Complete unit descriptions to

Geologic Map of the Rincon Valley Area, Pima County, Arizona

by

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Map Units

Quaternary to late Tertiary surficial deposits cover most of the piedmonts fringing the Rincon Mountains in Rincon Valley. This alluvium was deposited primarily by larger streams that head in the mountains. Smaller streams that head on the piedmont have eroded deeply into late Tertiary and Quaternary deposits in parts of Rincon Valley and have reworked some of these older deposits. Lower margins of the piedmonts are defined by their intersection with stream terraces or channels of Pantano Wash and lower Rincon Creek. Approximate age estimates for the various units are given in parentheses after the unit name. Abbreviations are ka, thousands of years before present, and Ma, millions of years before present.

d **Disturbed ground (Recent) —** Areas where human activity has obscured the geologic nature of underlying material.

Qs **Undivided surficial deposits (Quaternary) —** Undivided alluvial and colluvial deposits.

Qc **Colluvium and talus (Quaternary) —** Unit Qc consists of locally-derived deposits on moderately steep slopes. Colluvium is extensive in the mountains, but is mapped only where sufficiently thick and extensive as to obscure underlying bedrock. Deposits are very poorly-sorted, ranging from clay to cobbles and boulders. Clasts typically are subangular to angular because they have not been transported far. Bedding is weak and dips are quite steep, reflecting the steep depositional environment. Deposits are a few meters thick or less; thickest deposits are found at the bases of hillslopes. Some stable hillslopes are covered primarily with Pleistocene deposits, which are typically reddened, enriched in clay, and partially mantled with varnished gravel clasts. More active hillslopes are covered with Holocene deposits, which have minimal soil development.

Qy **Undifferentiated Holocene alluvium (0 to ~10 ka) —** Unit Qy includes both Qy_2 and Qy_1 deposits.

Qy_2 **Late Holocene alluvium (<~2 ka) —** Unit Qy_2 consists of channels and low terraces recently deposited by modern drainages. Channel deposits in or near mountains include coarse, very poorly-sorted sand, gravel, cobbles and boulders. Channels on lower piedmonts are typically finer-grained and well sorted with grain sizes ranging from sand to cobble. Qy_2 terraces are composed of sand, silt and clay but include pebble and cobble bar deposits. Channels typically are incised less than 2 m below adjacent young terraces, but along Rincon Creek channels are incised several meters below young terraces. Channel morphologies generally consist of a single-thread channel or multi-threaded channels with gravel bars adjacent to low flow channels. Terrace surfaces are planar, although small channels are common on terraces. Qy_2 deposits have no to weak soil development. Qy_2 surfaces appear dark on aerial photos due to vegetation density along channels.

Qy_1 **Older Holocene alluvium (~2 to 10 ka) —** Unit Qy_1 consists of terraces found at scattered locations along upper Rincon Creek. Qy_1 surfaces are about 3-4 m above adjacent active channels, slightly higher than adjacent Qy_2 surfaces and generally are not subject to flood inundation. Surfaces are generally planar; local relief may be up to 1 m where gravel bars are present, but typically is much less. Surfaces are silty or sandy but locally have fine, unvarnished open gravel lags. Qy_1 surfaces generally are lightly vegetated and appear somewhat lighter on aerial photos than Qy_2 surfaces. Qy_1 soils typically are weakly developed, with some soil structure, little clay and stage I to II calcium carbonate accumulation (see Machette, 1985, for description of stages of calcium carbonate accumulation in soils).

Qi_2 **Middle Pleistocene alluvium (~10-130 ka) —** Unit Qi_2 consists of moderately dissected relict alluvial fans with strong soil development found throughout the map area. Qi_2 surfaces are drained by extensive, moderately to deeply incised tributary channel networks; channels are typically several meters below adjacent Qi_2 surfaces. Well-preserved, planar Qi_2 surfaces are smooth with scattered pebble and cobble lags; surface color is reddish-brown (7.5 - 5 YR), and rock varnish is typically orange or dark brown. More eroded, rounded Qi_2 surfaces are characterized by scattered cobble lags with moderate to strong varnish. Qi_2 deposits vary in thickness and grain size. Qi_2 fans on upper piedmonts adjacent to mountain fronts are poorly-sorted, coarse deposits (sand to boulder size) that are several meters thick. Fans on the lower piedmonts, south of Rincon Creek, are moderately-sorted grussy sand, pebbles and cobbles. These deposits vary from a several meters thick to less than one meter and overlie older Qi_1 and QTs deposits. Well-preserved Qi_2 surfaces have a distinctive dark red color on color aerial photos, reflecting reddening of the surface soil and surface clasts. Soils contain reddened (5YR), clay argillic horizons, with obvious clay skins and subangular to angular blocky structure. Underlying soil carbonate development is typically stage III, with abundant carbonate through at least 1 m of the soil profile, but indurated petrocalcic horizons are rare. Lower piedmont fan deposits interfinger with river deposits from Rincon Creek and Pantano Wash.

Qi_1 Middle Pleistocene alluvium (~130-500 ka) — Unit Qi_1 consists of moderately to deeply dissected relict alluvial fans with variable soil. Qi_1 surfaces are typically 5 to 10 meters above adjacent active channels. Qi_1 surfaces are drained by well-developed, deeply incised tributary channel networks. Well-preserved planar Qi_1 surfaces are not common. Where they exist, they are smooth with pebble and cobble lags; rock varnish on surface clasts is typically orange to red. On color aerial photos Qi_1 surfaces appear dark red where well-preserved and whitish-gray where eroded. Well-preserved soils typically contain deep reddish-brown (5YR – 2.5YR) clay argillic horizons, with obvious clay skins and subangular blocky structure. Soil carbonate development is abundant and locally cements near-surface deposits, varying from stage III to IV. More eroded Qi_1 surfaces are characterized by loose cobble lags with moderate to strong varnish, ridge-and-valley topography, and carbonate litter on the side slopes.

Qio Middle to early Pleistocene alluvium (~500 ka to 1 Ma) — Unit Qio consists of moderately to deeply dissected relict alluvial fans with variable soil development on the upper piedmonts at the base of Tanque Verde Ridge. Qio surfaces are typically 5 to 10 meters above adjacent active channels. Qio surfaces are drained by well-developed, deeply incised tributary channel networks. Well-preserved planar Qio surfaces are not common; where they exist, they are smooth with pebble and cobble lags. Rock varnish on surface clasts is typically orange to red. Well-preserved soils typically contain deep reddish-brown clay argillic horizons, with obvious clay skins and subangular blocky structure. Soil carbonate development is variable, but locally is quite strong. More eroded Qio surfaces are characterized by loose cobble lags with moderate to strong varnish, ridge-and-valley topography, and carbonate litter on the side slopes. On aerial photos ridge crests on Qio surfaces are reddish-brown, reflecting reddening of the surface soil and surface clasts, and eroded slopes are gray to white. Qio surfaces generally support bursage, ocotillo, and creosote.

Qo Early Pleistocene alluvium (~1 to 2 Ma) — Unit Qo consists of a few very old, high, dissected alluvial fan remnants capping high ridges. Qo deposits and fan surface remnants are found only in a few places in the upper piedmonts. Qo deposits consist of cobbles, boulders, and sand and finer clasts, and have strongly cemented calcic horizons. Qo surfaces are dominated by grass, small shrubs, and ocotillo.

Axial Stream Deposits

Axial stream deposits include sediment deposited by Pantano Wash and Rincon Creek. These deposits vary from fine-grained clay, silt and sand floodplain deposits to sand, pebble, cobble and boulder channel deposits. Pantano Wash deposits include rounded clasts of lithologies reflecting the relatively large and lithologically diverse drainage basin. Rincon Creek river deposits are not as strongly rounded and reflect the lithologies of the Rincon Mountains source area.

Qycr Modern river channel deposits (< 100 years) — This unit consists of river channel deposits of Pantano Wash and lower Rincon Creek. Deposits vary from sand and gravel to cobbles and boulders. Modern channels are typically entrenched a few meters below adjacent young terraces. The current entrenched channel configuration began to evolve with the development of arroyos in the late 1800s, and continued to evolve through this century (Myrick, 1975; Dobyns, 1981). Channels are extremely flood prone and are subject to deep, high velocity flows in moderate to large floods. Most modern channel banks are formed in weakly to moderately cohesive late Holocene alluvium and may be subject to severe lateral erosion during floods. Erosion is likely to be most severe on the outside banks of channel bends.

Qy_2r **Late Holocene floodplain and terrace deposits (~100 to 2 ka) —** Unit Qy_2r consists of abandoned historical floodplains and lower terraces flanking unit Qycr, especially along lower Rincon Creek. Terrace surfaces are flat and uneroded, except immediately adjacent to channels. Qy_2r deposits along Rincon Creek consist of moderate to well-bedded, weakly to unconsolidated sand, silt, and clay. Soils are minimal to weakly developed, with weak soil structure in near surface horizons. Qy_2r deposits along Pantano Wash consist of bedded silt and mud deposits, moderately sorted, weakly cross-bedded sand and gravel deposits, well-sorted gravel lenses and poorly-sorted sand, pebble and cobble bar deposits. Lower Qy_2r terraces and overbank areas may experience sheetflooding during large floods in areas where the main channel is not deeply entrenched. Higher areas of the historical floodplain are no longer subject to flood inundation as result of entrenchment of the main channel and tributary channels. Unprotected channel banks of Qy_2r deposits are very susceptible to lateral erosion during flooding.

Qyr **Holocene floodplain and terrace deposits (<~10 ka) —** The Qyr unit consists of abandoned historical floodplains and lower terraces flanking the main channel along Pantano Wash. Terrace surfaces are flat and uneroded, except immediately adjacent to channels. Qyr deposits consist of well-bedded, weakly to unconsolidated sand, silt, and clay. Soils are minimally- to weakly-developed, with some carbonate filaments and fine masses, and weak soil structure in near surface horizons. Lower Qyr terraces and overbank areas may experience sheetflooding during large floods in areas where the main channel is not deeply entrenched. Higher areas of the historical floodplain are no longer subject to flood inundation as result of entrenchment of the main channel and tributary channels. Unprotected channel banks of Qyr deposits are very susceptible to lateral erosion.

Qi_2r **Middle Pleistocene river terrace deposits (~130 to 500 ka) —** Unit Qi_2r consists of remnant river terraces 10 to 15 m above the active channel along Pantano Wash and lower Rincon Creek. Preserved Qi_2r deposits consist of cobbles, gravels and fine-grained sediment. Qi_2r surfaces commonly have loose, open to moderately packed cobbles and gravel surface lags. Surface clasts exhibit moderate rock varnish. Soils contain reddened clay argillic horizons, with obvious clay skins and subangular to angular blocky structure. Underlying soil carbonate development is typically stage III, with abundant carbonate through at least 1 m of the soil profile. These river deposits are locally interbedded with Pleistocene piedmont deposits.

Qi_1r **Early Pleistocene river terrace deposits (~500 ka to 2 Ma) —** Unit Qi_1r consists of very high remnant river terraces 40 to 60 m above the active channel along Pantano Wash. Preserved Qi_1r deposits consist of cobbles, pebbles, and a few small boulders with sand and fine-grained sediment. Qi_1r surfaces commonly have a loose cobble, pebble, and boulder lag; surface clasts exhibit moderate to strong rock varnish. Qi_1r surfaces appear dark reddish-brown in color aerial photos. Soils typically have reddish-brown (2.5YR) clay argillic horizons over indurated stage IV to stage V carbonate horizons.

Qor **Early Pleistocene river terrace deposits (~1 to 2 Ma) —** Unit Qor consists of very high remnant river terrace deposits along Pantano Wash. The tops of these terraces are 40 to 60 m above the active channel of Pantano Wash. Qor deposits consist of cobbles, pebbles, and a few small boulders with sand and fine-grained sediment. Qor surfaces commonly have loose cobble and pebble lag. Surface clasts exhibit moderate to strong rock varnish. Qor surfaces appear dark reddish-brown in color aerial photos, reflecting reddening of surface clasts and relatively clay-rich surface soil horizon with some dark organic material. Soils typically have reddish-brown (2.5YR) clay argillic horizons over indurated stage IV carbonate horizons where surfaces are well preserved. In other places, argillic horizons have been removed by erosion. Dominant vegetation includes mesquite, prickly pear cactus, and creosote.

QTs Early Pleistocene to late Miocene alluvium (~1 to 10 Ma) — Unit QTs consists of very old, deeply dissected and highly eroded alluvial fan deposits. QTs surfaces vary from highly eroded ridges and deep valleys, with ridgecrests typically 10 to 50 meters above adjacent active channels near the mountains to broadly rounded ridges towards Pantano Wash. The thickness of QTs deposits is unknown. These fan deposits are drained by deeply incised tributary channel networks. Even the highest surfaces atop QTs ridges are rounded, and the original highest capping fan surfaces are not preserved. QTs deposits are dominated by gravel ranging from boulders to pebbles. Deposits are moderately to very strongly indurated and are quite resistant to erosion because of the large clast size and carbonate cementation. Soils are dominated by carbonate accumulation, which is typically stage V (cemented petrocalcic horizons with laminar cap) on ridgecrests. Carbonate litter is common on ridgecrests and hillslopes. On aerial photos, QTs surfaces are gray to white. QTs surfaces support creosote, mesquite, palo verde, ocotillo, and cholla.

QTsy Early Pleistocene to Pliocene alluvium (~1 to 5 Ma) — Unit QTsy consists of massive, buff-colored, well-consolidated conglomerate with a matrix of granule sand composed of disaggregated granitoid (grus). Conglomerate clasts are locally derived, and composition varies with local bedrock. Clasts are subangular to subround, and are mostly 10 to 40 cm in diameter, but range up to a maximum of about 2 m diameter. This unit unconformably overlies Pantano sandstone and conglomerate and locally appears to have 10-20 degree dip. Unit appears to be in fault contact with bedrock along edge of bedrock south of the east end of Tanque Verde ridge (UTM 529050E, 3555450N). Surface morphology is deeply dissected and highly eroded ridges and deep valleys, with ridgecrests typically 10 to 30 meters above adjacent active channels that form a deeply incised tributary channel network. The thickness of QTsy deposits is unknown. Sparse relict soils are dominated by carbonate accumulation, which is typically stage V (cemented petrocalcic horizons with laminar cap) on ridgecrests. Carbonate litter is common on ridgecrests and hillslopes. On aerial photos, QTsy surfaces are gray to white.

Tcb Chloritic breccia (Late Oligocene or early Miocene) — Black to very dark maroon gray, flinty, silicified, ultracataclasite to greenish-gray protocataclasite rock occurs immediately below detachment fault in some areas. Ultracataclasite contains 2-10% fragments of granitic(?) protolith. Cataclasite and protocataclasite consists of broken, variably mylonitic granitoid or metamorphic rock from the footwall. Mafic minerals in cataclasitic rocks are intensely chloritized, giving the rock a characteristic greenish-gray color. The base of this chloritic breccia is gradational over about 10 m. Black ultracataclasite forms a thin lens along detachment fault contact where present.

Tsi Silicified rock (Late Oligocene or early Miocene) — Massive, white to medium gray, chalcedony to medium-grained quartz, locally with relict texture preserving mylonitic foliation or cataclastic fabric. Relict granular texture suggests a protolith like Bolsa Quartzite is present but rare. The north side of the large outcrop area along Rincon Creek where it crosses the detachment fault is an abrupt boundary suggesting a fault contact, but the exact nature of the contact can not be determined. This silicified rock is bounded on top (on the west side of the outcrop) by the gently southwest-dipping detachment fault, and along most of its extent appears to form a sheet along the top of the footwall, with a thin chloritic breccia zone developed beneath the silicified rock. Silicified rock shows multiple silicification-brecciation cycles. There are scattered irregular marble blobs in the silicified zone, especially near contacts with gneiss. Some small zones of red-brown hematite staining and sparse pyrite altered to limonite are present.

Tx(Cb) Breccia derived from Bolsa Quartzite (Late Oligocene or early Miocene) — Shattered to brecciated Bolsa Quartzite that may be a tectonically brecciated fault sliver or rock avalanche deposit.

sXgd Silicified granodiorite (Late Oligocene or early Miocene) — Silicified Rincon Valley Granodiorite(?) in irregular pods adjacent to faults juxtaposing granite with Bisbee Group. Granite is interpreted to form klippen on top of granodiorite. Silcified rock is gray, with relict granitic texture.

sPq Silicified quartzite (Late Oligocene or early Miocene) — Silicified quartzite that forms a hill at the west end of near continuous detachment fault exposure on the north side of Rincon Valley. Relict, rounded, detrital quartz grains are visible in some samples, suggesting that the protolith is most likely Bolsa or Scherrer Formation, but rock may be silicified Bisbee sandstone. Pods of gray crystalline dolomitic carbonate are present. Similar rock forms a low hill along the fault between Bisbee Group and Rincon Valley Granodiorite near UTM 531400N, 3555250E.

sKb Silicified Bisbee Group rock (Late Oligocene or early Miocene) — Scattered pods of silicified Bisbee Group sedimentary rock.

sTc Silicified Pantano Formation (Late Oligocene or early Miocene) — Rubbly outcrop of shattered, tan, silicified quartz-rich feldspathic-lithic(?) sandstone, with sparse chert or quartzite cobbles, and limestone cobbles and boulders altered to white medium- to coarse-grained marble. sTc is found along south side of Pantano outcrop area in eastern Rincon Valley.

Tp Pantano Formation (Oligocene or early Miocene) — Typically red-brown to tan sandstone and conglomerate, ranging from well indurated to weakly consolidated. Less consolidated varieties tend to have tan or tan-gray color. Unit includes various facies, ranging from massive conglomerate to thin-bedded sandstone and mudstone. Massive, very poorly-sorted, pebble to boulder conglomerate has crude bedding defined by clast alignment, sandy lenses, and grain-size variations. Sandstones tend to be very thin to thin bedded, with planar beds separated by mudstone in laminations to very thin beds. Grain size is variable. Sparse fissile shale beds are also present. Sandstone facies typically includes at least a few interbedded thin to medium beds of conglomerate. Much of unit outcrop area is rubble of disaggregated material. Clasts in conglomerate include abundant Proterozoic granitoids of Rincon Valley (Xgd, Xg, Xgt, Xfg), and Bolsa Quartzite; present but not as abundant types include Apache Group quartzite, Middle Proterozoic(?) diabase, lower Mesozoic(?) lithic sandstone, Laramide hypabyssal and volcanic rocks, chert, and Paleozoic carbonate rock. Mylonitic biotite granitoid clasts are preset locally (especially in the area around UTM 538305E, 3554100N); these are believed to be pre-Tertiary based on their fabric. Maximum diameter of granitoid boulders is typically about 30 cm, but boulders as large as 1.25 m were observed. Clasts are typically subrounded. Debris flow deposits are locally present, but most of unit appears to be alluvial. Sedimentary structures include planar lamination, low angle cross bedding in 5-20 cm thick sets, and channels. A thin tuff bed is present in the section west of Loma Alta, exposed in a wash at UTM 528671E, 3554618E.

Tpcc Carbonate-clast conglomerate facies — One small area of distinctive conglomerate with clast population dominated by Paleozoic carbonate rocks was mapped near the eastern edge of conglomerate outcrop in Rincon Valley. This facies appears to be located at or very near the base of the section, overlying Bolsa Quartzite, Abrigo Formation, and indeterminate carbonate strata.

Tai Intermediate composition dike (Eocene, Oligocene or early Miocene) — A prominent, fine-grained, non-foliated granodiorite or dacite dike cuts across mixed gneissic leucogranite, pegmatite of unit TXg, and the gneissic fabric. This rock contains 1-2 mm hornblende needles, scattered sparse 2-3 mm quartz eyes, and abundant 1 mm-diameter euhedral plagioclase in a fine-grained (0.5 mm) granular groundmass. The dike is up to ~4 m thick, and becomes very fine-grained near margins. Exposures of the dike contact demonstrate a sharp truncation of all foliation in the host granitoid and gneiss.

TKd Mafic dikes (Cretaceous or Tertiary) — Dikes of medium to dark greenish-gray andesite or dacite intrude Proterozoic granitoid and Paleozoic to Mesozoic sedimentary rocks in the hanging wall of the detachment fault. These are typically fine to very fine-grained; some dikes have a plagioclase microlite with interstitial mafic mineral groundmass, others have anhedral granular feldspar + mafic minerals in groundmass. Some dikes have phenocrysts of an acicular mafic mineral (hornblende?) altered to chlorite, in other dikes quartz phenocrysts or quartz-feldspar glomerocrysts are present. Dikes are consistently altered, with whitish feldspar and mafic minerals altered to chlorite and epidote. Dikes are typically irregular and discontinuous; it is not clear to what extent this reflects original intrusive geometry or subsequent deformation. Where contacts are exposed, dikes have chilled margins. Disseminated pyrite altered to limonite is present in some dikes.

Krz Tuff breccia (Cretaceous or early Tertiary) — Rock interpreted as a tuff breccia crops out in a fault sliver between granodiorite (unit Xgd) and Tertiary conglomerate (unit Tc) on the west side of Bisbee Group outcrop on the north side of Rincon Valley. This unit is poorly-exposed as blocks of light gray crystalline carbonate with sparse stringy silica (Horquilla(?) limestone), and a few blocks of Bisbee sandstone or Bolsa Quartzite. Limestone blocks are up to about 5 m long. Carbonate lithology is variable, and crinoid columnals were observed in one block. Bedding orientation in blocks is variable. Tuff matrix(?) forms float and sparse pink tan to gray exposures, with sparse 1 mm quartz and feldspar crystals and fiamme or lithic fragments in a dense, light gray silicified groundmass.

Bisbee Group (Late Jurassic or Cretaceous)

Clastic sedimentary rocks correlated with the Bisbee Group form about 6 km^2 of outcrop along the north side of Rincon Creek in the hanging wall of the Catalina detachment fault. These rocks have been subdivided into a limestone-clast conglomerate unit and a mixed conglomerate-sandstone-limestone unit, and are locally undivided.

Kbu Bisbee Group, undivided — Undivided clastic sedimentary rock and limestone of the Bisbee Group.

Kbc Carbonate-clast conglomerate — Massive limestone-boulder conglomerate with quartz-rich, calcareous sandstone matrix. Clasts are 1 m or more in diameter, but are commonly slightly flattened. In some areas deformation has welded the clasts together to the degree that the rock appears to be limestone. Clasts of Escabrosa, Horquilla, and Martin Formations are recognized. Clasts of chert or sandstone are rare. This conglomerate appears to form a subhorizontal sheet capping ridges in the central part of the Bisbee outcrop area.

Kbsc Bisbee Group, sandstone and conglomerate — Unit Kbsc is composed of interbedded sandstone, conglomerate, mudstone and limestone. Sandstone ranges from quartz arenite to calc-clastic lithic sandstone. Typical sandstone consists of quartz-rich feldspathic-lithic sand with variable amounts of detrital carbonate grains. Grain size is highly variable; carbonate grains are most apparent in coarse-grained to granule sandstone. Sandstone forms thin to thick beds. Sedimentary structures include plane lamination, low-angle cross beds and channels. Mudstone rip-up clasts are common in some sandstone beds. Channels provide the most common indication of top direction, where channel margins are observed truncating lamination in older sediment. Indistinct graded bedding is observed in some beds. Limestones are generally in very thin to thin, medium gray beds, either grainstones that contain abundant indeterminate shell(?) hash and sparse oncolites in a crystalline carbonate matrix, or laminated dark and light gray limestone. There is a complete continuum from the carbonate grainstone to calc-clastic sandstone to calcareous quartzose sandstone. Mudstones are interbedded throughout, and are typically brownish-gray to light gray or maroon. The western outcrops appear to include more quartz arenite and interbedded maroon mudstone.

Diabase-clast sandstone and conglomerate (Marker bed) — Marker horizon 2-10 m thick, consisting of sandstone and conglomerate with abundant diabase detritus. Conglomerate contains 15-20% rounded cobbles of fine- to medium-grained diabase with distinct plagioclase microlites and sub ophitic texture, resembling the diabase associated with the Apache Group. Conglomerate also contains clasts of Paleozoic limestone and Bolsa Quartzite. Matrix is dark green-gray and contains abundant diabase detritus.

JTu **Lower Mesozoic volcanic and sedimentary rocks (Triassic or Jurassic) —** Volcanic-lithic sandstone and fragmental, intermediate-composition volcanic rock. Includes brown to red-brown, poorly-sorted, massive volcanic-lithic sandstone, red-brown massive to fragmental andesitic rock with 0.7 mm plagioclase prisms, and siliceous plagioclase-phyric felsite or tuff with a fine-grained (0.5 mm) groundmass that contains 5% 2-3 mm euhedral plagioclase crystals. Lithology resembles unit Jrv in Waterman Mountains and Gardner Canyon Formation in northern Santa Rita and Empire Mountains.

¼c **Undivided carbonate rocks (Paleozoic) —** Fault-bounded slivers of gray, fine-grained, crystalline carbonate interpreted to be Paleozoic carbonate rocks.

P³e **Earp Formation (Pennsylvanian or Permian) —** Interbedded fine-grained calcareous quartz arenite, red-brown mudstone or marl, and medium-gray, thin limestone beds. Small outcrop in fault sliver along west side of Bisbee outcrops includes distinctive chert pebble conglomerate marker bed diagnostic of Earp Formation.

³h **Horquilla Formation (Pennsylvanian) —** Light gray, nodular micritic limestone, pink-tan marl with limestone nodules, and sparse calcite-cemented quartz arenite. Medium to thick bedded. Fresh rock with well-preserved bedding forms small hill south of eastern end of Tanque Verde Ridge.

Ca **Abrigo Formation (Cambrian) —** Interbedded limestone, sandstone, and dark gray-green mudstone. Sandstone is a maroon-gray, laminated quartz arenite, locally calcareous, with sparse greenish glauconitic(?) sand grains, and local small-scale cross bedding. Sandstone is commonly bioturbated, and contains occasional indeterminate fossil fragments. Silvery greenish-gray or red-brown argillaceous partings separate sandstone beds. Limestone is composed of thin to very thin beds of mottled tan and gray argillaceous limestone, sandy limestone, and a few beds of edgewise conglomerate.

Cb **Bolsa Quartzite (Cambrian) —** Red-brown to gray, medium- to very coarse-grained, feldspathic, quartzose sandstone to quartzite. Strata are medium- to thick-bedded, with plane lamination and common planar tabular cross-bedding. Rock has darker brown color near contact with underlying diabase, which it overlies depositionally.

Yd **Diabase (Middle Proterozoic) —** Dark greenish-gray, fine-grained diabase associated with Pioneer Formation in small outcrop areas in eastern Rincon Valley. Bolsa Quartzite depositionally overlies Yd. Rock is generally shattered, strongly chloritized, and consists of chloritized mafic mineral interstitial to a framework of 2-5 mm long plagioclase crystals. Quartz is absent.

Yp **Pioneer Shale (Middle Proterozoic) —** Medium to dark purple-gray, fine-grained quartz sandstone or feldspathic quartzite, with some reduction spots 2-3 mm in diameter. Indistinct low-angle cross-lamination visible in some outcrops. No Scanlan Conglomerate observed. Yp occurs in several small outcrops along fault zone in eastern Rincon Valley.

Granitic rocks of Rincon Valley (Early Proterozoic)

Most of the central part of Rincon Valley is a low-relief pediment underlain by medium- to coarse-grained granodiorite to granite. These rocks include the Rincon Valley Granodiorite as defined by Drewes (1977). Although Drewes mapped all the granitic rocks of Rincon Valley as Rincon Valley Granodiorite, these rocks are here divided into several phases. The name 'Rincon Valley Granodiorite' is restricted to the granodiorite phase mapped here, which includes the type locality proposed by Drewes (1977), in Section 32 and the eastern part of section 33, T15S, R17E. Other phases mapped here include coarse-grained granite, fine-grained granodiorite of Loma Alta, and muscovite granite. Contacts between all the phases are gradational, suggesting they are all part of a single plutonic suite.

Xgm **Fine-grained muscovite granitoid —** Medium- to fine-grained, aplitic muscovite granitoid that is locally quartz-rich with up to 40 to 50% quartz and 2-5% muscovite in 1-2 mm flakes. Grain size is 1-2 mm. Xgm is intruded by sheets of mixed medium dark greenish-gray, very fine-grained, equigranular diorite and fine-grained equigranular granodiorite.

Xfg **Fine-grained granodiorite of Loma Alta —** Fine-grained, homogranular, granodiorite, with 5-7% biotite in 1-2 mm flakes. Forms angular outcrops.

Xgt **Rincon Valley Granodiorite and coarse-grained granitoid undifferentiated —** The contact between Rincon Valley Granodiorite and the coarse-grained granite phase is gradational. This undifferentiated unit was mapped separating the two units in some areas.

Xg **Coarse-grained granitoid —** Coarse-grained monzogranite or granodiorite consisting of 7-10 % biotite in 1-2 mm diameter books 1-2 mm thick, 25-35% quartz in 3-4 mm equant grains, 20-35% white plagioclase in 3-7 mm subhedral grains, and 25-35% white to light pink K-feldspar in 3-10 mm subhedral grains. Biotite is locally strongly chloritized, but predominantly weakly chloritized. Sparse mafic enclaves up to 10 cm in diameter are present, with 2-3 mm grain size. Aplite dikes intrude this unit in some areas. K-feldspar phenocrysts up to 5 cm in diameter are also locally present.

Xgd **Rincon Valley Granodiorite —** Medium-grained (2-4 mm), generally homogranular hornblende-biotite granodiorite. Rock consists of 15-30% 1-4 mm quartz, 50-60% 2-3 mm subhedral white plagioclase, 5-15% anhedral pink potassium feldspar, 7-15% biotite in 2-3 mm diameter books and hornblende in prisms up to about 5 mm long. Biotite is the predominant mafic mineral. Biotite and hornblende are typically altered to chlorite, epidote and catenulate. Euhedral plagioclase crystals up to 8 mm long are locally present. Quartz is typically more anhedral and interstitial to plagioclase than in coarse-grained granitoid. Accessory sphene in 1 mm honey-colored crystals is present. Zones of reddish iron oxide staining are common. Outcrop is rubbly and fractured on 5-15 cm scale. Enclaves composed of non-foliated, fine-grained plagioclase-mafic mineral granofels, with 2-5 mm plagioclase crystals are 5-15 cm long and ellipsoidal in section. Rock is weakly to moderately mylonitic in a thin, rarely preserved zone along the fault contact on Bisbee Group.

Footwall of the Catalina detachment fault

Rocks in the footwall of the detachment fault were not mapped in detail. The footwall consists of a heterogeneous assemblage of igneous and metamorphic rocks dominated by a leucocratic granitoid named the Wrong Mountain Quartz Monzonite Drewes (1977). This granitoid ranges from massive to strongly mylonitic, with fabric development generally intensifying with proximity to the Catalina detachment fault. The Wrong Mountain Quartz Monzonite intrudes older igneous and metamorphic rocks in a lit-par-lit fashion. These older rocks include schistose rocks and quartz-feldspar-biotite gneiss that may have been derived from a Pinal Schist-like protolith, and a variety of igneous rocks including equigranular gabbro(?) to quartz diorite, equigranular to slightly porphyritic biotite granodiorite, and porphyritic granite. Gneissic foliation in these rocks is variably developed and appears to have developed during intrusion of various granitoid phases, of which the Wrong Mountain Quartz Monzonite is the youngest. In places fine-grained, equigranular biotite granitoid dikes were observed cutting the gneissic foliation. Gneissic foliation is distinguished from mylonitic foliation that is spatially associated with the detachment fault based on the more granoblastic nature of grain boundaries and presence of cross cutting igneous phases in the gneissic foliation. The mylonitic foliation is characterized by 'greasy' looking quartz (reflecting the development of nearly cryptocrystalline subgrain texture in the quartz), broken feldspar grains, and the ubiquitous presence of stretching lineation in quartz-bearing rocks.

TPm **Marble, quartzite and calcsilicate metamorphic rocks (Middle Proterozoic, Paleozoic, Cretaceous, and Tertiary) —** This unit consists of marble, quartzite, and calc-silicate hornfels. Marble is typically massive, fine- to medium-grained, equant, and granular with a sugary texture. Brown, gray, and locally pink, feldspathic quartz arenite is commonly associated with the marble slivers. Epidote-garnet skarn is developed in and around the metasedimentary inclusions. Medium-grained, foliated meta-granodiorite inclusions are common in the gneiss complex around the metasedimentary inclusions. Leucogranite intrudes across foliation in the inclusions, skarn, and granodiorite, suggesting that skarn development was related to intrusion of the granodiorite before intrusion of the leucogranite. These inclusions of metasedimentary rock are interpreted to be derived from Paleozoic sedimentary rocks or the Apache Group. Our mapping indicates the inclusions are not associated with a thrust fault as depicted by Drewes (1977), but suggests that they are dismembered pendants in Laramide intrusive rocks, distributed in northeast-trending zones due to Laramide or middle Tertiary deformation.

TPc **Calcareous metamorphic rock (Tertiary or Cretaceous, possibly Paleozoic) —** Zones of epidote-rich granofels and siliceous hornfels that are not associated with marble, and for which the protolith is not clearly carbonate-rich supracrustal rock. TPc may be product of local metasomatism.

TXmy **Heterogeneous gneiss and mylonite near detachment fault (Proterozoic, Paleozoic, Cretaceous, and Tertiary) —** Rock in a thin zone beneath the detachment fault in Rincon Valley is a heterogeneous complex of interlayered marble, siliceous hornfels, mylonitic granitoid, mica schist, and pegmatite. These rocks are extensively weakly silicified, but locally can be strongly silicified. Zones of complete silica replacement are mapped as unit Tsi. The zone is dominated by rocks derived from pegmatite, leucogranite, biotite-feldspar-quartz gneiss, and granodioritic rocks typical in the footwall gneiss complex. Marble, calcsilicate, and quartzose rocks of probably Paleozoic or Mesozoic sedimentary protoliths are sparse to common. Marble may be hydrothermal carbonate or Paleozoic limestone and is typically a gray, fine- to medium-grained calcite(?) marble, locally with siliceous stringers. Buff dolomitic marble is also present. Associated epidote-rich siliceous hornfels may be derived from calcareous clastic rock. Silicified mylonitic rocks do not fracture along the mylonitic foliation, which is only apparent on close inspection. White to light tannish gray siliceous hornfels in some areas has relict granular texture suggesting derivation from quartzose sandstone (Bisbee Group or upper Paleozoic), and in other areas contains sparse relict phenocrysts(?) of quartz or feldspar 0.5-1 mm in diameter, suggesting derivation from a felsitic igneous rock. Muscovite-biotite mylonitic schist with 1-3 mm muscovite flakes is similar to some of the micaceous schistose rock in the footwall, but contains more muscovite than is typically observed in those rocks. Foliation in schist is wildly crenulated in the superimposed mylonitic foliation; new schistosity is developed in mylonite foliation orientation. Some thin quartz veinlets parallel to older foliation in schist are folded. Limonite staining is common, and 3-5 cm globs of massive specular hematite are observed locally in float. Lenses of dark gray, aphanitic, mafic rock appear to be dismembered dikes. Base of mixed-rock zone is more abrupt on the north side of Rincon Valley where more massive leucogranite forms the footwall beneath the zone. The boundary on the south side of Rincon Valley is much more gradational into the more heterogeneous footwall complex.

TXg **Mixed granitoid and gneiss (Proterozoic, Cretaceous, and Tertiary) —** Most of the footwall complex is mapped as a single unit of undifferentiated granite and gneiss. The dominant phase is a medium-grained, equigranular, leucogranite that contains 3-5% 0.5 mm biotite, 20-30% 2-3 mm quartz, 70-80% feldspar, (plagioclase>>potassium feldspar) in equant subhedral grains 2-5 mm in diameter.

Leucogranite ranges from homogeneous and relatively structureless to mylonitic. In some areas the rock contains an igneous(?) layering defined by grain size variations. Typically the granite has a weakly-developed grain shape fabric that is dominated by a stretching component such that foliation is difficult to define (l>s). The fabric is defined by elongate (deformed?) quartz grains, aligned feldspar crystals, and recrystallized(?) aggregates of mica. Thin shear zones with more strongly developed foliation are common.

Pegmatite dikes are common near contacts between relatively massive homogeneous bodies of leucogranite and gneissic rocks. The pegmatite dikes range from sub-concordant with gneissic foliation to cross-cutting, but invariably show some indication of deformation such as bent muscovite or biotite grains or broken feldspars, commonly with silica veinlets filling fracture arrays in the feldspar. Pegmatites consist of feldspar, quartz, muscovite and biotite, with feldspar grains up to about 10 cm in diameter. Garnet is rarely observed.

On the south side of Rincon Valley, heterogeneous gneissic zones between the more homogeneous bodies of leucogranite are quite variable, but appear to be derived from one or more generations of granodioritic intrusive rocks. Lithosomes include heteroblastic fine to very coarse-grained leucogranite in variable deformed dikes. This phase cuts gneissic foliation in a hornblende(?)-biotite, slightly porphyritic granitoid. Lenses of dark gray, fine-grained, equigranular biotite +/- hornblende-quartz-feldspar, sphene-bearing gneiss that have a foliation defined by quartz-feldspar laminations may be a strongly deformed and recrystallized igneous rock. Another distinctive lithosome consists of granoblastic, speckled, granodiorite gneiss with flasar foliation, not layered, which forms sheets in mixed leucogranite and pegmatite. Occasional dark gray hornblende-plagioclase granofels lenses are observed.

In the area around 538500E, 3443150N, quartz-biotite-muscovite-feldspar, fine-grained semi-schist and pegmatite lenses alternate with biotite granodiorite. The semi schist contains an older laminated differentiated folded foliation. A quartz porphyry-like facies is present in this area, with possible clasts or lithic fragments, which may have a volcanic protolith.

In footwall outcrops southeast of the Madrona Ranger station, fine-grained, weakly foliated to non-foliated, homogranular, leucogranite dikes with diffuse and/or irregular boundaries cut sharply across gneissic fabric. Other fine-grained granitoid dikes with sharper, more planar geometry cut gneissic foliation in this area, but have an internal schistose fabric parallel to gneissic foliation.

TKlg **Leucogranite (Early Tertiary or Late Cretaceous) —** Bodies of relatively homogeneous leucogranite (see description in unit TXg)

TXgn **Schist and gneiss (Proterozoic or Cretaceous) —** Gneissic rocks dominated by medium to dark gray biotite-feldspar-quartz gneiss. Subordinate pegmatite and leucogranite present. Mostly mapped on air photographs on which this unit contrasts sharply with the lighter colored leucogranite dominated unit TXg. Field observation suggests protolith is largely granodioritic intrusive rock, but may include Early Proterozoic supracrustal rock as well.

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