U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

Joshua Tree National Park

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Joshua Tree National Park

jotr_geology.pdf

Version: 4/15/2014

Geologic Resources Inventory Map Document for Joshua Tree National Park

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Geologic Resources Inventory Map Document

Joshua Tree National Park, California

Document to Accompany Digital Geologic-GIS Data

jotr_geology.pdf

Version: 4/15/2014

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Joshua Tree National Park, California (JOTR).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

National Park Service (NPS) Geologic Resources Inventory (GRI) Program staff have assembled the digital geologic-GIS data that accompanies this document.

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About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the Earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: http://irma.nps.gov/App/Reference/Search. To find GRI data for a specific park or parks select the appropriate park

(s), enter “GRI” as a Search Text term, and then select the Search Button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: http://www.nature.nps.gov/geology/inventory, or contact:

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The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

GRI Digital Map and Source Map Citations

The GRI digital geologic-GIS map for Joshua Tree National Park, California (JOTR):

GRI Digital Geologic Map of Joshua Tree National Park and Vicinity, California (*GRI MapCode JOTR*)

Sources used by the GRI to produce this digital geologic-GIS map are listed below,

Powell, R.E., Matti, J.C., and Cossette, P.M. , 2014, Joshua Tree National Park, Riverside and San Bernardino Counties, California: geologic map database version 2.0, Administrative Report for National Park Service, U.S. Geological Survey, unpublished digital data, scale 1:100,000. (Joshua Tree NP). *(GRI Source Map ID 75652*)

GIS database of the source map was obtained and converted to GRI data model (v2.1), with all geologic features captured and attributed as per the source data by the GRI.

NOTE: This is an administrative report to NPS for NPS use only. This version of the GIS database and ancillary document are considered pre-review draft. NPS may not serve or otherwise release the data to the public domain until the USGS has reviewed and published the data. Once the final USGS version has been published, the final version of the GIS database and ancillary document will be updated.

ESRI USA Topo Maps, 2013, Topographic base map of USGS scanned topographic maps using National Geographic Society, i-cubed, ESRI web map service, ESRI, Publication Date: 10/09/2013, scale1:24,000. (USA Topo). (*GRI Source Map ID 75750*)

***The source is a web service provided by ESRI used with ArcGIS. The web service shows a topographic basemap at multiple scales. This source was used to captured mine and spring features. The features were located at 1:24,000 scale in ArcGIS and digitized at 1:5,000 scale or larger.*

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Joshua Tree National Park, California (JOTR) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qyadm - Young alluvial deposits, dark-sourced piedmont apron, middle unit). Units are somewhat listed from youngest to oldest. As the preliminary source data did not denote age relationships beyond just a unit's age units are likely not listed in exact age order, especially for Tertiary and older igneous, metamorphic and sedimentary units. The listed order of units is expected to change upon the source map author providing a correlation of units figure and/or an unit listing as the source map nears closer to U.S. Geological Survey publication. Information about each geologic unit is also presented in the GRI Geologic Unit Information (JOTRUNIT) table included with the GRI geology-GIS data, and in other ancillary unit tables derived from the U.S. Geological Survey source digital GIS data (see Ancillary Unit Table Information). Some source unit symbols may have been changed from the U.S. Geological Survey source digital data to standardize the symbols by removing unnecessary blanks and/or adding or editing geologic time symbols.

Cenozoic Era

Quaternary Period

Holocene Epoch

Qart - Artificially modified landscape

Younger alluvial deposits, dark source

- Qyadm - Young alluvial deposits, dark-sourced piedmont apron, middle unit
- Qyadmi - Young alluvial deposits, dark-sourced piedmont apron, middle unit, inset
- Qyady - Young alluvial deposits, dark-sourced piedmont apron, younger unit
- Qyady-pd - Young alluvial deposits, dark-sourced piedmont apron, younger unit, intrapiedmont drainageway
- Qyady-td - Young alluvial deposits, dark-sourced piedmont apron, younger unit, landscape-transecting drainageway

Young alluvium, light-sourced piedmont apron

- Qyalmg - Young alluvium, light-sourced piedmont apron, middle unit, gravelly
- Qyalms - Young alluvium, light-sourced piedmont apron, middle unit, sandy
- Qyalms/QTwrs - Young alluvium, light-sourced piedmont apron, sandy middle unit on saprolite
- Qyalu - Young alluvium, light-sourced piedmont apron, undivided
- Qyaly - Young alluvium, light-sourced piedmont apron, younger unit
- Qyaly-td - Young alluvium, light-sourced piedmont apron, younger unit, landscape-transecting drainageway
- Qyaly-vd - Young alluvium, light-sourced piedmont apron, younger unit, valley-floor drainageway
- Qyalym - Young alluvium, light-sourced piedmont apron, younger and middle units

Young alluvium,mixed-sourced piedmont apron

- Qyamm - Young alluvial deposits, mixed-sourced piedmont apron, middle unit
- Qyamy - Young alluvial deposits, mixed-sourced piedmont apron, younger unit
- Qyamy-pd - Young alluvial deposits, mixed-sourced piedmont apron, younger unit, intrapiedmont drainageway
- Qyamy-td - Young alluvial deposits, mixed-sourced piedmont apron, younger unit, transecting drainageway
- Qyamy-vd - Young alluvial deposits, mixed-sourced piedmont apron, younger unit, valley-floor drainageway

Qyc - Young colluvial deposits

Young debris-apron deposits
- Qydad - Young debris-apron deposits, dark
- Qydal - Young debris-apron deposits, light
- Qydam - Young debris-apron deposits, mixed provenance
- Qydfd - Young debris-flow deposits, dark
- Qydfg - Young debris-flow deposits, granite-derived

Qye - Young eolian deposits
Qye/QTpbl - Young eolian deposits as veneer on QTpbl
Qyoal - Young and old alluvium, light-sourced upland pediment apron, sheetwash and channel deposits
Qyp - Young playa deposits
Qyado - Young alluvial deposits, dark-sourced piedmont apron, older unit
Qyado/Qoadmpm - Young alluvial deposits, dark-sourced piedmont apron, older unit/Old alluvial and debris-flow deposits, dark-sourced piedmont apron, middle unit
Qyamo/Qoammg? - Young alluvial deposits, mixed-sourced piedmont apron, older unit/Old alluvium, mixed-source apron, middle unit, gravelly

Quaternary Period (Holocene and Pleistocene Epochs)
Qc - Colluvial deposits
Qe - Young and (or) old eolian deposits?
Qls - Landslide deposits

Pleistocene Epoch
Old alluvium and debris-flow deposits, light-, mixed- , and dark-sourced deposits
- Qoalmg - Old alluvium, light-sourced piedmont apron, middle unit, moderately dissected gravelly deposits
- Qoalms - Old alluvium, light-sourced pediment apron, middle unit, sheetwash deposits
- Qoao - Old alluvial deposits, older unit
- Qoad+Qoe - Old alluvium, dark-sourced piedmont and old eolian deposits
- Qoadmpb - Old alluvial and debris-flow deposits, dark-sourced piedmont apron, middle unit, broadly dissected pavement surface
- Qoadmpm - Old alluvial and debris-flow deposits, dark-sourced piedmont apron, middle unit, moderately dissected pavement surface
- Qoadyp - Old alluvial and debris-flow deposits, dark-sourced piedmont apron, younger unit, slightly dissected pavement surface
- Qoadlmu - Old alluvial and debris-apron deposits, light-sourced canyon-bottom fill and hillslope deposits, undivided
- Qoalmw - Old alluvium, light-sourced pediment apron, middle unit, white
- Qoalyp - Old alluvial and debris-flow deposits, light-sourced piedmont apron, younger unit, slightly dissected pavement surface
- Qoammg - Old alluvium, mixed-source apron, middle unit, gravelly
- Qoamyp - Old alluvial and debris-flow deposits, mixed-sourced piedmont apron, younger unit, slightly dissected pavement surface

Qoc - Old colluvial deposits
Qodad - Old debris-apron deposits, dark
Qodal - Old debris-apron deposits, light
Qodf - Old debris-flow deposits, light
Qoe - Old eolian deposits
Qoe-Qolpm - Old eolian deposits-Old lake-margin deposits?
Qol - Old lacustrine deposits

Qolpm - Old lake- or playa-margin deposits?

Quaternary and Tertiary Periods
QTpb - Sedimentary strata of Pinto Basin
- QTpbc - Sedimentary strata of Pinto Basin, conglomerate beds
- QTpbd - Sedimentary strata of Pinto Basin, debris flow deposits
- QTpbl - Sedimentary strata of Pinto Basin, lacustrine beds
- QTpbs - Sedimentary strata of Pinto Basin, sandstone beds

QTs - Sedimentary strata

Weathering residuum, saprolite
- QTwrs/Kbc - Weathering residuum, saprolite on granodiorite of Blue Cut
- QTwrs/Khv - Weathering residuum, saprolite on granodiorite of Hidden Valley
- QTwrs/Kic - Weathering residuum, saprolite on monzogranite of Indian Cove
- QTwrs/Kpb - Weathering residuum, saprolite on granodiorite of Pinto Basin
- QTwrs/Kqm - Weathering residuum, saprolite on monzogranite of Queen Mountain
- QTwrs/Kggif - Weathering residuum, saprolite on foliated granitic, granodioritic, and intermediate rocks
- QTwrs/KJcwp - Weathering residuum, saprolite on monzogranite of Cottonwood Pass
- QTwrs/PRpgp - Weathering residuum, saprolite on metasedimentary rocks and orthogneiss of Pinkham Canyon

QTl - Lacustrine deposits

Tertiary Period
Tscf - Sedimentary Beds of Covington Flat
Tb - Basalt
Tdfl - Debris-flow conglomerate, lower unit
Tdfu - Debris-flow conglomerate, upper unit
Ts - Sedimentary rocks
Tm - Maniobra Formation

Weathering residuum, saprolite
- Twrs/Kbc - Weathering residuum, saprolite on granodiorite of Blue Cut
- Twrs/Khv - Weathering residuum, saprolite on granodiorite of Hidden Valley
- Twrs/Kic - Weathering residuum, saprolite on monzogranite of Indian Cove
- Twrs/Kqm - Weathering residuum, saprolite on monzogranite of Queen Mountain
- Twrs/Kggif - Weathering residuum, saprolite on foliated granitic, granodioritic, and intermediate rocks
- Twrs/KJwt - Weathering residuum, saprolite on White Tank Monzogranite
- Twrs/Jhl - Weathering residuum, saprolite on monzogranite of Hayfield Lake
- Twrs/MZPRmag - Weathering residuum, saprolite on mafic intrusive rocks, amphibolite, and gneiss
- Twrs/PRpgp - Weathering residuum, saprolite on metasedimentary rocks and orthogneiss of Pinkham Canyon

- Twrsr/Kbc - Weathering residuum, saprolitic rock on granodiorite of Blue Cut
- Twrsr/KJwt - Weathering residuum, saprolitic rock on White Tank Monzogranite

Cenozoic and Mesozoic Eras

Tertiary, Cretaceous, or Jurassic
TJh - Hypabyssal intrusive rocks?

Mesozoic Era

Cretaceous Period
Kbc - Granodiorite of Blue Cut
- Kbcd - Granodiorite of Blue Cut, dark phase
- Kbcmd - Granodiorite of Blue Cut, dark phase, intruded by monzogranitic dikes

Kccl - Granodiorite of Cadiz Lake
Kccp - Clarks Pass Granodiorite
Kcgd - Granodiorite
Kcge - Granite and granodiorite, equigranular
Kcgj - Granite and granodiorite, jointed
Kcgp - Granite and granodiorite, porphyritic
Kew - Granodiorite of East Wide Canyon
Kfc - Tonalite of Fargo Canyon
Kg - Granitic dike rocks
Kdg - Dike rocks, granitic
Khv - Granodiorite of Hidden Valley
Kic - Monzogranite of Indian Cove
Kjf - Granite of Juniper Flat
Klfimf - Layered felsic, intermediate, and mafic rocks, foliated
Klmiff - Layered mafic, intermediate, and felsic rocks, foliated
Kmgba - Monzogranite, biotite-aluminous enclave-bearing
Kmgf - Monzogranitic rocks, foliated
Kmif - Mafic and intermediate rocks, foliated
Kpb - Granodiorite of Pinto Basin
Ktc - Monzogranite of Thermal Canyon
Kys - Monzogranite of Yellow Spot Canyon
Kap - Aplite
Kog - Granite of Oasis
Kqm - Monzogranite of Queen Mountain
Kqm+MZPRgn - Monzogranite of Queen Mountain and orthogneiss
Kdp - Dacite porphyry
Kdu - Dike rocks, undivided
Kggif - Granitic, granodioritic, and intermediate rocks, foliated

Cretaceous or Jurassic Period
KJwt - Monzogranite of White Tank
KJmc - McCoy Mountains Formation of Miller (1944), Coxcomb Mountains strata
KJmcr - McCoy Mountains Formation of Miller (1944), Coxcomb Mountains strata, reddish siltite
KJcb - Monzogranite of Cottonwood Basin
KJcwp - Monzogranite of Cottonwood Pass
KJlf - Granite of Little Fargo Canyon
KJpg - Pink granite
KJdm - Dike rocks, mafic
KJdu - Dike rocks, undivided

Jurassic Period
Jhl - Monzogranite of Hayfield Lake
Jhlp - Monzogranite of Hayfield Lake, porphyritic
Jql - Quartz latite dike rocks
Jrb - Monzogranite of Red Butte Wash
Ja - Andesite
Jbqmm - Quartz monzonite, quartz monzodiorite, and monzogranite
Jbqmd - Quartz monzodiorite, monzogranite, and diorite
Jcp - Quartz monzonite of Cleghorn Pass
Jd - Diorite and quartz diorite
Jd+Jg - Diorite and granite
Jdl - Dale Lake Volcanics
Jg - Granite
Jgb - Granitoid Rocks of Goat Basin Mine
Jh - Hypabyssal rocks
Jl - Limestone
Jmi - Mafic and intermediate intrusive suite
Jpw - Granite of Pinto Wash
Jvhl - Volcanic and hypabyssal rocks, light-colored
Jdu - Dike rocks, undivided
Jdg - Dike rocks, granitic
Jbv - Virginia Dale Quartz Monzonite
Jsb - Monzonite, monzogranite, and granodiorite of San Bernardino Wash
Jvh - Volcanic and hypabyssal rocks
Jhd - Hypabyssal dike rocks?

Triassic Period
TRmc - Monzodiorite of Munsen Canyon
TRtp - Quartz Monzonite of Twentynine Palms

Phanerozoic and Proterozoic Eons

Mesozoic Era or Proterozoic Eon
MZPRmag - Mafic intrusive rocks, amphibolite, and gneiss
MZPRgn - Gneiss
MZPRlgg - Leucogranite gneiss

Proterozoic Eon

Granite gneiss of Joshua Tree
- PRjgg - Granite gneiss of Joshua Tree
- PRjgr - Granite of Joshua Tree

PRmag - Augen gneiss of Monument Mountain

Pinto Gneiss of Miller, 1938
- PRpgd - Pinto Gneiss of Miller, 1938, dark unit
- PRpgl - Pinto Gneiss of Miller, 1938, leucocratic granitic orthogneiss
- PRpgu - Pinto Gneiss of Miller, 1938, undivided

PRgp - Granitic and pegmatitic rocks

Dolomite of Iron Chief Mine
- PRid - Dolomite of Iron Chief mine
- PRidf - Dolomite of Iron Chief mine, ferriferous unit

PRjmr - Metamorphosed residual regolith

Quartzite of Pinto Mountain
- PRpq1 - Quartzite of Pinto Mountain, unit 1
- PRpq2 - Quartzite of Pinto Mountain, unit 2
- PRpq3 - Quartzite of Pinto Mountain, unit 3
- PRpq4 - Quartzite of Pinto Mountain, unit 4
- PRpq5 - Quartzite of Pinto Mountain, unit 5
- PRpq6 - Quartzite of Pinto Mountain, unit 6
- PRpq7 - Quartzite of Pinto Mountain, unit 7
- PRpq8 - Quartzite of Pinto Mountain, unit 8
- PRpq9 - Quartzite of Pinto Mountain, unit 9
- PRpqgd - Quartzite of Pinto Mountain, dark-gray unit
- PRpqgl - Quartzite of Pinto Mountain, light-gray unit
- PRpqp - Quartzite of Pinto Mountain, pelitic unit
- PRpqu - Quartzite of Pinto Mountain, undivided
- PRpqw - Quartzite of Pinto Mountain, white unit

PRpgp - Metasedimentary rocks and orthogneiss of Pinkham Canyon
PRssmj - Syenite-mangerite-jotunite of Big Wash
PRlgg - Leucogranitic gneiss
PRm - Mylonite

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below.

Qart - Artificially modified landscape (Anthropocene)

Human-modified materials, including workings associated with mines, the aqueduct, highways, the railroad, subdivisions, and Park facilities. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyadm - Young alluvial deposits, dark-sourced piedmont apron, middle unit (Holocene)

Gravel, sandy gravel, and gravelly sand, poorly to moderately sorted, typically consolidated. Unit is incised and occurs in geomorphic remnants of feeder-canyon fill deposits and piedmont-aprons fan deposits showing relict original depositional surface. Surfaces proximal to mountain range front exhibit prominent plumose bar and swale morphology; surfaces on sandier parts of fans exhibit braided bar and swale morphology generated by anastomosing channels. Moderately dark desert varnish is developed on clasts of gneiss and intermediate to mafic plutonic rocks, whereas desert varnish is slight or absent on clasts quartz-rich granite and quartzite, imparting a mottled gray appearance to gravel-bar surfaces. Lighter-colored swales exhibit pebbly pavements underlain by Av horizon of loess-like, vesicular very pale brown (10YR 6/4) calcareous silt, in turn underlain by pale brown silty B-horizon. Gravelly, proximal parts of fans are gray on true-color aerial photographs; gravelly and sandy medial parts mottled gray and pale brownish gray; sandy distal parts pale brownish gray. Color index appears to vary with provenance and decreases with younging age of undivided inset morphostratigraphic subunits. Desert varnish development, thickness of Av horizon, and presence of pale brown color silty B-horizon suggest a middle Holocene age. Unit surfaces generally correlative with Q3b surfaces of Bull (1991); in some places, darker proximal surfaces may be correlative with Bull's Q3a surfaces. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyadmi - Young alluvial deposits, dark-sourced piedmont apron, middle unit, inset (Holocene)

Gravel, sandy gravel, and gravelly sand, poorly to moderately sorted, typically consolidated. Where juxtaposed, unit inset into Qyadm and has somewhat lesser desert varnish development and thinner Av and B soil horizons than typical Qyadm. Otherwise similar to Qyadm, unit is incised and occurs in relict geomorphic remnants of fan and feeder-canyon aprons showing relict original depositional surface. Surfaces proximal to mountain range front exhibit prominent plumose bar and swale morphology; surfaces on sandier parts of fans exhibit braided bar and swale morphology generated by anastomosing channels. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyady - Young alluvial deposits, dark-sourced piedmont apron, younger unit (Holocene)

Pebbly to bouldery sandy gravel and gravelly sand, poorly to moderately sorted, unconsolidated. Consists of an array of young alluvium, including active and abandoned wash and fan deposits. Surfaces exhibit braided bar and swale morphology generated by anastomosing channels; surfaces of abandoned deposits show little or no incision. Coarser deposits occur in gravel bars. Surfaces typically show little or no desert varnish; Av horizon if present is very thin; and B-horizon typically absent. Unit occurs as younger feeder canyon and piedmont apron deposits; derived from dark-weathering source terrane of metamorphic and intermediate and mafic igneous rocks. Unit has pale brownish gray on true-color aerial

photographs. Surfaces correlative with Q3c? and Q4b surfaces of Bull (1991). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyady-pd - Young alluvial deposits, dark-sourced piedmont apron, younger unit, intrapiedmont drainageway (Holocene)

Pebbly to bouldery sandy gravel and gravelly sand, poorly to moderately sorted, unconsolidated. Surfaces exhibit braided bar and swale morphology generated by anastomosing channels; surfaces of abandoned deposits show little or no incision. Coarser deposits occur in gravel bars. Surfaces typically show little or no desert varnish; Av horizon if present is very thin; and B-horizon typically absent. Unit occurs as piedmont apron deposits in drainageways between major fans; derived from dark-weathering source terrane of metamorphic and intermediate and mafic igneous rocks. Unit has pale brownish gray on true-color aerial photographs. Surfaces correlative with Q3c? and Q4b surfaces of Bull (1991). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyady-td - Young alluvial deposits, dark-sourced piedmont apron, younger unit, landscape-transecting drainageway (Holocene)

Pebbly to bouldery sandy gravel and gravelly sand, poorly to moderately sorted, unconsolidated. Surfaces exhibit braided bar and swale morphology generated by anastomosing channels; surfaces of abandoned deposits show little or no incision. Coarser deposits occur in gravel bars. Surfaces typically show little or no desert varnish; Av horizon if present is very thin; and B-horizon typically absent. Deposits occur in drainageways that transect landscape from upland valley floors through canyons cut into basement, typically debouching onto lowland valley piedmonts; derived from dark-weathering source terrane of metamorphic and intermediate and mafic igneous rocks. Unit has pale brownish gray on true-color aerial photographs. Surfaces correlative with Q3c? and Q4b surfaces of Bull (1991). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyalmg - Young alluvium, light-sourced piedmont apron, middle unit, gravelly (Holocene)

Pebbly to bouldery sandy gravel and gravelly sand. Unit is present in canyon-floor fill and in light-colored piedmont and pediment aprons derived from quartz-rich light-colored granite source terrains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyalms - Young alluvium, light-sourced piedmont apron, middle unit, sandy (Holocene)

Sand and pebbly to cobbly sand. Unit is present in light-colored piedmont and pediment aprons derived from quartz-rich light-colored granite source terrains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyalms/QTwrs - Young alluvium, light-sourced piedmont apron, sandy middle unit on saprolite (Holocene)

Sand and pebbly to cobbly sand. Unit is present as thin veneer on saprolite on light-colored piedmont and pediment aprons derived from quartz-rich light-colored granite source terrains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyalu - Young alluvium, light-sourced piedmont apron, undivided (Holocene)

Aggradational piedmont alluvial deposits, undivided. Medium- to coarse-grained sand and pebbly sand, poorly to moderately sorted; unconsolidated to slightly consolidated. Appearing pale brownish gray to pale gray on true-color aerial photographs, unit occurs in light-colored piedmont and pediment aprons derived from quartz-rich light-colored granite source terrains. Little or no desert varnish; little or no soil development. Unit comprises: (1) small fans that debouch from small canyons in mountains or inselbergs, are inset proximally into Qyoal, and spread out distally to merge with the surface of Qyoal; proximal surfaces exhibit braided bar and swale micromorphology; (2) pediment veneer over regolith. In places, unit appears on aerial photographs to contain intricately intermingled exposures of alluvium and saprolitic residuum. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyaly - Young alluvium, light-sourced piedmont apron, younger unit (Holocene)

Young and very young sand and pebbly sand, poorly to moderately sorted; unconsolidated. No desert varnish and no soil development. Unit is present in light-colored piedmont and pediment aprons derived from quartz-rich light-colored granite source terrains. Deposits occur in piedmont and pediment drainageways inset into Qyoal, Qyalg, Qyalm, Qyalu. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyaly-td - Young alluvium, light-sourced piedmont apron, younger unit, landscape-transecting drainageway (Holocene)

Young and very young sand and pebbly sand, poorly to moderately sorted; unconsolidated. No desert varnish and no soil development. Unit is present in canyon-floor fill and in light-colored piedmont and pediment aprons derived from quartz-rich light-colored granite source terrains. Deposits occur in drainageways that transect landscape, downcut through crystalline-rock massif between upland basins and valley-floor piedmonts. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyaly-vd - Young alluvium, light-sourced piedmont apron, younger unit, valley-floor drainageway (Holocene)

Young and very young sand and pebbly sand, poorly to moderately sorted; unconsolidated. No desert varnish and no soil development. Deposits occur in axial drainageways along intermontane valley floors; derived from quartz-rich light-colored granite source terrains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyalym - Young alluvium, light-sourced piedmont apron, younger and middle units (Holocene)

Young, very young, and middle-young sand and pebbly sand, poorly to moderately sorted; unconsolidated. Little or no desert varnish and slight or no soil development. Unit is present in light-colored piedmont and pediment aprons derived from quartz-rich light-colored granite source terrains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyamm - Young alluvial deposits, mixed-sourced piedmont apron, middle unit (Holocene)

Pebbly to bouldery sandy gravel and gravelly sand; poorly to moderately sorted, typically consolidated. Unit is incised and occurs in relict geomorphic remnants of piedmont-aprons fan deposits showing relict

original depositional surface. Unit is present in piedmont aprons derived from mixed metamorphic and quartz-rich light-colored granite source terrains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyamy - Young alluvial deposits, mixed-sourced piedmont apron, younger unit (Holocene)

Young and very young sand and pebbly sand, poorly to moderately sorted; unconsolidated. No desert varnish and no soil development. Unit is present in feeder-canyon fill and piedmont aprons derived from mixed metamorphic and quartz-rich light-colored granite source terrains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyamy-pd - Young alluvial deposits, mixed-sourced piedmont apron, younger unit, intrapiedmont drainageway (Holocene)

Young and very young sand and pebbly sand, poorly to moderately sorted; unconsolidated. No desert varnish and no soil development. Unit is present in canyon fill and piedmont aprons derived from mixed metamorphic and quartz-rich light-colored granite source terrains. Deposits occur in drainageways that transect landscape, downcut through crystalline-rock massif between upland basins and valley-floor piedmonts. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyamy-td - Young alluvial deposits, mixed-sourced piedmont apron, younger unit, transecting drainageway (Holocene)

Young and very young sand and pebbly sand, poorly to moderately sorted; unconsolidated. No desert varnish and no soil development. Deposits occur in drainageways that transect landscape from upland valley floors through canyons cut into basement, typically debouching onto lowland valley piedmonts; derived from mixed metamorphic and quartz-rich light-colored granite source terrains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyamy-vd - Young alluvial deposits, mixed-sourced piedmont apron, younger unit, valley-floor drainageway (Holocene)

Young and very young sand and pebbly sand, poorly to moderately sorted; unconsolidated. No desert varnish and no soil development. Deposits occur in axial drainageways along intermontane valley floors; derived from mixed metamorphic and quartz-rich light-colored granite source terrains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyc - Young colluvial deposits (Holocene)

Hillslope colluvial deposits. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qydad - Young debris-apron deposits, dark (Holocene)

Debris apron deposits consisting of debris cones, debris flows, alluvium, and colluvium on hillslopes and on escarpment footslopes along mountain-range fronts and canyon sides; dark-sourced. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qydal - Young debris-apron deposits, light (Holocene)

Debris apron deposits consisting of debris cones, debris flows, alluvium, and colluvium on hillslopes and on escarpment footslopes along mountain-range fronts and canyon sides; light-sourced. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qydam - Young debris-apron deposits, mixed provenance (Holocene)

Debris apron deposits consisting of debris cones, debris flows, alluvium, and colluvium on hillslopes and on escarpment footslopes along mountain-range fronts and canyon sides; mixed-sourced. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qydfd - Young debris-flow deposits, dark (Holocene)

Debris-flow deposits; bouldery, matrix-supported metamorphic-rock-clast deposits along canyon bottoms. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qydfg - Young debris-flow deposits, granite-derived (Holocene)

Debris-flow deposits; bouldery, matrix-supported granite-clast deposits along canyon bottoms. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qye - Young eolian deposits (Holocene)

Windblown sand deposits. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qye/QTpbl - Young eolian deposits as veneer on QTpbl (Holocene)

Windblown sand deposits deposited as veneer on lacustrine deposits comprising claystone and mudstone beds that contain interbeds of siltstone and fine- to coarse-grained sandstone. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyoal - Young and old alluvium, light-sourced upland pediment apron, sheetwash and channel deposits (Holocene)

Sand and pebbly to cobbly sand forming aprons on pedimented mountain-front and inselberg piedmonts where source terrane consists of quartz-rich granitic rocks. Thickest where buttressed against inselbergs or range-front; tapers down-piedmont into thin veneers on Pleistocene deposits. Where unit is exposed in arroyo walls high on piedmont slopes, loose surficial sediment passes down-section into firmer slope wash and alluvial deposits. Deposits of this unit redden with depth and probably contain one or more buried soil horizons. In places, reddened sediment contains scattered equant blebs of filamentous calcite, indicating an incipient (Stage I) calcic soil, or to older, more pervasively pedogenic calcite-cemented horizons. Unit surfaces are young, smooth, sandy, and characterized by oxidized grains of potassium feldspar that range in color from reddish yellow (5YR 6/6 to 7/6) to yellowish red (5YR 5/6) to pink (5YR 7/4); appear orange on color aerial photographs. These grains occur as veneer underlain by pedogenic Av horizon of loess-like, vesicular very pale brown (10YR 7/3) calcareous silt, typically 1 to 4 cm thick. Av horizon underlain by pale-brown (10YR 6/3 to 6.5/3) to light yellowish-brown (10YR 6/4) sand. Unit inferred to include latest Pleistocene and (or) early to middle Holocene aggradational alluvial deposits as well as younger alluvial deposits that have accumulated as a result of sheet floods originating either as drainage basin discharge or as surface run-off across the older

deposits. Proximal parts of unit are incised by channels in which more recent young and very young alluvial deposits (Qyaly) have accumulated, in washes and fans. Down-piedmont, where more recent young alluvial deposits feather out onto Qyoal, Qyoal surfaces are slightly dissected by anastomosing network of braided channels surrounding small islands of Qyoal. Unit typically occurs as thin alluvial apron deposited on weathered granitic basement high on piedmont slopes and spread down-slope across older surficial deposits. Unit is present in light-colored piedmont and pediment aprons derived from quartz-rich light-colored granite source terrains. As mapped, unit may include undivided domains of more recent young alluvial deposits. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyp - Young playa deposits (Holocene)

Silt and clay, locally mixed with alluvial sand and gravel and windblown sand at playa margins. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyado - Young alluvial deposits, dark-sourced piedmont apron, older unit (Holocene)

Consolidated bouldery gravel and sandy gravel forming relict feeder-canyon fill and small fans adjacent to mountain-front escarpments. Unit commonly occurs as thin veneer on well cemented middle(?) Pleistocene deposits that previously back-filled feeder canyons and both are deeply incised; surface exhibits desert varnish and muted bar and swale morphology. On south flank of Cottonwood Mountains, surface underlain successively by pedogenic horizons including a thick Av horizon, a reddened B horizon showing filamentous carbonate blebs near its base. Elsewhere extent of unit is interpreted largely from aerial photographs. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyado/Qoadmpm - Young alluvial deposits, dark-sourced piedmont apron, older unit/Old alluvial and debris-flow deposits, dark-sourced piedmont apron, middle unit (Holocene/Pleistocene)

Consolidated bouldery gravel and sandy gravel forming relict feeder-canyon fill and small fans adjacent to mountain-front escarpments. Unit commonly occurs as thin veneer on well cemented middle(?) Pleistocene deposits that previously back-filled feeder canyons and both are deeply incised; surface exhibits desert varnish and muted bar and swale morphology. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qyamo/Qoammg? - Young alluvial deposits, mixed-sourced piedmont apron, older unit/Old alluvium, mixed-source apron, middle unit, gravelly (Holocene/Pleistocene)

Consolidated bouldery gravel and sandy gravel forming relict feeder-canyon fill and small fans adjacent to mountain-front escarpments. Unit occurs as thin veneer on well cemented middle(?) Pleistocene deposits that previously back-filled feeder canyons and both are deeply incised; surface exhibits desert varnish and muted bar and swale morphology. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qc - Colluvial deposits (Quaternary)

Hillslope colluvial deposits. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qe - Young and (or) old eolian deposits? (Quaternary)

Windblown sand deposits. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qls - Landslide deposits (Quaternary)

Landslide deposits on hillslopes; occur predominantly in Little San Bernardino Mountains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoalmg - Old alluvium, light-sourced piedmont apron, middle unit, moderately dissected gravelly deposits (middle? Pleistocene)

Sandy gravel and gravelly sand; light-colored alluvial and debris-flow deposits; clasts are predominantly granitic and range in size from pebble to boulder. Deposits are consolidated and are pervasively cemented by pedogenic calcite. Unit occurs as relict fans and canyon-fill in piedmont aprons and their feeder canyons along the base of mountain massifs consisting of quartz-rich granitic rocks. Surface is characterized by bar and swale morphology and is incised and slightly to moderately dissected. Deposits represent a significant aggradational event that typically back-filled feeder canyons. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoalms - Old alluvium, light-sourced pediment apron, middle unit, sheetwash deposits (middle? Pleistocene)

Sand, granule and pebbly sand; very thin- to thin-bedded alluvium. Unit deposited chiefly as sheetwash spread as a veneer on pediment(s) planed across weathering residuum onto parent quartz-rich granitic rocks, but includes channelized and sheet flood fan deposits where streams debouched from canyons onto piedmont. In gully walls, deposits exhibit pervasive pedogenic carbonate; loose, oxidized and reddened sandy material at surface of unit is largely reworked by younger surficial processes. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoao - Old alluvial deposits, older unit (middle? and early? Pleistocene)

Sandy gravel and gravelly sand; moderately to well cemented; unit exhibits ridge-and-ravine (ballena) morphology. Ridges are rounded and littered with calcrete fragments; no remaining pavement. Unit typically ramps up mountain-front footslopes rather than back-filling canyons; in at least some localities, unit is tectonically tilted. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoad+Qoe - Old alluvium, dark-sourced piedmont and old eolian deposits (Pleistocene)

Interfingering alluvial deposits and windblown sand. Gravelly alluvial deposits form apron on upper piedmont slope that interfingers with windblown sand forming a ramp lower on piedmont slope. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoadmpb - Old alluvial and debris-flow deposits, dark-sourced piedmont apron, middle unit, broadly dissected pavement surface (Pleistocene)

Sand and boulder gravel. Relict surface broadly dissected and deeply incised by dendritic network of ravines, producing a prominent ridge-and-ravine (ballena) morphology. Very well developed pavement characterized by darkly varnished pebbles and cobbles that formed on original surface is preserved only

in discontinuous remnants along ridge crests. Pavement underlain by pedogenic Av horizon of very pale brown (10YR 7/3), loess-like, vesicular silt. Unit has a moderately to well-cemented pedogenic Bk-horizon. Where pavement has been completely removed, erosional ridges are rounded and surface is littered with calcrete fragments. Deposits debouch from channels incised into bedrock. Erosional morphology of unit exhibits three markedly different surficial settings, each providing a distinct microenvironment: (1) dark pavement as discontinous relics on ridge crests; (2) colluvial debris on ridge slopes, including lighter-colored young(?) slope wash derived from parent rock and dark-colored slope-wash (Qoc) shed from the varnished pavement surface; and (3) ravine-bottom alluvium. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoadmpm - Old alluvial and debris-flow deposits, dark-sourced piedmont apron, middle unit, moderately dissected pavement surface (Pleistocene)

Sand and gravel. Very well developed pavement characterized by darkly varnished pebbles and cobbles. Pavements extremely dark; moderately to deeply incised by dendritic network of gullies. Pavement and Av horizon underlain by reddened pedogenic B-horizon, in turn underlain by pervasively pedogenically (Bk) chalky-cemented sand and gravel. Deposits are inset into older alluvial and debris-flow deposits (Qoadmpb). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoadyp - Old alluvial and debris-flow deposits, dark-sourced piedmont apron, younger unit, slightly dissected pavement surface (Pleistocene)

Matrix-supported bouldery deposits and sandy bouldery gravel. Unit is characterized by very well developed, darkly varnished desert pavement. Pavements generally continuous over broad relict surface; slightly to moderately incised by dendritic network of scattered to closely spaced gullies. Unit is generally thin and aggradational event that produced it not strong enough or prolonged enough to backfill feeder canyons. Deposits are inset into older alluvial and debris-flow deposits (Qoadmpm, Qoadmpb). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoadlmu - Old alluvial and debris-apron deposits, light-sourced canyon-bottom fill and hillslope deposits, undivided (Pleistocene)

Undivided coarse canyon-fill (Qoalmg) and hillslope debris aprons (Qodal) in Little San Bernardino Mountains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoalmw - Old alluvium, light-sourced pediment apron, middle unit, white (Pleistocene)

Pervasively chalky-cemented sandy, pebbly sandy, and gravelly sandy alluvial deposits; firm to hard; poorly sorted; cemented to well cemented. Unit is stripped to pedogenic carbonate horizon and appears white on aerial photographs. Unit exhibits disorganized texture; bedding features are typically absent or obscured by pedogenic cementation process. Thin veins of hard white laminar calcite 0.5 to 2 cm thick are abundant in these deposits. Pervasiveness and morphology of petrocalcic precipitation are consistent with Stage IV to VI calcic soil. Where exhumed, unit forms thin debris blanket mantling pediments beveled onto granodiorite and monzogranite and buttressed against base of inselbergs in Eagle Mts. Just east of paved highway through park (T. 4 S., R. 12 E., W1/2 sec. 6), chalky-cemented pediment-mantling Qoalmw contains rounded cobbles of aplite derived from dikes in the underlying granodiorite and stratigraphically interfingers with Qoadyp deposits that contain cobbles of gneiss transported from source several kilometers to west in Hexie Mts. Along south-central margin of Porcupine Wash quadrangle, Qoalmw caps deposits photo-interpreted as sedimentary (Qoao). Similar

rocks also crop out in the upper reaches of Big Wash. Unit is probably equivalent to parts of Qoalms and Qoalmg, especially Qoalmg as mapped along paved highway in the northernmost Coxcomb Mts. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoalyp - Old alluvial and debris-flow deposits, light-sourced piedmont apron, younger unit, slightly dissected pavement surface (Pleistocene)

Sandy gravel and gravelly sand. Unit is characterized by very well developed, light-colored desert pavement. Pavements generally continuous over broad relict surface; slightly to moderately incised by dendritic network of scattered to closely spaced gullies. Unit is generally thin and aggradational event that produced it not strong enough or prolonged enough to backfill feeder canyons. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoammg - Old alluvium, mixed-source apron, middle unit, gravelly (Pleistocene)

Sand and gravel; derived from a mixed source terrane of gneiss and quartz-rich granite. Very well developed pavement characterized by varnished pebbles and cobbles. Pavement moderately to deeply incised by dendritic network of gullies. Pavement and Av horizon underlain by reddened pedogenic B-horizon, in turn underlain by pervasively pedogenically (Bk) chalky-cemented sand and gravel. Deposits are inset into older alluvial and debris-flow deposits. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoamyp - Old alluvial and debris-flow deposits, mixed-sourced piedmont apron, younger unit, slightly dissected pavement surface (Pleistocene)

Sandy gravel and sandy bouldery gravel; derived from a mixed source terrane of gneiss and quartz-rich granite. Unit is characterized by very well developed, varnished desert pavement. Pavement generally continuous over broad relict surface; slightly to moderately incised by dendritic network of scattered to closely spaced gullies. Unit is generally thin and aggradational event that produced it not strong enough or prolonged enough to backfill feeder canyons. Deposits are inset into older alluvial and debris-flow deposits. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoc - Old colluvial deposits (Pleistocene)

Varnished debris aprons on recessive slopes below resistant cap rocks; varnished lag gravels. Colluvial debris is shed from resistant gneiss ridges down recessive granite slopes onto pediments and from flat-topped, pavemented surfaces of Qoai1 and Qoai2 down steep banks eroded into the underlying deposits. On older sedimentary deposits, colluvial deposits consist of lag gravels of varnished pebbles and cobbles. Debris aprons typically are dissected and partially eroded, leaving resistant flatirons of relict colluvium on slopes eroded into less resistant substrate. On slopes mantled with more than one generation of colluvium, flatirons on successively older deposits crop out progressively lower on slopes, providing a record of erosional retreat of capping unit. Well-developed pavements on colluvial deposits are very dark and smooth, consist of strongly varnished pebbles and cobbles, and are underlain by pedogenic Av horizon of very pale brown (10YR 7/3) loess-like, vesicular silt. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qodad - Old debris-apron deposits, dark (Pleistocene)

Debris apron deposits consisting of debris cones, debris flows, alluvium, and colluvium on hillslopes and on escarpment footslopes along mountain-range fronts and canyon sides; dark-sourced. (*GRI Source*

Map ID 75652) (Joshua Tree NP).

Qodal - Old debris-apron deposits, light (Pleistocene)

Debris apron deposits consisting of debris cones, debris flows, alluvium, and colluvium on hillslopes and on escarpment footslopes along mountain-range fronts and canyon sides; light-sourced. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qodf - Old debris-flow deposits, light (Pleistocene)

Debris flow deposits in piedmont apron and feeder canyon bottoms. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoe - Old eolian deposits (Pleistocene)

Windblown sand deposits, occurring both as dunes and as ramps on lower piedmonts in Pinto and Dale Lake basins. Ramp deposits are reworked to various degrees by younger alluvial and eolian processes. Proximal to mountain front, sand ramps interfinger with thin gravel aprons that exhibit pavements underlain by reddened soils. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qoe-Qolpm - Old eolian deposits-Old lake-margin deposits? (Pleistocene)

Windblown sand deposits and (or) lake-margin deposits, inferred to be a mixture of eolian and alluvial sand and lacustrine sand, silt, and mud in Pleasant Valley basin, but largely reworked by surficial processes. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qol - Old lacustrine deposits (Pleistocene)

Interlayered slightly consolidated mudstone, siltstone, and fine sandstone deposited in valley-floor basins; fossilferous in Pinto Wells area of Pinto Basin (Springer and others, 2004). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Qolpm - Old lake- or playa-margin deposits? (Pleistocene)

Lake- and (or) playa-margin deposits, inferred to be a mixture of eolian and alluvial sand and lacustrine sand, silt, and mud in Pleasant Valley basin, but largely reworked by surficial processes. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTpb - Sedimentary strata of Pinto Basin (Pleistocene and (or) Pliocene)

Tilted sedimentary strata in Pinto Basin south of Pinto Wash. Outcrops of lake beds in center of basin are probably Pliocene; outcrops of arkosic sandstone just north of Hexie Mountains may be Pliocene or Pleistocene. Stratigraphic parent unit that consists of: QTpbc, QTpbd, QTpbs, QTpbl. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTpbc - Sedimentary strata of Pinto Basin, conglomerate beds (Pleistocene and (or) Pliocene)

Boulder conglomerate forming coarse alluvial bed or beds derived from Proterozoic rocks in Hexie Mountains. In east-central Pinto Basin, conglomerate overlies and may interfinger with lacustrine deposits (QTpbl); proximal to Hexie Mountains, very similar boulder conglomerate mapped as old alluvial deposits, middle unit 1 (Qoam1) overlies arkosic sandstone beds (QTpbs). (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTpbd - Sedimentary strata of Pinto Basin, debris flow deposits (Pleistocene and (or) Pliocene)

Matrix-supported sedimentary breccia containing cobble-sized clasts derived from Jurassic plutonic rocks in Pinto Mountains; overlies lacustrine beds (QTpbl). (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTpbl - Sedimentary strata of Pinto Basin, lacustrine beds (Pleistocene and (or) Pliocene)

Claystone and mudstone beds containing interbeds of siltstone and fine- to coarse-grained sandstone. Some sandstone beds are cemented with white calcite; includes at least one thin bed of fresh-water limestone. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTpbs - Sedimentary strata of Pinto Basin, sandstone beds (Pleistocene and (or) Pliocene)

Reddened arkosic sandstone. Cross-bedded, coarse-grained sandstone containing lenses of pebble conglomerate. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTs - Sedimentary strata (Pleistocene and (or) Pliocene)

Sedimentary strata, tilted. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTwrs/Kbc - Weathering residuum, saprolite on granodiorite of Blue Cut (Quaternary and (or) Tertiary)

In situ regolith that underlies Quaternary pediments planed across older Tertiary saprolite onto granodiorite of Blue Cut. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTwrs/Khv - Weathering residuum, saprolite on granodiorite of Hidden Valley (Quaternary and (or) Tertiary)

In situ regolith that underlies Quaternary pediments planed across older Tertiary saprolite onto granodiorite of Hidden Valley. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTwrs/Kic - Weathering residuum, saprolite on monzogranite of Indian Cove (Quaternary and (or) Tertiary)

In situ regolith that underlies Quaternary pediments planed across older Tertiary saprolite onto monzogranite of Indian Cove. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTwrs/Kpb - Weathering residuum, saprolite on granodiorite of Pinto Basin (Quaternary and (or) Tertiary)

In situ regolith that underlies Quaternary pediments planed across older Tertiary saprolite onto granodiorite of Pinto Basin. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTwrs/Kqm - Weathering residuum, saprolite on monzogranite of Queen Mountain (Quaternary and (or) Tertiary)

In situ regolith that underlies Quaternary pediments planed across older Tertiary saprolite onto monzogranite of Queen Mountain. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTwrs/Kggif - Weathering residuum, saprolite on foliated granitic, granodioritic, and intermediate rocks (Quaternary and (or) Tertiary)

In situ regolith that underlies Quaternary pediments planed across older Tertiary saprolite onto foliated granitic, granodioritic, and intermediate rocks. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTwrs/KJcwp - Weathering residuum, saprolite on monzogranite of Cottonwood Pass (Quaternary and (or) Tertiary)

In situ regolith that underlies Quaternary pediments planed across older Tertiary saprolite onto monzogranite of Cottonwood Pass. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTwrs/PRpgp - Weathering residuum, saprolite on metasedimentary rocks and orthogneiss of Pinkham Canyon (Quaternary and (or) Tertiary)

In situ regolith that underlies Quaternary pediments planed across older Tertiary saprolite onto metasedimentary rocks and orthogneiss of Pinkham Canyon. (*GRI Source Map ID 75652)* (Joshua Tree NP).

QTl - Lacustrine deposits (Quaternary or Tertiary)

Silt, clay, and fine sand. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Tscf - Sedimentary Beds of Covington Flat (Pliocene?)

Conglomeratic sandstone and sandstone; light-colored; fluvial; conglomerate clasts include Pelona-Orocopia Schist, Paleogene sandstone, recycled Paleogene clasts, syenite, mangerite, volcanics. Paleocurrent data indicate north-northeast transport of deposits. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Tb - Basalt (late and middle Miocene)

Basalt flows; olivine-bearing, massive, black. Microphenocrysts include euhedral laths of labradorite, euhedral olivine partially altered to iddingsite, and clinopyroxene. Occurs as two small exposures in northeastern corner of quadrangle and more extensively east of quadrangle in northern Eagle and southern Pinto Mountains. South of quadrangle, forms pipes and (or) near-vent flows on small inselbergs rising above pediment that forms south slope of Pinto Basin. Similar basalt flows in Eagle Mountains southeast of quadrangle yields whole-rock conventional K-Ar ages of 7.8 and 10.2 Ma (Carter and others, 1987) and about 6 to 7 Ma (R. Fleck, oral communication, 2005). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Tdfl - Debris-flow conglomerate, lower unit (middle Miocene)

Matrix-supported sedimentary breccia containing boulder-sized clasts derived from Cretaceous plutonic rocks in Coxcomb Mountains; underlies fluvial and lacustrine beds (Ts) and basalt (Tb). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Tdfu - Debris-flow conglomerate, upper unit (middle Miocene)

Matrix-supported sedimentary breccia containing boulder-sized clasts derived from Cretaceous plutonic rocks in Coxcomb Mountains; overlies fluvial and lacustrine beds (Ts) and basalt (Tb). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Ts - Sedimentary rocks (middle Miocene)

Fluvial and lacustrine rocks that underlie basalt. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Tm - Maniobra Formation (Eocene)

Marine conglomerate, sandstone, and mudstone. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrs/Kbc - Weathering residuum, saprolite on granodiorite of Blue Cut (Tertiary)

Upper part of weathering residuum on granitic rocks, here granodiorite of Blue Cut, is light-gray to rusty-brown saprolite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrs/Khv - Weathering residuum, saprolite on granodiorite of Hidden Valley (Tertiary)

Upper part of weathering residuum on granitic rocks, here granodiorite of Hidden Valley, is light-gray to rusty-brown saprolite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrs/Kic - Weathering residuum, saprolite on monzogranite of Indian Cove (Tertiary)

Upper part of weathering residuum on granitic rocks, here monzogranite of Indian Cove, is light-gray to rusty-brown saprolite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrs/Kqm - Weathering residuum, saprolite on monzogranite of Queen Mountain (Tertiary)

Upper part of weathering residuum on granitic rocks, here monzogranite of Queen Mountain, is light-gray to rusty-brown saprolite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrs/Kggif - Weathering residuum, saprolite on foliated granitic, granodioritic, and intermediate rocks (Tertiary)

Upper part of weathering residuum on granitic rocks, here foliated granitic, granodioritic, and intermediate rocks, is light-gray to rusty-brown saprolite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrs/KJwt - Weathering residuum, saprolite on White Tank Monzogranite (Tertiary)

Upper part of weathering residuum on granitic rocks, here White Tank Monzogranite, is light-gray to rusty-brown saprolite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrs/Jhl - Weathering residuum, saprolite on monzogranite of Hayfield Lake (Tertiary)

Upper part of weathering residuum on granitic rocks, here monzogranite of Hayfield Lake, is light-gray to rusty-brown saprolite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrs/MZPRmag - Weathering residuum, saprolite on mafic intrusive rocks, amphibolite, and gneiss (Tertiary)

Upper part of weathering residuum on granitic rocks, here mafic intrusive rocks, amphibolite, and gneiss, is light-gray to rusty-brown saprolite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrs/PRpgp - Weathering residuum, saprolite on metasedimentary rocks and orthogneiss of Pinkham Canyon (Tertiary)

Upper part of weathering residuum on crystalline basement rocks, here metasedimentary rocks and orthogneiss of Pinkham Canyon, is light-gray to rusty-brown saprolite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrsr/Kbc - Weathering residuum, saprolitic rock on granodiorite of Blue Cut (Tertiary)

Lower part of weathering residuum on granitic rocks, here granodiorite of Blue Cut, is gray saprolitic rock. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Twrsr/KJwt - Weathering residuum, saprolitic rock on White Tank Monzogranite (Tertiary)

Lower part of weathering residuum on granitic rocks, here White Tank Monzogranite, is gray saprolitic rock. (*GRI Source Map ID 75652)* (Joshua Tree NP).

TJh - Hypabyssal intrusive rocks? (Tertiary, Cretaceous, and (or)Jurassic) (Tertiary, Cretaceous, or Jurassic)

Hypabyssal rocks, interpreted from aerial photographs. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kbc - Granodiorite of Blue Cut (Late Cretaceous)

Sphene-bearing biotite-hornblende granodiorite; medium- to coarse-grained. Crops out in western Hexie and central Little San Bernardino Mountains. Has yielded Late Cretaceous zircon U-Pb dates of 86 Ma (Wooden and others, 1991; Fleck and others, 1997). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kbcd - Granodiorite of Blue Cut, dark phase (Late Cretaceous)

Foliated sphene-bearing biotite-hornblende granodiorite; medium- to coarse-grained. Crops out in central Little San Bernardino Mountains. As mapped may include domains of Kmif or Klfimf. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kbcmd - Granodiorite of Blue Cut, dark phase, intruded by monzogranitic dikes (Late Cretaceous)

Foliated sphene-bearing biotite-hornblende granodiorite; medium- to coarse-grained. Contains abundant lighter-colored rock photo-interpreted to be monzogramitic dikes (Kmgf?). Crops out in central Little San Bernardino Mountains. As mapped may include domains of Kmif or Klfimf. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kccl - Granodiorite of Cadiz Lake (Late Cretaceous)

Medium- to coarse-grained, porphyritic granodiorite to monzogranite containing biotite, sphene, and sparse muscovite. Alkali-feldspar phenocrysts as large as 2.5 cm. In Park, unit occurs in northeasternmost Coxcomb Mountains, where it is intruded by unit Kcg and exhibits a mylonitic foliation. (After Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kccp - Clarks Pass Granodiorite (Late Cretaceous)

Medium-grained, mostly porphyritic, hornblende-bearing, sphene-biotite granodiorite. Potassium-feldspar phenocrysts typically subequant, 1–1.5 cm across. Mafic content 5–15 percent. Commonly foliated. Named for Clarks Pass at the south end of the Sheep Hole Mountains (Howard, 2002). In Park, unit is exposed in southern part of the Sheep Hole Mountains and 2 km southeast of Clarks Pass. Cut by rocks of the porphyritic granite and granodiorite facies (Kgdp) unit. Age is Late Cretaceous based on U-Pb dating of zircon (approximately 70 Ma; Wright and others, 1987). (After Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kcgd - Granodiorite (Late Cretaceous)

Biotite-hornblende granodiorite; medium- to coarse-grained; equigranular. Texturally, the rock is massive, displaying little or no foliation. Rock has yielded a biotite K-Ar date of 70.8 Ma (Armstrong and Suppe, 1973). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kcge - Granite and granodiorite, equigranular (Late Cretaceous)

Biotite and muscovite-biotite monzogranite and biotite granodiorite; equigranular. (After Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kcgj - Granite and granodiorite, jointed (Late Cretaceous)

Biotite and muscovite-biotite monzogranite and biotite granodiorite; equigranular; prominently jointed. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kcgp - Granite and granodiorite, porphyritic (Late Cretaceous)

Biotite granodiorite and monzogranite, porphyritic. Rocks contain alkali-feldspar phenocrysts as long as 1 to 5 cm. In places, gradational into Kcge. (After Calzia, 1982; Calzia and others, 1983; Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kew - Granodiorite of East Wide Canyon (Late Cretaceous)

Hornblende-biotite granodiorite; fine- to medium-grained; typically moderately foliated. Has yielded a U/Pb zircon age of 82 Ma (Needy and others, 2009). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kfc - Tonalite of Fargo Canyon (Late Cretaceous)

Biotite-hornblende tonalite; medium- to coarse-grained equigranular; medium- to dark-gray, slightly to strongly foliated. Has yielded a U/Pb zircon age of 75.4 +/- 0.8 Ma (Needy and others, 2009, their granodiorite of Fargo Canyon). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kg - Granitic dike rocks (Late Cretaceous)

Granitic dike rocks, medium to coarse-grained. Includes rocks equivalent to light-colored biotite-aluminous enclave-bearing monzogranite (Kmgba), monzogranite of Thermal Canyon (Ktc), and other finer-grained granitic rocks. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kdg - Dike rocks, granitic (Late Cretaceous)

Biotite monzogranite and syenogranite dikes; fine- to coarse-grained. Fine-grained dikes typically contain garnet. As mapped, may include Kg granitic dike rocks. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Khv - Granodiorite of Hidden Valley (Late Cretaceous)

Hornblende-biotite granodiorite; fine- to medium-grained; intruded by monzogranite of Indian Cove. Has yielded a U/Pb zircon date of 82 Ma (Needy and others, 2009). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kic - Monzogranite of Indian Cove (Late Cretaceous)

Biotite monzogranite; coarse-grained. In places, contains aluminous enclaves characterized by dark-colored cores of quartz, biotite, and garnet surrounded by an light-colored annular rim of quartz and

feldspar (polka-dots). Intrudes granodiorite of Hidden Valley. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kjf - Granite of Juniper Flat (Late Cretaceous)

Muscovite granite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Klfimf - Layered felsic, intermediate, and mafic rocks, foliated (Late Cretaceous)

Interlayered felsic, intermediate, and mafic rocks; typically strongly foliated. Felsic and felsic-intermediate rocks are more abundant than intermediate and mafic rocks. Overall unit is generally light-colored and widespread in Little San Bernardino Mountains as part of the Little San Bernardino Mountains plutonic complex. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Klmiff - Layered mafic, intermediate, and felsic rocks, foliated (Late Cretaceous)

Interlayered mafic, intermediate, and felsic rocks; typically strongly foliated. Mafic and felsic rocks roughly co-equal in abundance. Overall unit is generally dark-colored and widespread in Little San Bernardino Mountains as part of the Little San Bernardino Mountains plutonic complex. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kmgba - Monzogranite, biotite-aluminous enclave-bearing (Late Cretaceous)

Light-colored, fine- to medium-graned biotite monzogranite or granodiorite that contains spherical 0.5- to 2-cm aluminous nodules of biotite and cordierite or garnet surrounded by leucocratic rims of quartz and feldspar (polka dots). (Aluminous enclaves inherited from pelitic gneiss?). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kmgf - Monzogranitic rocks, foliated (Late Cretaceous)

Monzogranitic rocks, typically strongly foliated. Light-colored (white to light-gray to very pale brown); fine- to coarse-grained, ranging from equigranular to porphyritic; biotite- and muscovite-biotite-bearing rocks that range in composition from monzogranite to quartz monzonite. Unit is light-colored and widespread in Little San Bernardino Mountains as part of the Little San Bernardino Mountains plutonic complex. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kmif - Mafic and intermediate rocks, foliated (Late Cretaceous)

Mafic and intermediate plutonic rocks; typically strongly foliated. Medium gray to dark gray; fine- to coarse-grained; biotite- and biotite-hornblende-bearing rocks that range in composition from granodiorite to tonalite and quartz diorite. Unit is dark-colored and widespread in Little San Bernardino Mountains as part of the Little San Bernardino Mountains plutonic complex. As mapped, includes domains of Jurassic mafic and intermediate rocks. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kpb - Granodiorite of Pinto Basin (Late Cretaceous)

Sphene-bearing biotite-hornblende granodiorite; medium- to coarse-grained; locally seriate porphyritic. Has yielded late Cretaceous zircon date (L.T. Silver, oral communication, see Powell, 1981). Unit label is queried where unit assignment based on interpretation of aerial photographs is uncertain. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Ktc - Monzogranite of Thermal Canyon (Late Cretaceous)

As mapped, probably includes two or more distinct plutonic bodies. Mainly consists of white to light-gray to very pale brown, fine- to medium-grained biotite monzogranite; includes both equigranular and porphyritic rocks. Forms tabular bodies generally elongate parallel and subparallel to layering in older rocks of the Little San Bernardino Mountains plutonic complex, but clearly truncates the older layering; also occurs as dikes intruding the older rocks. Has yielded a U/Pb zircon age of 74 ± 2 Ma (Needy and others, 2009, their "Granite of Pinkham Canyon"). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kys - Monzogranite of Yellow Spot Canyon (Late Cretaceous)

Biotite-hornblende monzogranite; medium-gray; coarse-grained, porphyritic. Contains phenocrysts of alkali feldspar. Slightly to strongly foliated. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kap - Aplite (Late Cretaceous)

Fine-grained, saccharoidal aplite. White to pinkish white; takes on light- to medium-brown patina of desert varnish. Intrudes Kpb. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kog - Granite of Oasis (Cretaceous)

Muscovite granite. Equivalent to Oasis monzogranite of Trent (1984). Crops out in center of Queen Mountain massif. Has yielded muscovite 40Ar/39Ar date of 90 Ma (J.K. Nakata, unpub. data, 1991, cited in Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kqm - Monzogranite of Queen Mountain (Cretaceous)

Light-colored, hornblende-biotite monzogranite. Equivalent to Queen Mountain monzogranite of Trent (1984). Crops out on and around Queen Mountain in Pinto Mountains. Has yielded hornblende 40Ar/39Ar date of 75 Ma (J.K. Nakata, unpub. data, 1991, cited in Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kqm+MZPRgn - Monzogranite of Queen Mountain and orthogneiss (Mesozoic and Proterozoic (?))

Light-colored, hornblende-biotite monzogranite and orthogneiss. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kdp - Dacite porphyry (Cretaceous)

Gray hornblende-feldspar dacite porphyry containing abundant to sparse phenocrysts of zoned euhedral plagioclase (labradorite to andesine, as large as 1 cm), subordinate euhedral brown hornblende and brown biotite, and rare embayed quartz set in a gray microcrystalline groundmass of plagioclase, alkali

feldspar, quartz, sphene, apatite, and zircon. As mapped, may include andesite dikes. Dikes occur in prominent swarms that trend northeast through the Eagle and Pinto Mountains. Individual dikes, typically a few meters thick and commonly several hundred meters long, dip steeply, form resistant ribs, and exhibit dark brown patina of desert varnish. Some dikes included in unit intrude Cretaceous granodiorite (Kpb); most intrude Jurassic and older units; as mapped, may include Jurassic dikes. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kdu - Dike rocks, undivided (Cretaceous)

Dike rocks, undivided; intrude metamorphosed strata of McCoy Mountains Formation (KJmc) in southern Coxcomb Mountains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Kggif - Granitic, granodioritic, and intermediate rocks, foliated (Cretaceous)

Granitic, granodioritic, and intermediate rocks, foliated. Unit is light-colored and widespread in Little San Bernardino Mountains as part of the Little San Bernardino Mountains plutonic complex. (*GRI Source Map ID 75652)* (Joshua Tree NP).

KJwt - Monzogranite of White Tank (Cretaceous and Jurassic)

Medium- to coarse-grained biotite monzogranite. Typically equigranular; locally seriate, containing scattered small phenocrysts of alkali feldspar. Color index 5 to 10. Quartz-rich; allanite-bearing. Pluton as mapped appears to be a composite: rocks in the vicinity of White Tank exhibit a pervasive incipient fabric; rocks west of Geology Loop Road have yielded an zircon U-Pb date of 79.5 Ma (Needy and others, 2009, their “Granite of Squaw Tank”). Equivalent to White Tank Monzonite of Miller (1938) and White Tank monzogranite of Trent (1984) . Unit label is queried where unit assignment based on interpretation of aerial photographs is uncertain. (*GRI Source Map ID 75652)* (Joshua Tree NP).

KJmc - McCoy Mountains Formation of Miller (1944), Coxcomb Mountains strata (Cretaceous and Jurassic?)

Metamorphosed sedimentary strata. Rocks in Coxcomb Mountains comprise phyllitic metamorphosed siltstone, mudchip-clast siltstone, and calcareous siltstone. Phyllitic cleavage is axial planar to near-isoclinal folds. (*GRI Source Map ID 75652)* (Joshua Tree NP).

KJmcr - McCoy Mountains Formation of Miller (1944), Coxcomb Mountains strata, reddish siltite (Cretaceous or Jurassic?)

Metamorphosed sedimentary strata, Reddish phyllitic metamorphosed siltstone. Phyllitic cleavage is axial planar to near-isoclinal folds. (*GRI Source Map ID 75652)* (Joshua Tree NP).

KJcb - Monzogranite of Cottonwood Basin (Cretaceous or Jurassic)

Medium- to coarse-grained hornblende-biotite monzogranite, in places porphyritic. (*GRI Source Map ID 75652)* (Joshua Tree NP).

KJcwp - Monzogranite of Cottonwood Pass (Cretaceous or Jurassic)

Medium- to coarse-grained biotite monzogranite. Typically equigranular; locally seriate, containing scattered small phenocrysts of alkali feldspar. Color index 5 to 10. Quartz-rich; allanite-bearing. Crops out in in Eagle and Cottonwood Mountains in vicinity of Cottonwood Pass. Pluton as mapped appears to be a composite: In vicinity of Cottonwood Pass, rocks have yielded zircon U-Pb dates, including discordant zircon U-Pb data that suggest Jurassic or early Cretaceous age (J.L. Wooden, written communication, 1997, SHRIMP lab, Stanford Univ) a date of about 155 Ma (J. Girardi, written communication, 2012, lab at Univ of Arizona); northwest of Smoke Tree Well, rocks have yielded a zircon U-Pb date of 75 Ma (Needy and others, 2009, their “Granite of Smoke Tree Well”). Unit label is queried where unit assignment based on interpretation of aerial photographs is uncertain. (*GRI Source Map ID 75652)* (Joshua Tree NP).

KJlf - Granite of Little Fargo Canyon (Cretaceous or Jurassic)

Muscovite granite; medium-grained; leucocratic. Weathers very pale brown to orange-colored. Contact relations appear to indicate that the granite intrudes adjoining Cretaceous rocks, in apparent contradiction to a Jurassic age (150 +/- 2 Ma) reported by Needy and others (2009) based on U/Pb zircon date. (*GRI Source Map ID 75652)* (Joshua Tree NP).

KJpg - Pink granite (Cretaceous or Jurassic)

Medium-grained biotite monzogranite. Intrudes the quartz monzodiorite (Jbqm) unit and is intruded by the Clarks Pass Granodiorite (Kccp). Crops out in southern Sheep Hole Mountains. (After Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

KJdm - Dike rocks, mafic (Cretaceous or Jurassic)

Hornblende microdiorite dike rocks; medium- to dark-greenish gray; fine- to very fine-grained. Composed primarily of hornblende and plagioclase; typically altered propylitically to epidote, chlorite, and calcite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

KJdu - Dike rocks, undivided (Cretaceous and (or) Jurassic)

Dike rocks, undivided. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jhl - Monzogranite of Hayfield Lake (Late Jurassic)

Medium- to coarse-grained biotite monzogranite. Typically equigranular; locally seriate, containing scattered small phenocrysts of alkali feldspar. Color index 5 to 10. Quartz-rich; allanite-bearing. Present in southeastern Eagle Mountains. Intruded by Independence dike swarm (Jql). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jhlp - Monzogranite of Hayfield Lake, porphyritic (Late Jurassic)

Medium- to coarse-grained biotite porphyritic monzogranite. Contains abundant phenocrysts of pinkish gray alkali feldspar as large as 3 cm. Color index about 10. Quartz-rich; allanite-bearing. Intruded by dikes that have yielded zircon U-Pb ages of 148 Ma (James, 1989) Present in southeastern Eagle Mountains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jql - Quartz latite dike rocks (Late Jurassic)

Quartz latite and (or) rhyodacite; light to medium gray, siliceous aphanitic rock with microphenocrysts of quartz, microcline, plagioclase, and biotite. Present as prominent dike swarm in eastern Eagle Mountains; similar dikes occur in Pinto Mountains. A dike in Big Wash in east-central Eagle Mountains has yielded U-Pb zircon dates of 148 Ma and a sphene U-Pb age of 142 Ma (James, 1989). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jrb - Monzogranite of Red Butte Wash (Late Jurassic)

Medium- to coarse-grained biotite monzogranite. Typically equigranular; locally seriate, containing scattered small phenocrysts of alkali feldspar. Color index 5 to 10. Quartz-rich; allanite-bearing. Lithologically the same as monzogranite of Cottonwood Pass; metamorphic screen and fault intervene between the two monzogranite bodies. Unit has yielded a highly discordant array of zircon U-Pb data from southern Eagle Mountains suggesting a date of about 210 Ma (Barth and others, 1997), but is considered herein as equivalent to monzogranite of Cottonwood Pass. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Ja - Andesite (Jurassic)

Basaltic andesite; dark-gray, massive, aphanitic. Rock is pervasively altered hydrothermally; cut by hydrothermal veins and contains vesicles filled by hydrothermal minerals. Unit comprises several flows. Crops out in southernmost Coxcomb Mountains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jbqmm - Quartz monzonite, quartz monzodiorite, and monzogranite (Jurassic)

Medium-grained, equigranular hornblende-biotite quartz monzonite, quartz monzodiorite, and monzogranite. Locally contains clinopyroxene. Recrystallized and foliated where present near the Sheep Hole Pass Granite. Grades into the hypabyssal rocks (Jh) unit. Locally grades into the Virginia Dale Quartz Monzonite; elsewhere either cuts or is cut by that unit. Crops out in eastern Pinto Mountains. (After Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jbqmd - Quartz monzodiorite, monzogranite, and diorite (Jurassic)

Crops out in eastern Pinto Mountains (largely quartz monzodiorite), southern Sheep Hole Mountains (largely quartz diorite), and western Coxcomb Mountains (largely monzogranite). Contains biotite and commonly hornblende. Locally contains alkali-feldspar phenocrysts. Darker than unit Jbq. Recrystallized and foliated where present close to Cretaceous granitic intrusions. (After Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jcp - Quartz monzonite of Cleghorn Pass (Jurassic)

Hypabyssal porphyritic quartz monzonite; locally clinopyroxene-bearing (Jagiello, 1991). Rocks bleached white and albitized by hydrothermal alteration. Crops out in Pinto Mountains; tentatively correlated with Cleghorn Pass pluton in Bullion Mountains (see Jagiello, 1991; Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jd - Diorite and quartz diorite (Jurassic)

Fine- to medium-grained dioritic rocks; hypabyssal; hydrothermally altered. Crop out in southernmost Coxcomb Mountains and northeastern Eagle Mountains. Thoroughly altered volcanic and volcaniclastic rocks have been reported in Coxcomb Mountains (Calzia and others, 1983). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jd+Jg - Diorite and granite (Jurassic)

Intermingled granitic rocks (Jg) and dioritic rocks (Jd); hypabyssal; hydrothermally altered. Crop out in southernmost Coxcomb Mountains and northeastern Eagle Mountains. Thoroughly altered volcanic and volcaniclastic rocks have been reported in Coxcomb Mountains (Calzia and others, 1983). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jdl - Dale Lake Volcanics (Jurassic)

Intermediate and felsic volcanic and volcaniclastic rocks; consist of porphyritic, aphanitic, and epiclastic rocks, including flows, polymict breccias, and tuffaceous sedimentary rocks. Locally vuggy or laminated. Phenocrysts include plagioclase, chloritized biotite, chloritized hornblende, pyroxene pseudomorphs, quartz, and alkali feldspar; the alkali feldspar phenocrysts are generally lavender and subspherical and resemble phenocrysts in the Virginia Dale Quartz Monzonite and other units of the Bullion Mountains Intrusive Suite. In the type locality of the Dale Lake Volcanics, upright, graded-bedded tuffaceous sandstone contains clastic lavender alkali-feldspar crystals and underlies a sill or thick flow of porphyritic granitoid, indistinguishable from the Virginia Dale Quartz Monzonite, that contains identical alkali-feldspar crystals as phenocrysts. These relations are taken to indicate that crystal-bearing eruptive rocks of the Dale Lake Volcanics locally predated the Virginia Dale Quartz Monzonite, but the magmas were so closely similar that the Dale Lake Volcanics probably overlap in age with the Virginia Dale Quartz Monzonite. Analyzed volcanic rocks contain 64 to 66 percent SiO2 (5 samples) and exhibit potassium enrichment indicative of potassium metasomatism in the groundmass (Howard and Allen, 1988; Jagiello, 1991). Volcanics crop out in east-central part of Pinto Mountains. Age is Jurassic based on apparently coeval relations described above with the Virginia Dale Quartz Monzonite. (After Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jg - Granite (Jurassic)

Fine- to medium-grained, light-colored granitic rocks; hypabyssal; commonly altered hydrothermally. Crop out in southernmost Coxcomb Mountains and northeastern Eagle Mountains. Thoroughly altered volcanic and volcaniclastic rocks have been reported in Coxcomb Mountains (Calzia and others, 1983). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jgb - Granitoid Rocks of Goat Basin Mine (Jurassic)

Present in Pinto Mountains in southwestern corner of Sheep Hole Mountains quadrangle as the Goat Basin pluton. Consists of intergradational rock types: porphyritic biotite granite containing alkali-feldspar megacrysts as large as 6 cm, and medium-grained equigranular hornblende-biotite granodiorite (containing mafic enclaves), quartz diorite, and diorite. Contains euhedral epidote. Granodiorite has yielded zircon U-Pb dates 158–159 Ma (J.L. Wooden, written commun., 1994, as cited in Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jh - Hypabyssal rocks (Jurassic)

Rocks of intermediate composition. Present in Pinto Mountains. (After Howard, 2002) (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jl - Limestone (Jurassic)

Occurs as two small bodies in eastern Pinto Mountains (Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jmi - Mafic and intermediate intrusive suite (Jurassic)

Intermingled mafic and intermediate rocks of varied composition and texture. Color index ranges from 50 to >95. Includes coarse- to very coarse-grained hornblendite and hornblende gabbro, medium- to coarse-grained biotite-hornblende diorite, fine-grained, dark-colored diorite to quartz diorite, medium-grained diorite and quartz diorite, and coarse- to extremely coarse-grained gabbro-dioritic pegmatite. Intruded by quartz monzonite, monzogranite, and granodiorite of San Bernardino Wash (Jsbp). Unit label is queried where unit assignment based on interpretation of aerial photographs is uncertain. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jpw - Granite of Pinto Wash (Jurassic)

Granite; pea-sized (2-5 mm) phenocrysts of quartz in fine- to medium-grained matrix of quartz and feldspar; leucocratic. Unit label is queried where unit assignment based on interpretation of aerial photographs is uncertain. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jvhl - Volcanic and hypabyssal rocks, light-colored (Jurassic)

Light-colored rocks in hypabyssal-volcanic complex in Pinto Mountains. Interpreted from aerial photographs and NAIP imagery within rocks mapped as Jvh by Howard (2002). Likely includes rocks equivalent to Jcp. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jdu - Dike rocks, undivided (Jurassic)

Dike rocks, undivided. In Cottonwood Pass area, dikes are coeval with monzogranite of Cottonwood Pass (Jcwp) in places intruding monzogranite and in other places occurring as xenoliths within monzogranite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jdg - Dike rocks, granitic (Jurassic)

Biotite monzogranite dikes; coarse-grained. Includes dikes of monzogranites of Cottonwood Pass and White Tank (Jcwp and Jwt). As mapped, may include Cretaceous granitic dikes. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jbv - Virginia Dale Quartz Monzonite (Middle Jurassic)

Medium-grained, porphyritic sphene-hornblende-biotite and sphene-biotite quartz monzonite and monzogranite. Alkali-feldspar phenocrysts 1–2 cm across and typically lavender and round. Subspherical mafic enclaves 5–15 cm across common. Recrystallized and foliated (in places an augen gneiss) where near Cretaceous granitoids. Crops out in northeastern and north-central Pinto Mountains.

Has yielded biotite conventional K-Ar age of 167 Ma (Bishop, 1964) and zircon U-Pb ages of about 165 Ma (Wooden and others, 1994). (After Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jsb - Monzonite, monzogranite, and granodiorite of San Bernardino Wash (Middle Jurassic)

Medium- to coarse-grained porphyritic plutonic rocks; vary in composition from quartz monzonite to monzogranite and granodiorite. Locally grades into nonporphyritic diorite. Porphyritic rocks are characterized by lavender-tinted to pinkish-gray phenocrysts of alkali feldspar and typically contains less than 25 percent quartz. Mafic minerals consist of hornblende, biotite, and locally clinopyroxene; abundant sphene. Rocks are unfoliated to foliated and show widespread propylitic alteration. Extensively exposed in eastern Pinto and northeastern Eagle Mountains. Has yielded zircon U-Pb ages of about 165 Ma (L.T. Silver, 1978, oral communication; Wooden and others, 1994) in Pinto Mountains and Eagle Mountains. Unit label is queried where unit assignment based on interpretation of aerial photographs is uncertain. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jvh - Volcanic and hypabyssal rocks (Middle Jurassic)

Present in Pinto Mountains. Volcanic rocks in the unit are probably correlative with the Dale Lake Volcanics (see Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

Jhd - Hypabyssal dike rocks? (Jurassic?)

Interpreted from aerial photographs and NAIP imagery; parallel to known dikes. (*GRI Source Map ID 75652)* (Joshua Tree NP).

TRmc - Monzodiorite of Munsen Canyon (Triassic)

Leucocratic quartz alkali feldspar-plagioclase monzodiorite containing 5 to 10% quartz. Mafic minerals consist of clinopyroxene, hornblende, and biotite. Accessory minerals include zircon and sphene. Previously mapped as late Paleozoic(?) or early Mesozoic(?) (Powell, 1981) and represented as Triassic (Powell, 1993); subsequently interpreted as Permian or Triassic on basis of zircon U-Pb isotopic systematics (Barth and others, 1997). (*GRI Source Map ID 75652)* (Joshua Tree NP).

TRtp - Quartz Monzonite of Twentynine Palms (Triassic)

Porphyritic hornblende monzonite and quartz monzonite. Alkali-feldspar megacrysts 3 to 10 cm across. Commonly gneissic. Crops out around northeast, north, and northwest flanks of Queen Mountain; also occurs in central Pinto Mountains just north of Park (Dibblee, 1967b, 1968; Trent, 1984; Howard, 2002; Hopson, 1996). Zircons from the unit have yielded a U-Pb date of zircon of 242±30 Ma (Barth and others, 1997). Equivalent to informally named Twentynine Palms porphyritic quartz monzonite of Trent (1984). (*GRI Source Map ID 75652)* (Joshua Tree NP).

MZPRmag - Mafic intrusive rocks, amphibolite, and gneiss (Mesozoic or Proterozoic)

Mafic intrusive rocks, amphibolite, and orthogneiss. As mapped, may include Jmi. (*GRI Source Map ID 75652)* (Joshua Tree NP).

MZPRgn - Gneiss (Mesozoic or Proterozoic)

Orthogneiss. (*GRI Source Map ID 75652)* (Joshua Tree NP).

MZPRlgg - Leucogranite gneiss (Mesozoic or Proterozoic)

Leucomonzogranite and leucogranodiorite gneiss (after Howard, 2002). (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRjgg - Granite gneiss of Joshua Tree (Early Proterozoic)

Biotite-plagioclase-quartz-alkali feldspar flaser augen gneiss; very coarse-grained; monzogranitic and syenogranitic. Light gray to white, leucocratic; light to moderate rusty brown patina on weathered surfaces. Augen are typically elongate, spindle-shaped aggregates of alkali feldspar, plagioclase, and quartz; some augen have cores of microcline megacrysts with "pressure shadow" tails of recrystallized finer-grained quartz and feldspar. Gneissic foliation exhibited as quartzo-feldspathic layers 1 to 2 cm thick separated by wispy, discontinuous stringers of biotite. Folia typically are folded. Preliminary U-Pb dating of zircon indicates an age >1.65 Ga (L.T. Silver, 1978-1980, oral communication; see Powell, 1981). Metamorphosed and penetratively deformed after development of capping weathering residuum (Prjmr) and deposition of overlying quartzite of Pinto Mountain (Prpq). (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRjgr - Granite of Joshua Tree (Early Proterozoic)

Porphyritic granite; coarse- and very coarse-grained monzogranite and syenogranite. Light gray to white, leucocratic; light to moderate rusty brown patina on weathered surfaces. Phenocrysts of white to gray alkali feldspar and greenish-white plagioclase, and spheroidal quartz (<1 cm). Less than 10 percent biotite, typically in recrystallized clots. Preliminary U-Pb dating of zircon indicates an age >1.65 Ga (L. T. Silver, 1978-1980, oral communication; see Powell, 1981). (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRmag - Augen gneiss of Monument Mountain (Early Proterozoic)

Mesocratic megacrystic biotite-quartz-plagioclase-alkali feldspar augen gneiss; monzogranitic to granodioritic composition. Typically, unit is foliated porhyroclastic gneiss containing aligned alkali feldspar megacrysts of microcline and perthitic microcline; texturally, megacrysts display a range of deformation from tabular to ovoid to lenticular. Megacrysts, 1 to 6 cm long, are set in a dark, gray, coarse-grained groundmass of oligoclase-andesine, quartz, and biotite, subordinate sphene and apatite, and accessory epidote, allanite, ziron, and opaque minerals. At a locality in the upper part of Fried Liver Wash, an undeformed domain within the unit consists of porhyritic granitoid containing randomly oriented 1- to 6-cm-long phenocrysts of rapakivi-textured alkali feldspar. Deformed and undeformed parts of the unit both have yielded zircon U-Pb dates of 1.65 to 1.68 Ga (Silver, 1971; L.T. Silver, cited in Powell, 1981) in the Chuckwalla and Hexie Mountains, respectively. Unit contains inclusions of Pinto Gneiss, including leucocratic granitic gneiss, metamorphosed graywacke, quartz-rich siliceous granofels, and quartzite; pelitic rocks of Pinkham Canyon have not been observed as inclusions. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpgd - Pinto Gneiss of Miller, 1938, dark unit (Early Proterozoic)

Interlayered orthogneiss and paragneiss, including (1) biotite-quartz-feldspar gneiss; prominently layered, having alternating light-colored laminae rich in alkali feldspar and dark-colored laminae rich in biotite and

oligoclase; contains abundant quartz (30-50%); garnet is common; includes (a) gneiss spotted by dark chloritic pseudomorphs after garnet and (b) biotite-rich granitic augen gneiss containing alkali-feldspar augen 1 cm across (2) metasedimentary and metavolcanic(?), including (a) biotite-feldspar-quartz metamorphosed graywacke; bluish gray siliceous granofels consisting predominantly of coarse-grained quartz, plagioclase, and very fine-grained sericite that pseudomorphically has replaced plagioclase and possibly cordierite; and garnet quartzite and garnetite; and (3) minor amphibolite. May include Jmi or Prjgg that is darker than is typical. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpgl - Pinto Gneiss of Miller, 1938, leucocratic granitic orthogneiss (Early Proterozoic)

Foliated, lineated leucocratic biotite granite to granitic gneiss, medium- to very coarse-grained. Consists of alkali feldspar, plagioclase, quartz, and biotite; garnet is commonly present as isolated tiny crystals or as large, recrystallized clots of tiny garnets. As mapped in Pinto Mountains, includes parts of Dog Wash Gneiss (Howard, 2002). As mapped in Hexie and Cottonwood Mountains, may include masses of Prgp. Unit label is queried where unit assignment based on interpretation of aerial photographs is uncertain. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpgu - Pinto Gneiss of Miller, 1938, undivided (Early Proterozoic)

Interlayered dark-colored orthogneiss and paragneiss (Prpgd) and light-colored leucogranitic orthogneiss (Prpgl). Widespread in the western Pinto, Hexie, Cottonwood, and southwestern Eagle Mountains. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRgp - Granitic and pegmatitic rocks (Middle or Early Proterozoic)

Leucocratic granite and pegmatite, medium- to very coarse-grained; some bodies contain garnet, typically partly or completely replaced by chlorite. Unit intrudes Prmag. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRid - Dolomite of Iron Chief mine (Middle or Early Proterozoic)

Very coarse-grained dolomite marble having interlocking recrystallized grains as large as 1 cm. White to light gray, grayish orange (10YR 7/4) to pale yellowish to orangish (buff to tan) brown weathering. Thin to thick-layered intervals rich in dark-brown weathering siliceous nodules, pods, and lenses; sporadic layers of very coarse-grained white calcite marble (<3 m thick), quartzite, and dark-brown-weathering hematite-dolomite (iron ore). Contains scattered calc-silicate minerals, including garnet, diopside, and phlogopite. Includes Pridf. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRidf - Dolomite of Iron Chief mine, ferriferous unit (Middle or Early Proterozoic)

Very dark brown weathering hematite and dolomite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRjmr - Metamorphosed residual regolith (Middle or Early Proterozoic)

Metamorphosed aluminous rock; consists of quartz (50-55%), muscovite, and as much as 40 percent andalusite and (or) sillimanite; porphyroblastic granofels in Pinto Mountains, deformed to schist in Eagle Mountains. Unit occurs as 3 to 5 m thick layer that caps porphyritic granite (Prjgr) in Pinto Mountains or granite gneiss (Prjgg) in Eagle Mountains and is overlain by quartzite (Prpq); interpreted as

metamorphosed weathering residuum. Underlying granite and granite gneiss are increasingly muscovitic upward toward base of aluminous rock unit, which is characterized by abrupt disappearance of feldspar. Quartz grains in aluminous rock have about same size range and distribution as phenocrysts in underlying granite. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpq1 - Quartzite of Pinto Mountain, unit 1 (Middle Proterozoic)

Mottled light- to dark-gray to bluish-gray quartzite (>95% quartz); medium bedded to massive; contains andalusite and sillimanite. Conglomerate occurs in layers and lenses as thick as 3 m near unconformity at base of quartzite unit. Clasts consist of pebbles and cobbles of (1) very coarse-grained white quartzite or quartz (85-95%), (2) tabular clasts of fine-grained black specular hematite-rich quartzite (5-15%), and (3) rare fine-grained jasper. Matrix is mottled light to dark gray quartzite. Deformed clasts have aspect ratios as great as 10:2:1. Hematite imparts characteristic rusty brown stain. Deposited nonconformably on regolith developed on porphyritic granite of Joshua Tree. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpq2 - Quartzite of Pinto Mountain, unit 2 (Middle Proterozoic)

Very coarse-grained, vitreous, white to light-gray quartzite (98-99% quartz) with interlocking grains as large as 1 cm; grains are strongly recrystallized and have sutured boundaries; no evidence of relict rounded sedimentary grains; massive; bedding obscure or obliterated; thin seams rich in reddish black hematite and aluminosilicate minerals. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpq3 - Quartzite of Pinto Mountain, unit 3 (Middle Proterozoic)

Pelitic rocks; chiefly quartz-muscovite-sillimanite/andalusite rock. Porphyroblastic to granoblastic; not foliated in Pinto Mountains; schistose in Eagle Mountains southeast of quadrangle. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpq4 - Quartzite of Pinto Mountain, unit 4 (Middle Proterozoic)

Dark gray, coarse-grained, vitreous quartzite with granule to pebble conglomerate beds; cross-bedded; upright. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpq5 - Quartzite of Pinto Mountain, unit 5 (Middle Proterozoic)

Pelitic rocks; composed of andalusite, white mica, and quartz. Porphyroblastic to granoblastic; not foliated in Pinto Mountains; schistose in Eagle Mountains southeast of quadrangle. Well developed patina of desert varnish makes unit show as dark on color aerial photographs. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpq6 - Quartzite of Pinto Mountain, unit 6 (Middle Proterozoic)

Very coarse-grained, vitreous, white to light-gray quartzite (98-99% quartz) having interlocking grains as large as 1 cm. As mapped, may include domains of remobilized quartz. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpq7 - Quartzite of Pinto Mountain, unit 7 (Middle Proterozoic)

Pelitic rocks; composed of andalusite, white mica, and quartz. Porphyroblastic to granoblastic; not foliated in Pinto Mountains; schistose in Eagle Mountains southeast of quadrangle. Well developed patina of desert varnish makes unit show as dark on color aerial photographs. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpq8 - Quartzite of Pinto Mountain, unit 8 (Middle Proterozoic)

Dark gray, coarse-grained, vitreous quartzite containing granule to pebble conglomerate beds; cross-bedded; upright. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpq9 - Quartzite of Pinto Mountain, unit 9 (Middle Proterozoic)

White to light gray quartzite; chiefly interpreted from color aerial photographs. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpqgd - Quartzite of Pinto Mountain, dark-gray unit (Middle Proterozoic)

Dark-gray to bluish-gray quartzite (> 95% quartz). (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpqgl - Quartzite of Pinto Mountain, light-gray unit (Middle Proterozoic)

Light-gray to gray quartzite (> 95% quartz). As mapped, may include domains of remobilized quartz. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpqp - Quartzite of Pinto Mountain, pelitic unit (Middle Proterozoic)

Dark metamorphosed pelitic rocks, containing very abundant aluminosilicate minerals; chiefly composed of quartz, muscovite, sillimanite and (or) andalusite; biotite-bearing in places. Porphyroblastic to granoblastic; schistose to unfoliated in Pinto Mountains. Unit also contains dark-colored quartzite; as mapped, may include bodies of Jurassic mafic and intermediate intrusive suite (Jmiu). On east flank of Pinto Mountain, chiefly interpreted from color aerial photographs. Well developed patina of desert varnish makes unit show as dark on color aerial photographs. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpqu - Quartzite of Pinto Mountain, undivided (Middle Proterozoic)

Coarse to very coarse grained; vitreous; thin bedded to massive. Contains four intermingled lithosomes: (1) Mottled light- to dark-gray to bluish-gray quartzite (> 95% quartz); medium bedded to massive; contains andalusite and sillimanite. (2) Conglomerate occurs in layers and lenses as thick as 3 m near unconformity at base of quartzite unit. Clasts consist of pebbles and cobbles of very coarse grained white quartzite or quartz (85-95%), tabular clasts of fine-grained black specular hematite-rich quartzite (5-15%), and rare fine-grained jasper. Matrix is mottled light to dark gray quartzite. Deformed clasts have aspect ratios as great as 10:2:1. Hematite imparts characteristic rusty brown stain. (3) Very coarse grained, vitreous, white to light-gray quartzite (98-99% quartz) with interlocking grains as large as 1 cm; grains are strongly recrystallized and have sutured boundaries; no evidence of relict rounded sedimentary grains; massive; bedding obscure or obliterated; thin seams rich in reddish black hematite and aluminosilicate minerals. (4) Pelitic schist; chiefly quartz-muscovite sillimanite-andalusite schist; subordinate biotite-bearing pelitic schist. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpqw - Quartzite of Pinto Mountain, white unit (Middle Proterozoic)

Very coarse-grained, vitreous, white to light-gray quartzite (98-99% quartz) having interlocking grains as large as 1 cm; grains are strongly recrystallized and have sutured boundaries; no evidence of relict rounded sedimentary grains; massive; bedding obscure or obliterated. As mapped, may include domains of remobilized quartz. On east flank of Pinto Mountain, chiefly interpreted from color aerial photograph. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRpgp - Metasedimentary rocks and orthogneiss of Pinkham Canyon (Proterozoic)

Regionally, metamorphic rocks comprise (a) schistose garnet-sillimanite/andalusite-muscovite-biotite-quartz-feldspar pelitic gneiss, (b) compositionally laminated, siliceous granofels consisting predominantly of quartz and cordierite and containing varying amounts of sillimanite and (or) andalusite, garnet, staurolite, plagioclase, and alkali feldspar, biotite, and muscovite, and (c) scattered thin layers ferromagnesian schist and granofels. As mapped, also includes interlayered amphibolite and melano- to mesocratic orthogneiss. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRssmj - Syenite-mangerite-jotunite of Big Wash (Proterozoic)

Syenite consists predominantly of mesoperthite, plagioclase, minor quartz, and uralite and biotite pseudomorphous after orthopyroxene. Anorthosite and anorthositic gabbro predominantly contain andesine and uralite that is pseudomorphous after orthopyroxene. Syenite and mangerite consist predominantly of mesoperthite, plagioclase, minor quartz, and uralite+/- biotite pseudomorphous after orthopyroxene; jotunite is predominantly antiperthite, andesine, and uralite pseudomorphous after pyroxene. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRlgg - Leucogranitic gneiss (Proterozoic?)

Leucocratic granitic gneiss, strongly foliated. Unit intrudes Prpp. (*GRI Source Map ID 75652)* (Joshua Tree NP).

PRm - Mylonite (Proterozoic?)

Mylonite; juxtaposes Prpg and Prmag against Prpp. (*GRI Source Map ID 75652)* (Joshua Tree NP).

Ancillary Unit Table Information

The following information was taken from GIS tables provided with the preliminary U. S. Geological Survey digital data. Values in parentheses associated with groupings are abbreviations found in the GIS tables included with the GIS data. These GIS tables, USGS_Units (USGS Unit Information), ArchLvlAssem (Architectural Level Assemblages), QProvAssem (Quaternary Provenance Assemblages), MzBathBelts (Mesozoic Batholithic Belts), and MzPZBaseFrame (Mesozoic and Proterozoic Basement Framework) relate map units to an associated architectural level assemblage, provenance assemblage, Mesozoic batholith belt and/or Mesozoic and/or Proterozoic basement framework, respectively. Descriptions of each architectural level assemblage, provenance assemblage, Mesozoic batholith belt, and Mesozoic and Proterozoic basement framework is provided as follows:

Architectural Level Assemblages

Artificial Workings (art) - Anthropocene
Artificially modified landscape, including mine workings, road and railroad corridor workings, aqueduct workings, and subdivision and Park facility workings.

Surficial Deposits, Transported (srft) - Quaternary
Unconsolidated and consolidated sediment deposited in piedmont aprons flanking mountain blocks, and filling drainage-ways along canyon bottoms and valley floors.

Surficial Deposits, Colluvial (srfc) - Quaternary
Hillslope colluvial deposits.

Surficial Deposits, Landslide (srfls) - Quaternary
Hillslope landslide deposits.

Cover Strata (cov) - Quaternary and Tertiary
Unmetamorphosed, consolidated sedimentary and volcanic strata deposited on crystalline basement. Includes Eocene, Miocene, and Pliocene strata as well as early Quaternary deposits, commonly tilted as a result of deformation that accompanies regional faulting. As mapped, also includes some intrusive Miocene basalt.

Crystalline Basement, Weathering Residuum (xbmw) - Quaternary and Tertiary
No additional description provided.

Crystalline Basement (xbm) - Mesozoic and Proterozoic
Intrusive igneous, metamorphosed igneous, and metamorphosed sedimentary rocks.

***see GIS table USGS_Units (USGS Unit Information) for unit listings associated with each architectural level assemblage.*

Quaternary Provenance Assemblages

Dark-Sourced Surficial Deposits (dark-sourced)
Piedmont apron and feeder-canyon fill deposits derived from dark-colored source terranes consisting principally of relatively quartz-poor, biotite-hornblende granitoids, mafic plutonic rocks, amphibolite, and (or) biotite-rich gneiss.

Mixed-Source Surficial Deposits (mixed-sourced)
Piedmont apron and feeder-canyon fill deposits derived from source terranes consisting of a mixture of

light-colored granitic and dark-colored igneous and metamorphic rocks.

Light-Sourced Surficial Deposits (light-sourced)
Piedmont apron and feeder-canyon fill deposits derived from light-colored source terranes consisting principally of quartz-rich, biotite-bearing granitic rocks.

***see GIS table QProvAssem (Quaternary Provenance Assemblages) for unit listings associated with each assemblage. Note that not every Quaternary (Q) unit is present in the GIS table, only those applicable or included by the USGS source author.*

Mesozoic Batholith Belts

Eastern Plutonic Belt, Cordilleran Magmatic Arc (epb)
Plutonic rocks that comprise part of a north-northwest-trending batholithic belt east of the Transverse Ranges cratonic inlier and between that inlier and the main body of the North American craton and spatially intermingled with metamorphosed sedimentary and volcanic rocks associated with the magmatic arc.

Central Plutonic Belt, Cordilleran Magmatic Arc (cpb)
Plutonic rocks that comprise part of a north-northwest-trending batholithic belt spatially intermingled with Proterozoic rocks of the Transverse Ranges cratonic inlier.

Western Plutonic Belt, Cordilleran Magmatic Arc (wpb)
Plutonic rocks that comprise part of a north-northwest-trending batholithic belt west of the Transverse Ranges cratonic inlier and between that inlier and the main body of the North American craton and spatially intermingled with metamorphosed sedimentary rocks associated with the magmatic arc.

***see GIS table MzBathBelts (Mesozoic Batholithic Belts) for unit listings associated with each belt. Note that not every Mesozoic Era (Cretaceous, Jurassic and Triassic Periods) intrusive unit is present in the GIS table, only those included by the USGS source author.*

Mesozoic and Proterozoic Basement Framework

Magmatic Arc Sedimentary Strata, Metamorphosed (MZarcsed) - Mesozoic
Sedimentary rocks deposited and metamorphosed in a convergent magmatic arc setting.

Magmatic Arc Volcanic Rocks, Metamorphosed (MZarcvolc) - Mesozoic
Volcanic rocks deposited and metamorphosed in a convergent magmatic arc setting

Magmatic Arc Composite Batholith (MZcb) - Mesozoic
Composite batholith of all plutonic rocks emplaced in a convergent magmatic arc setting

North American Craton, Transverse Ranges Inlier (PRcr) - Proterozoic
Remnants of the Proterozoic North American craton in the Transverse Ranges that occur as an inlier belt flanked to the east and west by younger Mesozoic magmatic arc rocks.

***see GIS Table MzPZBaseFrame (Mesozoic and Proterozoic Basement Framework) for unit listings associated with each basement framework. Note that not every Mesozoic or Proterozoic basement unit is present in the GIS table, only those included by the USGS source author.*

USGS Unit Information Table

The GIS table USGSUnits contains information from the USGS (source) Unit Descriptions table, minus the lengthy description (text) field (the later information is presented in this document in the Map Unit Descriptions section). Some of this table's information is also found in the GRI Geologic Unit Information (JOTRUNIT) table. Fields present in this table: (Source) Map Unit Label, (Source) Unit Name, Unit Age, Stratigraphic Class, Geologic Genesis Evolution, Geologic Materials, Unit Form and Architectural Level Unit Label.

***see GIS Table USGSUnits (USGS Unit Information) for this additional unit information.*

GRI Source Map Information

Joshua Tree NP (Powell R.E., et. al, In Press)

Powell, R.E., Matti, J.C., and Cossette, P.M., 2014, Joshua Tree National Park, Riverside and San Bernardino Counties, California: Geologic Map Database version 2.0, Administrative Report for National Park Service, unpublished digital data, scale 1:100,000. (*GRI Source Map ID 75652*).

The provided unpublished digital data consisted of an ESRI file geodatabase complete with all geologic data layers/feature classes. Several GIS tables, including one table with unit descriptions. were included in the geodatabase. Also included with the digital data was a robust FGDC metadata record, usgs_jotr_metadata.txt (file renamed by the GRI), that has information about the source digital data.

This is an administrative report to NPS for NPS use only. This version of the GIS database and ancillary document are considered pre-review draft. See the note under GRI Digital Map and Source Citations section.

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USA Topo

ESRI USA Topo Maps, 2013, Topographic Basemap of USGS scanned topographic maps using National Geographic Society, i-cubed, ESRI web map service, ESRI, Publication Date: 10/09/2013, scale 1:24,000. (*GRI Source Map ID 75750*).

This map service presents detailed USGS topographic maps for the United States at multiple scales. Additional information is available from ESRI web page (last modified 10-09-2013, cited 11/12/2013) http://www.arcgis.com/home/item.html?id=99cd5fbd98934028802b4f797c4b1732

ESRI Description and "Use Constraints"
This map presents land cover and detailed topographic maps for the United States. The map includes the National Park Service (NPS) Natural Earth physical map at 1.24km per pixel for the world at small scales, i-cubed eTOPO 1:250,000-scale maps for the contiguous United States at medium scales, and National Geographic TOPO! 1:100,000 and 1:24,000-scale maps (1:250,000 and 1:63,000 in Alaska) for the United States at large scales. The TOPO! maps are seamless, scanned images of United States Geological Survey (USGS) paper topographic maps.

There is a known issue with minor positional shifts (~300 meters) of topo map sheets in the Alaska region. Because of the possibility that issues may exist, the positional accuracy of mine features were assigned an approximate accuracy.

GRI Digital Data Credits

This document was developed and completed by Greg Mack (PWR Seattle NPS) and Stephanie O'Meara (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory(GRI) Program. Quality control of this document by Stephanie O'Meara, with review by Derek Witt (Colorado State University).

The information in this document was compiled from GRI source maps, and intended to accompany the digital geologic-GIS maps and other digital data for Joshua Tree National Park, California (JOTR) developed by Greg Mack and Stephanie O'Meara (see the GRI Digital Map and Source Map Citations section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS map(s)).

GRI finalization by Stephanie O'Meara.

GRI program coordination and scoping provided by Bruce Heise and Tim Connors (NPS GRD, Lakewood, Colorado).