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Quaternary Faults in Nevada

Craig M. dePolo
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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

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

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.

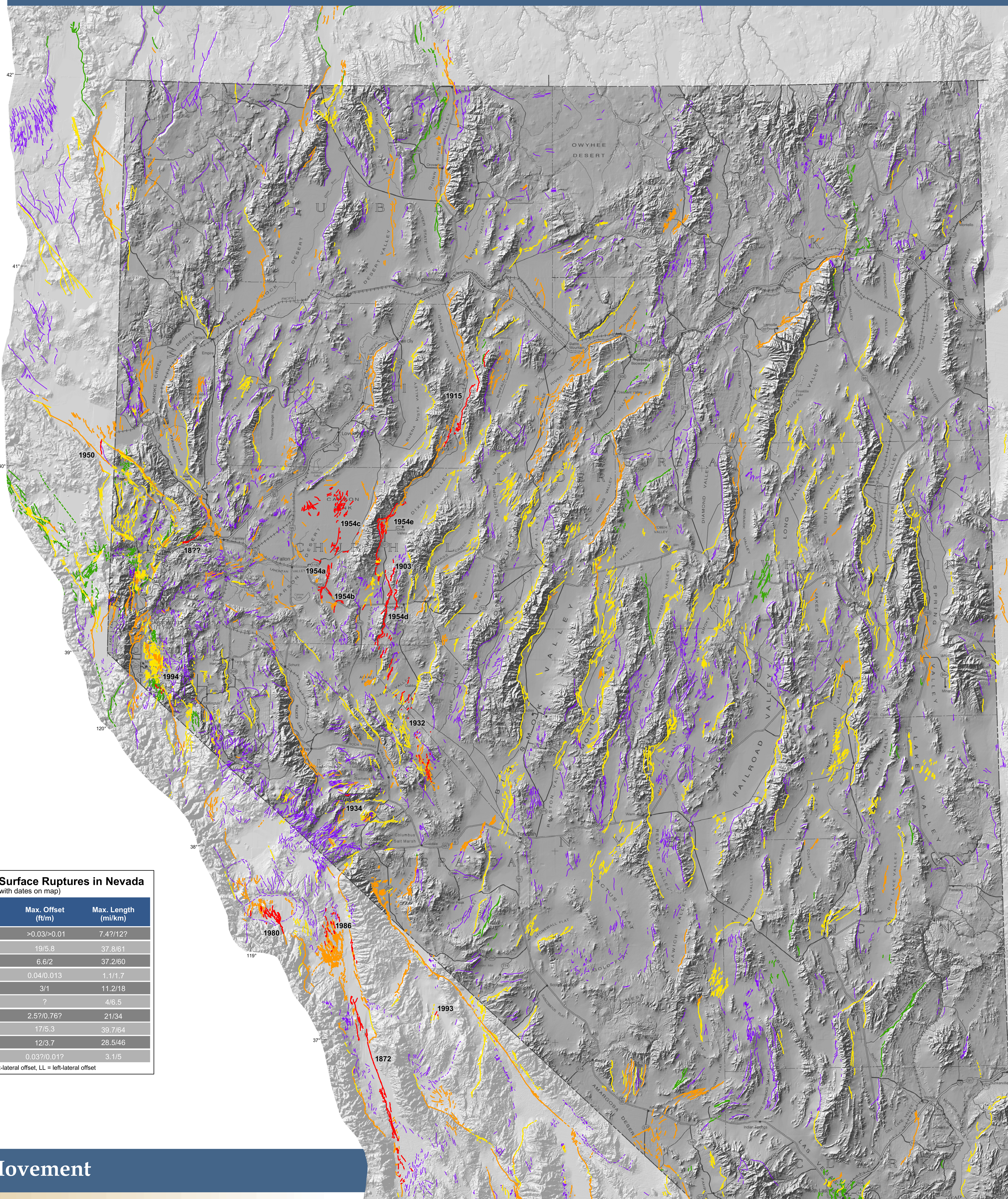
Figure 4. Setback of homes away from a Quaternary fault in Las Vegas. The fault is located in the central part of the grassy belt. Homes are located at least 50 feet (~15 m) away from the fault to avoid surface rupture from earthquakes, potential earth fissures related to groundwater pumping, and groundwater discharge along the fault.

Table 1. Historical Earthquake Surface Ruptures in Nevada
(ruptures shown in red with dates on map)

Date	Earthquake Magnitude	Type of Displacement	Max. Offset (ft/m)	Max. Length (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

Age of Latest Fault Rupture



Years Before Present of Latest Fault Rupture

- <150 — Historical
- <15,000 — Latest Pleistocene and Holocene
- <130,000 — Latest Quaternary
- <750,000 — Mid-Quaternary
- <1,800,000 — Quaternary

The age of the latest fault rupture is indicated by color on the map. **Red** lines represent faults with ruptures that have occurred within the last 150 years. The date of these historical earthquakes is shown on the map, with additional details in Table 1. **Orange** lines represent faults with latest Pleistocene and Holocene movement. The glacial lakes in northern Nevada were at their maximum levels about 15,000 years ago, and offset lake deposits and shorelines can be used to help identify these younger faults. **Yellow** lines represent latest Quaternary faults. Faults with movements younger than 750,000 years ago are shown as **green** lines, and faults with some Quaternary movement as **purple** lines. As detailed investigations of individual faults are undertaken, many faults may be found to be significantly younger than the age indicated.

In summary, the broad distribution of Quaternary faults illustrates that earthquake hazards are present throughout the state.

Figure 7. The fault plane is usually covered with rocks and soil or erodes away. This aerial view of a quarry shows the Genoa fault plane with vertical grooves caused by normal dip-slip movement. The exposed fault is approximately 100 feet (~30 m) high. *Oblique aerial photo.* Inset photo showing people for scale. *Photo by Kris Pizarro.*

Type of Fault Movement

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.

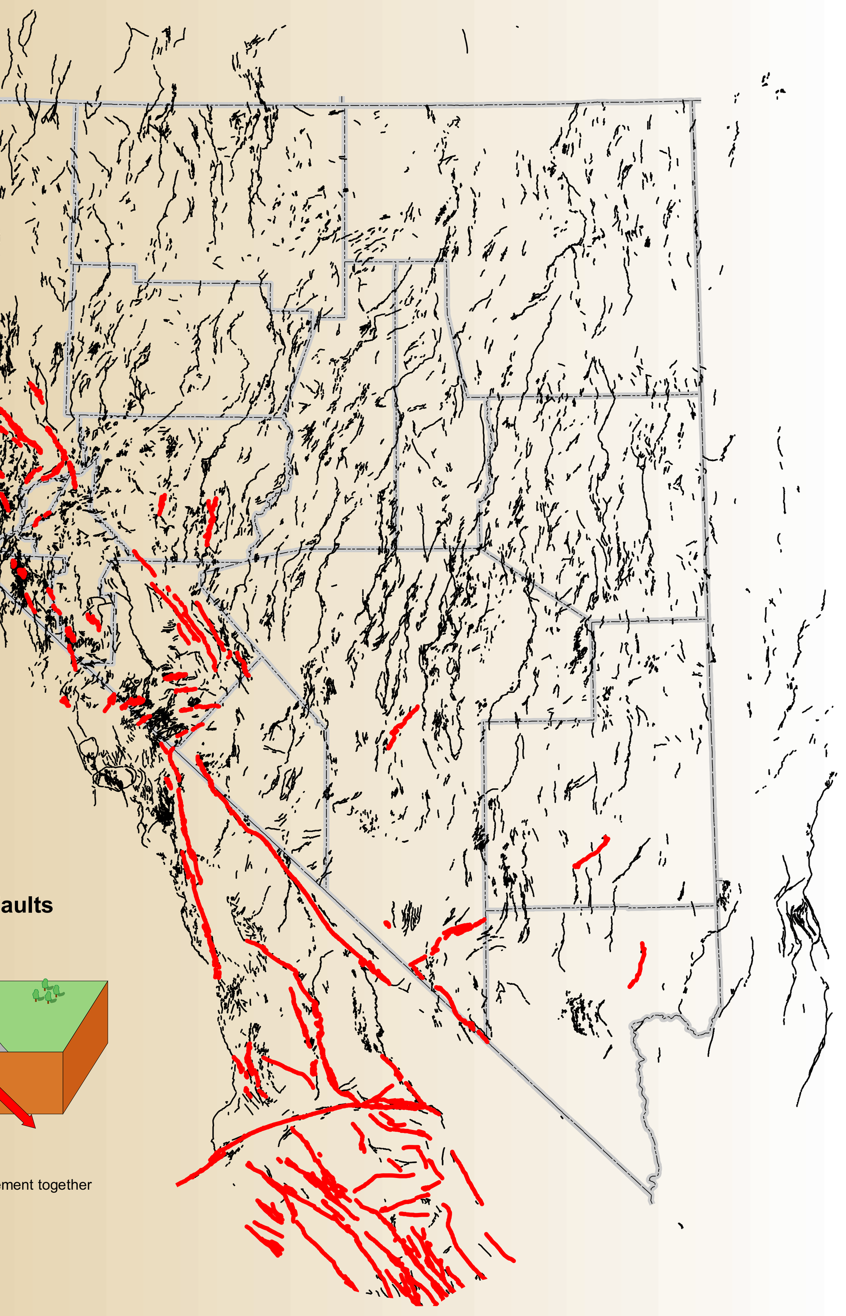
On a **normal fault**, the hanging wall moves down and the footwall moves up relative to one another; on a reverse dip-slip fault, the reverse happens—the hanging wall moves up and the footwall moves down. (There appear to be relatively few Quaternary reverse faults in Nevada.) A common feature along 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 and valley landscape was formed in the process.

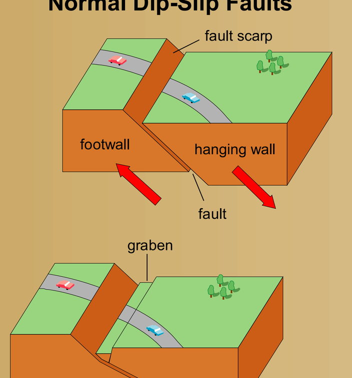
Strike-slip faults are also important in Nevada, especially in the western part where the majority of the historical earthquakes have had a strike-slip component. This concentration of strike-slip motion (highlighted in the figure to the right) accommodates some of the movement between the North American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

Fault Movement in Nevada

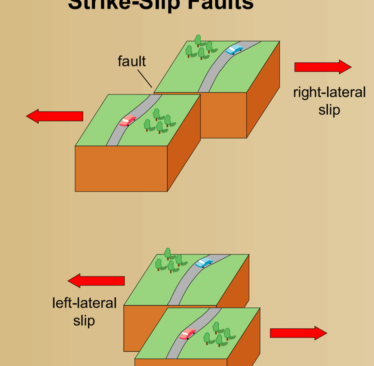
- Normal dip-slip fault (includes oblique-slip or unknown slip)
- Strike-slip fault (includes historical ruptures, some oblique-slip faults, inferred strike-slip movements, and some wrench patterns resulting from strike-slip movement)



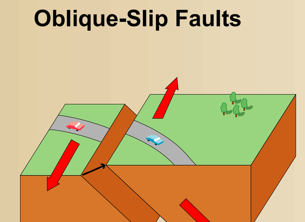
Normal Dip-Slip Faults



Strike-Slip Faults



Oblique-Slip Faults



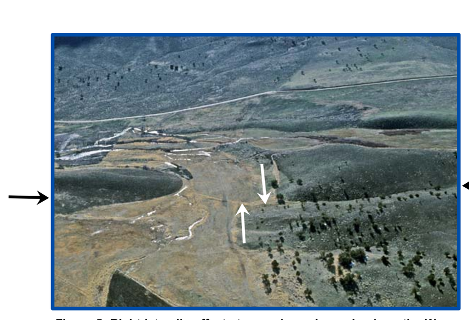


Figure 5. Right-laterally offset stream channel margin along the Warm Springs Valley fault system (the points indicated by white arrows were once together). The fault crosses the picture between the two black arrows.

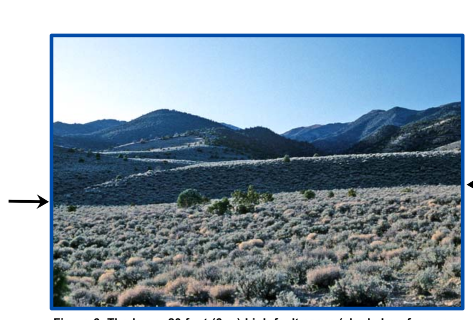


Figure 6. The large, 20-foot (6-m) high fault scarp (shaded surface near the center of the photograph) was created by many earthquakes along the Eastern Edwards Creek Valley fault zone. The sunlit area in front of the shadowed fault scarp and the sunlit top were joined before being faulted several times over the last few hundred thousand years.

0 10 20 30 40 50 Miles
0 20 40 60 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 Survey data.

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

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Nevada Bureau of Mines and Geology
University of Nevada, Reno / 178
Reno, Nevada 89557-0178
ph. (775) 784-6691, ext. 2
www.nbmg.unr.edu; nbmgsales@unr.edu

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