

SCALE 1:24,000 1 Kilometers Approximate mean 1000 2000 3000 4000 5000 Feet declination, 2019 opographic base map derived from the Wickenburg 7.5' USGS topographic quadrangle map originally with NAD27 datum. Reprojected to UTM NAD83 datum (zone 12) using iGage All Topo Maps V9. UTM NAD 83 grid and lat-long markers produced using ESRI ArcMap v. 10.4. **CONTOUR INTERVAL 40 FEET**

Symbols and Lines

Rectangles on upthrown block

—— Tephra ash bed

location accurate

Horizontal bedding

strike and dip

location accurate

approximate. Rectangles on upthrown block

location approximate. Arrows show relative motion

Felsic dike - Identity and existence certain,

Mafic dike - Identity and existence certain,

Approximate orientation of inclined bedding

- Showing approximate strike and dip

Inclined bedding - Showing strike and dip

to bedding—Showing strike and dip

—Showing bearing and plunge

Inclined eutaxitic foliation - Showing strike and dip

Inclined gneissic layering—Showing strike and dip

Inclined metamorphic or tectonic foliation—Showing

Inclined slickenline, groove, or striation on fault surface

Inclined metamorphic or tectonic foliation parallel

——— Contact - Identity and existence certain, location accurate ——— Contact - Identity and existence certain, location approximate ······ Contact—Identity and existence certain, location concealed ——— Fault - Identity and existence certain, location accurate ——— Fault - Identity and existence certain, location approximate

Fault (generic; vertical, subvertical, or high-angle; or unknown or unspecified orientation or sense of slip)—Identity and existence certain, location concealed Gradational contact - Identity and existence certain, location

Incised-scarp sedimentary contact—Identity and existence certain, location accurate. Hachures point downscarp Internal contact - Identity and existence certain, location approximate

Key bed—Identity and existence certain, location concealed Oblique-slip fault, right-lateral offset—Identity and existence certain, ——— location accurate. Arrows show relative motion; ball and bar on downthrown block

Normal fault—Identity and existence certain, location accurate. Ball and bar on downthrown block Normal fault—Identity and existence certain, location approximate. ——— Ball and bar on downthrown block

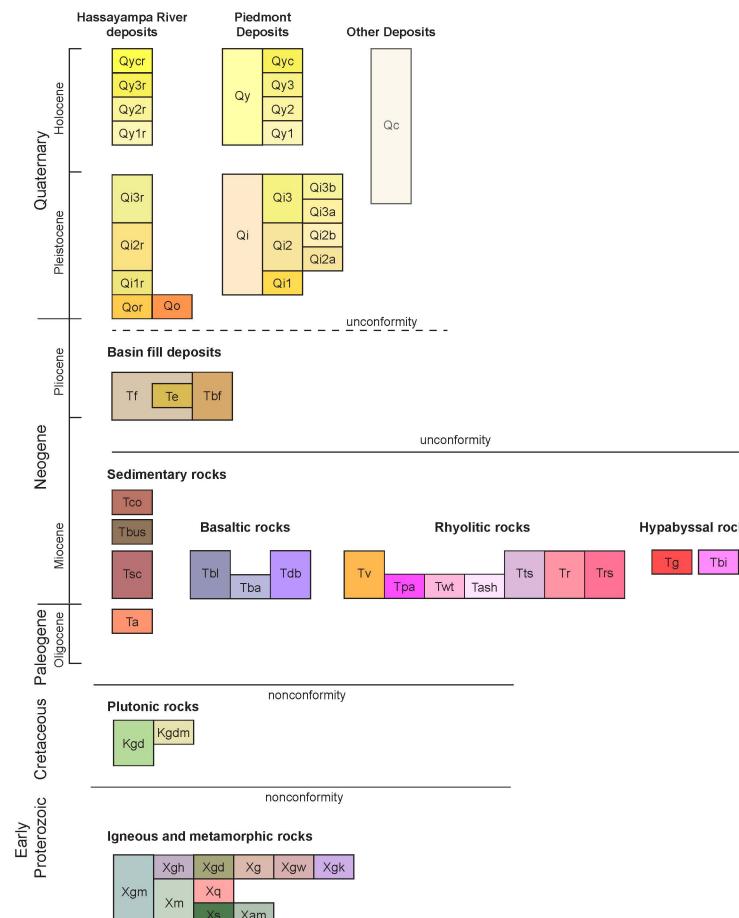
Normal fault—Identity and existence certain, location concealed. Ball and bar on downthrown block

Sediment transport direction determined from dune forms True dip direction and amount of fault Normal fault—Identity or existence questionable, location concealed. Ball and bar on downthrown block Vertical bedding - Showing strike

Reverse fault—Identity and existence certain, location accurate.

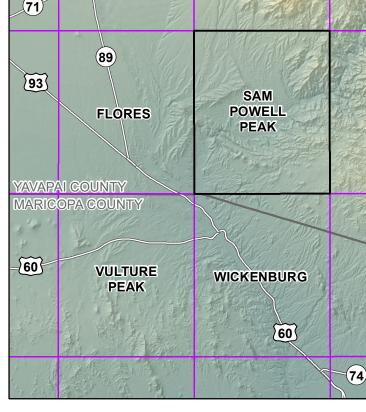
Strike-slip fault, right-lateral offset—Identity and existence certain,

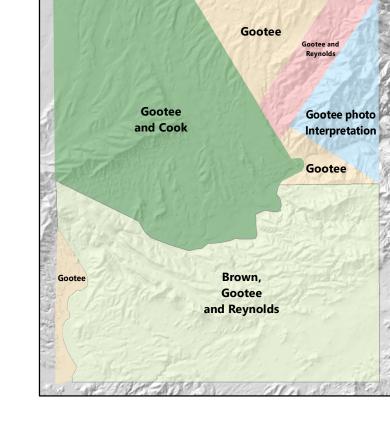
Reverse fault—Identity or existence questionable, location



Correlation of Map Units







Geologic map of Sam Powell Peak 7 ½' Quadrangle, Yavapai County, Arizona

Brian F. Gootee, Holly M. Brown, Joseph P. Cook and Stephen J. Reynolds Arizona Geological Survey

Digital Geologic Map 132 (DGM-132) January 2021

Sheet 1 of 2

Gootee, B.F., Brown, H., Cook, J.P., and Reynolds, S. J., 2021, Geologic map of the Sam Powell Peak 7 ½' Quadrangle, Yavapai County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-132, scale 1:24,000, 2 sheets.

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program under StateMap award number G18AC00298, 2018 and by EdMap award number G18AC00230. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

This geologic map is one of a series of four 7 1/2 quadrangle maps (AZGS DGM-131 through 134; Wickenburg, Sam Powell Peak, Flores, and Vulture Peak) in the Wickenburg area. New surficial mapping was conducted throughout the 4-quadrangle mapping area and bedrock mapping was compiled from existing geologic maps, with new bedrock mapping in Sam Powell Peak. Together, these maps include detailed surficial mapping of alluvium from the Date Creek, Weaver, Wickenburg, and Vulture Mountains as well as ancestral deposits of the Hassayampa River. The relationships between relict and modern alluvial fan and Hassayampa River deposits and their positions relative to pre-existing bedrock topography presents a glimpse into the arrival and development of the modern Hassavampa River system.

The Sam Powell Peak 7 ½ Quadrangle is located north of the town of Wickenburg and southeast of the town Congress in Yavapai County, Arizona. A system of interconnected dirt roads connects the map area to the town of Wickenburg and US Highway 93 to the south, and AZ Highway 89 to the west: Scenic Loop road, Stanton Hall road, and Angels Ranch road. Most of the mapping area is owned by State Trust lands and Bureau of Land Management (BLM) with minor private lands. The Hassayampa River Canyon Wilderness area along the Hassayampa and Sam Powell Peak areas is managed by BLM. Bedrock in the southern half of Sam Powell Peak quadrangle was mapped separately as part of the EDMAP grant (award no. G18AC00230).

The main focus of surficial mapping in the Sam Powell Peak quadrangle was Neogene and Quaternary basin-fill deposits, Hassayampa River deposits, and tributary deposits. The Hassayampa River flows between the Weaver Mountains (and its namesake Sam Powell Peak) to the north and northwest, the Wickenburg Mountains to the east, across the Black Hills to the south, and an unnamed topographic ridge and hydrologic boundary to the west. The intervening valley between these topographic highs is informally referred to as the "Sam Powell basin". Bedrock mapping focused on highly extended mid-Cenozoic volcanic and sedimentary rocks and their underlying Proterozoic and Laramide crystalline basement.

Geologic mapping was conducted under the joint State-Federal STATEMAP program, as specified in the National Geologic Mapping Act of 1992, and was jointly funded by the Arizona Geological Survey and the U.S. Geological Survey under STATEMAP assistance award #G18AC00298. Mapping in the southern half of the quadrangle was partially supported by the USGS and Arizona State University under EdMap award G18AC00230. Mapping was compiled digitally using ESRI ArcGIS software.

Surficial Geology

The surficial geologic units in the Sam Powell Peak 7 ½' Quadrangle consist of very high-standing relict alluvial fan deposits, extensive exposures of mildly dissected, well-rounded fanglomerate, inset alluvial terraces, and alluvium that records the arrival of the ancestral Hassayampa River. In the middle and distal piedmont deposits include widespread exposures of dissected fanglomerate and very old alluvial fan deposits sourced from the Weaver Mountains from the north. Clast composition and erosional character vary with parent material. Some of these deposits are armored by overlying Pleistocene alluvium. Deeply incised areas are filled by thin, unconsolidated Holocene to modern terrace and channel deposits. Broadly dissected, low-energy swales and valley bottoms are dominated by sheetflow and aggradational processes. Surficial geologic units were mapped using field observations, interpretation of digital aerial imagery, and digital elevation models (DEMs). Relative ages of alluvial deposits were estimated using characteristics of clast weathering, soil development, carbonate accumulation, and position in the landscape (Gile et al., 1981; Machette, 1985; Bull, 1991; and Birkland, 1999). Soil development and carbonate accumulation begin once a deposit is isolated from active alluvial processes. As a result, the degree of soil development and carbonate accumulation are one of the criteria used to identify the approximate ages of surficial units.

Younger alluvial deposits have little to no soil development, retain the original gray or brown color of the alluvial sediment, and little to no carbonate accumulation. Clasts in these deposits have no weathering rinds or surface patinas and thus appear brighter and fresher than older clasts. Young alluvial surfaces often retain original depositional characteristics such as bar and swale topography. Conversely, older alluvial deposits have better-developed soils that appear orange to red in color, with soil horizons reflecting clay and carbonate accumulation. Clasts on older alluvial deposits often exhibit darkened weathering rinds or rock varnish, and thus appear darker on the ground and in aerial photographs. Preserved alluvial surfaces may be smooth and flat (Qi3), becoming more rounded and coarser with age (Qi2). The oldest alluvial surfaces (Qi1 and Qo) are often eroded, well-rounded ridges with degraded soil preservation and carbonate horizon exposed. These surfaces appear white on aerial photos and ground surfaces due to widespread exposure of the carbonate horizon. Alluvial deposits sourced from granitic parent material exhibit very red, clay-rich surfaces with mature accumulation horizons and clay-coated clasts. Exposures of well-cemented older alluvium are present along active channels and within younger, unconsolidated alluvium in the middle and distal piedmont. Holocene alluvium along modern washes and arroyos is often inset below older deposits by several meters and confined to relatively narrow expanses within older alluvium. Within the modern incised channel bottom, young terraces are prone to flooding.

The Hassayampa River forms the main axial drainage in the quadrangle and originates from the Bradshaw Mountains just south of Prescott, AZ. The river then flows across the Milk Creek basin into the bedrock-cored Wickenburg and Weaver Mountains and enters the map area into and across basement crystalline bedrock, tilted mid-Cenozoic strata, and basin-fill deposits within the Sam Powell basin. Its major tributaries in the map area are Weaver Wash, Fools Canyon and unnamed washes between these. Categorically the Hassayampa River is a transverse drainage flowing across bedrock domains (Douglass and Schmeeckle, 2007), thus the river and many of its tributaries form slotted bedrock canyons between valleys and basins. In the Sam Powell basin, a thick 60- to 70m-thick deposit of gravel, cobbles and boulders forms an unnamed ridge west of the Hassayampa and south of Weaver Wash (map unit Qor). This unit overlies basin-fill coarse-grained fanglomerate (Tf), finer-grained alluvium (Tbf), and eolian deposits (Te) locally sourced from adjacent bedrock areas. The Qor deposit is sourced from bedrock lithologies within and outside the Sam Powell basin, upstream of the mapping area. Qor deposits are interpreted as representing an episode of aggradation in response to base-level change between upstream and downstream areas. Tributary deposits also track this aggradation and locally are as thick as Qor. The ancestral Hassayampa deposits and their map pattern are thought to occupy the former position of the ancestral Hassayampa River over the top and western portion of Black Hills, and can be tracked to the southwest into portions of the southern Sam Powell Peak, Flores, and

Powell Peak, but have subsequently been dissected by the Weaver and adjacent washes. The base of Qor deposits is planar, sharply unconformable with underlying basin-fill deposits, and its gradient slightly steeper than the modern river. Thickness of Qor deposits between Weaver Wash and Sols is not well constrained. Qor deposits lack any sign of deformation such as faulting or tilting. Calcic and argillic soil development on remnant (?) planar surfaces atop Qor are mapped separately as Qo deposits, indicated a likely early Pleistocene age of remnant soils; however, the age of ancestral Hassayampa River deposits and its integration are not known. Following deposition of Qor deposits, the Hassayampa River became superimposed near its present location over Black Hills. Pleistocene and Holocene Hassayampa deposits Qi1r through Qy3r record the subsequent incision and degradation of the river and are relatively thin deposits strathed on older basin-fill deposits.

Bedrock Geology

Bedrock exposures in the northern half of the Sam Powell Peak quadrangle form the eastern third of the map area. Bedrock generally consists of Early Proterozoic crystalline igneous and metamorphic rocks, and mid-Cenozoic volcanic and sedimentary rocks. The pre-Hassavampa River deposits are interpreted to be basin-fill related deposits that are middle to late Miocene or Pliocene. Basin-fill deposits north of Black Hills are sourced from Black Hills, Wickenburg Mountains to the east and northeast, and Weaver Mountains from the north and northwest. Coarse alluvial fan deposits flank the bedrock boundary, where eolian sand ramps and dunes are interbedded with alluvial fan deposits. Further down-dip, imbrication in basin-fill alluvial deposits indicate deposition towards the west and southwest. Cross section A-A' and B-B', combined with mapping and well data, indicate depth to bedrock in this basin is open to the west, and is generally less than 1,000 ft deep.

Bedrock exposures in Sam Powell Peak quadrangle record mid-Cenozoic extension (~30 to 15 Ma) that was associated with low-angle detachment faulting, moderate to low angle normal faulting, and mostly bimodal magmatism (Spencer and Reynolds, 1989). North-to northwest-trending normal faults mostly dip 40° or less to the southwest and cut and tilt the Proterozoic to Paleogene and Neogene units throughout the quadrangle, producing a domino-style repetition of sections (see cross section B-B'). Some faults are strongly curved, with northeast-trending segments that functioned as later ramps bounding tilted fault blocks. The Paleogene and Neogene units overlying the basement dip steeply to the northeast (55°) and shallow upsection (<35°), indicating that deposition and emplacement of the units was contemporaneous with tilting and faulting. Evidence for faulting during the accumulation of Paleogene and Neogene sequences is well expressed as a buttress unconformity between moderately to steeply tilted lower basalt and a less tilted overlying sedimentary deposits.

Bedrock exposures in the southern half of Sam Powell Peak quadrangle are mid-Cenozoic volcanic and sedimentary rocks that lie unconformably on top of metamorphic-plutonic Proterozoic (1.8-1.4 Ba) and Laramide (~60 Ma) crystalline rocks. Basal clastic late Paleogene and early Neogene deposits include a basal arkosic sandstone and conglomerate that record early erosion of granitic basement and deposition of this material by local streams. These basal clastic rocks are overlain by several welded tuffs and then by highly altered and manganese-mineralized basalt (locally called the "lower basalt"). The basalt is overlain by a sequence of debris-flow breccias and locally-sourced, stream-deposited conglomerates. The upturned Paleogene to Neogene sequence was eroded and partially covered by basin fill and surficial deposits, including those of the Hassayampa River.

The south-central portion of southern Sam Powell Peak quadrangle contains several newly discovered normal faults responsible for the down-dropping and tilting of the rocks exposed in the Hassayampa Box Canyon (see section 20 on map and cross sections C-C' and D-D'). The main fault likely has kilometers of displacement and to the southeast terminates an oblique-slip reverse fault (340°, 70° SW) that is interpreted to be an overturned normal fault. A third, major northeast-trending fault to the southwest is interpreted to be a leftlateral tear fault, or lateral ramp, with hundreds of meters of displacement. This fault apparently terminates against the oblique dip-slip

Adjacent regions were mapped in Wickenburg, southern Buckhorn, and Northwestern Hieroglyphic Mountains (Stimac et al. 1987, Grubensky et al. 1989). Similar bedrock units mapped in Sam Powell Peak and adjacent regions consist of metamorphic-plutonic Proterozoic rocks, Laramide crystalline rocks, and mid-Cenozoic San Domingo Volcanics, lower basalt, sedimentary conglomerate, and basin-fill sequences. Adjacent regions have exposures of early Neogene Hells Gate volcanics and upper basalt flows, units that are not exposed in Sam Powell Peak quadrangle, although are exposed immediately south and southwest of the quadrangle in the Flores, Vulture Peak and Wickenburg quadrangles. Units that are local to Sam Powell Peak quadrangle are the Box Canyon conglomerate

Mineralization is common in the region. Precious-metal and base-metal prospects occur in the mid-Cenozoic and Proterozoic units, mainly localized in veins and fault zones with intense brecciation (Stimac et al., 1987). The mapping area has been historically mined for copper, gold, silver, lead and zinc with or without lithium, beryllium, tungsten and other precious metals. Mining in the Rich Hills, Congress, Octave, Beehive and Bishop Districts lie immediately north of the mapping area within the Weaver Creek watershed, historically and principally mined for gold and silver (ADMMR, 2011). Mining in the Morgan Butte area, Wickenburg Mountains, was principally for copper. Host bedrock has been classified as granite, gneiss, diorite and porphyry dikes, veins and pegmatites, with mineralization of late Proterozoic, Laramide, and mid-Cenozoic age, respectively (ADMMR, 2011, Keith et al., 1983). Mineralization in the Paleogene and mid-Cenozoic rocks is a result of hydrothermal alteration during the extensional and magmatic period in the region around 25 to 15 Ma. Intermittent and active small-scale in-situ and placer mining is present locally in the mapping area. Exploration of porphyry copper mineralization associated with the large Late Cretaceous (Laramide) granodiorite pluton and stratiform manganese deposits (Grubensky et al., 1989; McAlpin, 2008; Ferguson and Johnson, 2014) is also ongoing. Pre-Cenozoic deposits have been tilted by mid-Cenozoic extension.

Acknowledgments

Mapping of the southern Sam Powell Peak quadrangle was supported by Arizona State University (ASU) and USGS EDMAP Program, which helped identify relationships between bedrock and alluvial units. We'd like to thank landowners in the northern mapping area for access to private property and access along the Hassayampa River.

ADMMR, 2011. Bishop District, 2011-01-0372, ADMMR mining collection, Arizona Geological Survey. Birkland, P.R., 1999, Soils and geomorphology (third edition): New York, Oxford University Press, 430 p.

Bull, W.B., 1991, Geomorphic Response to Climate Change: New York, Oxford University Press. Douglass, J. and Schmeeckle, M., 2007. Analogue modeling of transverse drainage mechanisms. Geomorphology, 84(1-2), pp.22-43. Ferguson, C.A. and Johnson, B.J., 2014, Geologic map of the western half of the Columbia 7 ½' Quadrangle and the eastern half of the Copperopolis 7 ½ Quadrangle, Yavapai County, Arizona. Arizona Geological Survey Digital Geologic Map DGM-109, scale:

Gile, L.H., Hawley, J.W., and Grossman, R.B., 1981, Soils and geomorphology in the basin and range area of southern New Mexico guidebook to the Desert Project: New Mexico Bureau of Mines and Mineral Resources, 222 p. Grubensky, M.J., 1989, Geologic map of the Vulture Mountains, west-central Arizona [Wickenburg SW, Vulture Mine, Wildcat Well, Wickenburg, Vulture Peak, Outlaw Hill, Black Butte, and Forepaugh Peak 7.5 min. Arizona Geological Survey, Map-27, 3 map

sheet, map scale 1:24,000. Grubensky, M.J., Stimac, A.J., Reynolds, S. J. and Richard, M.S., 1987, Geologic Map of the Northeastern Vulture Mountains and Vicinity, Central Arizona. Arizona Geological Survey Open File Report, OFR-87-10, 1 map sheet, map scale 1:24,000, 9 p. Keith, S.B., DeWitt, R.H., Troll, W. and Everson, A.B., 1983, Metallic Mineral Districts and Production in Arizona. Arizona Geological

Survey Bulletin 194. Machette, M.N., 1985, Calcic soils of the southwestern United States, in Weide, D.L., ed., Soils and Quaternary geology of the southwestern United States: Geological Society of America Special Paper 203, p. 1-21. McAlpin, D., 2008, Mid Cenozoic Geology of the Hassayampa River Canyon, Central Arizona. MS Thesis. Arizona State University.

Reynolds, S.J., Spencer, J.E., DeWitt, E., White, D.C. and Grubensky, M.J., 1988, Geologic map of the Vulture Mine Area, Vulture Mountains, west-central Arizona. Arizona Geological Survey Open File Report, OFR-88-10, 1 map plate, map scale 1:24,000, 5 p. Spencer, J.E., and Reynolds, S.J., 1989, Middle Cenozoic tectonics of Arizona and adjacent areas, in Jenney, J.P., and Reynolds, S.J., eds., Geologic evolution of Arizona: Arizona Geological Society Digest 17, p. 539-573. Stimac, J.A., Fryxell, J.E., Reynolds, S.J., Richard, S.M., Grubensky, M.J. and Scott, E.A., 1987, Geologic map of the Wickenburg, Southern Buckhorn, and Northwestern Hieroglyphic Mountains, central Arizona. Arizona Geological Survey Open File Report,

Map Unit Descriptions

Active river channel and bar deposits - Active river channel, shallow bar floodplain deposits. Unconsolidated, moderately to poorly sorted sand with some gravel. Clast

Vegetation along banks consists of mesquite, cottonwood, ash and dense shrubs. Active river floodplain banks and terrace deposits - Includes gravel, sand and silt deposited as bars and swales typically less than 1 m above active channel. May include Qy₃r coarser sediment in proximity to junctions with tributary washes.

lithologies consists of various granitoids, volcanics, schist and rare quartzite. Clast size generally pebble and cobble with less common clasts up to 1 m in long dimension.

Low floodplain river terraces - Unconsolidated gravel, sand, silt and some clay found adjacent to active river channel and floodplain Qy3r and Qycr deposits. Surfaces are Qy₂r about 2 m above the active channel and have moderate vegetation consisting of willow and young mesquite. Soil absent to weakly developed.

Low river terraces along modern floodplain margin - Low river terrace deposits consisting of unconsolidated gravel, sand, silt and some clay found 2 to 4 m above modern Qyır floodplain, and more heavily vegetated than younger deposits. Vegetation consists of cottonwood, mesquite, creosote, acacia, yucca, prickly pear, shrub, and grasses.

Lowest-intermediate river terraces and alluvium - Low-lying terraces along modern Hassayampa River consisting of unconsolidated to lightly consolidated boulders, gravel, sand and silt with minor clay. Qi3r deposits are undivided and are equivalent to tributary units Qi3a and Qi3b. Unit Qi3r terrace deposits form broad, flat terraces elevated 10 to 15 m above the modern river, with minimal dissection, and are commonly capped by Qi3 deposits. Qi3r deposits exhibit light to moderate argillic and calcic soil Low to high intermediate river terraces and alluvium - Unconsolidated to weakly consolidated boulders, grayel, sand, silt and minor clay found in terrace deposits elevated 30 to 50 m above the modern river corridor, with generally higher elevations north of Black Hills. Qi2r deposits undivided, and are equivalent to Qi2a and Qi2b, and can be

up to 15 m thick along the river, commonly capped by Qi2 tributary deposits. Soil development is moderate to strong stage III. North of Black Hills, scarps are present that

High-intermediate river alluvium - Unconsolidated to weakly consolidated silt, sand, gravel and boulders, with minor clay. Deposits are generally light tan, sand-supported es commonly clast-supported, crudely bedded with locally abundant cross-laminated sand. Clasts are very poorly to moderately sorted, subrounded to rounded, with derate sphericity. Qi1r deposits occur as both fill and strath deposits overlying bedrock and basin-fill paleo-topography and are overlain by Qi tributary deposits in many places along the river corridor. Qi1r deposits eroded into well-rounded landforms with some remnant planar or gravel lag surface. Clast lithology consists of varied granites, etamorphic rocks, pegmatitic and vein quartz, and felsic and mafic volcanic rocks derived locally and upstream outside the Wickenburg quadrangle. Strath deposits are generally 1 to 4 m thick and exhibit stage III and IV soil development on uppermost deposits, and stage II to III on colluvial slopes. Qi1r deposits are generally 90 to 100 m above the modern river upstream of Black Hills, and 60 m above the modern river downstream of Black Hills. Qi1r deposits represent the earliest river deposits found in Box Canyon, where the river is believed to have entrenched across Black Hills at this time.

Oldest river alluvium - Loose to moderately consolidated, poorly sorted, moderately rounded alluvial deposits. Lithology of clasts is very diverse and generally consist of well-mixed granitoids, metamorphic and volcanic rocks. Qor deposits are located high in the landscape, unconformably overlying basin-fill deposits north and west of Black Hills and are as much as 70 to 90 m thick. Remnant alluvial surfaces of Qor are capped with moderate to strong soil development, thick argillic and calcic horizons mapped as unit Qo. Qor deposits erode into well-rounded ridges and nobs, deeply dissected by modern washes and guillies graded to the modern Hassayampa River east and Weaver and Antelope washes west. The base of unit Qor dips gently to the southwest. Imbrication of clasts indicates consistent transport to the southwest. Qor deposits are interpreted to represent the initial integration of the Hassayampa River onto basin fill deposits (Tbf) and are sourced from diverse rock types upstream of the mapping area. Highest fanglomerate deposits (unit Tf) in the eastern part of the mapping area are considered equivalent to the highest Qor deposits. The western mapped boundary of Qor is not well defined and includes deposits sourced from Weaver and Antelope washes. Old pedogenic deposits associated with Qor - High-standing remnant alluvial deposits associated with underlying ancestral Hassayampa River deposits (Qor), and two

isolated exposures east of the river and north of Black Hills as colluvial remnants. Qo overlying Qor deposits exhibits a remnant planar surface that dips gently to the south-southwest and has strong argillic soil development and moderate calcic development. Soil thickness is estimated between 1 to 2 meters. Vegetation consists of creosote, ocotillo, saguaro, palo verde, cholla and small shrubs and grasses.

Piedmont Deposits

Basin Fill Deposits

derived from adjacent bedrock.

Active channel deposits - This unit includes active, open channels and tributary washes on the piedmonts that could be delineated at a scale of 1:24,000. This unit is Composed of moderately sorted sand, gravel, and pebbles with some cobbles in the lower piedmont areas to poorly sorted sand, gravel, pebbles, and cobbles in the upper piedmont areas. Channels are generally incised less than 0.5 to 1 meters below adjacent Holocene terraces. Channel morphologies consist of a single thread, deep, high-flow channel of multi-threaded shallow low-flow channels with adjacent gravel bars. The channels are flood prone and are subject to deep, high velocity flow during moderate to large flood events. Channels are subject to scouring and bar deposition. Banks are subject to lateral erosion. There is no soil development in this fluvially active unit, and little to no vegetation within the channels.

Active channel, bar and low terrace deposits - Moderate to poorly sorted, unconsolidated silt, sand and gravel deposits of active ephemeral washes and alluvial fans on the piedmonts of the Wickenburg Mountains. Characterized by fluvial channels and bars composed of locally derived gravel eroding from remnants of abandoned alluvial fans and ancestral Hassayampa river deposits. Terrace margins are typically elevated about 0.5 to 1 m above active washes and mantled with fine sand and silt, where soil development is absent to lightly developed. Lightly vegetated except along channel margins, bar islands, and low terraces. Channels are prone to flooding during moderate to large precipitation events with scouring and bar deposition and lateral erosion of banks.

Low terrace deposits along larger active washes - Alluvial deposits and surfaces related to active ephemeral washes that are frequently active or relatively recently abandoned and not laterally extensive. Deposits are composed of poorly to moderately sorted and bedded coarse sand and gravel and commonly capped by silt and sand

elevated 1 to 2 m above active washes with paired and unpaired terraces common. Well-preserved depositional micro-topography and fabric, with no varnish, no clay

accumulation, and weak carbonate accumulation in places. Vegetation includes creosote, palo verde, ironwood and mesquite. Low terrace deposits along inactive portions of active channels - The youngest, likely fully abandoned alluvial deposits and surfaces elevated about 1 to 3 m above active washes. Unconsolidated, poorly to moderately sorted sand and gravel. Surfaces have relict depositional micro-topographic bars and channels and hosts weakly integrated networks of very small distributary channels with thin sheetflood deposits. Soil development is weak with incipient carbonate accumulation, very minor clay accumulation with possible light varnish on large gravel. On upper piedmonts vegetation consists of predominantly creosote with some saguaro, ironwood, cholla and small palo verde. Along Hassayampa River Qy1 deposits occupy relatively wide embayments with thick riparian vegetation.

Qy Young piedmont deposits, undivided - Assemblage of Qyc, Qy3, Qy2, and Qy1.

appear to track incision and eastward migration of the river.

Qc Quaternary colluvium - Unconsolidated to moderately consolidated colluvium and talus hillslope deposits.

Intermediate piedmont deposits, undivided - Unconsolidated to weakly consolidated deposits of silt, sand, and gravel with rare boulders. Deposits comprise abandoned Qi terraces and alluvial fan remnants formed on bedrock, basin fill and older river deposits.

Low-intermediate piedmont deposits - Unconsolidated to weakly consolidated gravel, sand and silt with minor clay, forming generally wide planar surfaces. Qi3 deposits are about 1 to 4 m thick and exhibit light to moderate, stage II to III- soil development. Vegetation includes cholla, acacia, creosote, and dwarf mesquite. This unit includes older, higher-elevated Qi3a and younger, lower-elevated Qi3b units.

Lowest-intermediate terraces and alluvial fan deposits, younger member - Qi3b deposits are generally broader and less dissected than Qi3a deposits and along the river

Low to high intermediate piedmont deposits - Unconsolidated to weakly consolidated gravel, sand and silt found 40 to 70 m above modern washes as broad, moderately

Qi₃b conceals Qi3r deposits. Low-intermediate terraces and alluvial fan deposits, older member - Qi3a deposits closely resemble Qi3b deposits in morphology but occupy slightly higher positions in the

dissected remnant planar alluvial surfaces. Upper Qi2a and lower Qi2b deposits are separated by 15 to 20 m elevation. Qi2 deposits can be up to 15 m thick in places, which are thought to represent fill terraces, followed by Qi2 and Qi3 deposits inset into older Qi2 fill deposits. Soil development on surface remnants exhibit moderate ardillic and calcic accumulation.

Intermediate-low terraces and alluvial fan deposits, younger member - Qi2b deposits closely resemble Qi2a deposits in morphology but occupy slightly lower positions in

High-intermediate terraces and alluvial fan deposits, older member - Qi2a deposits closely resemble Qi2b deposits in morphology but occupy slightly higher positions in the High-intermediate piedmont deposits - Unconsolidated to weakly consolidated boulders, gravels, sand and minor silt and clay, forming well-rounded, linear alluvial deposits elevated 50 to 70 m above modern washes. Qi1 deposits are equivalent to Qi1r deposits and exhibit moderate to strong argillic and calcic soil development, stage III to IV.

Basin-fill deposits, undifferentiated - Tan to light gray brown, poorly consolidated to moderately consolidated gravel and sand with minor silt and clay, found generally in valleys between bedrock mountain ranges. Unit Tbf includes two facies: coarse-grained fanglomerate (Tf) and eolian fine-grained deposits (Te). Bedding is generally planar and discontinuous with medium, thick to massive bedforms. Eolian beds, lenses and horizons are interbedded with sand and gravel beds. Clasts consists of locally derived bedrock units found in the mapping area: plutonic, volcanic and metamorphic rocks. North of Black Hills unit Tbf dips gently to the west with consistent westward imbrication. South of Black Hills this unit dips gently to the southwest, with southward imbrication of clasts. Older beds of this unit are locally faulted, generally more consolidated, with gentle to moderate dips that decrease up-section (fanning dips). Up section beds are horizontal and generally poorly consolidated. Thin to medium beds of tephra occur in some exposures and are typically reworked. Unit Tbf can be several hundred feet thick in the map area.

Fanglomerate - Tan to gray, poorly consolidated to moderately consolidated gravel and sand with minor silt and clay, found generally adjacent to mountain ranges, deeply dissected by modern washes. Clasts consist of poorly sorted pebbles, cobbles and boulders derived from Proterozoic basement, primarily of granitic composition (Xg, Xgw, (gd, and granitic gneiss), and also include Cretaceous igneous rocks and mid-Cenozoic volcanic rocks. Unit Tf is matrix- and clast-supported and has bedding ranging from thin, crude to massive. Bedding in unit Tf exhibits a wide range of depositional dip, as much as 35° to as little as 1°, with greater dip adjacent to bedrock, and decreasing dip with higher stratigraphic position (fanning dips). The unit erodes into well-rounded ridges with an abundant gravel lag, where granitic boulders can be

Eolian deposits - Light gray to tan, Eolian deposits located adjacent to bedrock-dominated areas. Consists of very well to well-sorted, fine and medium quartz and lithic sand as sand sheets, sand dunes (multi-directional) with foreset and backset beds, and sand ramps. Eolian deposits are interbedded with coarse, proximal fan gravels and anglomerate (unit Tf), and with more distal alluvial deposits (unit Tbf). Light to moderate cementation, and locally faulted up to a few meters offset. Consists of well-rounded quartz and feldspar grains (0.5 to 1 mm). Clasts are locally bedded as sand-supported gravel and floating gravel in massive sand. Clasts consist of lithology

Tertiary Volcanic and Sedimentary Rocks

OFR-87-09, 2 map sheet, map scale 1:24,000, 21 p.

Box Canyon conglomerate - Red to reddish brown cliff-forming conglomerate that is matrix supported and well cemented within a coarse to medium sandy matrix. Consists of local upward-fining sequences bedded on a scale of 1 to 60 cm. Clasts are sub-angular to angular poorly sorted pebbles to boulders. Clasts consist of 50% (gd, 40% Tb to basaltic andesite (Tba), 10% Kgd, and <1% Tr. Clasts can be up to 30 cm in diameter. Basalt clasts are dark gray to reddish gray vesicular to non-vesicular with amygdules filled with calcite. The unit is locally capped by eolian sandstone (Te) and Tf. Bedding in all sections of the conglomerate lacks clear imbrication; may represent gravelly channel or debris-flow deposits that are locally derived, sourcing from volcanic and metamorphic sections near the present-day Box Canyon. Beds in the unit dip as much as 35°, with dips decreasing with higher stratigraphic position (fanning dips).

sub-mm mica phenocrysts, and vugs lined with milky quartz. Dike thicknesses are between 0.5 and 2 m. Dikes typically intrude into mid-Cenozoic low angle SW

Basaltic intrusions - Dark gray to dark brown and dark greenish gray, nonresistant, aphanitic to fine-grained basaltic dikes containing plagioclase microphenocrysts.

Rhyolite - Yellowish-cream to locally pink rhyolite tuff that weathers tan and forms massive exposed outcrops. Composed of yellow flattened pumice up to several cm

eucocratic granite - Light-gray, medium-grained, equigranular biotite granitoid that is locally flow foliated and contains miarolitic cavities. Biotite composes pproximately 10% to 15% of the rock and phenocrysts include plagioclase, K-spar, and quartz.

that makes up 30% to 40% of rock, 3% to 5% sanidine, 3% to 5% altered biotite, and 1% quartz. The rock is not bedded or sorted and has ~5% accidental lithics. The init is locally in an angular unconformity with unit Xm. The contact is irregular and exhibits a slight degree of baking or hydrothermal alteration, which includes calcite, barite, and manganese mineralization. Interpreted as a welded ash-flow tuff. Rhyolite flows, domes and dikes - Light-gray, resistant, flow-foliated, quartz and sanidine phyric rhyolite that is interbedded with and intrudes pyroclastic rocks (Tts).

Spherulites, geodes, and vugs lined with quartz are common. Rhyolite flows low in section are biotite poor, whereas those higher in section have 3% biotite. The hyolite contains 15% sanidine and 5% percent quartz. Hydrothermal alteration likely from fluids related to mid-Cenozoic faulting and volcanism. Mineral assemblage Pyroclastic rocks - Yellow, unwelded, massive to thin-bedded and laminated, locally cross-bedded tuff, lapilli tuff, and lithic lapilli tuff of pyroclastic flow-, fall-, and

surge-related origin. Phenocrysts consist of sanidine and biotite. Angular lithic fragments of crystal-poor rhyolite (unit Trs) are locally 4 m across. Description from

Tash likely from hydrothermal alteration.

Tuff to welded tuff - White to buff-colored aphyric to phenocryst-poor ash-flow and air-fall tuffs. Contains granule-sized lapilli and lithics and some small angular pebbles Air-fall and pyroclastic flow tuffs - Massive to lightly bedded, red and green airfall tuff and pyroclastic flows. Green tuff contains 10% quartz and feldspar, including some larger quartz that is 1 - 2 mm and greenish altered pumice up to 5 mm. Red tuff contains ~5% grains and 5 - 10% creamy pumice. The red tuff does not contain a lot of

Mixed Volcanics - Interbedded Tdb, Tash, Tr, Trs, Tts, and Tba.

Unit represents bimodal volcanism in the area

Dacite to rhyodacite - Gray to purplish gray, finely crystalline dacite with biotite, hornblende, quartz, and plagioclase. In contact with and interbedded with Tb and Tr. Locally contains purple-gray aphanitic flow-banded flow breccia.

obvious lithics while the green tuff has a slightly higher percentage, with 10% volcanic lithics that are mostly basalt. There is a fuzzy contact between the two tuffs,

indicating they happened around the same time. Contacts tuffaceous sandstone and is within the basaltic flow package outcropped in the Hassayampa Box Canyon.

Basalt and basaltic andesite - Dark gray to reddish gray, vesicular and aphanitic basalt to basaltic andesitic flows that are moderately to well exposed and heavily That | fractured. Mafic flows contain up to 5 to 20% phenocrysts, including up to 10% olivine and up to 10% plagioclase. Olivine phenocrysts and irregular masses can be altered to iddingsite. Mafic flows can be interbedded with rhyolitic flows (Tr, Trs), pyroclastic rocks (Tts), and clastic sedimentary rocks (Ta). Massive, well-consolidated flow breccia consisting of boulders to pebbles of angular Tba, Tbl, and Tdb clasts in a red scoria matrix are also present in the unit, along with local hydrothermal alteration with calcite veining and quartz, calcite, and chrysocolla amygdules. Unit mineral assemblages from Stimac et al. (1987). Lower basalt - Dark gray, fine-grained, nonresistant basaltic lava and scoria containing phenocrysts and microphenocrysts of plagioclase, clinopyroxene, and olivine.

livine phenocrysts are replaced by iddingsite; clinopyroxene phenocrysts are altered to green clays. Locally basalt is interbedded with arkosic sedimentary rocks. aximum exposed thickness is approximately 200 m. Volcanic conglomerate - Massive and poorly sorted sandy conglomerate with angular boulder to pebbles of angular vesicular and non-vesicular Tb in a sandy loosely nsolidated matrix. About 15 to 20 meters thick

Arkosic conglomerate and volcanics - Interbedded Ta, Tba, and tuffaceous sandstone. Arkosic rock is coarse-grained, reddish quartz in a sandy matrix with moderately sorted pebbles to cobbles of scoria, quartzo-feldspathic red granite, epidote, and Xgw in a well indurated matrix. Tuffaceous sandstone is red to white and contains 50% grains, primarily quartz. Deposition of unit Tsc is interpreted to be contemporaneous with volcanism.

Basal arkose - Medium to dark reddish-brown, coarse-grained arkosic conglomerate and conglomeratic sandstone with subangular to subrounded pebbles to cobbles of quartz- and feldspar-bearing rocks, in part originating from Xgh. The unit contains no volcanic or metamorphic clasts. Bedding is 10 to 60 cm thick, crude to massive. Matrix-supported conglomerate consists of red quartz sand. Unit dips NE at 48 – 55° and are cut by southwest-dipping normal faults. In the northeastern part of the map area Ta dips 30 to 45 degrees. Cretaceous Rocks

indeformed and intrudes Proterozoic basement rocks. Unit mineral assemblages from Stimac et al. (1987).

Laramide granodiorite and mafic dikes - Unit Kgd intruded by mafic dikes. Mafic dikes are dark gray/brown to dark green and are aphanitic to fine-grained with square kgdm plagioclase microphenocrysts. Dikes are likely diabase and Tb. Intrusive contacts are best represented in the mapping area by zones of baking.

Laramide granodiorite - White to gray, locally porphyritic, medium-grained granodiorite with 10% to 25% plagioclase, 10% to 25% quartz, 10% to 20% thick biotite

books, 5% to 20% hornblende, and trace sphene. Locally contains angular inclusions of diorite and amphibolite that are typically a few inches across. Unit is relatively

Granitic rocks - Light-gray to white, tan, and orangish-brown medium-and fine-grained, foliated, leucocratic, biotite granite. The unit includes several granitic lithologies, the most common being a medium-and fine-grained, foliated light-gray biotite granite. Phenocrysts include 15 percent quartz, 50 percent plagioclase, 30 percent K-spar (which can be slightly porphyritic grains 5 mm to 1 cm across), and 2-3 percent biotite. Forms grus covered erosional surfaces. Unit mineral assemblages from Stimac et al. (1987). The next most abundant lithology is a medium to mostly fine-grained orangish-brown K-spar and quartz rich granite, which weathers golden red and gray. Fresh faces are golden pink.

Granodiorite - Light to medium gray to pinkish gray and greenish gray, medium-grained, weakly to moderately foliated granodiorite with 25-30% quartz, 5 to 20% biotite, 3% epidote, 1% hornblende. Unit Xgd has light and dark coloring and subtle banding, with metamorphic screens and pendants of amphibolic banded gneiss, strongly foliated with occasional isoclinal folds, migmatite, and lit-par-lit injection gneiss. Crosscut by tourmaline-bearing pegmatitic veins with pinkish selvages that are 40% quartz, 60% potassium feldspar non-deformed and lightly deformed.

Graphic granite - White to pinkish-tan, pegmatitic granite to pegmatite with graphic texture and foliation. Contains magnetite up to 8 mm and biotite up to 2 cm. Dikes are relatively non-foliated and can be up to 2 m wide. Locally intrudes Xm, Xgm, and Xgh.

Alkali feldspar granite - Pink to cream-colored, medium-grained potassium-feldspar-rich granite. Crystal assemblages estimates are 70% potassium feldspar, 30%

Hassayampa granite - Gray to reddish-brown, foliated to strongly foliated, coarse-grained granite with aligned feldspar phenocrysts (5 – 8 cm) that are characterized as a boxcar texture. The unit forms red grus slopes. The rock has a 15% biotite matrix aggregate and commonly contains tourmaline either in granite or especially in pegmatitic phases. Intruded locally by Xgw and Tdr, and mafic dikes in the northeastern portion of the quadrangle.

Mixed granitoid and metamorphic rocks - Heterogeneous assemblage of crystalline rocks (gneissic granite, granitic gneiss, pegmatite, units Xg, Xgd) and dikes (Xgw and Kgd), and metamorphic rocks (Xam, Xs, and Xm). Gneissic granite and granitic gneiss are light gray, fine to medium grained and grained, and foliated with 70% quartz and feldspar, and 20% biotite.

Schist - Dark- to medium-gray, quartzo-feldspathic biotite schists and quartzo-feldspathic schist.

Xam Amphibolite - Dark gray, foliated to lineated, plagioclase-amphibolite schist. Quartzite - Light red to pink and light gray fine- to medium-grained quartzite and orthoquartzite, massive to weak-bedded. Intrafoliated micaceous screens may represent

relic bedding. Quartz 85 to 98% with 0 to 15% mica. Generally non-foliated to very weakly foliated in structural contact with strongly foliated schist.

Metamorphic rocks: dark banded gneiss, schist, amphibolite, and mylonitic rocks - Foliated and folded banded gneiss, whose dark component is composed of dark qray biotite schist and amphibolite schist. Rock contains parallel granite and guartz layers vertical to foliation with isoclinal folds. Gneiss includes a dark mafic rock composed of 70% amphibole, 30% quartz, and meter-sized granitic intrusions. Granitic intrusions within gneiss are coarse to medium grained and feldspar rich, with elongated feldspars parallel to foliation. Protoliths of the metamorphic rocks were likely shale (pelite) for the schist, mica -rich components for the gneiss, and basalt for the nibolite. Protoliths of mylonitic rocks were gneiss and granitoid rocks. The foliation of the rock is N50W – N60W, 85° NE / 90° NE dip. Locally by Tr (N35W, 65°NE).

