National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Mojave National Preserve

Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory Digital Geologic Data for Mojave National Preserve

moja_geology.pdf

Version: 8/3/2011

Geologic Resources Inventory Map Document for Mojave National Preserve

Table of Contents

Geologic Resources Inventory Map Document 1
About the NPS Geologic Resources Inventory Program 2
Map Unit List 4
Map Unit Descriptions 7
Qp - Playa deposits (Holocene) 7
Qaf - Alluvial fan deposits and alluvium (Holocene and Pleistocene) 7
Qes - Eolian sand deposits (Holocene and Pleistocene) 7
QTp - Playa and pluvial-lake deposits (Pleistocene and Pliocene) 7
QTg - Gravel (Pleistocene and Pliocene) 7
QTl - Landslide and sedimentary-breccia deposits (Pleistocene and Pliocene) 7
QTbc - Basalt cinder deposits (late Miocene to Pleistocene) 7
QTbl - Basalt lava flows (late Miocene to Pleistocene) 8
Tg - Gravel (Pliocene and Miocene) 8
Tbr - Sedimentary-breccia deposits (Pliocene or Miocene) 8
Tv1 - Younger volcanic rocks (Miocene) 8
Tv2 - Older volcanic rocks (Miocene) 8
Ti - Shallow-intrusive rocks (Miocene) 8
Tbmv - Basalt flows in Mid Hills and Van Winkle Mountain Areas (Miocene) 8
Tts - Tortoise Shell Mountain Rhyolite of McCurry (1988) (Miocene) 9
Tw - Wild Horse Mesa Tuff of McCurry (1988) (Miocene) 9
Ths - Hackberry Spring Volcanics of McCurry (1988) (Miocene) 9
Tdf - Domes and flows (Miocene) 9
Tps - Peach Springs Tuff of Young and Brennan (1974) (Miocene) 9
Tal - Air-fall tuff and lava flows (Miocene) 9
Ttb - Tuff breccia (Miocene) 9
Tda - Dacite and andesite flows (Miocene) 10
Tbcp - Basalt flows in Castle Mountains-Piute Range Area (Miocene) 10
Td - Dacite (Miocene) 10
Tdr - Dacite and rhyolite (Miocene) 10
Tab - Andesite and basalt (Miocene) 10
Tga - Arkosic gravel (Miocene) 10
TKf - Felsite (Tertiary and/or Cretaceous) 10
Kpg - Porphyritic granodiorite (Cretaceous) 11
Kg1 - Younger granitoid rocks (Cretaceous) 11
Kem - Equigranular monzogranite (Cretaceous) 11
Kpm - Porphyritic monzogranite (Cretaceous) 11
Kgd - Granodiorite (Cretaceous) 11
Kgm - Garnet two-mica monzogranite (Cretaceous) 11
Kmh - Mid Hills adamellite of Beckerman and others (1982) (Cretaceous) 11
Kt - Teutonia adamellite of Beckerman and others (1982) (Cretaceous) 12
Klo - Live Oak Canyon granodiorite of Beckerman and others (1982) (Cretaceous) 12
Kks - Kessler Springs adamellite of Beckerman and others (1982) (Cretaceous) 12
Kbc - Black Canyon hornblende gabbro of Beckerman and others (1982) (Cretaceous) 12
Krs - Rock Spring monzodiorite of Beckerman and others (1982) (Cretaceous) 12

Kg2 - Older granitoid rocks (Cretaceous) ... 13
Kb - Biotite-rich granitoid rocks (Cretaceous) ... 13
Kd - Diorite (Cretaceous) ... 13
KJg - Granitoid rocks (Cretaceous and Jurassic) ... 13
KJgr - Granite (Cretaceous and/or Jurassic) ... 13
KJcm - Granitoid rocks of Cow hole Mountain (Cretaceous and/or Jurassic) ... 13
Jg - Granitoid rocks (Jurassic) ... 13
Jsd - Sheeted dikes (Jurassic) ... 14
Js - Sands Granite (Jurassic?) ... 14
Jlg - Leucocratic granite (Jurassic) ... 14
Jtn - Granite of Tough Nut Spring (Jtn) ... 14
Ji - Ivanpah granite of Beckerman and others (1982) (Jurassic) ... 14
Jfp - Fountain Peak Rhyolite of Hazzard (1954) (Jurassic) ... 14
Jw b - Quartz syenite of Winston Basin (Jurassic) ... 14
Jcf - Felsic rocks of Colton Hills (Jurassic) ... 15
Jqd - Quartz diorite gneiss (Jurassic) ... 15
Jsq - Spotted quartz monzonite (Jurassic) ... 15
Jgo - Quartz monzonite of Goldstone (Jurassic) ... 15
Jcm - Mesocratic rocks of Colton Hills (Jurassic) ... 15
Jqs - Syenogranite of Quail Spring (Jurassic) ... 15
Jd - Diorite (Jurassic) ... 15
Jqg - Quartz monzodiorite and granodiorite (Jurassic) ... 16
Jsm - Striped Mountain pluton (Jurassic) ... 16
Jbp - Breccia pluton (Jurassic) ... 16
Jh - Hypabyssal and metavolcanic rocks (Jurassic) ... 16
Ja - Aztec Sandstone (Jurassic) ... 16
MZv - Volcanic and sedimentary rocks (Mesozoic) ... 16
TRm - Moenkopi Formation (Triassic) ... 17
PDl - Limestone (Devonian to Permian) ... 17
PZc - Carbonate rocks (Paleozoic) ... 17
Cd - Dolomite (Cambrian) ... 17
CZs - Siliciclastic rocks (Cambrian and Late Proterozoic) ... 17
Zs - Sedimentary rocks (Late Proterozoic) ... 17
Yg - Granitoids (Middle Proterozoic) ... 17
Xg - Gneiss and granitoids (Early Proterozoic) ... 18
Xg1 - Younger granitoids (Early Proterozoic) ... 18
Xg2 - Intermediate-age granitoids (Early Proterozoic) ... 18
Xa - Amphibolite (Early Proterozoic) ... 18
Xg3 - Older granitoids (Early Proterozoic) ... 18
Xm - Migmatite (Early Proterozoic) ... 18

GRI Source Map Citations ... 19

USGS Bulletin 2160 ... 19
USGS Bulletin 2160 Correlation of Map Units ... 20
USGS Bulletin 2160 Index Map ... 21
USGS Bulletin 2160 Sources of Mapping ... 22
USGS Bulletin 2160 Geologic Map Legend ... 23
USGS Bulletin 2160 Pediments Map Legend ... 23
USGS Bulletin 2160 Mineral Occurrences Map Legend ... 24
USGS Bulletin 2160 Rock Samples Map Legend ... 25

GRI Digital Data Credits ... 26

Geologic Resources Inventory Map Document

Mojave National Preserve, California

Document to Accompany Digital Geologic-GIS Data

moja_geology.pdf

Version: 8/3/2011

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Mojave National Preserve, California (MOJA).

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.

For information about the status of GRI digital geologic-GIS data for a park contact:

Tim Connors
Geologist/GRI Mapping Contact
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2093
fax: (303) 987-6792
email: Tim_Connors@nps.gov

For information about using GRI digital geologic-GIS data contact:

Stephanie O'Meara
Geologist/GIS Specialist/Data Manager
Colorado State University Research Associate, Cooperator to the National Park Service
1201 Oak Ridge Drive, Suite 200
Fort Collins, CO 80525
phone: (970) 491-6655
fax: (970) 225-3597
e-mail: stephanie.omeara@colostate.edu

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 Natural Resource Information Reference Search Application: http://nrinfo.nps.gov/Reference.mvc/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:

Bruce Heise
Inventory Coordinator
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2017
fax: (303) 987-6792
email: Bruce_Heise@nps.gov

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

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Mojave National Preserve, California (MOJA) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qal - Alluvium). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the Geologic Unit Information (UNIT) table included with the GRI geology-GIS data.

Geologic Map Units

Cenozoic

Quaternary
Qp - Playa deposits (Qp)
Qaf - Alluvial fan deposits and alluvium (Qaf)
Qes - Eolian sand deposits (Qes)

Quaternary-Tertiary
QTp - Playa and pluvial-lake deposits (QTp)
QTg - Gravel (QTg)
QTl - Landslide and sedimentary-breccia deposits (QTl)
QTbc - Basalt cinder deposits (QTbc)
QTbl - Basalt lava flows (QTbl)

Tertiary
Tg - Gravel (Tg)
Tbr - Sedimentary-breccia deposits (Tbr)
Tv1 - Younger volcanic rocks (Tv1)
Tv2 - Older volcanic rocks (Tv2)
Ti - Shallow-intrusive rocks (Ti)
Tbmv - Basalt flows in Mid Hills and Van Winkle Mountain Areas (Tbmv)
Tts - Tortoise Shell Mountain Rhyolite of McCurry (1988) (Tts)
Tw - Wild Horse Mesa Tuff of McCurry (1988) (Tw)
Ths - Hackberry Spring Volcanics of McCurry (1988) (Ths)
Tdf - Domes and flows (Tdf)
Tps - Peach Springs Tuff of Young and Brennan (1974) (Tps)
Tal - Air-fall tuff and lava flows (Tal)
Ttb - Tuff breccia (Ttb)
Tda - Dacite and andesite flows (Tda)
Tbcp - Basalt flows in Castle Mountains-Piute Range Area (Tbcp)
Td - Dacite (Td)
Tdr - Dacite and rhyolite (Tdr)
Tab - Andesite and basalt (Tab)
Tga - Arkosic gravel (Tga)

Tertiary-Cretaceous
TKf - Felsite (TKf)

Mesozoic

Cretaceous

Kpg - Porphyritic granodiorite (Kpg)
Kg1 - Younger granitoid rocks (Kg1)
Kem - Equigranular monzogranite (Kem)
Kpm - Porphyritic monzogranite (Kpm)
Kgd - Granodiorite (Kgd)
Kgm - Garnet two-mica monzogranite (Kgm)
Kmh - Mid Hills adamellite of Beckerman and others (1982) (Kmh)
Kt - Teutonia adamellite of Beckerman and others (1982) (Kt)
Klo - Live Oak Canyon granodiorite of Beckerman and others (1982) (Klo)
Kks - Kessler Springs adamellite of Beckerman and others (1982) (Kks)
Kbc - Black Canyon hornblende gabbro of Beckerman and others (1982) (Kbc)
Krs - Rock Spring monzodiorite of Beckerman and others (1982) (Krs)
Kg2 - Older granitoid rocks (Kg2)
Kb - Biotite-rich granitoid rocks (Kb)
Kd - Diorite (Kd)

Cretaceous-Jurassic

KJg - Granitoid rocks (KJg)
KJgr - Granite (KJgr)
KJcm - Granitoid rocks of Cowhole Mountain (KJcm)

Jurassic

Jg - Granitoid rocks (Jg)
Jsd - Sheeted dikes (Jsd)
Js - Sands Granite (Js)
Jlg - Leucocratic granite (Jlg)
Jtn - Granite of Tough Nut Spring (Jtn)
Ji - Ivanpah granite of Beckerman and others (1982) (Ji)
Jfp - Fountain Peak Rhyolite of Hazzard (1954) (Jfp)
Jwb - Quartz syenite of Winston Basin (Jwb)
Jcf - Felsic rocks of Colton Hills (Jcf)
Jqd - Quartz diorite gneiss (Jqd)
Jsq - Spotted quartz monzonite (Jsq)
Jgo - Quartz monzonite of Goldstone (Jgo)
Jcm - Mesocratic rocks of Colton Hills (Jcm)
Jqs - Syenogranite of Quail Spring (Jqs)
Jd - Diorite (Jd)
Jqg - Quartz monzodiorite and granodiorite (Jqg)
Jsm - Striped Mountain pluton (Jsm)
Jbp - Breccia pluton (Jbp)
Jh - Hypabyssal and metavolcanic rocks (Jh)
Ja - Aztec Sandstone (Ja)

Jurassic-Triassic

MZv - Volcanic and sedimentary rocks (MZv)

Triassic

TRm - Moenkopi Formation (TRm)

Paleozoic

Permian-Devonian
PDl - Limestone (PDl)

Permian-Cambrian
PZc - Carbonate rocks (PZc)

Cambrian
Cd - Dolomite (Cd)

Cambrian-Late Proterozoic
CZs - Siliciclastic rocks (CZs)

Proterozoic

Late-Proterozoic
Zs - Sedimentary rocks (Zs)

Middle-Proterozoic
Yg - Granitoids (Yg)

Early-Proterozoic
Xg - Gneiss and granitoids (Xg)
Xg1 - Younger granitoids (Xg1)
Xg2 - Intermediate-age granitoids (Xg2)
Xa - Amphibolite (Xa)
Xg3 - Older granitoids (Xg3)
Xm - Migmatite (Xm)

Map Unit Descriptions

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

Qp - Playa deposits (Holocene)

Unconsolidated clay, silt, and sand. Light colored and sparsely vegetated. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Qaf - Alluvial fan deposits and alluvium (Holocene and Pleistocene)

Unconsolidated deposits of poorly sorted gravel, sand, and silt. Deposited as alluvial cones at mouths of canyons and gullies, as alluvial floodplains that border streams, and as braided-stream sediments in stream channels. Older deposits form piedmonts that flank mountain ranges, as well as typically underlie raised, paved, and varnished surfaces. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Qes - Eolian sand deposits (Holocene and Pleistocene)

Unconsolidated, fine- and medium-grained sand that forms dunes and sand sheets. Most of unit is present in vicinity of Kelso Dunes. *GRI Source Map ID 74819* (USGS Bulletin 2160).

QTp - Playa and pluvial-lake deposits (Pleistocene and Pliocene)

Dissected deposits of claystone, fluvial siltstone, silty peat, sandstone, carbonate or siliceous tufa, and pebbly sandstone. Crops out east and west of southern Piute Range and north of Cima Dome. *GRI Source Map ID 74819* (USGS Bulletin 2160).

QTg - Gravel (Pleistocene and Pliocene)

Moderately consolidated pebble, cobble, and sand deposits. Typically underlies highly incised surfaces. Locally contains extensive pedogenic calcite. *GRI Source Map ID 74819* (USGS Bulletin 2160).

QTl - Landslide and sedimentary-breccia deposits (Pleistocene and Pliocene)

Displaced deposits of disaggregated rock and alluvium that form hummocky terranes. Composite of detached masses of brecciated bedrock west of Providence Mountains is probably made up of gravity-slide masses. *GRI Source Map ID 74819* (USGS Bulletin 2160).

QTbc - Basalt cinder deposits (late Miocene to Pleistocene)

Unconsolidated deposits of basalt-scoria fragments, consolidated pyroclastic breccia, and tuffaceous conglomerate formed by phreatic eruption during vent opening. *GRI Source Map ID 74819* (USGS Bulletin 2160).

QTbl - Basalt lava flows (late Miocene to Pleistocene)

Alkaline basalt and hawaiite flows. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tg - Gravel (Pliocene and Miocene)

Moderately consolidated, crudely bedded, fluvial boulder to pebble gravel and sand interbedded with coarse to extremely coarse debris-flow deposits, avalanche breccia, and gravity-slide breccia. Sand is siliciclastic and volcaniclastic, locally arkosic. In and east of New York Mountains, typically forms highly incised raised terraces. Intercalated gravity-slide blocks between Cima Dome and Old Dad Mountain consist of breccias of dolomite, limestone, chert, quartzite, and volcanic, metamorphic, and granitoid rocks. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tbr - Sedimentary-breccia deposits (Pliocene or Miocene)

Deposits of disaggregated rock and alluvium that form hummocky terranes. Deposits lie along north flank of Granite Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tv1 - Younger volcanic rocks (Miocene)

Rhyolite lava flows and ash flows, basalt flows, and dacite lava flows that overlie unit Tps, Peach Springs Tuff of Young and Brennan (1974). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tv2 - Older volcanic rocks (Miocene)

Rhyolite lava flows and ash flows, tuffaceous sedimentary rocks, tuff breccia, basalt flows, and andesite flows. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Ti - Shallow-intrusive rocks (Miocene)

Felsic, intermediate-composition, and mafic igneous rocks emplaced as shallow intrusions and domes. Present in Granite Mountains and Lanfair Valley. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tbmv - Basalt flows in Mid Hills and Van Winkle Mountain Areas (Miocene)

Alkali basalt and andesite lava flows. Olivine andesite that overlies unit Tts, Tortoise Shell Mountain Rhyolite of McCurry (1988), is ~10 Ma in age (McCurry, 1988). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tts - Tortoise Shell Mountain Rhyolite of McCurry (1988) (Miocene)

Rhyolite lava flows and plugs, as well as interbedded pyroclastic material. Aphyric to porphyritic and has sparse sanidine. Rhyolite was dated at 15.8 Ma (McCurry, 1988) and is chemically similar to upper cooling unit (Tw) of Wild Horse Mesa Tuff of McCurry (1988). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tw - Wild Horse Mesa Tuff of McCurry (1988) (Miocene)

Prominently layered sanidine rhyolite ash-flow tuff that contains abundant sanidine phenocrysts and rare quartz, biotite, clinopyroxene, and magnetite phenocrysts. Mostly welded; consists of three compound cooling units that total as much as 320 m thick. Locally rich in lithic fragments. Forms conspicuous mesas in Woods Mountains area. Dated at ~15.8 Ma in age (McCurry, 1988). Probable source is trap-door caldera in western Woods Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Ths - Hackberry Spring Volcanics of McCurry (1988) (Miocene)

Interlayered lava flows, domes, ash flows, and dikes and plugs of trachyte, trachydacite, and rhyolite. Dated at ~16 Ma in age (McCurry, 1988). Crops out widely on Hackberry Mountain. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tdf - Domes and flows (Miocene)

Extrusive domes and related lava flows composed of rhyodacite. Crops out near Wild Horse Mesa. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tps - Peach Springs Tuff of Young and Brennan (1974) (Miocene)

Widely distributed, welded rhyolite ash-flow tuff that contains conspicuous sanidine, ubiquitous but minor amounts of sphene, and variable amounts of biotite and hornblende. Age is 18.5 Ma (Nielson and others, 1990). Includes underlying thin deposits of arkosic gravel in New York Mountains and limestone-clast conglomerate in Providence Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tal - Air-fall tuff and lava flows (Miocene)

White to buff, bedded rhyolite air-fall tuff and thin rhyolite lava flows. Includes distinctive flow-banded rhyolite at Van Winkle Mountain. Locally, olivine-pyroxene basalt flows form uppermost part of unit. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Ttb - Tuff breccia (Miocene)

Light-colored deposits of tuff breccia and minor amounts of both air-fall tuff and tuffaceous sedimentary rocks. Locally includes rhyolite, basalt, dacite, and andesite flows. Sedimentary rocks include water-laid tuffaceous rocks, conglomerate, and lacustrine siltstone and sandstone. Crops out at Van Winkle

Mountain and south of Granite Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tda - Dacite and andesite flows (Miocene)

Thin lava flows and associated domes of intermediate composition. Crops out south of Granite Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tbcp - Basalt flows in Castle Mountains-Piute Range Area (Miocene)

Crops out in Homer Mountain area. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Td - Dacite (Miocene)

Dacite to andesite breccia, domes, and lava flows. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tdr - Dacite and rhyolite (Miocene)

Shallow intrusions and extrusive plugs and domes and adjacent flows and breccia composed of rhyolite, rhyodacite, and dacite. Crops out mainly in Castle Mountains. Age of unit dated between 16.1±0.4 and 12.8±0.2 Ma (Turner and Glazner, 1990). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tab - Andesite and basalt (Miocene)

Lava flows and breccia composed of hornblende-pyroxene andesite and basaltic andesite. Includes sedimentary-breccia deposits composed largely of andesite. Locally, also includes interbedded conglomerate, fanglomerate, sandstone, and siltstone. Present in New York Mountains and Piute Range . *GRI Source Map ID 74819* (USGS Bulletin 2160).

Tga - Arkosic gravel (Miocene)

Generally coarse, locally derived fluvial conglomerate and grus, mainly consisting of Proterozoic and Mesozoic gneiss and granite materials. Variably indurated. Present in Piute Range. *GRI Source Map ID 74819* (USGS Bulletin 2160).

TKf - Felsite (Tertiary and/or Cretaceous)

Fine-grained felsitic igneous rocks that form dikes and irregularly shaped intrusions. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kpg - Porphyritic granodiorite (Cretaceous)

Light-colored, coarse-grained biotite granodiorite and monzogranite that contains K–feldspar phenocrysts. Present in Fenner Hills, Piute Range, Homer Mountain, and nearby areas. Feldspar phenocrysts are 1–2 cm wide except in southern Piute Range, where they are 2–4 cm wide. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kg1 - Younger granitoid rocks (Cretaceous)

Monzogranite and granodiorite probably of Late Cretaceous age. Crops out east of Piute Range and at northern end of Piute Mountains, just south of map area. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kem - Equigranular monzogranite (Cretaceous)

Interior unit of zoned pluton in eastern Granite Mountains. Consists of medium-grained biotite monzogranite. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kpm - Porphyritic monzogranite (Cretaceous)

Light-gray, coarse-grained biotite monzogranite that contains K–feldspar phenocrysts. Crops out widely in eastern Granite Mountains and part of Providence Mountains. These rocks were called granite of Arrowweed in southern Providence Mountains by Miller and others (1985). Locally fine grained. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kgd - Granodiorite (Cretaceous)

Granodiorite that forms exterior unit on south side of zoned pluton in eastern Granite Mountains and also forms sheetlike pluton in western Granite Mountains. Consists of equigranular hornblende-biotite granodiorite. Intruded by porphyritic monzogranite (Kpm). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kgm - Garnet two-mica monzogranite (Cretaceous)

Medium-grained syenogranite to monzogranite that crops out east of Blind Hills. Minimum age is suggested by K–Ar age of 83 Ma on apparently primary muscovite. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kmh - Mid Hills adamellite of Beckerman and others (1982) (Cretaceous)

Informally named unit. Medium- to coarse-grained, porphyritic to equigranular, light-tan leucocratic monzogranite. Locally contains minor amounts of hornblende. Contains common aplite and pegmatite dikes. Crops out over much of Mid Hills and southern New York Mountains. Unit also includes intrusive breccia and brecciated felsite plugs in northern Providence Mountains. Dated ~93 Ma in age by U–Pb

methods on zircon (Ed DeWitt, 1985, oral commun.). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kt - Teutonia adamellite of Beckerman and others (1982) (Cretaceous)

Informally named unit. White to light-tan, equigranular to porphyritic (contains pink alkali-feldspar phenocrysts) biotite monzogranite, generally medium and coarse grained. Locally varies in composition to syenogranite and quartz monzonite. Minor muscovite present in places. These rocks were called granitic rocks of Kelso Peak by Dunne (1972). Crops out over much of Cima Dome, where it was dated at 97 Ma in age by U–Pb methods on zircon (DeWitt and others, 1984). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Klo - Live Oak Canyon granodiorite of Beckerman and others (1982) (Cretaceous)

Informally named unit. White to light-tan, equigranular to porphyritic (contains pink alkali-feldspar phenocrysts) biotite monzogranite, generally medium and coarse grained. Locally varies in composition to syenogranite and quartz monzonite. Minor muscovite present in places. These rocks were called granitic rocks of Kelso Peak by Dunne (1972). Crops out over much of Cima Dome, where it was dated at 97 Ma in age by U–Pb methods on zircon (DeWitt and others, 1984). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kks - Kessler Springs adamellite of Beckerman and others (1982) (Cretaceous)

Informally named unit. White, strongly porphyritic biotite monzogranite and granodiorite. Phenocrysts of pink alkali-feldspar are set in gray, medium-grained groundmass. Contains minor hornblende. Crops out northeast of Cima Dome. K–Ar age on biotite is ~92–93 Ma (Burchfiel and Davis, 1971) and on hornblende is 92.1±0.5 (Beckerman and others, 1982). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kbc - Black Canyon hornblende gabbro of Beckerman and others (1982) (Cretaceous)

Informally named unit. Texturally and compositionally variable, black hornblende gabbro, which contains minor amounts of quartz diorite, and monzodiorite. Medium grained and equigranular. Contains abundant hornblende and lesser amounts of clinopyroxene or biotite. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Krs - Rock Spring monzodiorite of Beckerman and others (1982) (Cretaceous)

Informally named unit. Porphyritic, dark-gray to brown, compositionally variable rocks that make up a zoned pluton in Mid Hills. Common rock types are hornblende-biotite monzodiorite, quartz monzodiorite, and quartz monzonite; mafic hornblende-clinopyroxene diorite is present along north edge of pluton. Contains abundant mafic inclusions. Considered to be Jurassic in age by Beckerman and others (1982), but dated ~97 Ma by U–Pb methods on zircon (Ed DeWitt, 1985, oral commun.). Intruded by unit Kmh, Mid Hills adamellite of Beckerman and others (1982). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kg2 - Older granitoid rocks (Cretaceous)

Monzogranite, granodiorite, and more mafic rocks that are similar to granitoids of the mid-Cretaceous Teutonia batholith. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kb - Biotite-rich granitoid rocks (Cretaceous)

Gray, equigranular to porphyritic (contains small pink alkali-feldspar phenocrysts), biotite-rich granitoid rocks, generally medium or coarse grained. Biotite content 10 volume percent or greater; biotite-rich schlieren widely present, abundant in places. Mapped in Halloran Wash and to south. Considered Cretaceous in age by DeWitt and others (1984). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Kd - Diorite (Cretaceous)

Hornblende diorite present west of Cima Dome. *GRI Source Map ID 74819* (USGS Bulletin 2160).

KJg - Granitoid rocks (Cretaceous and Jurassic)

Monzogranite, granodiorite, and more mafic rocks of Mesozoic age. Present in Soda, Ivanpah, and Kelso Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

KJgr - Granite (Cretaceous and/or Jurassic)

White, medium- to coarse-grained granite present near Baker (Grose, 1959). *GRI Source Map ID 74819* (USGS Bulletin 2160).

KJcm - Granitoid rocks of Cowhole Mountain (Cretaceous and/or Jurassic)

Hornblende-bearing monzogranite, quartz monzonite, and quartz monzodiorite that is pink to purplish pink, medium grained, and equigranular to porphyritic, having phenocrysts of K–feldspar (Dunne, 1972). Locally contains secondary epidote and chlorite (Novitsky-Evans, 1978). Age uncertain, but pinkish color suggests that it may be Jurassic (Miller and others, 1982). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jg - Granitoid rocks (Jurassic)

Hornblende-biotite granodiorite, porphyritic granite and alkali granite, biotite-hornblende monzodiorite, and related rocks. K–feldspar phenocrysts in porphyritic granitoids are typically pink or purple. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jsd - Sheeted dikes (Jurassic)

Felsic to intermediate-composition dikes in complex sheeted mass located along west side of southern Providence Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Js - Sands Granite (Jurassic?)

Unit of Hewett (1956). Pale-pink, coarse-grained, leucocratic alkali-feldspar granite that is characterized by perthitic K–feldspar phenocrysts and granophyric texture (Dunne, 1972; Novitsky-Evans, 1978). Crops out in Devils Playground area. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jlg - Leucocratic granite (Jurassic)

Pale-pink, medium-grained, leucocratic granite present in Granite Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jtn - Granite of Tough Nut Spring (Jtn)

Dark-pink to medium-brown, coarse-grained, subequigranular to porphyritic biotite syenogranite and monzogranite. K–feldspar phenocrysts typically pink or purple. Originally mapped as Ivanpah granite of Beckerman and others (1982) by Goldfarb and others (1988), but these rocks are less porphyritic. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Ji - Ivanpah granite of Beckerman and others (1982) (Jurassic)

Informally named unit. Dark-pink to tan, coarse-grained, porphyritic biotite syenogranite to monzogranite that crops out in the Ivanpah Mountains and east of Cima Dome. Weakly developed magmatic foliation defined by aligned feldspar and biotite is common. Minor hornblende or muscovite is present. K–Ar ages of 136–138 Ma (Sutter, 1968) interpreted here as minimum ages; preliminary U–Pb data for zircon suggest crystallization age of 145 Ma (J.D. Walker, 1991, oral commun.). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jfp - Fountain Peak Rhyolite of Hazzard (1954) (Jurassic)

Dark-pink, hypabyssal granite and siliceous, generally aphyric, flow-banded rhyodacite. Locally contains biotite. Feeder dike for rhyodacite dated as Jurassic (J.D. Walker, 1988, oral commun.). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jwb - Quartz syenite of Winston Basin (Jurassic)

Coarse-grained, melanocratic quartz syenite, syenogranite, and monzogranite. Strongly porphyritic; contains purple to pink phenocrysts. Contains augite, hornblende, and biotite. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jcf - Felsic rocks of Colton Hills (Jurassic)

White, coarse-grained, porphyritic biotite monzogranite and gray, finer grained felsic rocks. Includes yellow to pink, quartz-rich, coarse-grained biotite monzogranite near Bonanza King Well on east side of Providence Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jqd - Quartz diorite gneiss (Jurassic)

Hornblende quartz diorite and quartz monzodiorite that contains megacrysts of K–feldspar. Age is about 160 Ma. Present in Granite Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jsq - Spotted quartz monzonite (Jurassic)

Buff, medium- to fine-grained hornblende-biotite quartz monzonite. Small mafic-mineral clots are conspicuous. Present in Granite Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jgo - Quartz monzonite of Goldstone (Jurassic)

Dark, medium- and coarse-grained, porphyritic to subequigranular rocks; predominant composition is quartz monzonite but also includes quartz syenite and quartz monzodiorite. Mafic phases are biotite, hornblende, and augite. K–Ar age on biotite is 157.0±3.9 Ma; U–Pb age on zircon is ~162–164 Ma (Miller and others, 1985). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jcm - Mesocratic rocks of Colton Hills (Jurassic)

Dark, fine- to coarse-grained, complexly variable suite of rocks that includes monzonite, quartz monzonite, quartz syenite, monzogranite, and minor amounts of gabbro. Biotite, hornblende, and augite are main mafic minerals. Rocks are commonly altered. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jqs - Syenogranite of Quail Spring (Jurassic)

Dark, medium- to coarse-grained, hornblende-biotite syenogranite; varies in composition to quartz monzonite and quartz monzodiorite. Commonly extensively altered. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jd - Diorite (Jurassic)

Dark-brown to black hornblende diorite, hornblende-biotite monzodiorite, and mafic porphyritic hornblende-biotite quartz monzonite. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jqg - Quartz monzodiorite and granodiorite (Jurassic)

Foliated medium-grained rocks that vary in composition from granodiorite to diorite. Locally porphyritic. Present in Clipper Mountains. Forms Goldhammer pluton. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jsm - Striped Mountain pluton (Jurassic)

Hornblende diorite that crops out on Striped Mountain. K–Ar age on hornblende is about 162–167 Ma, so we consider pluton to be similar in age to other Jurassic granitoids; however, Burchfiel and Davis (1971) suggested that it might be as old as 200 Ma. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jbp - Breccia pluton (Jurassic)

Hornblende diorite in Mescal Range. K–Ar age on hornblende is ~190–200 Ma, which may indicate Triassic age for pluton (Burchfiel and Davis, 1971). Mapped unit includes similar rocks in Clark Mountain Range. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Jh - Hypabyssal and metavolcanic rocks (Jurassic)

Dark-weathering, strongly chloritized, quartz-poor hypabyssal and volcanic rocks. Crops out in southeastern Providence Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Ja - Aztec Sandstone (Jurassic)

Prominently crossbedded quartz arenite that is typically red, yellow, or buff. Contains lenses of conglomerate in exposures at Old Dad Mountain, as well as interbeds of felsic volcanic rocks in several places. Also present at Cowhole Mountain and in Mescal Range. *GRI Source Map ID 74819* (USGS Bulletin 2160).

MZv - Volcanic and sedimentary rocks (Mesozoic)

Volcanic flows, flow breccia, tuff, volcaniclastic rocks, quartzite, and conglomerate. Includes rocks (termed "Delfonte volcanic rocks" locally) that interfinger with or overly Aztec Sandstone (Ja), as well as metavolcanic rocks that lie above Moenkopi Formation (TRm) and its laterally equivalent sedimentary rocks. Volcanic rocks that lie above Aztec Sandstone at Cowhole Mountain were dated at 167 Ma by Busby-Spera (1988). Metavolcanic rocks that lie below Moenkopi Formation are considered Triassic or Jurassic in age (Dunne, 1977). Locally includes hypabyssal rocks. Unit in central New York Mountains consists of felsic metavolcanic rocks and lesser amounts of sedimentary rocks, all underlain by basal conglomerate (Burchfiel and Davis, 1977). Sedimentary rocks included with this unit in Providence Mountains are shale, sandstone, conglomerate, and impure limestone; part of this section probably correlates with Moenkopi Formation (Hazzard, 1954). Also present at Soda Mountains and Ivanpah Mountains. *GRI Source Map ID 74819* (USGS Bulletin 2160).

TRm - Moenkopi Formation (Triassic)

Thin-bedded limestone, sandy and silty limestone, calcareous shale, and sandstone present at Old Dad Mountain and in Mescal Range. Metamorphosed calc-silicate rocks in New York Mountains are described as "tentatively correlated with the Triassic Moenkopi Formation" (Burchfiel and Davis, 1977). *GRI Source Map ID 74819* (USGS Bulletin 2160).

PDl - Limestone (Devonian to Permian)

Carbonate rocks that consist of Pennsylvanian and Permian Bird Spring Formation (thick-bedded cherty, sandy, and pure limestone), Mississippian Monte Cristo Limestone (massive pure, coarse limestone, cherty in lower part), and Devonian Sultan Limestone (medium-bedded, interlayered limestone and dolomite). *GRI Source Map ID 74819* (USGS Bulletin 2160).

PZc - Carbonate rocks (Paleozoic)

Dolomite, limestone, and marble; metamorphosed in many places. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Cd - Dolomite (Cambrian)

Buff and gray, generally thin bedded dolomite; argillaceous in lower part. Consists of Nopah and Bonanza King Formations. Widely distributed over map area. *GRI Source Map ID 74819* (USGS Bulletin 2160).

CZs - Siliciclastic rocks (Cambrian and Late Proterozoic)

Interbedded limestone, siltstone, and shale in upper part of unit and quartzitic rocks in lower part. Includes Carrara Formation, Zabriskie Quartzite, Wood Canyon Formation, and Stirling Quartzite. Probably includes thin stratigraphic equivalents of Johnnie Formation and (or) Noonday Dolomite in Old Dad Mountain and Providence Mountains (Stewart, 1970; Dunne, 1977). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Zs - Sedimentary rocks (Late Proterozoic)

Shale, siltstone, diamictite, and dolomite. Stratigraphically equivalent to Johnnie Formation, Noonday Dolomite, and Kingston Peak Formation. Outcrop makes up thrust sheets of Ivanpah Mountains, Mescal Range, and Clark Mountain Range. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Yg - Granitoids (Middle Proterozoic)

Alkalic igneous rocks that include granite, syenite, shonkinite, and carbonatite in Mountain Pass area. Age is ~1,400 Ma (DeWitt and others, 1987). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Xg - Gneiss and granitoids (Early Proterozoic)

Undivided migmatite, granitoid gneiss, and granitoids mapped in many poorly known locations across map area. Also includes quartzite and quartzo-feldspathic paragneiss at Old Dad Mountain. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Xg1 - Younger granitoids (Early Proterozoic)

Granite, granodiorite, and diorite dated between 1,660 and 1,695 Ma (Wooden and Miller, 1990). Common rock types are strongly porphyritic biotite granite, inequigranular leucocratic granite, and hornblende-biotite granodiorite. Locally foliated. Crops out widely from northern New York Mountains south to Vontrigger Hills. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Xg2 - Intermediate-age granitoids (Early Proterozoic)

Augen gneiss and subequigranular gneiss of biotite-granite and biotite-granodiorite composition; dated ~1,700–1,715 Ma (Wooden and Miller, 1990). One pluton crops out in northern New York Mountains, and an igneous suite of this age crops out in northern Providence Mountains. Orthogneiss of this age was identified in the hills near Halloran Spring (DeWitt and others, 1984) but is mapped herein with surrounding undivided gneiss and granitoids (Xg). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Xa - Amphibolite (Early Proterozoic)

Massive amphibolite and layered amphibolite gneiss that contains amphibole, pyroxene, garnet, and biotite in varying ratios. Includes granulite-facies mafic rocks that contain orthopyroxene. Intrudes older granitoid rocks (Xg3) and is interlayered within migmatite (Xm). *GRI Source Map ID 74819* (USGS Bulletin 2160).

Xg3 - Older granitoids (Early Proterozoic)

Pyroxene diorite, biotite-hornblende tonalite, and biotite granodiorite augen gneiss >1,730 Ma (Wooden and Miller, 1990). Crops out as mafic rocks suite west of Ivanpah Valley. *GRI Source Map ID 74819* (USGS Bulletin 2160).

Xm - Migmatite (Early Proterozoic)

Highly metamorphosed, compositionally layered rocks of supracrustal protoliths. Includes quartzo-feldspathic gneiss, garnet-bearing leucocratic layers and dikes, pelitic biotite-sillimanite-K-feldspar gneiss, tonalitic gneiss, and biotite-garnet gneiss. Compositional range for many rocks is similar to intermediate-composition volcanic rocks such as dacite or immature sedimentary rocks such as graywacke (Wooden and Miller, 1990). *GRI Source Map ID 74819* (USGS Bulletin 2160).

GRI Source Map Citations

The GRI digital geologic-GIS map for Mojave National Preserve, California (MOJA) was compiled from the following source:

USGS Bulletin 2160

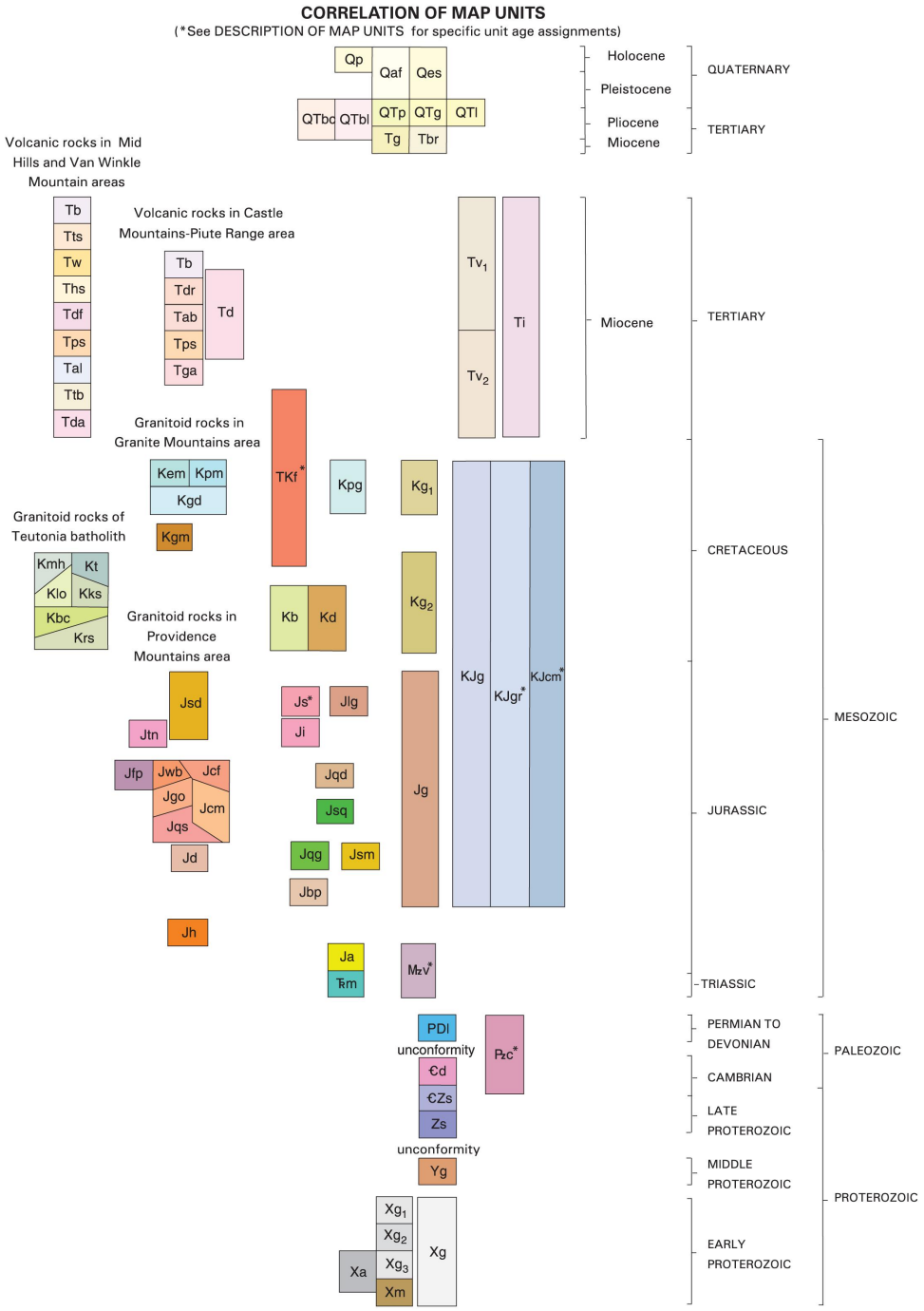
Theodore, T.G., et al., 2007, Geology and mineral resources of the East Mojave National Scenic Area, San Bernardino County, California, U.S. Geological Survey, Bulletin 2160, 1:125000 scale (*GRI Source Map ID 74819*)

Additional information pertaining to each source map is also presented in the Source Map Information (MAP) table included with the GRI geology-GIS data.

The full report for Bulletin 2160 can be found here.

The full report and 6 map plates (including plates that were not added to the GRI's data product) can be downloaded at: http://pubs.usgs.gov/bul/b2160/.

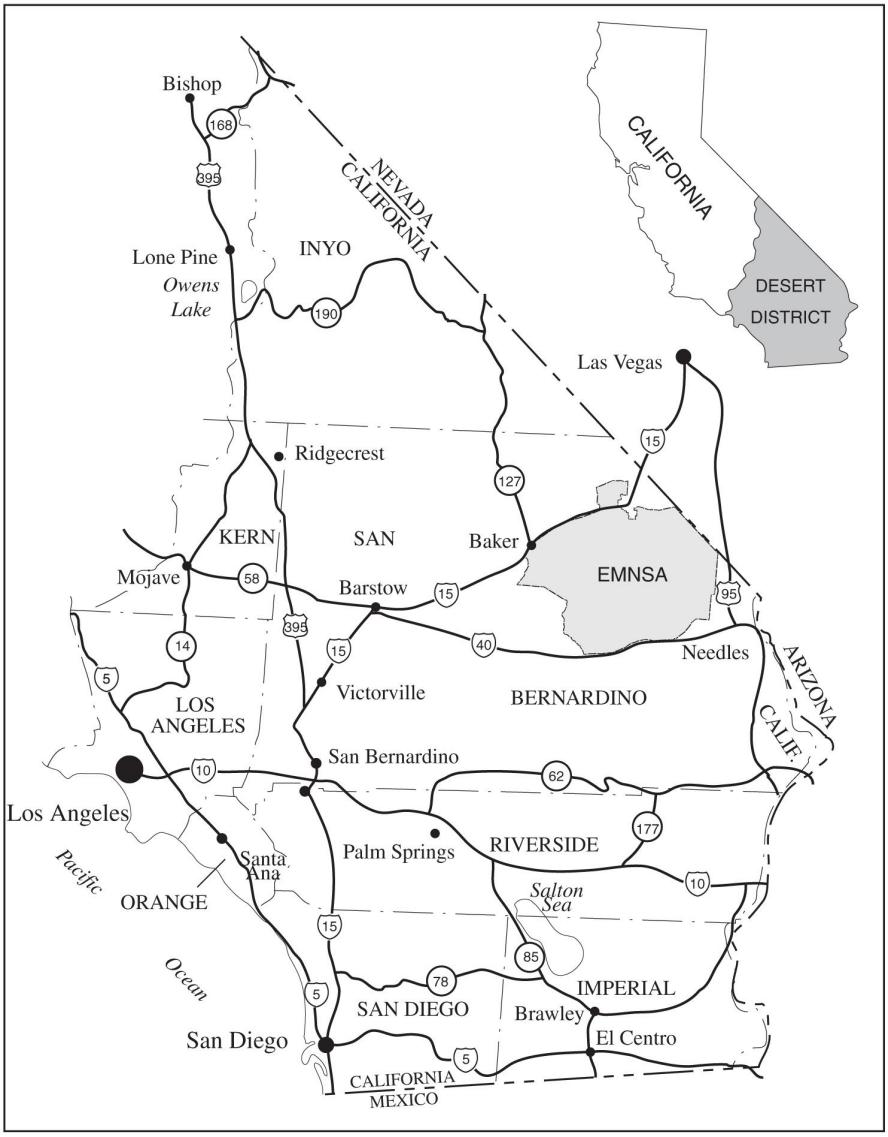
USGS Bulletin 2160 Correlation of Map Units



Extracted from: (USGS Bulletin 2160).

Note: Groupings of units, such as Granitoid rocks of Teutonia batholith, are only represented in this figure, and are not found with the unit descriptions above.

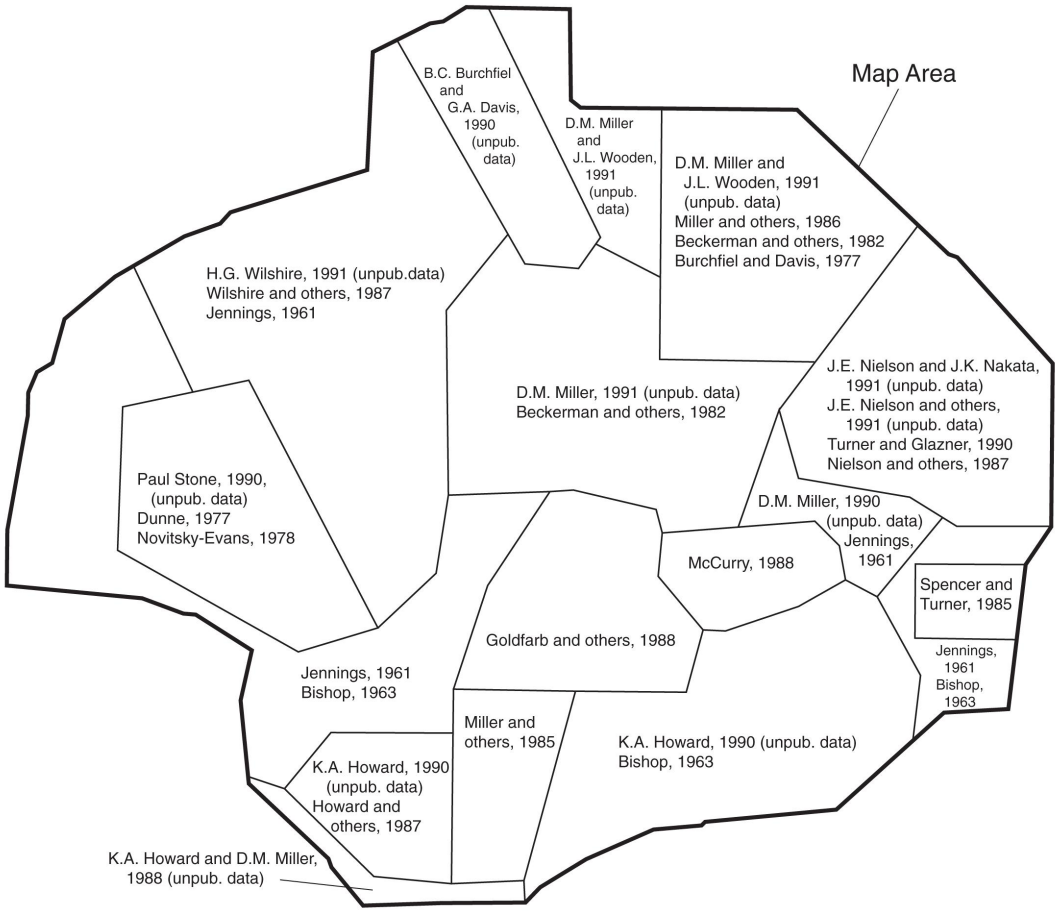
USGS Bulletin 2160 Index Map



INDEX MAP SHOWING LOCATION OF EAST MOJAVE
NATIONAL SCENIC AREA (EMNSA)

Extracted from: (USGS Bulletin 2160).

USGS Bulletin 2160 Sources of Mapping



SOURCES OF MAPPING

Compiled in 1992 from geology mapped by D.M. Miller (1983-91), assisted by L.L. lick (1984-87), Steve Darwin (1984), R.H. Husk (1983), and Sharon Gus (1986); R.J. Miller (1990); J.E. Nielsen (1983-91), assisted by J.S. Nolle, R.D. Turner, Jacqueline Huntoon, and C.A. Armco; H.G. Wiltshire (1986-91), assisted by Doug Prose; K.A. Howard (1980-90), assisted by B.E. John (1980), J.W. Goodge (1981), and T.T Fitzgibbon (1984); and Paul Stone (1990). Also see Sources of Mapping above

Digital database by R.J. Miller
Edited by T.A. Lindquist and J.L. Zigler
Digital cartography by R.D. Koch
Manuscript approved for publication September 11, 1996

Extracted from: (USGS Bulletin 2160).

USGS Bulletin 2160 Geologic Map Legend

Contact—Dashed where approximately located

Lava flow front—Hachures on upper flow

Normal fault—Dashed where inferred; dotted where concealed

Thrust fault—Dotted where concealed. Sawteeth on upper plate

Low-angle normal fault—Dotted where concealed. Hachures on upper plate

Fold

- **Anticline**
- **Overturned anticline**
- **Syncline**
- **Overturned syncline**

Approximate boundary of Woods Mountains caldera—Hachures point into caldera (McCurry, 1988)

Mine

Mountain summit

Extracted from: (USGS Bulletin 2160).

USGS Bulletin 2160 Pediments Map Legend

EXPLANATION

Jgo
Jqs
Jwb
PDl

Unit labels—Indicate composition of detritus comprising the alluvial deposits (labels shown in red represent the dominant lithologic component); unit labels refer to units described on Plate 1

Approximate boundaries between areas having crudely homogeneous composition of surface detritus

Topographic range front (as interpreted from aerial photography)

Alluvial deposits exceed 300 m in thickness on hachured side of boundary

Drainage divide

Distribution of mapped geologic units generalized from Plate 1:

Quaternary and Tertiary sedimentary rocks and surficial deposits

Quaternary and Tertiary volcanic rocks

Mesozoic plutonic rocks

Mesozoic to Late Proterozoic sedimentary and volcanic rocks

Proterozoic plutonic and metamorphic rocks

Extracted from: (USGS Bulletin 2160).

USGS Bulletin 2160 Mineral Occurrences Map Legend

EXPLANATION

[Where symbols overprint, see database to clarify deposit type]

Gold deposit

- ◆ Epithermal quartz-alunite, quartz-adularia gold
- ⧫ Breccia pipe
- ⊗ Low-sulfide, gold-quartz vein
- ☼ Placer gold-platinum group elements

Gold-silver deposit

- ▲ Distal disseminated
- ● Gold-silver quartz-pyrite vein

Silver deposit

- ◊ Silver-copper brecciated dolostone

Polymetallic deposit

- × Fault
- △ Replacement
- □ Skarn
- ○ Vein

Tungsten deposit

- ◪ Skarn
- ◕ Vein

Other metal deposit

- ☆ Carbonatite, rare-earth-element
- ⊠ Copper skarn
- ■ Iron skarn
- ✸ Placer-iron-titanium
- ✚ Porphyry molybdenum, low-fluorine
- ◩ Tin skarn
- ⊞ Zinc-lead skarn
- + Unclassified

Nonmetallic deposit

- C Clay
- ◐ Fluorite vein
- M Marble, dolomite, limestone
- S Sand and gravel
- ⊕ Vein barite
- ⊖ Vein magnesite
- V Volcanic cinders, perlite, and pumice

Extracted from: (USGS Bulletin 2160).

USGS Bulletin 2160 Rock Samples Map Legend

EXPLANATION

+ **Location of mineral occurrences not analyzed by U.S. Bureau of Mines (1990a)**

Locations of mineral occurrences analyzed by U.S. Bureau of Mines (1990a)

• **Rock sample that contains less than 500 parts per billion gold**

○ **Rock sample that contains more than 500 parts per billion gold**

Extracted from: (USGS Bulletin 2160).

GRI Digital Data Credits

This document was developed and completed by Derek Witt (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory (GRI) Program.

The information contained here was compiled to accompany the digital geologic-GIS map(s) and other digital data for Mojave National Preserve, California (MOJA) developed by Heather Stanton with assistance from Jim Chappell and Derek Witt (Colorado State University).

GRI finalization by Heather Stanton (Colorado State University).

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