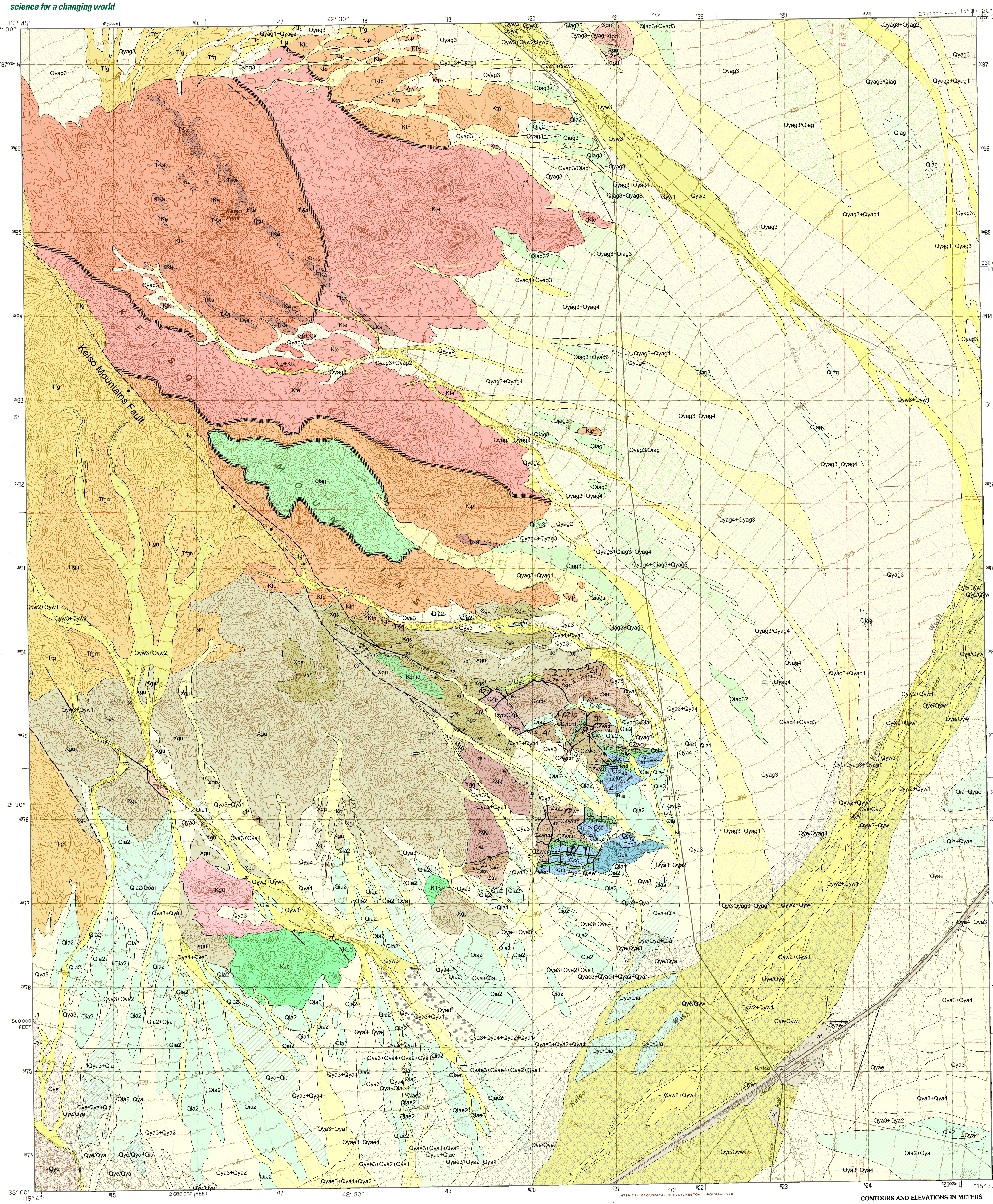
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Open-File Report
OF 03-501



PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY....USGS, NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN....1978
FIELD CHECKED....1980. MAP EDITED....1983
PROJECTION....UNIVERSAL TRANSVERSE MERCATOR
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR....ZONE 11
10,000-FOOT STATE GRID TICKS....CALIFORNIA, ZONE 5
UTM GRID DECLINATION....0°45'EAST
1980 MAGNETIC NORTH DECLINATION....14°EAST
VERTICAL DATUM..NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM....1927 NORTH AMERICAN DATUM
To place on the predicted North American Datum of 1983, move the projection lines as shown by dashed corner ticks (3 meters north / 77 meters east)
There may be private inholdings within the boundaries of any Federal and State Reservations shown on this map
Certain land lines are omitted because of insufficient data

APPROXIMATE MEAN DECLINATION, 1995

SCALE 1:24 000

CONTOUR INTERVAL 10 METERS
SUPPLEMENTARY CONTOUR INTERVAL 5 METERS
NATIONAL GEODETIC DATUM OF 1929

QUADRANGLE LOCATION

CONTOURS AND ELEVATIONS IN METERS

Geology by David R. Bedford, 1998-2003

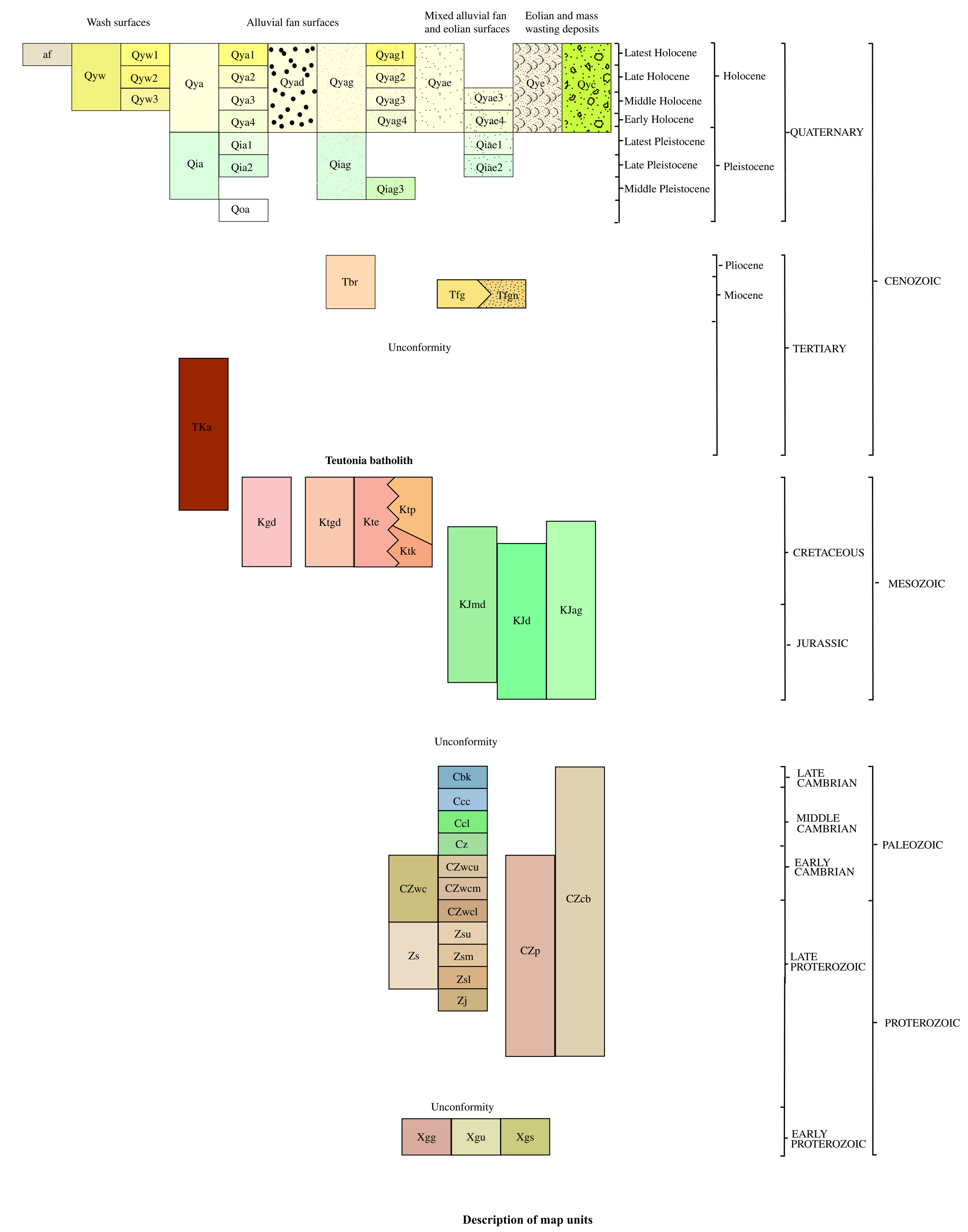
Surficial and Bedrock Geologic Map Database of the Kelso 7.5 Minute Quadrangle, San Bernardino County, California

By

David R Bedford

2003

CORRELATION OF MAP UNITS



Description of map units

Surficial geologic units commonly exist as thin (< 2 m) veneers over older units. In areas where this relationship is common the unit designators are shown on the map separated by a slash (/). The younger, or overlying, unit is indicated first. Thus, Qya/Qia indicates an area where a veneer of young alluvial fan deposits overlies old alluvial fan deposits.

The lateral extent of individual deposits is commonly so small that each deposit cannot be shown individually at the database map scale. Areas made up of deposits too small to show individually (representing more than 20 percent of the area) are indicated by deposits separated by a plus sign (+), with the most common deposit listed first. Thus, Qya3+Qya1 indicates an area with both Qya3 and Qya1 deposits and associated surfaces, and that Qya3 is more common than Qya1; other deposits in the area compose less than 20 percent. Many Quaternary surfaces, particularly Holocene surfaces, are incised by and contain deposits of younger geomorphic surfaces that contribute less than 20 percent area. For instance, an area mapped as Qya3 will also contain units Qya2 and Qya1, which will not be noted unless the amounts of Qya2 or Qya1 exceed 20 percent.

Ages of alluvial, eolian and wash deposits are classified as young, intermediate and old based on surface micromorphology, pattern and degree of channel dissection of alluvial fan surfaces, degree of soil development, desert pavement development, and intensity of rock varnish developed on surface clasts. Correlations with locally dated deposits provide age control.

Soil A_V and B horizon descriptions are after Birkeland and others (1991). Carbonate stage morphology is from Gile and others (1966), modified after Machette (1985).

af — **Artificial Fill (Latest Holocene)** – Loose sand and gravel constructions by humans such as railroad beds, levees, berms, diversion channels, and settlements. Unit denotes areas where natural drainages may be sufficiently altered to change runoff patterns

Wash surfaces and underlying deposits

Qyw — **Young Wash Deposits, Undifferentiated (Holocene)** – Moderately- to well-sorted, moderately bedded loose sand and gravel. Grains generally subangular to poorly rounded. Occupies large integrated drainages and valley centers. May be prone to flooding during heavy rain

Qyw1 — **Youngest Wash Deposits (Latest Holocene)** – Moderately- to well-sorted, moderately bedded loose sand and gravel occupying major ephemeral stream channels. Sediments are typically derived from granitoids and deposited in active channels by flow within the last few decades. Active channels inset 0.5 to 2.5 meters into older wash and alluvial deposits. Very sparse to no perennial vegetation with occasional annual grasses. Prone to flooding during heavy rain

Qyw2 — **Younger Wash Deposits (Late Holocene)** – Lithologically and morphologically similar to unit Qyw1. Surface lies 15 to 30 cm above active wash channel. Well-developed bar and swale topography, lacks soil development. Vegetation is commonly denser than found on active channels and older wash surfaces, with creosote brush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*). Cheesebush (*Hymenoclea salsola*) and Smoke tree (*Psorothamnus spinosus*) are generally restricted to Qyw deposits, and tend to be a diagnostic vegetation assemblage. Prone to flooding during heavy rain

Qyw3 — **Young Wash Deposits (Holocene)** – Lithologically and morphologically similar to unit Qyw2. Surface lies 20 to 75 cm above active wash channel, and 10 to 40 cm above Qyw2 surfaces. Surfaces commonly have subdued bar and swale topography. Weak to incipient 0.5 to 2 cm thick A_V horizon, very weak B horizon, stage I- to I calcic development. Partially vegetated with annuals and perennials such as creosote bush, white bursage, and cheesebush

Alluvial fan surfaces and underlying deposits

Qya — **Young Alluvial Fan Deposits, Undifferentiated (Holocene and latest Pleistocene)** – Moderately- to poorly-sorted sand and sandy gravel. Coarser-grained especially near non-granitic mountain fronts where boulders and cobbles are common. Light tan to brown, but varies according to source material. Loose to slightly compact. Abundant bar and swale topography up to 1 m in relief near mountain fronts and less developed toward toe of fans. Deposits lack well-developed desert pavements and varnish. Soils exhibit weakly developed A_V, cambic horizons, and stage I to II calcic development on older surfaces. Deposits grade from active channels incised into older alluvial fan surfaces near mountain fronts, to undulating surfaces with age determinations made on degree of soil development away from mountain fronts. Sparse perennial vegetation with localized abundant annual grasses. During and following heavy rains, deposits may be prone to channelized floods near mountain fronts and shallow but possibly wide sheet floods away from mountain fronts

Qya1 — **Youngest Alluvial Fan Deposits (Latest Holocene)** – Moderately- to poorly-sorted sand and sandy gravel. Coarser grained especially near non-granitic mountain fronts where boulders and cobbles are not uncommon. Light tan to brown, but varies according to source material. Active channel deposits in channels receiving sediments on decadal time scales. Abundant bar and swale topography and vertical cutbanks along channel margins near mountain fronts and rounded transitions to older deposits toward toe of fans. No soil development, varnished clasts, or desert pavement. Rarely occupied by annual grasses, lacks perennial vegetation and cryptobiotic crusts. During and following heavy rains, deposits may be prone to channelized floods near mountain fronts and shallow but possibly wide sheet floods away from mountain fronts

Qya2 — **Younger Alluvial Fan Deposits (Late Holocene)** – Lithologically and morphologically similar to Qya1 with similar trends in grain sizes with proximity to mountain fronts as unit Qya. Surfaces lie 10 to 40 cm above washes and more active areas of unit Qya1. Bar and swale microtopography is prevalent, and lacks varnished clasts or desert pavement. Minor soil development expressed as very incipient A_V horizons or accumulations of very fine sand and silt in upper portions of the soil profile. Unit tends to be moderately to well vegetated with perennial shrubs such as creosote and white bursage, and is commonly densely populated with cryptobiotic crusts. Prone to flooding and sheet flow during and after heavy rains. Active on centennial time scales

Qya3 — **Young Alluvial Fan Deposits (Holocene)** – Moderately- to poorly-sorted sand and gravel, with similar trends in grain sizes with proximity to mountain fronts as unit Qya. Surface lies approximately 30 cm to 2 m above Qya1 surfaces and 15 cm to 1 m above Qya2 surfaces. Loose. 20 to 60 cm of rounded bar and swale microtopography, no desert pavement or varnish. Soil development consists of 1 to 3 cm thick fine sand and silt A_V, and occasional reddening of subsurface (cambic B) horizons, stage I calcic development. Incised by active channels, which are commonly 10 to 30 m apart, with on less active channels and higher surfaces. Moderately vegetated with perennial shrubs creosote and white bursage, dense cryptobiotic crusts

Qya4 — **Young Alluvial Fan Deposits (Early Holocene and latest Pleistocene)** – Lithologically and morphologically similar to Qya3, with similar trends in grain sizes with proximity to mountain fronts as unit Qya. Surfaces lie 10 to 60 cm above Qya3 surfaces, bar and swale topography typically very subdued with 1 to 5 m^2 patches of incipient pavement and clast varnishing. Soil development consists of 1 to 4 cm thick A_V horizon, weak cambic to Btw horizon, stage I to II calcic. Dated at 10 ka in Fenner Wash near the town of Fenner, and lies on 13 ka deposits in lower Kelso Wash near Soda Lake (Shannon Mahan, written communications)

Qyad — **Young Alluvial Fan Deposits Dominated by Debris Flows (Holocene and latest Pleistocene)** – Lithologically and morphologically similar to Qya, but primarily consisting of bouldery, matrix-supported material. Bar and swale microtopography is well pronounced on the order of 0.5 to 1 m high. Mapped only where determined from field study; deposits are much more widespread than shown

Qyag — **Young Alluvial Fan Deposits Composed of Grus, Undifferentiated (Holocene and latest Pleistocene)** – Characteristics similar to unit Qya, with the exception that inset surface relations are more subdued and commonly less that 50 cm from active wash to the highest surfaces. Also tends to be less incised near mountain fronts. Coarsest grain size fraction is rarely larger than fine gravel, and tends to be moderately sorted at the medium to coarse sand fraction. Soil development weaker that unit Qya, commonly with sandy A_V, weaker cambic, and less developed, but deeper calcic horizons

Qyag1 — **Youngest Alluvial Fan Deposits Composed of Grus (Latest Holocene)** – Characteristics similar to unit Qya1but with subdued channeling. Also tends to have less significant fining of clast size away from mountain fronts

Qyag2 — **Younger Alluvial Fan Deposits Composed of Grus (Late Holocene)** – Soil characteristics similar to unit Qya2 with subdued channeling and very subdued to no bar and swale morphology. Tends to have less significant fining of clast size away from mountains

Qyag3 — **Young Alluvial Fan Deposits Composed of Grus (Holocene)** – Characteristics similar to unit Qya3 with subdued channeling and microtopography. Soil development weak with sandy incipient to weak A_V, poorly developed cambic horizons, stage I to I+ calcic horizons

Qyag4 — **Young Alluvial Fan Deposits Composed of Grus (Early Holocene and latest Pleistocene)** – Characteristics similar to unit Qya4 with subdued soil development. Surfaces lack clast varnishing and generally lack moderately developed desert pavements. Soil development is typically consists of a weak A_V and cambic to argillic B horizon, and stage I to II calcic horizon. Deposits tend to be incised by unit Qyag3 and younger surfaces in proximal fan environments and buried or at grade with unit Qyag3 surfaces in distal fan environments

Qia — **Intermediate Age Alluvial Fan Deposits (Pleistocene)** – Light to dark brown poorly- to moderately-sorted sand and gravel. Clasts mostly subangular to sub-rounded and coarsen toward mountain fronts. Moderate-to well-developed interlocking desert pavement containing moderate to strong varnish coating on clasts, with the exception of granitoid clasts, which rarely varnish. Moderately developed soil profile, with moderate- to well-developed A_V horizon that is as much as 6 cm thick, distinct argillic B horizons up to 50 cm thick and with weak to moderate stage II to III calcic horizons. Surfaces lie 1 to 3 meters above young alluvial fan surfaces (Qya). Surface remnants flat to slightly rounded between incised younger channels. Sparse and stunted vegetation, typically along shoulders of incised channels or isolated on the surface

Qia1 — **Intermediate Age Alluvial Fan Deposits (Latest Pleistocene)** – Poorly- to moderately-sorted sandy gravel. Surfaces commonly compact with moderately developed desert pavement consisting of non-interlocking mosaics of mixed size clasts. Relic bar and swale microtopography remains in some areas. Surface is light brown to dark brown to black depending on source lithology and degree of varnish. Varnishing of clasts variable, with granitic clasts having little or no varnish, to quartzite and other sedimentary rocks being very well varnished. Moderately- to well-developed soil profiles consisting of 2 to 6 cm thick silt and fine sand vesicular A_V horizon above 25 to 30 cm reddish argillic Bt horizon, with stage II to III- calcic development. Surfaces lie 1 to 2 m above active stream channels and younger deposits, inset 30 to 100 cm into unit Qia2. Sparsely vegetated. Deposit uncommon or indistinguishable from unit Qia2 in remote sensing, mapped where visited in field

Qia2 — **Intermediate Age Alluvial Fan Deposits (Late Pleistocene)** – Similar characteristics to unit Qia1, with more pronounced soil development especially in thickness and degree of A_V horizon development, which ranges from 2 to 8 cm. Argillic Bt horizon with stage II to III calcic development. Pavement surfaces often very flat with well varnished, compact interlocking clasts. Surface is light brown to black. Vegetation is very sparse and tends to be isolated perennials such as creosote or Mojave Yucca (*Yucca schidigera)*, or concentrated along shoulders of incisions. Surfaces are the most common of those of intermediate age

Qiag — **Intermediate Age Alluvial Fan Deposits Composed of Grus (Pleistocene)** – Characteristics similar to those for unit Qia, although soil development is less pronounced: sandy weak- to moderately-developed A_V and weak cambic horizons with stage I to II calcic. Generally lacks varnish and pavements. Pavements and varnish, when present, often composed of igneous dike material. Absence of diagnostic inset relationships and soil-geomorphic characteristics generally prevent correlation to unit Qia and its subdivisions, as well as subdivisions within unit Qiag

Qiag3 — **Intermediate Age Alluvial Fan Deposits Composed of Grus (Late – Middle Pleistocene)** – Distinct rounded surfaces in areas between young incised channels, with argillic horizons exposed in channels indicating that surface is being degraded. Pavement less extensive than on younger Qia surfaces with A_V and B horizon exposed at the surface or along shoulders, reflecting erosion of the landform. Varnish coatings moderate to strong on clasts that develop varnish. Soil development consists of moderately developed A_V horizon ranging in thickness from 2 to 8 cm, moderately developed Btw horizon with stage I to II calcic development, when present. Associated with Mojave Yucca, which is sparse to moderate in density, and generally suggests the presence of unit Qiag3 at the surface or shallowly (< 1 m) buried. Correlated to unit Qia3 of Yount and others (1994) based on evidence for surface degradation and soil development

Qoa — **Old Alluvial Fan Deposits (Pleistocene)** – Unit identified by 2 to 5m thick deposits of stage IV calcic horizons exposed in sides of washes, and correlated to deposits described by McDonald (1994) and Yount and others (1994). Found in the southern Kelso Mountains where top of unit not exposed due to erosion and subsequent deposition and soil development of intermediate age alluvial fan deposits (Qia2) above unit

Mixed alluvial fan and eolian surfaces and underlying deposits

Qyae — **Young Mixed Alluvial and Eolian Deposits (Holocene and latest Pleistocene)** – Alluvial and eolian sediments that are thoroughly mixed, with alluvial processes dominating. Forms flatter surfaces than alluvial systems lacking significant eolian sand because eolian sand additions mute topography. Gravelly sand with vague to well-defined thin bedding. Soil development similar to or less pronounced than correlative alluvial units. Contacts with alluvial and eolian dominated units are gradational. Sparsely vegetated, generally supporting creosote bush, white bursage, and annual grasses.

Qyae3 — **Young Mixed Alluvial and Eolian Deposits (Holocene)** – Characteristics similar to unit Qya3, particularly in surface morphology. Shows addition of very fine sand and silt in upper 30 cm of soil profile suggesting eolian contribution to the original deposit or as illuvial material prior to deposition of inset units Qya1 and Qya2. Younger inset surfaces in the map area lack eolian contribution features. Lacks eolian features at the surface such as coppice mounds

Qyae4 — **Young Mixed Alluvial and Eolian Deposits (Early Holocene and latest Pleistocene)** – Characteristics similar to unit Qya4, particularly in surface morphology. Shows addition of very fine sand and silt in upper 30 cm of soil profile, suggesting eolian contribution to the original deposit or as illuvial material prior to deposition of inset units Qya1 and Qya2

Qiae1 — **Intermediate Age Mixed Alluvial and Eolian Deposits (Late Pleistocene)** – Similar in characteristics to unit Qia1, particularly in surface morphology. Shows addition of very fine sand and silt in upper 30 to 40 cm of soil profile, suggesting eolian contribution to the original deposit or as illuvial material prior to deposition of units Qya1 and Qya2. In the outcrops in the southern Kelso Mountains immediately south of the carbonate breccia landslide 'spurs', unit is approximately 3 m thick and consists of reworked eolian and alluvial sediments consistent with a sand ramp depositional setting

Qiae2 — **Intermediate Age Mixed Alluvial and Eolian Deposits (Late Pleistocene)** – Similar in characteristics to unit Qia2, particularly in surface morphology. Shows addition of very fine sand and silt in upper 30–40 cm of soil profile, suggesting eolian contribution to the original deposit or as illuvial material prior to deposition of inset units Qya1 and Qya2

Eolian and mass wasting deposits

Qye — **Young Eolian Sand Deposits (Holocene)** – Well-sorted light-brown very fine-grained sand and silt forming sand sheets and dunes. Massive to weakly cross-bedded. Develops sandy coppice dunes around perennial vegetation with dune morphology and volume of sand indicating degree and relative age of eolian influx. Weak to no soil development

Qyc — **Colluvial Deposits (Holocene)** – Poorly sorted angular to subangular boulders, cobbles and sand. Talus or rockfall below areas of steep bedrock areas that obscures underlying bedrock. Weaksoil development, similar to unit Qya

Older Semi Consolidated Deposits

Tbr — **Breccia (Pliocene-Miocene)** – Moderately well cemented breccia containing clasts of granodiorite, cross-bedded quartzite, schist, amphibolite, siltstone, and minor gneiss. Clasts as large as 1 to 5 m in diameter. Age limited by Cretaceous age of youngest clasts, and inferred from localized faulting related to Miocene to possibly Pliocene tectonics

Tfg — **Granitoid Fanglomerate (Miocene)** – Unconsolidated boulder gravel and coarse sand alluvial dominated deposits derived largely from local granitic sources. Generally poorly bedded, although lower sections can be well bedded, including cross-beds. Large (1 to 2 m) partially rounded volcanic boulders identified as Peach Springs Tuff give a maximum age of 18.5 Ma (Nielson and others, 1990). Deposits commonly highly colluviated, with bedding exposed in active wash or road cuts. Interfingered with unit Tfgn

Tfgn — **Gneissic Fanglomerate (Miocene)** – Unconsolidated boulder gravel and coarse sand alluvial dominated deposits derived from local Proterozoic gneiss. Generally poorly bedded, although lower sections can be well bedded, including cross-beds. Boulders of Chambless Limestone as large as 2 to 3 m also observed. Deposits on hilltop surfaces commonly have well developed desert pavements, equivalent to a Qia2 surface

Intrusive rocks of Mesozoic and Tertiary age

TKa — **Andesite (Tertiary and Cretaceous)** – Porphyritic andesite dikes and small intrusive bodies in Cretaceous granitoids. Fine-grained dark-gray to black aphanitic groundmass with 8 to 10 percent zoned feldspar phenocrysts, generally 5 to 8 mm diameter, but up to 1 to 2 cm. Contains 0 to 1percent biotite

Kgd — **Granodiorite (Cretaceous)** – Medium- to coarse-grained subequigranular biotite granodiorite. Biotite in small phenocrysts constitutes approximately 10 to 12 percent rock. Tan to gray plagioclase and potassium feldspar. Jointed at 0.3 to 1 m intervals. Intrudes units KJd and Xgu

Granitoids of the Teutonia Batholith

Ktgd — **Biotite Granodiorite (Cretaceous)** – Medium- to coarse-grained porphyritic biotite granodiorite. Biotite phenocrysts in 0.5 to 1 cm booklets comprise approximately 15 percent of rock. Tan to light brown on fresh surfaces, moderate dark brown varnish common. Minor chloritized injection breccia observed at contacts where it intrudes Proterozoic rocks. Intrudes unit Xgu and Zs?

Kte — **Equigranular Quartz Monzonite (Cretaceous)** – Equigranular- to subequigranular medium- to coarse-grained biotite quartz monzonite. Approximately 30 percent tan, flesh colored, and occasionally salmon pink colored potassium feldspar crystals up to 3 cm diameter, small 8 to 10 percent biotite crystals, 35 percent tan to milky gray plagioclase, 10 to 15 percent milky quartz. Weathers to light tan color, occasionally to rounded dark brown varnish or rinds, often in very large boulders. Intrudes unit Ktp

Ktp — **Porphyritic Quartz Monzonite (Cretaceous)** – Medium- to coarse-grained porphyritic biotite quartz monzonite. Phenocrysts consists of 30 percent potassium feldspar up to 4 cm wide, 10 to 12 percent 1 to 5 mm wide disseminated biotite crystals. Groundmass consists of 35 percent plagioclase, 15 percent 2 to 6 mm milky quartz crystals. Light tan to brown in color, weathers to dark tan to brown, occasionally with dark brown to black weathering rinds

Ktk — **Quartz Monzonite of Kelso Peak (Cretaceous)** – Equigranular medium-grained biotite quartz monzonite. Biotite approximately 4 to 8 percent in isolated, small 5 to 10 mm phenocrysts, 30 to 35 percent white to light gray potassium feldspars, very rarely pink colored. 15 percent translucent to milky white quartz crystals and 40 percent light gray to white plagioclase feldspars. White to light tan in color, weathers to grus and occasional 1m high pinnacles and boulders. Unit distinguished from unit Kte by uniform medium grain size, whiter color. Intruded by unit Kte: enclaves of unit Ktk are present in unit Kte along southeastern contacts of the pluton

KJmd — **Hornblende Biotite Monzodiorite (Cretaceous and Jurassic)** – Medium-grained equigranular hornblende biotite monzodiorite, approximately 1 to 5 percent hornblende, 25 to 30 percent biotite, 5 to 10 percent milky quartz, 15 percent potassium feldspar, and 40 percent light to dark gray plagioclase feldspar. Salt-and-pepper colored (dark gray with flecks of white crystals) on fresh surfaces, light gray on weathered surfaces. Consists of two phases, which are not individually mapped: a northerly leucocratic phase with less biotite, and a southerly more mafic, or melanocratic, phase

KJd — **Diorite (Cretaceous and Jurassic)** – Fine-grained porphyritic biotite-hornblende diorite, dark gray aphanitic groundmass, 1 to 4 percent biotite, 5 to 10 percent hornblende, 8 percent milky white plagioclase phenocrysts. Dark gray on fresh surfaces, light blue-gray on older weathered surfaces, commonly dark-brown to black varnished and pitted on highly weathered surfaces. Commonly intrudes Proterozoic gneiss along foliation creating 30 to 70 cm wide interlayered bands

KJag — **Albitized Granite (Cretaceous and Jurassic)** – Medium- to coarse-grained granite with various degrees of alteration of alkali feldspars to albite. In central portions of map unit, albitization is pervasive enough to give the rock an entirely white color. Along margins of map unit, albitization occurs in nearly horizontal bands ranging from centimeters to meters in thickness, and also occurs in irregular patches. Host rock appears to be granitic in composition with 1 to 5 percent biotite content, and occasional large quartz crystals up to 2 cm in length. Pink to light tan in unaltered phases, light gray to cream colored in albitized phases

Paleozoic and Late Proterozoic sedimentary rocks

Cbk — **Bonanza King Formation (Late and Middle Cambrian)** – Dark-blue to smoky-gray fine-to medium-grained mottled limestone and dolomite. Brown silty mottling generally less than 1 cm thick, indistinct bedding approximately 10 cm to 2 m. Heavily fractured with white recrystallized calcite in fractures. Rocks closely resemble lower "Member No. 1" of the Bonanza King Formation (Stone and others, 1983), but correlation is difficult based on structural complexity. Thickness indeterminate due to faulting

Carrara Formation (Middle and Early Cambrian) – Divided into:

Ccc — **Chambless Limestone (Early Cambrian)** – Light-gray fine-grained limestone containing 10 to 30 percent 2 to 3 cm dark blue gray concentric algal nodules (*Girvenella*). Bedding 1 to 2 meters thick. Heavily fractured with white recrystallized calcite in fractures, typically more fractured in lower sections. Thickness indeterminate due to faulting

Ccl — **Latham Shale (Early Cambrian)** – Dark-green to locally brown and red shale, containing sporadic 1 to 3 cm beds of buff fine-grained quartzite. Marker bed at approximately 2 to 3 m below top of unit consists of buff sandy limestone, 0.7 to 1.5 m thick, locally contains shell fragments. Thickness of unit approximately 8 to 15 m

Cz — **Zabriskie Quartzite (Early Cambrian)** – Light pink, yellow and white medium- to coarse-grained massive to faintly planar cross-bedded quartzite. Contains vertical 1cm diameter trace fossil burrows (Scolithus), white in color, commonly with a black hematite ring around the outside edge. Bedding 0.4 to 1 m thick. Thickness of unit approximately 18 to 20 m. Contacts with Latham Shale and Wood Canyon Formation are sharp at 1 m scale

CZwc — **Wood Canyon Formation, undivided (Early Cambrian and Late Proterozoic)** – Interbedded fine- to medium-grained dark-colored quartzite and fine-grained green shale. Locally divided into:

CZwcu — **Upper member (Early Cambrian)** – Fine-grained green shale and silty shale rhythmically interbedded with 0.10 to 0.4 m thick beds of fine-grained quartzite

CZwcm — **Middle member (Early Cambrian)** – Fine- to coarse-grained dark-colored quartzite with occasional beds of dark green to black shale. Basal 1 to 3 m consists of distinctive quartz and jasper pebble conglomerate. Above pebble conglomerate is medium to coarse-grained massive quartzite overlain by red-brown trough cross-bedded quartzite

CZwcl — **Lower member (Early Cambrian to Late Proterozoic)** – Fine-grained medium- to thick-bedded dark green shale with occasional interbeds of fine-grained quartzite

Zs — **Sterling Quartzite (Late Proterozoic)** – Divided into:

Zsu — **Upper member** – Dark-gray to black medium-grained poorly sorted quartzite with rare discontinuous lenses of 1cm pebble conglomerate

Zsm — **Middle member** – Thin-bedded green-gray shale, poorly exposed in saddles. Approximately 20 m thick

Zsl — **Lower member** – Basal reddish to white basal pebble conglomerate grades up to well-sorted white fine-grained quartzite. Weathers to red-brown in color. Approximately 30 m thick

Zj — **Johnnie Formation (Late Proterozoic)** – Consists of predominately 3 to 5 m thick beds of fine-grained white, gray, and buff quartzite interbedded with minor 0.2 to 0.5 m thick beds of pebble conglomerate, 1 to 10 cm thick shale, and 0.5 to 0.75 m thick buff dolomite beds. Locations where init is queried consist of thick, heavily fractured massive buff dolomite similar to that in the Johnnie Formation. Outcrops that are stratigraphically displaced from all other units may also be part of the Cambrian Nopah Formation

CZp — **Phyllite and Phyllitic Schist (Late Proterozoic and Cambrian?)** – Black and dark-green fine-grained phyllite and phyllitic schist. Structural complexity and metamorphism makes correlations difficult, but may include portions of the Johnnie, Wood Canyon, Nopah, or Cadiz Formations. Thickness indeterminate

CZcb — **Carbonate Breccia (Late Proterozoic and Cambrian?)** – Blocks of tan and blue-gray limestone and dolomite, thoroughly brecciated and displaced from stratigraphic context. Thoroughly brecciated and cemented, forms ridge crests and prominent spurs. May include Johnnie Formation, Chambless Limestone, Bonanza King, and possibly portions of the Nopah Formation, Noonday Dolomite, or Pahrump Group

Proterozoic metamorphic rocks

Xgg — **Granofels (Early Proterozoic)** – Microgranitic to fine- to medium-grained granofels containing very few mafic minerals. Composition is approximately 45 percent plagioclase, 35 percent potassium feldspar, 20 percent quartz, and 0 to 1 percent biotite. Faint jointing strikes from 250 to 10 degrees, and may indicate localized foliation. Intruded by very coarse-grained pegmatite, fine-grained rhyolitic dikes, and hornblende-biotite granodiorite of indeterminate ages

Xgu — **Granitic Gneiss Undivided (Early Proterozoic)** – Medium-grained well-foliated biotite gneiss. Biotite content ranges from 10 to 20 percent. Mafic minerals segregated into needle shaped compositional banding leading to a distinctive weathering pattern, which is informally described as 'tiger striped gneiss'. Intruded by very coarse-grained pegmatite, fine-grained rhyolitic dikes, and hornblende-biotite granodiorite of indeterminate ages

Xgs — **Biotite Schist and Biotite Gneiss (Early Proterozoic)** – Medium-grained well-foliated biotite gneiss with biotite content typically greater than 20 percent. Mafic minerals occasionally segregated into needle shaped compositional banding. In one outcrop, biotite has replaced 3 to 7 cm garnet phenocrysts. Biotite schist is common in small outcrops, which contain 15 to 10 percent quartz and 5 to 10 percent feldspars. Intruded by very coarse-grained pegmatite, fine-grained rhyolitic dikes, and hornblende-biotite granodiorite of indeterminate ages

Contact – Dashed where location uncertain, dotted where concealed, queried where existence uncertain
Gradational Contact – Dashed where gradational with eolian processes, bars where through intrusive processes
Fault – Showing dip, dashed where location uncertain, dotted where covered; queried where existence uncertain
Normal Fault – Dashed where location uncertain, dotted where covered. Ball and bar on downthrown side
Dike – Dike composed of unit TKa material
Levee – Shown to denote areas of altered drainage patterns

Bedding — Showing strike and dip
Vertical Bedding — Showing strike
Crenulated bedding – Showing approx. strike and dip
Foliation — Showing strike and dip
Vertical foliation — Showing strike
Joint — Showing strike and dip
Minor anticline — Showing bearing
Minor syncline — Showing bearing
Lineation — S denotes slickenline