatirons had developed on earlier alluvial-slope aprons. Deposits inset into Qoa_m units. As mapped, may include older Qoa_m units having atypically light-colored pavement

Qoa_m **Old alluvial deposits, middle unit (Pleistocene)**—Sand and gravel. Surfaces consist of very well-developed pavements of strongly varnished pebbles and cobbles; surfaces are dark and smooth. Pavements underlain by pedogenic Av horizon of very pale brown (10YR 7/3), loess-like, vesicular silt. Relict pavements and underlying old alluvial deposits are more deeply dissected with increasing age. Includes:

Qoa_{m3} **Middle unit 3 (late Pleistocene)**—Sand and gravel. Pavements are generally continuous over broad relict surfaces; slightly to moderately incised by dendritic network of scattered to closely spaced gullies. Deposits are inset into extant old and very old alluvial deposits (Qoa_{m2}; Qvoa)

Qoa_{m2} **Middle unit 2 (middle? Pleistocene)**—Sand and gravel. Pavements extremely dark; moderately to deeply incised by dendritic network of gullies. Pavement and Av horizon underlain by reddened pedogenic B-horizon, in turn underlain by pervasively chalky-cemented sand and gravel. Deposits are inset into extant old and very old alluvial deposits (Qoa_{m1}; Qvoa)

Qoa_{m1} **Middle unit 1 (middle and early Pleistocene)**—Sand and boulder gravel. Very well developed pavement with strongly varnished pebbles and cobbles. Prominent ridge-and-ravine (ballena) morphology; pavements extremely dark, deeply incised by dendritic network of ravines, and preserved only in discontinuous remnants along ridge crests. Moderately to well-cemented pedogenic K-horizon. Where pavement has been completely removed, erosional ridges are rounded and surface is littered with calcrete fragments. Pavement underlain by pedogenic Av horizon of very pale brown (10YR 7/3), loess-like, vesicular silt. Deposits debouch from channels incised into bedrock. Erosional morphology of unit exhibits three markedly different surficial settings, each providing a distinct microenvironment: (1) dark pavement as discontinous relics on ridge crests; (2) colluvial debris on ridge slopes, including lighter-colored young(?) slope wash derived from parent rock and dark-colored slope-wash (Qoc) shed from the varnished pavement surface; and (3) ravine-bottom alluvium

Qvoa **Very old alluvial deposits (early Pleistocene)**—Moderately to well-cemented sand and boulder gravel; unit exhibits strongly dissected geomorphic surfaces characterized by ridge-and-ravine (ballena) morphology and by truncated Av/K soil profiles. Carbonate morphology in K horizon is consistent with pedogenesis in the range of Stage IV-VI; pervasive hard to very hard chalky cementation is typically accompanied by abundant veins of laminar calcrete. Ridges are rounded and littered with calcrete fragments; no remaining pavement

QTa **Alluvial deposits (Quaternary and (or) Tertiary)**—Conglomerate and sandstone that occur as erosional remnants perched on upland surfaces. Stratigraphic parent unit that consists of:

QTcq **Conglomerate, quartzite-clast**—Boulder conglomerate and sandstone shed in coarse alluvial apron from quartzite outcrops on Pinto Mountain and in northwestern Eagle Mountains. As mapped, may include very old alluvial deposits (Qvoa) in the Eagle Mountains

QTsu **Sedimentary deposits, undivided**—Interpreted from aerial photographs. Deposits are reddened and beveled by pediment. Just south of quadrangle, deposits overlie an older bedrock pediment. Restricted to small areas of exposure along south margin of quadrangle. As mapped, may include deposits equivalent to sandstone unit of sedimentary strata of Pinto Basin (QTpbs) mapped west of quadrangle (Powell, 2002), to oxidized old alluvial deposits (Qoaos) or old alluvial and (or) regolithic deposits (Qoars) mapped south of quadrangle (Powell, 2001a), or to Tertiary sedimentary deposits (Ts) and (or) saprolite

EOLIAN DEPOSITS

Qe **Eolian deposits (Quaternary)**—Windblown sand. Stratigraphic parent unit that includes all Pleistocene and Holocene eolian deposits

Qvyye **Very young and (or) young eolian deposits (Holocene)**—Windblown sand, unconsolidated. Occurs in central part of quadrangle. Where it occurs in discontinuous surficial veneers, Qvyye is represented by a red-dot overlay pattern. As mapped, may include some old eolian deposits

PLAYA DEPOSITS

Qp **Playa deposits (Quaternary)**—Clay, silt and sand. Stratigraphic parent unit that includes all Pleistocene and Holocene playa deposits

Qvyyp **Very young and (or) young playa deposits (Holocene)**—Micaceous silt and clay containing minor sand and scattered granules and pebbles; very pale brown to pale brown. Light-colored surface on aerial photographs. Sparsely to moderately vegetated. Occurs in two small areas along Pinto Wash, one on west-central edge of quadrangle and one in center. Older parts of this unit overlain locally by windblown sand and distal fan deposits

COLLUVIAL DEPOSITS

Qc **Colluvial deposits (Quaternary)**—Colluvium and talus. Stratigraphic parent unit that includes all Pleistocene and Holocene colluvial deposits

Qoc **Old colluvial deposits (Holocene? and Pleistocene)**—Consolidated colluvium deposited in debris aprons. Old deposits exhibit slightly to strongly dissected geomorphic surfaces; gravelly deposits have well-developed and strongly varnished pavements; granitic debris characterized by Av/Bt/Bk/Cox soil profiles; Stage III-IV carbonate morphology. Colluvial aprons typically consist of debris shed from resistant ledge- or ridge-forming units across slopes cut into underlying recessive units. Stratigraphic parent unit that consists of:

Qocu **Old colluvial deposits, undivided (Pleistocene)**—Varnished aprons of colluvial debris shed from granite inselbergs north of Pinto Wash. Well-developed pavements on colluvial deposits are very dark and smooth, consist of strongly varnished pebbles and cobbles, and are underlain by pedogenic Av horizon of very pale brown (10YR 7/3), loess-like, vesicular silt. Includes:

Qoc_3 **Unit 3**—In southeastern corner of quadrangle, varnished aprons of colluvial debris shed from flat-topped, pavemented surfaces of Qoa_{m1} and Qoa_{m2} down steep banks eroded into the underlying deposits. Aprons connected with source rock outcrops. Units 1 and 2 crop out west of quadrangle (Powell, 2002)

COVER DEPOSITS

Tb **Basalt (late and middle Miocene)**—Basalt flows; olivine-bearing, massive, black. Microphenocrysts include euhedral laths of labradorite, euhedral olivine partially altered to iddingsite, and clinopyroxene. Occurs as two small exposures in northeastern corner of quadrangle and more extensively east of quadrangle in northern Eagle and southern Pinto Mountains. South of quadrangle, forms pipes and (or) near-vent flows on small inselbergs rising above pediment that forms south slope of Pinto Basin. Similar basalt flows in Eagle Mountains east and southeast of quadrangle yield whole-rock conventional K-Ar ages of 7.8 and 10.2 Ma (Carter and others, 1987)

Ts **Sedimentary deposits (late? and middle Miocene)**—Arkosic sandstone and siltstone; minor conglomerate. As mapped, may include Tertiary weathering regolith

CRYSTALLINE BASEMENT ROCKS

TJdu **Dike rocks, undivided (Tertiary, Cretaceous, and (or) Jurassic)**—Dacite porphyry, microdiorite, and quartz latite or rhyodacite dikes. Names are based on phenocryst percentages. Dacite dikes are gray hornblende-feldspar porphyry containing abundant to sparse phenocrysts of zoned euhedral plagioclase (labradorite to andesine) as large as 1 cm, subordinate euhedral brown hornblende and brown biotite, and rare embayed quartz set in a gray microcrystalline groundmass of plagioclase, alkali feldspar, quartz, sphene, apatite, and zircon. Dacite dikes trend northeast and are typically a few meters thick, several hundred meters long, and dip steeply. They form resistant ribs, and exhibit dark brown patina of desert varnish. Similar dacite dikes intrude Cretaceous granodiorite and monzogranite in Eagle Mountains southeast of quadrangle. Microdiorite dikes are medium- to dark-greenish gray, fine- to very fine-grained, and composed primarily of hornblende and plagioclase; typically altered propylitically to epidote, chlorite, and calcite. Quartz latite dikes typically trend north. Along southern margin of quadrangle, subdivided into:

Jql **Quartz latite dike (Late Jurassic)**—Light to medium gray, siliceous aphanitic rocks containing microphenocrysts of quartz, microcline, plagioclase, and biotite. Quartz latite dikes comprise swarms in eastern

Chuckwalla, Eagle, and Pinto Mountains (Index Map). Quartz latite dike in Big Wash in east-central Eagle Mts. yields zircon U-Pb intercept age of 145 Ma and sphene U-Pb age of 142 Ma (James, 1989)

Jsb **Quartz monzonite, monzogranite, and granodiorite of San Bernardino Wash (Middle Jurassic)**—Ranges from diorite to granite; predominantly quartz monzonite, monzogranite, and granodiorite. Extensively exposed in eastern Pinto and southeast of quadrangle in northeastern Eagle Mountains (fig. 1). Typically contains less than 25 percent quartz; porphyritic rocks are characterized by lavender-tinted phenocrysts of alkali feldspar. Mafic minerals consist of hornblende, biotite, and locally clinopyroxene; abundant sphene. Rocks show widespread propylitic alteration. Stratigraphic parent unit that consists of:

Jsbp **Porphyritic unit**—Medium- to coarse-grained porphyritic plutonic rocks; vary in composition from quartz monzonite to monzogranite and granodiorite. Unfoliated to foliated. Hornblende-biotite to biotite-hornblende; phenocrysts are lavendar-tinted to pinkish-gray alkali feldspar; propylitically altered. Yields biotite conventional K-Ar age of 167 Ma (Bishop, 1963) in Pinto Mountains north of quadrangle and zircon U-Pb ages of about 165 Ma (L.T. Silver, 1978, oral communication; Wooden and others, 1994) in Pinto Mountains north of quadrangle and in Eagle Mountains southeast of quadrangle

Jsbe **Equigranular unit**—Mineralogically similar to porphyritic unit, but is nonporphyritic and ranges in composition to quartz monzodiorite. Equigranular unit is typically mafic-rich and grades into porphyritic unit

Jmi **Mafic and intermediate intrusive suite, undivided (Jurassic)**—Intermingled mafic and mafic intermediate rocks of varied composition and texture. Color index ranges from 50 to >95. Includes coarse- to very coarse-grained hornblendite and hornblende gabbro, medium- to coarse-grained biotite-hornblende diorite, fine-grained, dark-colored diorite to quartz diorite, medium-grained diorite and quartz diorite, and coarse- to extremely coarse-grained gabbro-dioritic pegmatite. Intruded by quartz monzonite, monzogranite, and granodiorite of San Bernardino Wash (Jsbp)

Ꝑe **Eagle Mountains assemblage (Proterozoic)**—Regional grouping of metamorphic rock units comprising granitic basement terrane depositionally overlain by metasedimentary supracrustal section. Eagle Mountains assemblage is widespread in Eagle, Pinto, and Chuckwalla Mountains. Tectonostratigraphic parent unit that, in San Bernardino Wash quadrangle, consists of:

Ꝑems **Metasedimentary rocks (Middle or Early Proterozoic)**—Metamorphosed platform section of quartzite, pelitic schist and porphyroblastic granofels, ferriferous feldspathic schist, dolomite, and minor limestone. Not all rock types crop out in quadrangle. Thermally metamorphosed throughout region. Deformed in the Chuckwalla, Eagle, and southern Pinto Mountains; undeformed in central Pinto Mountains. Stratigraphic parent unit that consists of:

Ꝑid **Dolomite of Iron Chief mine (Middle or Early Proterozoic)**—Very coarse-grained dolomite marble having interlocking recrystallized grains as large as 1 cm. White to light gray, grayish orange (10YR 7/4) to pale yellowish to orangish brown weathering. Thin to thick-layered intervals rich in dark-brown weathering siliceous nodules, pods, and lenses; sporadic layers of very coarse-grained white calcite marble (<3 m thick), quartzite, and dark-brown-weathering hematite-dolomite (iron ore). Contains scattered calc-silicate minerals, including garnet, diopside, and phlogopite

Ᵽpq **Quartzite of Pinto Mountain (Middle or Early Proterozoic)**—Consists of three interfingering lithofacies: (1) gray to bluish gray quartzite, coarse- to very coarse-grained, vitreous, thin bedded to massive, containing granule and pebble conglomerate beds; (2) white quartzite, coarse- to very coarse-grained, vitreous, massive; and (3) pelitic rocks. Stratigraphic parent unit that consists of: two sequences of units, one designated by number and one by color and composition:

Ᵽpqg **Gray unit**—Gray quartzite. Stratigraphic parent unit that consists of:

Ᵽpqgl **Light gray unit**—Light-gray to gray quartzite (> 95% quartz). As mapped, may include domains of remobilized quartz

Ᵽpqw **White unit**—Very coarse-grained, vitreous, white to light-gray quartzite (98-99% quartz) having interlocking grains as large as 1 cm; grains are strongly recrystallized and have sutured boundaries; no evidence of relict rounded sedimentary grains; massive; bedding obscure or obliterated. As mapped, may include domains of remobilized quartz

Ᵽpqp **Pelitic unit**—Dark metamorphosed pelitic rocks, containing very abundant aluminosilicate minerals; chiefly composed of quartz, muscovite, sillimanite and (or) andalusite. Porphyroblastic to granoblastic; schistose in Eagle Mountains; schistose to unfoliated in Pinto Mountains. Unit also contains dark-colored quartzite; as mapped, may include bodies of Jurassic mafic and intermediate intrusive suite (Jmi). Well developed patina of desert varnish makes unit show as dark on color aerial photographs