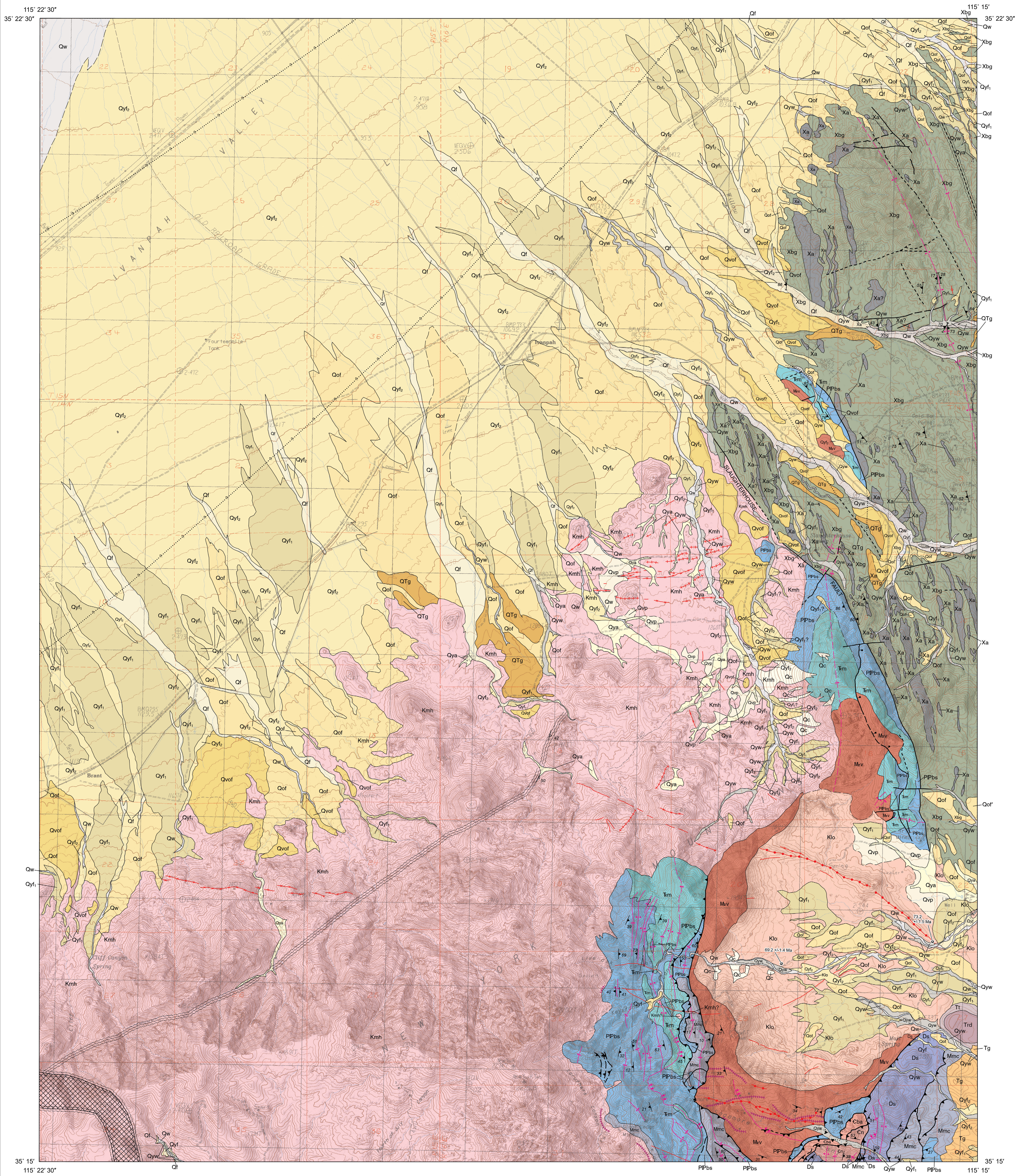
California geologic maps are available at https://www.conservation.ca.gov/cgs



PRELIMINARY GEOLOGIC MAP OF THE IVANPAH 7.5′ QUADRANGLE, NEW YORK MOUNTAINS, SAN BERNARDINO COUNTY, CALIFORNIA

California Department of Conservation
California Geological Survey

VERSION 1.1

By
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2022

DESCRIPTION OF MAP UNITS

QUATERNARY SURFICIAL DEPOSITS

Qc — **Colluvial deposits (Holocene)**—Unconsolidated to weakly consolidated slope deposits consisting of colluvial debris and talus derived from up-slope outcrops. Some deposits are degraded by erosion and likely older Holocene in age. Distinguished only where deposits are prominent or conceal relationships between underlying units.

Qw — **Modern Wash deposits (late Holocene)**—Unconsolidated sand, gravel, cobbles, and local boulders deposited in recently active stream channels. Occur as narrow deposits in canyons upstream of the mountain front and as anastomosing to elongate deposits where active flow paths continue beyond the mountain front and traverse older fan deposits, but do not form fan-shaped landforms; locally includes small areas of Qyf deposits. Sediments are generally derived from local bedrock or reworked from adjacent older Quaternary deposits. Materials subject to mobilization and redeposition during storm events and therefore lack oxidation on clasts and only support local, sparse vegetation.

Qf — **Modern alluvial fan deposits (late Holocene)**—Unconsolidated to weakly consolidated, poorly sorted, sand, gravel, cobble, and local boulder deposits with intermixed silt forming active, essentially undissected, alluvial fans. Fan apices commonly occur at or upstream of the mountain front, and locally form outboard of the mountain front and downgradient of incised older fans. Sediments subject to mobilization and redeposition during storm events and therefore only support local, sparse vegetation. Clasts are derived from up-slope rock sources and reworked from adjacent older fan deposits; clasts typically unweathered with little to no oxidation or desert varnish. Fans are typically braided and include a composite mix of sediment-rich stream deposits and poorly bedded and poorly sorted debris flow deposits, containing angular to sub-angular pebble- to boulder-size clasts closer to the mountain front.

Qyw — **Younger wash deposits (middle Holocene to late Pleistocene)**—Weakly consolidated sand, gravel, cobbles, and local boulder deposits. Commonly occurs as elongate deposits on the margins of active Qw deposits in larger canyons upstream of the mountain front. Sediments are generally derived from bedrock in upstream source areas. Sediments may be subject to mobilization and redeposition during large storm events. Vegetation may be sparse to moderately dense.

Qyf — **Younger alluvial fan deposits, undifferentiated (middle Holocene to late Pleistocene)**—Unconsolidated to weakly consolidated, poorly sorted, sand, gravel, cobble, and local boulder deposits with intermixed silt, generally lacking pedogenic carbonate, form undissected to slightly dissected alluvial fans with ubiquitous small-scale surface roughness. Cones and broad aprons with fan apices typically occur upstream of the mountain front in the larger canyons but also occur at or outboard of the mountain front downstream of older incised fans. Locally includes narrow active Qf/Qw deposits and small areas of Qof. Sediments may be subject to local mobilization and redeposition during large storm events; vegetation may be sparse to moderately dense. Clasts are derived from up-slope sources and reworked from adjacent older fan deposits; clasts are typically weakly weathered with weak oxidation and desert varnish. Fans are composed of a composite mix of sediment-laden stream deposits and poorly bedded, poorly sorted debris flow deposits containing pebble- to boulder-size clasts closer to the mountain front.

Qyf_2 — **Younger alluvial fan deposits, younger facies (middle Holocene to late Pleistocene)**—Younger facies of Qyf that is are undissected to weakly dissected with sparse vegetation and weak oxidation of clasts. Sediments of Qyf_2 are subject to mobilization and redeposition during large storm events and flow avulsions.

Qyf_1 — **Younger alluvial fan deposits, older facies (middle Holocene to late Pleistocene)**—Older facies of Qyf that is slightly to moderately dissected with degraded/smoothed small-scale roughness compared to Qyf_2, sparse to moderate vegetation density, and weak to moderate oxidation of clasts. Deposits mapped as Qyf_1 likely represent more than one age of deposition and may overlap in age with deposits mapped as Qof, particularly on the east flank of the New York Mountains. Qyf_1 locally overlies Qof or Qvof, particularly in the Pinto Valley Quadrangle. Sediments in this unit are rarely subject to mobilization and redeposition by storm runoff.

Qya — **Younger alluvium (Holocene and late Pleistocene)**—Unconsolidated silty sand, grusy sand, gravel, cobbles, and local boulders. Deposited in canyon areas upstream of the mountain front, either in broad alluvial valleys or in narrower valleys where active wash deposits are subordinate or lacking. Alluvial surfaces are slightly elevated from active channels and support common vegetation, suggesting they are only inundated during larger, uncommon flood events. Clasts are generally unweathered with little oxidation. Locally more than one level of younger alluvium may be present.

Qvp — **Pediment veneer deposits (Holocene to middle Pleistocene)**—Weakly to moderately consolidated sand, gravel and local cobble-sized fragments composed of angular to subangular granitic clasts. Unit forms thin veneer of decomposed granite and sheet wash deposits overlying older, fan-like erosional surfaces developed on bed rock units; includes local areas of low bedrock outcrops.

Qof — **Older fan deposits (late to middle Pleistocene)**—Slightly to moderately consolidated, poorly sorted, silty, pebbly sand to coarse gravel and boulder fan deposits. Broad to isolated fan surfaces are typically smooth to moderately dissected and isolated by intervening younger fan deposits; surfaces support stable vegetation and clasts exhibit moderate oxidation/desert varnish patinas and desert pavement. Surfaces are generally elevated at least several meters above active channel grade, and not subject to historic flood inundation. The underlying bedrock is locally exposed around margins of deposits. Qof is commonly overlain by Qyf_1 in the Pinto Valley Quadrangle and exposed due to geologically young incision. Deposits occur both upstream and downstream of the mountain front and typically range from less than 1 m to about 5 m thick on the west flank of the New York Mountains; on the east flank of the range deposits tend to be thicker; deposits mapped as Qoa in the Watson Wash drainage in the Pinto Valley Quadrangle range up to 40 m thick and may be a distinct older unit that includes old wash deposits. Deposits include light to moderate pedogenic carbonate development along selected beds and fractures, which is typically weakly indurated. An IRSL date of 70.09 +/- 7.27 ka was determined for sample CRBS098 located on west flank of New York Mountains in the Crescent Peak Quadrangle.

Qvof — **Very old fan deposits (early Pleistocene)**—Moderately to well-consolidated silt, sand, gravel, cobbles, and boulders locally exceeding 1 m in diameter and forming deposits up to 15 m thick; some clasts are exotic to local source areas. Fan surfaces are smooth or rounded and degraded such that the original surface and surface oxidation patinas are commonly lost; eroded surfaces range in color from light gray to light brown. Fan surfaces may extend up to tens of meters above adjacent channel grade and underlying bedrock may be exposed. Deposits generally found a short distance upstream or downstream of the mountain front; pedogenic carbonate moderately indurated, where observed.

QTg — **Ancient gravel deposits (Pleistocene to Pliocene)**—Light-gray weathering, moderately consolidated, pebble, cobble, and sand deposits with locally extensive pedogenic carbonate. Deposits are highly dissected and degraded such that the original alluvial surfaces and oxidation patinas are commonly lost. Deposits range up to 20 m thick and are less related to current topographic conditions than younger alluvial fan deposits. Deposits are most extensive in the Castle Peaks Quadrangle, both on the southeast flank of the New York Mountains and where they locally extend westward across the range crest and infill an ancient drainage. The deposit is also extensive on the northern portion of the Crescent Peak Quadrangle where they overlie Miocene volcanic rock and are commonly tilted down to the southeast and locally cut by faulting.

TERTIARY UNITS

Tg — **Gravels (Miocene)**—Moderately to well consolidated fluvial boulder to pebble gravel to coarse debris-flow deposits; local avalanche breccia and gravity-slide breccia sequences. Exotic clasts of porphyritic and augen gneiss with boulders up to 3 m in diameter. Sand interbeds of siliciclastic, volcaniclastic, and locally arkosic makeup. Caliche development and clast types not derived from local sources are characteristic of unit, indicating through-going fluvial environments and (or) far-travelled breccia sheets. Notable lack of volcanic clasts. Locally interfingers with Tab in the Crescent Peak quadrangle area.

Tt — **Tuff (Miocene)**—A single occurrence within mapped area, roughly two miles south of Barnwell and adjacent to Trd. May represent a pyroclastic eruptive phase of the same magma that produced Trd (Miller and Wooden, 1993).

Trd — **Rhyolite dome (Miocene)**—Rhyolite Dome of Miller and Wooden (1993). The unit occurs as a single dome within mapped area, roughly two miles south of Barnwell. Described by Miller and Wooden (1993) as aphyric, flow banded rhyolite with zones of minor plagioclase phenocrysts. Likely part of a sequence of dacitic and rhyolitic domes, plugs, and associated flows/flow breccias (Theodore, 2007; Turner and Glazner, 1990) that outcrop within the Castle Mountains Quadrangle dated 16.1±0.4 to 12.8 ± 0.2 Ma (Turner and Glazner, 1990).

MESOZOIC AND PALEOZOIC UNITS

Granitoid rocks of the Teutonia batholith (Cretaceous)

Klo — **Live Oak Canyon Granodiorite (Late Cretaceous)**—Light-gray to salt-and-pepper to tan biotite granodiorite (Miller and Wooden, 1993). Typically, medium-to coarse-grained with hypidiomorphic, equigranular texture; locally porphyritic with alkali feldspar phenocrysts. Plagioclase, alkali feldspar, and quartz are the primary minerals, with biotite the primary mafic mineral. Accessory minerals include hornblende, opaque oxides, sphene, allanite, and apatite (Beckerman, 1982). Quartz porphyry and undifferentiated dikes are common within the unit. Near the gradational contact with the Mid Hills adamellite, the granodiorite develops a porphyritic texture becoming indistinguishable from the adamellite (Beckerman, 1982). Beckerman (1982) report a K-Ar biotite date of 79.9 +/- 2.4 Ma for the granodiorite and Burchfiel and Davis (1977) reported a minimum K-Ar age of 71.7 +/-0.8 Ma for the quartz porphyry dikes. New U-Pb dating of porphyritic Klo produced a Late Cretaceous age of 69.2 +/-0.6 [1.4] Ma (MSWD = 3.7), and dating of the youngest zircons from the longest quartz porphyry dike cutting the Klo pluton in the Ivanpah Quadrangle produced an age of 73.2 +/-1.4 [1.5] (MSWD = 1.7) (age +/-internal 2SE uncertainty; [total 2% uncertainty]). Analyses were conducted on zircons using laser ablation ICPMS analyses at the CSUN Laser Lab. These dates suggest that initial crystallization of the pluton was occurring by about 80 Ma, which was cut by quartz porphyry dikes at about 72 to 73 Ma, and then locally intruded by a younger porphyritic facies at about 69 Ma. The porphyritic Klo and quartz porphyry dike both contained a significant component of inherited Paleoproterozoic zircons, and the quartz porphyry contained a significant population of zircons similar in age to the previously reported K-Ar date.

Kmh — **Mid Hills Quartz Monzonite (Late Cretaceous)**—Salt-and-pepper to light gray to tan, with a composition ranging from granite to quartz monzonite (adamellite of Beckerman, 1982 and Miller and Wooden, 1993). The quartz monzonite is medium- to coarse-grained with porphyritic to equigranular texture. The majority of the minerals in the equigranular phase occur in sizes between 1.2 mm and 5.6 mm (Beckerman, 1982). The porphyritic phase contains euhedral to subhedral alkali feldspar phenocrysts ranging in length from 1 – 7.5 cm with the matrix minerals ranging in size from 0.3 – 6 mm in size (Beckerman, 1982). Alkali feldspar, plagioclase, and quartz are the dominant minerals with biotite and minor hornblende making up the mafic assemblage. Accessory minerals include opaque oxides, sphene, allanite, and apatite (Beckerman, 1982). Aplite and pegmatite dikes are common within the unit (Miller and Wooden, 1993). Beckerman (1982) reported K-Ar dates ranging from 73.4 to 104.5 Ma and Miller and Wooden (1993) report a U-Pb date of about 93 Ma was obtained by Ed DeWitt (1985 pers com). New U-Pb dating of zircons and titanites collected from a foliated fine-grained diorite enclave in the Pinto Valley Quadrangle produced Early Cretaceous ages of 107.5 +/-0.7 [2.2] (MSWD = 2.5) and 107.9 +/-0.9 [2.2] Ma (MSWD = 8.6) (age +/-internal 2SE uncertainty; [total 2% uncertainty]). Analyses were conducted using laser ablation ICPMS analyses at the CSUN Laser Lab.

Jv — **Volcanic and sedimentary rocks (Mesozoic)**—Metamorphosed rhyolites and sedimentary rocks (Miller and Wooden, 1993) including vitric rhyolitic tuffs, lithic rhyolitic tuffs, and quartzites. Tuffs display varying degrees of alteration and recrystallization, including bands of silica (1–2 mm thick) and red-green argillic alteration. Quartzites are fine-grained, white to gray color, and display weak foliation visible in outcrop and defined by lenses of coarser grained quartz crystals and very fine-grained biotite visible in thin section. Foliation is cut by quartz veins in some places.

TRm — **Moenkopi Formation (Triassic)**—250 to 300 m thick sequence of pale-green quartz-tremolite-diopside calc-silicate rocks and quartzite. Unit includes silty limestone, massive calc-silicate hornfels, pelitic hornfels, and shale (Burchfiel and Davis, 1977). The weathered limestone varies from green to reddish brown with increasing silt, while the dolomitic calc-silicate rock weathers orange (Burchfiel and Davis, 1977). The unit unconformably(?) overlies the Bird Spring Formation and is tentatively correlated to the unmetamorphosed thin-bedded, silty and sandy limestone, calcareous shale, and sandstone parts of the Moenkopi Formation found in adjacent ranges (Hewett, 1956; Burchfiel and David, 1977). However, this unit may represent a local Mesozoic formation not present to the north or west (Burchfiel and David, 1977).

PPbs — **Bird Spring Formation (Permian-Pennsylvanian)**—400 to 430 m thick sequence of thin to thick bedded limestone, silty limestone, and dolomite that conformably overlies the Monte Cristo limestone (Brown, 1995; Burchfiel and Davis, 1977). Upper member is medium to dark gray siliceous and tremolitic dolomite (Brown, 1989). Middle member is white to buff where weathered, siliceous, tremolitic dolomite (Brown, 1989). Lower member is thin bedded to massive, light gray to white, calcite marble with occasional dolomitized pods and sandy, siliceous, and cherty intervals (Brown, 1989). Where unmetamorphosed, the lower member is a medium olive-gray limestone with local crinoid debris. However, most exposures of the unit in the map area are metamorphosed and recrystallized (Brown, 1989; Burchfiel and Davis, 1977).

Mmc — **Monte Cristo Limestone (Mississippian)**—Approximately 150 m thick (Burchfiel and Davis, 1977) sequence of thin-bedded to massive limestone, coarse marble, dolomitized pods and siliceous layers that conformably overlies the Sultan Formation (Brown, 1989). Recognizable members in the map area are the Bullion, Anchor, and Dawn members (Burchfiel and Davis, 1977). The upper most of the three, the Bullion member, is thick bedded to massive, light gray to white, limestone and coarse-grained marble containing rare chert nodules (Brown, 1989; Burchfiel and Davis, 1977). The Anchor member is medium bedded, gray to dark gray limestone and marble with chert nodules and occasional crinoidal debris (Brown, 1989; Burchfiel and Davis, 1977). The lowermost unit, the Dawn member, is thin to thick bedded, light to dark gray, recrystallized marble and irregularly dolomitized at the base (Brown, 1989; Burchfiel and Davis, 1977).

Ds — **Sultan Formation (Devonian)**—Thin-to medium-bedded interlayered limestone and dolomite (Brown, 1989) with two recognizable members that unconformably overly the Nopah Formation (Burchfiel and Davis, 1977). The upper unit, the Crystal Pass member, consists of an upper sequence of extensively dolomized and iron-stained marble, a middle section of thinly laminated white limestone or coarse-grained white marble, and lower section of thin bedded light and dark gray marble (Brown, 1989; Burchfiel and Davis, 1977). The Crystal Pass member often weathers brown to orange (Burchfiel and Davis, 1977) and has irregular dolomitization near the top and base (Brown, 1989). The lower Valentine member is a sequence of interbedded calcite and dolomite marble with ghosts of silicified stromatoporoids, which have metamorphosed and altered to ovoid tremolite clots (Burchfiel and Davis, 1977). The tremolite clots and stromatoporoid ghosts are near the base of the unit and are used to distinguish the lower part of the Sultan from the Nopah Formation (Burchfiel and Davis, 1977).

Ꞓn — **Nopah Formation (Cambrian)**—Approximately 250 m thick sequence of thin bedded to massive, fine- to coarse-grained dolomite, silty limestone, and calc-silicate hornfels (Burchfiel and Davis, 1977). The upper section is a sugary fine- to coarse-grained dolomite that ranges in color from white to blue- gray to black (Burchfiel and Davis, 1977). At the base of the unit is a sequence of silty limestone that weathers orange, a calcareous shale, calc-silicate hornfels, and gray limestone. This sequence is equivalent to the Dunderberg Shale member of the Nopah Formation (Burchfiel and Davis, 1977). The similarities in rock type between the top of the Nopah Formation and base of the Sultan Formation have made the contact difficult to define (Burchfiel and Davis, 1977).

Ꞓbk — **Bonanza King Formation (Cambrian)**—Thin-bedded to massive sequence of dolomite, marble, and dolomitic limestone (Brown, 1989). The upper most member is known as the Banded Mountain member. It is an approximately 330 m thick sequence of white to light-gray, interbedded calcite and dolomite marble with a basal calc-silicate or a silty carbonate unit. (Burchfiel and Davis, 1977). The Papoose member is below the Banded Mountain member and is estimated to be at least a 150 m thick sequence of dark gray to mottled limestone and dolomite and thinly laminated dolomite, or massive marble where recrystallized. Faulting has made thickness estimations difficult (Burchfiel and Davis, 1977).

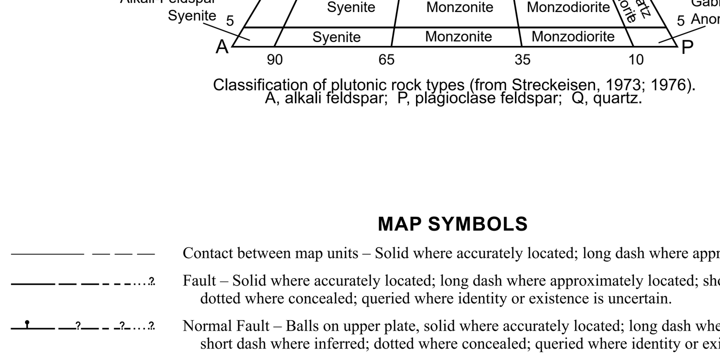
PROTEROZOIC BASEMENT UNITS

Yd — **Diabase (Mesoproterozoic)**—Dark-green to brown, altered, subophitic diabase. Occurs as dikes in map area. Composed of 50–60% plagioclase and 40–50% clinopyroxene. Dated at 1100 Ma (Howard, 1991).

Metamorphic rocks of Willow Wash (Paleoproterozoic)

Xbg — **Biotite-garnet gneiss (Paleoproterozoic)**—Gray to brown, well-foliated, interspersed biotite garnet gneiss, quartzo-feldspathic gneiss, biotite-sillimanite gneiss, and migmatite. Mineral composition ranges from a quartzo-feldspathic gneiss with 95% quartz plus feldspar and 5% biotite; to the biotite-sillimanite gneiss with 70% quartz plus feldspar, 20% biotite, 5% sillimanite, 3% garnet, and 2% opaque minerals. Other accessory minerals throughout the unit include hornblende and apatite. The unit also includes 1- to 2-m-wide, foliation-parallel, medium grained phaneritic to porphyritic, quartzo-feldspathic dikes or leucosomes, with and without garnet. This unit forms the dominant rock type in the Willow Wash and Ivanpah areas. The unit becomes increasingly mylonitized to the east near the contact with Xgs. The mylonitization produced augen shaped, feldspar porphyroclasts and an augen-gneissic texture in this area. Miller and Wooden (1994) report U-Pb and Pb-Pb ages of zircons ranging from 1.7 Ga to 1.9 Ga.

Xa — **Amphibolite (Paleoproterozoic)**—Black to salt-and-pepper appearance, massive to foliated amphibolite. The amphibolite ranges from fine- to coarse-grained, and is comprised of plagioclase, hornblende, quartz, +/- clinopyroxene, +/- biotite, and rare garnets. Xa includes granulite facies mafic rocks, containing orthopyroxene (Miller and Wooden, 1993). Interlayered in all metamorphic units, mapped where large bodies are present.



Classification of plutonic rock types (from Streckeisen, 1973; 1976). A, alkali feldspar; P, plagioclase feldspar; Q, quartz.

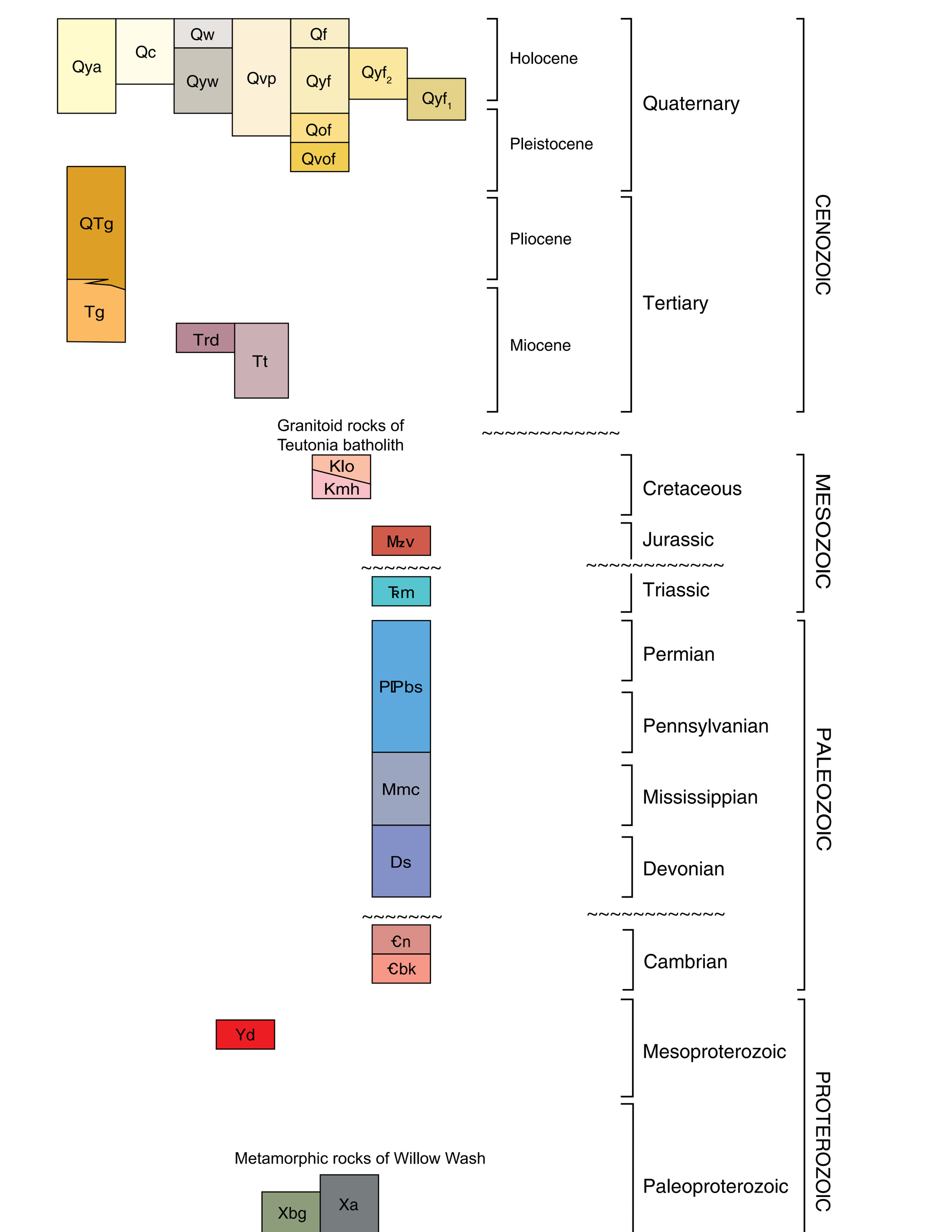
MAP SYMBOLS

- Contact between map units – Solid where accurately located; long dash where approximately located.
- Fault – Solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed; queried where identity or existence is uncertain.
- Normal Fault – Balls on upper plate, solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed; queried where identity or existence is uncertain.
- Thrust Fault – Barbs on upper plate; solid where accurately located; long dash where approximately located; dotted where concealed; queried where identify or existence is uncertain.
- Syncline/Synform – Synclines only observed in Paleozoic rocks within the field area Synforms observed within Proterozoic rocks of the field area. Solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed; queried where identity or existence is uncertain.
- Anticline/Antiform – Anticlines only observed in Paleozoic rocks within the field area. Antiforms observed within Proterozoic rocks of the field area. Solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed; queried where identity or existence is uncertain.
- Overturned syncline – solid where accurately located; long dash where approximately located; dotted where concealed; queried where identity or existence is uncertain.
- Overturned anticline – solid where accurately located; long dash where approximately located; dotted where concealed; queried where identity or existence is uncertain.
- Dike, undifferentiated
- Rhyolite dike
- Dacite dike
- Quartz Porphyry dike
- Diabase dike
- Vein
- Mylonite zone
- Ductile shear zone
- U-PB geochronology point (two samples)

Strike and dip of geologic structure; number indicates dip angle in degrees.

- 50 Foliation
- 40 Foliation, igneous
- 50 Gneissic foliation
- 50 Mylonitic foliation

CORRELATION OF MAP UNITS



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AERIAL PHOTO/DIGITAL IMAGERY

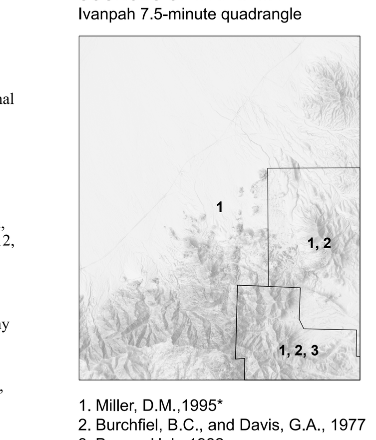
U.S. Department of Agriculture, 2020, Farm Service Agency–Aerial Photography Field Office, National Agriculture Imagery Program (NAIP), 60cm, resolution. http://datagateway.nrcs.usda.gov/

U.S. Geological Survey, 2015, NASA ASTER Level 1T Digital Geospatial Data, U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center.

U.S. Geological Survey, 2020, USGS Lidar Point Cloud CA_MountainPass_2019: U.S. Geological Survey.

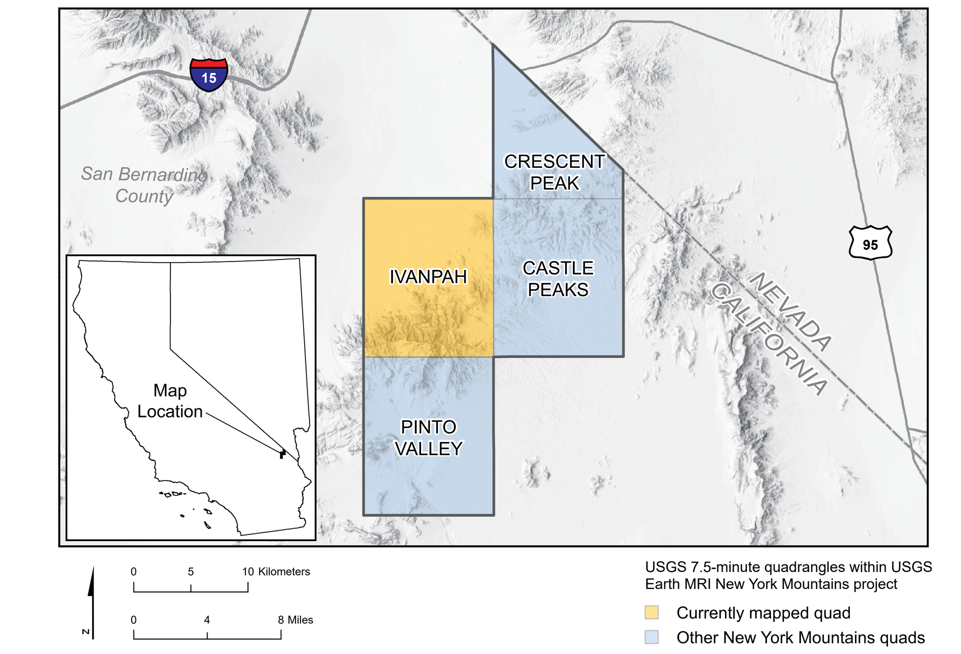
SOURCES OF MAP DATA

Ivanpah 7.5-minute quadrangle



1. Miller, D.M.,1995*
2. Burchfiel, B.C., and Davis, G.A., 1977
3. Brown, H.J., 1982

*Data source covers entire quadrangle



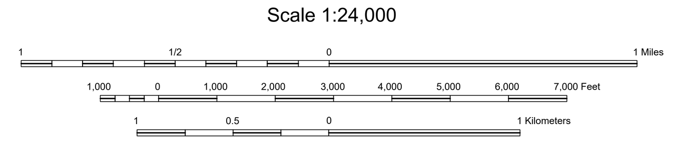
USGS 7.5-minute quadrangles within USGS Earth MRI New York Mountains project

- Currently mapped quad
- Other New York Mountains quads

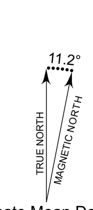
Coordinate System:
Universal Transverse Mercator, Zone 11N, North American Datum 1927

Topographic base from U.S. Geological Survey,
Ivanpah 7.5-minute quadrangle, 1983.
Shaded relief image derived from USGS Lidar DEM, 2019.

Scale 1:24,000



Contour Interval: 10 Meters
National Geodetic Vertical Datum of 1929



Approximate Mean Declination, 2022

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LIMITATIONS: This map is considered preliminary, and the California Department of Conservation makes no warranties as to the suitability of this product for any given purpose. This map should not be considered as an authoritative or comprehensive source for landslide and seismic hazard data. For landslide data, please visit the California Geological Survey Landslides web page at: https://www.conservation.ca.gov/cgs/landslides. For seismic hazard data and Zones of Required Investigation, please visit the California Geological Survey Seismic Hazards Program web page at: https://www.conservation.ca.gov/cgs/sh/program.

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