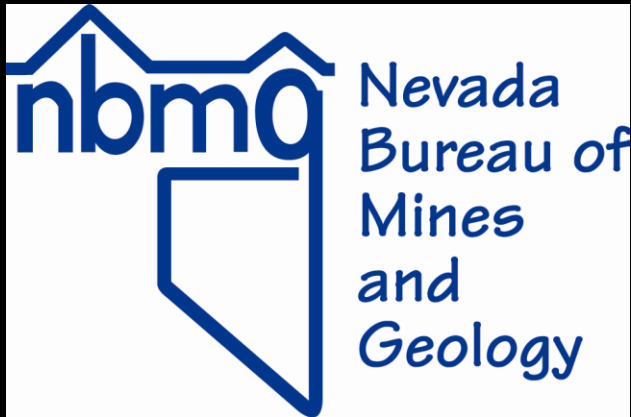


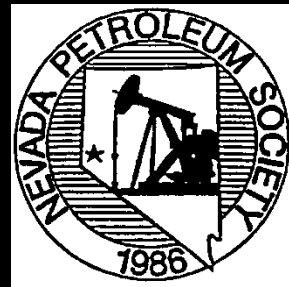
# Why Nevada Geology is So Exciting!

**Jon Price**

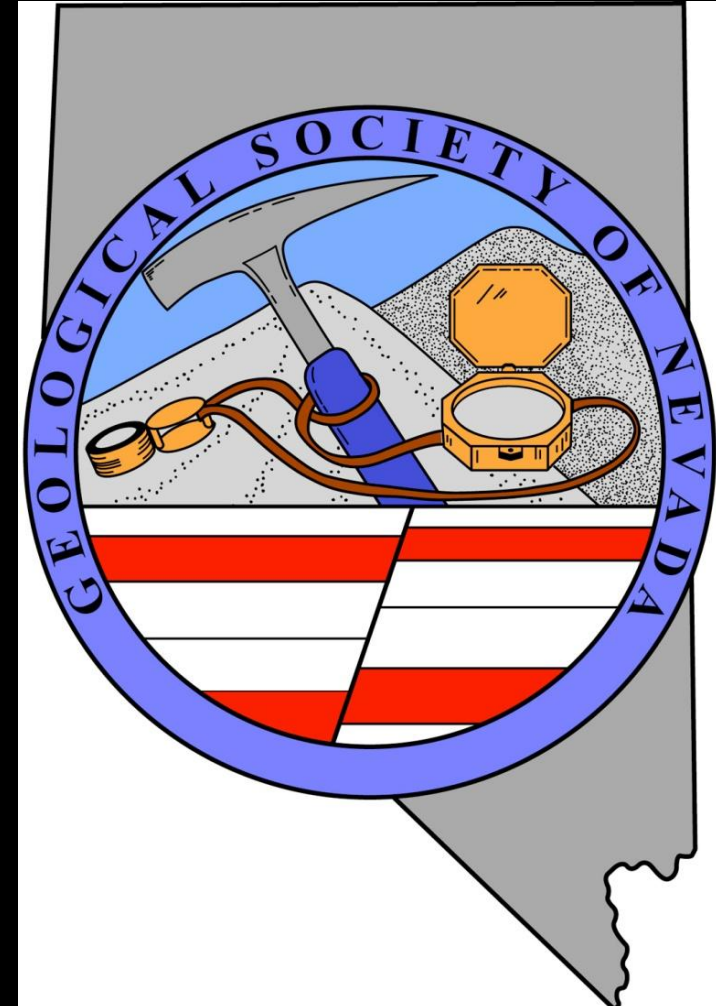
**Nevada Bureau of Mines and Geology**



Division of Minerals



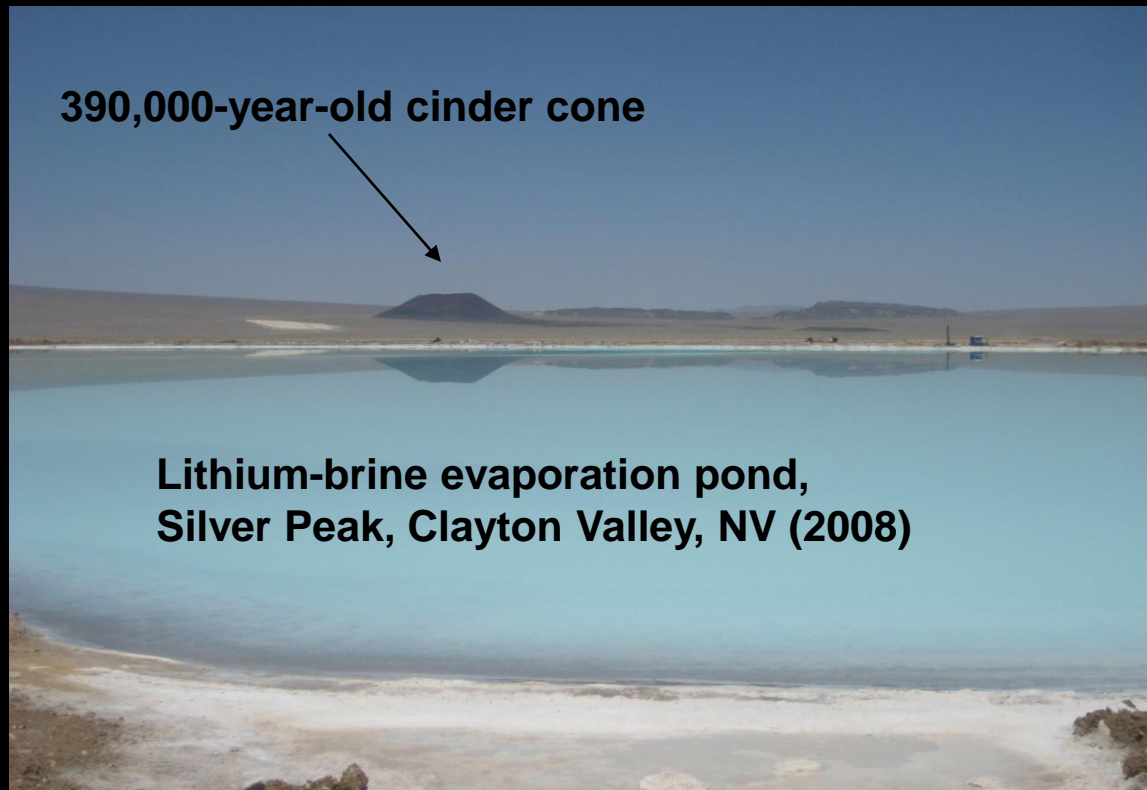
**AEG**



# Why Nevada Geology is So Exciting!

## FOUR MAIN REASONS:

### 1. The rocks and the resources in them



# Why Nevada Geology is So Exciting!

## 2. The hazards



Collapse of unreinforced masonry building, Wells, 21 February 2008, magnitude 5.0 earthquake

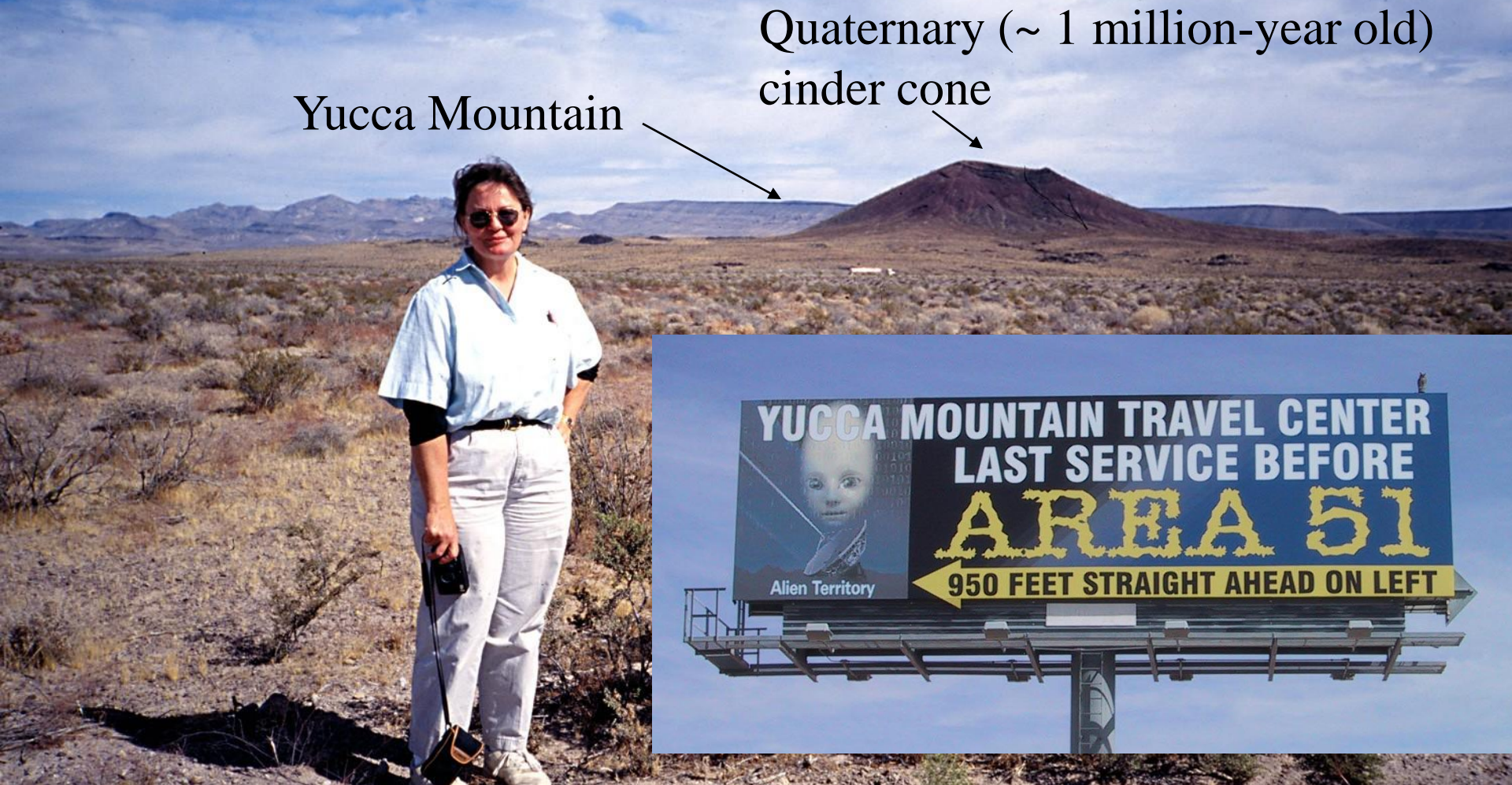


Damage to water flume, Mogul, 25 April 2008, magnitude 5.0 earthquake

Photos by C. dePolo, NBMG

# Why Nevada Geology is So Exciting!

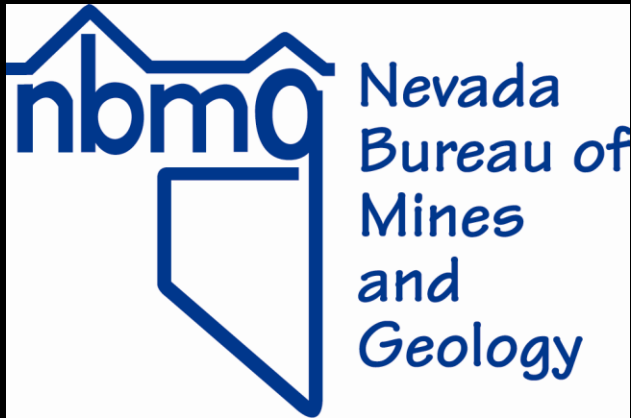
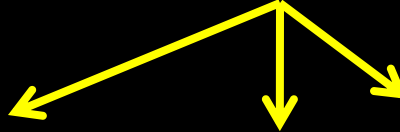
## 3. The environmental issues



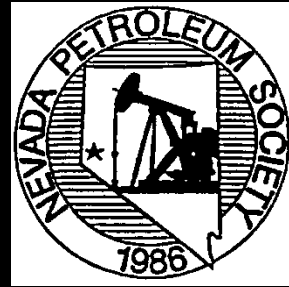
**Black Cone in Crater Flat, Yucca Mountain in background to the east**

# Why Nevada Geology is So Exciting!

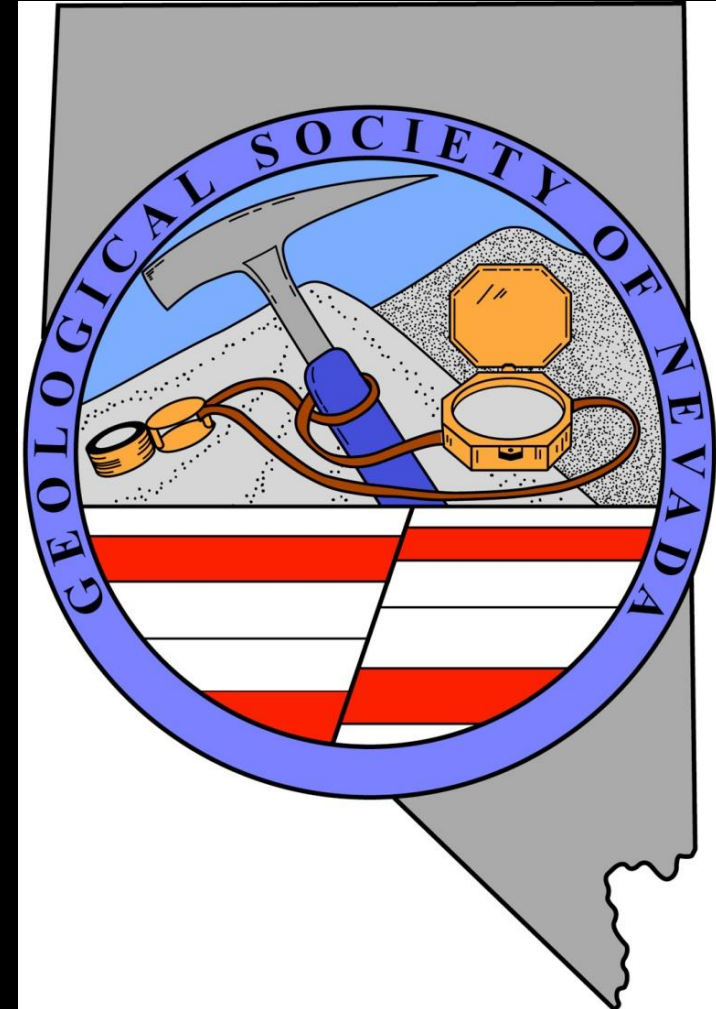
## 4. The geos



Division of Minerals



AEG



# Why Nevada Geology is So Exciting!

## 1. The rocks and the resources in them



Gold, Round Mountain,  
3.3 cm high

J. Scovil photos



Gypsum, Robinson District,  
12 cm long



Opalized wood, Virgin Valley,  
2.5 cm diameter

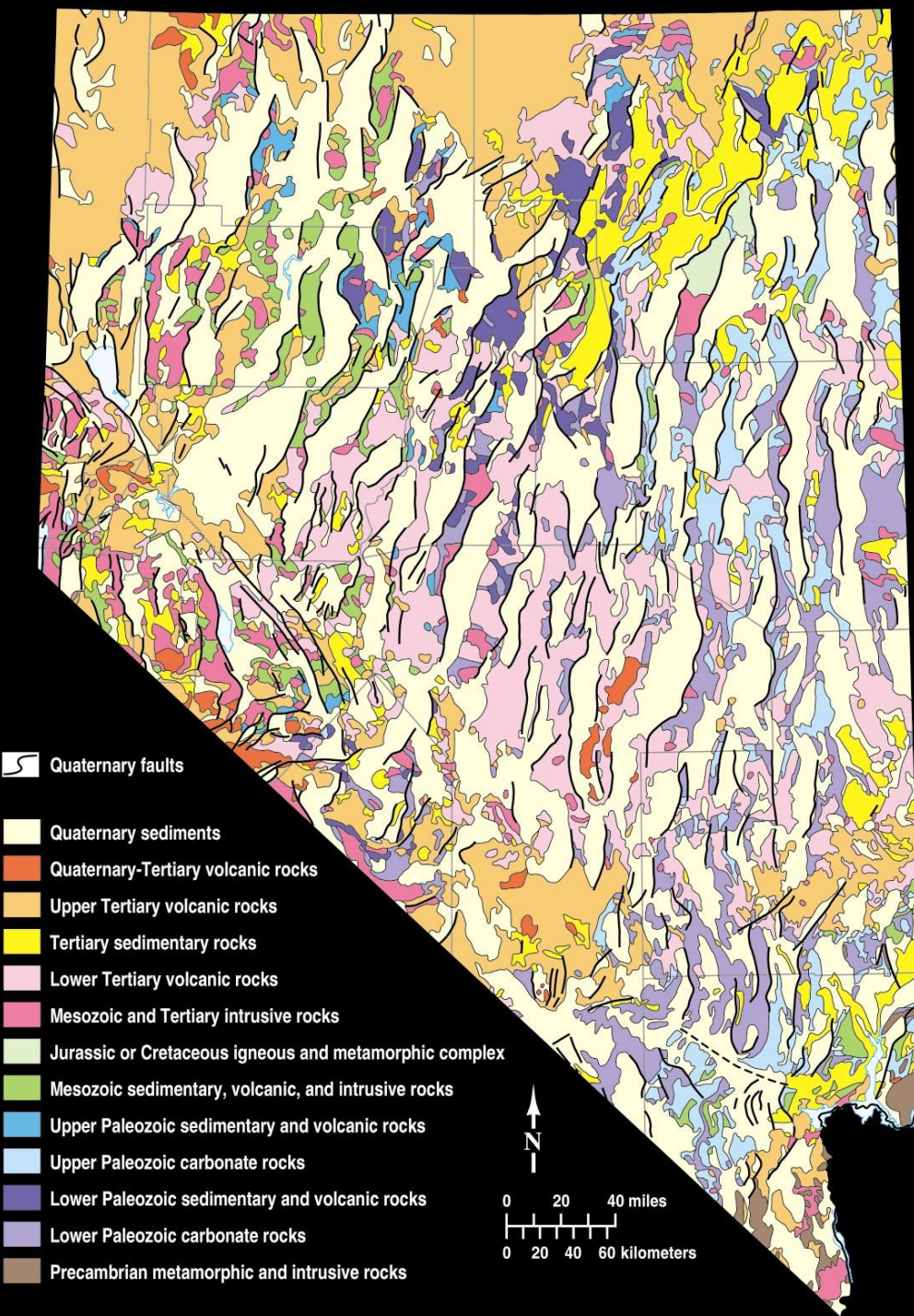
## Quick Review of Nevada Geologic History

**Precambrian events – thrusting, folding, metamorphism, intrusions, sediments.**

**Paleozoic thrusting, folding, oceanic crust and sediments.**

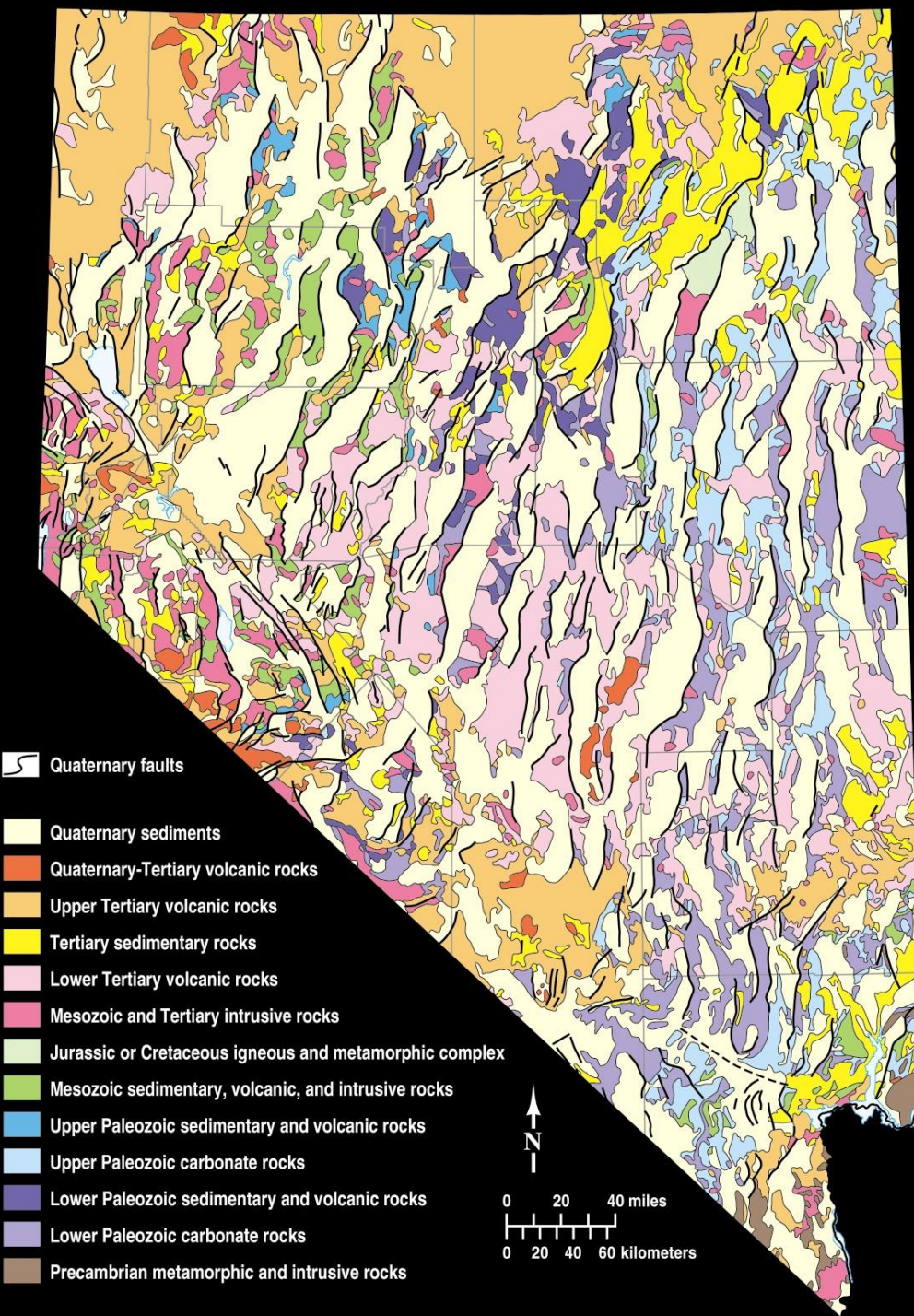
**Mesozoic thrusting, folding, intrusion and volcanism.**

**Cenozoic volcanism and intrusion, compression followed by crustal extension, faulting, including right-lateral strike-slip faulting.**



## Quick Review of Nevada Geologic History

**Precambrian events (before 540 million years ago) – thrusting, folding, metamorphism, intrusions, sediments.**



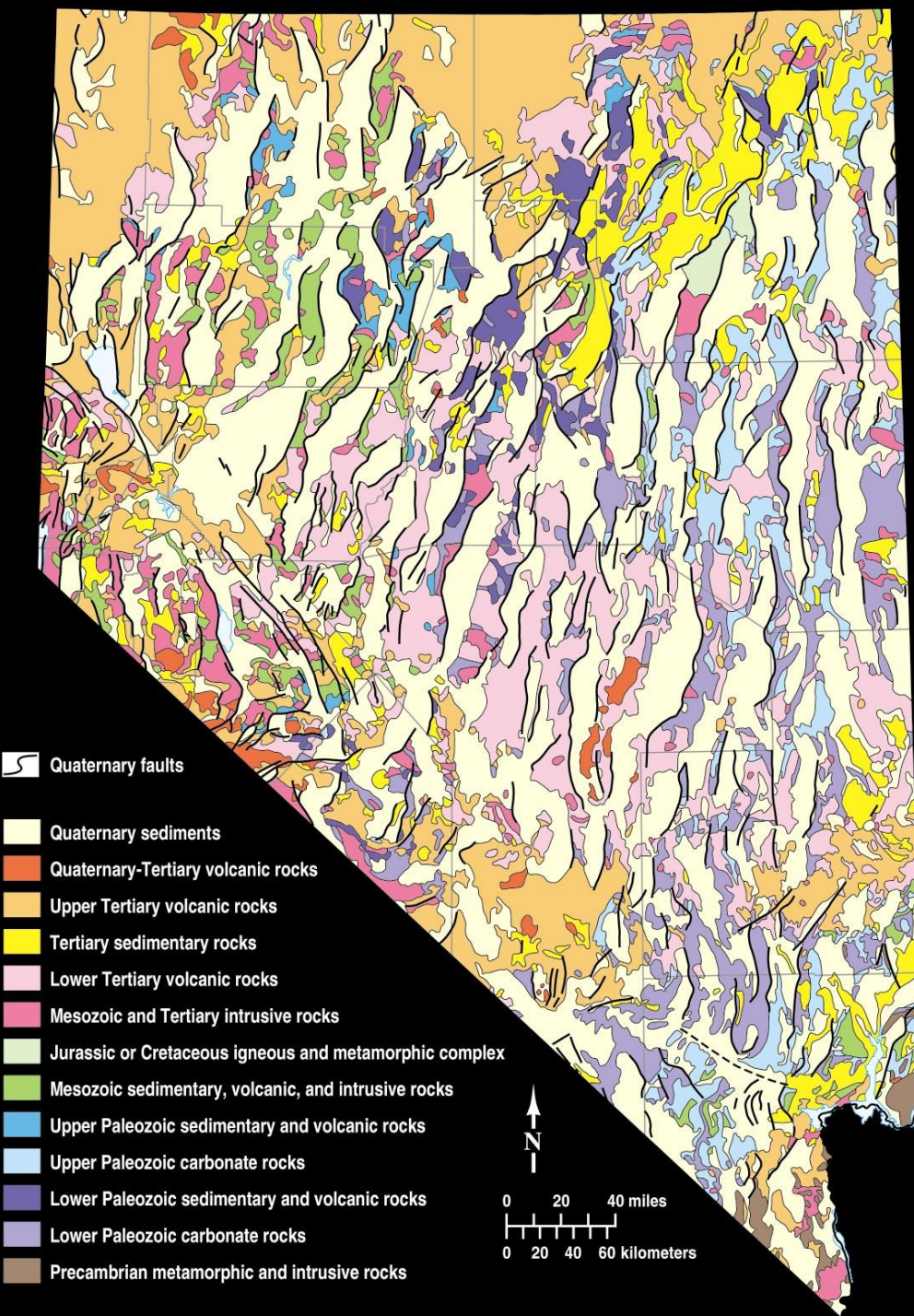


**Archean (~2.5 billion years old) gneiss in  
metamorphic core complex,  
Angel Lake, East Humboldt Range, Elko County**

## Quick Review of Nevada Geologic History

**Precambrian events – thrusting, folding, metamorphism, intrusions, sediments.**

**Paleozoic (from 540 to 248 million years ago) — thrusting, folding, oceanic crust and sediments.**



Folded Paleozoic limestones  
north of Apex, west of US 93



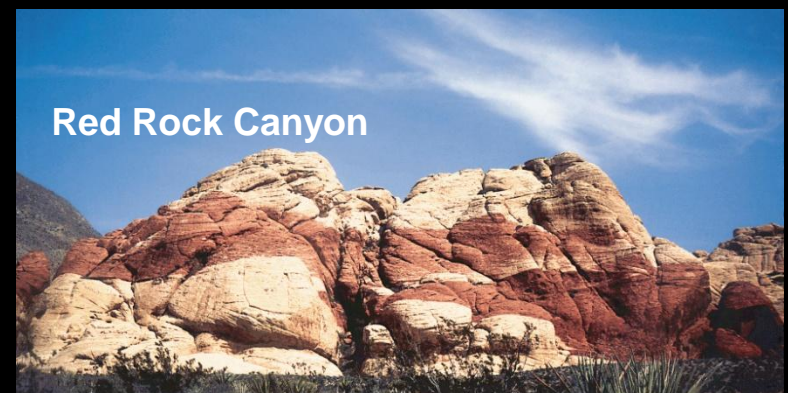
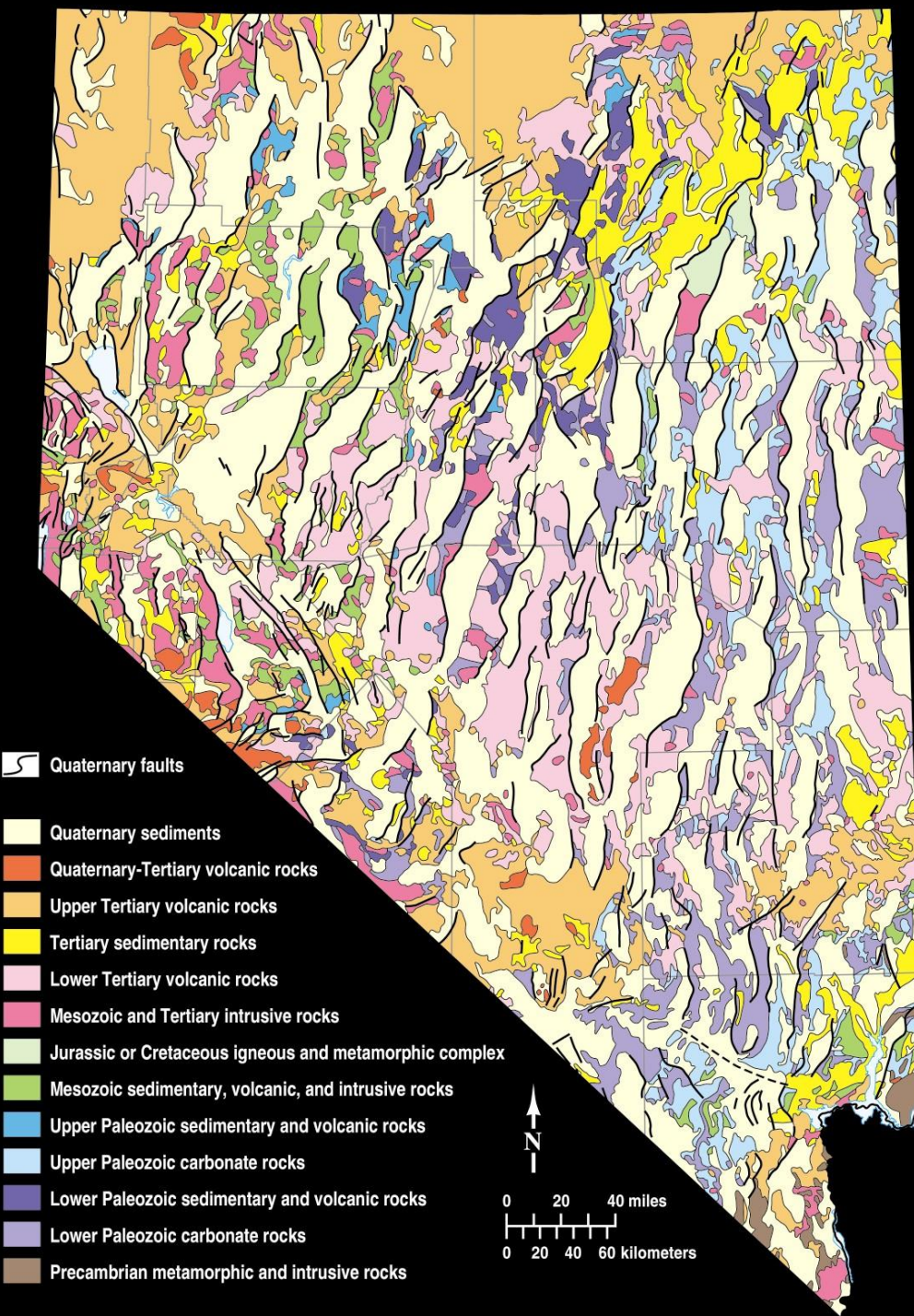
Refolded folds in  
gneiss in the Ruby  
Mountains

## Quick Review of Nevada Geologic History

**Precambrian events – thrusting, folding, metamorphism, intrusions, sediments.**

**Paleozoic thrusting, folding, oceanic crust and sediments.**

**Mesozoic (from 248 to 65 million years ago) — thrusting, folding, intrusion and volcanism.**



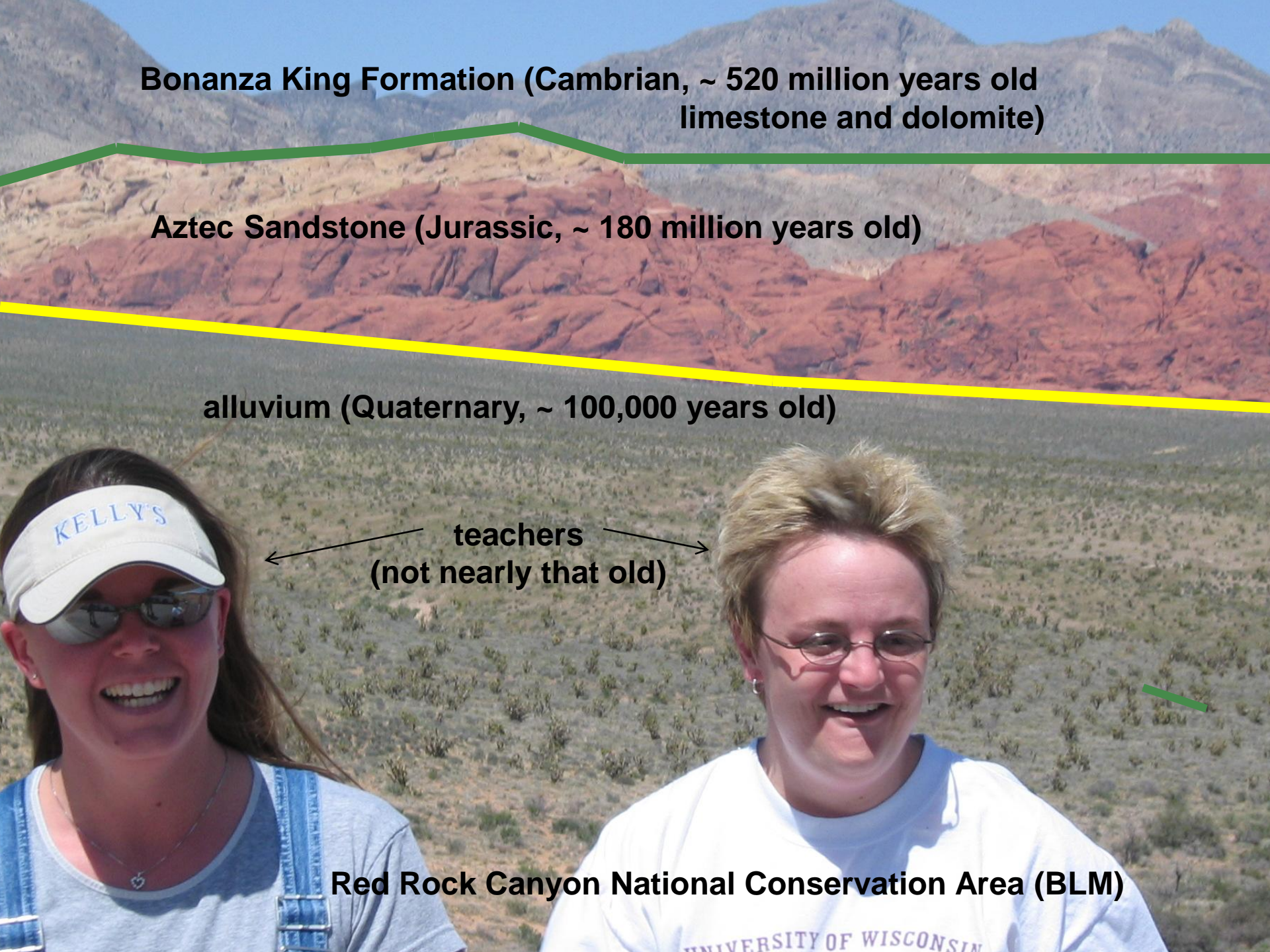
**Bonanza King Formation (Cambrian, ~ 520 million years old  
limestone and dolomite)**

**Aztec Sandstone (Jurassic, ~ 180 million years old)**

**alluvium (Quaternary, ~ 100,000 years old)**

← **teachers** →  
**(not nearly that old)**

**Red Rock Canyon National Conservation Area (BLM)**



## Splitting flagstone at Rainbow Rock



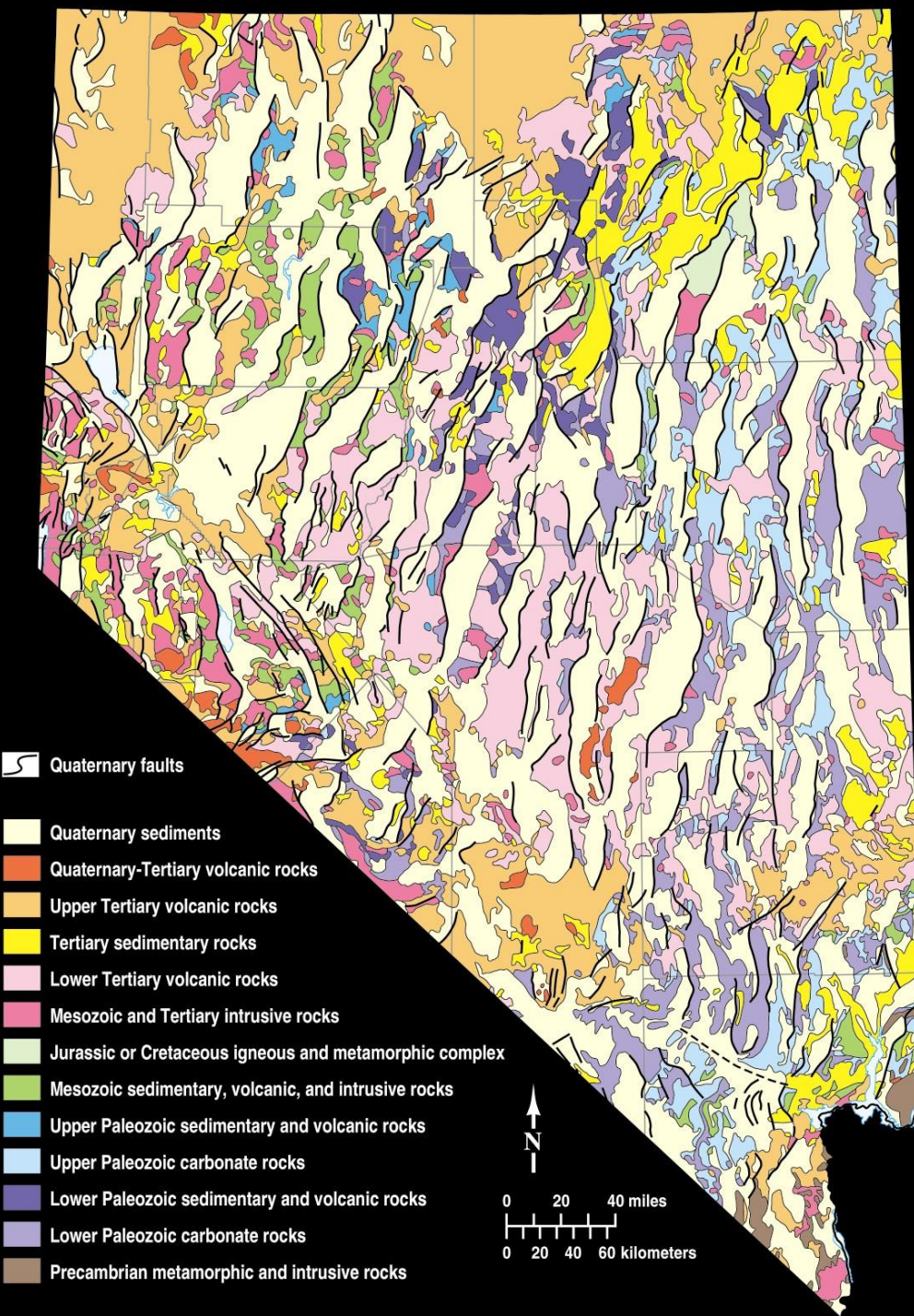
## Quick Review of Nevada Geologic History

**Precambrian events –  
thrusting, folding,  
metamorphism, intrusions,  
sediments.**

**Paleozoic thrusting, folding,  
oceanic crust and  
sediments.**

**Mesozoic thrusting, folding,  
intrusion and volcanism.**

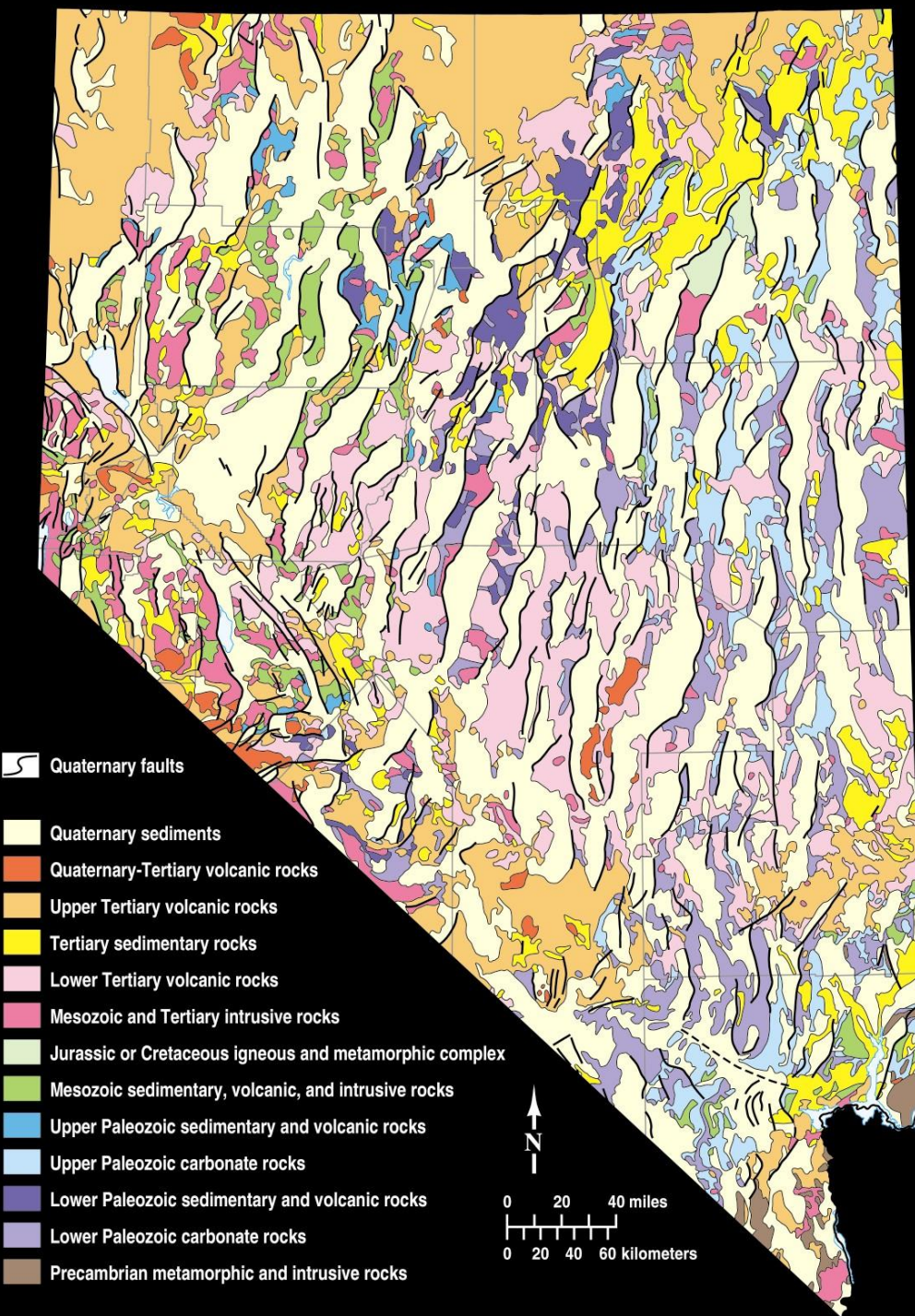
**Cenozoic (<65 million years old)  
— volcanism and intrusion,  
compression followed by  
crustal extension, faulting,  
including right-lateral strike-slip  
faulting.**



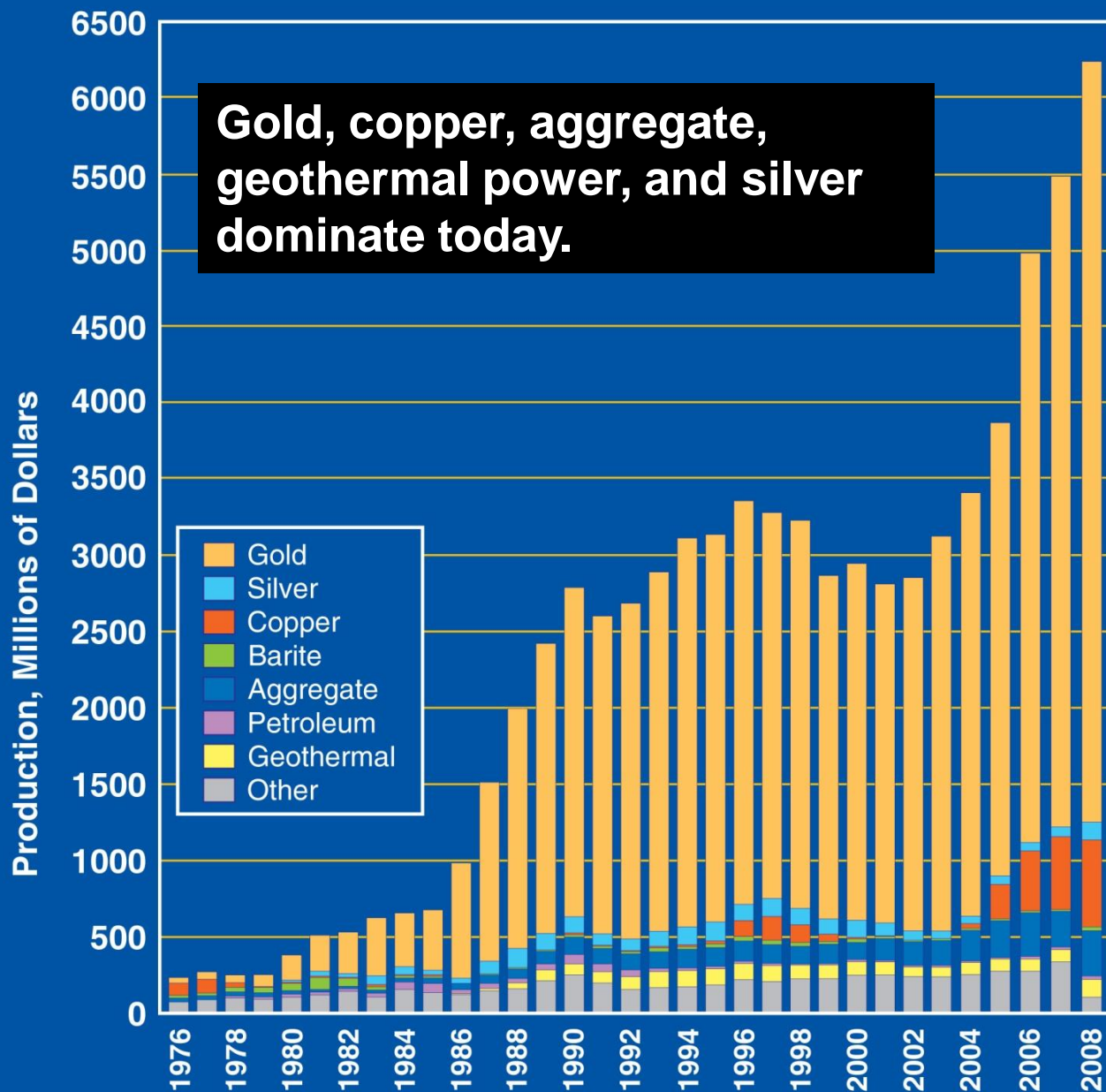
**Everything pink, red, and orange on the map is igneous.**



**There are ore deposits associated with many of the Mesozoic and Cenozoic intrusions.**

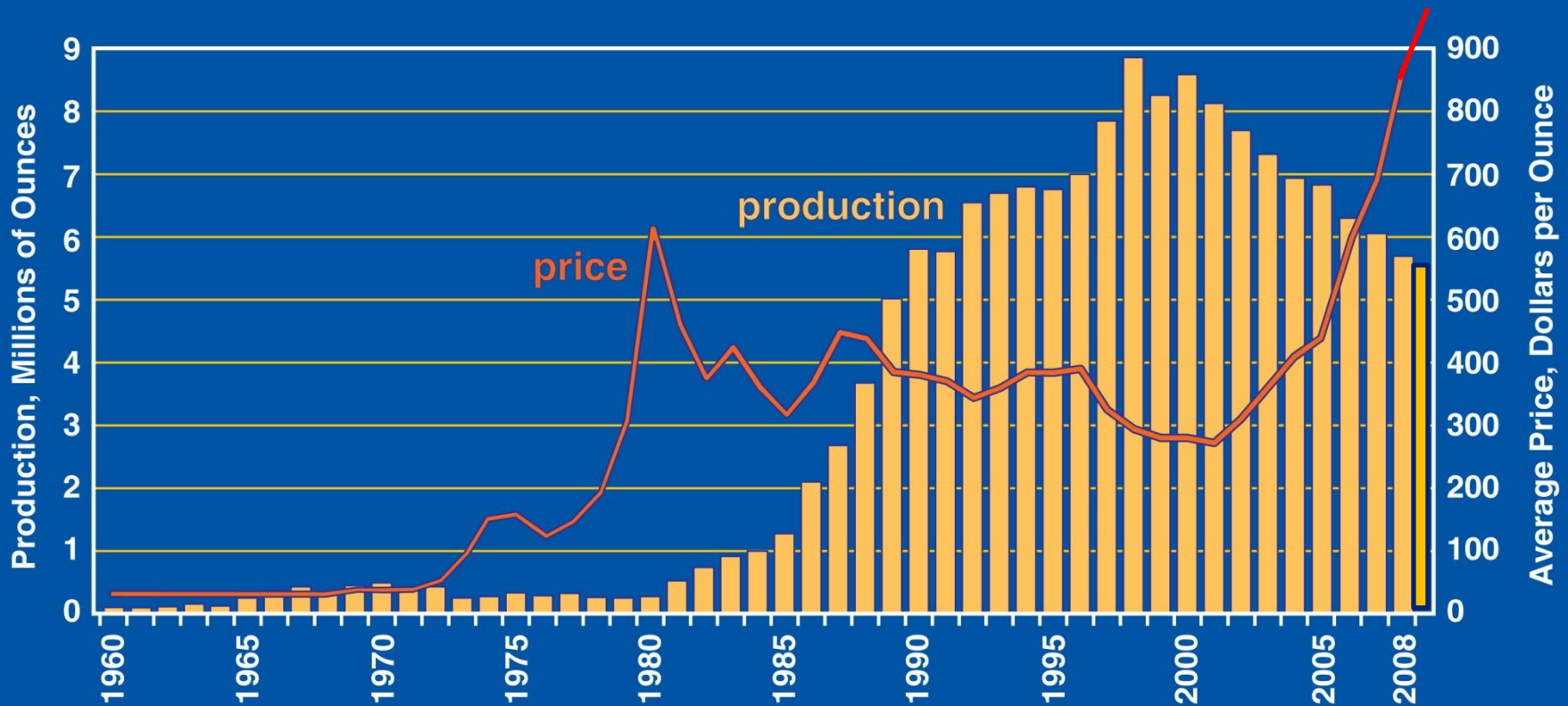


# Nevada Mineral, Petroleum, and Geothermal Production



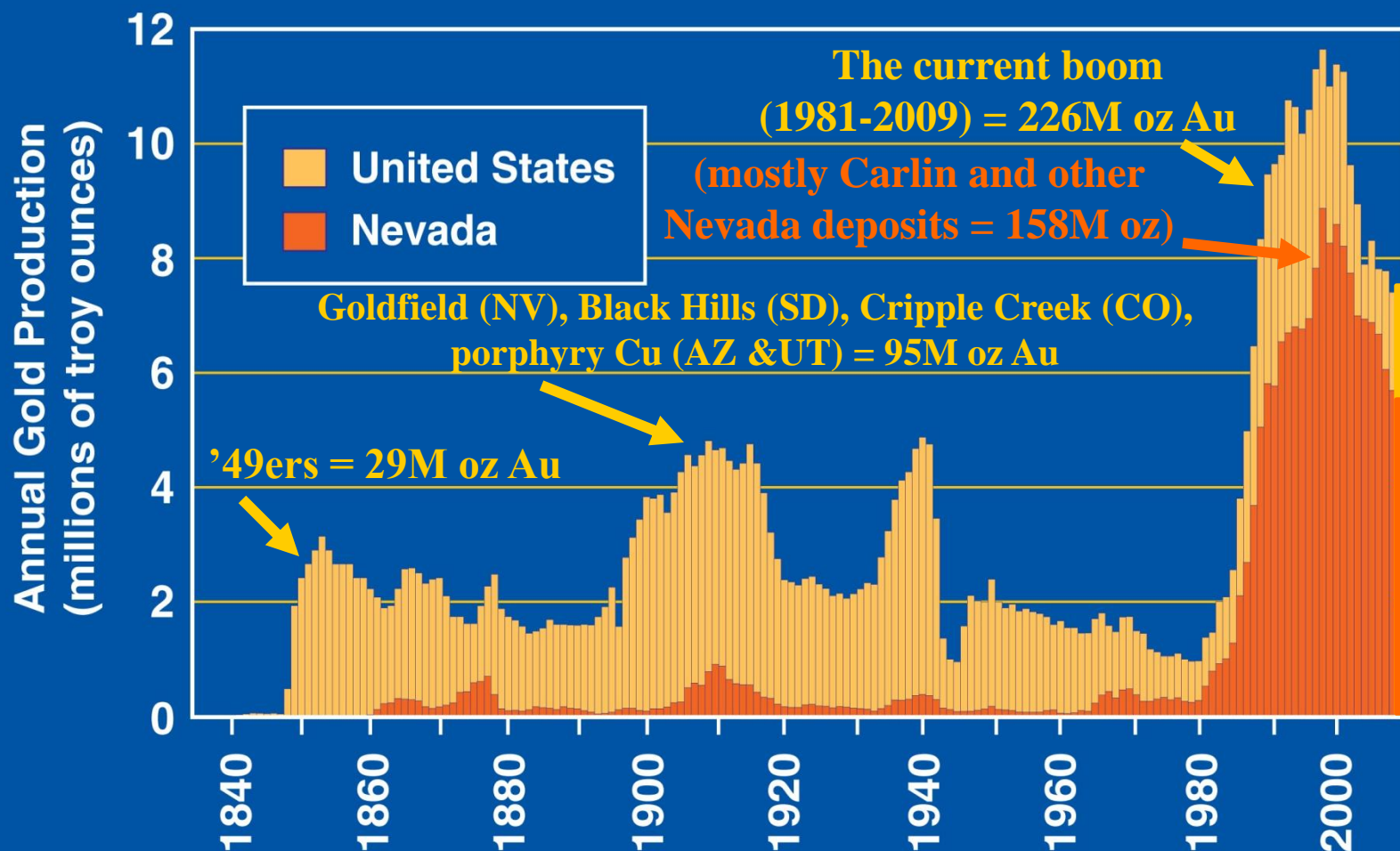
**5.6 million ounces\* in 2009; \$950 per ounce average price**

# Nevada Gold



\* Nevada Division of Minerals statistics

# Gold Production, 1835-2009



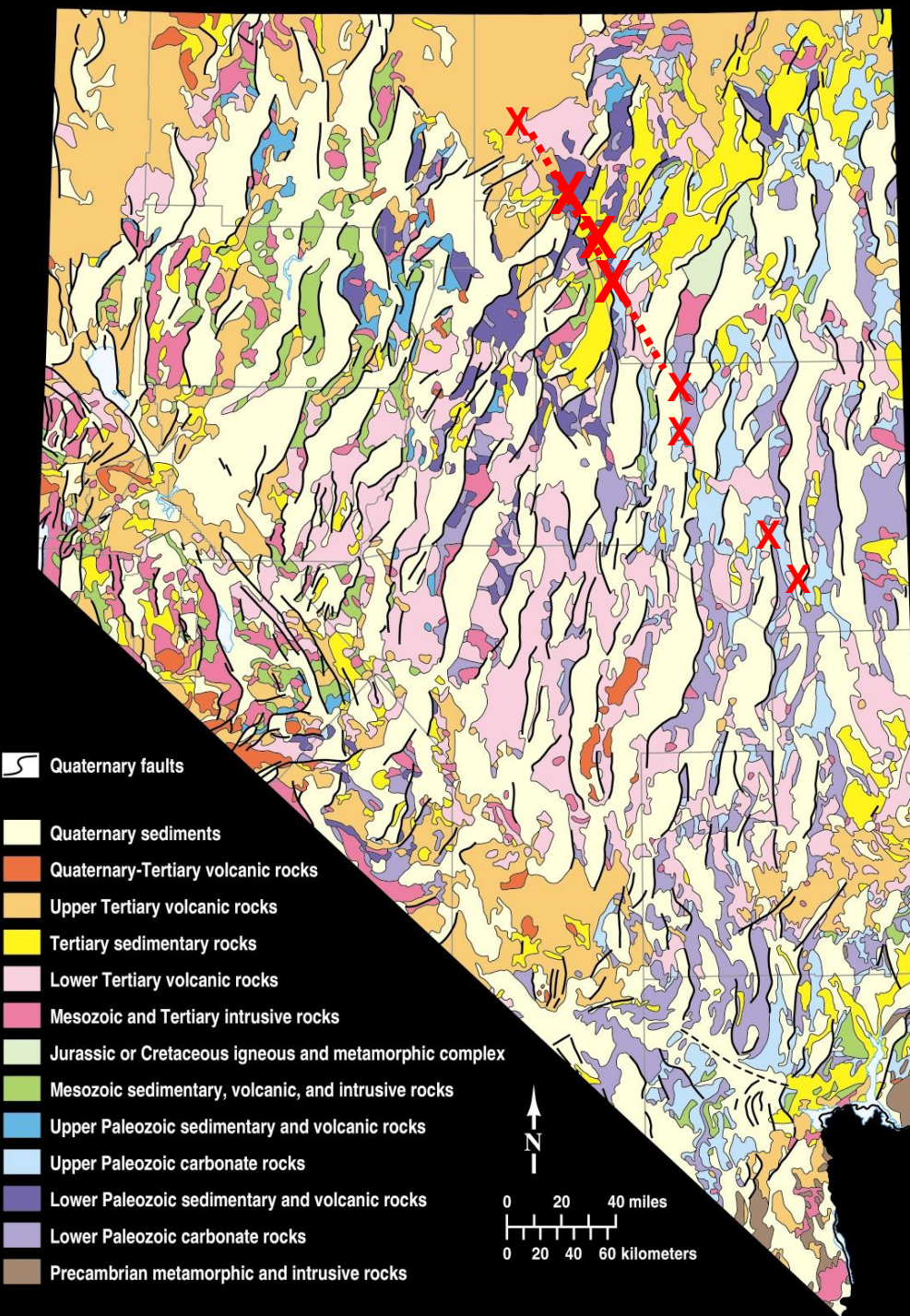
**We are in the midst of the biggest gold boom in American history.**

Nevada is a really great place to explore for and mine gold - and many other mineral commodities



## Trends of Mineral Deposits

**Carlin trend –**  
accounted for 53% of  
Nevada gold production in  
2009.



**X Metals (mostly Au, Cu, Ag)**

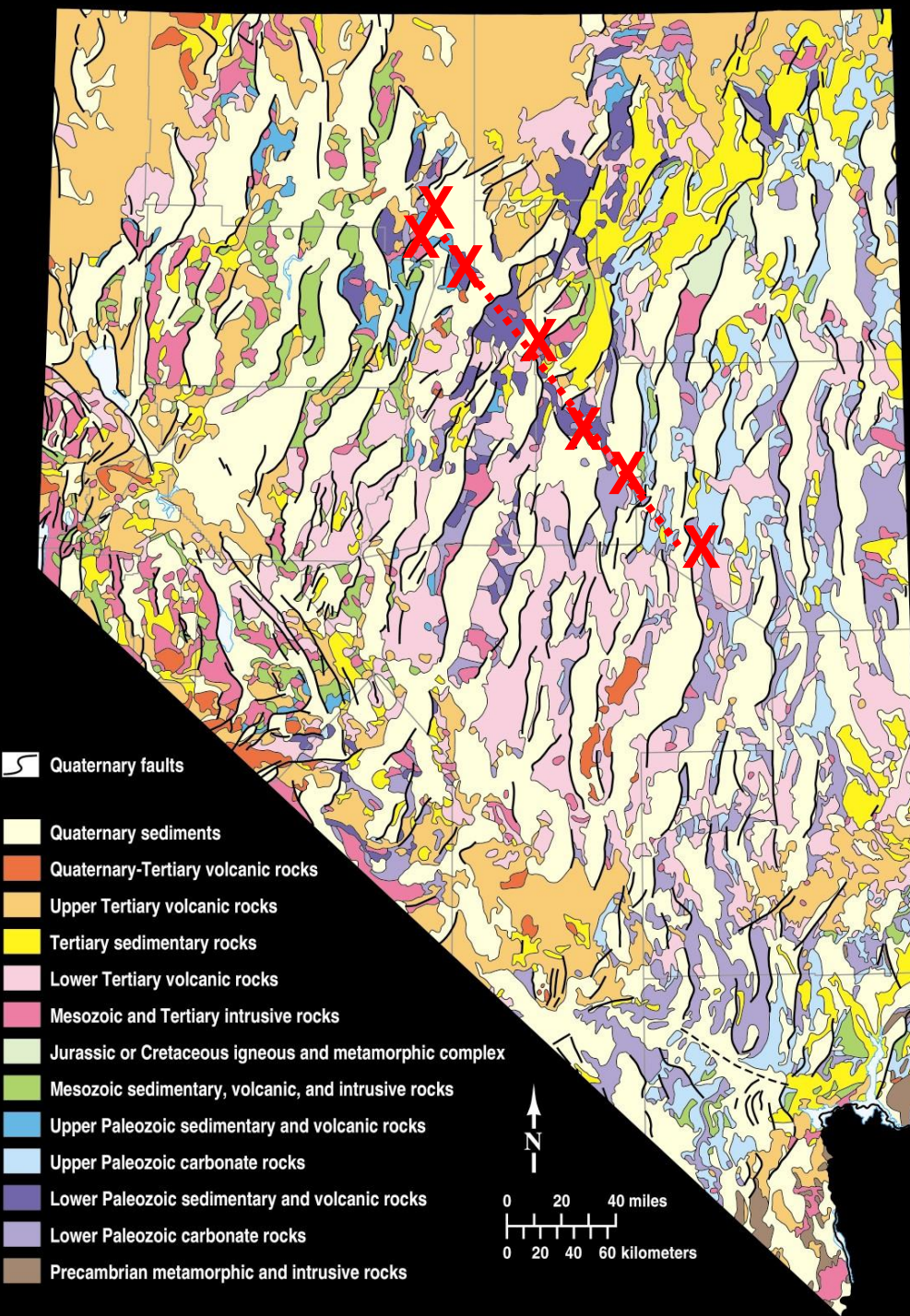
# Trends of Mineral Deposits

## Battle Mountain-Eureka trend

(aka Cortez trend and with Getchell and Twin Creeks included) –

Seven deposits in 2009 produced >100,000 oz of gold, including Pipeline at 567,785 oz and Cortez Hills at 125,057 oz.

X Metals (mostly Au, Cu, Ag)



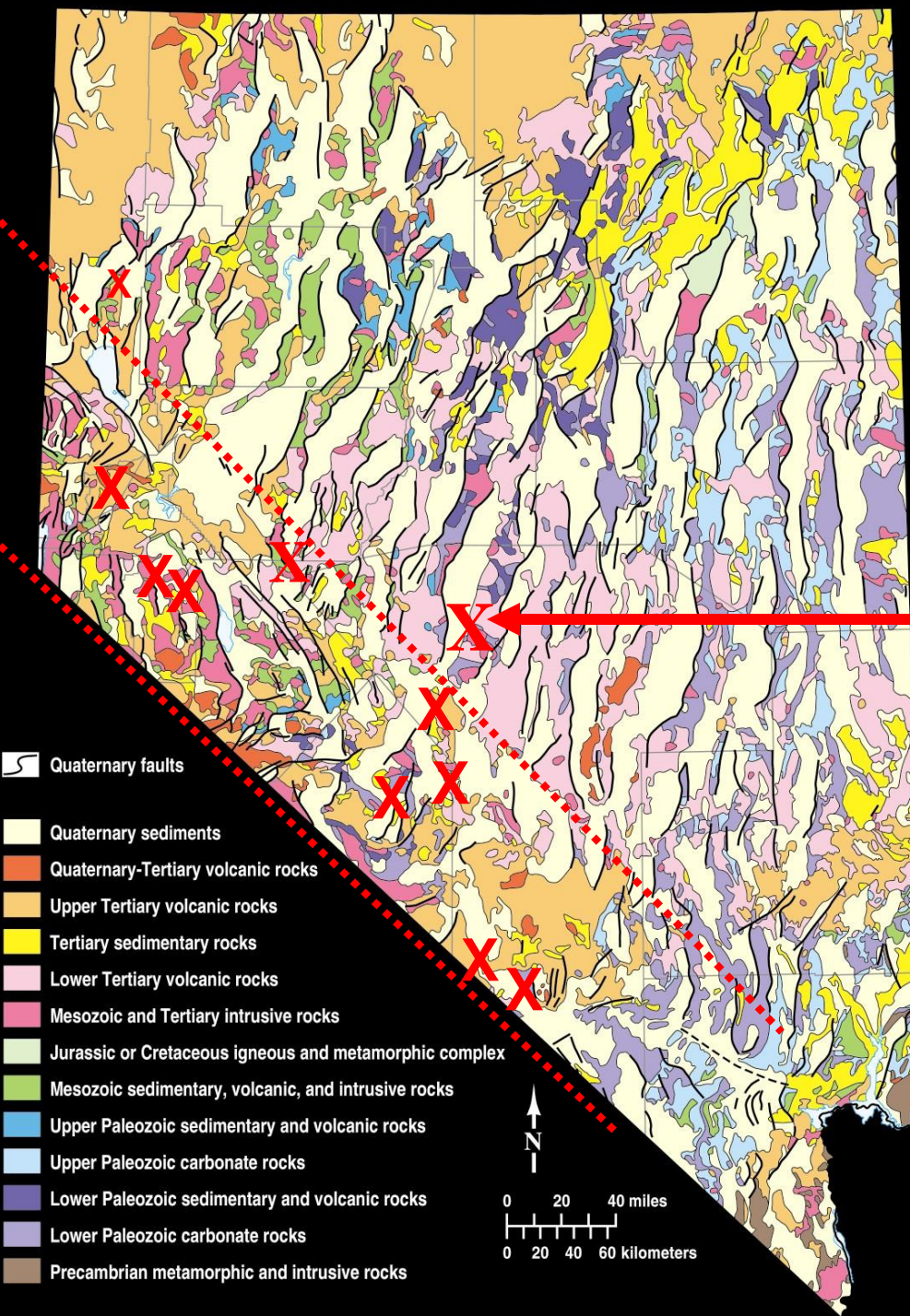
## Trends of Mineral Deposits

# Walker Lane

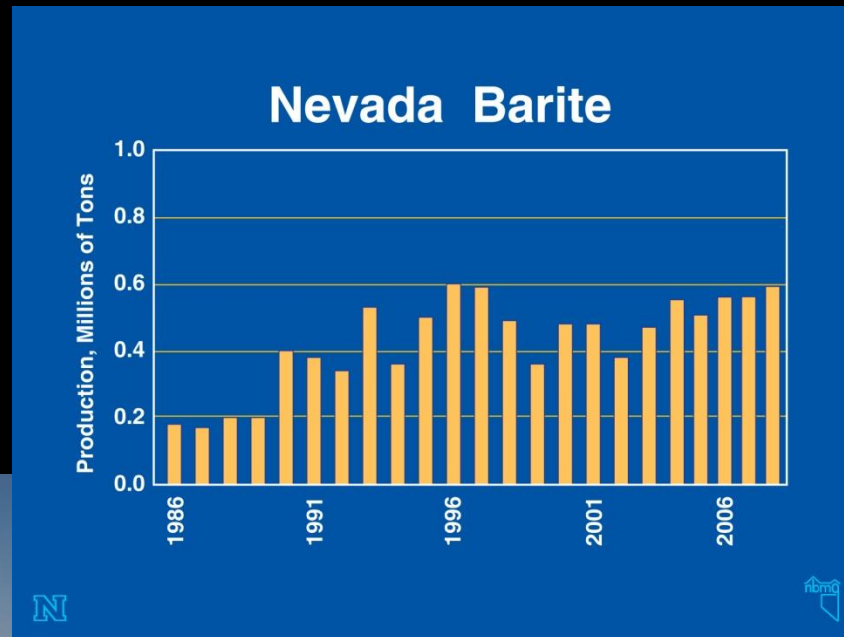
Also off any trend

Round Mountain Mine =  
414,941 oz of Au in 2009

X Metals (mostly Au, Cu, Ag)



Nevada is a significant producer of other **(energy-related)** mineral resources (e.g., lithium, barite, copper, silver).



390,000-year-old cinder cone

Lithium-brine evaporation pond,  
Silver Peak, Clayton Valley, NV (2008)



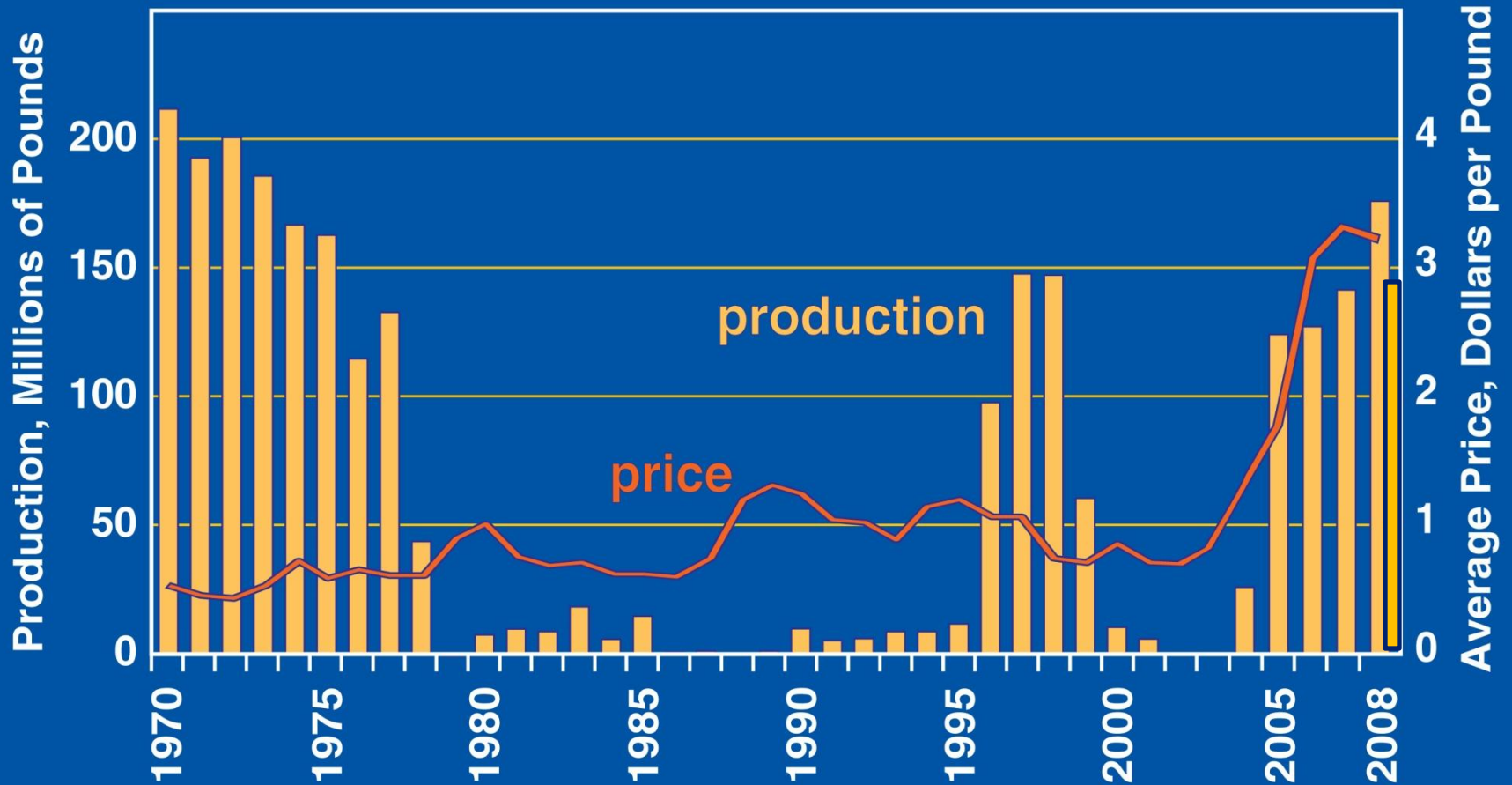
Gold, Round Mountain, NV (2007)

**Lithium mining – unconventional; extraction of brine from wells, concentration by solar evaporation in ponds, in Clayton Valley, Esmeralda County.**

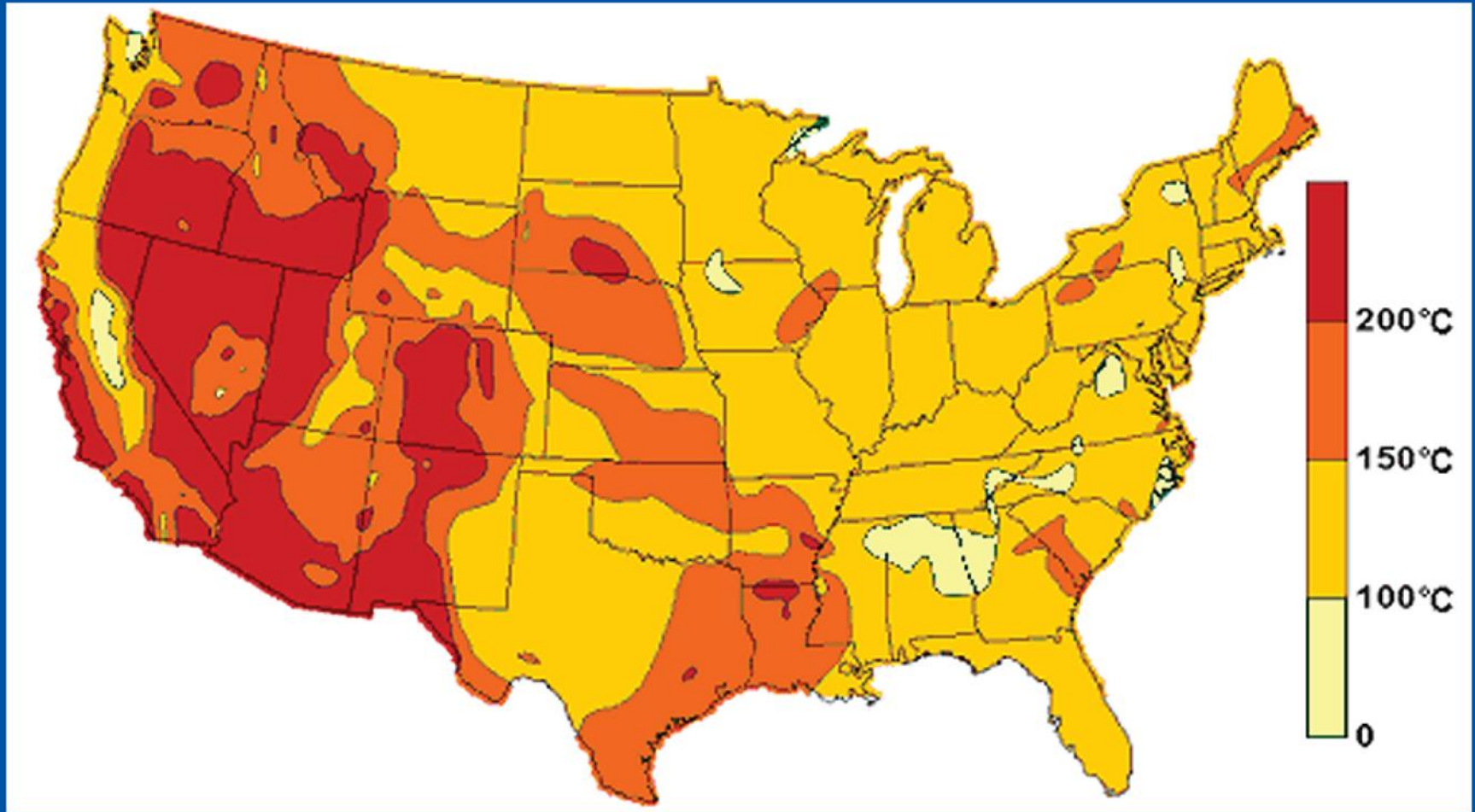
**This is the only active lithium-mining operation in the United States. Lithium is needed for light-weight batteries.**



# Nevada Copper



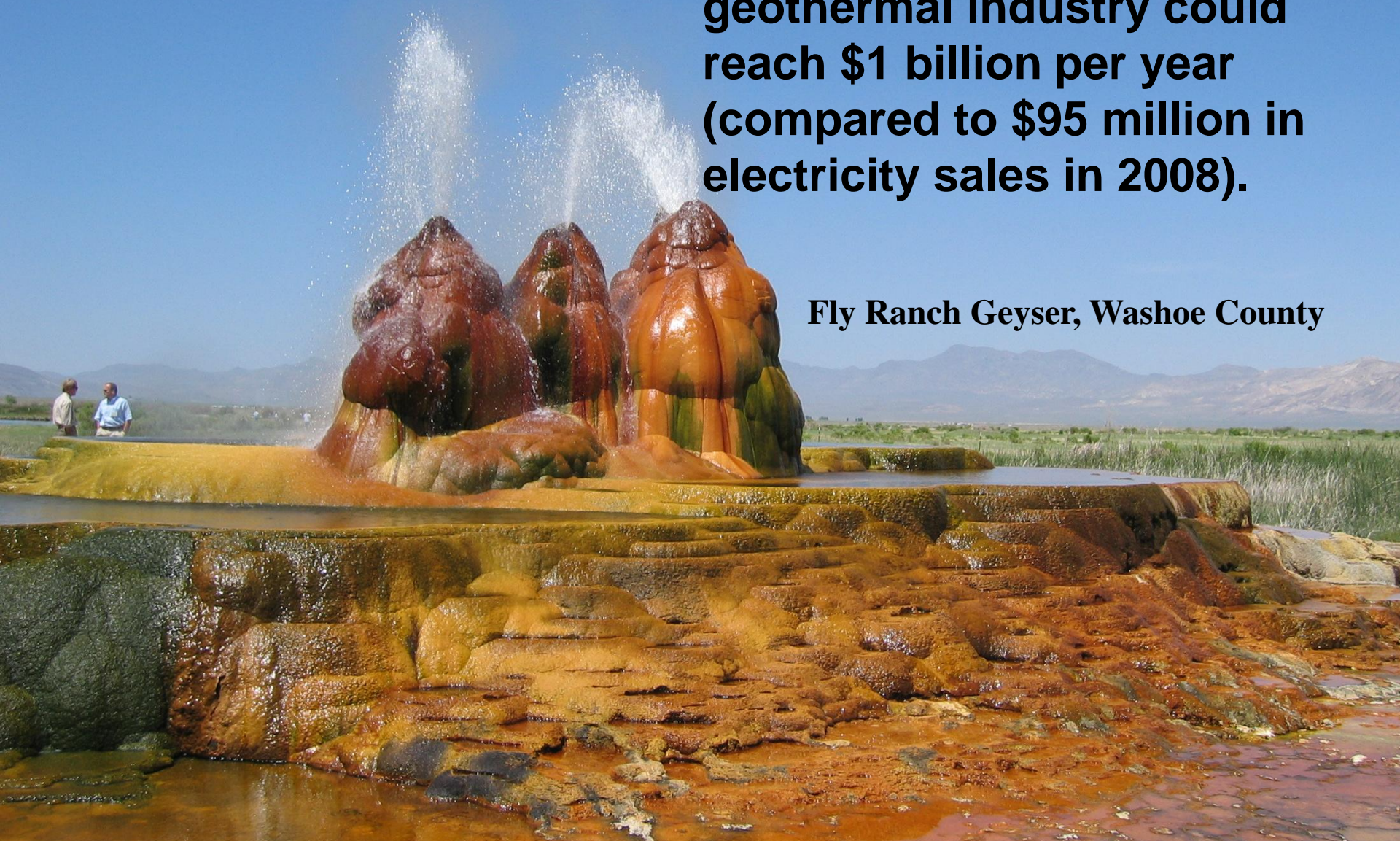
# U.S. Geothermal Resources



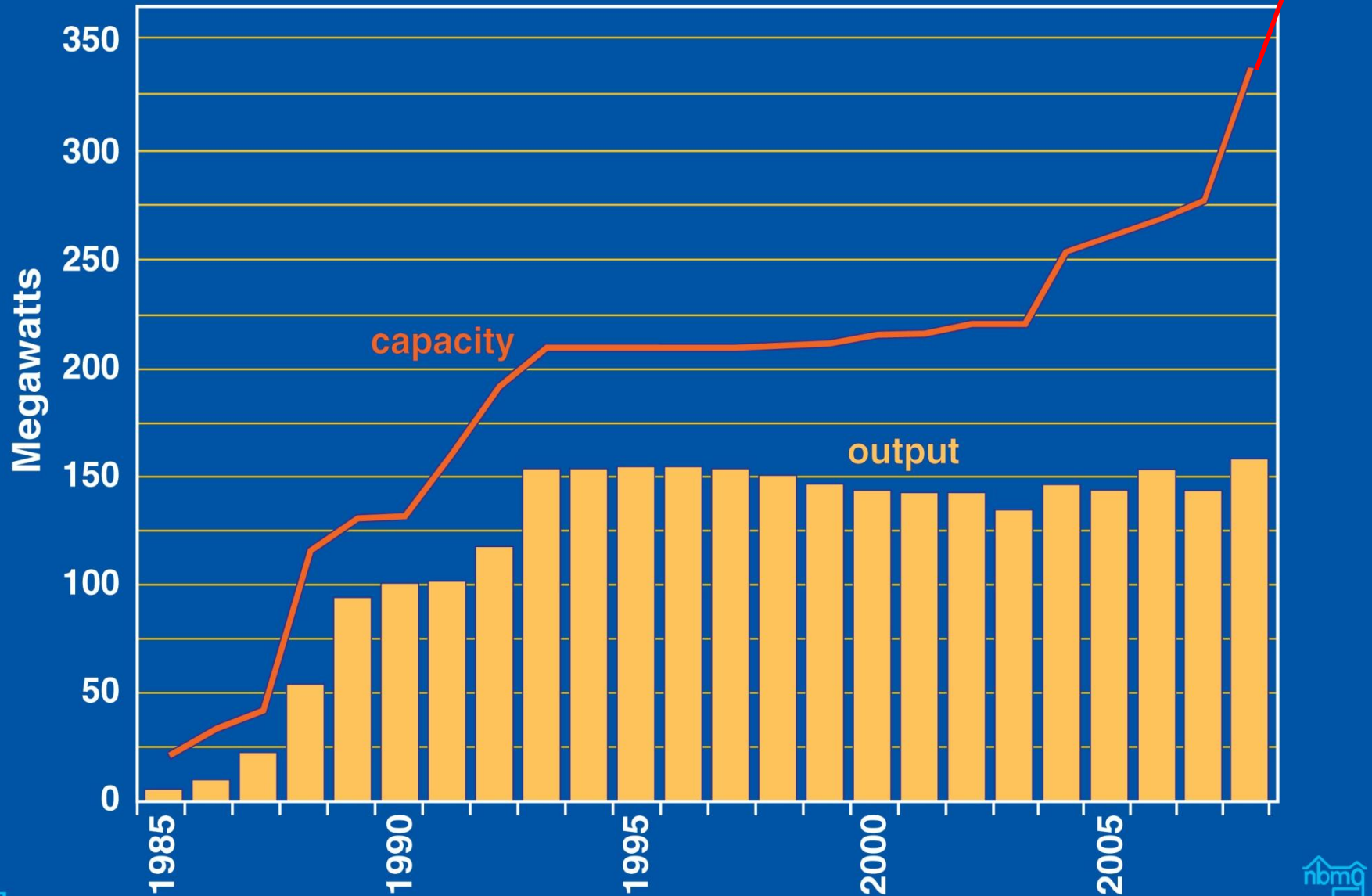
**High-temperature geothermal resources are mostly in the west, where there is active faulting or active volcanism.**

**Given the resource potential and likely rise in energy prices in coming decades, Nevada's geothermal industry could reach \$1 billion per year (compared to \$95 million in electricity sales in 2008).**

**Fly Ranch Geyser, Washoe County**



# Nevada Geothermal Power



# Why Nevada Geology is So Exciting!

## 2. The hazards



Collapse of unreinforced masonry building,  
Wells, 21 February 2008,  
magnitude 5.0 earthquake



Damage to water flume, Mogul,  
25 April 2008, magnitude 5.0 earthquake

Photos by C. dePolo, NBMG

An aerial photograph showing a multi-car freight train derailed in a desert wash. The train consists of several green and white boxcars. Some cars are still on the tracks, while others have rolled off and are lying on their sides in the muddy, rocky floodwater. The surrounding landscape is arid with sparse green shrubs and trees. The sky is clear and blue.

## Meadow Valley Wash, January 2005

(photo courtesy of Gale Fraser, Clark County Regional Flood Control District)

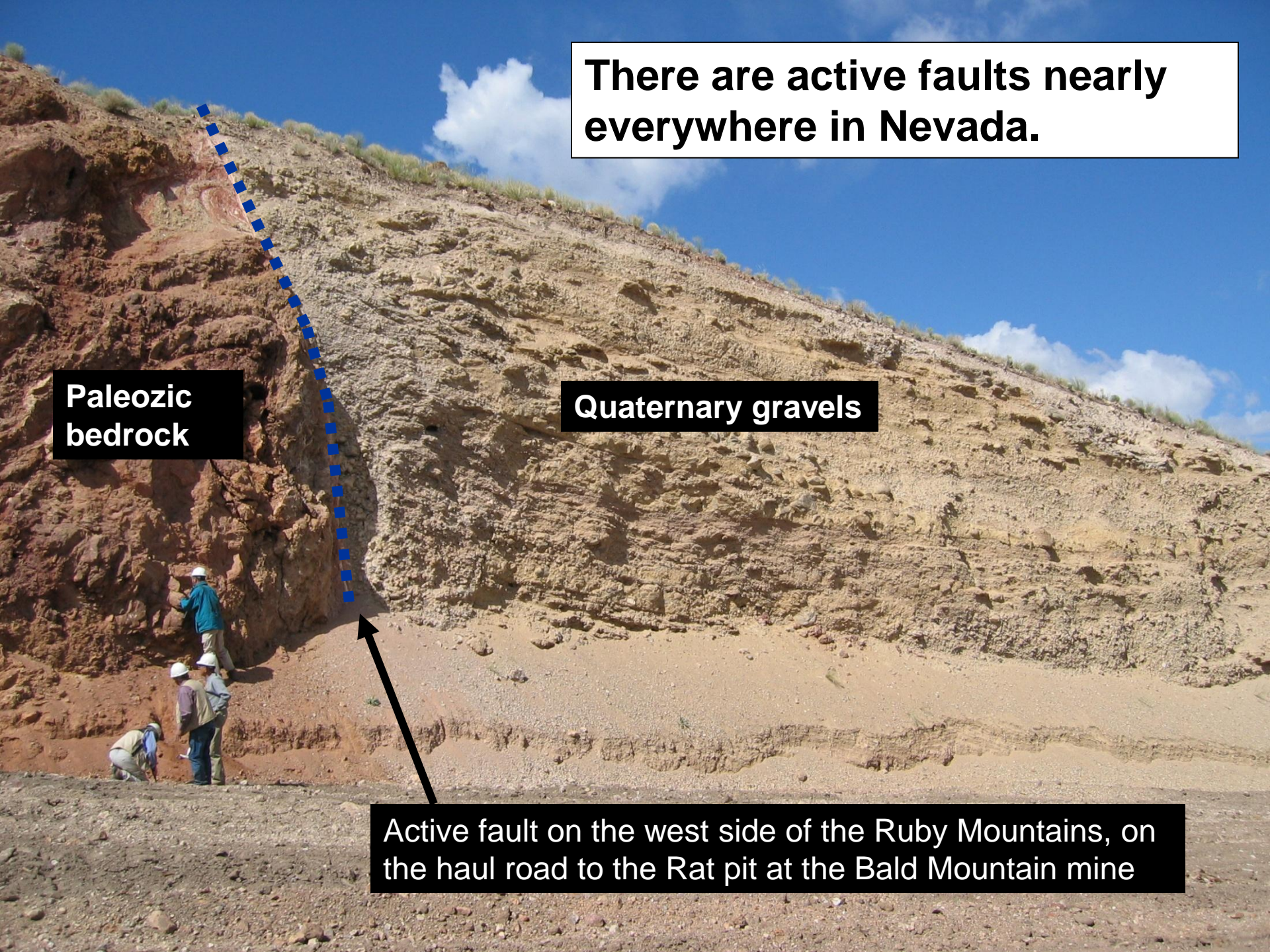
**Floods are fairly common,  
even in the Nevada desert.**

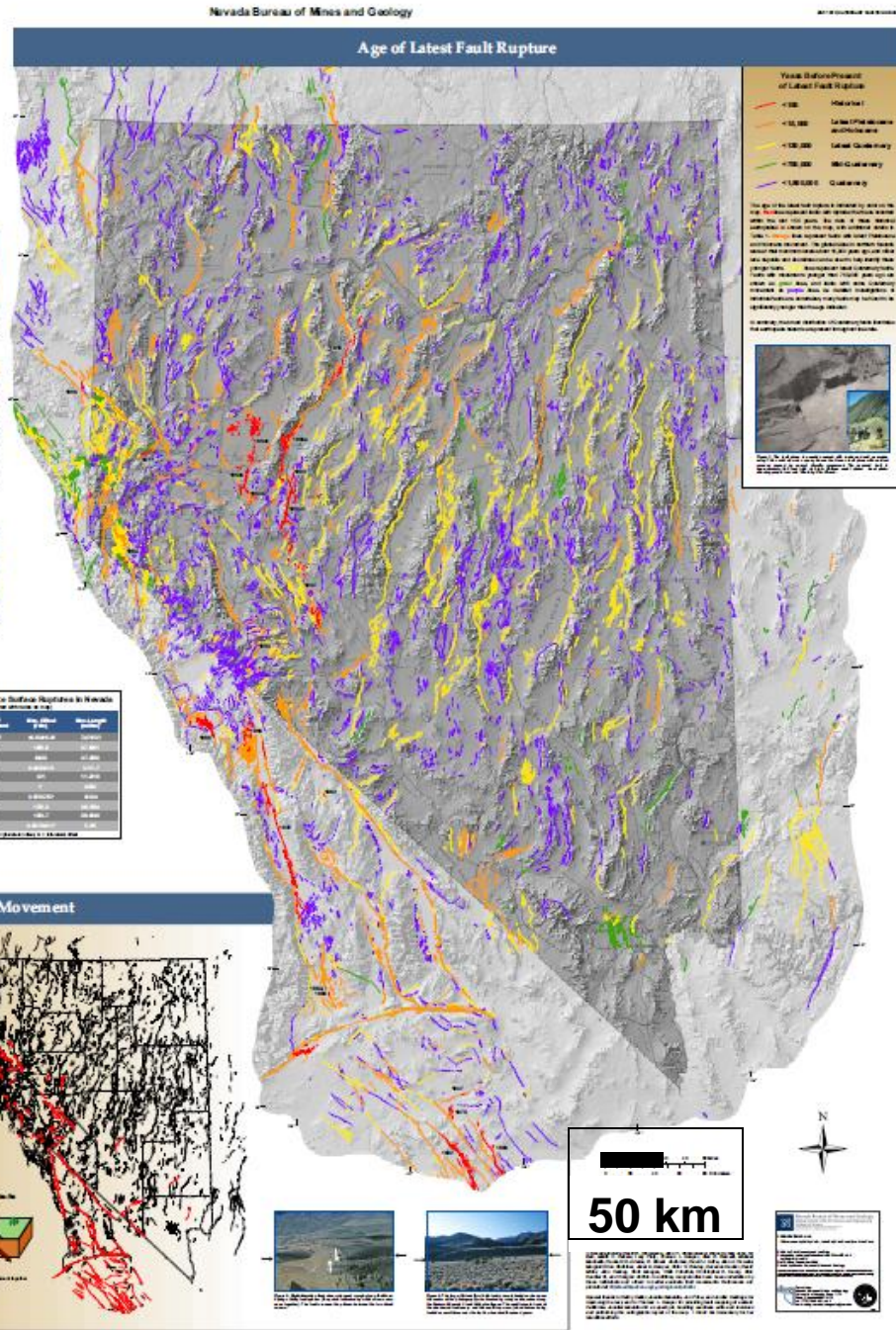
**There are active faults nearly everywhere in Nevada.**

**Paleozoic  
bedrock**

**Quaternary  
gravels**

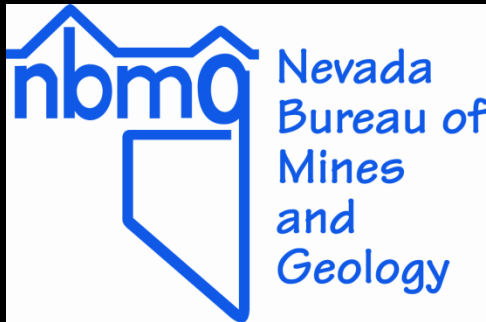
**Active fault on the west side of the Ruby Mountains, on  
the haul road to the Rat pit at the Bald Mountain mine**





**Earthquake faults occur throughout Nevada,  
and potential losses from earthquakes are high  
for many communities.**

**NBMG Map 167, *Quaternary Faults in Nevada*, is now  
available not only as a poster but also as an interactive  
map (Open-File Report 09-9) on line at  
[www.nbm.unr.edu](http://www.nbm.unr.edu). You can use it to locate your home  
or business.**



Look for a fault | Find Address

Display faults, colored by age of most recent movement, on topographic or aerial photographic base maps.

## Results

- ☒ 1001 E 9th Street, Reno, NV
- ☒ 1001 E 9th St, Reno, NV

## Map Contents

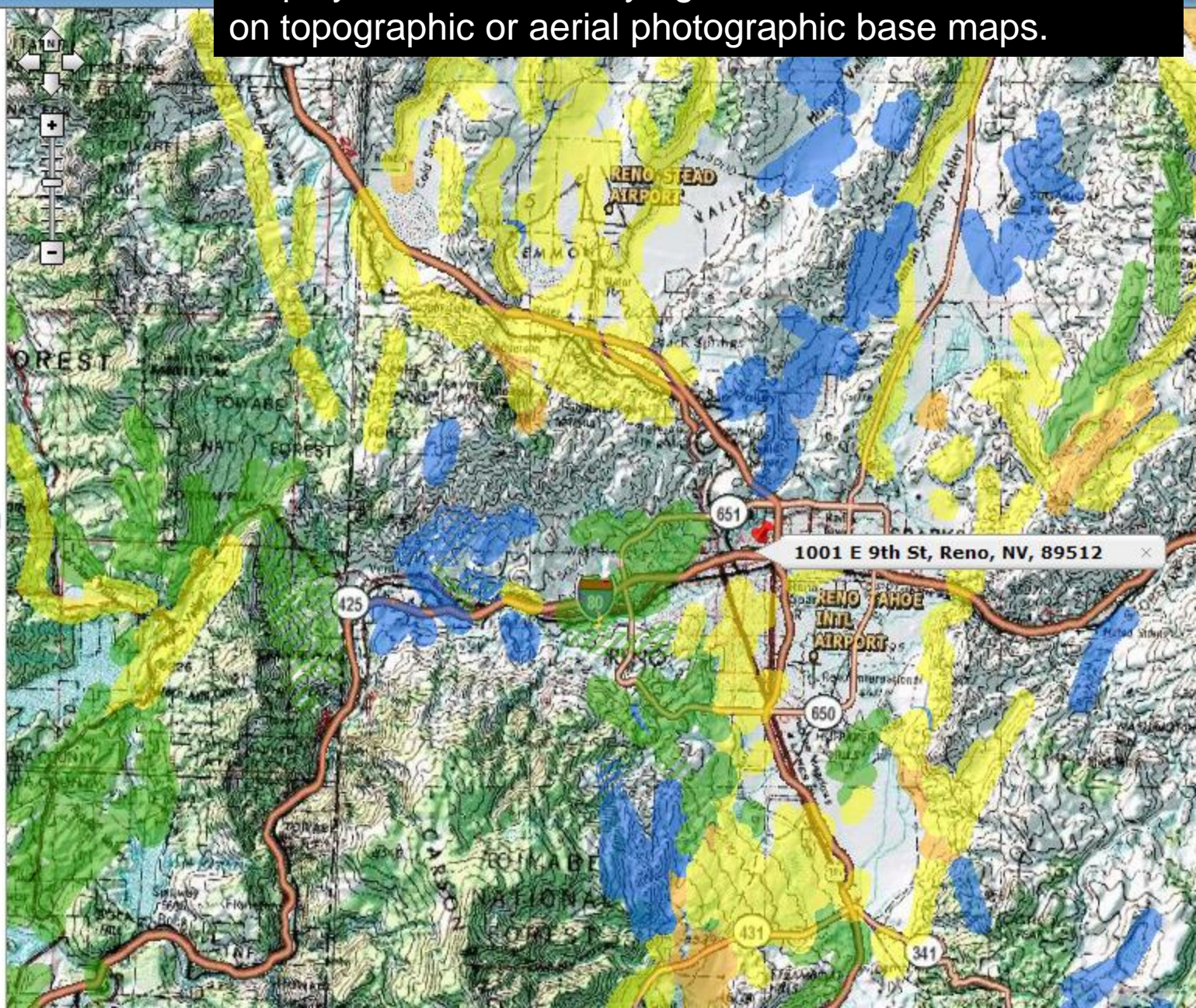
- ☒ Quaternary\_Faults

### Legend

- ☒ Historic - within the last 10,000 years
- ☒ Historic - within the last 10,000 years
- ☒ latest Pleistocene
- ☒ latest Pleistocene
- ☒ late Quaternary - within the last 10,000 years
- ☒ late Quaternary - within the last 10,000 years
- ☒ middle Quaternary - within the last 10,000 years
- ☒ middle Quaternary - within the last 10,000 years
- ☒ Quaternary - within the last 10,000 years
- ☒ Quaternary - within the last 10,000 years

### Base Data

- ☒ 9i10glj\_TOPO\_data
- ☒ Base Data
- ☒ USGS\_aerial\_photograph
- ☒ Base Data



Look for a fault | Find Address

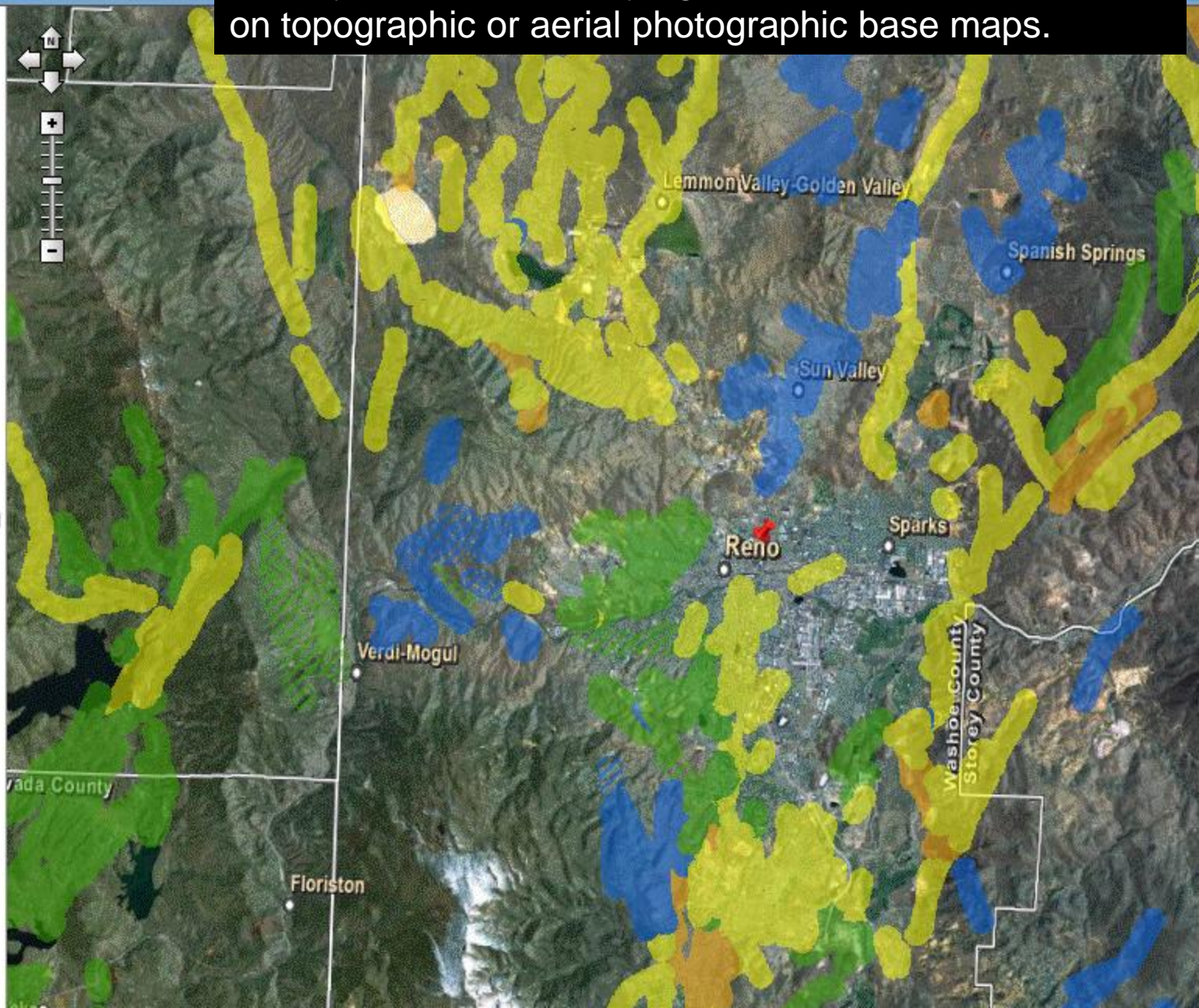
Display faults, colored by age of most recent movement, on topographic or aerial photographic base maps.

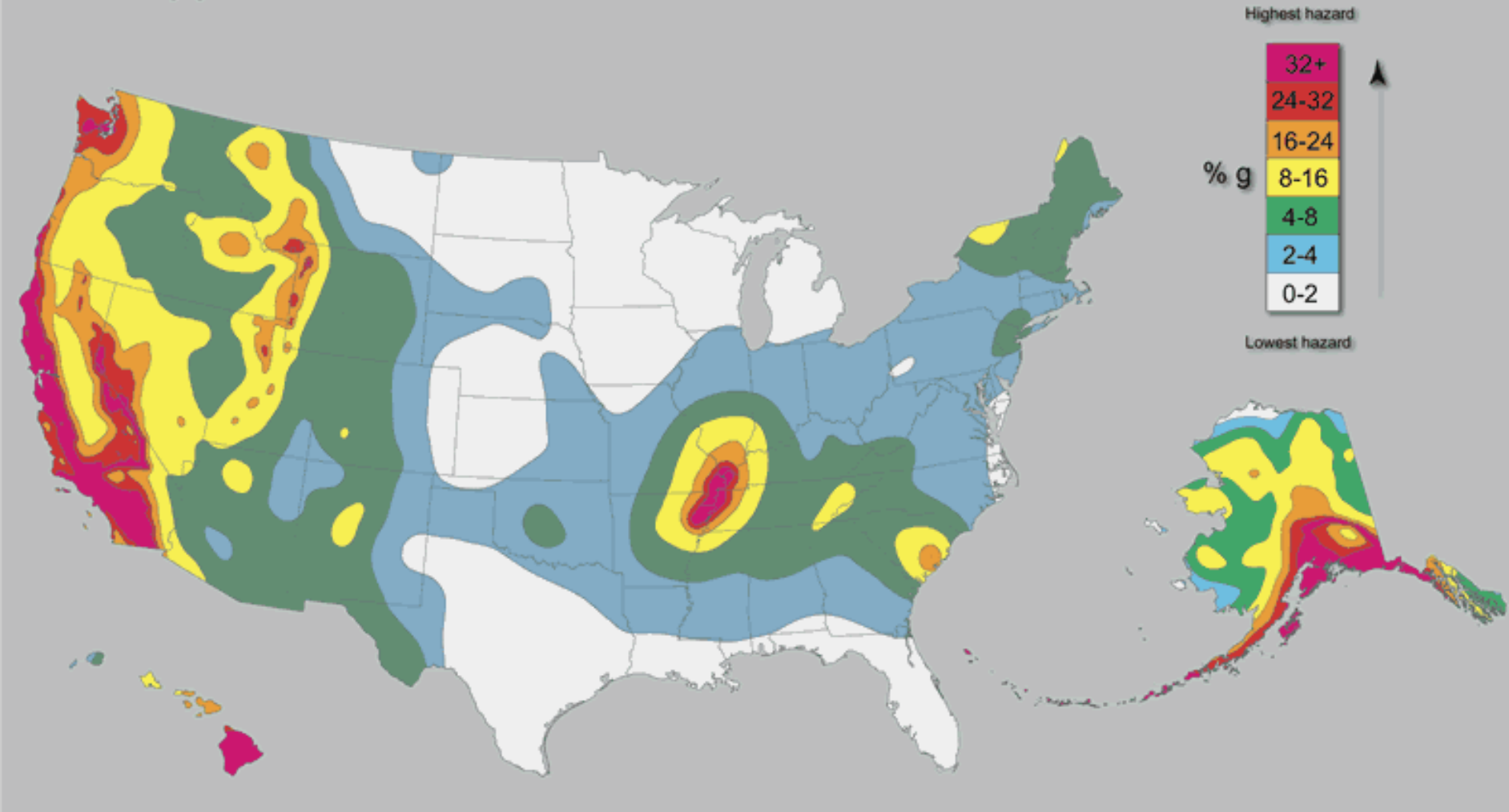
Results

- ☒ 1001 E 9th Street, Reno
- ☒ 1001 E 9th St, Reno,

Map Contents

- ☒ Quaternary\_Faults
  - Legend
    - Historic - within the
    - Historic - within the
    - latest Pleistocene
    - latest Pleistocene
    - late Quaternary -
    - late Quaternary -
    - middle Quaternary
    - middle Quaternary
    - Quaternary - within
    - Quaternary - within
  - ☐ Base Data
- ☐ 9i10glj\_TOPO\_data
  - ☐ Base Data
- ☒ USGS\_aerial\_photograph
  - ☒ Base Data



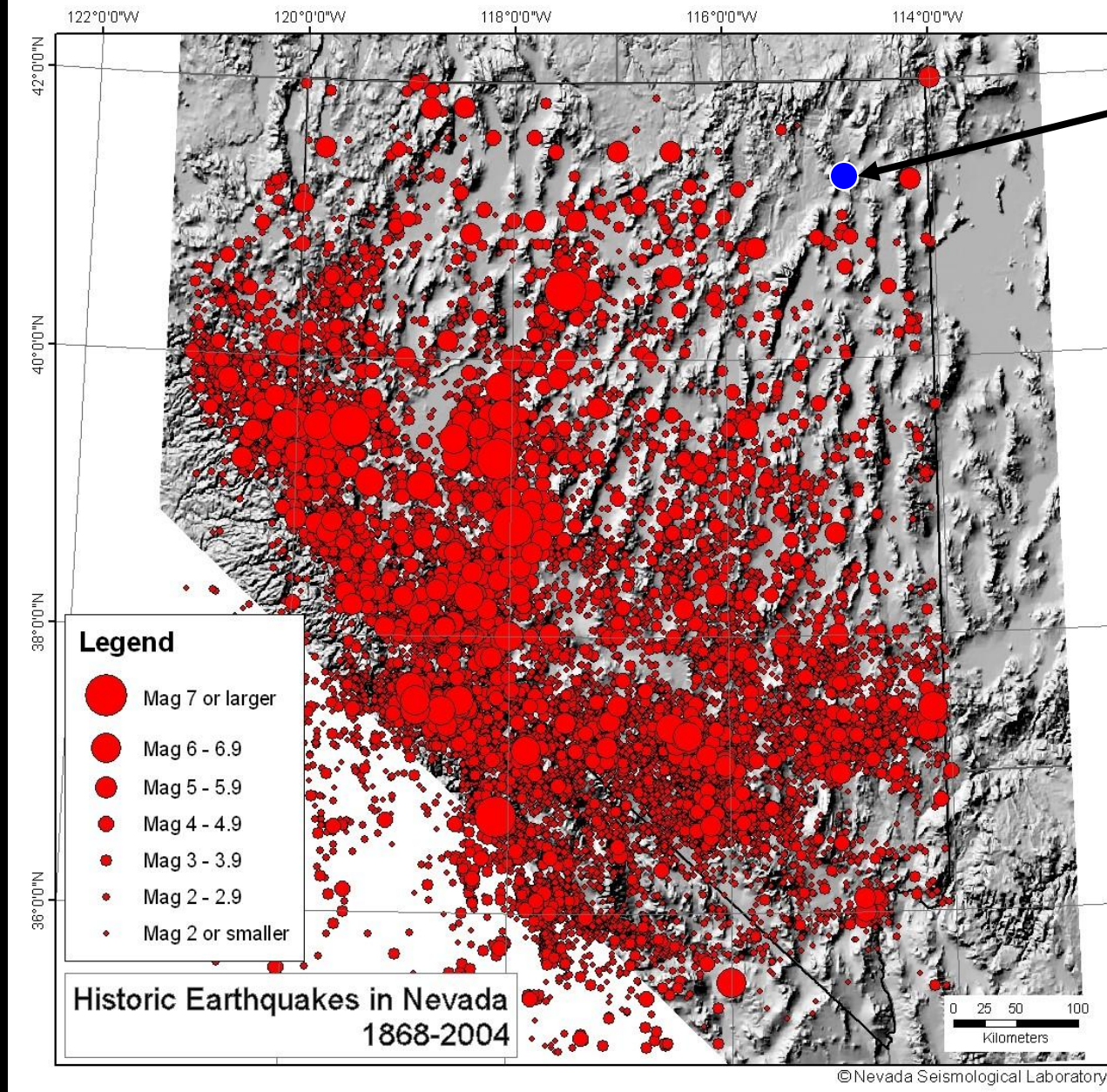


**The USGS integrates (1) fault, (2) earthquake, and (3) geodetic data into its probabilistic seismic hazard analysis.**



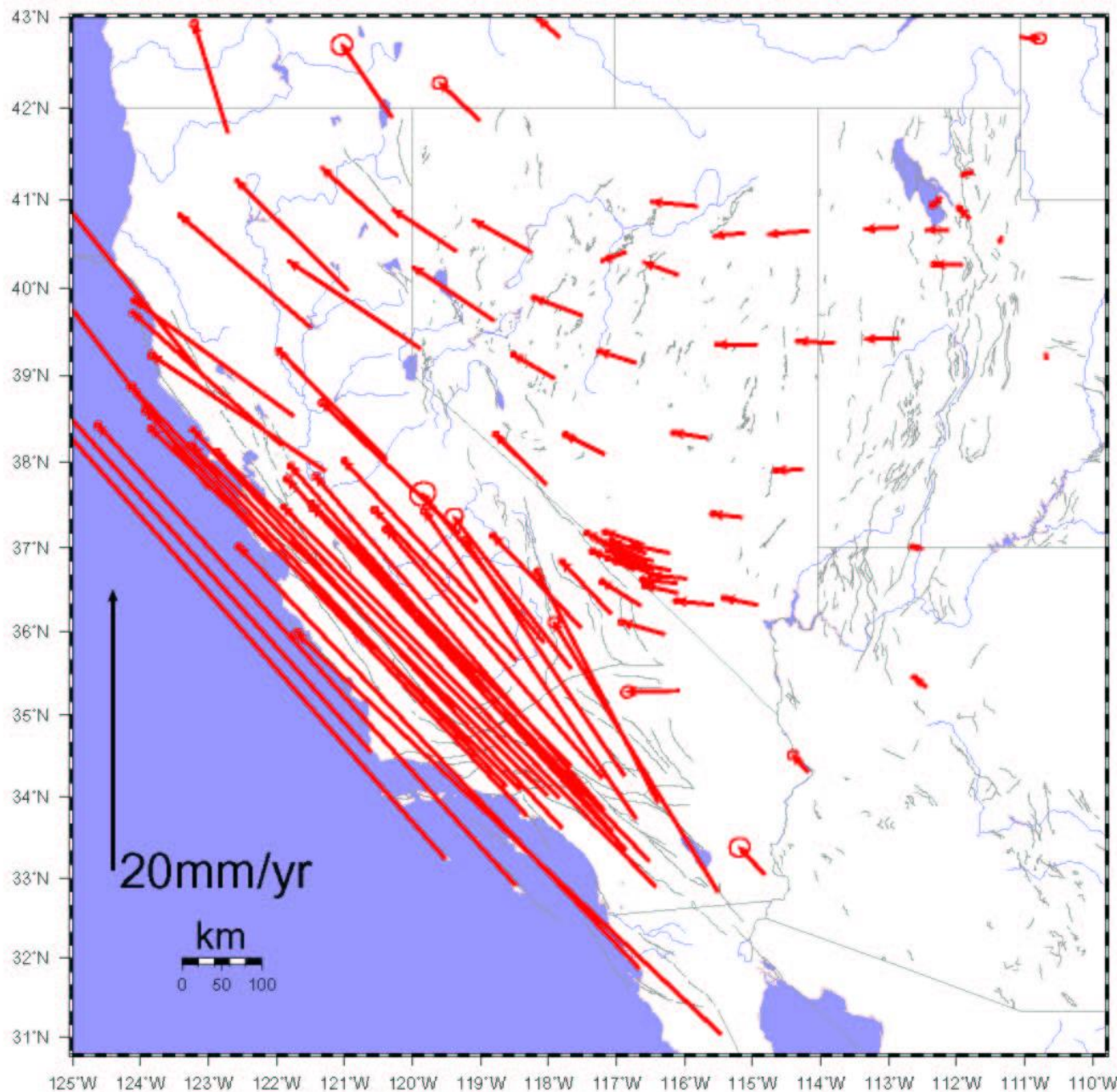
**(1) Active faults occur nearly everywhere in Nevada, including Washoe County.**

This is a topographic map of Nevada, showing the state's terrain with shaded relief. Overlaid on the map are numerous active faults, represented by colored lines. Purple lines are the most numerous and are distributed across the entire state. Yellow and orange lines are also widespread, often following major mountain ranges and valleys. Green lines are less frequent and appear in specific regions. The map includes labels for major geographical features such as the Owyhee Desert in the northeast, the Sierra Nevada in the west, and various valleys like the Lahontan Valley and the Great Salt Lake Valley. Several earthquake epicenters are marked with red dots and labeled with years: 1950, 1877, 1954a, 1954b, 1954c, 1954d, 1954e, 1903, and 1915. A black box with white text is positioned in the upper right quadrant of the map.



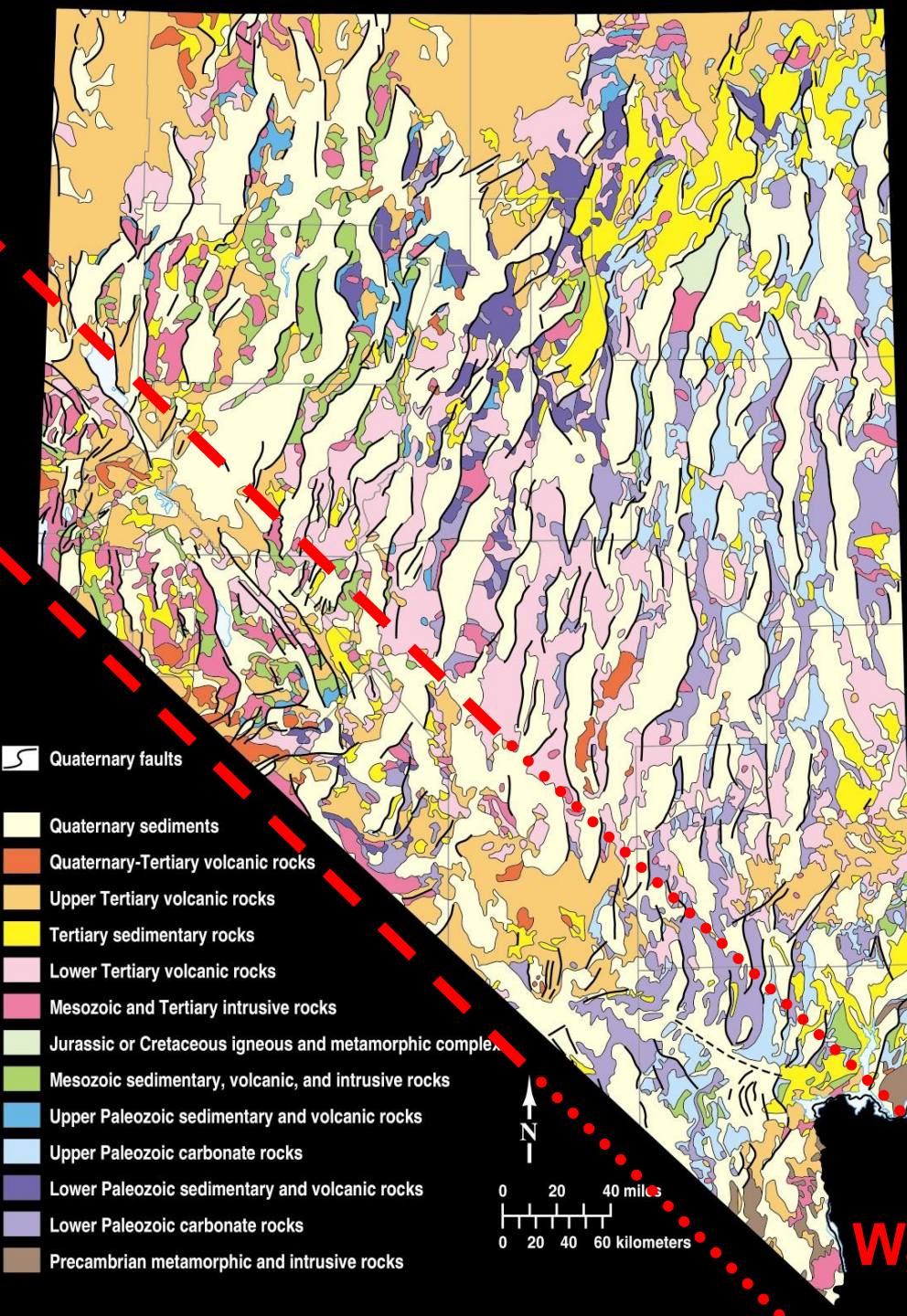
**Wells**  
**21 Feb 08**  
**M = 6.0**

**(2) Earthquakes have occurred throughout Nevada.**



**(3) Geodetic data indicate that the Basin and Range province is gaining about 1.3 acres of area per year through crustal extension, and that western Nevada is accommodating ~20% of the North American-Pacific plate interaction.**

**Kreemer and Hammond (2007)**



In Nevada, much of the right-lateral shear between the North American and Pacific plates occurs along northwest-striking strike-slip faults of the Walker Lane.

Extension largely is accommodated along N- to NE-striking, basin-bounding normal faults.

**Walker Lane**

# The hazard: expressed in terms of probability of an earthquake of a given magnitude occurring within 50 years and within 50 km of the community.

Community	% Probability of magnitude greater than or equal to magnitude				
	5.0	5.5	6.0	6.5	7.0
Dayton	>90	~80	70-75	50-55	12-15
Carson City	>90	~80	70	50-55	12-15
Reno	>90	~80	67	50	12-15
<b>Sparks</b>	<b>&gt;90</b>	<b>~80</b>	<b>67</b>	<b>50</b>	<b>12-15</b>
Incline Village	>90	~80	60-70	40-50	10-12
Stateline	>90	~80	60-70	40-50	10
Fallon	80-90	~60	35	20-25	6-8
Gerlach	40	~25	10-15	6-10	2-3
Las Vegas	40-50	~30	12	4-5	<0.5
Elko	30-40	~25	10-15	6-8	0.5-1
Wells	30-40	~20	9	6	0.5-1
Laughlin	10-20	~5	2-3	0.5-1	<0.5

Data are from the USGS at <http://eqint.cr.usgs.gov/eqprob/2002/index.php> .  
 Values for magnitude 5.5 are extrapolated between 5.0 and 6.0.

**Earthquake risks in Nevada are assessed by the Nevada Bureau of Mines and Geology using the Federal Emergency Management Agency's loss-estimation model, HAZUS-MH, and the U.S. Geological Survey's probabilistic seismic hazard analysis.**

**NBMG Open-File Report 09-8, *Estimated Losses from Earthquakes near Nevada Communities*, contains HAZUS scenarios for magnitude 5.0, 5.5, 6.0, 6.5, and 7.0 earthquakes near 38 communities in Nevada.**

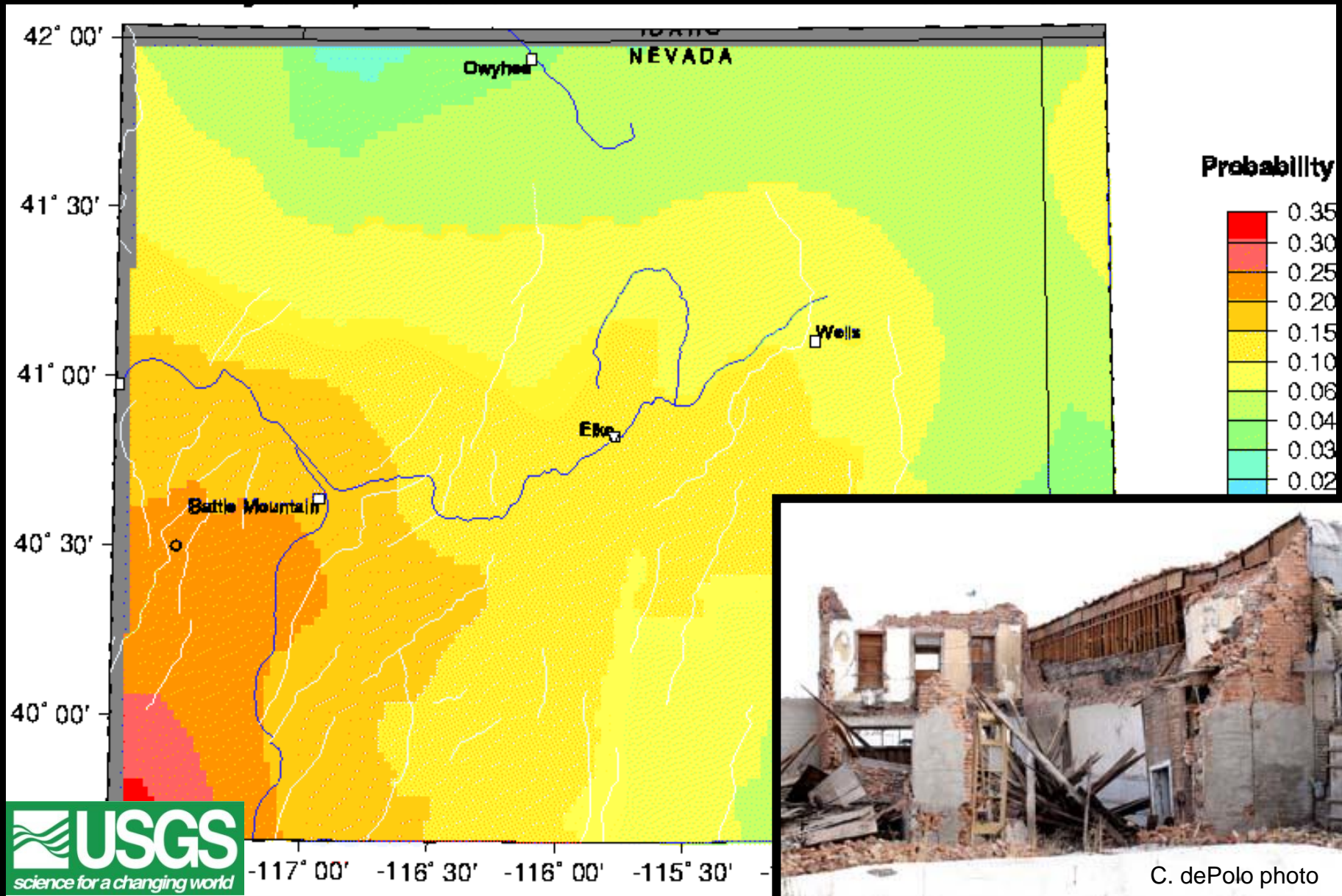
**Uncertainties in the location of epicenters, depths, and magnitude, when combined with changing population and uncertainties in local effects (soil and rock types, assumptions about attenuation, basin geometry, liquefaction potential, and directivity), make loss estimates generally consistent within one order of magnitude (a factor of 10), although experience with urban earthquakes in the US has generally yielded numbers within a factor of 2 or 3 of the actual damages.**

**HAZUS estimates for total economic loss from a magnitude 6.0 earthquake and probability of an earthquake of this magnitude or greater occurring within 50 years and within 50 km of the community.**

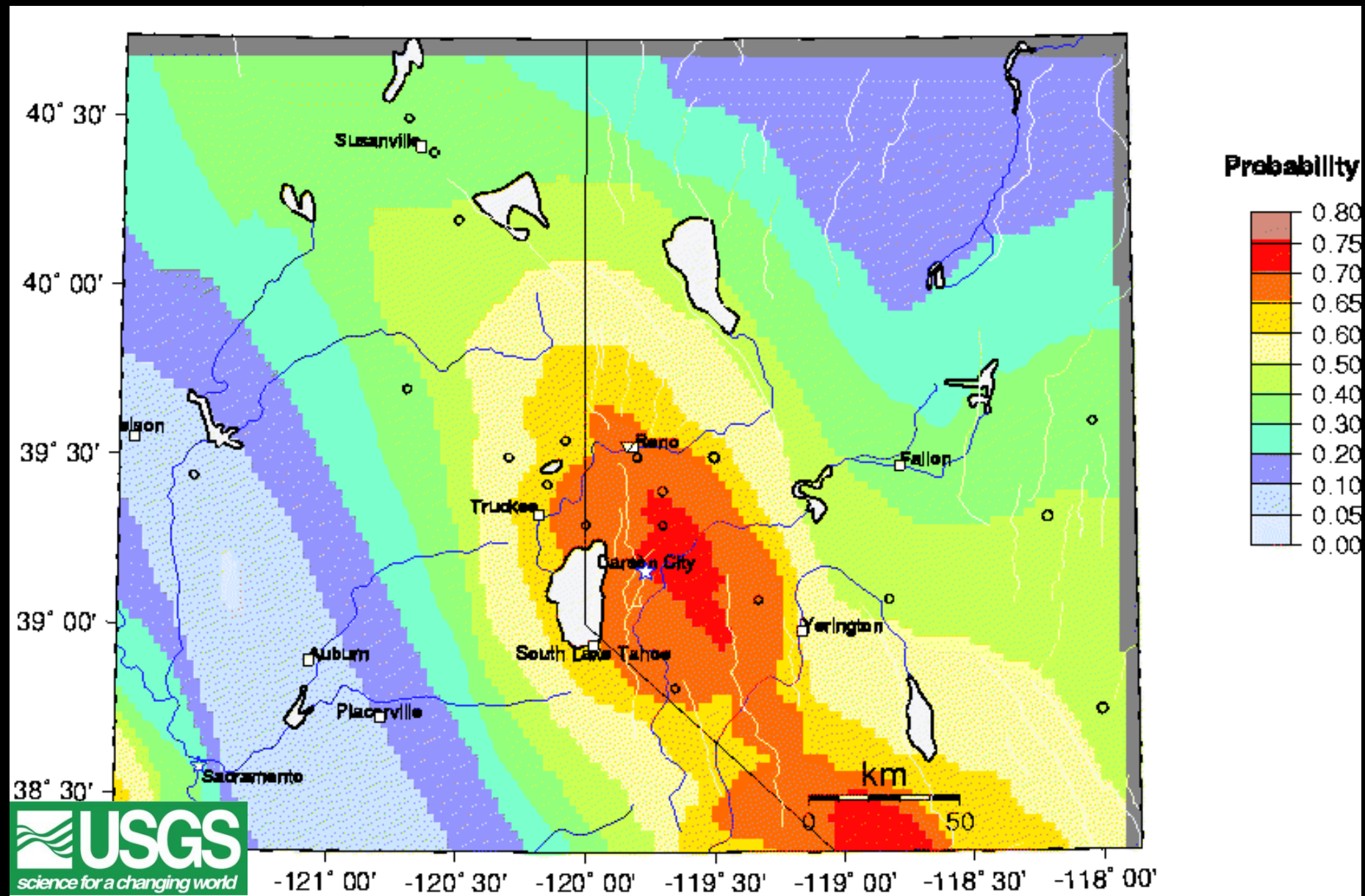
<b>Community</b>	<b>Total Economic Loss</b>	<b>Probability in 50 years within 50 km</b>
<b>Las Vegas</b>	<b>\$7.2 billion</b>	<b>12%</b>
<b>Reno</b>	<b>\$1.9 billion</b>	<b>67%</b>
<b>Sparks</b>	<b>\$1.8 billion</b>	<b>67%</b>
<b>Incline Village</b>	<b>\$510 million</b>	<b>60 to 70%</b>
<b>Elko</b>	<b>\$160 million</b>	<b>10 to 15%</b>
<b>Fallon</b>	<b>\$110 million</b>	<b>35%</b>
<b>Gerlach</b>	<b>\$39 million</b>	<b>10 to 15%</b>
<b>Wells</b>	<b>\$30 million</b>	<b>9%</b>

Total economic loss is from HAZUS. Probabilities are from the USGS at <http://eqint.cr.usgs.gov/eqprob/2002/index.php> .

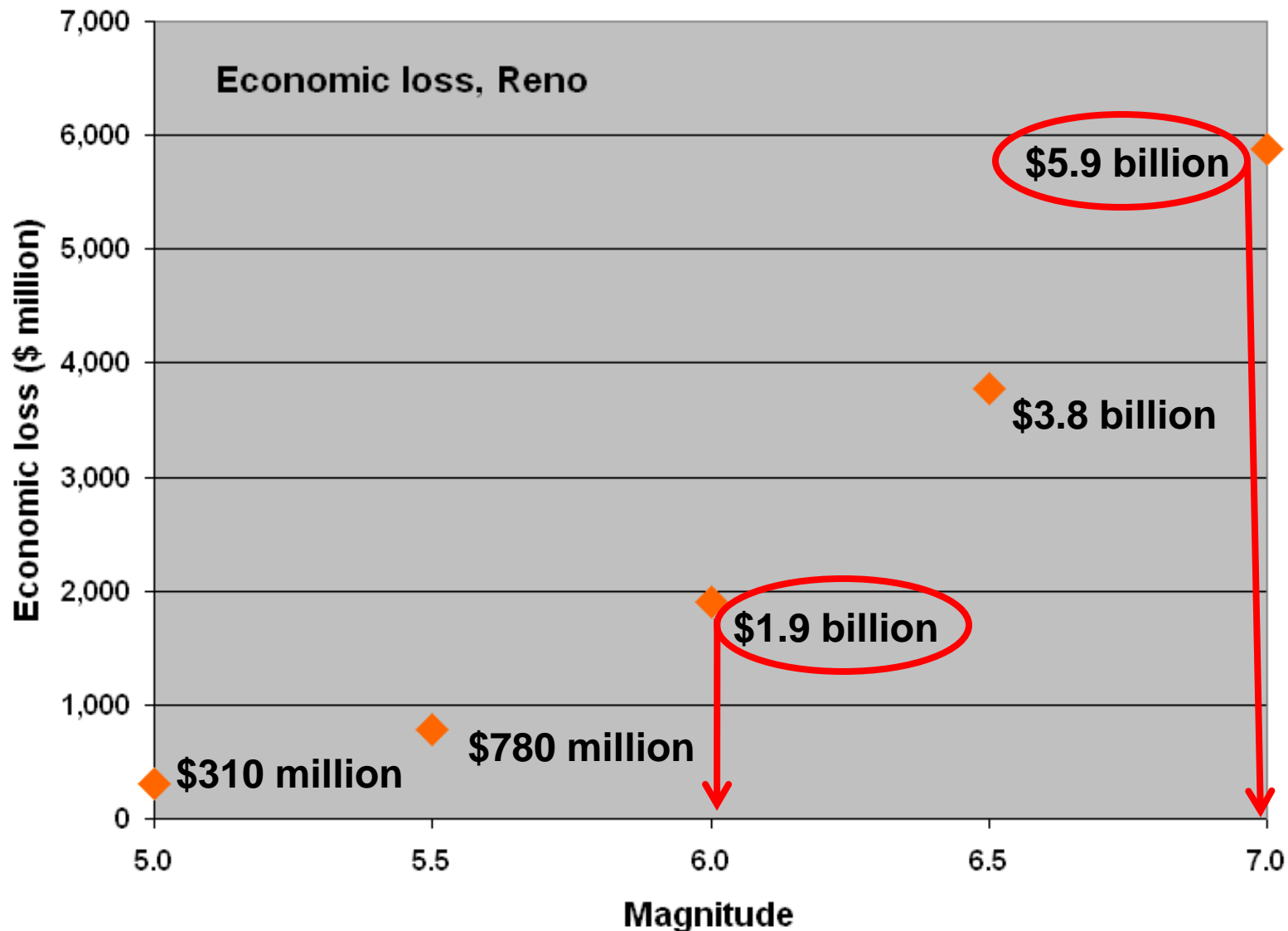
**The probability of a magnitude 6.0 earthquake occurring within 50 km of Wells, Nevada within the next 50 years is approximately 9%.**  
**It happened on 21 February 2008.**



**The probability of a magnitude 6.0 earthquake occurring within 50 km of Reno or Sparks within the next 50 years is approximately 67%, 7.4 times higher than for Wells.**

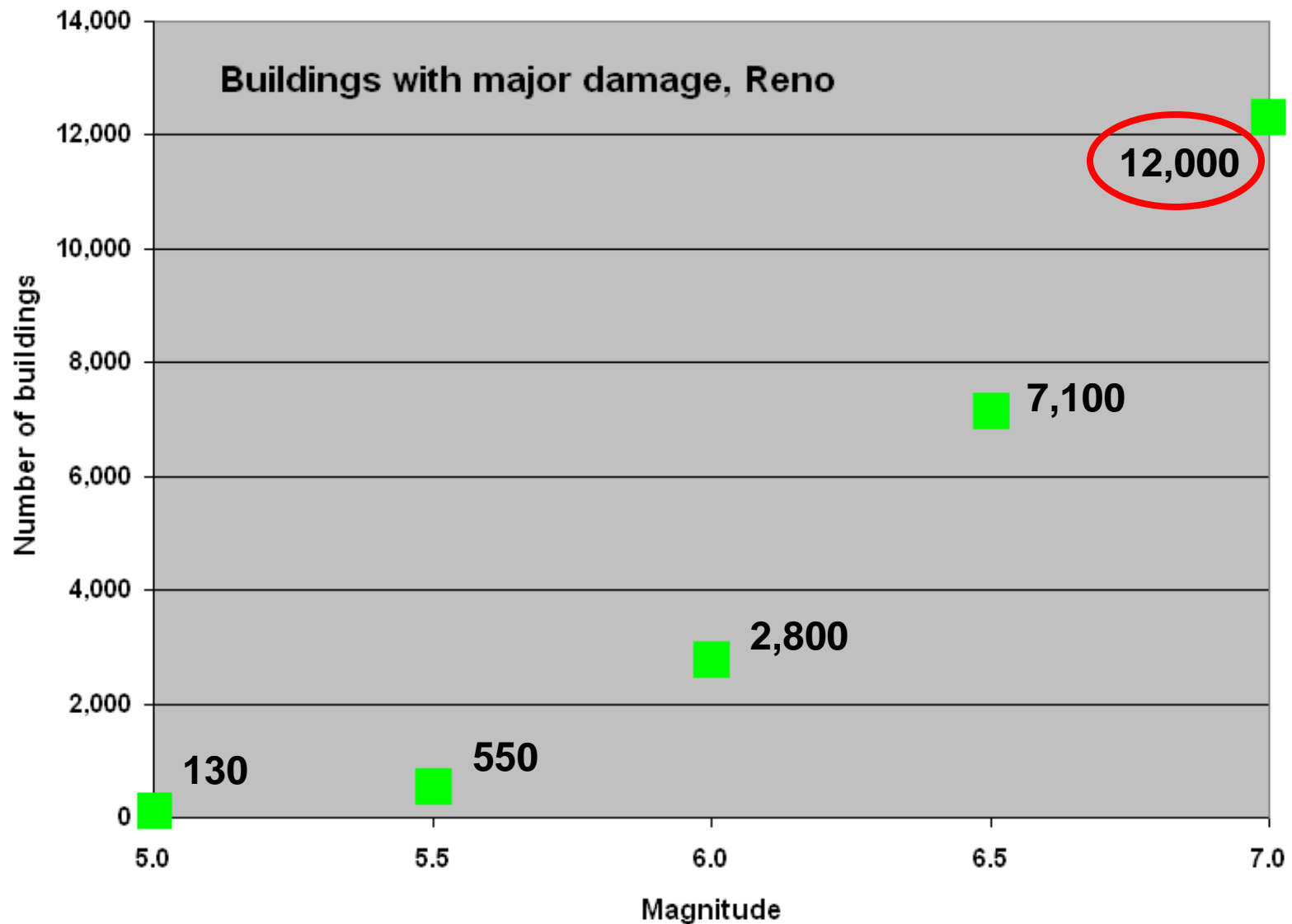


## HAZUS estimates (total) economic loss:



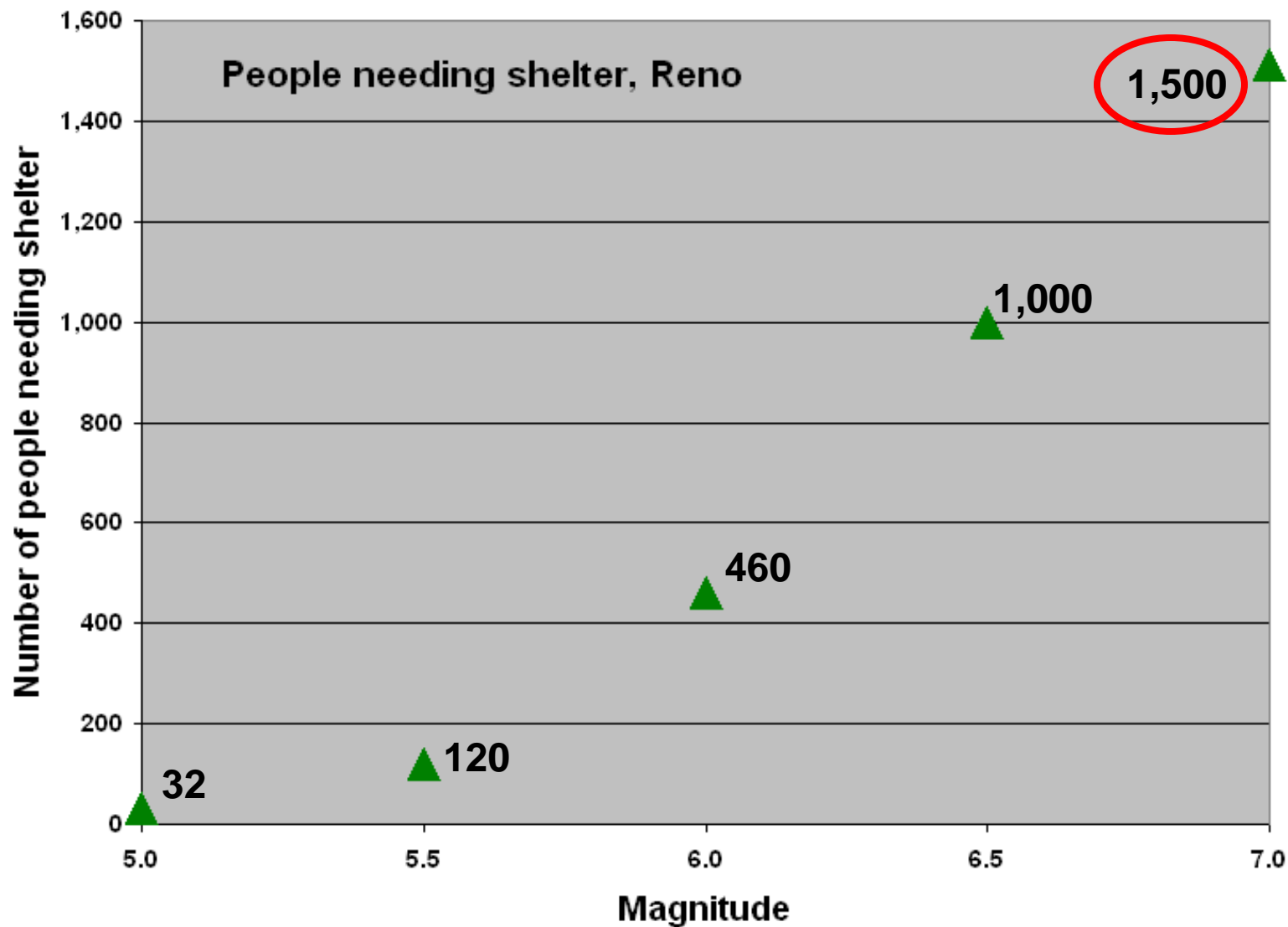
Note that the graphs are similar, but the scale changes with what is at risk.

## HAZUS estimates building damage:



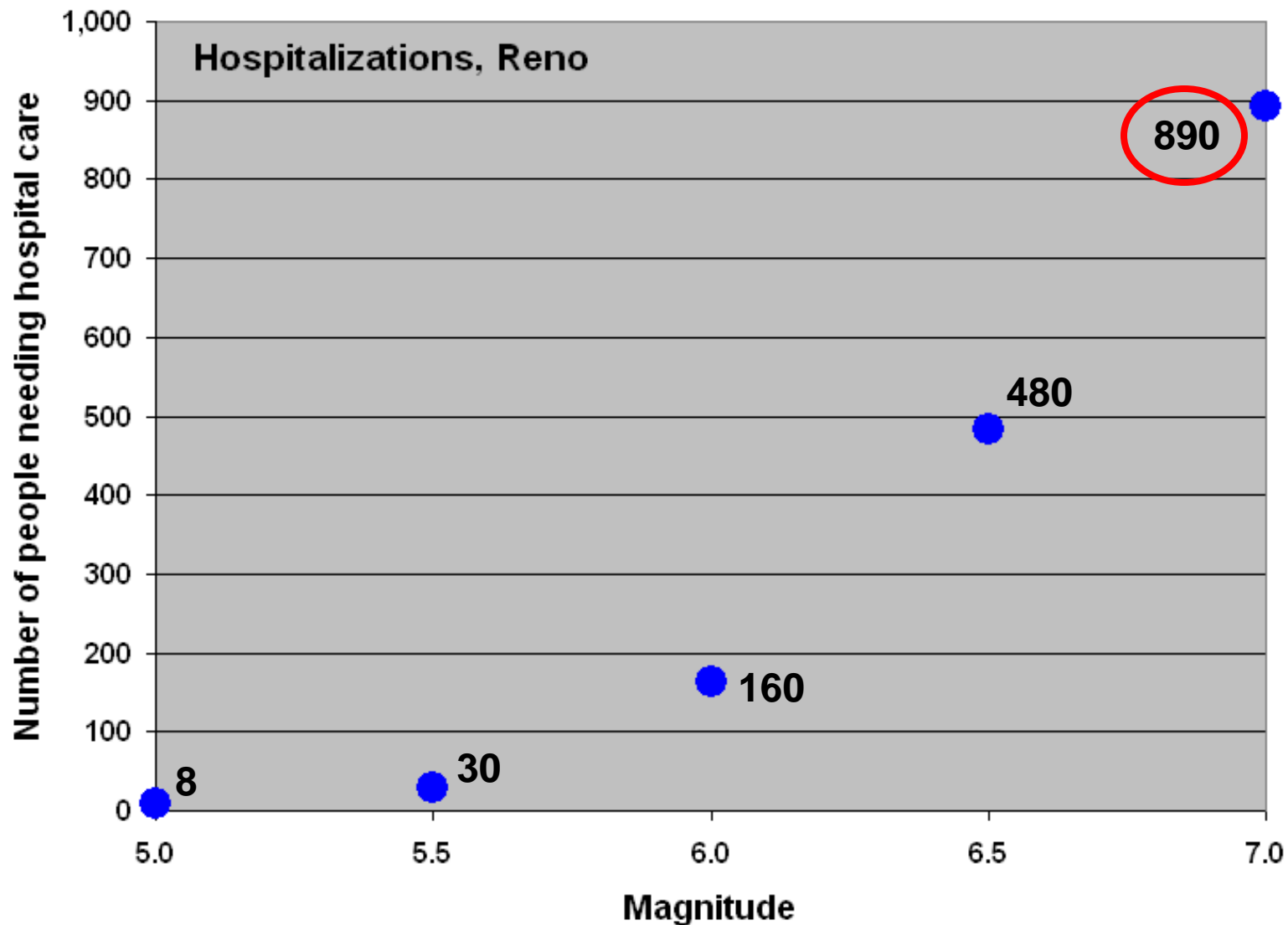
Note that the graphs are similar, but the scale changes with what is at risk.

## HAZUS estimates public shelter needs:



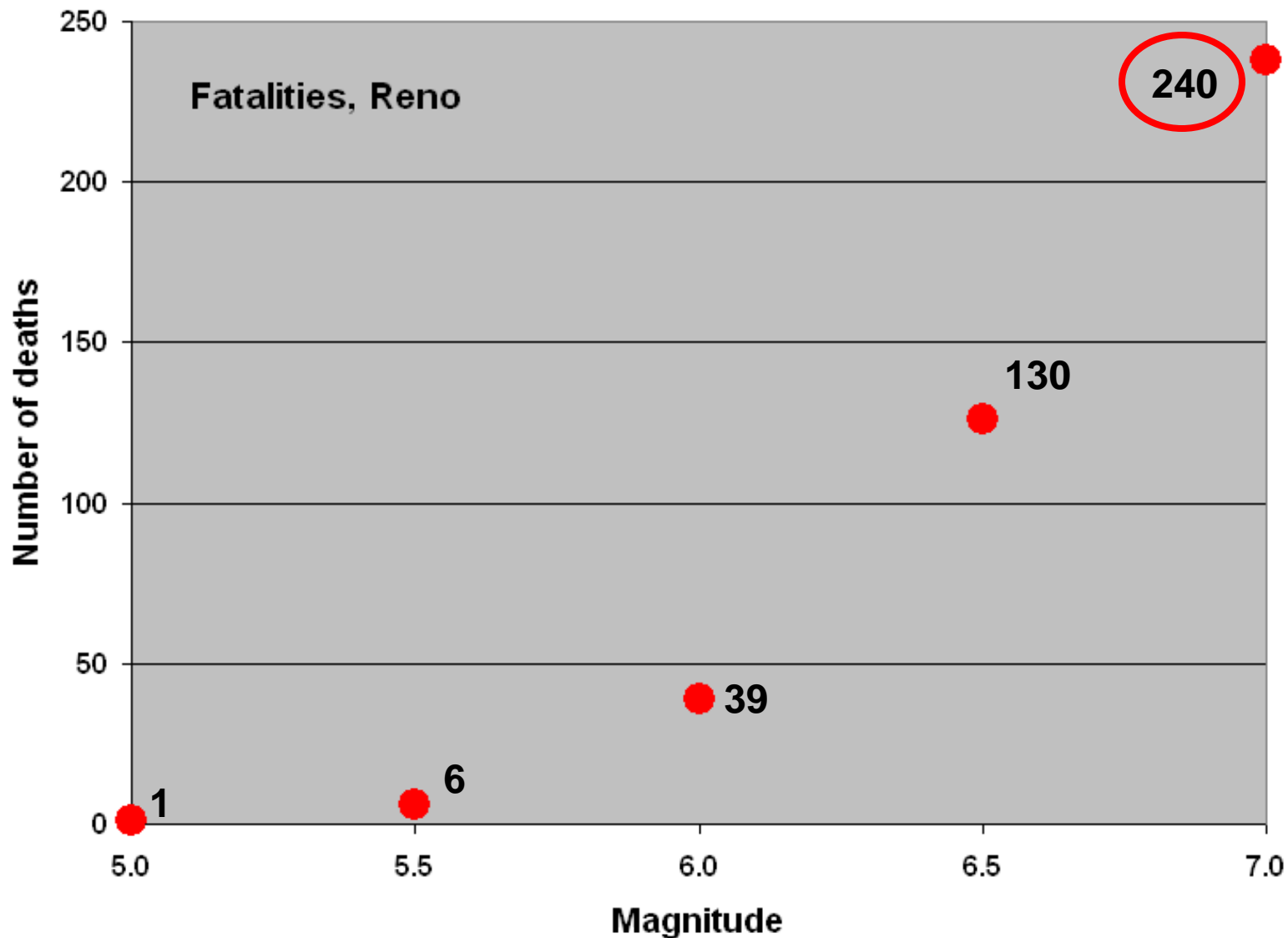
Note that the graphs are similar, but the scale changes with what is at risk.

## HAZUS estimates hospital needs:



Note that the graphs are similar, but the scale changes with what is at risk.

## HAZUS estimates fatalities:



Note that the graphs are similar, but the scale changes with what is at risk.

**Earthquake faults occur throughout Nevada, and potential losses from earthquakes are high for many communities.**

**The consequences of earthquakes can be huge in Nevada, particularly if individuals are not prepared.**

**A. Be prepared to respond.**

**B. Mitigate structural risks, largely through building codes and avoiding faults and areas of liquefaction.**

**C. Mitigate nonstructural risks.**

Unreinforced masonry building (URM)  
that collapsed during the Wells  
earthquake on 21 February 2008



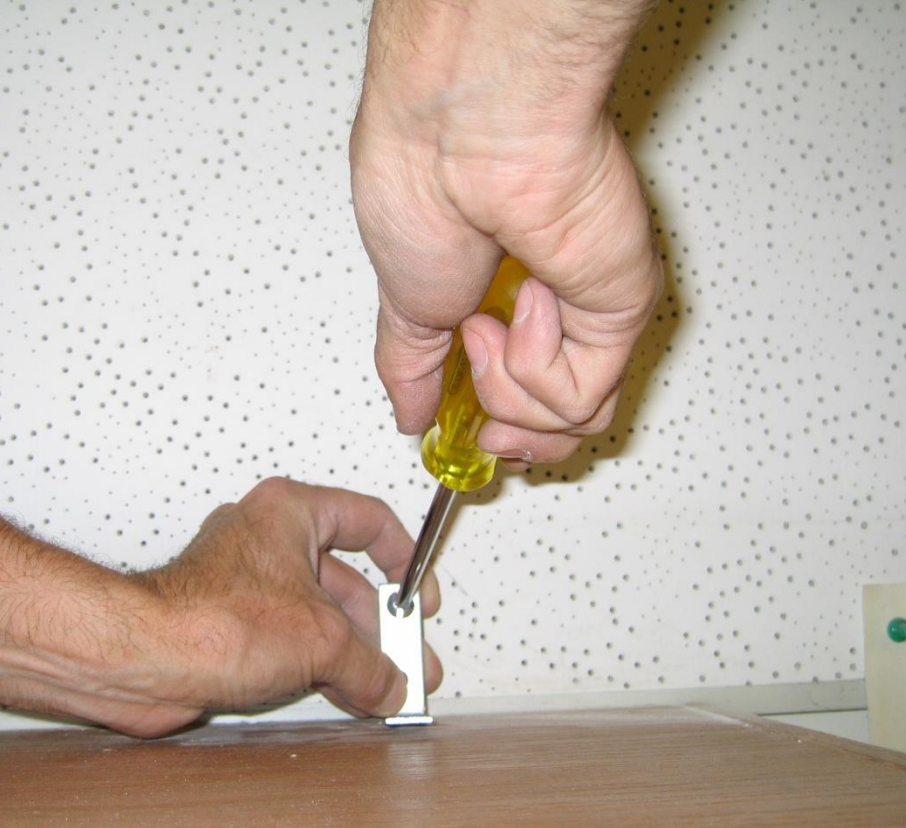
View from back, 20 May 2009



View from front, 20 May 2009



**Nonstructural damage often can be easily prevented.**



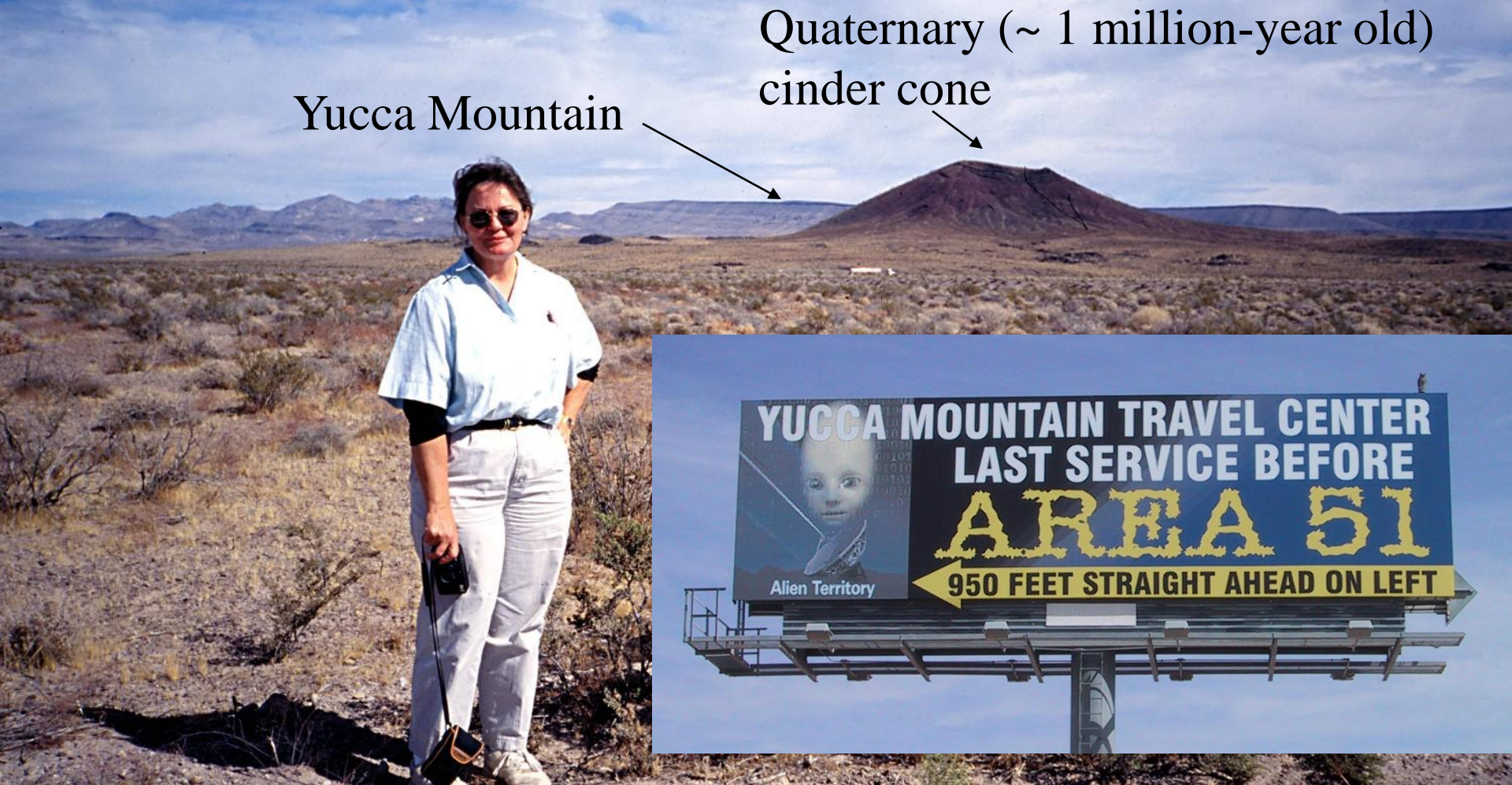
**Earthquake-secure bookshelves in the office of the State Geologist**



**Secured computers at the  
Clark County Building Department**

# Why Nevada Geology is So Exciting!

## 3. The environmental issues



**Black Cone in Crater Flat, Yucca Mountain in background to the east**

**Climate changes through geologic time.**

**Hazen pit, Lyon County  
(during Earth Science Week field  
trip – second full week of October)**

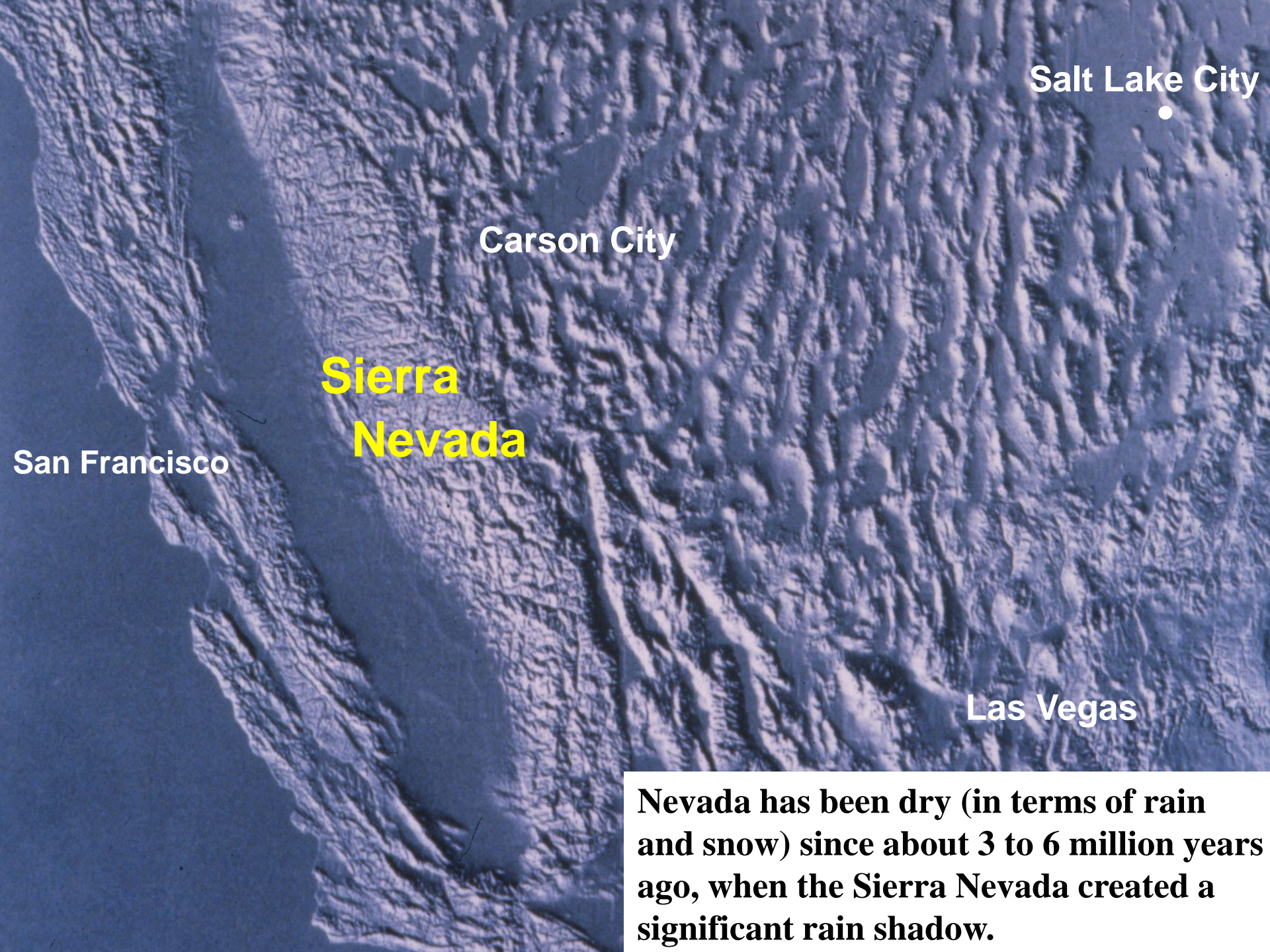
**Miocene (~ 15 million  
year old) fish in  
diatomite – evidence of  
wetter times in the past**

Lake Mead at Hoover Dam, 24 May 2004 – Water is a critical resource, but it doesn't rain much in Nevada.

Calcite and gypsum, deposited from evaporating water, whitewash the volcanic rocks above Lake Mead.

↑  
~ 30 m  
↓





Salt Lake City

Carson City

**Sierra  
Nevada**

San Francisco

Las Vegas

**Nevada has been dry (in terms of rain and snow) since about 3 to 6 million years ago, when the Sierra Nevada created a significant rain shadow.**



Lake Las Vegas



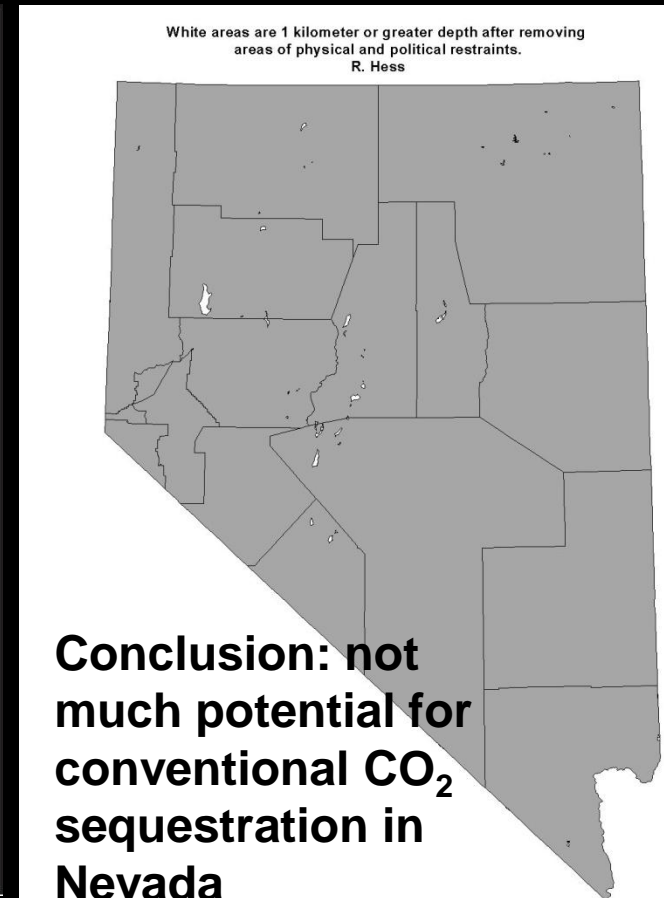
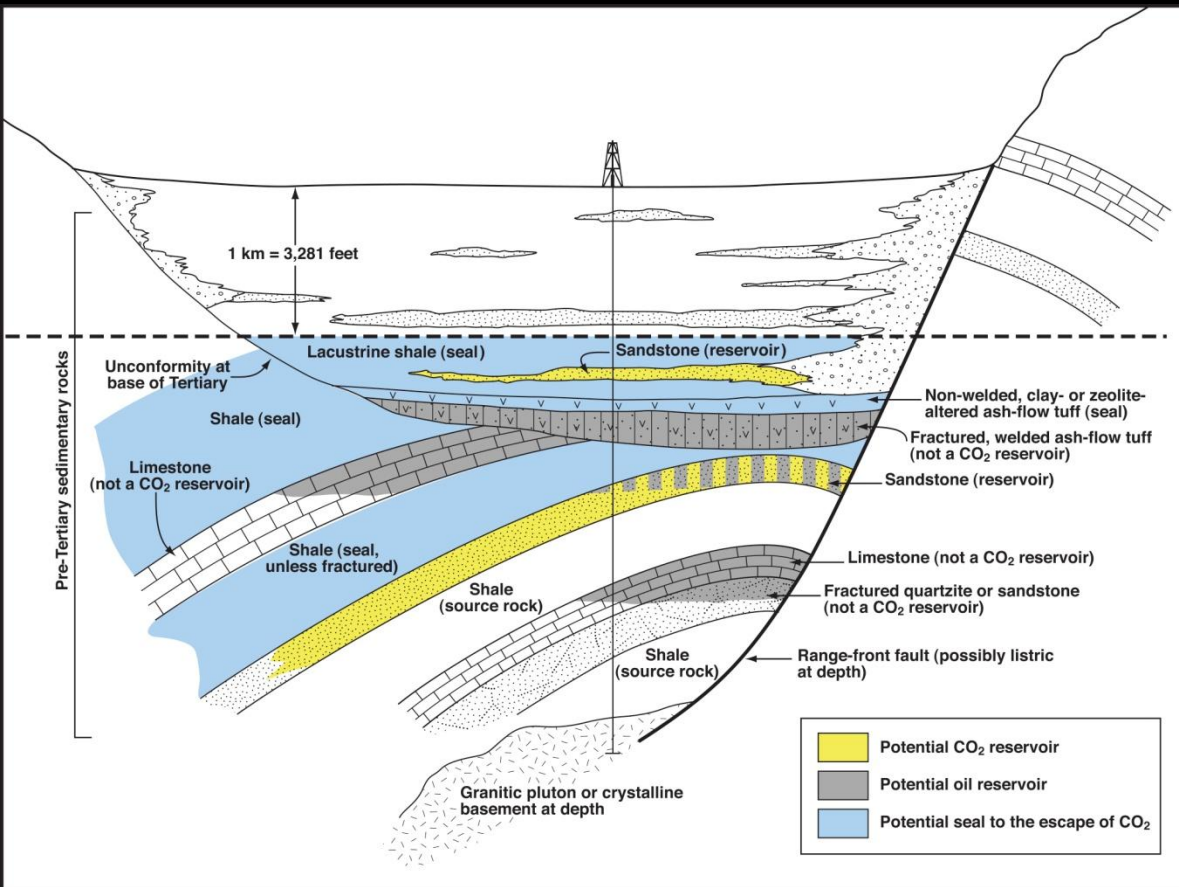


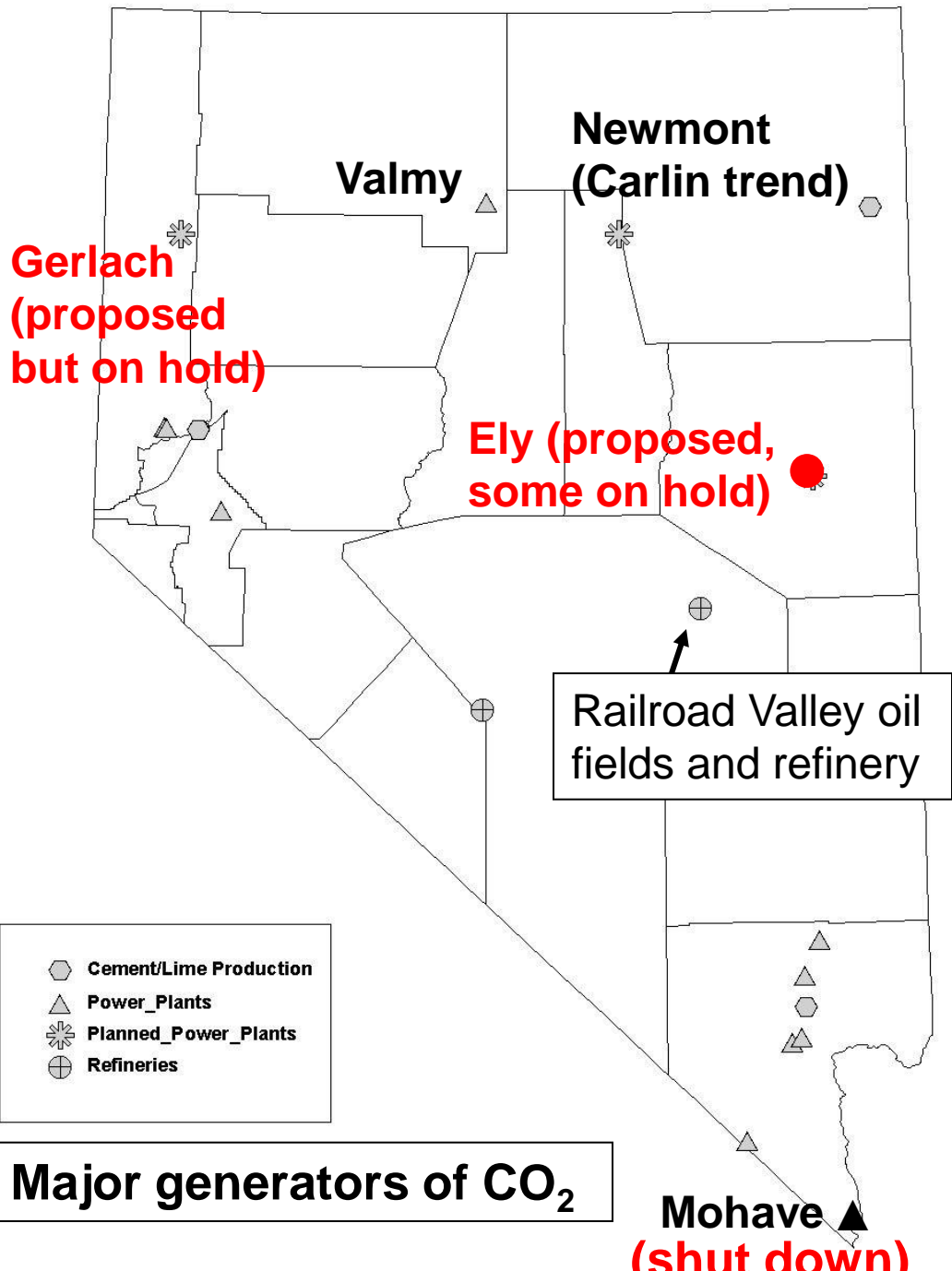
Subsidence and fissuring in Las Vegas Valley

# Will utility companies be allowed to continue to burn coal, if they can't find a way to capture and store the CO<sub>2</sub>?

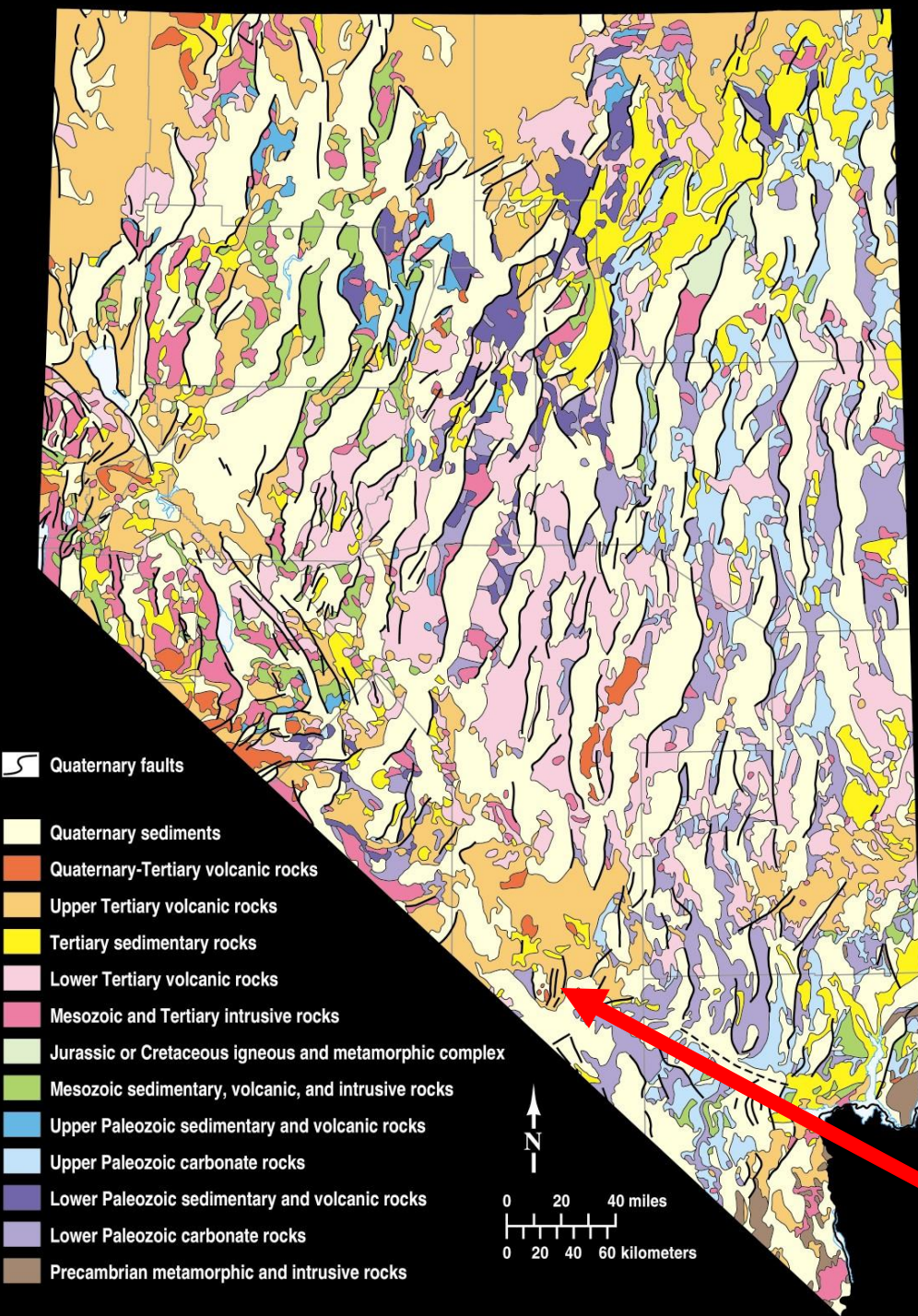
## “Preliminary Assessment of the Potential for Carbon Dioxide Disposal by Sequestration in Geological Settings in Nevada”

Nevada Bureau of Mines and Geology Report 51 (2005)





If coal is not favored because of CO<sub>2</sub>, what about nuclear power?



**Yucca Mountain – the nation's only site proposed for nuclear waste from power plants.**

# Issues at Yucca Mountain (human health over a one-million-year time period):

**Earthquake hazards (shaking, faulting and fracturing)**

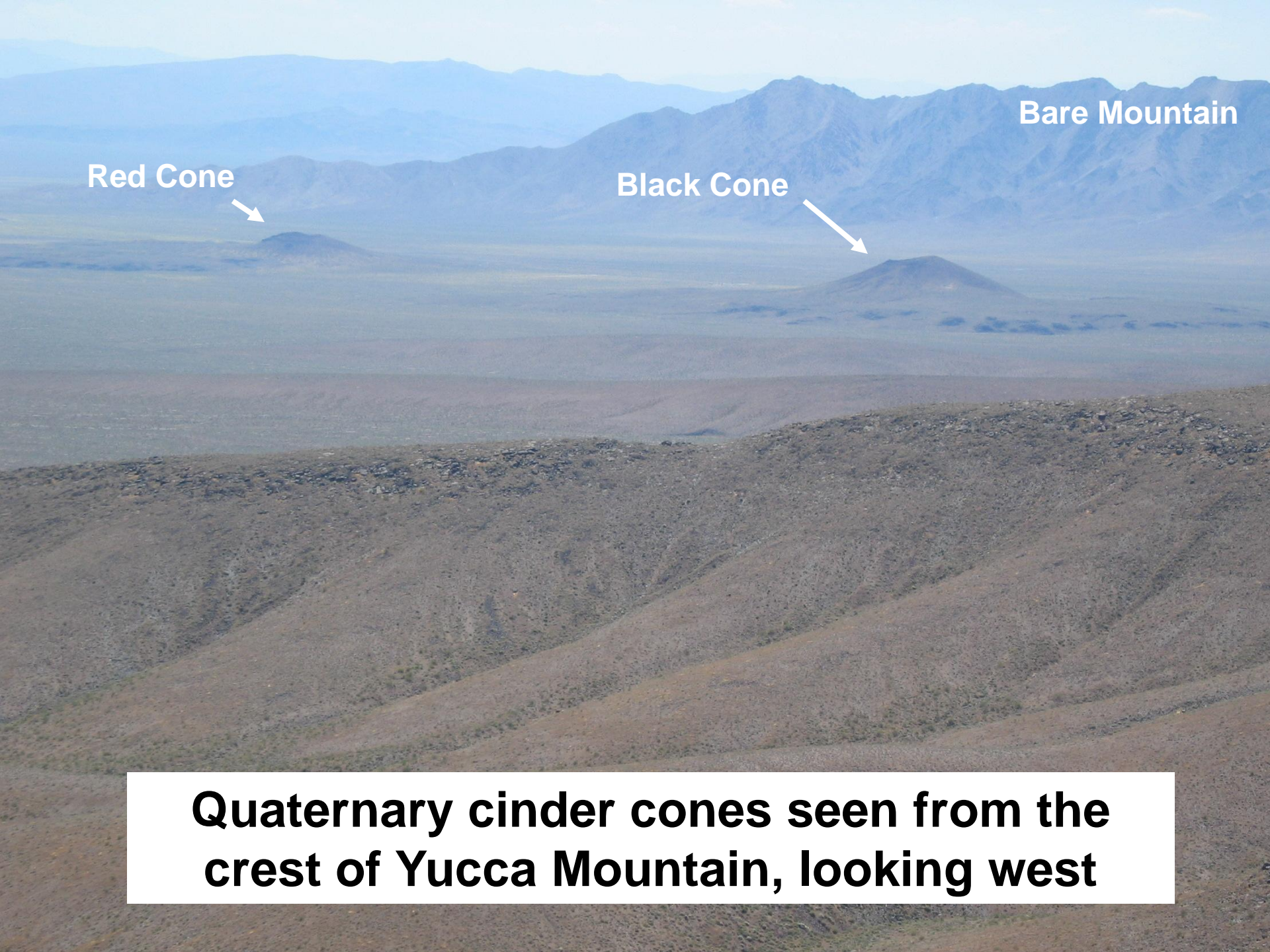
**Fluid flow (fractures, flow paths to springs, saturated and unsaturated flow)**

**Corrosion of containers**

**Volcanism**

**Transportation**





Red Cone



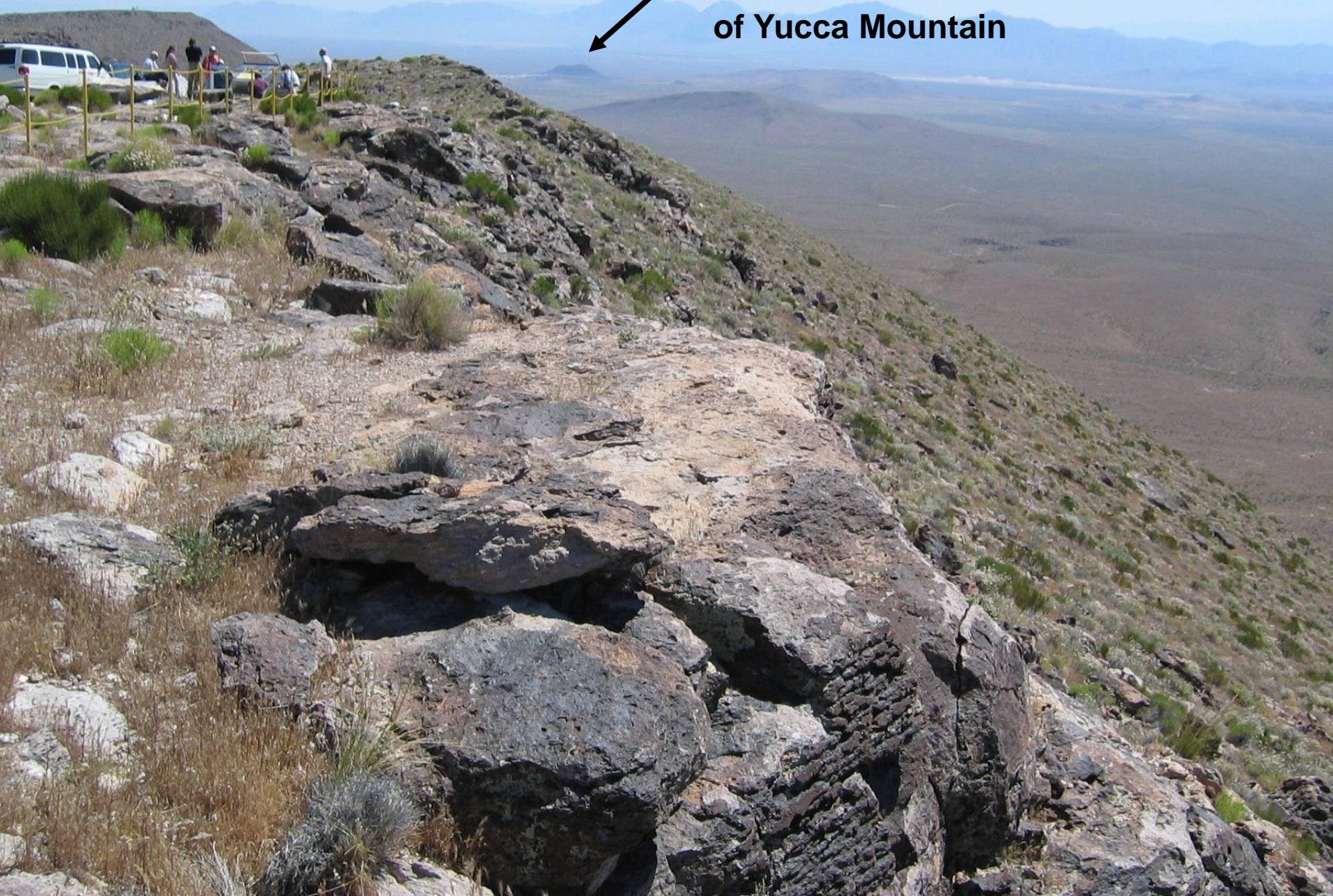
Black Cone



Bare Mountain

**Quaternary cinder cones seen from the crest of Yucca Mountain, looking west**

**looking south at the Lathrop  
Wells cinder cone from the crest  
of Yucca Mountain**





**looking north at Lathrop Wells cinder cone,  
~80,000 years old**



Will there be a preferred NNE alignment of future eruptions?

**On 30 September 2008, EPA released its final standards for radiation release at Yucca Mountain: 15 millirems per year in Amargosa Valley for the first 10,000 years and 100 millirems per year for the next 990,000 years.**

**On 10 October 2008, Nevada Attorney General Catherine Cortez Masto filed a federal lawsuit asking judges to throw out new radiation limits, stating that the radiation exposure standards set by the EPA will fail to protect Nevadans "from cancer-causing radioactive contamination" if nuclear waste is buried at the site.**

**Jul. 31, 2009**

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**“Reid declares Yucca victory -  
Senator says licensing funds  
erased”**



**"The only funding allocated for Yucca will be used to conclude the work being done at the site, bringing the ill-conceived project to its rightful end," Reid, D-Nev., said in a statement.**



**Aug. 01, 2009**

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**“Gibbons to Reid: Kill Yucca already - Senate leader asked to repeal law to stop project and licensing”**

**May 3, 2010**

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**“Administrative law judges** on the Atomic Safety and Licensing Board, a branch of the Nuclear Regulatory Commission, have set oral arguments on whether the Yucca Mountain license application should be terminated. It will rule by June 30.”

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**May 4, 2010**

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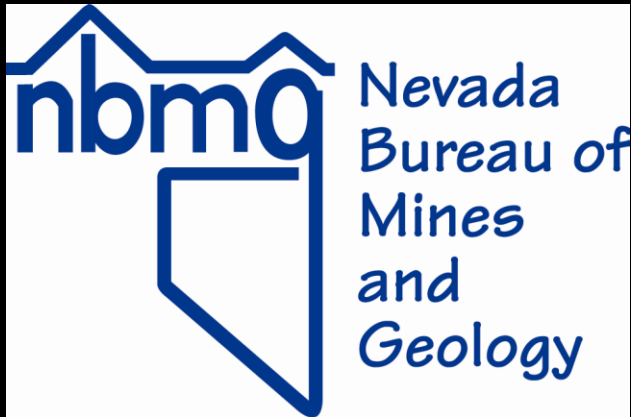
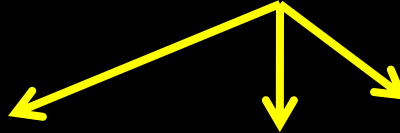
**“The Department of Energy** has been given the green light to move full speed ahead with its shutdown for the Yucca Mountain nuclear waste program. A **federal appeals court** dismissed a request to freeze termination activities until later this year, after judges have weighed lawsuits challenging the shutdown. The states of Washington and South Carolina have charged in federal lawsuits that the DOE does not have the authority to end the program without legislation from **Congress.**”



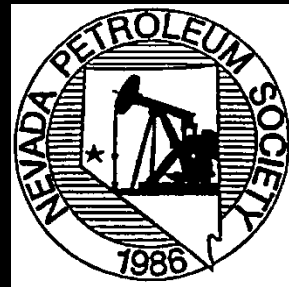
**Scientific issues are important, and could be the key to whether Yucca Mountain is ever used as a repository for nuclear waste, but legal and political issues are perhaps even more germane to a decision at this point.**

# Why Nevada Geology is So Exciting!

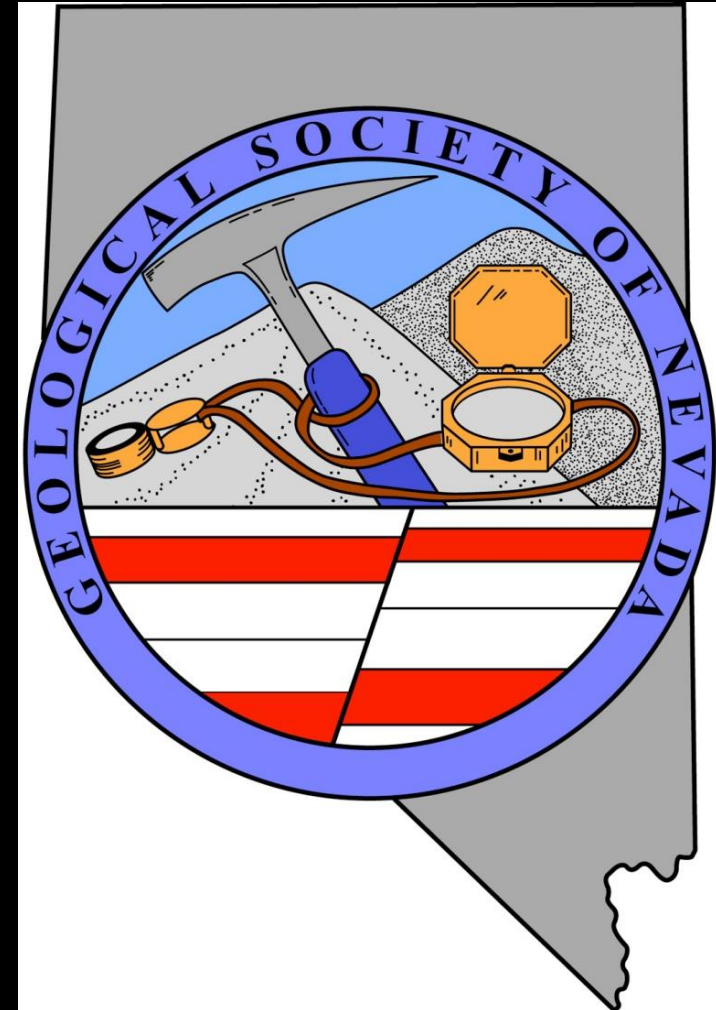
## 4. The geos



Division of Minerals



AEG



# Welcome to our new facility, also home for GSN.



## GREAT BASIN SCIENCE SAMPLE AND RECORDS LIBRARY



**Nevada Bureau of Mines and Geology  
University of Nevada, Reno**

**on the Campus of the Desert Research Institute**



**Gold\* on windows – reflects heat but transmits visible light, and therefore saves energy for both heating and air conditioning.**



**[26 windows x (4 ft x 6 ft)/window + 20 ft x 20 ft for vestibule] x (1 m/3.2808 ft)<sup>2</sup> x [1.73 x 10<sup>-8</sup> m thick gold coating] x 19.3 metric tons/m<sup>3</sup> x 3.21507 x 10<sup>4</sup> troy ounces/metric ton = **1.02 troy ounces of gold** on these windows.**

**\*Nevada produced ~71% of the gold in the U.S. and 7% of the world's gold in 2009  
We are in the biggest gold-mining boom ever, and Nevada is in the forefront.**

Seismic base isolation  
for storage racks in the  
warehouse section,  
6 May 2009





The Records Library is open from 8:00 a.m. to 4:00 p.m., Monday-Friday.

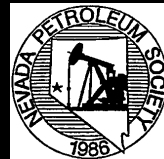
# Why Nevada Geology is So Exciting!

1. The rocks and the resources in them
2. The hazards
3. The environmental issues
4. The geos –

## THANK YOU!



Division of  
Minerals



AEG

