Text and references accompanying Nevada Bureau of Mines and Geology Open-File Report 13-6

Preliminary Geologic Map of the Valley of Fire East Quadrangle, Clark County, Nevada

by

Thomas W. Muntean
Geology Department, Adrian College, Adrian, MI

2013

Disclaimer: NBMG Open-File Reports are preliminary. They have not been thoroughly edited or peer reviewed.

INTRODUCTION

The Valley of Fire East quadrangle geologic map is a compilation of previous maps (1:62,500- to 1:250,000-scale maps) from the region and new mapping. New geologic mapping was primarily conducted to resolve the local stratigraphy of, and structural features affecting, the late Neogene Muddy Creek Formation (MCF) at the 1:24,000 scale. Compilation mapping was predominantly used to improve the resolution of pre-MCF unit contacts and exposures within the map area.

METHODS

The Valley of Fire East quadrangle geologic map was prepared using a combination of methods: (1) compilation from existing maps, (2) aerial photography mapping, (3) field and reconnaissance mapping, and (4) spot-checking of features mapped using aerial photography and/or compiled from previous studies. Compilation mapping reinterprets and expands on previous 1:62,500-scale (Bohannon, 1983), 1:100,000-scale (Beard et al., 2007), and 1:250,000-scale (Felger and Beard, 2010) geologic mapping and was primarily used to map pre-MCF geologic features. Aerial photographs were used to map contacts (stratigraphic and structural) of pre-MCF units and were essential for mapping geologic features in areas with low topographic relief. The contour interval of the USGS topographic maps for the region is 10 meters and in areas with low topographic relief, this interval provided insufficient detail to accurately locate contacts without the aid of aerial photography overlain (digitally) on a topographic base. Aerial photographic sources included USGS digital orthophoto quadrangles, the USDA National Agriculture Imagery Program (NAIP), USDA NAIP Colorized Infrared Imagery, and Google Earth imagery. Detailed field mapping and reconnaissance mapping were predominantly focused on the MCF.

DESCRIPTION OF MAP UNITS

Quaternary Deposits

Qdl Disturbed land (Holocene) Areas where naturally exposed geologic features have been obscured or modified by excavation or fill activities such that they are no longer recognizable. In the vicinity of the southern limit of Overton Ridge, previous mapping (Bohannon, 1983) showed Qdl is underlain by Kbr, Kbw, Kwt, and Ja.

Qlm Lake Mead deposits (Holocene) Predominantly light tan silt and mud with lesser marginal wave-reworked sand and gravel beach deposits locally derived from the Muddy Creek Formation, Pliocene-Pleistocene(?) alluvial deposits, and/or modern washes; silt and mud are unconsolidated, planar horizontal laminated; marginal sand and gravel deposits are unconsolidated, typically lacking distinct lamination. Unit is exposed in areas formerly covered by Lake Mead. Unit is partially dissected by the Muddy River and modern washes. Thickness ranges from several centimeters to greater than several meters.

Qa Alluvium (Holocene) Alluvium of active washes and rivers. Pale-orange to tan sand and sandy gravel; unconsolidated.

Qe Eolian deposits (Holocene to Pleistocene) Pale orange to red-orange sand; unconsolidated to poorly indurated, fine- to medium-grained, well sorted, fine laminations common but lacks bedding. Occurs as sheets and dunes of limited aerial extent. Thickness ranges from less than 10 centimeters to greater than several meters.

Qoa_1 Older Alluvium (Upper to Middle Pleistocene) Light tan to brown conglomerate, sandstone, and siltstone. Typically clast-supported; poorly rounded to rounded clasts ranging from pebble to cobble size and

predominantly consisting of limestone with lesser sandstone, volcanic (felsic to mafic), and quartzite clasts. Matrix predominantly consists of quartz sand; very fine- to medium-grained, angular to rounded grains. Uncemented to weakly cemented with carbonate cement; however, many clasts have a discontinuous carbonate coating up to several millimeters thick. Bedding ranges from massive to discontinuous with beds up to 50 centimeters thick with planar and trough cross-laminations. Typically ranges from less than ten centimeters to greater than ten meters thick. Occurs as alluvial fans and floodplain deposits. Locally fills paleo-topographic lows (paleo-canyons).

Qoag Older Alluvium, gypsiferous (Upper to Middle Pleistocene) Gypsiferous spring deposits exposed in the vicinity of Rogers Spring and Blue Point Spring. Up to two meters thick (Bohannon, 1983).

Qp Petrocalcic soil, undifferentiated (Middle Pleistocene? to Upper Pliocene?) Petrocalcic soil; typically capping Qoa_2, Tmcu, and Tmcl. Forms resistant caps that have commonly been left elevated as a remnant surface, due to recent regional incision (Bohannon, 1983). Occurs in variable stages of development; undivided on map. Northern and west-central Qp occurrences are up to stage III petrocalcic development; up to two meters in thickness (Beard et al., 2007); typically capping Qoa_2. East-central Qp occurrences are up to stage V development or greater; up to 5 meters thick (Beard et al., 2007; Brock and Buck, 2009); typically caps Tmcu or Tmcl.

Qoa_2 Older Alluvium (Middle Pleistocene to Upper Pliocene?) Light tan to brown conglomerate, sandstone, and siltstone. Conglomerate is typically clast-supported; angular to rounded clasts ranging from pebble to cobble size and predominantly consisting of limestone and cherty limestone with lesser chert, sandstone, volcanic (felsic), and quartzite clasts. Matrix predominantly consists of quartz sand; fine- to medium-grained, rounded to well-rounded grains. Uncemented to weakly cemented with carbonate cement, however many clasts have a discontinuous carbonate coating up to several millimeters thick. Bedding ranges from massive to discontinuous beds up to 50 centimeters thick with planar and trough cross-laminations. Typically less than five meters thick. Occurs as alluvial fans and floodplain deposits.

Tertiary Rocks

Muddy Creek Formation (Pliocene to Upper Miocene) The Muddy Creek Formation represents the youngest widespread basin deposits within the Lake Mead Region and predominantly consists of sandstone, siltstone, and claystone, with common gypsum and gypsiferous beds and lesser conglomerate beds (Bohannon, 1984). The basal age of the MCF is reported to range from approximately 8 Ma (Lamb et al., 2005) to younger than 10.6 Ma (the upper age of the underlying red sandstone unit; Bohannon, 1984). The upper age of the MCF is at least as young as 4.1 ± 0.2 Ma (Williams, 1996), based on whole-rock K-Ar analysis of a basalt flow interbedded near the top of formation in the vicinity of Mesquite, Nevada.

The Muddy Creek Formation is interpreted to represent Late Miocene post-tectonic deposition within a series of internally drained basins (Bohannon, 1984). However, the formation is at least locally (within the map area) syn-tectonic; due to post-6.62 ± 0.03 Ma motion along the Rogers Spring and Hen Spring faults (Muntean, 2012). In the vicinity of the map area, the formation was derived from far-traveled Basin and Range and Colorado Plateau sources, in addition to materials with a local provenance (Muntean, 2012).

The Muddy Creek Formation is divided into three informal members within the map area: upper sandstone and conglomerate member (Tmcu); lower sandstone, siltstone, and gypsiferous siltstone member (Tmcl); and lower coarse-grained member (Tmcc).

Tmcu Muddy Creek Formation—upper sandstone and conglomerate member (Pliocene to Upper Miocene) Interbedded tan, light pink, and red-orange sandstone and conglomerate with some siltstone. Poorly to weakly indurated. Planar-laminated and tabular and trough cross-laminated discontinuous beds; typically ranging from 10 centimeters to less than 50 centimeters in thickness. Sandstone is fine- to medium-grained; moderate- to well-sorted; sub- to well-rounded; composed predominantly of quartz with lesser feldspar and lithic grains. Conglomerate is matrix- and clast-supported; pebble to cobble size; sub- to well-rounded; composed of 20–30% volcanic (felsic to intermediate), 10–15% carbonate (limestone with minor dolomite), 10–20% chert, <5% clastic sedimentary, 40–50% metamorphic clasts (mostly quartzite with lesser gneiss and minor schist). Maximum thickness greater than 100 meters.

Tmcl Muddy Creek Formation—lower sandstone, siltstone, and gypsiferous siltstone member (Upper Miocene) Interbedded tan, light pink, and red-orange sandstone, siltstone, and gypsiferous siltstone with sparse conglomerate beds. Poorly to weakly indurated. Predominantly siltstone with gypsiferous siltstone, sandy siltstone, and sandstone in central and southern exposures. Records a southward-fining lateral facies change, from sandstone- and siltstone-dominated deposits in the north to siltstone- and gypsiferous siltstone-dominated deposits in the south (Muntean, 2012). Planar-laminated continuous beds predominate in southern exposures; typically ranging from one to ten centimeters in thickness. Planar-laminated continuous and discontinuous beds and tabular and trough cross-laminated discontinuous beds are common in northern and eastern exposures; typically ranging from several centimeters to less than 0.5 meters

thick. Sandstone is very fine- to medium-grained; sub- to well-rounded; sorted to well-sorted; composed predominantly of quartz with lesser feldspar and lithic grains. Thin basalt flows (Tb) are interbedded within the formation. Sparse ash beds (lacking phenocrysts) are interbedded within Tmcl. Glass within these ashes is typically devitrified but one sample collected near the intersection of Northshore Road (Highway 169) and Overton Beach Road (State Route 12) yielded a tephrochronologic correlation to the Blacktail Creek Tuff (Muntean, 2012), which has been dated at 6.62 ± 0.03 Ma (Morgan and McIntosh, 2005). Thickness is approximately 900 meters, based on borehole data from the Virgin basin (Bohannon et al., 1993).

Mannion (1963) described exposed salt domes (all but one now covered by Lake Mead) in the vicinity of Salt Cove (southeastern edge of the map area) and a thick subsurface salt deposit in the southeastern region of the map area. The subsurface salt deposit is locally at least 300 meters to greater than 535 meters thick; consisting of impure halite, glauberite, and lesser anhydrite beds occurring with fine sand, silt, and clay beds (Mannion, 1963). Mannion (1963) concluded that the salt deposit was part of the basal Muddy Creek Formation.

Tmcc Muddy Creek Formation—lower coarse-grained member (Upper Miocene) Gray-brown conglomerate; locally derived; accumulated along margin of the main Muddy Creek Formation basin (Bohannon, 1983; Beard et al., 2007). Only exposed along the eastern flank of Overton Ridge, in the north-central region of the map, where it unconformably overlies Thr and intertongues with Tmcl (Bohannon, 1983; Beard et al., 2007).

Tb Basalt—flows (Upper Miocene) Olivine- and olivine-augite-bearing basalt flows (Bohannon, 1983; Beard et al., 2007) interbedded with the Muddy Creek Formation lower sandstone, siltstone and gypsiferous siltstone member (Tmcl). Exposed south and west of Overton Beach. Amygdules are commonly filled by natrolite and analcime (Bohannon, 1983). Chloritic alteration is present in most exposures. Flows are typically thin, ranging from approximately one to ten meters in thickness. Reported ages vary. The flow exposed in the vicinity of Black Point yielded ages of 6.02 ± .39 Ma (plagioclase K-Ar; Feuerbach et al., 1991), 6.15 Ma, and 6.6 Ma (preliminary $^{40}Ar/^{39}Ar$ isochron ages; Beard et al., 2007). A flow exposed approximately two kilometers west of the Black Point flow and reported to be located at 36°24'53"N / 114°24'25"W (referenced to NAD27) yielded a whole-rock K-Ar age of 8 Ma (Eberly and Stanley, 1978). However, the dated samples are all believed to have been collected from a single flow unit, indicating inaccuracy in one or more of the analyses, possibly due to chloritic alteration and/or analysis methodology.

Ti Mafic rocks—intrusive (Upper Miocene) Mafic dikes and plugs intruding Paleozoic rocks and bearing hypersthene, augite, and olivine (Bohannon, 1983; Beard et al., 2007). Exposed within the northeastern Muddy Mountains.

Trs Red sandstone unit (Upper to Middle Miocene) Rocks informally named the red sandstone unit (Bohannon, 1984) and consisting of interbedded red to tan sandstone, siltstone, gypsiferous siltstone, pebbly sandstone, and tephra beds crop out within the map area, predominantly to the northeast of the Muddy Mountains (Bohannon, 1983, 1984; Beard et al., 2007). Previous mapping (Beard et al., 2007) conducted within the map area shows that the red sandstone unit unconformably overlies Mesozoic strata and is unconformably overlain by the Muddy Creek Formation. The ages of red sandstone unit outcrops exposed within the map area are undetermined. However, ages obtained elsewhere from the unit show the red sandstone unit is at least as old as 11.70 ± 0.08 Ma, based on a tephra occurring near the base of the unit (Harlan et al., 1998; Beard et al., 2007). The basal age is less than 12.93 ± 0.10 Ma, based on an age obtained from a dacite clast occurring within an interbedded megabreccia block (Harlan et al., 1998; Beard et al., 2007). The upper age of the unit is at least as young as 10.05 ± 0.03 Ma (Anderson et al., 1994). Lamb et al. (2005) suggested the red sandstone unit may be as young as approximately 8.5 Ma.

Trc Red sandstone unit—conglomerate facies (Upper to Middle Miocene) Tan to gray conglomerate and sandstone interpreted by Bohannon (1983) and Beard et al. (2007) to be coeval with the informally named red sandstone unit of Bohannon (1984). Exposed in the vicinity of the northern Muddy Mountains within fault blocks and adjacent to faults (Bohannon, 1983; Beard et al., 2007). Clasts are subangular to angular, range in size from 5 to 40 centimeters in diameter, and are composed of locally exposed Paleozoic rocks (Bohannon, 1983; Beard et al., 2007). The conglomerate is interpreted by Beard et al. (2007) to be older than 8 to 9 Ma and at least as old as 11.72 ± 0.06 Ma (based on a tephra occurring near the base of the unit). Bohannon (1983) reported a thickness of 0 to 300 meters for the conglomerate.

Thl Horse Spring Formation—Lovell Wash Member (Miocene) The youngest of four members of the Horse Spring Formation, the Lovell Wash Member predominantly consists of interbedded carbonate (limestone and dolomite), siliciclastic (gray and white claystone and brown tuffaceous sandstone), and tephra beds (Bohannon, 1983, 1984; Beard et al., 2007). The unit is exposed at only a single locality, within the southwestern-most region of the map area. The ages of exposures within the map area are undetermined, though the Lovell Wash Member is considered to range from 13 to 11.9 Ma (Bohannon, 1984). The thickness of the Lovell

Wash Member is stated to be as great as 450–500 meters (Bohannon, 1983; Beard et al., 2007).

Thr Horse Spring Formation—Rainbow Gardens Member (Upper Oligocene to Lower Miocene) The oldest of four members comprising the Horse Spring Formation, the Rainbow Gardens Member consists of (1) a basal conglomerate, (2) a middle lithofacies consisting of interbedded red and yellow sandstone, gypsiferous sandstone, and carbonate beds; and (3) an upper white to reddish white limestone (Bohannon 1983, 1984; Beard et al., 2007). Only the basal conglomerate unit is exposed within the map area; cropping out along Overton Ridge, within the north-central region of the study area. At Overton Ridge, the unit consists of interbedded conglomerate and sandstone (Rice, 1987). Clasts compositions range from 42–56% limestone (predominantly containing Paleozoic fossils), 21–44% dolomite, and 8–22% chert, with sandstone clasts comprising 0.5–4% of the total (Rice, 1987). Sandstone samples are poorly sorted and angular, with grains typically consisting of 55–80% lithic carbonate fragments, 10–30% monocrystalline quartz, and 5–15% chert (Rice, 1987). Sedimentary structures include imbricated clasts and trough cross-laminated and ripple-laminated sandstone (Rice, 1987). The Rainbow Gardens Member spans from less than 18.8 Ma to older than 26 Ma (Beard, 1996). Within the map area, the unit is anticipated to be approximately 26 Ma, where it unconformably overlies Cretaceous Baseline Sandstone (Kbr) and is unconformably overlain by the Muddy Creek Formation. Total thickness of the Rainbow Gardens member is approximately 375 meters (Bohannon, 1983). The basal conglomerate at Overton Ridge is up to approximately 100 meters thick.

Mesozoic Rocks

Baseline Sandstone (Upper? to Lower Cretaceous) The Baseline Sandstone consists of foreland basin deposits (sandstone and conglomerate) of the Sevier thrust belt (Beard et al., 2007). Four members comprise the formation (Bohannon, 1983). The upper red sandstone member (Kbr) and Overton Conglomerate Member (Kbo) are coeval and intertongue in the northwestern region of the map area; deposited as a northward-coarsening facies assemblage (Bohannon, 1983; Beard et al., 2007). The middle White Sandstone Member (Kbw) is also exposed in the northwestern region of the map area, underlying Kbr and conformably overlying the Willow Tank Formation (Kwt). The lower conglomerate member is absent from the section exposed within the map area.

Kbr Baseline Sandstone—Red sandstone member (Upper? to Lower Cretaceous) Red and red-brown quartz arenite, cemented by limonite and hematite (Bohannon, 1983). Sandstone is fine- to medium-grained, well-sorted, well-rounded, grain supported, poorly indurated, and was deposited in a fluvial environment (Bohannon, 1983; Beard et al., 2007). Low-angle, large-scale trough cross-laminations are common; beds 20 to 50 centimeters thick (Bohannon, 1983; Beard et al., 2007). Intertongues (laterally) with the Overton Conglomerate Member (Kbo) to the north (Beard et al., 2007). Member thickness is approximately 600 meters (Bohannon, 1983).

Kbo Baseline Sandstone—Conglomerate Member (Upper? to Lower Cretaceous) Gray-brown conglomerate; clast-supported with sandy matrix (Bohannon, 1983). Clasts are poorly to moderately sorted, pebble to boulder size (mostly 1 centimeter to more than 1 meter diameter), coarse angular, and predominantly consist of locally derived Paleozoic and Mesozoic sandstone and carbonate rocks, with abundant clasts of petrified wood derived from the Chinle Formation (Bohannon, 1983, 1992; Beard et al., 2007). Intertongues (laterally) with the red sandstone member (Kbr) to the south (Beard et al., 2007). Member is greater than 400 meters thick (Bohannon, 1992).

Kbw Baseline Sandstone—White sandstone member (Lower Cretaceous) White, pale-green, pale-purple, and pale-yellow quartz arenite (Bohannon, 1983). Sandstone is medium-grained, well-sorted, rounded, poorly indurated, and was deposited in a fluvial environment (Bohannon, 1983; Beard et al., 2007). Low-angle, large-scale trough cross-laminations are common; beds are discontinuous, curved, and non-parallel (Bohannon, 1983; Beard et al., 2007). Thickness is approximately 500 meters (Bohannon, 1983).

Kwt Willow Tank Formation (Lower Cretaceous) Claystone, siltstone, shale, sandstone, bentonitic tuff, and conglomerate (Bohannon, 1983; Beard et al., 2007). In the vicinity of the Valley of Fire, the formation includes a white to tan basal conglomerate that ranges in thickness from 5 to 35 meters but is typically approximately 5 meters thick (Bohannon, 1983; Beard et al., 2007). Basal conglomerate contains clasts of quartzite and chert and includes clasts reworked from the Shinarump Conglomerate Member of the Chinle Formation (Beard et al., 2007). Interbedded claystone, white to tan siltstone, dark gray to black carbonaceous shale, and brown to yellow-brown sandstone (locally pebbly; containing 2 to 4 centimeter diameter clasts of chert, quartzite, and sandstone) occur throughout the section, above the basal conglomerate (Bohannon, 1983; Beard et al., 2007). Tuff samples collected approximately 15 to 25 meters above the base of the formation yielded K-Ar ages of 96.4 and 98.4 Ma (Fleck, 1970). SHRIMP-RG U-Pb analysis of zircons from three ash beds within the formation yielded ages ranging from 101.6 ± 1 to 99.9 ± 2 Ma (Troyer et al., 2006). Thickness is approximately 150 meters (Bohannon, 1983).

Ja Aztec Sandstone (Lower Jurassic) Red-orange eolian quartz arenite with hematite cement (Bohannon, 1983; Beard et al., 2007). Quartz grains are medium-grained, well rounded and frosted, and well sorted (Bohannon, 1983; Beard et al., 2007). The formation predominantly displays large-scale and high-angle cross-bedding, with discontinuous cross-laminated beds up to 4 meters thick (Bohannon, 1983; Beard et al., 2007). The formation is up to 1,200 meters thick (Bohannon, 1983).

Jmk Moenave and Kayenta Formations, Undivided (Lower Jurassic) (From Bohannon, 1983) Gypsiferous sandstone and siltstone: brick-red, nonresistant, and poorly indurated. Even, parallel beds range from 5 to 1.5 meters thick. Thickness between 200 and 600 meters.

Trc Chinle Formation (Upper Triassic) Siltstone, sandstone, conglomerate, and lesser limestone that are divided into two members (not mapped separately): (1) lower Shinarump Conglomerate Member and (2) upper Petrified Forest Member (Bohannon, 1983; Beard et al., 2007). Shinarump Conglomerate Member consists of: (1) lower gray and gray-brown limestone, arenaceous limestone, and pebbly limestone beds that are parallel-bedded and 10 centimeters thick and (2) upper brown and buff conglomerate and buff sandstone that typically form wavy, nonparallel 50 centimeter-thick beds (Bohannon, 1983). Clasts within the Shinarump Conglomerate Member are well-rounded to rounded, typically pebble-size, and predominantly consist of chert and quartzite, with lesser carbonate clasts (Beard et al., 2007). Petrified Forest Member consists of interbedded chocolate-brown, pale-purple, gray, and pale-red sandstone and siltstone and white to light-gray claystone, occurring as discontinuous, wavy, nonparallel beds that are typically 10 to 15 centimeters thick (Bohannon, 1983; Beard et al., 2007). Petrified wood fragments commonly occur throughout the formation (Bohannon, 1983). Formation is approximately 250 meters thick (Beard et al., 2007).

Trm Moenkopi Formation (Middle? and Lower Triassic) Mudstone, siltstone, sandstone, conglomerate, gypsum, gypsiferous siltstone, limestone, and dolomite (Bohannon, 1983; Beard et al., 2007); divided into six members by Reif and Slatt (1979). The members, from lower to upper, consist of: (1) Timpoweap Member—upward fining sequence of basal conglomerate, conglomeratic sandstone, fine-grained sandstone, and siltstone, with limestone at some localities; (2) Lower red member—red mudstone and grayish red siltstone with thin gypsum and limestone interbeds and common gypsum veins, slope-forming; (3) Virgin Limestone Member—light-gray and yellow marine limestone, resistant and commonly containing crinoids, pelecypods, gastropods, crustaceans, and ooids; (4) Middle red member—red mudstone, siltstone, carbonate rocks, and gypsum, typically only 5 meters thick or not present in the section; (5) Shnabkaib Member – interbedded pale-gray to white gypsum, gray limestone, and siltstone; and (6) Upper red member – red to brown siltstone and sandstone, slightly gypsiferous and non-resistant (Bohannon, 1983; Beard et al., 2007). Formation is approximately 600 to 650 meters thick (Bohannon, 1983; Beard et al., 2007).

Paleozoic Rocks

PMb Bird Spring Formation (Lower Permian to Upper Mississippian) Gray to light-gray limestone with interbedded cherty limestone and quartz-rich sandstone (Bohannon, 1983; Beard et al., 2007). Limestone beds are 0.5 to 3 meters thick and are alternately resistant and non-resistant, resulting in a bench-and-step weathering pattern (Bohannon, 1983). Formation is highly fossiliferous; containing fusulinids, ostracodes, brachiopods, bryozoans, corals, gastropods, pelecypods, and sponges (Beard et al., 2007). Formation is at least 500 meters thick in the map area (Bohannon, 1983).

Mm Monte Cristo Limestone (Upper and Lower Mississippian) Medium-gray limestone with some brown cherty limestone zones (Bohannon, 1983; Beard et al., 2007); parallel beds, 15 centimeters to several meters thick (Bohannon, 1983); divided into four members, as described by Hewett (1931). The members, from lower to upper, consist of: (1) Dawn Member—light-gray limestone, resistant with sparse fossils; (2) Anchor Member—gray limestone with interbedded discontinuous cherty zones, resistant; (3) Bullion Member—light-gray limestone, poorly bedded and resistant; and (4) Yellowpine Member—cherty limestone, resistant (Bohannon, 1983; Beard et al., 2007). Bohannon (1983) states that the Arrowhead Member of Hewett (1931) may also be present between the Bullion and Yellowpine Members, but that it cannot be consistently defined. Formation thickness is 250 to 300 meters (Bohannon, 1983).

MDs Sultan Limestone (Mississippian and Devonian) Limestone and minor dolomite; divided into three members (Bohannon, 1983; Beard et al., 2007). The members, from lower to upper, consist of: (1) Ironside Member—dark-gray to brown limestone, resistant and containing stromatoporids, including *Amphipora*; (2) Valentine Member—fossiliferous medium-gray limestone, medium- to thick-bedded and resistant; and (3) Crystal Pass Member—fossiliferous light-gray limestone, medium- to thick-bedded and resistant (Bohannon, 1983; Beard et al., 2007). Formation is approximately 190 meters thick (Beard et al., 2007).

Op Pogonip Formation (Lower Ordovician) Previously mapped as the Monocline Valley Formation by Bohannon (1983), as defined by Longwell and Mound (1967). Beard et al. (2007) reinterpreted the unit to be the Pogonip Formation based on conodont correlations. Upper

35 meters of the formation consist of light- to medium-gray, thick-bedded dolomite that is underlain by 14 meters of impure and weakly resistant brown dolomite (Bohannon, 1983; Beard et al., 2007). Underlying the impure dolomite is approximately 170 meters of gray, thin- to medium-bedded dolomite containing layers and lenses of brown-weathering chert (Beard et al., 2007). The lower 25 meters of the formation consist of yellowish to yellow-brown silty dolomite (Beard et al., 2007; Bohannon, 1983). Formation is approximately 220 meters thick (Bohannon, 1983).

Cn Nopah Formation (Upper Cambrian) Previously mapped as the Buffington Formation by Bohannon (1983), as defined by Longwell and Mound (1967). Beard et al. (2007) reinterpreted the unit to be the Nopah Formation based on stratigraphic position and description. Light- to medium-gray dolomite; medium- to thick-bedded with differential weathering of beds (Bohannon, 1983; Beard et al., 2007). Dunderberg Shale Member (Cd) is mapped separately. Formation is approximately 150 meters thick (Bohannon, 1983).

Cd Dunderberg Shale Member of Nopah Formation (Upper Cambrian) Yellow-brown to yellow-gray dolomitic sandstone, sandy dolomite, and dolomite (Bohannon, 1983). Non-resistant to moderately resistant beds, where resistance decreases with increasing sand content (Bohannon, 1983). Member is approximately 40 meters thick (Bohannon, 1983).

Cbk Bonanza King Formation (Upper and Middle Cambrian) Black to light-gray dolomite; thin- to medium-bedded; alternating light- and dark-gray colors present a banded appearance (Bohannon, 1983; Beard et al., 2007). Descriptions from Bohannon (1983) and Beard et al. (2007) indicate that exposures within the map area belong to the Banded Mountain Member of the Bonanza King Formation. Thickness is at least 300 meters (Bohannon, 1983).

REFERENCES

Anderson, R.E., Barnhard, T.P., and Snee, L.W., 1994, Roles of plutonism, midcrustal flow, tectonic rafting, and horizontal collapse in shaping the Miocene strain field of the Lake Mead area, Nevada and Arizona: Tectonics, v. 13, no. 6, p. 1381–1410.

Beard, L.S., 1996, Paleogeography of the Horse Spring Formation in relation to the Lake Mead fault system, Virgin Mountains, Nevada and Arizona: Geological Society of America Special Paper 303, p. 27–60.

Beard, L.S., Anderson, R.E., Block, D.L., Bohannon, R.G., Brady, R.J., Castor, S.B., Duebendorfer, E.M., Faulds, J.E., Felger, T.J., Howard, K.A., Kuntz, M.A., and Williams, V.S., 2007, Preliminary geologic map of the Lake Mead 30' x 60' quadrangle, Clark County, Nevada, and Mohave County, Arizona: U.S. Geological Survey Open-File Report 2007-1010, 84 p.

Bohannon, R.G., 1983, Geologic map, tectonic map and structure sections of the Muddy and northern Black Mountains, Clark County, Nevada: U.S. Geological Survey Miscellaneous Investigation Series, Map I-1406, scale 1:62,500, 2 plates.

Bohannon, R.G., 1984, Nonmarine sedimentary rocks of Tertiary age in the Lake Mead region, southeastern Nevada and northwestern Arizona: U.S. Geological Survey Report P-1259, 72 p.

Bohannon, R.G., 1992, Geologic map of the Weiser Ridge quadrangle, Clark County, Nevada: U.S. Geological Survey Geologic Quadrangle Map, GQ-1714, scale 1:24,000.

Bohannon, R.G, Grow, J.A., Miller, J.J., and Blank, R.H., Jr., 1993, Seismic stratigraphy and tectonic development of Virgin River depression and associated basins, southeastern Nevada and northwestern Arizona: Geological Society of America Bulletin, v. 105, p. 501–520.

Brock, A.L., and Buck, B.J., 2009, Polygenetic development of the Mormon Mesa, NV petrocalcic horizons: Geomorphic and paleoenvironmental interpretations: Catena, v. 77, p. 65–75.

Eberly, L.D., and Stanley, T.B., 1978, Cenozoic stratigraphy and geologic history of southwestern Arizona: Geological Society of America Bulletin, v. 89, p. 921–940.

Felger, T.J., and Beard, L.S., 2010, Geologic map of Lake Mead and surrounding regions, southern Nevada, southwestern Utah, and northwestern Arizona, in Umhoefer, P.J., Beard, L.S., and Lamb, M.A., eds., Miocene tectonics of the Lake Mead region, central Basin and Range: Geological Society of America Special Paper 463, p. 29–38.

Feuerbach, D.L., Smith, E.I., Shafiqullah, M., and Damon, P.E., 1991, New K-Ar dates for Late Miocene to Early Pliocene mafic volcanic rocks in the Lake Mead area, Nevada and Arizona: Isochron West, no. 57, p. 17–20.

Fleck, R.J., 1970, Tectonic style, magnitude, and age of deformation in the Sevier orogenic belt in southern Nevada and eastern California: Geological Society of America Bulletin, v. 81, p. 1705–1720.

Harlan, S.S., Duebendorfer, E.M., and Deibert, J.E., 1998, New 40Ar/39Ar isotopic dates from the Miocene volcanic rocks in the Lake Mead area and southern Las Vegas Range, Nevada: Canadian Journal of Earth Science, v. 35, p. 495–503.

Hewett, D.G., 1931, Geology and Mineral Resources of the Goodsprings quadrangle, Nevada: U.S. Geological Survey Professional Paper 275, 172 p.

Lamb, M., Umhoefer, P.J., Anderson, E., Beard, S.L., Hickson, T., and Martin, L.K., 2005, Development of Miocene faults and basins in the Lake Mead region: A tribute to Ernie Anderson and a review of new research on basins: in Pederson, J., and Dehler, C.M., eds., Interior Western United States: Geological Society of America Field Guide 6, p. 389–418.

Longwell, C.R., and Mound, M.C., 1967, A new Ordovician formation in Nevada dated by conodonts: Geological Society of American Bulletin, v. 78, no. 3, p. 405–412.

Mannion, L.E., 1963, Virgin Valley salt deposits, Clark County, Nevada: Symposium on salt, Cleveland, 1962, Northern Ohio Geological Society, p. 166–175.

Morgan, L.A., and McIntosh, W.C., 2005, Timing and development of the Heise volcanic field, Snake River Plain, Idaho, western USA: Geological Society of America Bulletin, v. 117, no. 3/4, p. 288–306.

Muntean, T.W., 2012, Muddy Creek Formation: A record of Late Neogene tectonics and sedimentation in southern Nevada: University of Nevada, Las Vegas, Ph.D. dissertation, 272 p.

Reif, D.M.., and Slatt, R.M., 1979, Red bed members of the Lower Triassic Moenkopi Formation, southern Nevada: Sedimentology and paleogeography of a muddy tidal flat deposit: Journal of Sedimentary Petrology, v. 49, no. 3, p. 879–890.

Rice, J.A., 1987, Sedimentology, provenance, and tectonic significance of the basal conglomerate of the Rainbow Gardens Member of the Miocene Horse Spring Formation, Lake Mead area, southeastern Nevada: University of Nevada, Las Vegas, M.S. thesis, 171 p.

Troyer, R., Barth, A.P., Wooden, J.L., and Jacobson, C., 2006, Provenance and timing of Sevier foreland basin sediments in the Valley of Fire, southern Nevada, from U-Pb Geochronology: Geological Society of America Abstracts with Programs, v. 38, no. 7, p. 369.

Williams, V.S., 1996, Preliminary geologic map of the Mesquite quadrangle, Clark and Lincoln Counties, Nevada, and Mohave County, Arizona: U.S. Geological Survey Open-File Report 96-676, Scale 1:24,000.

Suggested citation:

Muntean, T.W., 2013, Preliminary geologic map of the Valley of Fire East quadrangle, Clark County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 13-6, scale 1:24,000, 7p.