Map Unit Properties Table: Tumacácori National Historical Park

Colored rows indicate units mapped within Tumacácori National Historical Park. Colors are based on U.S. Geological Survey standard timescale colors.

Age		Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Cultural Resources	Mineral Occurrence	Habitat	Recreation	Geologic Significance
QUATERNARY	(Holocene)	Modern river channel deposits (Qycr)	Less than 150 years old. Primarily sand and gravel, river channel deposits of the Santa Cruz River and Sopori Wash, about 18 km (11 mi) north of the Tumacácori Mission Unit. Channels are entrenched several meters below adjacent young terraces along the Santa Cruz River and are extremely flood prone. Moderate to large flow events produce deep, high velocity channels. In the map area, generally unprotected channels are subject to severe lateral erosion during floods.	Low. Susceptible to lateral erosion	River channel. Potential damage to bridges and trails during floods.	Flooding and debris flows. Bank collapse.	Subject to washing away during flooding.	Sand and gravel.	Cottonwood – willow riparian environment.	Hiking trail. Water unsafe to touch.	History of channel incision; current erosional processes.
		Alluvium and Talus (Qal)	Younger alluvium and talus. No further description given by Simons (1974).	Low.	Roads, buildings, infrastructure.	Flash flooding.	Potential cultural sites.	Sand and gravel.	Ephemeral stream vegetation.	Roads near units.	Current erosional processes.
		Alluvium (Qy2, Qy1)	Qy2: Late Holocene (less than 2,000 years old). Channels, low terraces, and small alluvial fans of cobbles, sand, silt and boulders. Deposited by modern drainages. Sand and finer sediment typically mantle terraces. Generally, channels are incised less than 1 m (3 ft) below adjacent terraces and fans. Locally, incision may be as much as 2 m (7 ft). Terrace and fan surfaces are brown, and generally appear darker than surrounding areas on aerial photos; sandy to gravelly channels appear light-colored on aerial photos (fig. 15). Qy1: Approximately 2,000 to 10,000 years old. Scattered, low terraces along incised drainages on the piedmonts. Inundation of the slightly higher Qy1 surfaces is less than adjacent Qy2. Generally, planar surfaces with local relief as much as 1 m (3 ft) where gravel bars are present. Surfaces are: 1) less than 2 m (7 ft) above adjacent active channels, 2) typically sandy but may have gravel lags, 3) fairly dark on aerial photos, but light-colored where a gravel lag is present. Alluvial fan channels form weakly integrated distributary (branching downstream) systems. Units are mapped east of the Santa Cruz River; south of the Tumacácori Unit.	Low. Unconsolidated fine sediment is less resistant to erosion than cobbles and boulders.	Roads and borrow pits.	Unknown.	American Indian and early settler sites are possible.	Sand and gravel.	Dense mesquite, acacia, ash and willow; dense shrubs and grass. Smaller washes contain mesquite, acacia and shrubs.	Hiking and potential off-road use.	Provides data for channel incision history.
		Undifferentiated alluvium (Qy)	Less than 10,000 years old. Smaller incised drainages on the piedmonts and more extensive young alluvial fans at the base of the piedmonts, adjacent to the Santa Cruz floodplain. Includes both Qy2 and Qy1 deposits. Used where exposures did not allow differentiation between Qy1 and Qy2 surfaces at a 1:24,000 scale. Mapped on the western edge of the Tumacácori Unit.	Low, especially finer-grained sediment.	Limited areal extent in the park.	Incised drainages. Erosion potential.	American Indian and early settler sites are possible.	Material for adobe bricks (?)	Qy1 and Qy2 vegetation types.	Limited exposure.	History of Quaternary channel incision.
		Floodplain and terrace deposits (Qyr)	Less than 10,000 years old. Weakly to unconsolidated sand, silt, and clay on floodplains and terraces flanking the main channel system along the Santa Cruz River and Sopori Wash. Terrace surfaces are flat and uneroded, except immediately adjacent to channels. Typically altered to agricultural fields or urban development. Some surfaces are part of the active floodplain and may be inundated in large floods. However, most terraces were abandoned during the arroyo cutting of the late 1800s and are no longer part of the active floodplain. Local surfaces may experience sheetflooding during large floods in areas where the main channel is not deeply entrenched, and because of flooding on local tributaries that discharge onto Qyr surfaces.	Unprotected channel banks formed in Qyr deposits are very susceptible to lateral erosion.	Primary surface of Tumacácori Unit. Underlies buildings, roads, paths.	Sheet flooding during large flood events.	Agricultural, early settler, or American Indian sites.	Sand and clay for adobe bricks (?)	Ash, Hackberry, and Mexican elderberry mix with mesquite, acacia and palo verde trees near riparian corridor.	Forms the surface at Tumacácori Mission Unit.	History of channel incision over the last 10,000 years.
		Hillslope colluvium (Qc)	Locally-derived deposits on moderately steep hill slopes in the mountains. Clay to cobbles and boulders; very poorly sorted. Subangular to angular clasts deposited close to the point of origin. Mapped only where the unit can be identified in aerial photographs; not mapped in the park.	Variable.	Unstable slopes.	Potential landsliding.	Hillslopes may be adjacent to cultural sites.	Unknown.	Vegetation limited by slope and aspect.	Limited potential.	None.
	Pleistocene Upper	River terrace deposits and alluvium (Ql, Qlr, Qlyr)	Approximately 130,000 to 10,000 years old. Surfaces commonly have loose lags of pebbles and cobbles. Ql and Qlr clasts have weak to moderate rock varnish. Light orange to dark orange on color aerial photos (fig. 15). Ql: Pebbles, cobbles, and finer-grained sediment on slightly to moderately dissected relict alluvial fans and terraces. Found on the upper, middle and lower piedmont. Moderately to well developed, slightly to moderately incised tributary drainage networks. Active channels incised up to about 2 m (7 ft) below Ql surfaces. Incision typically increases toward the mountain front, and toward the southern end of the Santa Cruz Valley. Fans and terraces are commonly lower in elevation than adjacent Qm and older surfaces, but the lower margins of Ql deposits lap out onto more dissected Qm surfaces in some places. Qlr: Gravels, cobbles, and finer-grained sediment form river terraces typically 3 to 5 m (10 to 16 ft) above Qlyr terraces. Often intermixed with late Pleistocene distal piedmont Ql deposits along drainages. Qlyr: Unit Qlr overlain by thin veneers of units Qy, Qy2 and Qy1. Terrace deposits 2 to 3 m (7 to 10 ft) above Qyr floodplains. Reddened Pleistocene alluvium exposed in patches on low ridges, in roads, and cut banks of washes. Holocene surfaces usually are light brown. The units are not mapped in the park.	Low to variable. Coarse-grained material is more resistant to erosion than finer-grained sediment.	Gradual slopes would make this unit attractive to residential and commercial development.	Unknown.	Potential for American Indian and early settler sites.	Sand and gravel. Sand and clay for adobe bricks (?)	Ql: Grasses, small shrubs, cholla, prickly pear, barrel cacti, and mesquite. Ocotillo where carbonate parent material exists. Qlr: Vegetation is sparse; mesquite, grasses.	Limited surface exposures.	History of channel incision.

Age		Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Cultural Resources	Mineral Occurrence	Habitat	Recreation	Geologic Significance
QUATERNARY	Pleistocene Middle	Alluvium (Qm) River terrace deposits (Qmr)	Approximately 750,000 to 130,000 years old. Neither unit is mapped in the park. Qm: Well-preserved, planar, reddish-brown surfaces. Scattered pebble and cobble lags form moderately to highly dissected alluvial fans and terraces. Drained by well developed, moderately to deeply incised tributary channel networks. Dissection increases towards the mountains and the southern end of the map area. More eroded, rounded surfaces have scattered cobble lags with moderate to strong orange or dark brown rock varnish and broad, ridge-like topography. Well-preserved surfaces have a distinctive dark red color on color aerial photos (fig. 15). Qmr: Boulders, cobbles, gravels and finer-grained sediment. High, scattered river terrace remnants on unit QTs. Typically 45 to 50 m (150 to 160 ft) above the modern Santa Cruz River. Less than 2 m (7 ft) thick. Reddish-orange in color aerial photos, reflecting reddening of surface clasts and soil (fig. 15).	Low to variable. Coarse-grained material is more resistant to erosion than finer-grained sediment.	Unstable surface exposures, shrink/swell clay, and incised tributary channels may pose a challenge for development.	Erosion potential. Some clays in Qm will swell when wet and shrink upon drying (shrink/swell potential).	Potential for American Indian and early settler sites.	Sand and gravel.	Grasses, cholla, prickly pear, barrel cacti, mesquite, and ocotillo.	The unit may be transected by roads and trails.	History of channel incision.
	Pleistocene Lower	Alluvium (Qo)	Approximately 750,000 to 2 million years old. Cobbles, boulders, sand and finer clasts form very old alluvial fan remnants on top of highly dissected basin fill deposits (unit QTs). Surfaces are moderately to well-preserved with strong soil development. The unit is best preserved on the upper piedmonts near the mountain fronts. Unit is not mapped within the park.	Moderate. Stabilized by soil development.	Any infrastructure may be impacted by flash flooding or sheetflow on upper piedmont surfaces.	Some potential for swelling clays. Underlies ephemeral streams with flash flood potential.	Potential early settler, ranching, and American Indian sites.	Potential boulders for landscaping designs.	Mesquite, ocotillo, scattered cacti, and grasses dominate.	Possible hiking and horse trails along mountain front and upper piedmonts.	Surfaces record highest levels of aggradation in the Santa Cruz Valley.
		Alluvium (QTs)	Approximately 1 million to 5 million years old. Subangular to subrounded boulders, cobbles, and gravels with layers and lenses of sand, silt and clay. Basin fill consisting of very old, deeply dissected and highly eroded alluvial fan deposits derived from nearby mountains. Moderately indurated. Eroded ridges alternate with deep valleys. Drained by deeply incised tributary channel networks. Most predominant valley unit outside the park boundaries. Thickness varies from a few meters near the mountains to 260 m (850 ft) near Amado, about 16 km (10 mi) north of the Tumacácori Mission Unit.	High. Resistant due to large clasts size and carbonate accumulation.	Deep, incised channel networks should discourage development.	Potential flash flooding in incised drainages.	Potential early settler and American Indian sites.	Sand and gravel. Potential boulders for landscaping designs.	Grasses with scattered cacti, mesquite, acacia, and ocotillo.	Informal trails and potential for off-road vehicle use.	History of channel incision.
NEOGENE	Pliocene	Quaternary and Tertiary Older alluvium (QTal)	Slightly-to-moderately consolidated alluvium. Indurated. Forms cliffs in canyons northeast of the Guevavi Mission Unit.	Moderate. Partly consolidated.	Underlies roads, Guevavi Mission ruins, Nogales International Airport and other buildings.	Potential rockfall from cliffs northeast of the park.	Mission ruins. Potential sites of American Indians.	Sand and gravel.	Mesquite and acacia trees; cholla and barrel cacti.	Mission closed to the public.	History of basin filling.
	Miocene	Nogales Formation, undivided (Tn)	Epiclastic volcanic conglomerate containing abundant beds of sandstone and grit. Clasts are from the Grosvenor Hills Volcanics, north of the Calabazas Mission Unit. Forms Cuates Buttes, immediately north of the Calabazas Unit.	High.	Should provide a relatively stable foundation.	Unknown.	Potential American Indian sites outside park.	None.	Mesquite scrub environment.	Mission closed to the public.	Type locality is Nogales, AZ.
		Nogales Formation Lower Member (Tnl)	Light-gray to light-brown (rarely pale-red) conglomerate, fanglomerate, tuffaceous conglomerate and sandstone, and tuff; contains beds of water laid silicic tuff and tuffaceous sandstone. Coarse fanglomerate composed of granitic detritus along the upper Santa Cruz River grades westward toward Nogales into epiclastic volcanic conglomerate containing minor granitic components. Thickness may be as much as 1,500 m (5,000 ft). Mapped south of the Guevavi Unit.	Erosion resistance will depend on matrix cement.	High. Underlies buildings, roads, and most of Nogales, AZ.	Unknown.	Potential sites of early settlers and American Indians. Modern culture.	No significant minerals in the unit.	Mesquite scrub environment.	Not applicable with regard to activities within park boundaries.	Named for exposures east, in, and north of Nogales, AZ.
PALEOGENE	Oligocene	Bedrock, undifferentiated (R)	Extrusive rhyolite and rhyodacite of the Tumacácori Mountains, west of the Tumacácori Mission Unit. Light-gray to grayish-pink, vitric to fine-grained, porphyritic lava flows, welded tuff, pyroclastic rocks, and some epiclastic rocks. Commonly a few tens to a few thousands of meters thick. Dated at 23, 24, 25, 26, and 27 million years old (Drewes 1980). Drewes (1980) labeled the unit "Tv." The unit is not mapped in the park.	High.	Steep slopes and canyons present challenges for construction.	Rockfall.	Potential sites of American Indians, early settlers, miners.	Unknown. Some prospect pits.	Mountain vegetation.	Backcountry activities in Tumacácori Mountains.	Record extensive upper Oligocene to lower Miocene volcanic activity.

Age		Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Cultural Resources	Mineral Occurrence	Habitat	Recreation	Geologic Significance
PALEOGENE	Oligocene	Latite (?) dike (Tla)	Light-brownish-gray, 4.6 to 7.6 m (15 to 25 ft) thick; contains a few small phenocrysts of plagioclase, augite, and altered hornblende(?). Linear features in the Grosvenor Hills. Mapped in the San Cayetano Mountains.	High.	Low (linear features).	None. Linear exposures.	Linear feature.	Plagioclase, augite.	Mesquite scrub environment.	Not applicable.	Crosscutting relationships help age-date the igneous rocks.
		Biotite-hornblende rhyodacite (Tr)	Brownish- to pinkish-gray, porphyritic; plugs and dikes. Mapped in the Grosvenor Hills. Mapped north of Cuates Buttes (north of the Calabazas Unit).	High.	Limited areal extent.	Minor rockfall.	Limited areal extent.	Biotite, hornblende.	Mesquite scrub environment.	Not applicable.	
		Grosvenor Hills Volcanics (Thr, Thb, Thl, Tht)	Mapped in Grosvenor Hills, which includes Fresno Canyon, approximately 5.5 km (3.4 mi) north of the Calabazas Mission Unit, and Ash Canyon, about 10 km (6 mi) northeast of the Calabazas Unit. Thr: Light-brownish-gray to pale-red, coarse-grained, hornblende-biotite rhyodacitic or dacitic tuff. Thb: Grayish-red, brownish-gray, or light-gray, coarse-grained porphyritic biotite-hornblende rhyodacitic tuff, agglomerate, and flow breccia. Rhyodacitic agglomerate in upper part has blocks up to 1 m (3 ft) across. West of Fresno Canyon, flow breccia is overlain by a 1.2-m (4-ft) layer of chalcedony, and tuff breccia. East of Fresno Canyon, the unit contains some gray to grayish-red hornblende-hypersthene-biotite vitrophyre. Thl: Biotite latite. Gray, porphyritic, with conspicuous flow layering. West of Ash Canyon, base of Thl has massive flow breccia as thick as 30 m (100 ft). Some light-colored biotite rhyolite welded tuff in Ash Canyon. Tht: Orange-pink to pink or light-gray biotite rhyolitic vitric-lithic tuff. Thick-bedded, moderately consolidated, and pebbly. Many 0.3-m (1-ft) layers of pebble conglomerate and a few beds of boulder conglomerate as much as 3 m (10 ft) thick; silicic volcanic lithic clasts. In upper Fresno Canyon, lower part includes beds of rhyolite ("r"), well-bedded tuffaceous sandstone and tuff ("s"), and porphyritic biotite(?) andesite and andesitic agglomerate ("a").	High.	Volcanic rock would provide firm foundation, but building on faults should be avoided.	Potential rockfall on steep slopes and cliffs.	Potential sites of American Indians, early settlers, and miners.	Hornblende, biotite, augite, hypersthene, and chalcedony.	Mesquite scrub environment. Mesquite and acacia trees; cholla and barrel cacti.	Limited areal extent.	Equivalent to Tv mapped by Drewes (1980). Radiometric age dates of 27 and 28 million years old (Oligocene).
	Eocene	No deposits of this age in the map area									
	Paleocene	Heterogeneous volcanic and volcaniclastic rocks (Tgga)	Mostly gray, greenish-gray, or reddish-purple pyroxene andesite lava and flow breccia. Contains some andesitic tuff and breccia, light-gray to pink latitic to rhyolitic tuff and lava, and coarse volcanic conglomerate. Mapped north of the Calabazas and Guevavi Units in Ash Canyon, Mary Kane Canyon, and at the head of Guebabi Canyon, which is located between the Calabazas and Guevavi Units.	High.	Not applicable. Limited exposures.	Unit is mapped on gradual slopes with limited rockfall or other hazard potential.	Limited areal extent.	Pyroxene.	Mesquite scrub environment.	Not applicable; limited areal extent.	Equivalent to Tv of Drewes (1980). Oligocene?
CRETACEOUS	Upper	Salero Formation (Ks)	Gray, grayish-red, greenish-gray, or olive-brown arkosic (feldspar-rich) sandstone and pebbly sandstone; includes minor conglomerate and silicic tuff and welded tuff. Principal detrital minerals are plagioclase and potassium feldspars; less abundant components are quartz, biotite, and volcanic rock fragments. In the lower Santa Cruz River and within the Calabazas Unit, Ks is a gray, locally pale-red, distinctly bedded epiclastic volcanic conglomerate that contains subangular clasts as large as 0.3 m (1 ft) in diameter, although most clasts are less than 2.54 cm (1 in) in diameter. Volcanic rocks dominate the unit, but granitic rocks, diabase, aplite, and quartzite are also present. Unconformable contact with Jb. Thickness probably 610 m (2,000 ft) or more.	Variable. Welded tuff more resistant than sandstone.	Probably would provide a firm foundation. Strata dip about 35° to 40° west, but topography is relatively flat.	No major hazards.	Mapped in fault blocks of limited areal extent. Potential sites of American Indian and early settlers.	Plagioclase and potassium feldspars.	Rocky ground. Mesquite and "Coyote gourds" (Calabazas means "squash" or "gourds" in Spanish).	Mission closed to the public.	Derived from Jurassic granitic rocks and Triassic-Jurassic volcanic rocks.
	Lower	No deposits of this age in the map area.									
JURASSIC	Upper										

Age		Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Cultural Resources	Mineral Occurrence	Habitat	Recreation	Geologic Significance
JURASSIC	Middle	Quartz Monzonite of Mount Benedict (Jb, Jbm)	Minor exposures are mapped within the southern border of the Guevavi Mission Unit. Jb: Biotite-hornblende quartz monzonite. Light- to light-brownish-gray, coarse porphyritic; contains some granodiorite and quartz diorite. Mineral composition: 20% quartz, 36% plagioclase feldspar, 36% perthitic potassium feldspar, 4% biotite, 3% pale-green hornblende, and 1% accessories, mainly sphene. Radiometric ages range from approximately 164 to 160 million years old (K-Ar dates on biotite and hornblende). Jbm: Quartz monzonite. Light brown to light-gray, fine- to coarse-grained; contains abundant fine-grained or aplitic quartz monzonite on Mount Benedict, and much epidote-quartz-chlorite rock (epidosite) north and east of Mount Benedict. Probably is older than Jb. Numerous northwest-to-southeast trending, linear, lamprophyre dikes (see "dike" below) cut both units.	High.	Steep terrain. Jeep trails; roads; prospect pits and mines.	Potential rockfall in higher elevations. No major hazard in Guevavi Unit.	Remnants of past mining activities on Mount Benedict, but not within the park.	Plagioclase and potassium feldspar; biotite; epidote; hornblende; quartz; sphene.	Mesquite scrub environment. Mesquite and acacia trees; cholla and barrel cacti.	Limited exposures in the park. Jeep trails, roads, and hiking available outside the park boundaries.	Jurassic igneous intrusions.
JURASSIC	Uncertain Age Assignment	Minor units within the Quartz Monzonite (Jb, Jbm) (r, s, p, a, dike, vein)	None of these units are mapped in the park. r: Rhyolite or quartz latite dike. May be Cretaceous or Tertiary in age. s: Metasedimentary rocks. Inclusions of gray to black vitreous quartzite and other metasedimentary (?) rocks. Three isolated outcrops of limited areal extent south of the Guevavi Mission Unit. p: Microdiorite plug. a: Aplite dike. Many unmapped. dike: Lamprophyre dike. Mainly greenish-gray hornblende-plagioclase lamprophyre (spessartite); some micro-diorite or diabase. Most dikes are 2 to 10 feet thick; maximum thickness is about 200 feet. Commonly somewhat altered to epidote, chlorite, and carbonate; some dikes completely reconstituted. Intrudes units Jb and Jbm. Age not indicated. vein: No description. Intrudes units Jb and Jbm. Age not indicated.	High.	Linear features with limited areal extent.	None.	Not applicable. Limited areal extent.	Unknown, but limited areal extent.	Mesquite scrub environment.	Not applicable. Limited areal extent.	Records igneous activity.

Reference maps:

1) Simons, F.S. 1974. Geologic map and sections of the Nogales and Lochiel quadrangles, Santa Cruz County, Arizona. U.S. Geological Survey Investigations Map I-762 (scale 1:48,000).

2) Youberg, A. and W. R. Helmick. 2001. Surficial Geology and Geologic Hazards of the Amado-Tubac Area, Santa Cruz and Pima Counties, Arizona. Arizona Geological Survey Digital Geologic Map 13 (DGM-13) (scale 1:24,000).