Text and references accompanying Nevada Bureau of Mines and Geology Map 181

Geologic Map of the Devils Throat Quadrangle, Clark County, Nevada

by

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INTRODUCTION

The Devils Throat 7.5-minute quadrangle was mapped from 1989 to 1990, using the 1983 U.S. Geological Survey provisional 7.5-minute quadrangle topographic base map and 1976 Bureau of Land Management color aerial photography (1:31,680-scale). The map was originally published as U.S. Geological Survey Open-file Report 91-132 (Beard and Campagna, 1991). In addition, it was generalized for compilation of the *Geologic Map of the Lake Mead 30′x60′ Quadrangle* (Beard et al., 2007). For this publication, some contacts and faults were added or revised from the original map and two cross sections were constructed. This publication is also the first digital color version of this quadrangle. Three adjoining 7.5-minute quadrangles, St. Thomas Gap, Whitney Pocket, and Virgin Peak, have also been mapped (fig. 1: Beard, 1992; Beard, 1993; and Beard, unpublished data). The following discussion is partly summarized from Beard (1996) and Beard et al. (2010), which contain detailed descriptions and analysis of the Cenozoic stratigraphy and structure of the quadrangle and surrounding areas.

The Devils Throat quadrangle lies in the central part of the Virgin Mountains, east of the Overton Arm of Lake Mead and west of the Grand Wash trough. The quadrangle is in a relatively low area within the Virgin Mountains with an average elevation of about 1000 m. Higher terrain includes South Virgin Peak Ridge to the north of the quadrangle, Whitney Ridge to the east, Lime Ridge to the west and south, and Tramp Ridge to the south. The quadrangle is bisected by the Bureau of Land Management Gold Butte Backcountry Byway, which enters from the north through Wechech Basin and exits on the southeast near St. Thomas Gap (fig. 1). A loop of the byway turns

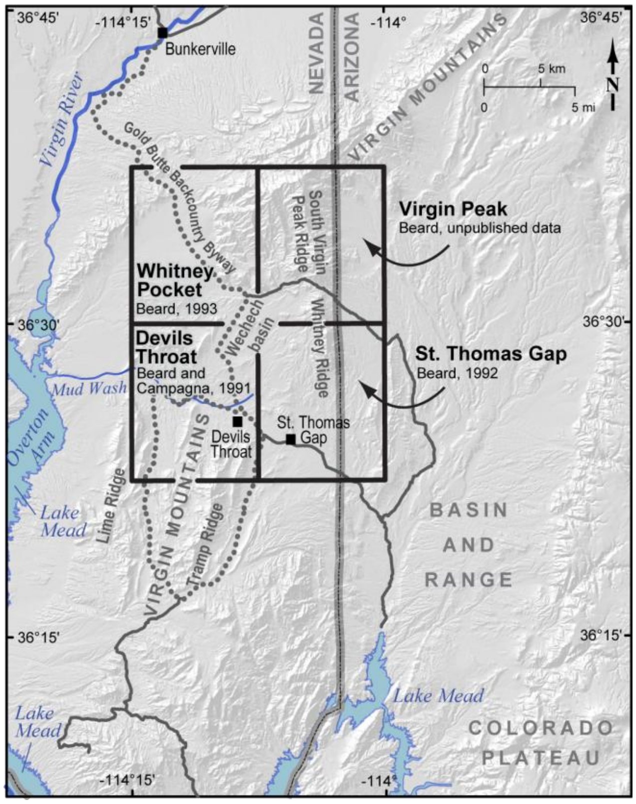

Figure 1. Map showing location of Devils Throat 7.5-minute quadrangle, southeast Nevada, and surrounding quadrangle geologic maps. Base is 90m digital elevation model (DEM). Boundary between Colorado Plateau and Basin and Range parallels cliff visible on DEM just west of Colorado Plateau label.

west down Mud Wash to the west end of the quadrangle. This west loop includes a side trip to scenic Devils Throat, the deepest and most active of several sinkholes in the area.

The quadrangle lies within the Lake Mead domain of the eastern Basin and Range (Faulds et al., 2001; Anderson and Beard, 2010). The unextended Colorado Plateau is about 30 km to the east. The Virgin Mountains have been deformed by Tertiary strike-slip, normal, and reverse faulting related to the eastern part of the Lake Mead fault system (Beard, 1996; Beard et al., 2010; Campagna and Aydin, 1994; Quigley et al., 2010). The Lake Mead fault system is a system of northeast-striking left-lateral faults that extend from the Virgin Mountains westward across Lake Mead to Eldorado Valley. The fault system was active mostly from about 16 Ma to post-10 Ma, and locally includes scarps with Quaternary slip both within and north and west of the quadrangle.

STRATIGRAPHY

Paleozoic, Mesozoic, and Cenozoic strata are exposed within the quadrangle. Paleozoic rocks include Cambrian through Permian marine rocks deposited along the miogeocline of the western margin of North America. The Paleozoic rocks are transitional between the thin cratonal section exposed to the east in the Grand Canyon, and thicker miogeoclinal rocks exposed in the upper plate of Mesozoic thrusts to the west.

Mesozoic strata include Triassic and Jurassic rocks deposited in the continental back arc of the Mesozoic arc that lay to the west. Cretaceous foreland basin deposits were formed in front of southeast-directed thrusts of the Sevier orogeny. The foreland basin deposits are preserved only in the north-central part of the quadrangle, west of the Gold Butte Backcountry Byway road.

Erosion of the landscape in the early Cenozoic beveled the Paleozoic and Mesozoic rocks to progressively deeper levels to the south (Bohannon, 1984). The oldest Cenozoic deposit, the basal conglomerate of the Rainbow Gardens Member of the Horse Spring Formation, overlies the beveled surface in slight angular unconformity. The middle and upper parts of the pre-extensional Rainbow Gardens Member were deposited in a lacustrine environment filling low topographic areas and receiving tuffaceous material from volcanism to the north (Beard, 1996).

Rapid extension, beginning at about 16–17 Ma (Fitzgerald et al., 2009; Quigley et al., 2010), disrupted the landscape with faulting and development of new basins that filled with playa, marginal playa, and alluvial fan deposits of the Thumb Member of the Horse Spring Formation. Large landslide blocks interbedded in the Thumb sedimentary rocks were derived from nearby fault scarps. Deformation of the rocks in the quadrangle related to the extension includes normal and strike-slip faulting, and northeast- and northwest-trending folds. Sometime after 14 Ma, deposition in the Virgin Mountains ceased, due to uplift relative to surrounding areas. The mountains subsequently became a source area to subsiding basins developing to the east, west, and north (Beard, 1996). Surficial deposits, mostly alluvial fans and washes, are graded to the Virgin River, about 8 km west of the quadrangle (now drowned by Overton Arm of Lake Mead).

STRUCTURE

The Devils Throat quadrangle includes the east-northeast-striking Lime Ridge fault of the Lake Mead fault system. Most of the quadrangle is underlain by a single, mildly to moderately east-tilted fault block north of the Lime Ridge fault that exposed upper Paleozoic, Mesozoic, and Tertiary sedimentary rocks. The Paleozoic, Mesozoic, and lower Tertiary rocks are cut by a poorly exposed northeast-striking fault along Mud Wash that shows ~1.5 km of left separation. Two northwest-striking right-latera-reverse faults cut the northeast part of the quadrangle. The eastern part of the block is underlain by rocks of the Horse Spring Formation that are complexly folded and faulted (Beard et al., 2010). Northeast-trending fold axes parallel the Lime Ridge and Mud Wash left-lateral faults, and northwest-trending fold axes parallel the right-lateral reverse faults.

The northwest end of the fault block is deformed by the Bitter Ridge fold and thrust, a southwest-vergent structure inferred to be Mesozoic in age. Bedding-parallel attenuation faults thin Permian rocks in the overturned limb of a footwall fold. The thrust is cut on the northwest by the northeast-striking Bitter Ridge left-lateral strike-slip fault. The Bitter Ridge fault is a young segment of the Lake Mead fault system and forms the southeast side of a pull-apart basin that underlies the Overton Arm of Lake Mead (Campagna, 1990; Campagna and Aydin, 1994).

South of the Lime Ridge fault, Tramp Ridge is underlain by east-tilted Paleozoic and Mesozoic rocks, bounded on the west by a large west-side-down low-angle normal fault that curves eastward and joins the Lime Ridge fault. West of the normal fault, Permian rocks are repeated in several east-tilted fault blocks bounded by west-dipping low- to high-angle faults.

Numerous northeast-striking Quaternary faults and fractures cut a degraded calcic soil that caps the surface of Pleistocene alluvial deposits. These structures parallel folds and a fault cutting underlying Thumb Member rocks and may reflect Quaternary reactivation of Miocene structures. In addition, a Quaternary gypsiferous deposit is offset by as much as 3–4 m, north-side down, by a fault that coincides with the inferred trace of the Miocene Lime Ridge fault.

DEVILS THROAT SINKHOLE

Devils Throat is a favorite destination site along the Gold Butte Backcountry Byway. The sinkhole is about 30 m diameter and 41 m deep. At least six to ten other sinkholes are mapped within a few km of Devils Throat, and a large shallow one is mapped about 6 km north in Wechech basin. According to Al-Fares (2005), Devils Throat sinkhole was generated as a massive collapse in the early 1940s and has been gradually increasing in size for the past few years. They measured up to 0.5 cm per year of subsidence within the sinkhole area, with a steep gradient in subsidence rates adjacent to it. The measurements were made within a five-year observation period of Spaceborne Synthetic Aperture Radar (SAR) data, extending from 1992 to 1997. The sinkholes are likely formed by evaporite dissolution; a seismic study by McLaurin et al. (2005) suggested dissolution of gypsum beds is the likely cause of sinkhole development. New mapping shows numerous faults that cut Quaternary surfaces in the general vicinity of Devils Throat. Snelson et al. (2005) conducted a magnetic survey that imaged one fault projecting toward a sinkhole and suggested that the faults provide pathways for dissolution and sinkhole formation. Devils Throat may be localized in steeply dipping gypsiferous Miocene Thumb rocks, as exposed at the surface to the west of the sinkhole, and/or in downfaulted Quaternary gypsiferous deposits shown on the map as Qgp.

Devils Throat and a small sinkhole in Mud Wash are the only deep open sinkholes in the map area. They are probably cover collapse sinkholes in the terminology of Gutierrez et al. (2008). The remainder have shallow flat floors and are probably cover-sagging or suffusion sinkholes, depending on whether there is only dissolution thinning of subsurface rocks or an active dissolution conduit at depth, respectively (Gutierrez et al., 2008). Ground-penetrating-radar surveys (McLaurin et al., 2005) across three of the shallow flat-floored sinkholes indicate silt- and clay-dominated centers with gravelly margins, and that sub-surface stratification dips toward the center of the sinkholes. Although McLaurin et al. (2005) suggested the sinkholes could be in an early stage of development, the style of sinkhole formation is an important and unknown factor for determining age and hazard potential of these sinkholes.

DESCRIPTION OF MAP UNITS

Surficial Deposits

[Distinguished chiefly by photogeologic techniques and field-checked]

Qay Young alluvium (Holocene) Gray to tan or red-tan, unconsolidated, poorly sorted boulders, cobbles, sand, silt and clay. Clasts are typically sub-angular but in some deposits are subrounded. Clast types are dominantly Paleozoic carbonates, although Proterozoic clasts are usually present and locally abundant. Includes deposits in active washes, as well as active or recently active alluvial fan and alluvial plain deposits. Thickness ranges from 5 to more than 20 m.

Qai Intermediate alluvial and pediment deposits (late and middle Pleistocene) Unconsolidated, poorly sorted material similar to unit Qay, but slightly dissected and 1–3 m higher than nearby Qay surfaces. Clasts at surface of deposit have undercoatings of carbonate. Thickness about 0 to 30 m.

Qct Colluvial, talus, and rockfall deposits (Holocene) Unconsolidated, very poorly sorted, locally derived slope wash, talus, and rockfall material. Thickness 0 to 10 m.

Qs Dune and sand sheet deposits (Holocene and Pleistocene?) Red-orange, unconsolidated, well sorted eolian sand deposited as dunes and sand sheets. Deposits confined to northwest part of quadrangle; sand derived mostly from nearby or underlying Aztec Sandstone. Thickness about 0 to 5 m.

Qgp Gypsiferous deposits (Pleistocene?) Includes exposures of white to gray, massive-bedded, sandy, calcareous gypsum near trace of the Lime Ridge fault in the east-central part of the quadrangle. The larger of the outcrops is south of Devils Throat. The gypsum surrounds and overlies the Moenkopi Formation, from which the bulk of the gypsum was probably derived. The northwest part of the deposit is cut by a northeast-striking fault coincident with the Miocene Lime Ridge fault. The northwest edge of the deposit is offset as much as 3–4 m down to the north; the fault appears to die eastward. The smaller outcrops north of Devils Throat are dissected by modern alluvial channels. The washes expose about 2–3 m of fine-grained sandy to silty deposits, interbedded with thin conglomeratic layers, which underlie the gypsum. Abundant root casts in the fine-grained sediments suggest local ponding or possible groundwater discharge deposits. Exposed thickness 0 to 10 m.

Qls Landslide deposits (Holocene and Pleistocene) Unconsolidated, very poorly sorted, unstratified, house-sized blocks, boulders, cobbles, sand, silt, and clay, derived from rocks immediately upslope from deposits. Deposits have hummocky topographic expression and lobate shape. Thickness 0 to about 20 m.

Qoct Older colluvial, talus and rockfall deposits (Pleistocene) Isolated deposits of unconsolidated, very poorly sorted, locally derived slope-wash, talus, and rockfall material. Topographically higher or farther from slopes than Qct deposits. Thickness 0 to 15 m.

Qao Older alluvial and pediment deposits (middle or early Pleistocene) Slightly to moderately consolidated, discontinuous alluvial-plain deposits and pediment gravels that are lithologically similar to Qai deposits, but dissected and 5–15 m higher than Qay. Surface typically has well-developed and degraded calcic soil about 0.5 to 1.0 m thick, forming flat-topped surfaces. Deposit southwest of Devils Throat is underlain by conglomerate and sandstone unit of Thumb Member of Horse Spring Formation. Thickness from 0 to as much as 20 m.

QTa Old alluvial deposits (early Pleistocene or Pliocene) Slightly to moderately consolidated, isolated alluvial plain and fan deposits that are lithologically similar to Qai and Qao deposits, but dissected and topographically higher. Best developed where underlain by conglomerate of the Thumb Member of the Rainbow Gardens Formation. Deposits form rounded slopes with no visible remnant calcic soil. Thickness 0 to 25 m or more.

QTs Sandy alluvial deposits (Pleistocene, Pliocene, or Miocene?) White to pinkish-white, fine-grained, calcareous-cemented sand and silt deposits; mostly derived from Aztec Sandstone. Stratified, with common root casts, some soil horizons. Locally includes micritic limestone, or white chalky marl beds. Deposits fill drainage system cut through Aztec Sandstone in vicinity of Red Rock Springs, now moderately dissected. Capped by gypsiferous deposit, 1–3 m thick, similar to Qgp unit. At downstream end of deposit, travertine deposits locally mantle the Aztec Sandstone. Probably of similar age to QTa deposits, but possibly marginal facies of Muddy Creek Formation or younger Pliocene rocks. At maximum fill level, the Muddy Creek Formation may have extended into this part of the quadrangle prior to post-Muddy Creek erosion. Thickness 0 to 5 m.

Bedrock Units

Tmc Muddy Creek Formation (Pliocene and Miocene) Pale-tan to red- or orange-tan, poorly to moderately consolidated, conglomerate, sandstone, and siltstone, with minor gypsum and claystone. Exposed only in northwest corner of map along Bitter Ridge strike-slip fault. Thickness unknown, probably as much as 500 to 800 m.

Horse Spring Formation (Miocene and Oligocene) Includes, in descending order, the Thumb and Rainbow Gardens members (Bohannon, 1984).

Thumb Member (Miocene) Stratigraphy of Thumb Member is complicated due to rapid facies changes and structural disruptions, but in general consists of lacustrine and alluvial facies (Bohannon, 1984). Divided into five units for mapping purposes: 1) conglomerate and sandstone; 2) sandstone and conglomerate; 3) sandstone, siltstone, gypsum, calcareous sandstone, and tuff; 4) megabreccia; and 5) algal limestone.

Thtc Conglomerate and sandstone unit (Miocene) Red-tan to pale-brown conglomerate, sandy conglomerate and conglomeratic sandstone, poorly exposed. Overlies and possibly interbedded with the lower Thumb unit (Tht). Placed within the Thumb Member here but may include younger deposits. Clast types and sizes vary stratigraphically both upward and laterally. Clast types include the following: Proterozoic gneisses, foliated granites, and schists that match rock types exposed in Whitney Ridge several kilometers east of the quadrangle; Paleozoic carbonate and to a lesser extent, clastic rocks; and minor well-rounded quartzite and chert pebbles and cobbles that are probably recycled from Mesozoic conglomerates. Clasts range mostly from pebble- to cobble-size, although boulders up to 1 m diameter are present. In northern exposures, clasts of Proterozoic rock dominate lower 10–20 m of section and are overlain by an influx of clasts of Paleozoic rock. In southern part of quadrangle, just north of the Lime Ridge fault, Paleozoic clasts dominate throughout the exposed section. Maximum thickness unknown, but probably at least 350 m.

Thts Sandstone and conglomerate unit Brown to red, fine- to coarse-grained sandstone, conglomerate, and siltstone. Sandstone and siltstone well-bedded, commonly cross-stratified, with parallel to lenticular bedding. Locally contains abundant thin beds of channel-filling conglomeratic sandstone and conglomerate, as well as medium to thick beds of massive to crudely stratified, poorly-sorted sandstone with floating pebbles and granules. Occurs only in northeast corner of quadrangle, beneath Thtc unit; most likely lateral coarser grained equivalent to Tht unit.

Tht Sandstone, siltstone, gypsum, calcareous sandstone and tuff unit Dominant rock types are sandstone and siltstone, with local thick deposits of gypsum; also contains calcareous sandstone and thin reworked, ash-fall tuffs. Total thickness difficult to determine but as much as 500 m.

Sandstone and siltstone units Clastic rocks are brown to red, fine- to coarse-grained sandstone and siltstone, commonly cross-stratified, with parallel to lenticular bedding and thin, channel-filling conglomeratic sandstone beds. Can transition laterally to brown, fine-grained, well-sorted sandstone or siltstone in thin, parallel continuous beds, which are commonly calcareous, locally ripple-laminated, with some thin granule or pebbly layers. Locally includes medium to thick beds of massive to crudely stratified, poorly sorted sandstones with floating pebbles and granules.

Gypsum unit White to gray gypsum occurs in laterally continuous, even- to wavy-bedded, thick layers that are finely laminated or massive and recrystallized. Gypsum layers typically pure, but locally can contain sandstone and siltstone.

Calcareous sandstone unit Yellow-tan to yellow-gray, very thin- to thin-bedded with laminated structure. Locally these calcareous sandstones contain raindrop impressions and desiccation cracks on bedding surfaces. Unit occurs in minor amounts except for one thick deposit (about 40 m thick and exposed for about 300 m laterally) that grades laterally into gypsum deposits in the east-central part of the quadrangle.

Tuff unit Pale-green to white or gray, fine-grained, ash-fall tuffs with rare to common phenocrysts of biotite, hornblende, sanidine and plagioclase; locally contain lithic fragments and commonly reworked at base and top. Tuff beds fill channels and are massive or cross-bedded; occur as thin to thick beds throughout most of the section. Beds range in thickness from a few cm to 5 m.

Thtb Megabreccia beds Two isolated lenticular deposits of monolithologic breccia interbedded with Tht in southeast part of quadrangle. Western deposit composed of several slightly disrupted blocks of Mesozoic sandstone and shale. Eastern deposit consists of several blocks, poorly exposed beneath QTa, of basal conglomerate and/or carbonate of the Rainbow Gardens Formation (Thr) that are as much as 10 m long and several m thick.

Thtl Algal limestone unit Limestone is dark to medium gray, typically well bedded with algal laminations and locally hemispheroidal algal mounds and oncolites. Limestone grades rapidly laterally or upward to white thin- bedded dolomitic limestone with spring mound features or to fine-grained clastic rocks and gypsum (Tht). The base of the section is locally marked by granule to small cobble conglomerate containing clasts of underlying Rainbow Gardens upper carbonate unit, or in rare outcrops, landslide breccia masses of Rainbow Gardens carbonate that intertongue laterally with the algal limestone. These rocks were originally mapped as part of the upper limestone unit of the Rainbow Gardens Member (Bohannon, 1983, 1984; Beard and Campagna, 1991; Beard, 1992), but were determined to be a facies of the Thumb Member by Beard (1996) and to overlie an angular unconformity to disconformity at the top of the Rainbow Gardens in the Virgin Mountain area (Beard, 1996).

Thr Rainbow Gardens Member (Miocene to Oligocene) Consists of three units: upper capping cliff-forming, nonmarine limestone that grades downward to a middle slope-forming, lithologically variable unit of sandstone, siltstone, and limestone. The base is formed by a resistant basal conglomerate. Unit typically faulted, but maximum total thickness probably about 300 m.

Upper limestone unit White to pink-white, coarsely crystalline limestone; poorly bedded in the lower part, grading upward into gray, fine-grained to micritic, medium- to thin-bedded limestone. Contact with overlying Thumb Member is a disconformity within quadrangle, but is locally an angular unconformity in Virgin Mountains.

Middle sandstone, siltstone, and limestone unit Includes green-white or red, thin-bedded, lithic sandstone; some beds contain abundant, small (2–4 cm) black chert pebbles. Green-gray, thick-bedded, claystone with floating chert pebbles occurs locally with the lithic sandstones. Red-orange to orange-tan, thin-bedded, calcareous siltstone and silty limestone are commonly found just above the basal conglomerate, and pink to red, vuggy, crystalline limestone with vertical calcite-filled tubelets, interpreted as root casts (Bohannon, 1984), typically occur at the contact with the overlying limestone unit, which is gradational.

Basal conglomerate unit Dark-brown to red-brown, pebble to cobble conglomerate, composed almost exclusively of subangular to subrounded, poorly- to non-imbricated, carbonate and chert clasts of Paleozoic rock, in a calcareous, sandy matrix. The conglomerate lies on a surface that gradually truncates, from north to south, the underlying Cretaceous deposits and Jurassic Aztec Sandstone (Bohannon, 1984). Gradational contact with overlying unit. Thickness about 1 to 5 m.

Kb Baseline Sandstone (Lower Cretaceous) Red, purple-red, and yellow-tan, fine-grained quartz sandstone; medium-bedded, commonly cross-bedded. Lithologically similar to and probably derived from Aztec Sandstone. Rests conformably on Willow Tank Formation. Occurs only in north-central part of quadrangle, where it is overlain with gentle (1–2) angular unconformity by Rainbow Gardens Member of Horse Spring Formation (Thr). Considered equivalent to Baseline Sandstone (Bohannon, 1979) exposed in the Muddy Mountains west of the quadrangle because of similar lithology and stratigraphic setting. Thickness 0 to 60 m.

Kw Willow Tank Formation (Lower Cretaceous) Variegated light- to dark-gray, tan, and red claystone, with interbedded, lenticular bodies of brown and yellow-brown sandstone. Sandstone in lower part of formation is in part conglomeratic, with sparse to abundant, small (2–4 cm) clasts of black and gray chert, red-brown quartzite, and orange-brown pebbly lithic sandstone. Pale-brown, moderately rounded, cobble conglomerate occurs very locally at base. This basal conglomerate includes clasts (5–20 cm diameter) of quartzite, carbonate, and chert in a sandy matrix. Disconformable contact with underlying Aztec Sandstone. Thickness ranges from about 0 to 100 m.

Ja Aztec Sandstone (Lower Jurassic) Red, less commonly white or pale-yellow, medium- to fine-grained, eolian quartz sandstone. Bedding discontinuous, nonparallel, with distinctive large-scale (up to 15 m thick) planar cross-stratification except near base of unit where thinner (0.5–2 m), low-angle tangential cross-stratification bedding common. Variable thickness due to pre-Rainbow Gardens erosion. Thickness ranges from over 900 m at north end of the quadrangle to less than 280 m in the southern part.

Jmk Kayenta and Moenave Formations, undivided (Lower Jurassic) Kayenta Formation (upper of two formations) is red and orange sandstone and siltstone, with medium to thick parallel beds with large-scale cross-stratification. Bleached spots, 1–2 cm diameter, common in siltstone layers. The Moenave Formation is brick-red sandstone and siltstone, with minor thin limestone beds and local gypsiferous claystone. Base of formation commonly marked by dark red-brown to green-brown, trough-cross-stratified, pebble conglomerate. Clasts are mostly well-rounded, highly polished quartzite and chert, but also include limestone and sandstone. Where conglomerate missing, lower part of unit is dominated by lenticular deposits of gypsiferous claystone. Underlain by erosional disconformity on Chinle Formation. Thickness about 300 m.

Trc Chinle Formation (Upper Triassic) Includes in descending order, the Petrified Forest and Shinarump Members. Thickness of Chinle Formation about 250 m.

Petrified Forest Member Chocolate-brown, gray, and pale-red to pale-purple, interbedded sandstone, siltstone, and claystone. Bentonitic clay derived from volcanic ash occurs in some of the mudstones.

Shinarump Member Yellow- or green-brown to dark red-brown conglomerate, conglomeratic sandstone and sandstone. Includes well-rounded to rounded chert, quartzite, and minor carbonate clasts. Forms disconformable contact with underlying Moenkopi Formation.

Moenkopi Formation (Middle? and Lower Triassic) Includes in descending order: the upper red, Shnabkaib, middle red, Virgin, and the lower red members, as defined by Stewart et al. (1972). The middle red is only locally present. Two formal members have been mapped separately, the lower red (Trml), and the upper red (Trmu). The Shnabkaib, middle red, and Virgin are mapped as one informal unit (Trmsv). Thickness of Moenkopi ranges from about 600 to 650 m.

Trmu Upper red member Red shale, gypsiferous, interlayered with thin, resistant, red-brown, ripple-laminated, fine-grained sandstone and siltstone; poorly exposed. White to yellow-brown, fine-grained sandstone lenses with rare, small chert pebbles in the lower half. Also includes purple and white mottled conglomeratic sandstone that occurs locally about 5–10 m below the top of the Moenkopi. Above sandstone are dark red-brown, thin massive mudstone to siltstone beds, separated by thin recessive green shale with vertical silt-filled mudcracks. Gradational contact with underlying Shnabkaib Member.

Trmvs Shnabkaib, middle red, and Virgin Limestone Members, undivided Aggregate thickness about 200 m.

Shnabkaib Member Thin interlayered beds of white gypsum, gray limestone, and pale-green or red siltstone and shale.

Middle red member Present only locally between the Virgin and Shnabkaib. Unit is interbedded, pale red-brown, laminated to massive, siltstone and shale.

Virgin Limestone Member Composed of light-gray to yellow-gray, fine-grained to aphanitic, thin-bedded dolomite and limestone, interbedded with gray or green-gray siltstone. Commonly crops out as two resistant ridges, separated by a slope.

Trml Lower red member Pale-red to red-brown gypsiferous shale interbedded with dark-red or red-brown, ripple-laminated, siltstone and fine-grained sandstone; generally very poorly exposed. A limestone-clast breccia to conglomerate occurs locally at the base of the lower red member, where it fills erosional channels cut into the underlying Kaibab Formation. This conglomerate is probably equivalent to the Timpoweap Member of the Moenkopi Formation in southwestern Utah.

Pk Kaibab Formation (Lower Permian) Includes, in descending order, the Harrisburg and the Fossil Mountain Members, as defined by Sorauf and Billingsley (1991). Thickness is variable due to sub-Triassic unconformity, ranging from 120 to 170 m.

Harrisburg Member White-gray to gray and light-red, interbedded limestone, dolomite, gypsum, and siltstone. The gypsum and siltstone are usually slope-forming, and the limestone and dolomite form ledges so that the member erodes into a stair-step topography.

Fossil Mountain Member Pale yellow-brown to gray, medium- to thick-bedded limestone; fossiliferous with brachiopods, bryozoans, gastropods, bivalves, corals, and crinoids. Chert is very common, occurring as nodules, ribbons, or fine disseminated networks. Typically forms a cliff.

Ptc Toroweap Formation and Coconino Sandstone, undivided (Lower Permian) Includes, in descending order, the Woods Ranch, Brady Canyon, and Seligman Members of the Toroweap Formation as defined by Sorauf and Billinglsey (1991) and the Coconino Sandstone.

Toroweap Formation Total thickness about 110 m.

Woods Ranch Member White to yellow-gray or medium-gray, interbedded gypsum, calcareous siltstone and sandstone, and minor limestone and dolomite. Forms slope.

Brady Canyon Member Medium-gray, thick-bedded limestone and dolostone; cliff-former. Fossil fragments, especially crinoids and brachiopods, are common as are rounded nodules and ribbons of chert. Has gradational contact with overlying Woods Ranch and underlying Seligman members.

Seligman Member Tan to red- and yellow-tan or gray-orange, slope-forming unit that contains siltstone, sandstone, and limestone; locally, thick gypsum deposits dominate unit. Intertongues with underlying Coconino Sandstone.

Coconino Sandstone White to buff-colored, coarse- to medium-grained sandstone with 1 m cross-bedded sets; forms a cliff when present. Has a sharp disconformable contact with the underlying Hermit Shale. Unit is thin to nonexistent (15–0 m) throughout the study area.

Ph Hermit Shale (Lower Permian) Brick-red to red-brown, thin- to medium-bedded, fine-grained, in part cross-stratified sandstone and siltstone, interbedded with deep-red, massive to ripple-laminated, shaly siltstone. Forms steep slopes that are commonly covered by talus and colluvium. Disconformable contact with underlying Esplanade Sandstone. Thickness ranges from about 270 to 300 m.

Pe Esplanade Sandstone (Lower Permian) White to pink or pale-red, fine- to medium-grained, well-sorted, medium- to thick-bedded, well-sorted sandstone. Exhibits both large-scale planar cross-stratification and low-angle, tangential cross-stratification in thin sets. Basal 6 m of formation typically consist of red shale interbedded with red sandstone and pale-red gypsum; thin-bedded. Contact with underlying Pakoon Limestone is conformable and gradational where upper Pakoon contains abundant gypsum. Thickness about 60 to 80 m.

Pp Pakoon Limestone (Lower Permian) White to light-gray, fine- to coarse-grained, thin- to medium-bedded, cherty dolomite (McNair, 1951). Gypsum is commonly, but not always, interbedded with gypsiferous dolomite in the upper 15–20 m. Unit weathers into ledge-slope, with slightly gentler topographic profile than underlying Callville Limestone. Disconformable, locally erosional contact with Callville. Thickness about 120 to 140 m.

IPc Callville Limestone (Pennsylvanian) Medium-gray, medium-grained, cherty, fossiliferous limestone; interbedded with light-gray, fine-grained dolomite and calcareous sandstone or shaly siltstone that weathers orange. Cliff-forming limestone and slope-forming sandstone and siltstone produce stair-step topography. Chert occurs as red nodules and stringers; most abundant in the middle part. Dolomite increases in proportion to limestone toward top, and sandstone is more common in the upper half of the formation. Forms disconformable, mildly channeled contact with underlying Redwall Limestone. Thickness about 140 to 200 m.

Mr Redwall Limestone (Upper and Lower Mississippian) Medium-gray, fine-grained to coarsely crystalline, fossiliferous limestone that forms a massive cliff. Distinctive banded chert unit, about 45 m above base of formation, contains 5–10 cm thick bands of white to gray chert that weathers yellow and black and forms a distinctive marker bed. Locally dolomitized. Has disconformable contact with underlying Temple Butte Limestone. Thickness about 140 m.

Dtb Temple Butte Limestone (Upper and Middle Devonian) Upper part is light-gray, fine-grained to micritic limestone that weathers to very light-gray and forms a cliff. Commonly dolomitized and characteristically has strong fetid odor when freshly broken. Lower part is brown to black, mostly fine-grained dolomite, with interbedded red-brown sandstone and sandy shale in the lower 10 m. A fish locality in the sandstone layers found in Virgin Mountain 7.5-minute quadrangle to the northeast includes Upper Middle Devonian *Pacodermi* fragments (Elliott and Johnson, 1997). Dolomite forms cliffs and sandstone forms slopes creating stair-step topography. Basal contact is erosional disconformity. Thickness about 180 m.

Ꞓu Unclassified Dolomite (Upper and Middle Cambrian) Light-gray to medium-gray or light-brown, medium-grained to coarsely crystalline dolomite and sandy dolomite; shale partings common in lower part of section. Thin- to medium-bedded, with beds even and continuous. Fine laminae and mottling typical on weathered surfaces. Upper 30 m is yellow-brown glauconitic dolomite; previously mapped as Pogonip Group rocks of Ordovician age (Morgan, 1968, Seager, 1966), because McNair (1951) found small fragments of brachiopods and trilobites possibly younger than Cambrian at Whitney Ridge (about 6 km east of quadrangle). However, these beds included here with Unclassified Dolomites. Rowland and others (1990) described similar beds as upper informal members of Muav Limestone. Exposed thickness about 140 m.

Ꞓm Muav Limestone (Middle Cambrian) Medium- to dark-gray, coarse- to medium-grained, medium- to thin-bedded dolomite, interbedded with thin-bedded light-gray or white sandy dolomite, and gray, fine-grained limestone. Medium- to dark-gray beds are characteristically mottled yellow-gray or light-gray on weathered surfaces because of extensive burrowing. Exposed thickness about 120 m.

The following units are shown only in the subsurface of cross-section B. Descriptions from exposures of these rocks in Gold Butte 7.5-minute quadrangle to south:

Ꞓba Bright Angel Shale (Middle Cambrian) Dominantly green micaceous shale, complexly burrowed. Lower 3–4 m consists of red-brown micaceous and glauconitic shale interlayered with thin red-brown sandstone beds. Upper contact placed at base of first thick limestone bed. Gradational with underlying Tapeats Sandstone. Forms slope. Thickness about 120 m.

Ꞓt Tapeats Sandstone (Lower Cambrian) Divided into two units. Lower unit is dark red, thin-bedded arkosic sandstone that rests with nonconformity on Proterozoic basement rocks and is locally absent. Thickness 0–10 m. Upper unit is light-brown, medium-bedded orthoquartzite, cross-bedded, locally burrowed, commonly exhibiting complex liesegang bands on weathered surfaces. Thickness of upper unit about 65 m.

Xu Undivided crystalline rocks (Early Proterozoic) Tan to red, locally dark-gray granite and gneiss, with minor quartz-feldspar pegmatite veins. Dark-gray granite contains as much as 5 percent magnetite.

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Beard, L.S., Campagna, D.J., 2012, Geologic Map of the Devils Throat quadrangle, Clark County, Nevada: Nevada Bureau of Mines and Geology Map 181, scale 1:24,000, 9 p.

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NEVADA BUREAU OF MINES AND GEOLOGY

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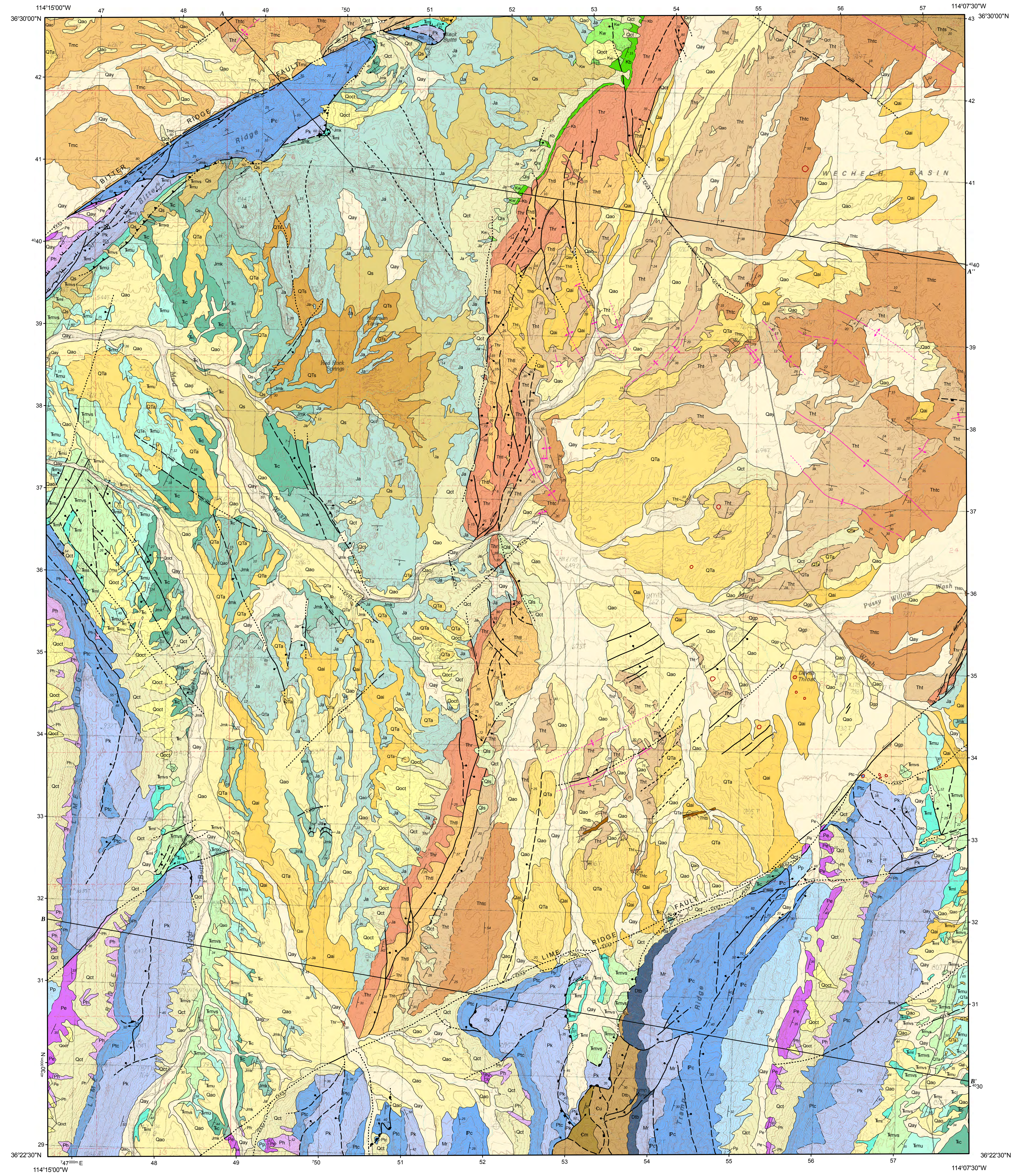
MAP 181
GEOLOGIC MAP OF THE DEVILS THROAT QUADRANGLE, CLARK COUNTY, NEVADA
Text accompanies map



SURFICIAL DEPOSITS

Qay	**Young alluvium**
Qai	**Intermediate alluvial and pediment deposits**
Qct	**Colluvial, talus, and rockfall deposits**
Qs	**Dune and sand sheet deposits**
Qgp	**Gypsiferous deposits**
Qls	**Landslide deposits**
Qoct	**Older colluvial, talus and rockfall deposits**
Qao	**Older alluvial and pediment deposits**
QTa	**Old alluvial deposits**
QTs	**Sandy alluvial deposits**

BEDROCK UNITS

Tmc	**Muddy Creek Formation, Horse Spring Formation, and Thumb Member**

Horse Spring Formation, Thumb Member

Thtc	**Conglomerate and sandstone unit**
Thts	**Sandstone and conglomerate unit**
Tht	**Sandstone, siltstone, gypsum, calcareous sandstone and tuff unit**
Thtb	**Megabreccia beds**
Thtl	**Algal limestone unit**
Thr	**Horse Spring Formation, Rainbow Gardens Member**
Kb	**Baseline Sandstone**
Kw	**Willow Tank Formation**
Ja	**Aztec Sandstone**
Jmk	**Kayenta and Moenave Formations**
₹c	**Chinle Formation**

See accompanying text for full unit descriptions and references for this map.

Moenkopi Formation

₹mu	**Upper red member**
₹mvs	**Shnabkaib, middle red, and Virgin Limestone Members, undivided**
₹ml	**Lower red member**
Pk	**Kaibab Formation**
Ptc	**Toroweap Formation and Coconino Sandstone, undivided**
Ph	**Hermit Shale**
Pe	**Esplanade Sandstone**
Pp	**Pakoon Limestone**
IPc	**Callville Limestone**
Mr	**Redwall Limestone**
Dtb	**Temple Butte Limestone**
€u	**Unclassified Dolomite**
€m	**Muav Limestone**

These units shown in cross section only

€ba	**Bright Angel Shale**
€t	**Tapeats Sandstone**
Xu	**Undivided crystalline rocks**

Symbology (per FGDC-STD-013-2006)

Contact Solid where certain and location accurate; long-dashed where approximate.

Fault, unknown offset Solid where certain and location accurate; short-dashed where inferred.

Normal fault Solid where certain and location accurate; long-dashed where approximate; short-dashed where inferred; dotted where concealed. Ball on downthrown side; arrow shows bearing and plunge of slickenlines. *On cross sections, arrows show relative motion.*

Strike-slip fault Solid where certain and location accurate, dashed where approximate, dotted where concealed; queried if identity or existence uncertain. Arrows show relative motion. *On cross sections, A=away, T=toward.*

Thrust fault Solid where certain and location accurate; dashed where approximate; dotted where concealed. Sawteeth on upper plate.

Low-angle normal fault Solid where certain and location accurate; dashed where approximate; dotted where concealed. Half-circles on upper plate.

Reverse fault Dashed where approximate; dotted where concealed. Rectangles on upthrown block.

Attenuation fault Dashed where approximate. Hatchures on upper plate.

Anticline Solid where certain and location accurate; dashed where approximate; dotted where concealed.

Syncline Solid where certain and location accurate; dashed where approximate; dotted where concealed.

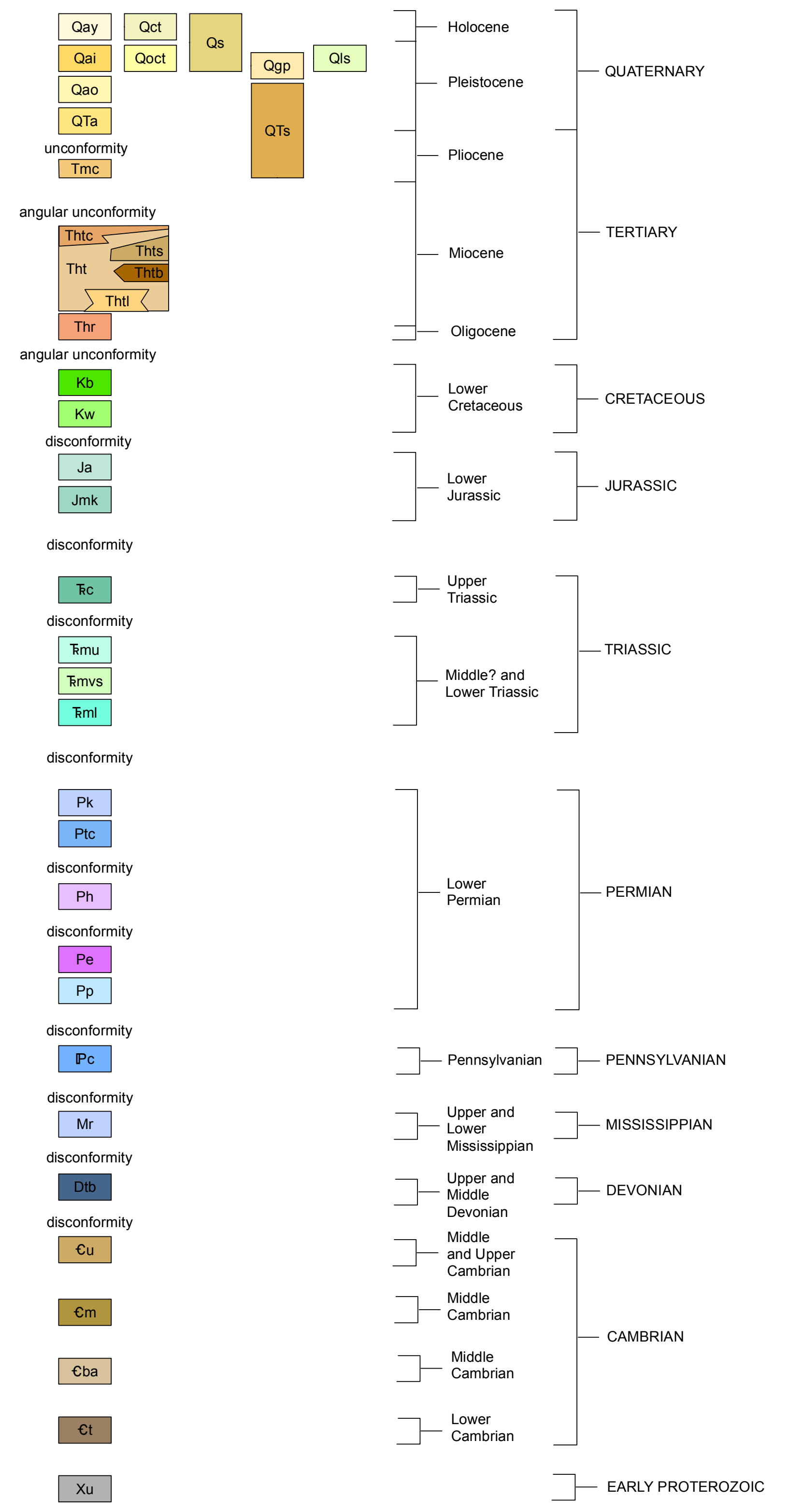
Monocline Solid where certain and location accurate. Arrow shows direction of dip.

A——*A'*
Line of cross section

○ **Sinkhole**

Strike and dip of bedding

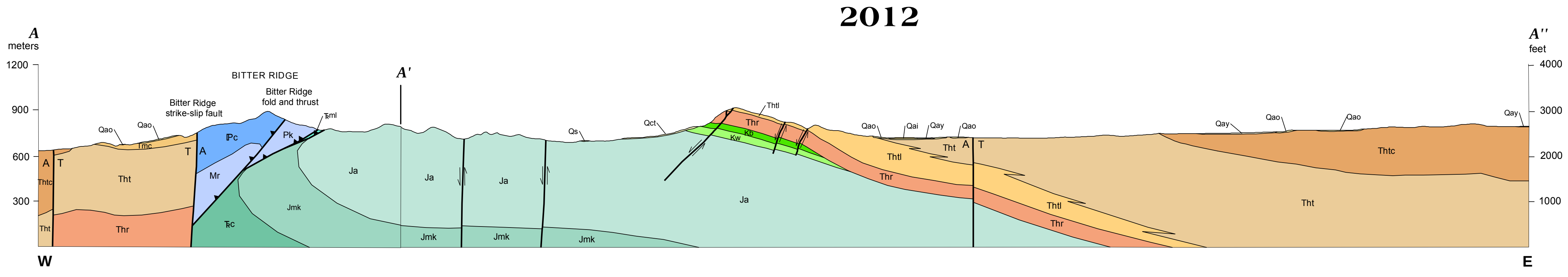
41 Inclined Overturned Vertical



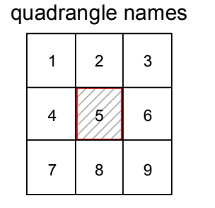
GEOLOGIC MAP OF THE DEVILS THROAT QUADRANGLE, CLARK COUNTY, NEVADA

L. Sue Beard[1] and David J. Campagna[2]
[1]U.S. Geological Survey, Flagstaff AZ; [2]Department of Geology and Geography, West Virginia University

2012

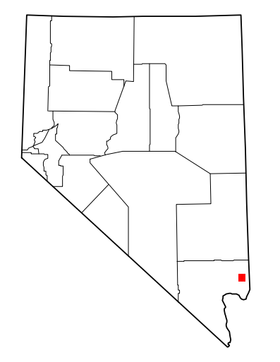


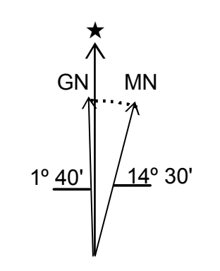
Adjoining 7.5' quadrangle names



1 Overton SE
2 Whitney Pocket
3 Virgin Peak
4 Overton Beach
5 Devils Throat
6 St. Thomas Gap
7 Lime Wash
8 Gold Butte
9 Azure Ridge

Map location





UTM GRID AND
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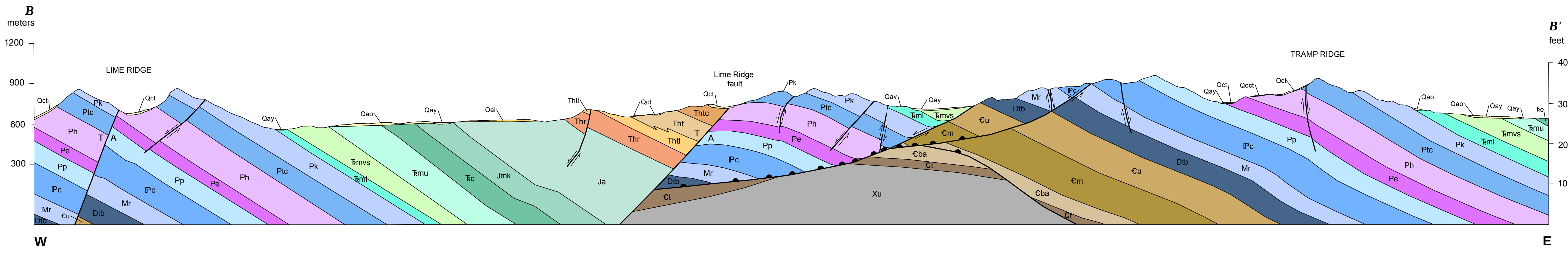

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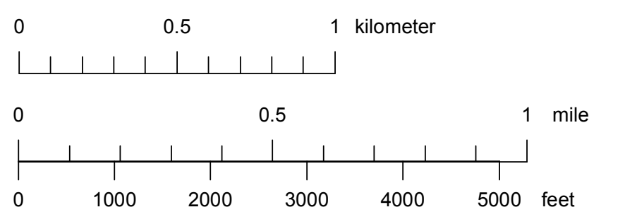

CONTOUR INTERVAL 10 METERS

Projection: Universal Transverse Mercator, Zone 11, North American Datum 1927 (m)

Base map: U.S. Geological Survey Devils Throat 7.5' quadrangle (1983)

Nevada Bureau of Mines and Geology
Mackay School of Earth Sciences and Engineering
College of Science
University of Nevada, Reno

Field work done in 1989–1990
Supported by the U.S. Geological Survey and the Bureau of Land Management (Agreement No. FAA070026)
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PEER-REVIEWED MAP
Office review by George Billingsley (USGS), Alan R. Ramelli (NBMG), and Paul Umhoefer (NAU)
Field review by James E. Faulds (NBMG) and George Varhalmi (BLM)

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