Normal fault Dashed where approximately located, short dashes where inferred; dotted where concealed, ball on downthrown side; showing strike and dip of fault

Strike and dip of bedding $\stackrel{43}{-}$ Inclined \oplus Horizontal \longrightarrow Vertical

meters

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> Field work done in 2002. reliminary geologic map. Has not undergone office r field review. May be revised before publication. First Edition, first printing 2002
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Agreement No. 01-HQ-PA-0003) 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

2002

3000 -2000 -1000 --1000 - -2000 ICEBERG CANYON **FAULT** -3000 -Pcu -4000 -Pcu

Landslide and talus deposits (Pliocene? to (fossilierous). Basal bed is a thin (~1-2 m), red, cobble Holocene) Slump blocks and unconsolidated rubbly conglomerate, composed of clasts of $\mathbb{P}c_1$ and $\mathbb{P}c_2$ in a matrix of debris composed of angular cobbles and boulders of local medium to coarse red sand; this bed is very recessive and rarely bedrock; blocks range up to \sim 50 m in length and are up to \sim 10 m exposed. Total thickness \sim 150 m. Pt Toroweap Formation (Permian) Thick to medium bedded, cliff-forming, light gray to pinkish gray, Older alluvial fan and pediment deposits aphanitic limestone, includes dark brown chert stringers and (Pliocene? to Pleistocene) Gray to brown, poorly nodules (fossiliferous); distinguishable from Pk primarily by sorted, poorly to moderately consolidated, subangular to angular difference in color and less abundant chert. Total thickness ~85 m. pebble to cobble clast-supported conglomerate with medium- to coarse-grained sand matrix and subordinate lenses and beds of coarse-grained sandstone; beds generally up to 2 m thick; Ph Hermit Formation and Coconino Sandstone (Permian) The Hermit Formation is a red, fine coarse-grained sand matrix and subordinate lenses and beds of lithologically similar to Qf with clasts locally derived, often from dissected older conglomerate (QTcg, QTg, QTfm, and Tcg). grained sandstone and mudstone; bedding generally indistinct, with occasional thick (~2 m) beds of red and white cross-Occurs as slightly to strongly dissected erosional remnants as bedded, medium grained sandstone. Includes at its top the much as 3 m higher than nearby Qf and Qa. Some upper Coconino sandstone, which is a grayish yellow to orange,

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strata. Tbp probably originated as large rock-avalanche deposits

derived from the steep slopes of the South Virgin Mountains.

11.6±1.2 Ma (Bohannon, 1984); this tuff is intercalated with Tsgw

near or at the shore of Lake Mead in the Pearce Ferry area.

Th Horse Spring Formation (middle Miocene) Brown to red cobble conglomerate and medium to coarse-

sandstone; beds 10 to 50 cm thick; well indurated. Clasts include

Paleozoic carbonates and sandstones, and Proterozoic gneiss

limestone with abundant dark brown chert stringers and nodules

thickness ~475 m.

Spring Formation. Total thickness is ~140 m.

Muav Limestone Formation, Units 3 and 4 (Middle

Cambrian) Equivalent to the Papoose Lake Membe

green and reddish brown shale containing worm burrows. scillation ripples, and local cross-beds. The upper part consists

Pcu Undifferentiated Proteiozolo Systematics (Proteiozolo) Includes a variety of foliated and

Xmgf Proterozoic) Interleaved reddish-brown, fine-to

granodiorite: consists mainly of potassium feldspar, plagioclase

quartz, hornblende, and biotite. Mafic mineral content 10-15%

Xog Wasserburg and Lanphere, 1965; Bennett and

leucocratic portions in which foliation is weakly developed of

absent, possibly equivalent to the migmatitic portions of Xgr

et al., in press). Protolith age is probably 1.69 Ga or older (e.g. Wasserberg and Lanphere, 1965; Karlstrom and Bowring, 1991).

Banded Mountain Member of the Bonanza King Formation. Unit

Tuff of Pearce Ferry (middle Miocene) White fine-

to medium-grained nonwelded biotite tuff with

Pediment, stream, and alluvial fan deposits of Grapevine Wash (Pliocene? to Pleistocene)

Pq Queantoweap Sandstone (Permian) Medium to thick bedded, moderate red and white, medium Grapevine Wash (Pliocene? to Pleistocene) Unconsolidated to poorly consolidated, moderately to grained, cross-bedded sandstone. Total thickness ~110 m. subrounded, poorly sorted pebble to cobble clast-supported conglomerate and subordinate sandstone lenses and beds.

Clasts are apparently derived from Tc and exposed Paleozoic

(Pennsylvanian) Thick to medium bedded, slope Clasts are apparently derived from Tc and exposed Paleozoic units in Wheeler Ridge, they range in diameter from a few mm to forming, light gray limestone and pinkish gray sandy limestone, 0.75 m and consist of various lithologies including varnished with occasional beds of yellowish gray sandy limestone. Basal basalt, granite, Paleozoic and Mesozoic limestone, chert, and bed is cross-bedded sandy limestone ~2 m thick that usually sandstone. Medium- to coarse-grained sand matrix. Exposed as weathers to form a conspicuous dark brown horizon. Upper ~30 a thin veneer in the southeast corner of the quadrangle. m is equivalent to the Pakoon Limestone (c.f. Billingslev, 1997). Total thickness ~100 m.

Fanglomerate of Million Hills (Pliocene? to Pleistocene) Weakly to moderately indurated, Pleistocene) Weakly to moderately rounded to Pleistocene) Weakly to moderately rounded to PC1 (Pennsylvanian) Thick bedded, slope forming, very process to reddish brown chert medium to thick beds of poorly sorted, moderately rounded to subangular clast-supported conglomerate containing a coarse- light gray limestone. Abundant orange to reddish brown chert grained sand matrix cemented by calcite; clast lithologies include stringers occur near the top of the unit. Total thickness ~150 m. abundant Proterozoic gneiss and granite, as well as Paleozoic and Mesozoic limestone, chert, and sandstone. Crops out as a deeply incised alluvial fan surface throughout the Million Hills, bedded yellowish-gray limestone and dolostone overlain by a conspicuous horizon of interbedded gray dolostone between Grand Wash Bay and Azure Ridge; laps onto Tbg, and dark brown chert, generally fossiliferous, in turn overlain by indicating a Pliocene or younger age. medium bedded light gray to yellowish gray sucrosic dolostone. This formation is a very prominent cliff-former, commonly holding

Colorado River gravels (Pliocene to Pleistocene) Unconsolidated to weakly consolidated, moderately to up ridge crests in the area. Total thickness is ~150 m. well-sorted, clast-supported conglomerate. Clasts are composed of well rounded to rounded pebbles and cobbles (1.5-20 cm in length) of resistant Paleozoic limestone, chert, fine-grained abundant silicified stromatolites or vugs, overlain by less sandstone/quartzite (each ~30%), and ~10% Proterozoic granite, resistant, well-bedded olive gray to light gray dolostone. Wellgneiss and pegmatitic quartz with a fine to coarse sand matrix. sorted, well-rounded pale pink to white quartzarenite beds or Clasts are commonly coated with rock varnish. Crops out only as pinkish-gray sandy dolostone beds are occasionally found below erosional remnants (usually < 2 m thick) exposed on tops of the olive gray dolostone. These may belong to the Mountain

Basalt of Grand Wash Bay (early Pliocene)
Porphyritic olivine basalt; columnar jointed with spacing ranging from ~20 cm at the top to ~50 cm at the base;

Muav Limestone Formation, Unit 5 (Late Cambrian)
Equivalent to the upper part of the Banded Mountain of the Bonanza King Formation, although the beds layering suggests at least 3 flows in the vicinity of Cormorant equivalent to the uppermost Banded Mountain Member have Cove; overlain by QTf, QTfg, and QTfm; intercalated with Trg.

The basalt has yielded a 3.8±0.11 Ma K-Ar age (Damon and others, 1978) and has been correlated to the Sandy Point basalt value. The basalt has yielded a 3.8±0.11 Ma K-Ar age (Damon and others, 1978) and has been correlated to the Sandy Point basalt value. (Lucchitta, 1966), which yielded an ⁴⁰Ar/³⁹Ar age of 4.41±0.03 gray to white cryptalgal dolomite. Total thickness is ~300 m. Ma (whole rock) (M. Kunk, as discussed by Wallace and others, in press), which overlies QTcq, indicating that a through-goin Colorado River had developed by ~4.41 Ma. Red sandstone and siltstone of Grand Wash Bay some orange overprint on silt-rich portions. Unit 4 is slightly less (middle Miocene? to early Pliocene) Red, poorly to resistant, dark to medium gray dolostone with interbeds of light

moderately consolidated sandstone and siltstone. Alternating gray to white cryptalgal dolomite. A prominent horizon of brown beds of fine- to medium-grained sandstone, siltstone, and chert lenses occurs ~10 m above the base of Unit 4. Total mudstone with subordinate lenses and minor interbeds of pebble thickness is ~80 m. conglomerate with coarse sand matrix; clasts mostly composed of granite or individual angular to subrounded grains of quartz, feldspar, and mafic minerals, clasts of Tbg locally abundant; lenses of primary and/or secondary(?) gypsum locally common of the Bonanza King Formation. Prominent cliff-forming light gray with individual laths 1-2 cm in length oriented perpendicular to limestone overlain by medium gray, bedded, burrow mottled bedding. This unit was previously included in the sandstone and limestone and dolostone with an orange overprint, particularly on siltstone facies of the Muddy Creek Formation (Longwell, 1936) silt-rich burrows and along some bedding planes. The top of Unit and Muddy Creek Complex (Lucchitta, 1966), and the red 2 is marked by a recessive orange buff, cross-bedded carbonate sandstone unit of the rocks of the Grand Wash trough grainstone. Total thickness is ~200 m. (Bohannon, 1984). Trg is intercalated with Tbg, suggesting an (Bohannon, 1984). Trg is intercalated with ruly, suggesting and early Pliocene age for its top, the age of the base of the unit is

Bright Angel Formation (white Cambridge) and subordinate limestone. The basal parts consist of and subordinate limestone. The basal parts consist of unknown; this unit is possibly correlative in part with Tsgw.

onglomerate of Grand Wash Bay (middle of a light brown and dark gray oncolitic silty limestone, which is Miocene? to early Pliocene) Medium grayish-red, overlain by green shale with worm burrows. Approximate poorly to moderately consolidated conglomerate and sandstone. thickness ranges from 20 to 40 m Alternating beds of medium to coarse-grained sandstone and pebble to cobble conglomerate with coarse sand matrix; clasts mostly composed of granite or individual angular to subrounded grains of quartz, feldspar, and mafic minerals, with lesser thick bedded, locally cross-bedded fine- to coarse-grained amounts of Paleozoic carbonate and sandstone. Crops out sandstone; includes both silica and calcite cement. Ununderneath Trg on the west side of Grand Wash Bay; it is unclear conformably overlies Early Proterozoic metamorphic rocks. whether this represents the base of Trg, or a coarse-grained bed intercalated with Trg; this unit is possibly correlative with Tsgw

andstone and siltstone of the Grand Wash trough

Yg, Xlg, Xmfg, Xum, and Xgn, and Xog. Ecu exposed only in (middle Miocene to early Pliocene?) Red to gray and brown poorly to moderately consolidated sandstone and siltstone. Alternating beds of fine- to medium-grained sandstone. siltstone, and mudstone with subordinate lenses and minor interbeds of pebble conglomerate with coarse sand matrix; clasts rapakivi granite, light gray, weathering to light brownish gray. mostly composed of granite or individual angular to subrounded This rock is distinctive because of abundant perthite phenocrysts grains of quartz, feldspar, and mafic minerals; root/stem traces and ovoids commonly 1-3 cm long, and 0.5-2 cm wide, with and burrowing are common: lenses of primary and/or some phenocrysts as long as 5 cm (Volborth, 1962); within the secondary(?) gypsum locally common with individual laths 1-2 map area these large feldspar phenocrysts generally compos cm in length oriented perpendicular to bedding. This unit was >50% of the rock by volume, but both abundance and size of ously named the sandstone and siltstone facies of the crystals decreases westward (Fryxell et al., 1992). Occasionally Muddy Creek Formation (Longwell, 1936) and Muddy Creek the perthite phenocrysts are rimmed with oligoclase and albite Complex (Lucchitta, 1966), as well as being included in the red (rapakivi texture). Average modal analysis (Volborth, 1962): sandstone unit of the rocks of the Grand Wash trough
1.2% sphene, 0.75% chlorite (hornblende), 1.1% fluorite, oxides, area (Ttpf) intercalated within Tsgw yielded fission track ages of nonwelded air-fall tuff was found intercalated within Tsgw, near lake level, ~2 km north of Pearce Ferry and just east of the edge equigranular to coarsely pegmatitic, light gray to pink, except of the quadrangle, and was dated at 13.94±0.12 Ma (plateau where altered to red immediately under the sub-Cambrian age, 40Ar/39Ar; step heating experiment; isochron age: unconformity (this alteration also affects other leucocratic rocks 13.69±0.11 Ma). Tsgw crops out in the southeast corner of the in the area); composed of quartz, potassium feldspar, Mountain to the south, or a paleo-Colorado or Virgin River

quadrangle, east of Wheeler Ridge, where it interfingers plagioclase, and less than 5% biotite. Includes rare garnet westward with Tc. Tsgw could be sourced from the South Virgin phenocrysts (xenocrysts?). Equivalent to the microcline grain Mountains to the west, the Infernal Mountains or Garnet of Volborth (1962). flowing from the north and/or east. Exposed thickness is as much as 120 m; probably was much more extensive before Gregg Basin (middle Miocene to early Pliocene) Brown, pinkish, and light gray poorly sorted, moderately to poorly consolidated fanglomerate facies of the Grand Wash trough and Gregg Basin. Previously named Gregg's breccia by Lee (1908), the conglomerate and breccia units of the Muddy Creek Formation (Longwell, 1936), and conglomerate-breccia facies of the Muddy Creek Complex (Lucchitta, 1966). Angular to subangular clasts of the conglomerate range in size from intruded by migmatitic dikes from Xqn. The current mineral pebbles to large boulders (>5 m). Bedding thickness ranges up assemblage was probably metasomatized from an assemblage to ~2 m; weakly to moderately cemented by calcite. Grades of hypersthene, diopside, hornblende, biotite, olivine, actinolite laterally into and interfingers with overlying sandstone/siltstone and calcic plagioclase (Leighton, 1967). facies (Tsgw). Clasts of Gold Butte granite and pebble imbrication indicate a predominant westerly provenance from the

Gold Butte block in the South Virgin Mountains 6-15 km away. The clasts have been described by Volborth (1962) as a rapakivi-

euhedral to subhedral perthite-biotite granite with a medium- to quartz plagioclase and biotite. The perthite is mantled by oligoclase and albite and clumps of biotite aggregates; local sericitization and saussuritization have also been documented The Gold Butte granite has yielded 40Ar/39Ar (Brady, 1998; Reiners and others, 2000) and K-Ar (Wasserburg and Lanphere, 1965) ages of 1.4 Ga on muscovite and a U-Pb zircon age of 1.45±0.25 Ga (Silver and others, 1977). Within the quadrangle, and magnetite (Volborth, 1962; Thomas et al., 1988), migmatitic To crops out along the west flank of Gregg Basin, in the valley portions contain variably thick (1cm to > 10 m) layers of very west of Wheeler Ridge, and in the southeastern corner of the coarse grained quartz, feldspar, and garnet, with no internal quadrangle as a deeply incised alluvial fan, which was fabric. Garnet porphyroblasts are generally unaltered, and apparently sourced from the South Virgin Mountains to the west, surrounded by halos of quartz and feldspar, forming striking and built eastward through a paleo-canyon that cuts through white on red contacts; westward from the west edge of the Wheeler Ridge. Total thickness is unknown but exposed

Gently dipping normal fault Dashed where approximately located; short dashes

Strike slip fault Dashed where approximately located, short dashes where inferred;