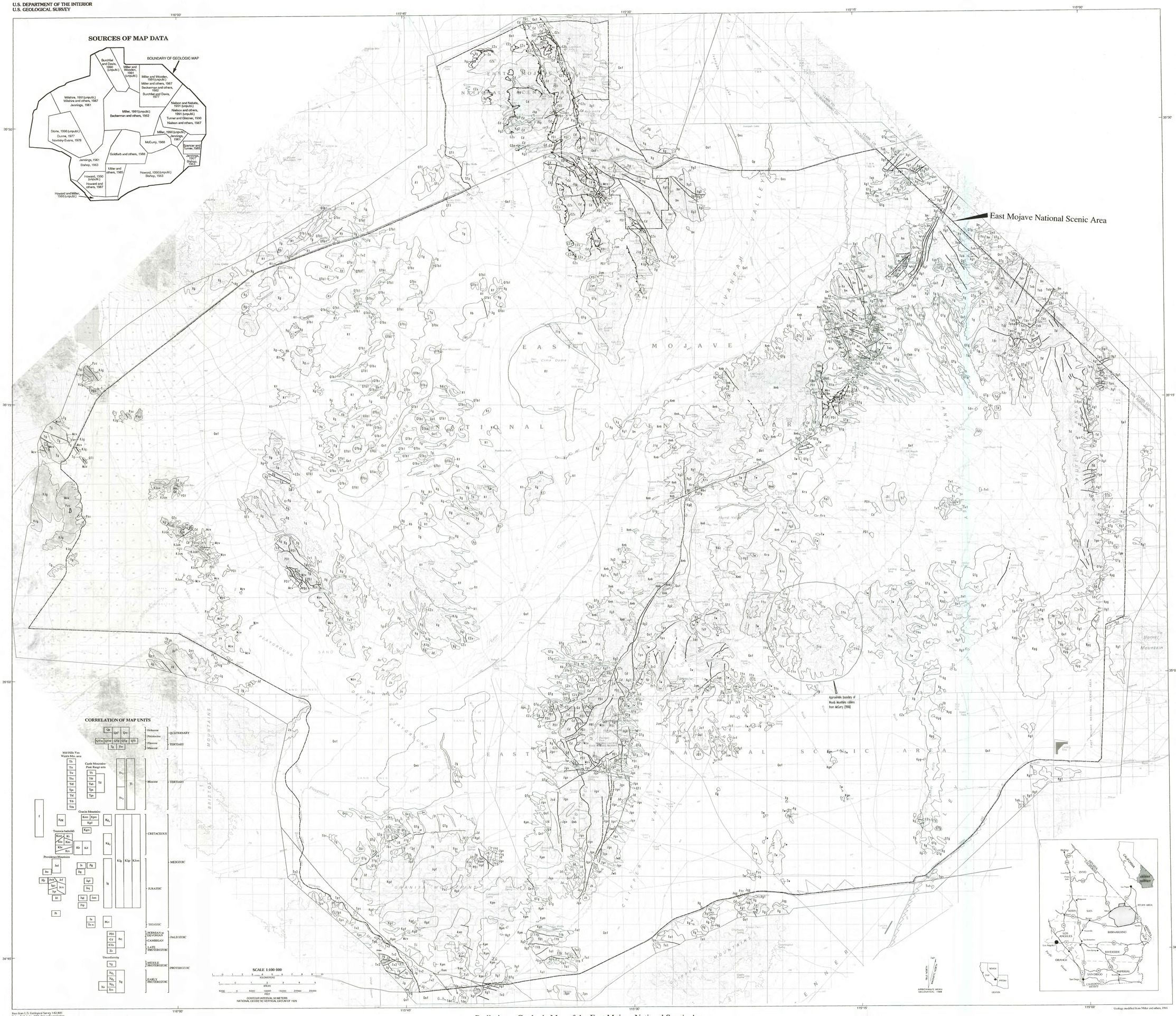

Base from U.S. Geological Survey 1:62,500:
Baker, Soda Lake, 1965; Polyconic projection
1:62,500: Amboy, Cinco Finis, Iverson, Mesquite Lake, Needles, 1965; Universal Transverse Mercator projection

Preliminary Geologic Map of the East Mojave National Scenic Area

DESCRIPTION OF MAP UNITS

Qp Playa deposits (Holocene)—Unconsolidated clay, silt, and sand. Light-colored and sparsely vegetated

Qsf 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 bordering streams, and as braided-stream sediment in stream channels. Older deposits form pediments flanking mountain ranges and typically underlie eroded, paved, and varnished surfaces

Qes Eolian sand (Holocene and Pleistocene)—Unconsolidated fine- and medium-grained sand forming dunes and sand sheets. Most dunes sand is composed of quartz and feldspar

QTbs Basalt cinder deposits (Holocene to late Miocene)—Unconsolidated deposits of basalt scoria fragments, consolidated pyroclastic breccia, and tuffaceous conglomerate formed by phreatic eruption during vent opening

QTbf Basalt lava flows (Pleistocene to late Miocene)—Alkaline basalt and hawaiite flows.

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 Pinto Range and north of Cima Dome

QTg Gravel (Pleistocene and Pliocene)—Moderately consolidated pebble, cobble, and sand deposits; typically underlies highly incised surfaces. Locally contains extensive pedogenic calcite

QTl Landslide and sedimentary breccia deposits (Pleistocene and Pliocene)—Displaced deposits of disaggregated rock. Most are Pliocene landslides; however, some are Pleistocene. Large landslide composed of brecciated bedrock west of Providence Mountains is probably made up of gravity-slide masses

Tg Gravel (Pliocene and Miocene)—Moderately consolidated, crudely bedded, fluvial boulder- to pebble-gravel and sand interbedded with coarse to extremely coarse debris flows deposits, avalanche breccias, and gravity-slide breccias. Sand is siliciclastic and volcaniclastic, locally arkosic. In east end of New York Mountains typically forms highly incised island remnants. Internalized gravity slide blocks between Cima Dome and Old Dad Mountain consist of breccias of dolomite, limestone, chert, quartzite, and volcanic, metamorphic, and granitoid rock

Ttw Sedimentary breccia deposits (Pliocene or Miocene)—Deposits of disaggregated rock and alluvium that form hummocky terranes. Deposits lie along north flank of Granite Mountains

VOLCANIC ROCKS IN THE MID HILLS-VAN WINKLE MOUNTAIN AREA

Tb Basalt (Miocene)—Alkali basalt and andesite lava flows. Olivine andesite overlying Tortoise Shell Mountain Rhyolite is about 10 Ma (McCurry, 1988).

Tts Tortoise Shell Mountain Rhyolite (Miocene)—Rhyolite lava flows and plugs, and interbedded pyroclastic material. Aphyric to porphyritic with sparse sanidine. Rhyolite is dated at 15.8 Ma (McCurry, 1988) and is chemically similar to the upper cooling unit of the Wild Horse Mesa Tuff

Tw Wild Horse Mesa Tuff (Miocene)—Prominently layered sanidine rhyolite ash-flow tuff containing common sanidine phenocrysts, and rare quartz, biotite, clinopyroxene, and magnetite phenocrysts. Mostly welded; forms three compound cooling units totalling as much as 320 m in thickness. Locally rich in lithic fragments. Forms conspicuous mesas in Woods Mountains area. Dated at about 15.8 Ma (McCurry, 1988). Probable source is a trap-door caldera in western Woods Mountains

Tha Hackberry Spring Volcanics (Miocene)—Intermediate lava flows, domes, ash flows, and dikes and plugs of trachyte, trachyandesite, and rhyolite. Dated at about 16 Ma (McCurry, 1988). Crops out widely on Hackberry Mountain

Tbf Dome of Bedford Formation—Extrusive domes and related lava flows composed of rhyodacite. Crops out near Wildhorse Mesa

Tps Peach Springs Tuff of Young and Brennan (1974) (Miocene)—Widely distributed welded ash-flow tuff composed of rhyolite containing conspicuous sanidine, with essential but minor quartz, 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

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 upper part

Ttb Tuff breccia (Miocene)—Lahar and debris flow deposits of tuff breccia, minor air-fall tuff, and tuffaceous sedimentary rocks. Lahar deposits includes rhyolite, basalt, dacite, and andesite flows. Sedimentary rocks include waterlain tuffaceous rocks, conglomerate, and lacustrine siltstone and sandstone. Crops out at Van Winkle Mountain and south of the Granite Mountains

Tda Dacite and andesite flows (Miocene)—Thin lava flows and associated domes of intermediate composition. Crops out south of the Granite Mountains

VOLCANIC ROCKS IN THE CASTLE MOUNTAINS-PLUTE MOUNTAINS AREA

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 between 16.1 ± 0.4 and 12.6 ± 0.3 Ma (Beckerman and others, 1982)

Tab Andesite and basalt (Miocene)—Lava flows and breccia composed of hornblende-pyroxene andesite and basalt. Includes minor dacite and rhyolite breccia deposits composed largely of andesite. Locally includes interbedded conglomerate, fanglomerate, sandstone, and siltstone. Present in New York Mountains and Piute Range

Tga Arkosic gravel (Miocene)—Generally coarse, locally derived fluvial conglomerate and grus, mainly containing of Proterozoic and Mesozoic gneiss and granite. Variably indurated. Present in Piute Range

Td Dacite (Miocene)—Dacite to andesite breccia, domes, and lava flows

Tv_1 Younger volcanic rocks, undivided (Miocene)—Rhyolite lava and ash flows, basalt flows, and dacite lavas that overlie the Peach Springs Tuff

Tv_2 Older volcanic rocks, undivided (Miocene)—Rhyolite lava and ash flows, tuffaceous sedimentary rocks, tuff breccia, and basalt and andesite flows

Ti Shallow intrusive rocks (Miocene)—Felsic, intermediate and mafic igneous rocks emplaced as shallow intrusions and domes. Present in Granite Mountains and Lanfair Valley

f Felsite (Tertiary and/or Cretaceous)—Fine-grained felsitic igneous rocks that form dikes and irregular-shaped intrusions

Kpg Porphyritic granodiorite (Cretaceous)—Light-colored, coarse-grained biotite granodiorite and monzogranite containing potassium feldspar phenocrysts. Present in the Fenner Hills, Piute Range, Homer Mountain, and nearby areas. Feldspar phenocrysts are 3-2 cm across except in the southern Piute Range, where phenocrysts are 2-4 cm.

GRANITOID ROCKS IN THE GRANITE MOUNTAINS AREA

Kem Equigranular monzogranite (Cretaceous)—Interior unit of zoned plutons in eastern Granite Mountains. Consists of medium-grained biotite monzogranite

Kpm Porphyritic monzogranite (Cretaceous)—Light-gray, coarse-grained biotite monzogranite containing potassium feldspar phenocrysts. Crops out widely in eastern Granite Mountains and part of Providence Mountains. It was termed the Granite of Arrowweed in southern Providence Mountains (Miller and others, 1985). Locally fine-grained

Kgd Granodiorite (Cretaceous)—Forms exterior unit on south side of zoned pluton in the eastern Granite Mountains and also forms a dress-like pluton in the western Granite Mountains. Consists of equigranular hornblende biotite granodiorite. Intruded by the porphyritic monzogranite unit

Kg_2 Granitoid rocks (Cretaceous)—Monzogranite, granodiorite, and more mafic rocks probably of Late Cretaceous age. Crops out east of Piute Range and at north end of Piute Mountains

Kgm Garnet-two-mica monzogranite (Cretaceous)—Medium-grained syntectonic to monzogranite that crops out east of Blind Hills. A minimum age is suggested by a K-Ar age of 83 Ma on muscovite

GRANITOID ROCKS OF THE TILTOTNA BATHOLITH

Kmh Mid Hills Adamellite of Beckerman and others (1982) (Cretaceous)—Medium- to coarse-grained, porphyritic to equigranular, light tan, leucocratic monzogranite. Locally contains minor hornblende. Contains common aplite and pegmatite dikes. Crops out over much of the Mid Hills and southern New York Mountains. Unit includes intrusive breccia and brecciated felsic plugs in southern Providence Mountains. Dated as about 93 Ma by U-Pb on zircon (Ed DeWitt, 1985, oral commun.)

Ki Teutonia Adamellite of Beckerman and others (1982) (Cretaceous)—White to light tan, equigranular to porphyritic (pink alkali-feldspar phenocrysts) biotite monzogranite, generally medium and coarse grained. Locally ranges in composition to syenogranite and quartz monzonite. Minor muscovite present in places. Termed "granitic rocks of Kelso Peak" by Dazey (1972). Crops out over much of Cima Dome, where it was dated as 97 Ma by U-Pb on zircon (DeWitt and others, 1986)

Klo Live Oak Canyon Granodiorite of Beckerman and others (1982) (Cretaceous)—Equigranular, medium- to coarse-grained, light gray biotite granodiorite. Crops out in central New York Mountains. Contains rare hornblende. Contact with Mid Hills Adamellite was gradational

Klks Kessler Springs Adamellite of Beckerman and others (1982) (Cretaceous)—Strongly porphyritic, white, coarse-grained monzogranite. Potassium feldspar phenocrysts and biotite are set in gray, medium-grained groundmass. Contains minor hornblende. Crops out northeast of Cima Dome. K-Ar age of biotite about 92 to 93 Ma (Burchfiel and Davis, 1971) and K-Ar age of hornblende is 92.1 ± 0.5 (Beckerman and others, 1982)

Klbc Black Canyon Hornblende Gabbro of Beckerman and others (1982) (Cretaceous)—Texturally and compositionally variable black hornblende gabbro, with minor quartz diorite, and monzodiorite. Medium grained and equigranular. Contains abundant hornblende and lesser clinopyroxene or biotite

Krs Rock Spring Monzodiorite of Beckerman and others (1982) (Cretaceous)—Porphyritic, dark-gray to brown, compositionally variable rock composed of monzodiorite, quartz monzodiorite, and quartz monzonite. Common rock types are hornblende monzodiorite, quartz monzodiorite, and quartz monzonite. Contains abundant mafic inclusions. Considered to be Jurassic in age by Beckerman and others (1982), but dated as about 93 Ma by U-Pb on zircon (Ed DeWitt, 1985, oral commun.). Intruded by Mid Hills Adamellite

Kb Biotite-rich granitoid (Cretaceous)—Gray equigranular to porphyritic (small pink alkali-feldspar phenocrysts) biotite granitoid rocks, generally medium or coarse-grained. Biotite content 10% by volume or greater; biotite-rich schlieren widely present, abundant in places. Mapped in Hackness Wash and to south. Considered Cretaceous by DeWitt and others (1986)

Kd Diorite (Cretaceous)—Hornblende diorite west of Cima Dome

Kg_1 Granitoid rocks (Cretaceous)—Monzogranite, granodiorite, and more mafic rocks similar to granitoids of the mid-Cretaceous Teutonia batholith

JURASSIC GRANITOID ROCKS OF THE PROVIDENCE MOUNTAINS AREA

Jsd Shonzo dikes (Jurassic)—Felsic to intermediate dikes in complex sheeted main along west side of southern Providence Mountains

Jss Granite of Tough Nut Spring (Jurassic)—Dark pink to medium brown, coarse-grained, subequigranular to porphyritic biotite syenogranite and monzogranite. Potassium feldspar phenocrysts typically pink or purple. Mapped as Iwanpah Granite by Goldfarb and others (1988), but is less porphyritic

Jfp Fountain Pink Rhyolite (Jurassic)—Dark pink, hypabyssal granite and siliceous, generally aphyric, flow-banded rhyolite. Locally contains biotite. Feeder dike dated as Jurassic (D. Walker, 1988, oral commun.)

Jwb Quartz syenite of Wentzen Basin (Jurassic)—Coarse-grained, markedly porphyritic quartz syenite, syenogranite, and monzogranite. Melanocratic with purple to pink phenocrysts. Contains augite, hornblende, and biotite

Jcf Felsic rocks of Colton Hills (Jurassic)—White, coarse-grained, porphyritic biotite monzogranite and finer grained felsic rocks of gray color. Includes yellow to pink, quartz-rich, coarse-grained biotite monzogranite near Bonanza King Well, east side of Providence Mountains

Jgs Quartz monzonite of Goldstone (Jurassic)—Dark-colored, medium- and coarse-grained, porphyritic to subequigranular rock of variable composition; quartz monzonite predominates but rock ranges to quartz syenite and quartz monzodiorite. Mafic phases are biotite, hornblende, and augite. K-Ar age for biotite is 157.0 ± 3.8 Ma; U-Pb age for zircon is approximately 162 to 164 Ma (Miller and others, 1985)

Jcm Monzonitic rocks of Colton Hills (Jurassic)—Dark-colored, fine- to coarse-grained, compositionally variable rocks ranging in composition from monzonite, quartz syenite, monzogranite, and minor gabbro. Biotite, hornblende, and augite are chief mafic minerals. Rocks are widely altered

Jqs Syenogranite of Quail Spring (Jurassic)—Dark-colored, medium- to coarse-grained, hornblende-biotite syenogranite; ranges to quartz monzonite and quartz monzodiorite. Commonly extensively altered

Jd Diorite (Jurassic)—Dark brown to black hornblende diorite, hornblende-biotite monzodiorite, and mafic porphyritic hornblende-biotite quartz monzonite

Jh Hypabyssal and metavolcanic rocks (Jurassic)—Dark-weathering, highly chloritized, quartz-poor hypabyssal and volcanic rocks. Crops out in southeastern Providence Mountains

Js Sandy Granite of Hewett (1956) (Jurassic)—Pale pink, coarse-grained, leucocratic alkali-feldspar granite characterized by perthitic potassium feldspar phenocrysts and granophyric texture (Dunne, 1977; Novisky-Evans, 1978). Crops out at Devils Playground area

Jlg Leucocratic granite (Jurassic)—Dark pink, medium-grained, leucocratic granite in Granite Mountains

Jsg Iwanpah Granite (Jurassic)—Dark pink to tan, coarse-grained, porphyritic biotite syenogranite to monzogranite in the Iwanpah Mountains and east of Cima. Common weakly developed magmatic foliation is defined by aligned feldspar and biotite. Minor hornblende or muscovite is present. K-Ar ages of 156 to 138 Ma (Satter, 1968) interpreted here as minimum ages; preliminary U-Pb data for zircon suggest crystallization age of 145 Ma (D.P. Walker, 1991, oral commun.)

Jgf Quartz diorite gneiss (Jurassic)—Hornblende quartz diorite and quartz monzodiorite containing megacrysts of potassium feldspar. Age about 180 Ma. Present in the Granite Mountains

Jsq Spread quartz monzonite (Jurassic)—Dark-colored, medium-grained hornblende quartz monzonite, buff-weathering, commonly contains mafic inclusions. Present in the Granite Mountains

Jgg Quartz monzodiorite and granodiorite (Jurassic)—Foliated medium-grained rocks ranging in composition from granodiorite to diorite. Locally porphyritic. Present in the Clipper Mountains. Forms the Goldhammer photo

Jsm Striped Mountain plutonic (Jurassic)—Hornblende diorite that crops out in Striped Mountain. K-Ar age of hornblende about 167 to 167 Ma so we consider it to be similar in age to other Jurassic granitoids, but Burchfiel and Davis (1971) suggested that it might be as old as 200 Ma

Jbp Breccia photo (Jurassic)—Hornblende diorite in Mescal Range. K-Ar age of hornblende at about 190 to 200 Ma may indicate a Triassic age (Burchfiel and Davis, 1971). Map unit includes similar rocks in Clark Mountain

Jg Granitoid rocks, undivided (Jurassic)—Hornblende-biotite granodiorite, porphyritic granite and alkali granite, quartz monzonite, hornblende monzodiorite and related rocks. Potassium feldspar phenocrysts in porphyritic granitoids typically pink or purple

KJg Granitoid rocks, undivided (Cretaceous and Jurassic)—Monzogranite, granodiorite, and more mafic rocks of Mesozoic age. Present in Soda, Iwanpah, and Kelso Mountains

Klgr Granite (Cretaceous and/or Jurassic)—White, medium- to coarse-grained granite near Baker (Grose, 1959)

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 with phenocrysts of potassium feldspar (Dunne, 1973). Locally contains secondary epidote and chlorite (Novisky-Evans, 1978). Age uncertain but pinkish color suggests possibly Jurassic (cf. Miller and others, 1985)

Ja Anorthosite (Jurassic)—Medium-grained, hybridized quartz anorthosite, typically red, yellow, or buff in color. Contains lenses of conglomerate in Old Dad Mountain exposures and interbeds of felsic volcanic rocks in several places. Also present at Cowhole Mountain and Mescal Range

TRm Moenkopi Formation (Triassic)—Thin-bedded limestone, sandy and silty limestone, calcareous shale, and sandstone present at Old Dad Mountain and Mescal Range. Metamorphosed calcisiliceous rocks in New York Mountains are tentatively correlated with the Moenkopi (Burchfiel and Davis, 1977)

Mzv Volcanic and sedimentary rocks (Mesozoic)—Volcanic flows, flow-breccia, tuff, volcaniclastic rocks, quartzite, and conglomerate. Includes rocks formed the Dellbrook Volcanics locally interfingering with or overlying Aztec Sandstone and metavolcanic rocks lying above the Moenkopi Formation and equivalent sedimentary rocks. Volcanic rocks lying above the Moenkopi Formation in New York Mountains were dated at 167 Ma by Bushy Spring (1968). Metavolcanic rocks lying below the Moenkopi Formation are tentatively correlated with the Dellbrook Volcanics (Dunne, 1977). Locally includes hypabyssal rocks. Unit in central New York Mountains consists of felsic metavolcanic rocks with lesser sedimentary rocks, all underlain by basal conglomerate (Burchfiel and Davis, 1977). Sedimentary rocks included in this unit in Providence Mountains are shale, sandstone, conglomerate, and impure limestone; part of this section probably correlates with the Moenkopi Formation (Hazzard, 1954). Also present at Soda Mountains and Iwanpah Mountains

PDf Limestone (Permian to Devonian)—Consists of the Permian and Pennsylvanian Bird Spring Formation (thick-bedded cherty, sandy and part limestone); the Mississippian Monte Cristo Limestone (massive pure, coarse limestone, cherty in lower part); and the Devonian Sultan Formation (medium-bedded, interlayered limestone and dolomite)

Cd Dolomite (Cambrian)—Buff and gray, generally thin bedded dolomite; argillaceous in lower part. Consists of the Cambrian Bonanza King Formation. Widely distributed over map area

CZs Siliciclastic rocks (Cambrian and Late Proterozoic)—Interbedded limestone, siltstone, and shale in upper part of unit and quartzite rocks in lower part. Includes the Carrara Formation, Zabriskie Quartzite, Wood Canyon Quartzite, and Stirling Quartzite. Probably includes time equivalents of one or both of the Johnnie Formation and the Noonday Dolomite in Old Dad Mountain and Providence Mountains (Dunne, 1973; Stewart, 1970)

Pzc Carbonate rocks (Paleozoic)—Undivided dolomite, limestone, and marble; metamorphosed in many places

Zs Sedimentary rocks (Late Proterozoic)—Shale, siltstone, diamictite, and dolomite. Corresponds to the Johnnie Formation, Noonday Dolomite, and Kingston Peak Formation. Outcrop is in thrust slivers of the Iwanpah Mountains, Mescal Range, and Clark Mountain

Yg Granitoids (Middle Proterozoic)—Alkalic igneous rocks including granite, syenite, shonkinite, and monzonite. Age is about 1400 Ma (DeWitt and others, 1987)

Xgi Younger granitoids (Early Proterozoic)—Granite, granodiorite, and diorite between 1660 and 1695 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 Vontriegger Hills

Xgi Intermediate-age granitoids (Early Proterozoic)—Augen gneiss and subequigranular gneiss of biotite granite and biotite granodiorite composition, about 1700 to 1715 Ma (Wooden and Miller, 1990). One phase crops out in northern New York Mountains, and an igneous complex of this age crops out in the northern Providence Mountains. Orthogneiss of this age was identified in the Hackness Hills (DeWitt and others, 1986) but is geochemically and with surrounding undeformed granitoids of Jurassic age

Xa Anorthosite (Early Proterozoic)—Massive anorthosite and leucocratic anorthositic gneiss containing minor amounts of mafic minerals and potassium feldspar. Includes granulite facies mafic rock containing orthopyroxene. Intrudes older granitoids and is interlayered in migmatite

Xgi Older granitoids (Early Proterozoic)—Pyroxene diorite, biotite-hornblende tonalite, and biotite granodiorite augen gneiss older than 1730 Ma (Wooden and Miller, 1990). Crops out as mafic complex west of Iwanpah Valley

Xm Migmatite (Early Proterozoic)—Highly metamorphosed, compositionally-layered rocks of supracrustal parentage. Includes quartzo-feldspathic gneiss, garnet-bearing leucocratic layers and dikes, pelitic biotite-sillimanite-gneissose-feldspar gneiss, amphibolite gneiss, and biotite-garnet gneiss. Compositional range for many rocks is similar to metamorphic volcanic rocks such as dacite or immature sedimentary rocks such as greywacke (Wooden and Miller, 1990)

Xg Gneiss and granitoids (Early Proterozoic)—Undivided migmatite, granitoid gneiss, and granitoids mapped at many poorly known locations across Scenic Area. Includes quartzite and quartzofeldspathic paragneiss on Old Dad Mountain

CONTACT—Dotted where covered

HIGH-ANGLE FAULT—Dashed where location inferred; dotted where concealed

THRUST FAULT—Dashed where location inferred; dotted where concealed; barbs on hanging wall

LOW-ANGLE NORMAL FAULT—Dashed where inferred; dotted where concealed; barbs on hanging wall

DUCTILE SHEAR ZONE

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.