Quaternary Faults in Nevada

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Faults and Earthquakes

A fault is a break in the Earth's crust, along which movement has taken place. Faults can be of any length, from inches to hundreds of miles; they can be oriented vertically, horizontally, or at an angle to the Earth's surface. Faults are further classified by which way the adjacent sides move past each other (see box below).

An earthquake occurs where there is rapid fault movement, releasing stresses that have built up in the Earth. During an earthquake, the sides of a fault move (or "slip") rapidly past each other, often violently. Rocks are broken and the ground is heaved rapidly, sending shock waves through the Earth. Earthquakes can also be caused in other ways, such as volcanic explosions or magma movement, but in Nevada most earthquakes are related to faults.

Large earthquakes typically leave visible surface ruptures, which over time create identifiable landforms. However, destructive earthquakes can also occur on faults that do not intersect the surface; these blind faults are not included on this map.

Earthquakes are ranked according to their magnitude, a number that characterizes their relative size. The amount of energy that is released during an earthquake generally increases with the length of the surface rupture and the amount of displacement across the fault. Each unit increase in magnitude corresponds to a 32-fold increase in energy release. Small earthquakes (magnitude 1 to 2) might not be felt at the Earth's surface, whereas large earthquakes (magnitude 6 to 7 and above), particularly those that rupture tens of miles of faults, can cause violent shaking over a large area.

Countless faults have formed throughout geological time. Generally, faults that have slipped during the Quaternary period (the last 1.8 million years) are most likely to slip again, giving rise to earthquakes. Faults that slipped during the last 130,000 years are commonly considered in seismic hazard studies, because most historical earthquakes have occurred along them. Faults that have slipped multiple times in the last 15,000 years have the highest likelihood of being involved in large earthquakes in the future.

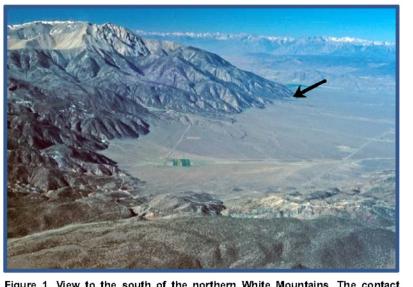


Figure 1. View to the south of the northern White Mountains. The contact between the base of the mountain and the smooth alluvial apron is a major normal-oblique-slip fault (indicated by arrow).

Faults in Nevada

Nevada has been a highly active part of the Earth's crust, most recently being pulled apart in an east-west direction and wrenched northwestward on its western side. Consequently, the state is highly faulted, with literally thousands of Quaternary faults, hundreds of which are considered major (capable of producing earthquakes of magnitude 7+). Although faults are most common along range fronts (Figures 1 and 2), they also occur within valleys and mountain ranges.

Typically, dip-slip faults appear as steps in the landscape (Figures 1-4, 6, 7), whereas strike-slip faults are expressed by linear features such as elongate valleys and alignments of springs and streams (Figure 5). Earthquakes have ruptured both types of faults in Nevada (Table 1).

The next major earthquake in Nevada will likely be on a fault colored red, orange, or yellow; however, many of the faults colored green and purple have not been extensively studied, and many of these may be younger than indicated. Thus, a major earthquake on any Quaternary fault in Nevada would not be a scientific surprise



Figure 2. 1915 Pleasant Valley earthquake rupture. The light-colored line along the base of the mountains is an 8- to 15-foot (2.5- to 4.5-m) vertical offset that occurred during the 1915 magnitude 7.6 Pleasant Valley, Nevada earthquake. Oblique aerial photo by Burt Slemmons.

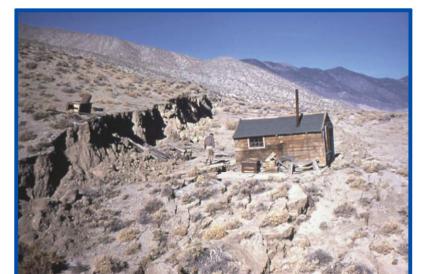


Figure 3. Fault offset of approximately 8 feet (~2.5 m) occurred during the 1954 Dixie Valley earthquake, forming the small cliff (fault scarp) to the left of the cabin. *Photo by Karl Steinbrugge*.

About this Map

data from the U.S. Geological Survey's Quaternary Fault and Fold Database for the United States (available at: http://earthquake.usgs.gov/regional/qfaults). Updates came primarily from geological maps published by the Nevada Bureau of Mines and Geology and numerous geotechnical consulting reports. Mapped faults are shown as solid lines, whereas faults that are inferred are shown as dashed lines. However, many Quaternary faults remain undetected and unmapped, especially in the alluvial valleys where they are covered by young sediments, in the mountains where lack of young sediments makes determination of a Quaternary age difficult, deep in the Earth where detection relies on seismology and other remote sensing techniques, and in areas that have not yet been studied.

This map of Quaternary faults in Nevada is an updated depiction of

Because the map is at small scale, and some fault traces in areas of clustered faults have been eliminated for clarity, it should not be used for planning or engineering purposes. The map is primarily intended for general education purposes.



Figure 4. Setback of homes away from a Quaternary fault in Las Vegas. The

fault is located in the central part of the grassy belt. Homes are located at least 50 feet (~15 m) away from the fault to avoid surface rupture from earthquakes, potential earth fissures related to groundwater pumping, and groundwater discharge along the fault.

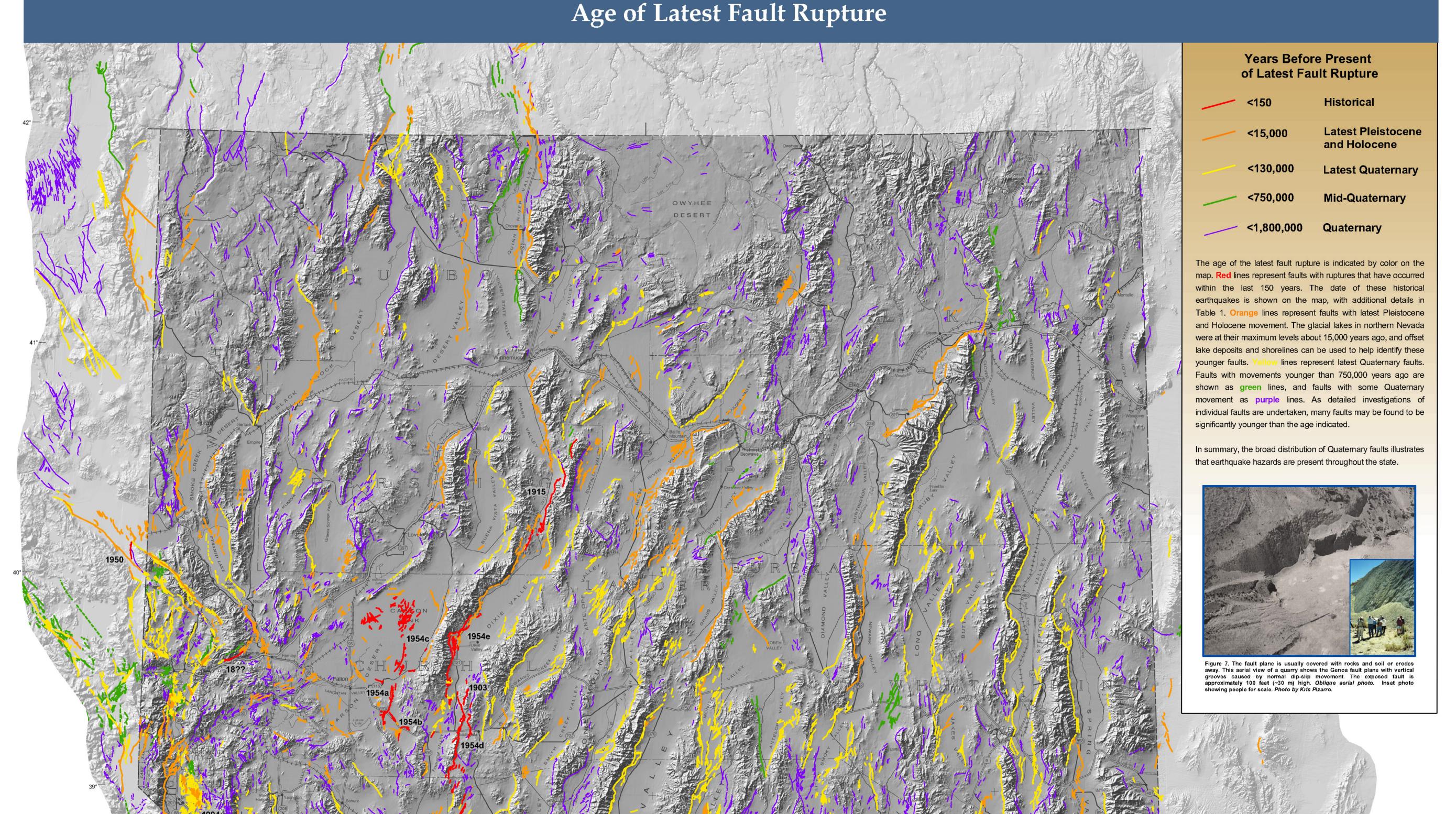


Table 1. Historical Earthquake Surface Ruptures in Nevada (ruptures shown in red with dates on map) Earthquake Type of Max. Offset Max. Length

Date	Magnitude	Displacement	(ft/m)	(mi/km)
1903	6.5?	N?, RL?	>0.03/>0.01	7.4?/12?
1915	7.6	N	19/5.8	37.8/61
1932	7.1	RL	6.6/2	37.2/60
1934	6.3	N, LL?	0.04/0.013	1.1/1.7
1954a	6.6	N, RL	3/1	11.2/18
1954b	6.4	N, RL	?	4/6.5
1954c	6.8	N, RL	2.5?/0.76?	21/34
1954d	7.1	N, RL	17/5.3	39.7/64
1954e	6.8	N	12/3.7	28.5/46
1994	5.8	N, RL	0.03?/0.01?	3.1/5
N = normal dip-slip offset, RL = right-lateral offset, LL = left-lateral offset				



Movement on a fault can be in any direction. Faults are classified into two basic categories: strike-slip and dip-slip motion as illustrated below.

Strike-slip earthquakes commonly occur on near-vertical fault planes where one side of the fault slides horizontally past the other. If the far side of the fault shifts to the right, it is a right-lateral fault; if it shifts to the left, it is a left-lateral fault. With dip-slip earthquakes, the fault usually dips at an angle, and one side moves up or down with respect to the other. For faults that dip at an angle, the area above the fault is known as the hanging wall, and the area below the fault as the footwall. These areas are named after their appearance in mines: miners hung their lanterns on the hanging wall and walked on the footwall.

On a **normal fault**, the hanging wall moves down and the footwall moves up relative to one another; on a reverse dip-slip fault, the reverse happens—the hanging wall moves up and the footwall moves down. (There appear to be relatively few Quaternary reverse faults in Nevada.) A common feature along normal faults is for the hanging wall to collapse at the surface and create a down-dropped area near the fault called a graben. If a fault has a combination of strike-slip and dip-slip movement, it is known as an oblique-slip fault.

In Nevada, most faults are normal dip-slip faults, although some are oblique-slip faults with dominantly normal dip-slip movements. During an earthquake, one side of the fault drops abruptly. The side that moves down is commonly a valley, and the side that remains or is uplifted slightly is a highland or mountain. Much of Nevada's picturesque mountain

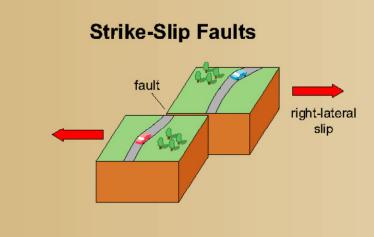
Strike-slip faults are also important in Nevada, especially in the western part where the majority of the historical earthquakes have had a strike-slip component. This concentration of strike-slip motion (highlighted in the figure to the right) accommodates some of the movement between the North American and Pacific plates.

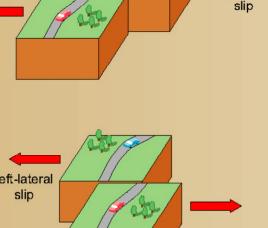
Normal Dip-Slip Faults

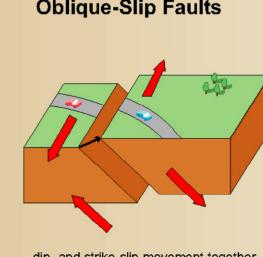
and valley landscape was formed in the process.

Fault Movement in Nevada (includes oblique-slip or unknown slip) (includes historical ruptures, some oblique-slip

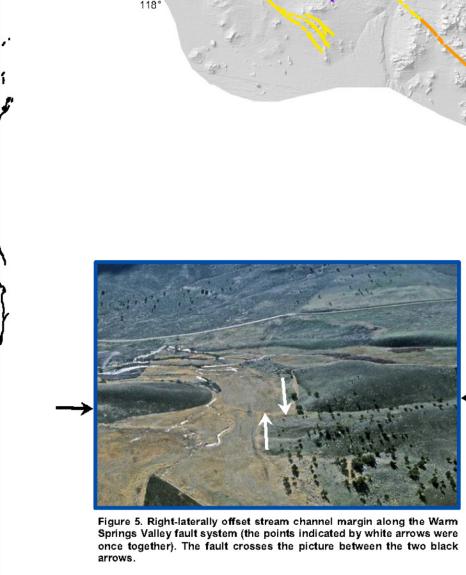
faults, inferred strike-slip movements, and some wrench patterns resulting from strike-slip movement)

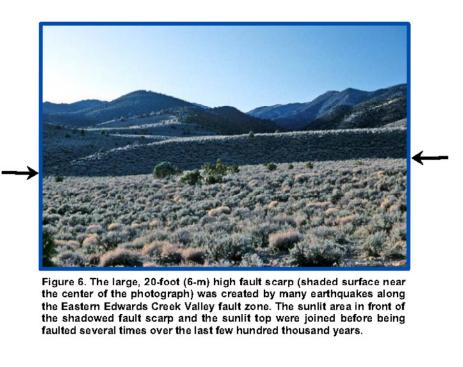












80 Kilometers Scale 1:1,000,000 1 inch equals approximately 16 miles Projection: Universal Transverse Mercator, Zone 11, North American Datum 1927 (m) Base map modified from NBMG Map 43 (1995) with digital shaded relief created from U.S. Geological

in Nevada include David B. Slemmons, John C. Dohrenwend, Bruce Schell, John W. Bell, Marith C. Reheis, Lucy Piety, Thomas L. Sawyer, Alan R. Ramelli, Michael Machette, Kenneth D. Adams, R. Ernest Anderson, David J. Lidke, John A. Oswald, Margaret Hiza Redsteer, Janet E. Sawyer, Peter C. Rowley, Suzanne Hecker, David Miller, John Caskey, Chris Menges, Chris Friedrich, Christopher D. Henry, Rich Koehler III, and Craig M. dePolo. In addition, many studies have been undertaken by these individuals and others to better evaluate fault movements. References are provided at http://earthquakes.usgs.gov/regional/qfaults/. Special thanks to Kathy Haller, Jennifer Mauldin, Jon Price, and Jordan Hastings for

improving the text, and to Thomas L. Sawyer for providing fault mapping of eastern

California. Jennifer Mauldin did a superb job handling countless edits and revisions

and performing the cartographic layout of the map. I thank her immensely for her

Major contributors to the identification, location, and compilation of Quaternary Faults Edited by Dick Meeuwig and Jon Price artography and map production in ESRI ArcGIS v9.2 by Jennifer Mauldin First Edition, December 2008 Printed by Nevada Bureau of Mines and Geology This map was printed on an electronic plotter directly from digital files. Dimensional calibration may vary between electronic plotters and X and Y directions on the same plotter, and paper may change size; therefore, scale and proportions may not be exact on copies of this map.

Nevada Bureau of Mines and Geology Mackay School of Earth Sciences and Engineering College of Science Office review by Kathy Haller, John Bell, Alan Ramelli, and Jon Price

