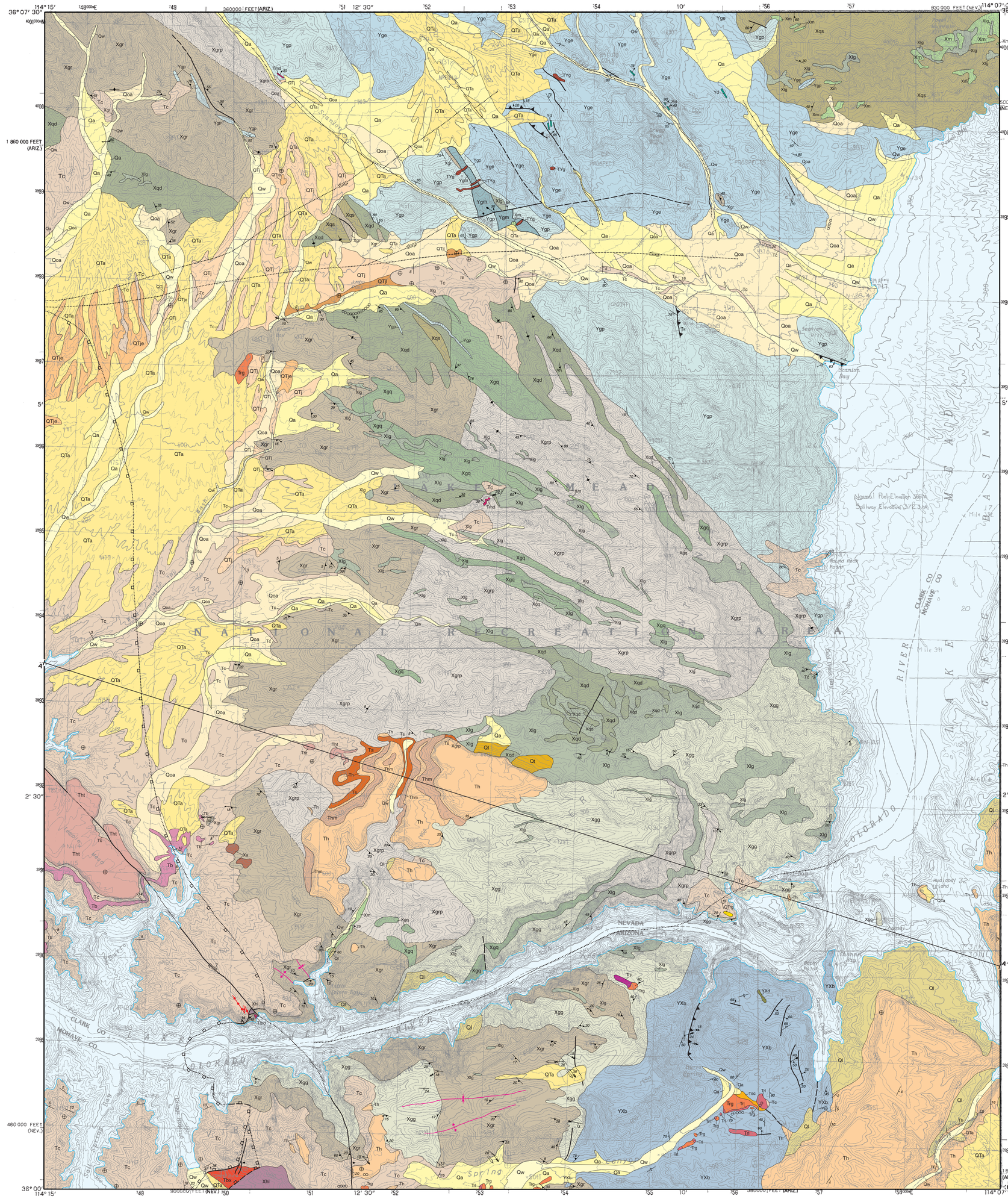
Nevada Bureau of Mines and Geology

Prepared in cooperation with the U.S. Geological Survey and the National Aeronautics and Space Administration



Geology mapped by K.A. Howard, March-April, and November 1997. Assisted by G. Phelps. Outlines of Xgg, Xqs, Xqd units aided by study of Thermal Infrared Mapping Spectrometer images processed by Simon Hook of NASA Jet Propulsion Laboratory. Digital database construction by Debra Block.

Office Reviewers: R. Ernest Anderson, USGS, Denver; Robert Brady, Cal. State Bakersfield; James Faulds, NBMG; Joan Fryxell, Cal. State San Bernardino; Mel Kuntz, USGS, Denver.

Field Reviewers: Ernest Dubendorfer, Northern Arizona University; James Faulds, NBMG; Joan Fryxell, Cal. State San Bernardino; Nathan Blythe, Northern Arizona University.

Funding provided by the U.S. Geological Survey's National Cooperative Geologic Mapping Program. The National Park Service's Lake Mead National Recreation Area provided logistic support.

First Edition, first printing, 2003
Printed by Nevada Bureau of Mines and Geology
Edited by Dick Meeuwig; cartography by Robert Chaney

Nevada Bureau of Mines and Geology
University of Nevada, Mail Stop 178
Reno, Nevada 89557-0088
(775) 784-6691, ext. 2; www.nbmg.unr.edu; nbmgsales@unr.edu

GEOLOGIC MAP OF THE HILLER MOUNTAINS QUADRANGLE CLARK COUNTY, NEVADA, AND MOHAVE COUNTY, ARIZONA

Keith A. Howard, Simon J. Hook, Geoffrey A. Phelps, and Debra L. Block
2003

Scale 1:24,000
0 0.5 1 kilometer
0 0.5 1 mile
0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 10 METERS
Base from U.S. Geological Survey, Hiller Mountains, 1983.
Universal Transverse Mercator projection; 1927 North American Datum
Clark 1866 Ellipsoid, Zone 11

Ql **Landslide deposits (Holocene and Pleistocene)** Slump blocks derived from Hualapai Limestone and from gneiss. Slumps blocks in Virgin Canyon are of solid gneiss, and are bordered by fresh steep headwall scarps 3–7 m high that indicate slumping within the last few decades, perhaps related to fluctuations in level of Lake Mead. Slump blocks in the southeast part of the quadrangle derived from Hualapai Limestone, and developed where mudstone in the Hualapai Limestone failed; locally exhibit open fissures indicative of recent historical movement. Thickness up to about 100 m.

Qt **Talus deposits (Holocene and Pleistocene)** Limestone blocks and scree.

Piedmont sedimentary deposits

Poorly sorted, poorly stratified alluvial-fan deposits of sheet-flood and debris-flow origins. Clasts chiefly derived from Proterozoic rocks. Subunits gradational and boundaries not necessarily time-correlative. Divided into:

Qw **Wash deposits (Holocene)** Sand and gravel in washes that are subject to periodic flooding or debris flows. Thickness up to about 3 m.

Qa **Alluvium (Holocene)** Sandy gravel in terraces and alluvial fans. Poorly sorted. Clasts angular to subangular. Surface characteristically exhibits bar-and-swale forms. Subject to sheet floods. Overlies and inset into topographically higher old alluvium (Qoa) unit. Thickness up to 5–10 m.

Qoa **Old alluvium (upper Pleistocene)** Sandy gravel in dissected alluvial fans and terraces. Poorly sorted. Clasts angular to subangular. Surface characterized by poorly to moderately developed dark pavement of varnished stones. Forms partly dissected terraces standing 5–20 m above unit Qa. Overlies and inset into topographically higher older alluvium (QTa) unit. Thickness up to about 10–15 m.

QTa **Older alluvium (Pleistocene and Pliocene?)** Sandy gravel in alluvial-fan deposits. Poorly sorted. Clasts angular to subangular. North of Jumbo Pass in northern part of quadrangle, fills southwestward-draining paleovalleys that predate modern southeastward drainage down lower Scanlon Wash and Gregg Wash. Dissected into ridge and ravine morphology; locally a desert pavement surface preserved. Thickness to at least 30 m. Contact with underlying conglomerate unit (Tc) in southwestern part of quadrangle indistinct on aerial photographs, poorly exposed, very approximately located.

QTj **Deposits of Jumbo Pass (Pleistocene and Pliocene?)** Reddish orange sandstone, light gray limestone, and gravel. Gravel dominates, consisting of angular to subangular gneiss cobbles and pebbles, locally imbricated, matrix reddish orange sand; interbedded with reddish brown mudstone. Adjacent to gneiss outcrops, includes talus blocks of gneiss in reddish sand matrix. Locally subdivided into:

QTje **Eolian sand** Medium sandstone, reddish orange to very light gray, exhibits planar to tangential cross beds as wide as 30 m and dipping as steeply as 30°; interbedded with locally derived angular-clast conglomerate and reddish brown cobbly sandstone diamictite. Along west edge of quadrangle, unconsolidated very light gray to pale orange sand; internal structure not exposed; may include fluvial as well as eolian components. Thickness about 10 m.

QTjl **Limestone, roundstones, and sandstone** Reddish orange sandstone, light gray limestone, and roundstone conglomerate containing sparse to moderately abundant rounded pebbles, cobbles, and rare small boulders of far-traveled limestone, chert, and quartzite. Rounded clasts interpreted as reworked from eroded or unexposed deposits of the ancestral Colorado River. Light-gray limestone, spring deposit, resembles Hualapai Limestone; exhibits travertine flowstone structures, stromatalites and laminated algal structures, and tubular plant casts; encloses isolated roundstone pebbles and cobbles, and isolated boulders derived from porphyritic Gold Butte Granite. In conglomerate, roundstones constitute a minority compared to angular gneiss and granite-derived pebbles; concentrations common of angular feldspar-crystal pebbles derived from relict phenocrysts in colluvial grus weathered from porphyritic granite. Conglomerate varies from well bedded and clast-supported to poorly bedded and matrix-supported. Thickness to about 10 m. Laps unconformably around eroded hills of the conglomerate unit (Tc).

Deposits of the ancestral Colorado River

QTrg **Younger roundstone gravel (Pleistocene or Pliocene)** Well sorted, well rounded pebbles, cobbles, and local small boulders, of quartzite, chert, and limestone. Occurs as loose uncemented clasts lacking outcrop. Distinguished only by lower elevation from the older roundstone gravel. Occurs near Virgin Reef at elevation 390 m, or 140 m above the early 20th-century Colorado River; a lag of roundstone pebble float perches at similar elevation on Hualapai Limestone 0.7 km to east. Thickness about 3 m.

Trg **Older roundstone gravel (Pliocene)** Clast-supported roundstone gravel. Well sorted, well rounded pebbles, cobbles, and rare small boulders of quartzite, chert, limestone, volcanic rocks, and other resistant, far-traveled rocks. Mostly occurs as loose clasts lacking outcrop; includes some reworked lag. Occurs at elevations of 470 to 555 m, or 220 to 305 m above the early 20th-century Colorado River. Roundstone pebble float indicating buried or former existence of this unit (shown by circle symbols) occurs as high as 605 m elevation near Jumbo Pass and at head of Spring Canyon. In Spring Canyon, contains some subangular cobbles and small boulders of gneiss and granite; unit rarely crops out as calcite-cemented conglomerate exhibiting pebble imbrication; maximum thickness >12 m; overlies rubble unit. Exposure near Black Box in northwest part of quadrangle is at lower elevation than, and may be reworked deposit younger than, adjacent deposits of Jumbo Pass (QTj). Solution pits etched as deep as 6 cm into carbonate parts of chert-limestone clasts due to post-rounding, post-deposition exposure. Overlies the limestone blocks (Trl) rubble. However, similar roundstone gravel present in slump block (mapped as landslide deposits), 1 km northeast of Hualapai Island, underlies limestone rubble similar to Trl.

Rubble (Pliocene) Thickness 0 to >5 m. Underlies the high-level gravel unit (Trg) at Spring Canyon and on the south side of Virgin Canyon. Subdivided into:

Trl **Limestone blocks** Angular blocks as wide as 6 m derived from Hualapai Limestone. Within 0.5 km south beyond the quadrangle in Spring Canyon area, locally includes porphyritic granite boulders 1-m across reworked from the adjacent conglomerate (Tc), locally derived angular gneiss-pebble conglomerate >1 m thick at top below the older roundstone gravel (Trg), and at base includes >2 m poorly sorted alluvial fanglomerate containing clasts derived from gneiss and Hualapai Limestone.

Trp **Porphyritic granite blocks** Local occurrence in saddle on southeast flank of Virgin Canyon. Subround blocks as wide as 5 m derived from porphyritic granite. Includes rarer subangular gneiss blocks as wide as 1 m. Overlies gneiss and underlies the older roundstone gravel unit. Location in valley suggests unit occupies thalweg of paleochannel cut into gneiss. Granite clasts are more than 300 m northwest of nearest possible source.

Tsc **Sand, silt, clay, and pebbly grus (Pliocene)** Local occurrence in Spring Canyon. Sand, silt, clay, and colluvial pebbly grus of angular feldspar-crystal pebbles derived from relict phenocrysts weathered from porphyritic granite. Fine-grained parts not bedded, may be spring deposits. Cavernous weathering of nearby bedrock granite suggests alteration or extreme chemical weathering. Thickness about 2–5 m. Appears to underlie the limestone blocks rubble unit (Trl).

Tc **Conglomerate (upper Miocene)** Poorly sorted, subangular, cobble to boulder, arkosic, alluvial-fan conglomerate containing sandstone beds. Clasts are gneiss and granite. Locally contains boulders of porphyritic granite as wide as 5 m, as at Greggs Hideout. Locally reddish gray (Spring Canyon). Clasts in lower Wild Burro Wash and west of Greggs Hideout include non-retrograded garnet gneiss likely derived from northeast of the quadrangle. Underlies and interfingers with basalt flow and with Hualapai Limestone near Burro Bay. On Temple Mesa, top of unit, above basalt flow and below limestone of Temple Mesa member (Tht) of Hualapai Limestone, consists of 5–10 m of pebble conglomerate gradationally overlain by 15 m rhythmically bedded sandstone. Forms tongue of conglomerate 10 m thick above Temple Mesa member of Hualapai Limestone (Tht). West of Jumbo Pass 1–3 km, unit indistinguishable lithologically from older alluvium unit (QTa) but underlies deposits of Jumbo Pass (QTj, QTje). East of Jumbo Pass 0–2 km consists of gneiss clasts derived from Hiller Mountains; pebble imbrication indicates deposition westward (now-upslope direction) toward Jumbo Pass; better sorted than piedmont sedimentary deposits; unit locally cemented and stained with limonitic (yellowish orange) color; erosionally unconformable below QTjl subunit of deposits of Jumbo Pass, which laps around eroded hill of this unit. East of Jumbo Pass 3–5 km, unit contains clasts of porphyritic granite as large as 4 m and includes yellowish pebbly sandstone in close proximity suggesting they are separate deposits, one perhaps inset into the other along unexposed internal contact; pebble imbrication in sandstone indicates deposition eastward toward Gregg Basin; dips generally steeper eastward than ground surface. Unit thickness 0 to >300 m. Lower part in low-angle-normal fault contact against Proterozoic rocks at mouth of Virgin Canyon and at Greggs Hideout; upper part not cut by this fault, depositional on Proterozoic rocks. Commonly has been included in Muddy Creek Formation but here separated on basis of coarse grain size, uncertain connection to Muddy Creek Formation basin, and likely lower stratigraphic position than Muddy Creek Formation. Equivalent to Greggs breccia of Lee (1908) and conglomerate of Grand Wash trough and Gregg basin of Wallace and others (in press).

Th **Hualapai Limestone (upper Miocene)** Algal, laminated, very light gray to pink resistant lacustrine limestone. In southeast part of quadrangle, includes interbedded reddish sandstone, moderate reddish orange limy sandstone, clay, gypsiferous reddish mudstone, and rare, poorly sorted reddish-matrix grit and pebble conglomerate derived from gneiss; abundant burrows and sole marks in clastic beds. Overlies Proterozoic rocks in buttress unconformity, or overlies and interfingers with conglomerate unit (Tc). Present in Gregg Basin east of Virgin Canyon, and in Temple Basin west of Virgin Canyon (Longwell, 1936). The upper part of the limestone in these two basins probably correlates and was physically connected, but lower parts in the two basins buttress against intervening older rocks, likely were not connected, and may be of different ages. Dates on tuff interbeds in nearby quadrangles 11 to 6 Ma (Spencer and others, 1998; Wallace and others, in press). Although Blair (1978) proposed the formation be assigned to the Muddy Creek Formation as a member, Bohannon reinstated the Hualapai Limestone because its basins of deposition are not known to be connected to the type Muddy Creek Formation. Was interpreted as marine by some authors (for example, Blair, 1978), but isotopic data and fossil assemblages strongly support lacustrine origin (Wallace and others, in press). In southwestern Hiller Mountains and Burro Bay area includes:

Thm **Mudstone, limestone, and sandstone** Weathers recessively. Forms two layers between resistant limestone (Th). Lower layer (Thm) is 15 m thick and consists of mudstone, yellowish gray limy mudstone, and limestone; overlies 10 m of resistant limestone (Th) and underlies 35 m of resistant limestone (Th). Above that 35 m of resistant limestone is the upper layer (Thm), 50 m thick, consisting of limy gypsiferous mudstone, moderate reddish orange sandstone, and limestone; underlies 50 m of higher resistant limestone (Th) that forms the uppermost part of the formation.

Tht **Limestone of Temple Mesa** Forms a lower resistant limestone member of the Hualapai Limestone in southwest part of quadrangle on Temple Mesa. Consists there of 5 m of laminated porous limestone containing stromatolitic heads 0.5 m high, overlain by 10 m of interbedded limestone and micaceous sandstone, overlain by 5 m of resistant limestone. Gradational down-section with planar bedded sandstone that forms part of underlying conglomerate unit (Tc). Assignment to the Hualapai Limestone follows Longwell (1936) and Lucchitta (1979). Two small patches in Hiller Mountains 2 km northeast of Temple Mesa contain tubular plant(?) casts, form tongue into conglomerate (Tc), grade laterally to limestone-matrix gneiss-clast conglomerate at 2-m-thick tip of tongue, and likely correlate to rest of member.

Ts **Sandstone (upper Miocene)** In southwest part of Hiller Mountains. Reddish orange. Large aeolian cross beds. Thickness 20–25 m. Underlies much of the Hualapai Limestone but overlies a tongue of the conglomerate (Tc), which in turn overlies the limestone of Temple Mesa member (Tht) of Hualapai Limestone.

Tb **Basalt flow (upper Miocene)** Olivine basalt. Contains local pepperite where sandstone intrusions fill cracks and form matrix of basalt breccia. Forms a layer overlain and underlain by the conglomerate unit (Tc). Preliminary age about 8.4 Ma by $^{40}Ar/^{39}Ar$ dating (M. Kuntz and M. Kunk, written commun., 2000). Underlying sandstone and conglomerate unit (Tc) baked reddish orange through a thickness of 5 m. Thickness 0–20 m.

Tmd **Mafic dikes (Miocene)** Swarm of biotite andesite dikes with chilled borders (30° W dip) near center of quadrangle, and a biotite-hornblende microdiorite dike (30° NE dip) near northwest corner of quadrangle. Miocene age based on abundance of Miocene volcanic rocks nearby to the west, and on fine grain size and locally chilled borders interpreted as indicating that intrusion occurred after the (middle Miocene) partial denudation of host Proterozoic rocks.

Tbx **Breccia derived from gneiss (Miocene)** Grayish yellow breccia and gouge derived from gneiss and leucogranite. Adjacent to Greggs Hideout campground near southwest corner of quadrangle. May be landslide deposit reworked tectonically by faults above and below.

TYg **Granite (Tertiary, Mesozoic, or Proterozoic?)** Very light gray leucocratic pegmatite, aplite, and pegmatitic feldspar-quartz vein rock; locally contains very coarse biotite. Intrudes the Gold Butte Granite in veins and dikes up to a few meters thick. Lithologically similar small unmapped granitic veins and 1- to 2-m-thick dikes, including some with light gray K-feldspars, intrude the diabase unit (Yd). A minimum age of ~1000 Ma on a similar pegmatite dike in the Gold Butte block north of the quadrangle is indicated by $^{40}Ar/^{39}Ar$ dating of muscovite (Reiners and others, 2000).

Yd **Diabase (Middle Proterozoic)** Short, variably dipping diabase dikes intrusive into Gold Butte Granite in northern part of quadrangle. Ophitic to subophitic. Plagioclase laths as large as 0.5 x 2 mm. Uralite (amphibole) replaces pyroxene. Biotite-bearing. Correlated lithologically with 1100-Ma diabase in Arizona and southern California (Howard, 1991).

Gold Butte Granite (Middle Proterozoic) Cut by dikes of granite (TYg). Named by Longwell (1936). Described by Volborth (1962). Included among southern Nevada granites assigned an age about 1450 Ma by Stewart (1980, using personal commun. from L.T. Silver). Subdivided into:

Ygp **Porphyritic facies** Biotite granite. Contains 20–30% (locally as low as 5%) phenocrysts of K-feldspar 1–3 cm across. Matrix medium grained. Mafic mineral content about 6–20%. Preferred alignment of tabular phenocrysts defines faint igneous foliation. Locally a porphyry gneiss at internal contacts. Two dikes in northern Hiller Mountains, 0.5 km S of Jumbo Pass, are quartz-rich (40–45%) monzogranite porphyry gneiss containing 30–40% euhedral K-feldspar augen 1 cm across; dikes cut unmapped leucogranite gneiss and cut by unmapped leucogranite containing very light gray, 2-cm-long K-feldspar.

Yge **Equigranular facies** Medium-grained. K-feldspar phenocrysts 1–2 cm across 0–25%, mostly <20%. Locally contains hornblende. Mafic mineral content 15–20%. Includes quartz monzodiorite locally along borders.

Ygm **Quartz monzodiorite facies** Northeast of Jumbo Pass. Occurs at border of plutonic facies and adjacent to screen of gneiss (Xgr). Equigranular to porphyritic (K-feldspar phenocrysts). Groundmass grain size varies from medium grained to very fine grained.

YXb **Granite of Burro Spring (Middle or Early Proterozoic)** In east part of Virgin Canyon in southeast part of the quadrangle. Porphyritic biotite granite. Abundant light gray to yellowish gray K-feldspar phenocrysts 2 cm across. Mafic mineral content about 10–15%. Quartz interstitial, about 20%. K-feldspar more abundant than plagioclase. Contains local angular inclusions of gneiss and elliptical mafic enclaves. Mafic minerals vary from fresh biotite in some areas to green chlorite in others. Western border of unit commonly more mafic, equigranular, and gneissic than the rest. Crude preferred alignment of tabular feldspar phenocrysts defines faint igneous foliation. Closely resembles Gold Butte Granite. Apparently assigned to Gold Butte Granite by Longwell (1936), who stated of the Gold Butte Granite (before Colorado River valley was flooded by Lake Mead) that "[a] large body of this granite is exposed at the head of Virgin Canyon, where it includes xenoliths of the invaded gneiss and schist." Also assigned to Gold Butte Granite by Volborth (1962). Correlated by Blacet (1975) instead with porphyritic granite of Garnet Mountain, 25 km southeast of the quadrangle, which since was dated by the U-Pb method as 1680 Ma (Chamberlain and Bowring, 1990); however, lacks conspicuous coarse quartz grains found in that granite.

YXd **Diabase xenolith (Middle or Early Proterozoic)** Plagioclase-phyric diabase and associated leucocratic gneiss. Forms inclusion in granite of Burro Spring.

Xhl **Leucogranite of Greggs Hideout (Early Proterozoic?)** In west part of Virgin Canyon. Medium-grained. Contains chloritic biotite and muscovite. Contains discrete quartz grains 3 mm in diameter. Highly fractured and faulted. Weathers light gray. Directly south of quadrangle, this rock is deformed in mylonitic zones, and includes gneissic dikes that intrude older gneiss. Included by Blacet (1975) with porphyritic granite of Garnet Mountain (1680 Ma; Chamberlain and Bowring, 1990).

Xlg **Leucogranite gneiss and pegmatite gneiss (Early Proterozoic)** In northeast corner of quadrangle and in Hiller Mountains. Medium- to coarse-grained light gray leucogranite gneiss. Locally contains partially retrograded garnets. Partly cuts mafic and ultramafic rock unit and quartz syenite gneiss unit. Includes rocks of two or more generations, some rocks likely intruded by granitic gneiss unit and other rocks that intrude the granite gneiss. As mapped, may include some younger pegmatite related to granite of Burro Spring. Dikes and sills schematically illustrated on cross section.

Xm **Mafic and ultramafic gneiss (Early Proterozoic)** Biotite-rich and hornblende-rich mafic to locally ultramafic gneiss. Includes sheared, serpentized pyroxenite gneiss in Little Burro Bay wash. Intrudes the garnet gneiss and the porphyritic quartz syenite gneiss units as dikes and small irregular bodies.

Xgg **Granitic gneiss (Early Proterozoic)** Medium-grained granodiorite and granite gneiss. Mafic mineral content 10–15%. As mapped, locally may include part of the gneissic border phase of granite of Burro Spring. Broadest patch in south-central Hiller Mountains is granodiorite composition where sampled at northwest margin and may be uniformly granodiorite as suggested by remote sensing information.

Xqs **Quartz syenite gneiss (Early Proterozoic)** Medium- to coarse-grained, felsic, porphyritic hornblende-biotite quartz syenite, syenite, and quartz monzonite gneiss having K-feldspar megacrysts 1–2 cm long, and about 5% mafic minerals. Described as syenite by Volborth (1962). As mapped, may include some mafic and ultramafic rock.

Xqd **Quartz diorite gneiss (Early Proterozoic)** Medium-grained, locally schistose quartz diorite gneiss containing 15–40% fine-grained biotite, hornblende, and chlorite; and metadiorite consisting of hornblende, chlorite, and plagioclase. As mapped, locally includes porphyritic quartz syenite gneiss.

Xgq **Quartz-poor gneiss (Early Proterozoic)** Mapped largely from interpretation of Thermal Infrared Multispectral Scanner (TIMS) imagery. Includes diorite gneiss and quartz-poor garnet-bearing paragneiss.

Xa **Amphibolite (Early Proterozoic)** Near Burro Bay. Black, hornblende-rich, medium grained.

Garnet gneiss (Early Proterozoic) Largely paragneiss; includes rare impure quartzite. Locally contains sillimanite replacing kyanite. Protolith age of similar rocks elsewhere in the Mojave crustal province are dated as 1700-1900 Ma and contain relict zircons as old as late Archean (Wooden and Miller, 1990; Wooden and others, 1994). Prograde metamorphism and polyphase deformation likely about 1700 Ma (Ivanpah orogeny of Wooden and Miller, 1990). Garnets completely or largely replaced by sericitic and chloritic pseudomorphs due to retrogressive metamorphism. Garnet (or garnet pseudomorph) content decreases southward. Correlated to the south in the White Hills with paragneiss unit of Blacet (1975) and gneiss unit of Theodore and others (1987). Internal subdivision boundary indistinct, gradational, arbitrarily mapped as crossing ridges and valleys as if steep. Subdivided according to extent of retrogressive metamorphic effects (following Fryxell and others, 1992) into:

Xgr **Retrograded garnet gneiss** Dark biotite-quartz-perthite-plagioclase paragneiss, biotite-perthite-quartz paragneiss, and abundant pods centimeters to tens of meters across of garnet leucogranite gneiss. Biotite well formed. Abundant secondary chlorite, sericite, epidote. Includes lesser amounts of garnet-pseudomorph-bearing granite gneiss, amphibolite, and feldspathic quartzite. Equivalent to retrograded gneiss unit of Fryxell and others (1992) to the north in the Gold Butte area, where pseudomorphs after garnet are more abundant than in this map area.

Xgrp **Partially retrograded garnet gneiss** Garnet pseudomorphs contain relict garnet cores visible without magnification. Equivalent to partially retrograded gneiss unit of Fryxell and others (1992).

See accompanying text for discussion of stratigraphic and structural framework of the quadrangle, and references cited.

Contact Dashed where approximately located, showing dip.

Fault Dashed where inferred, dotted where concealed, queried where uncertain (cross section only); ball and bar on downthrown side; arrow and number indicate direction and amount of dip.

Low-angle normal fault Dashed where inferred; dotted where concealed; box indicates upper plate.

Strike-slip fault Dotted where concealed; arrows indicate inferred direction of strike separation.

Mylonite and cataclasite shear zone Sawteeth on upper plate, showing dip.

Roundstone pebble float Placed at maximum local elevation. Near Jumbo Pass, mouth of Gregg Wash, Virgin Reef, lower Spring Canyon, and head of Spring Canyon.

Antiform axis North and south of Virgin Canyon.

Synform axis North and south of Virgin Canyon.

Calcite vein West of Little Burro Bay.

Strike and dip of bedding

Inclined Horizontal

Strike and dip of inclined foliation

Magmatic foliation Aligned feldspar phenocrysts or biotite.
Mylonitic foliation
Metamorphic foliation

Strike of vertical foliation

Magmatic foliation
Metamorphic foliation

Trend of mineral lineation

In plane of measured foliation; plunge amount locally indicated.

Trend of mylonitic lineation

In plane of measured foliation; plunge amount locally indicated.

Shear-sense direction

Showing sense of ductile movement of top over bottom. Determined from s-c structures and from shape of tails of porphyroclasts.

Slickenlines azimuth on fault