2022 Basin and Range Earthquake Summit

Utah Geological Survey

Geology - Day 1

Technical Session 1 - Significant Recent Earthquakes in the Basin and Range

Conveners: Alex Hatem (U.S. Geological Survey), Rich Koehler (University of Nevada, Reno/Nevada Bureau of Mines and Geology), and Zach Lifton (Idaho Geological Survey)

Technical Session 2 - Investigations of Low Slip-Rate Faults in the Basin and Range

Conveners: Alex Hatem (U.S. Geological Survey), Rich Koehler (Nevada Bureau of Mines and Geology), and Zach Lifton (Idaho Geological Survey)

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GEOLOGY - DAY 1

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Geologic Setting and Geologic Effects of the March 2020 M_w 5.7 Magna, Utah, Earthquake; *Adam Hiscock and Adam McKean, Utah Geological Survey*

Field Response and Surface-Rupture Characteristics of the 2020 M 6.5 Monte Cristo Range Earthquake, Central Walker Lane, Nevada; *Rich Koehler, University of Nevada, Reno/Nevada Bureau of Mines and Geology*

Tectonic Background of the 2020 M_w 6.5 Stanley, Idaho, Earthquake and a Summary of Current Work; *Zach Lifton, Idaho Geological Survey*

The 2020 M_w 5.8 Lone Pine, Eastern California, Normal-Faulting Earthquake Sequence; *Egill Hauksson, Caltech*

Mapping of Potentially Active Faults in the Vicinity of the 2019 Ridgecrest Earthquake Ruptures, California; *Jessica Thompson Jobe, U.S. Geological Survey*

GEOLOGIC SETTING AND GEOLOGIC EFFECTS OF THE MARCH 2020 M_W 5.7 MAGNA, UTAH, EARTHQUAKE

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ABSTRACT

The March 18, 2020, M_w 5.7 Magna earthquake was the largest earthquake in Utah since the 1992 M_L 5.8 St. George earthquake. This normal-faulting earthquake occurred in the northwest corner of the Salt Lake Valley, home to 1.2 million people. The geologic setting of the Magna earthquake is well documented by recent geologic mapping and geophysical data in the Salt Lake Valley, in addition to seismicity data from the mainshock and aftershock sequence. Based on these data, we believe the mainshock of the Magna earthquake occurred on a relatively gently dipping part of the Salt Lake City segment of the Wasatch fault zone, with aftershocks concentrated on the West Valley fault zone and other subsidiary faults. Post-earthquake rapid reconnaissance teams organized by the Utah Geological Survey documented geologic effects using a small, unmanned aircraft system (sUAS) to obtain aerial photos and videos to supplement ground-based observations. Observed geologic effects include liquefaction in the form of sand boils, tension cracks, lateral spreading, and localized subsidence near the earthquake epicenter, along the Jordan River, and along the shoreline of the Great Salt Lake. Potential syneresis cracking and pooling in large areas indicated fluctuating groundwater likely related to earthquake ground shaking. No primary surface fault rupture was observed. A web-based digital clearinghouse was established to collect, distribute, and archive data related to the earthquake (https://geodata.geology.utah.gov/pages/search.php?search=!collection609). Ground shaking caused at least $70 million in public infrastructure damage in Salt Lake and Tooele Counties, with additional damage to residential and commercial properties. The moderate magnitude, associated geologic effects, and infrastructure damage values from the Magna earthquake highlight the critical importance of earthquake research from multidisciplinary fields in the geosciences and preparedness along the Wasatch Front.

A video of this talk is available at the following link:

https://geodata.geology.utah.gov/pages/view.php?ref=77145

A PDF version of the author's slide presentation is available at the following link:

https://ugspub.nr.utah.gov/publications/misc_pubs/mp-177/mp-177-d1t1.pdf

FIELD RESPONSE AND SURFACE-RUPTURE CHARACTERISTICS OF THE 2020 M 6.5 MONTE CRISTO RANGE EARTHQUAKE, CENTRAL WALKER LANE, NEVADA

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ABSTRACT

The M 6.5 Monte Cristo Range earthquake that occurred in the central Walker Lane on 15 May 2020, was the largest earthquake in Nevada in 66 years and resulted in a multidisciplinary scientific field response. The earthquake was the result of left-lateral slip along largely unmapped parts of the Candelaria fault, one of a series of east–northeast-striking faults that comprise the Mina Deflection, a major right step in the north–northwest structural grain of the central Walker Lane. We describe the characteristics of the surface rupture and document distinct differences in the style and orientation of fractures produced along the 28-km-long rupture zone. Along the western part of the rupture, left-lateral and extensional displacements occurred along northeasterly and north-striking planes that splay off the eastern termination of the mapped Candelaria fault (Figure 1). To the east, extensional and right-lateral displacements occurred along predominantly north-striking planes that project toward well-defined Quaternary and bedrock faults. Although the largest left-lateral displacement observed was ~20 cm, the majority of displacements were < 5 cm and were distributed across broad zones up to 800 m wide, which are not likely to be preserved in the geologic record. The complex pattern of surface rupture is consistent with a network of faults defined in the shallow subsurface by aftershock seismicity and suggests that slip partitioning between east-striking left-lateral faults and north to northwest-striking right-lateral faults plays an important role in accommodating northwest-directed transtension in the central Walker Lane. Prominent tectonic geomorphology along the unruptured western Candelaria fault (west of the 2020 surface rupture) including linear side-hill benches and troughs and left-laterally displaced channels suggests that potentially larger earthquakes are possible in the Mina Deflection.

A video of this talk is available at the following link:

https://geodata.geology.utah.gov/pages/view.php?ref=77146

A PDF version of the author's slide presentation is available at the following link:

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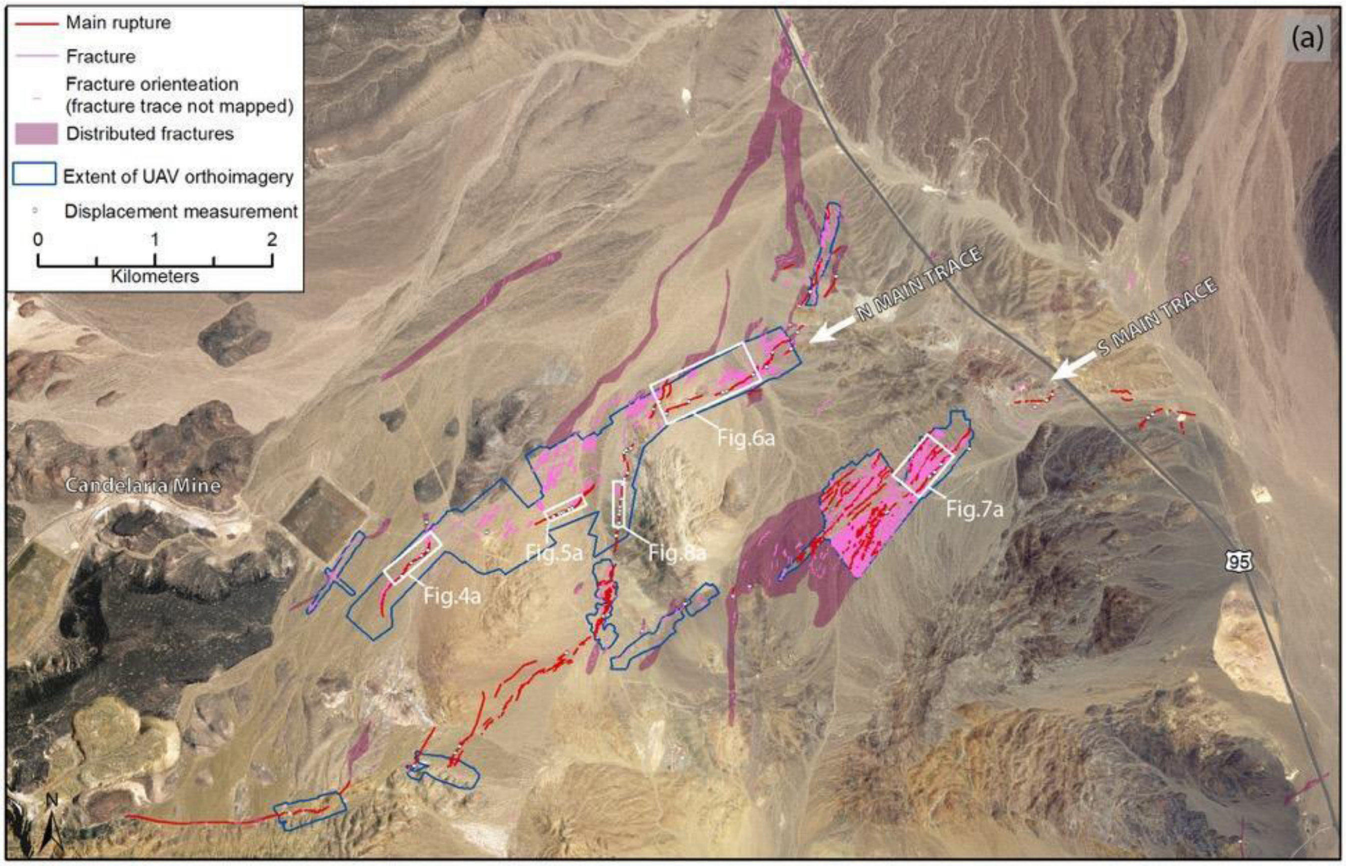

Figure 1. *Mapping results from the western part of the Monte Cristo Range earthquake surface-rupture showing main ruptures, fractures, and wide zones of distributed fracturing (Koehler et al., 2021; Dee et al., 2021).*

TECTONIC BACKGROUND OF THE 2020 M_w 6.5 STANLEY, IDAHO, EARTHQUAKE AND A SUMMARY OF CURRENT WORK

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ABSTRACT

The moment magnitude (M_w) 6.5 earthquake that occurred March 31, 2020, near Stanley, Idaho, was felt widely across the western U.S., yet it caused only minor damage due to its remote location. No evidence has been found of surface rupture related to the earthquake, but InSAR interferograms show broad surface deformation of several centimeters. Secondary effects such as rockfall, snow avalanches, and liquefaction were observed throughout the epicentral region. The area is remote and sparsely instrumented, with the closest station to the mainshock approximately 100 km away. A robust, ongoing aftershock sequence has been recorded by a temporary network of 15 broadband seismometers and 24 nodal sensors.

The epicenter of the 2020 M_w 6.5 Stanley earthquake was located within the granitic Idaho Batholith in central Idaho at the northern boundary of the Basin and Range Province. The segment of the Basin and Range Province north of the Snake River Plain, which includes the Sawtooth, Lost River, Lemhi, and Beaverhead faults, is part of the seismically active Centennial Tectonic Belt. The northern end of the Sawtooth fault is bound by the northeast-striking Trans-Challis fault system, a zone of Eocene-age normal faults that are no longer active, but which may influence modern seismicity. Several moderate historical earthquakes have struck the 2020 epicentral area, including a M_s 6.1 event in 1944 and a M_s 6.0 event in 1945.

One of the biggest questions arising from this event is the location and geometry of the source fault. While the east-dipping Sawtooth normal fault would be an obvious source for an earthquake at this location, the mainshock was located north of the mapped trace of the Sawtooth fault and the focal mechanism suggested left-lateral strike-slip motion on a north-striking fault. Aftershocks plot on a plane steeply dipping to the west. Several researchers are analyzing the earthquake and aftershock sequence to understand the rupture mechanism and fault geometry. The emerging picture is of a complex rupture, not on the Sawtooth fault but on one or more unmapped faults. Current work focuses on mapping surficial fault scarps with new lidar, dating key landforms to constrain the timing of past surface rupturing earthquakes, and attempting to excavate paleoseismic trenches.

A video of this talk is available at the following link:

https://geodata.geology.utah.gov/pages/view.php?ref=77147

A PDF version of the author's slide presentation is available at the following link:

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THE 2020 M_w 5.8 LONE PINE, EASTERN CALIFORNIA, NORMAL-FAULTING EARTHQUAKE SEQUENCE

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ABSTRACT

The 2020 M_w 5.8 Lone Pine earthquake, the largest earthquake on the Owens Valley fault zone, eastern California, since the 19th century, ruptured an extensional step over in that fault. Owens Valley separates two normal faulting regimes, the western margin of the Great Basin and the eastern margin of the Sierra Nevada, forming a complex seismotectonic zone, and a possible nascent plate boundary. Foreshocks began on 22 June 2020; the largest M_w 4.7 foreshock occurred at ~6 km depth, with primarily normal faulting, followed ~40 hours later on 24 June 2020 by a M_w 5.8 mainshock at ~7 km depth. The sequence caused overlapping ruptures across a ~0.25 km^2 area, extended to ~4 km^2, and culminated in a ~25 km^2 aftershock area. The mainshock was predominantly normal faulting, with a strike of 330° (north-northwest), dipping 60° to 65° to the east-northeast. Comparison of background seismicity and 2020 Ridgecrest aftershock rates showed that this earthquake was not an aftershock of the Ridgecrest mainshock. The M_w-m_B relationship and distribution of ground motions suggest typical rupture speeds. The aftershocks form a north-northwest-trending, north-northeast-dipping, 5-km-long distribution, consistent with the rupture length estimated from analysis of regional waveform data. No surface rupture was reported along the 1872 scarps from the 2020 M_w 5.8 mainshock although the dipping rupture zone of the M_w 5.8 mainshock projects to the surface in the general area. The mainshock seismic energy triggered rockfalls at high elevations (>3.0 km) in the Sierra Nevada at distances of 8 to 20 km, and liquefaction along the western edge of Owens Lake. Because there were ~30% fewer aftershocks than for an average southern California sequence, the aftershock forecast probabilities were lower than expected. ShakeAlert, the earthquake early warning system, provided first warning within 9.9 s, as well as subsequent updates.

A PDF version of the author's slide presentation is available at the following link:

https://ugspub.nr.utah.gov/publications/misc_pubs/mp-177/mp-177-d1t4.pdf

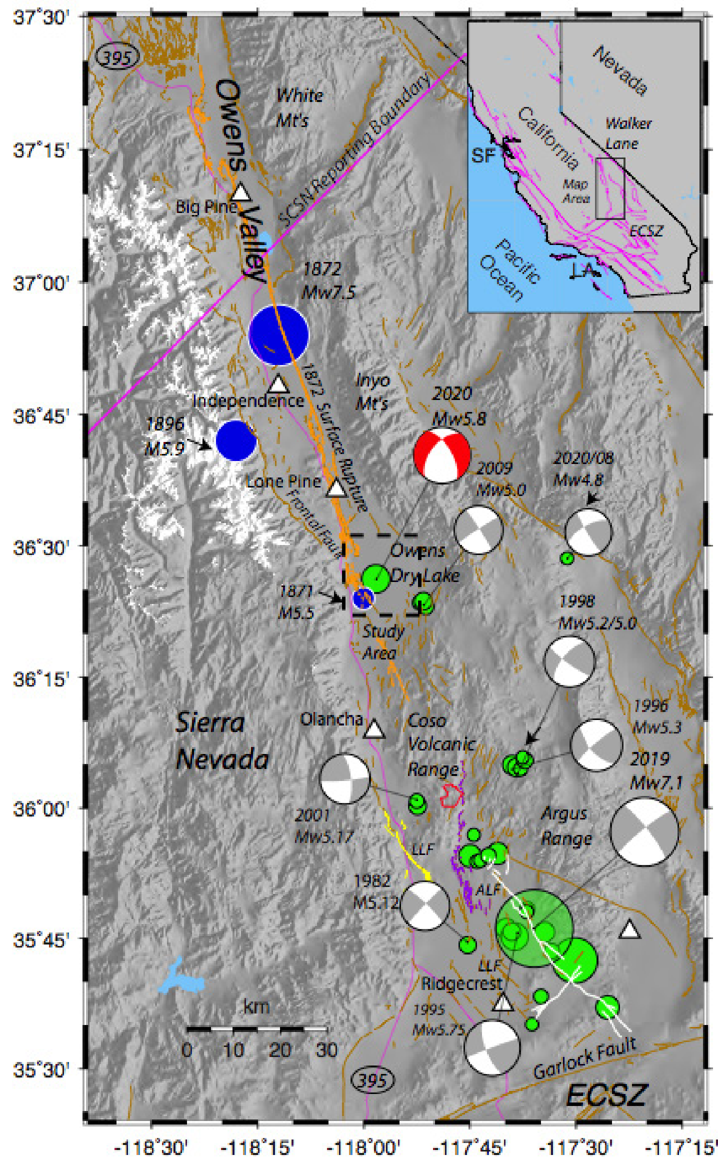

Figure 1. *Map of Owens Valley and adjacent regions in eastern California. Major earthquakes that occurred in the late 19th century are shown as labeled blue dots scaled with magnitude (Felzer and Cao, 2008; Ellsworth, 1990). Location of this map is shown in the upper-right corner. Late Quaternary faults from Jennings and Bryant (2010) are shown in brown. The 1872 M_w 7.5 surface rupture is shown in orange (Haddon et al., 2016). Seismicity of M≥5 since 1980 is shown as green dots scaled with magnitude, with lower hemisphere focal mechanisms shown for significant events. The focal mechanism of the 2020 M_w 5.8 Lone Pine earthquake is shown in red. The 2020 August M_w 4.8 Stovepipe Wells earthquake is also included for reference. The detailed study area that is shown in later figures is outlined with dashed black lines. The SCSN northern reporting boundary is shown in magenta. ECSZ = Eastern California shear zone. The U.S. 395 highway is shown as a curvy magenta line and local towns are marked as triangles (From: Hauksson et al., 2021).*

MAPPING OF POTENTIALLY ACTIVE FAULTS IN THE VICINITY OF THE 2019 RIDGECREST EARTHQUAKE RUPTURES, CALIFORNIA

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ABSTRACT

The region near the July 2019 Ridgecrest earthquake sequence in southeastern California had not been comprehensively examined for active faults prior to those earthquakes. No long continuous faults or fault zones spanning the entire rupture had been recognized in the area, and only ~35% of the rupture occurred on previously mapped faults (Figure 1). Using pre-event high-resolution (<2 m) topography and optical imagery, in combination with post-event field observations and unmanned aerial vehicle imagery, we document geomorphic evidence of pre-2019 faulting along both the Paxton Ranch (M7.1 surface rupture) and Salt Wells Valley (M6.4 surface rupture) fault zones. These fault-related features include tufa lineaments, sheared Quaternary deposits, scarps, deflected drainages, and topographic, vegetation, and ground color lineaments and contrasts. These features reveal a network of orthogonal northeast- and northwest-striking fault traces, a subset of which ruptured in 2019. Neotectonic features are commonly short (<2 km), discontinuous, and display left-stepping en echelon patterns along both the M6.4 and M7.1 surface ruptures. Faults are generally better expressed and preserved outside the late-Pleistocene lake basins and in areas where substantial vertical motion occurred in 2019. Both the northeast- and northwest-striking active fault systems are subparallel to regional bedrock fabrics that were established as early as ~150 Ma. These fault systems may be reactivating older structures subparallel to the bedrock fabric. The newly identified faults recognized in the pre-event data are being integrated with new mapping on post-earthquake high-resolution lidar data to develop an updated Quaternary fault map for the region.

Overall, we estimate that 50%–70% of the 2019 surface ruptures could have been recognized as active faults with detailed inspection of pre-earthquake data. Similar detailed mapping of potential neotectonic features could help improve seismic hazard analyses in other regions of the Walker Lane–Eastern California Shear Zone, and elsewhere where there are distributed or incompletely mapped faults. To characterize regions of distributed faulting in seismic hazard analyses in areas where faults cannot be resolved as discrete throughgoing structures, we recommend using polygons that represent zones of potentially active faults, with slip distributed throughout the polygons.

A video of this talk is available at the following link:

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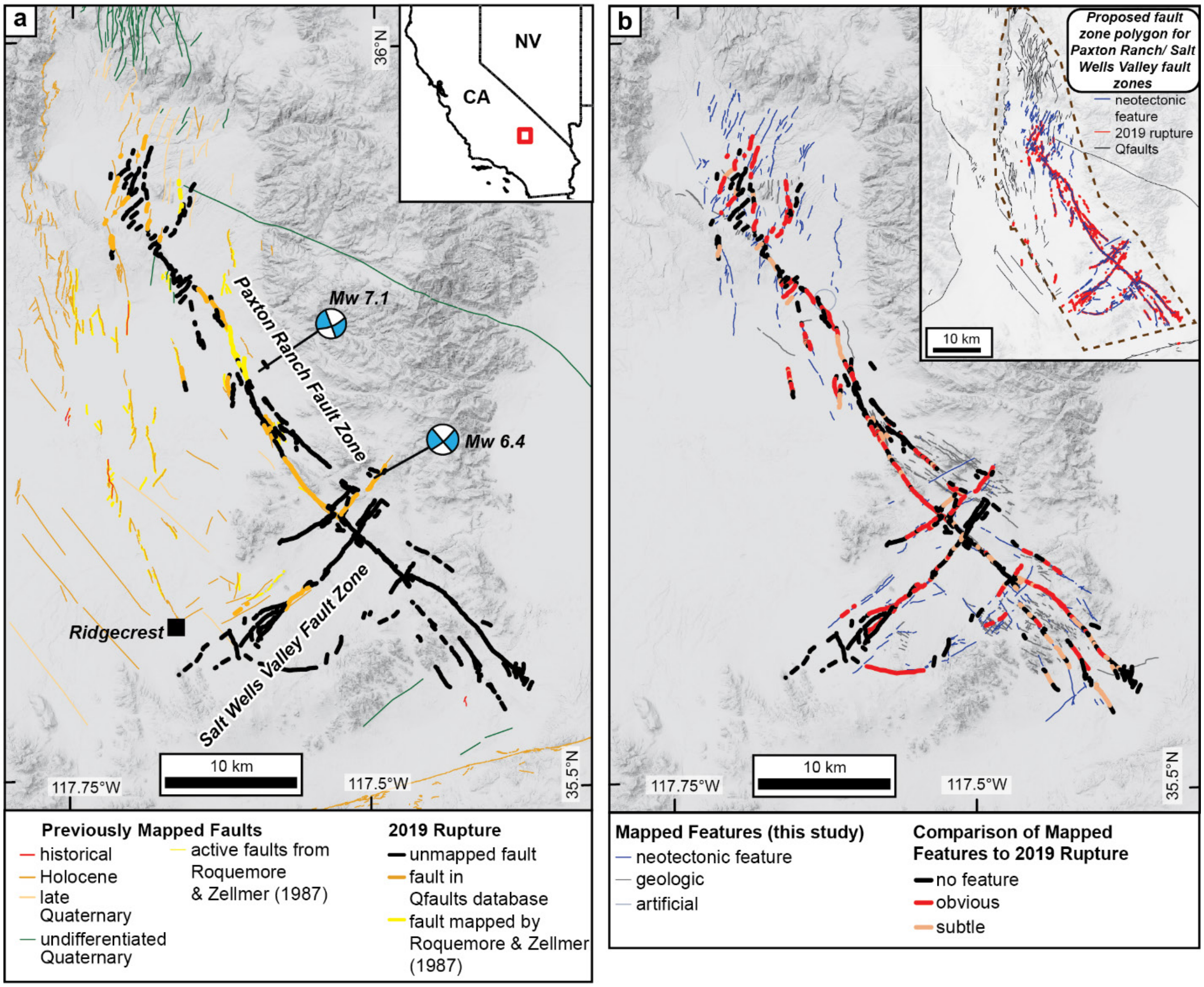

Figure 1. ***(a)*** *Comparison of the 2019 ruptures to previously mapped faults from the Quaternary fault and fold database/California fault activity map (Qfaults) and Roquemore and Zellmer (1987). Approximately 35% of the 2019 surface ruptures were on previously mapped faults. Inset shows location of Ridgecrest area in southern California.* ***(b)*** *Comparison of the 2019 surface rupture to the newly mapped neotectonic features from pre-earthquake data (gray lines represent geologic features, such as shorelines or dikes; light blue lines represent artificial features, which are likely anthropogenic in origin but appear as lineaments within the vicinity of the 2019 ruptures). Approximately 70% of the 2019 rupture occurred along pre-existing neotectonic features (red lines where neotectonic features were obvious; pink lines where neotectonic features were subtle and may not have been recognized prior to the 2019 events; black lines where no neotectonic features were observed along the 2019 surface rupture). Inset shows proposed fault zone polygon (brown dashed lines) for the Paxton Ranch and Salt Wells Valley fault zones, based on existing Quaternary faults, the 2019 rupture, and the neotectonic features. Figure modified from Thompson Jobe and others, 2020.*

GEOLOGY - DAY 1

Technical Session 2 - Investigations of Low Slip-Rate Faults in the Basin and Range

Conveners:
Alex Hatem (U.S. Geological Survey)
Rich Koehler (Nevada Bureau of Mines and Geology)
Zach Lifton (Idaho Geological Survey)

Timing of Mead Slope Fault Ruptures, Lake Mead Area, Arizona; *Jeri Young Ben-Horin, Arizona Geological Survey*

Late Quaternary Slip Rates and Surface Rupture of the Bitterroot Fault, Western Montana; *Yann Gavillot, Montana Bureau of Mines and Geology*

Paleoseismic Investigation of the South Granite Mountains Fault, Central Wyoming; *Seth Wittke, Wyoming State Geological Survey*

Faults on the Fringe: New Mapping of Discreet Faults in Northwest Wyoming; *James Mauch, Wyoming State Geological Survey*

Evidence For Quaternary Activity on the Deadwood-Reeves Creek Fault, West-Central Idaho; *Lucy Piety, U.S. Bureau of Reclamation*

Geologic Mapping, Geochronology, and Fault Characterization in the Las Vegas Basin; *Seth Dee, Nevada Bureau of Mines and Geology*

TIMING OF MEAD SLOPE FAULT RUPTURES, LAKE MEAD AREA, ARIZONA

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ABSTRACT

The Mead Slope fault (MSF) has been considered an active late-Quaternary fault for several decades; however, until this study, there have been weak constraints on slip rates, and the age and size of surface-rupturing earthquakes. We used high-resolution DEMs, cosmogenic dating of alluvial fans, OSL dating of faulted sediments, and detailed examination of fault exposures to better constrain the earthquake histories for the main fault strand. Detailed fault mapping was accomplished using DEMs generated from multiple drone flights and ground-control points. We determined that the fault zone consists of two main strands, both offsetting Quaternary alluvial-fan remnants. The northwestern strand offsets late- to latest-Pleistocene fan deposits, as well as relatively young tributary gravel deposits exposed below a wave-cut bench associated with past high levels of Lake Mead. Examination of this exposure revealed 2 or 3 identifiable surface ruptures that occurred within the past ~60,000 yrs. We collected 21 surface rock samples from various Quaternary landforms displaced by the fault for exposure dating via cosmogenic ^{3}He. Preliminary exposure dates from several alluvial fans provide age constraints for a long-term slip rate as well as a slip rate for the past 150 ky. Three samples were taken from large boulders exposed on the surface of a Qo alluvial fan resulting in preliminary exposure ages that range from 620 to 880 ka. Given the Qo landform has been left-laterally offset by at least 80 m, the long-term slip rates for the northwestern most strand range from 0.09 to 0.13 mm/yr. Three samples collected from large boulders on late Pleistocene fan units (Qi3-4) yielded preliminary ^{3}He exposure ages ranging from 80 to 147 ka. Left-lateral offsets on the Qi3-4 surfaces are approximately 5–6 m, with less than 2 m of vertical offset. This indicates a lateral slip rate of 0.03 to 0.06 mm/yr since 150 ka. Given the fault exposure in the tributary sediments reveals at least 2 events since 60 ka and at least one older earthquake, it is likely that they are represented in the 5–6 m of offset of the Qi3-4 fan surfaces.

A video of this talk is available at the following link:

https://geodata.geology.utah.gov/pages/view.php?ref=77149

A PDF version of the author's slide presentation is available at the following link:

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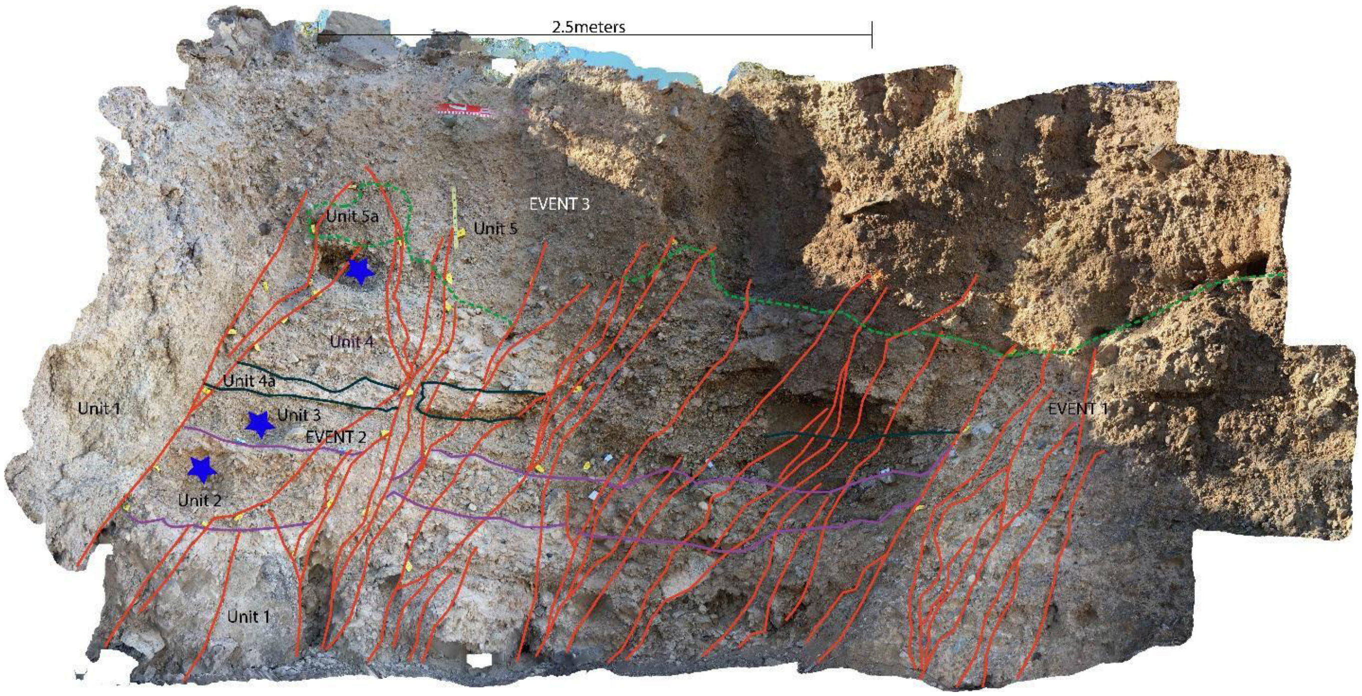

Figure 1. *Faulted tributary sediments exposed by Lake Mead lake level. Multiple strands shown as red line work, blue stars are OSL sample locations, units numbered in black. There are 2 to 3 events recorded in these sediments with one occurring in older gravels near the base of the wall, and on its west side (right side in photo) and one occurring after deposition of unit 2. There may be an additional event recorded in the uppermost portion of the exposure; View to the south.*

LATE QUATERNARY SLIP RATES AND SURFACE RUPTURE OF THE BITTERROOT FAULT, WESTERN MONTANA

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ABSTRACT

The Bitterroot fault is a 100-km-long active normal fault that bounds the eastern margin of the north-south-trending Bitterroot Mountains and accommodates extension within the Intermountain Seismic Belt. Earthquake and fault history are unknown for the Bitterroot fault, although the seismic risk is potentially high given the proximity of the rapidly growing towns in the Missoula–Bitterroot valleys. New detailed mapping using lidar along the southern Bitterroot Range documents multiple generations of fault scarps in Holocene-Pleistocene deposits with vertical offsets that increase in magnitude with age. Fault mapping indicates a complex fault geometry characterized by an *en echelon* pattern of discontinuous segments of 45°–70° east-dipping normal faults that appear to cut the older Eocene detachment fault, and locally 70°–80° west-dipping antithetic normal faults. ^{10}Be cosmogenic radionuclides surface exposure dating technique provides age control for 32 boulders sampled in glacial deposits. Near Como Dam, a dated 16–17 ka Pinedale moraine offset by the Bitterroot fault scarp with a vertical separation of 3.5 ± 0.1 m, yields a fault slip rate of 0.2–0.3 mm/yr. Glacial Lake Missoula shorelines inset into a dated ~15 ka Pinedale moraine and vertically offset 4.6 ± 1.5 m by an antithetic strand of the Bitterroot fault, yield fault slip rates of 0.2–0.4 mm/yr. In the Ward Creek Fan located ~15 km to the north of Como Dam, two dated ~17 ka and 63–70 ka fan surfaces offset by the Bitterroot fault with vertical separations of 2.4 ± 0.2 m and 4.5 ± 0.1 m, yield fault slip rates of 0.1–0.2 mm/yr and 0.1 mm/yr, respectively. Our results indicate broadly consistent fault slip rates with an along-strike preferred average of 0.2–0.3 mm/yr for the southern Bitterroot fault. Fault scaling relations, structural model constraints and our slip rate results indicate both a seismogenic low-angle and high-angle fault geometry are possible at depth, which could generate a M_w ~7.2 earthquake or larger. We speculate the Bitterroot fault is likely characterized by a millennia-timescale earthquake recurrence interval. Forthcoming paleoseismic trench results on the Bitterroot fault will aim to develop a Holocene-Pleistocene paleoearthquake chronology. Data from this study suggest seismic hazards from the Bitterroot fault potentially pose a significant risk to the Missoula metropolitan area, the State's second most populous region, and major infrastructures across the Missoula-Bitterroot valleys.

A video of this talk is available at the following link:

https://geodata.geology.utah.gov/pages/view.php?ref=77150

A PDF version of the author's slide presentation is available at the following link:

https://ugspub.nr.utah.gov/publications/misc_pubs/mp-177/mp-177-d1t7.pdf

PALEOSEISMIC INVESTIGATION OF THE SOUTH GRANITE MOUNTAINS FAULT, CENTRAL WYOMING

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ABSTRACT

The northwest-trending, 135-km-long South Granite Mountains fault (SGMF) is a significant contributor to the seismic hazard at multiple U.S. Bureau of Reclamation (BOR) facilities along the North Platte River in central Wyoming. The SGMF bounds the northern extent of the Seminoe and Ferris Mountains, Green Mountain, and Crooks Mountain. Evidence of the down-to-the-north, high-angle fault system consists of linear but discontinuous fault scarps, vegetation lineaments and springs, apparent offset drainages, hillside benches, and topographic slope breaks. The SGMF is divided into five major segments. From east to west these are the Seminoe Mountains, Ferris Mountains, Muddy Gap, Green Mountain, and Crooks Mountain segments. To better characterize the SGMF for hazard analysis, we excavated three paleoseismic trenches along the two most proximal segments to BOR facilities; two trenches along the Seminoe Mountains segment, and one along the Ferris Mountains segment. Previous paleoseismic studies have recognized only the Ferris Mountains and Green Mountain segments to have late Quaternary activity. Our data show possible Quaternary faulting on the Seminoe Mountains segment and supporting evidence for late Pleistocene and early Holocene ground rupturing earthquakes on the Ferris Mountain segment.

A video of this talk is available at the following link:

https://geodata.geology.utah.gov/pages/view.php?ref=77151

A PDF version of the author's slide presentation is available at the following link:

https://ugspub.nr.utah.gov/publications/misc_pubs/mp-177/mp-177-d1t8.pdf

FAULTS ON THE FRINGE: NEW MAPPING OF DISCREET FAULTS IN NORTHWEST WYOMING

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ABSTRACT

Active normal faults in the Greater Yellowstone region reflect the influence of uplift associated with the Yellowstone hotspot superimposed on Basin and Range lithospheric extension. Along the northeast (leading) edge of the hotspot track are inconspicuous and enigmatic faults believed to be in an early stage of development. Because these faults lack the topographic signature of longer-lived range-bounding structures their detection is difficult, and they remain lightly studied. We present detailed mapping and scarp profile measurements of several such faults in easternmost Jackson Hole, Wyoming, which displace Pinedale-1 (~20 ka) and Pinedale-2 (~15 ka) glacial till and other Quaternary deposits.

The proposed Uhl Hill fault is a 4.5-km-long, southeast-dipping normal fault in eastern Grand Teton National Park with newly recognized Quaternary activity. Scarps in Pinedale-1 moraines have vertical surface offset (VSO) values two-to-three times greater than scarps in Pinedale-2 moraines, suggesting post-15 ka displacement and the possibility of multiple surface rupturing events from 20–15 ka. The Uhl Hill fault is expressed at its southern end by a 1-m-high scarp across part of the Spread Creek alluvial fan. A 1.5 km-long scarp in Pinedale-1 till ~4 km to the northeast across the Buffalo Fork valley may be a northern extension of the fault. 20 km east, the Togwotee Lodge faults form a complex system of sharp, east-facing, en echelon scarps in Bull Lake till (~150 ka), Pinedale-1 till, and colluvium. Scarps in Pinedale-1 till have highly variable VSO values with some of the largest measurements occurring near the northern terminus of the mapped fault system, suggesting a greater fault length than currently recognized. Field observations of scarps beyond the mapped extent are difficult due to obstruction by landslides and dense forest cover, and mapping of the Togwotee Lodge faults should be revisited once lidar data become available.

Our work highlights the need for future paleoseismic studies on these faults to answer unresolved questions of rupture timing, relation to regional structures like the Teton fault, and seismic hazard from other incipient faults in the Greater Yellowstone region.

A video of this talk is available at the following link:

https://geodata.geology.utah.gov/pages/view.php?ref=77152

A PDF version of the author's slide presentation is available at the following link:

https://ugspub.nr.utah.gov/publications/misc_pubs/mp-177/mp-177-d1t9.pdf

EVIDENCE FOR QUATERNARY ACTIVITY ON THE DEADWOOD-REEVES CREEK FAULT, WEST-CENTRAL IDAHO

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ABSTRACT

The Deadwood-Reeves Creek fault is a north-striking fault in the Idaho batholith. Its interpretation as Quaternary-active has been debated, and the fault is generally poorly understood. Uncertainties in its mapped location, style of deformation, and recency of activity stem largely from a complex geologic setting characterized by plutonic rock and a landscape altered by multiple Pleistocene glaciations. There is limited stratigraphy from which to measure long-term fault displacement, and Quaternary deposits are limited in extent, creating a challenging setting in which to assess Quaternary activity. Dense vegetation and steep terrain have also historically complicated evaluation based on aerial imagery and field reconnaissance. Although the Deadwood-Reeves Creek fault has previously been interpreted as a normal fault, its structure and topographic expression are distinctive from Basin and Range style normal faults to the east and west. It is steeply dipping and characterized by linear, incised glacial valleys in mountainous terrain, with basins located at bends in the mapped traces. These characteristics suggest that the Deadwood-Reeves Creek fault may be strike-slip or oblique.

Lidar encompassing the fault reveals previously unmapped fault scarps, the most prominent of which are within Deadwood basin. In 2021, we excavated a trench across a scarp at the northern end of Deadwood basin near Habit Creek. The Habit Creek scarp crosses a high surface, an inset alluvial surface, and beheads several southeast-flowing drainages. Vertical separations range from ~2.6 to 4.9 m across the high surface and ~0.34 m across the alluvial surface. The Habit Creek scarp is antithetic to the primary basin-bounding fault and has not previously been mapped as a fault trace. A seismic reflection profile at the trench location shows clearly offset reflectors to a depth of at least 80 m. At depths shallower than ~50 m, there is a complex zone of offset and deformation up to ~60 m wide. The trench was excavated across the primary offset reflector corresponding to the geomorphic scarp, exposing glaciolacustrine deposits in fault contact with fine grained sediment at the base of the scarp. Minor displacements of the fine sediment persist away from the primary fault, consistent with a broad zone of deformation. Work to refine the activity rate of the Deadwood-Reeves Creek fault is ongoing.

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GEOLOGIC MAPPING, GEOCHRONOLOGY, AND FAULT CHARACTERIZATION IN THE LAS VEGAS BASIN

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ABSTRACT

A recent investigation into the seismic hazard of the Las Vegas basin includes a new surficial geology and Quaternary fault map, luminescence dating, and paleoseismic investigations of the Las Vegas Valley fault system (LVVFS) and Frenchman Mountain fault system (FMFS). The new 1:50,000 scale map involved the compilation of twenty published 1:24,000 scale maps and new geologic mapping. The compilation utilized historical aerial imagery, lidar, and a new orthophoto mosaic and DEM derived from 1965 aerial stereo photos. This new mapping improves the accuracy of Quaternary fault locations and yields a consistent characterization of surficial units displaced by the faults. The mapping was accompanied by 37 new luminescence ages to better constrain the age of offset stratigraphy. The luminescence data includes ages from the fine-grained ground water discharge deposits of the Las Vegas Formation (LVF) as well as alluvial-fan deposits.

The LVVFS is a set of east-facing, northerly striking, intra-basin fault scarps up to 30 m high that displace LVF and alluvial-fan deposits within the Las Vegas metropolitan area. Two paleoseismic trenches were excavated across the Eglington-Decatur fault, the westernmost in the LVVFS and the only fault with a continuous section of undeveloped scarps. The trenches exposed broadly warped LVF stratigraphy with 4–5 m of displacement and no evidence for brittle faulting. Luminescence and radiocarbon ages constrain the age of warp formation as occurring between ~27 and ~8 ka, with no displacement for the preceding ~300,000 years. Preliminary displacement rates derived from the trench results have significant temporal variability, a shorter-term rate of ~0.15 –0.18 mm/yr and a maximum longer-term rate of ~0.03 mm/yr.

The FMFS is an arcuate, west-dipping, range-bounding normal and dextral-oblique fault on the eastern side of the Las Vegas basin. The entire length of the FMFS was remapped during this investigation utilizing lidar data and the pre-development orthophoto mosaic. The new mapping identified scarps along a southern section of the fault that displace an alluvial-fan surface of probable late-Pleistocene, and adjacent fault kinematics documenting dextral-oblique slip. These observations confirm a component of dextral slip along the southern FMFS and extends the total fault length with evidence for Quaternary displacement to ~33 km. We also conducted a paleoseismic investigation of a previously excavated fault exposure in a late-Pleistocene alluvial fan along the northern section of the FMFS. Logging of the excavation documents evidence for three paleoearthquakes with luminescence ages from colluvial wedge deposits ranging from ~54 to ~25 ka. Scarp profiling conducted during previous investigations prior to widespread development coupled with new luminescence ages from displaced deposits yield a preliminary, vertical slip rate estimate of 0.11–0.20 mm/yr.

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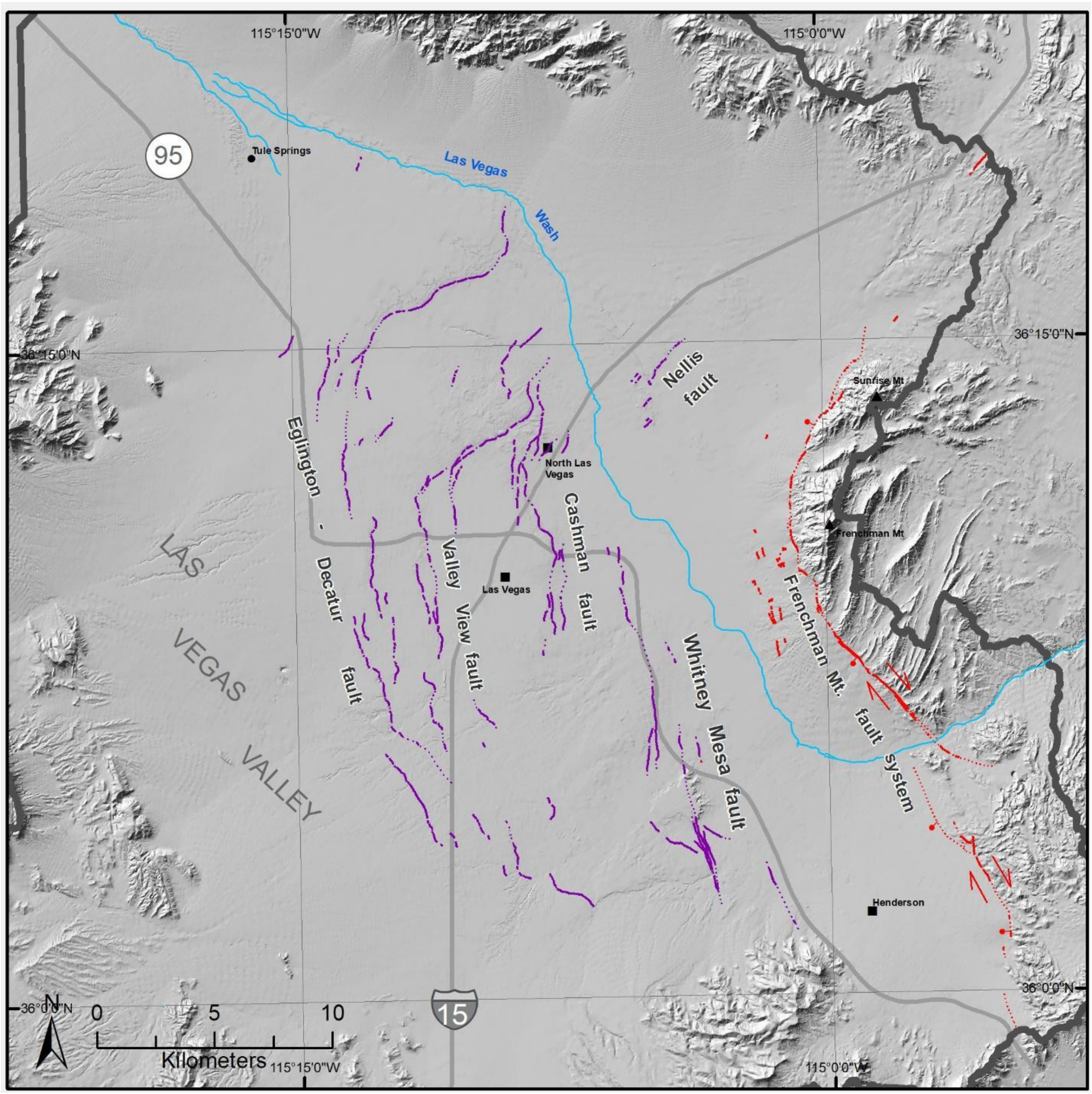

Figure 1. Quaternary faults of the Las Vegas Valley. Faults are dotted where concealed or inferred. The Las Vegas Valley fault system, shown in purple, includes the Eglington-Decatur, Valley View, Cashman, Nellis, and Whitney Mesa faults. Other faults, including the Frenchman Mountain fault system, are shown in red, with a bar and ball symbol showing the downthrown side of the fault and arrows showing dextral oblique sections.