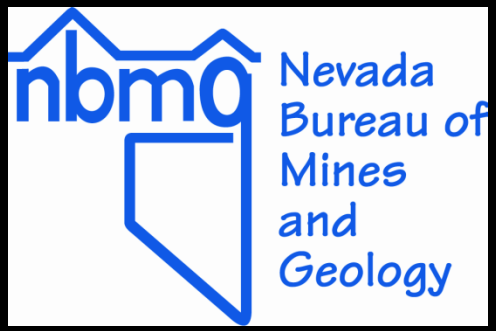
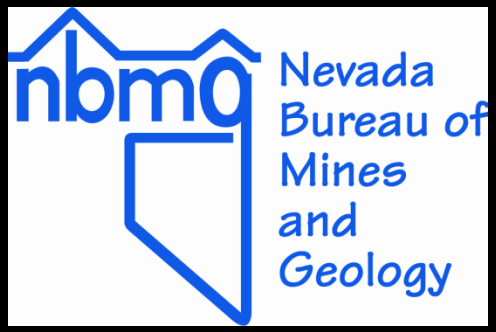
Earthquake Hazards in Storey County

Presentation by Jonathan G. Price
Nevada Bureau of Mines and Geology

Nevada Hazard Mitigation Planning Committee
Virginia City
25 August 2011



Earthquake faults occur throughout Nevada, and potential losses from earthquakes are high for many communities, including those in Storey County



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.nbmg.unr.edu. You can use it to locate your home or business.

Nevada Bureau of Mines and Geology

University of Nevada, Reno
Statewide • Worldwide

FEMA

Nevada Department of Public Safety
Division of Emergency Management

Nevada Earthquake Safety Council

USGS
science for a changing world

Nevada Seismological Laboratory

The Great Seal of the State of Nevada
All for our country

Age of Latest Fault Rupture

< 150 years (historical)

< 15,000 years

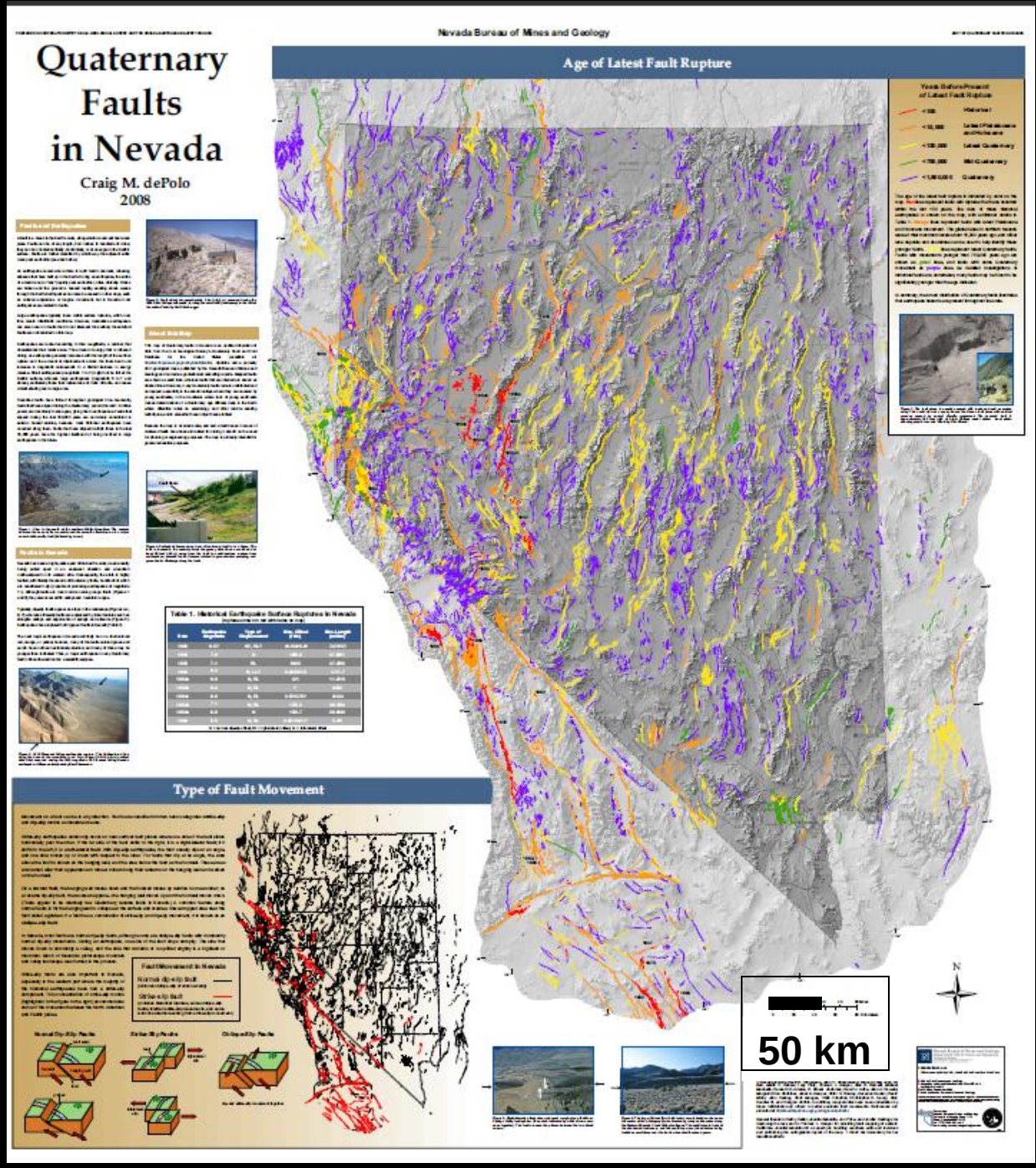
< 130,000 years

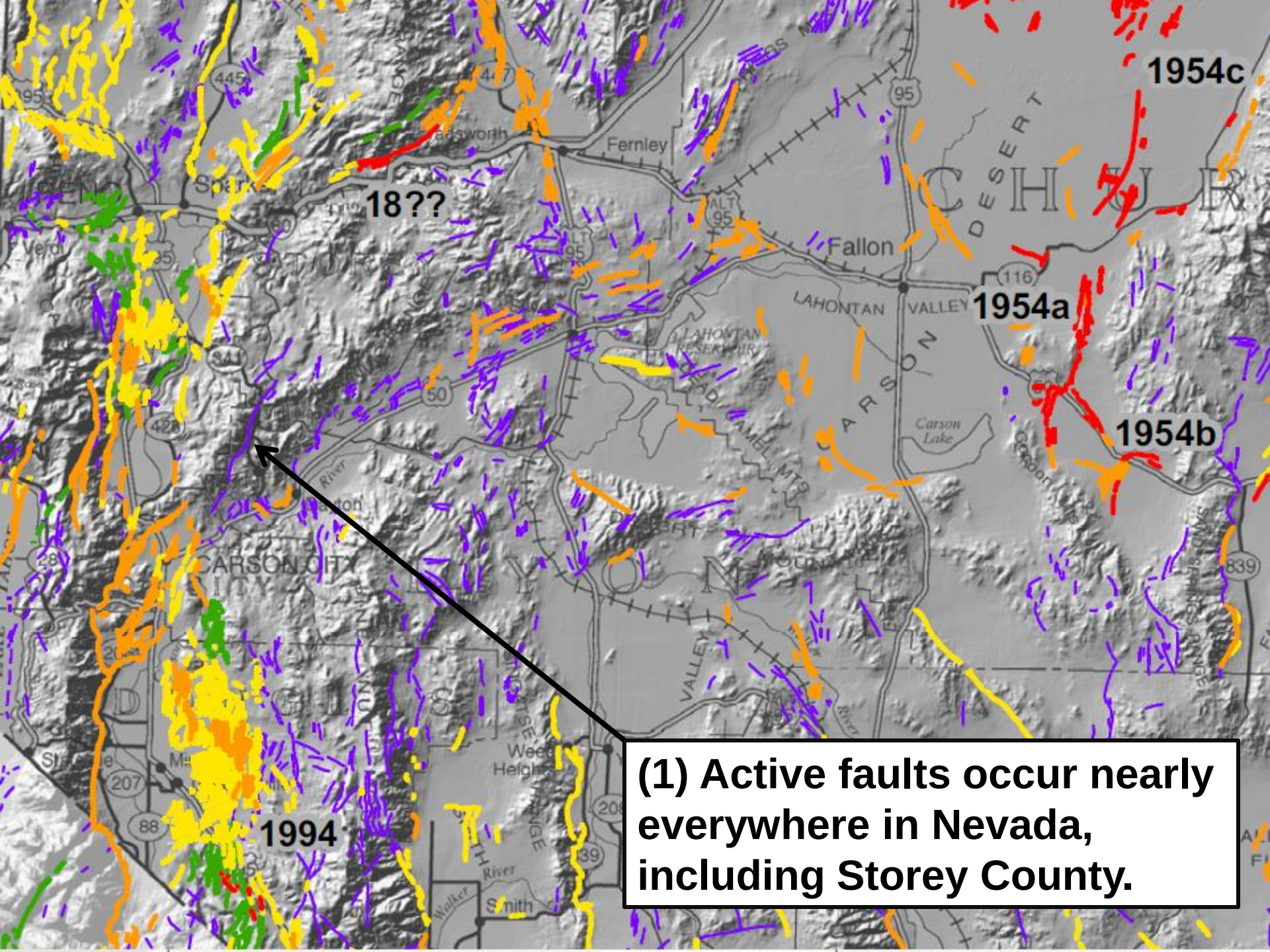
< 750,000 years

< 1,800,000 years (Quaternary)

There are active faults nearly everywhere in Nevada.
A magnitude 6.0 earthquake can occur anywhere in Nevada.

www.nbmg.unr.edu




1954c
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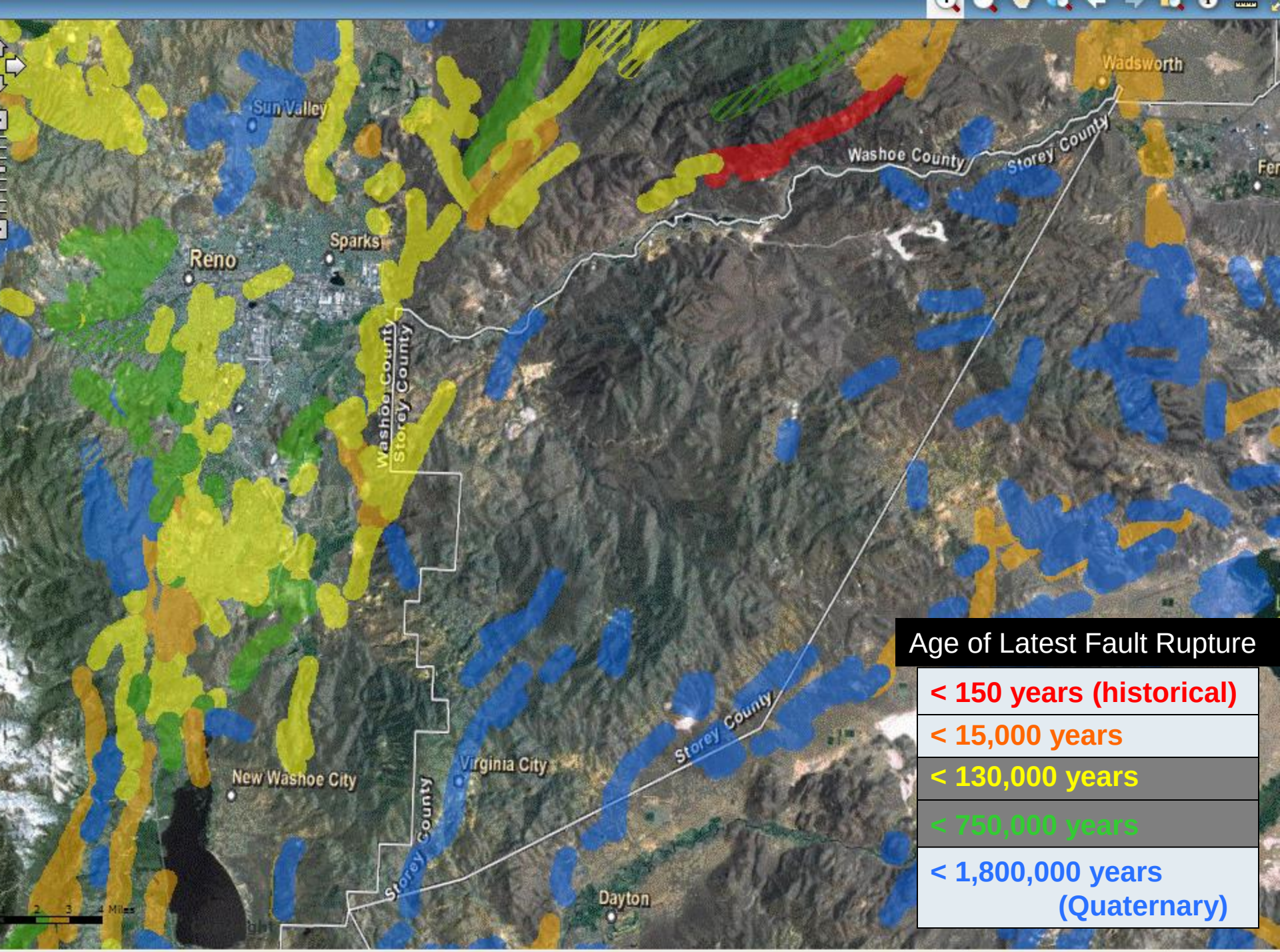
(1) Active faults occur nearly everywhere in Nevada, including Storey County.


Wadsworth
Sun Valley
Washoe County
Storey County
Reno
Sparks
Washoe County
Storey County
Storey County
New Washoe City
Virginia City
Storey County
Storey County
Dayton
Age of Latest Fault Rupture
< 150 years (historical)
< 15,000 years
< 130,000 years
< 750,000 years
< 1,800,000 years (Quaternary)

Quaternary Faults in Nevada - Online Interactive Map

www.nbmg.unr.edu

Look for a fault | Find Address

Easy to pinpoint an address

Results

Map Contents

Find Address

Street or Intersection: C Street

City: Virginia City

State: Nevada

ZIP: 89440

Find Your Address

Quaternary Faults in Nevada - Online Interactive Map

www.nbmg.unr.edu

Look for a fault | Find Address

Multiple ways to zoom in to a location

Results

C Street, Virginia City, Nevada

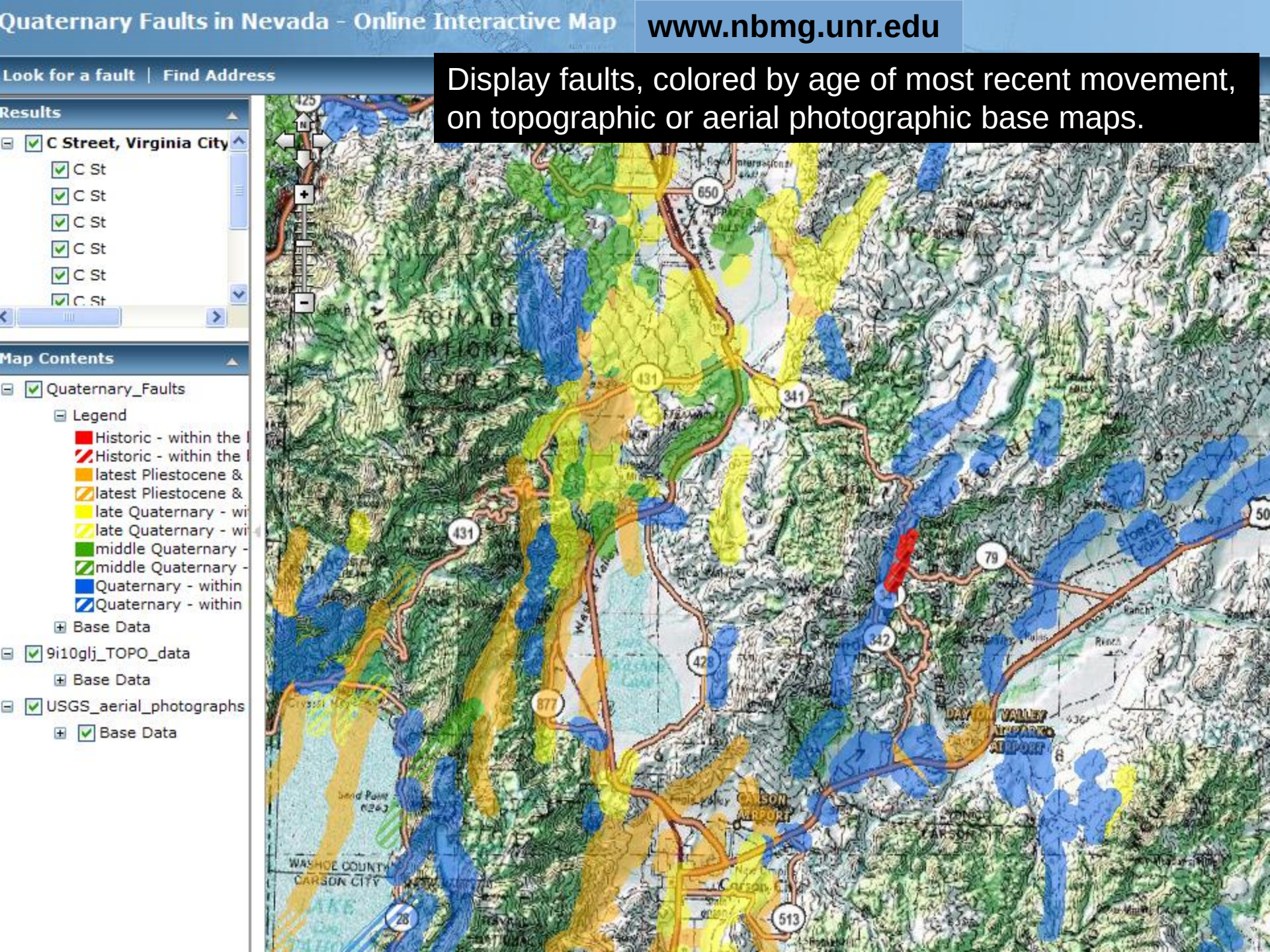
Zoom to

Pan to

Remove

Map Contents

- Quaternary_Faults
  - Legend
  - Base Data
- 9i10glj_TOPO_data
  - Base Data
- USGS_aerial_photographs
  - Base Data


Quaternary Faults in Nevada - Online Interactive Map
www.nbmg.unr.edu
Look for a fault | Find Address
Display faults, colored by age of most recent movement, on topographic or aerial photographic base maps.
Results
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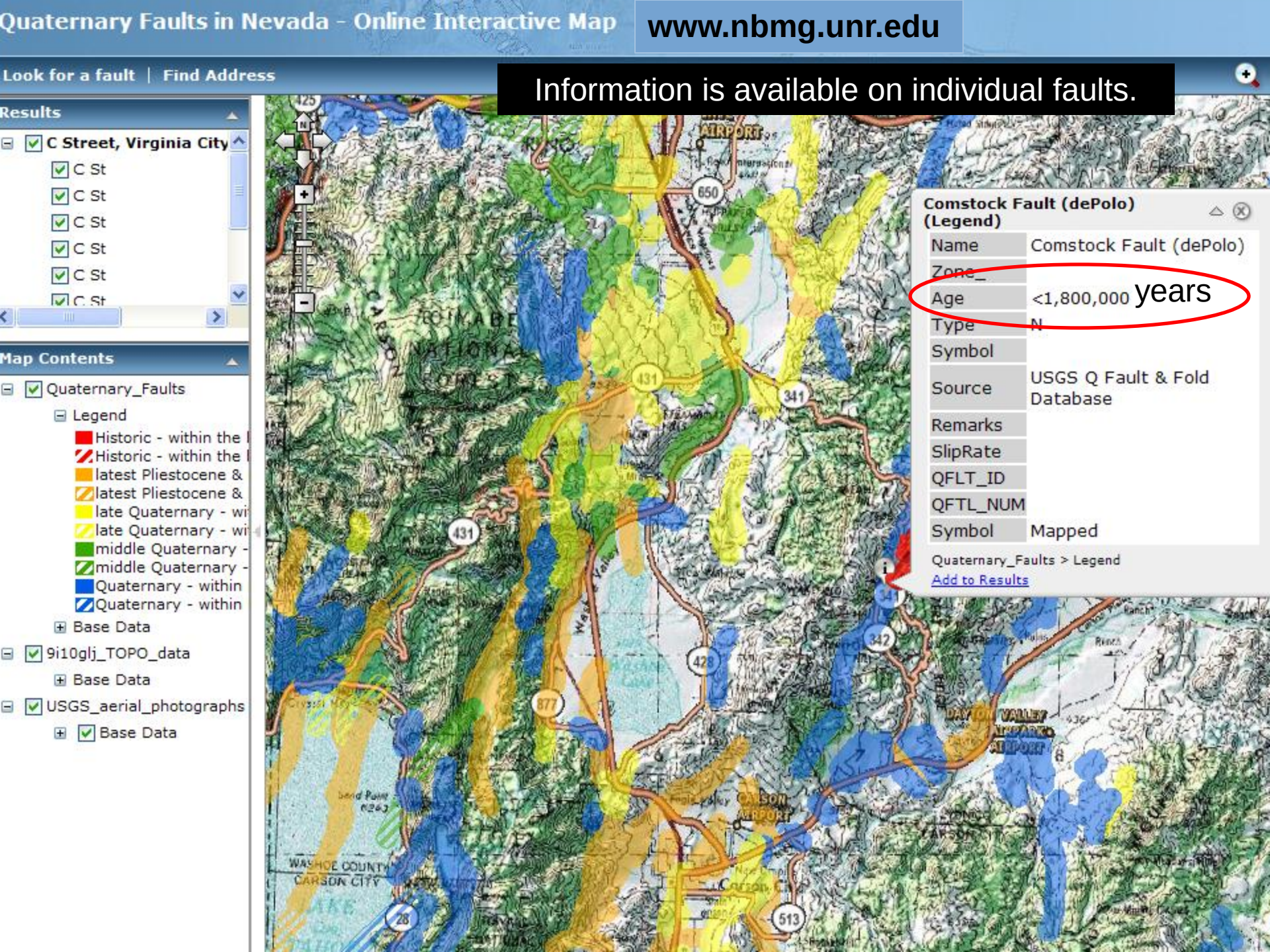
WASHOE COUNTY
CARSON CITY
CARSON AIRPORT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Information is available on individual faults.
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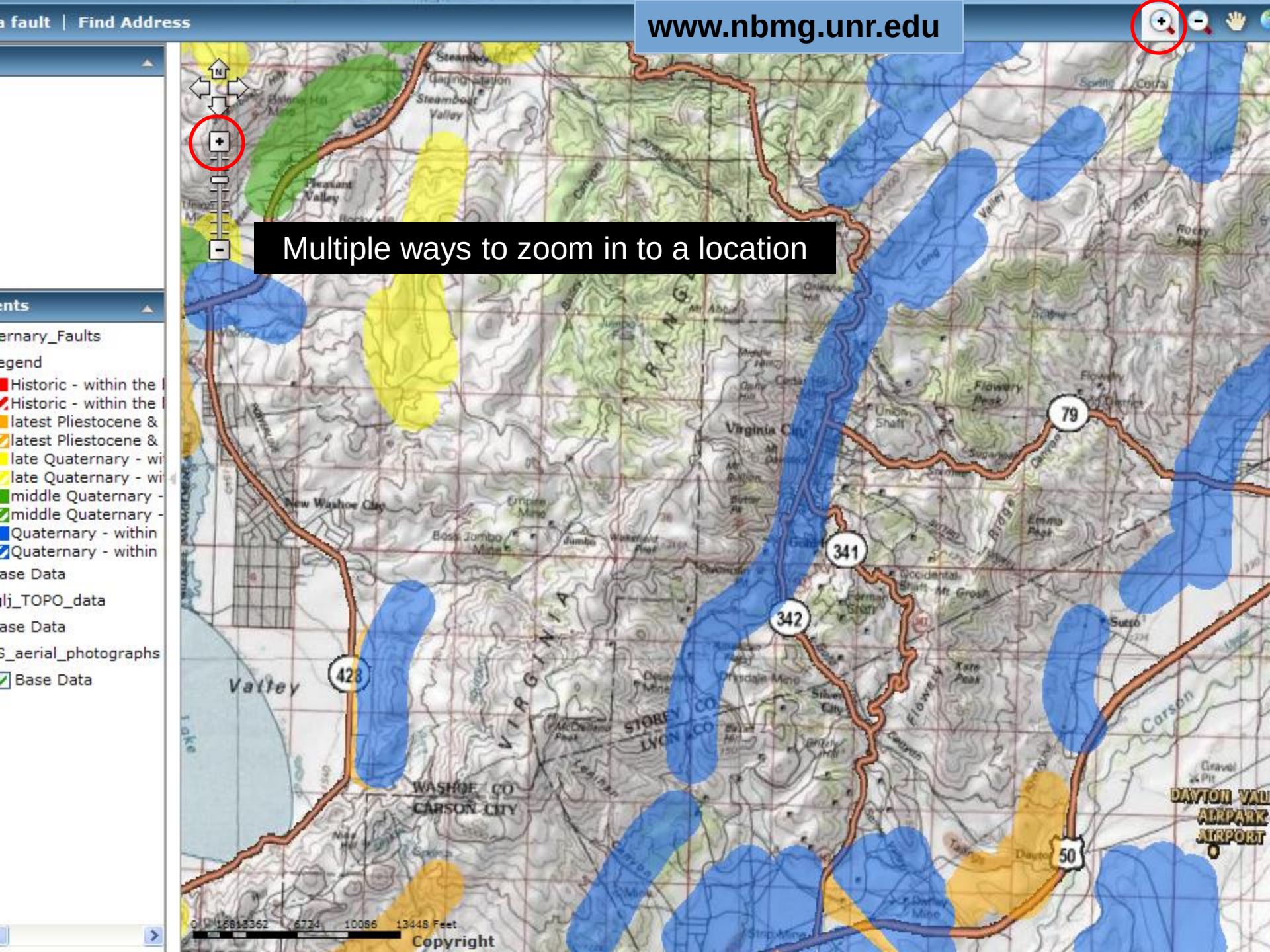
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Steamboat Valley
Pleasant Valley
Virginia City
New Washoe City
Boss Jumbo Mine
Occidental Shaft
Mt Grosh
Sutro
Flowery Peak
Union Shaft
Silver City
Dayton
Carson
Valley
Lake
WASHOE CO
CARSON CITY
STOREY CO
LYON CO
VIRGINIA
RANGE
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DAYTON VAL
AIRPARK
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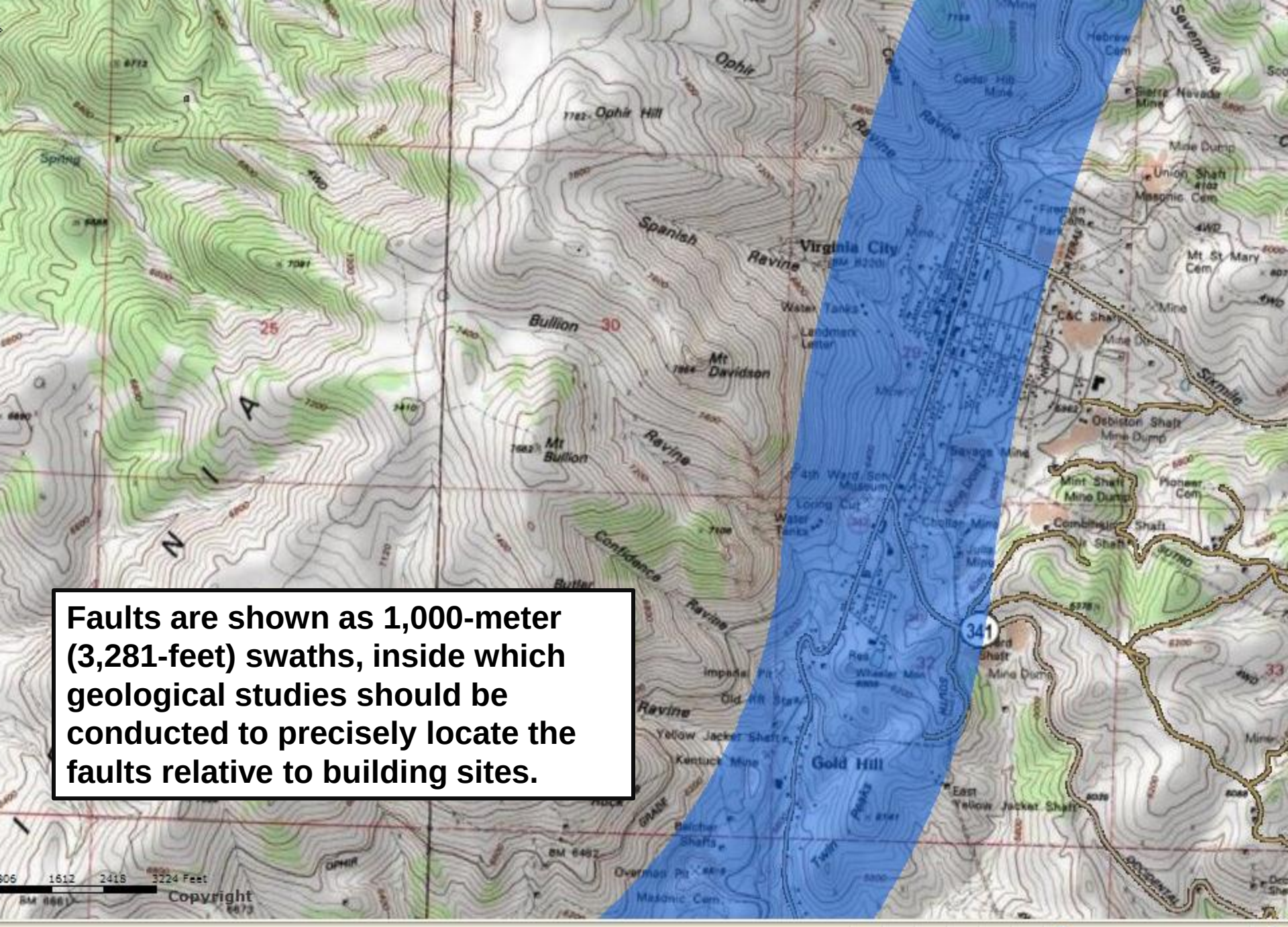
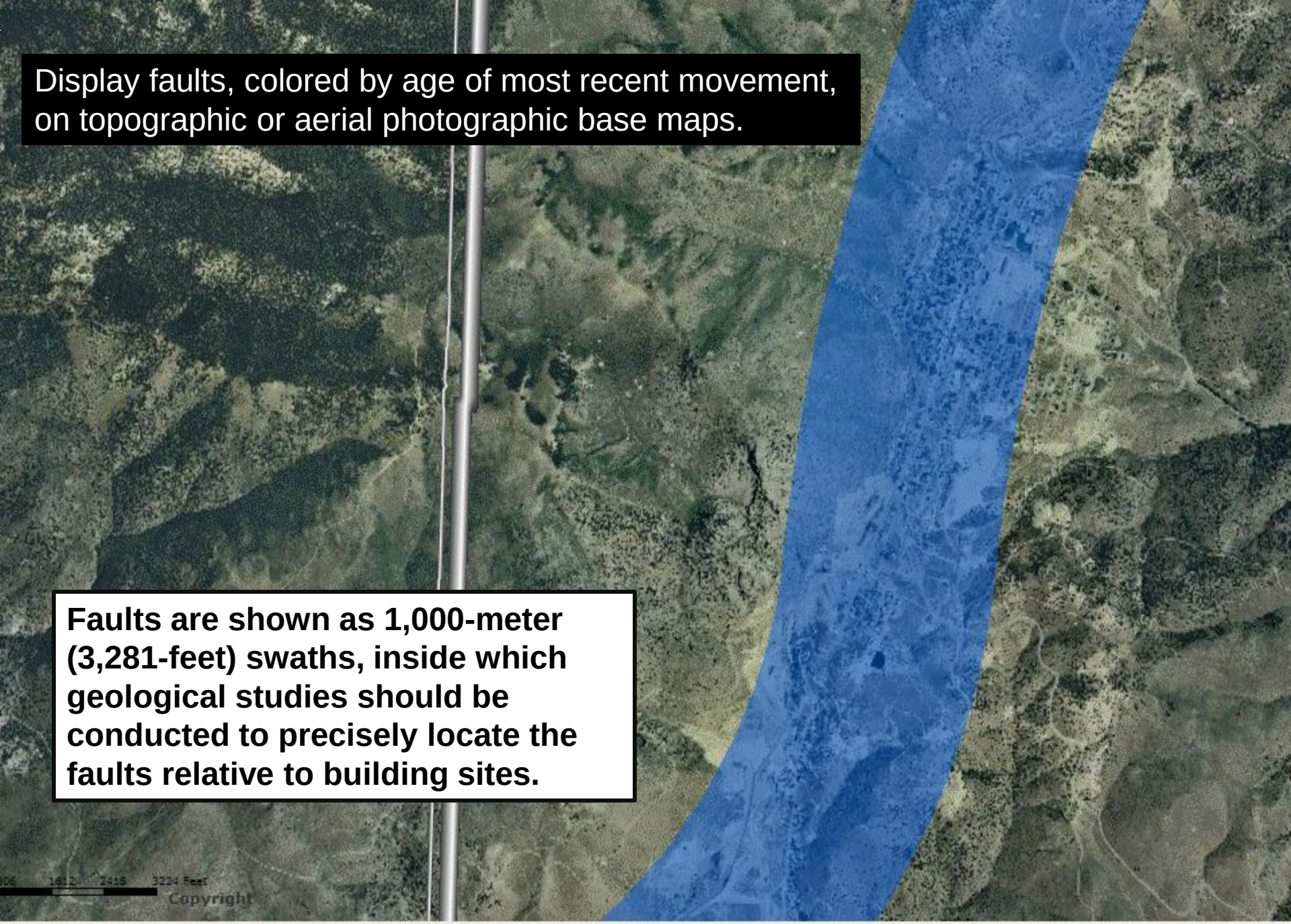
Copyright



Faults are shown as 1,000-meter (3,281-feet) swaths, inside which geological studies should be conducted to precisely locate the faults relative to building sites.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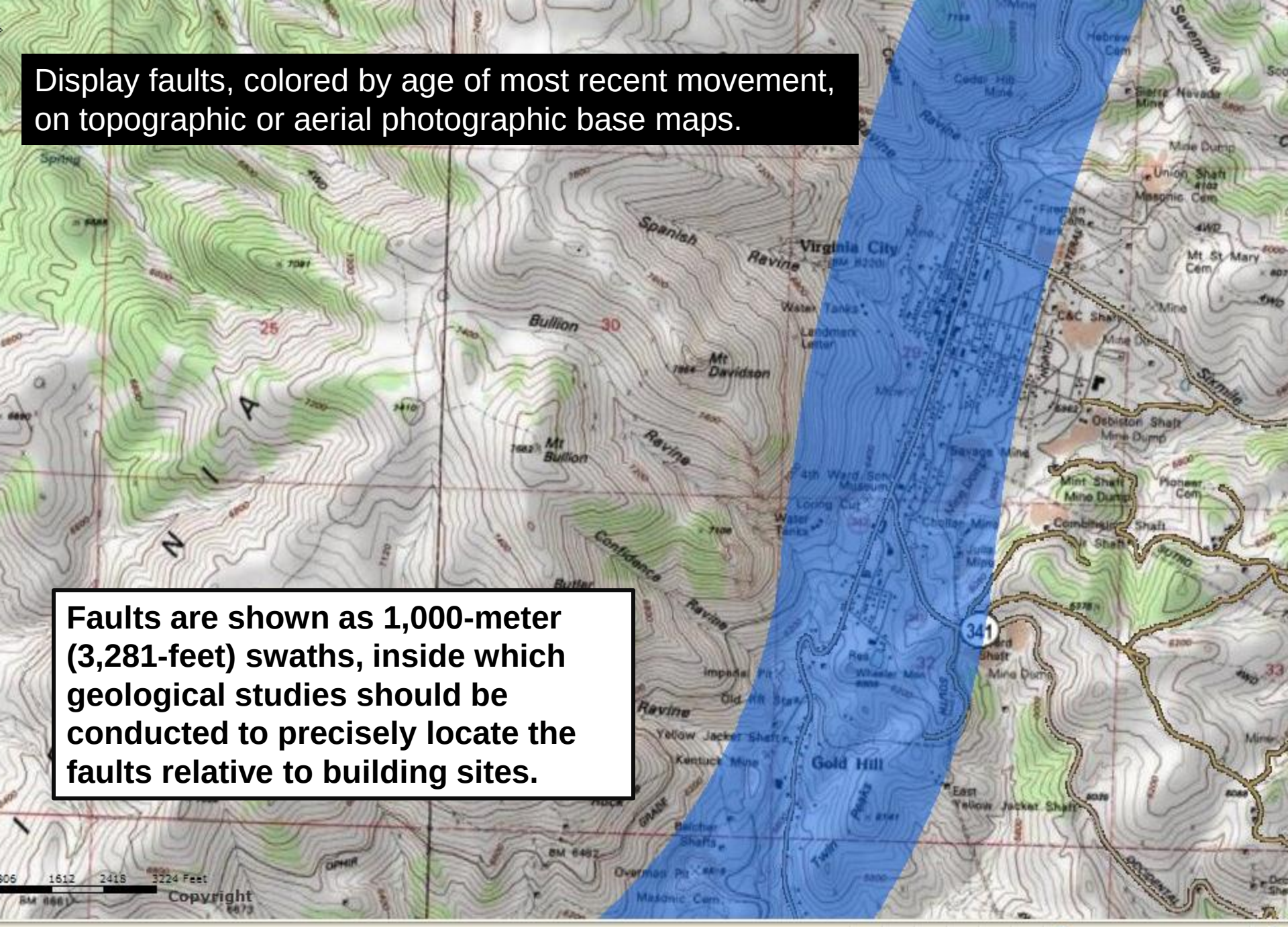
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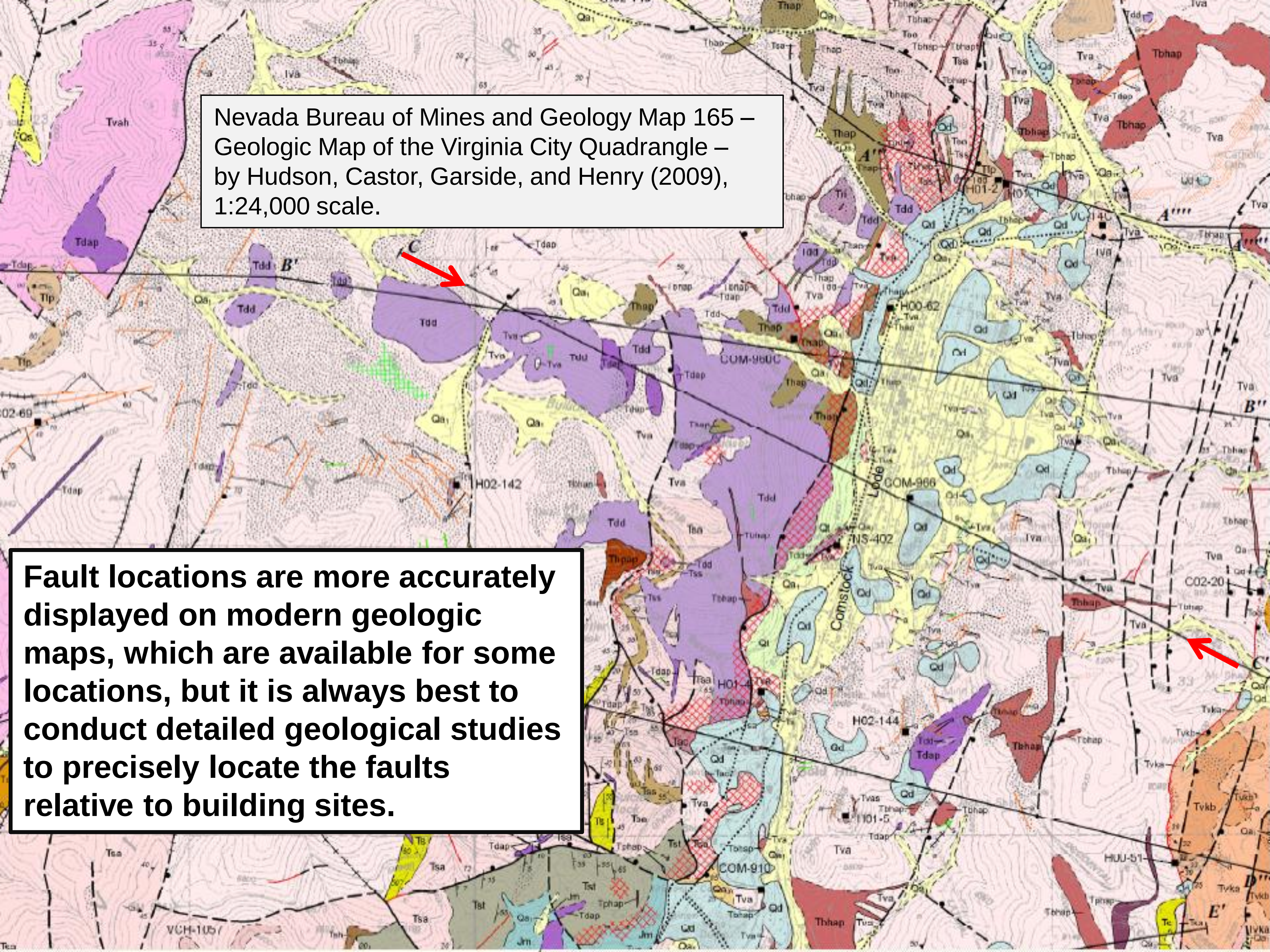
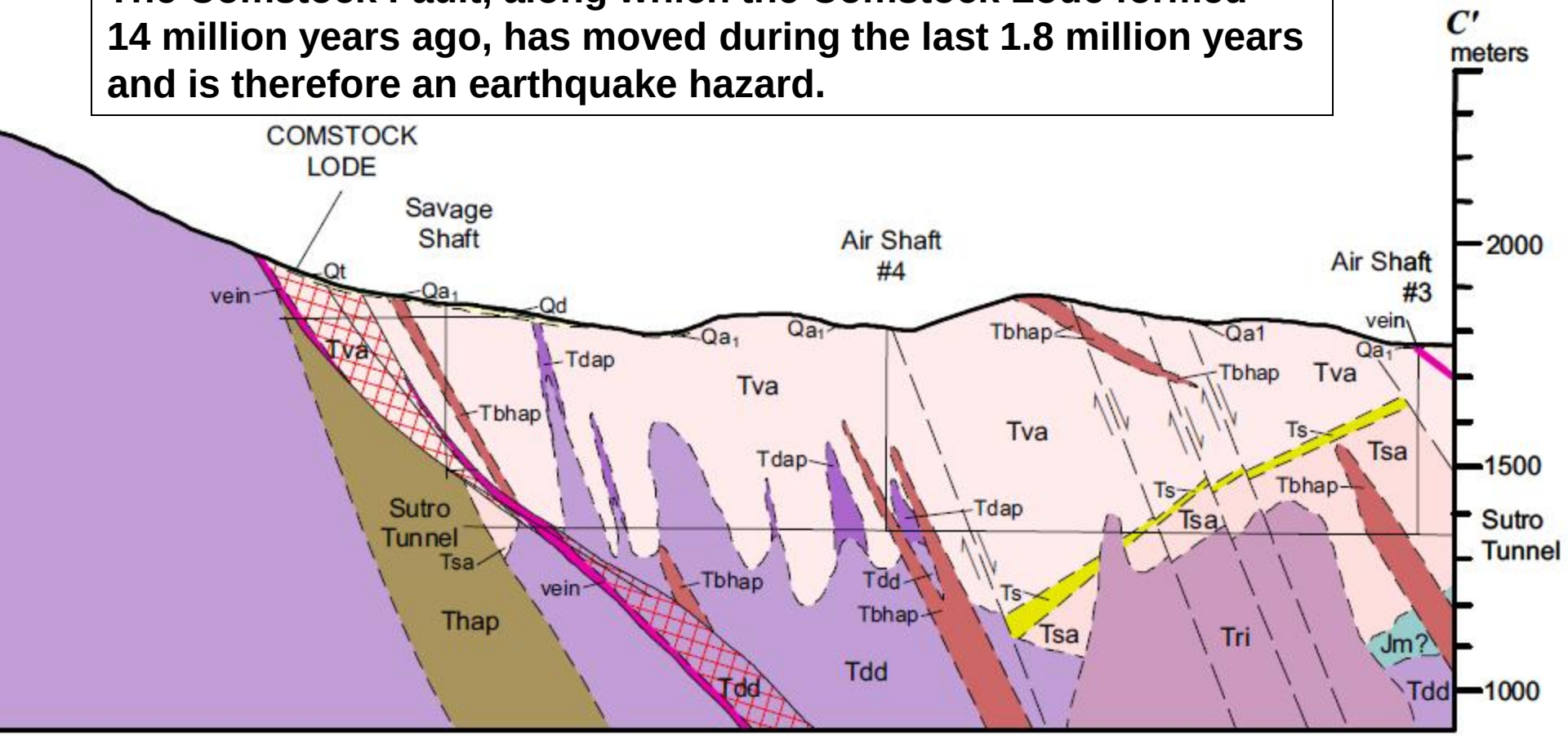
Virginia City
Bullion
Mt Davidson
Mt Bullion
Confidence Ravine
Gold Hill
Sixmile
Union Shaft
Mt St Mary Cem
Osbiston Shaft
Mint Shaft
Pioneer Cem
Yellow Jacket Shaft
Kentuck Mine
East Yellow Jacket Shaft
Hebrew Cem
Sierra Nevada Mine
Cedar Hill Mine
Masonic Cem
Imperial Pit
Overman Pit
341
Copyright
Internet



Nevada Bureau of Mines and Geology Map 165 – Geologic Map of the Virginia City Quadrangle – by Hudson, Castor, Garside, and Henry (2009), 1:24,000 scale.

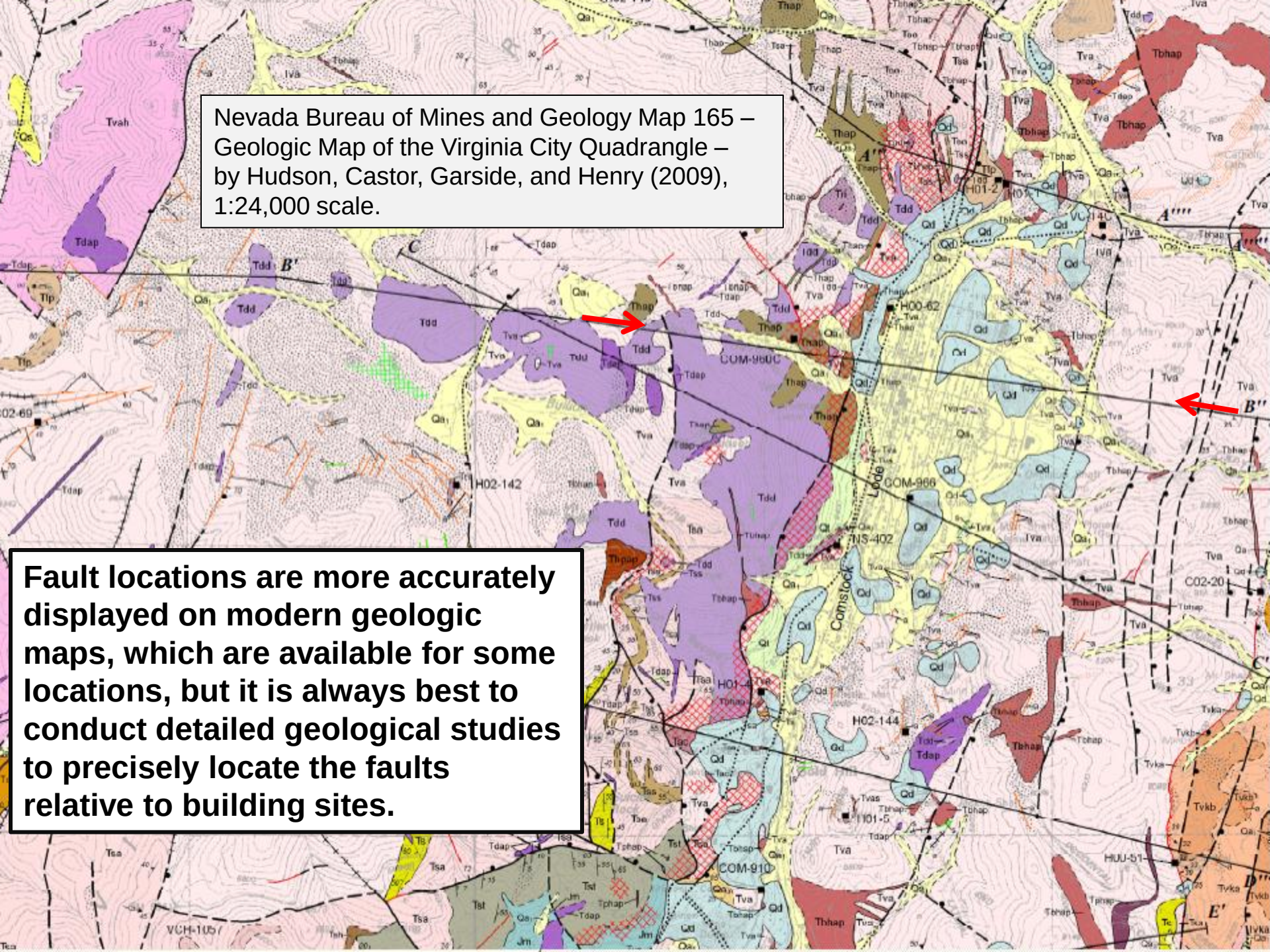
Fault locations are more accurately displayed on modern geologic maps, which are available for some locations, but it is always best to conduct detailed geological studies to precisely locate the faults relative to building sites.

The Comstock Fault, along which the Comstock Lode formed 14 million years ago, has moved during the last 1.8 million years and is therefore an earthquake hazard.



Cross section, looking north, across the Comstock Lode, Nevada Bureau of Mines and Geology Map 165 – Geologic Map of the Virginia City Quadrangle – by Hudson, Castor, Garside, and Henry (2009), 1:24,000 scale.

nbmg Nevada Bureau of Mines and Geology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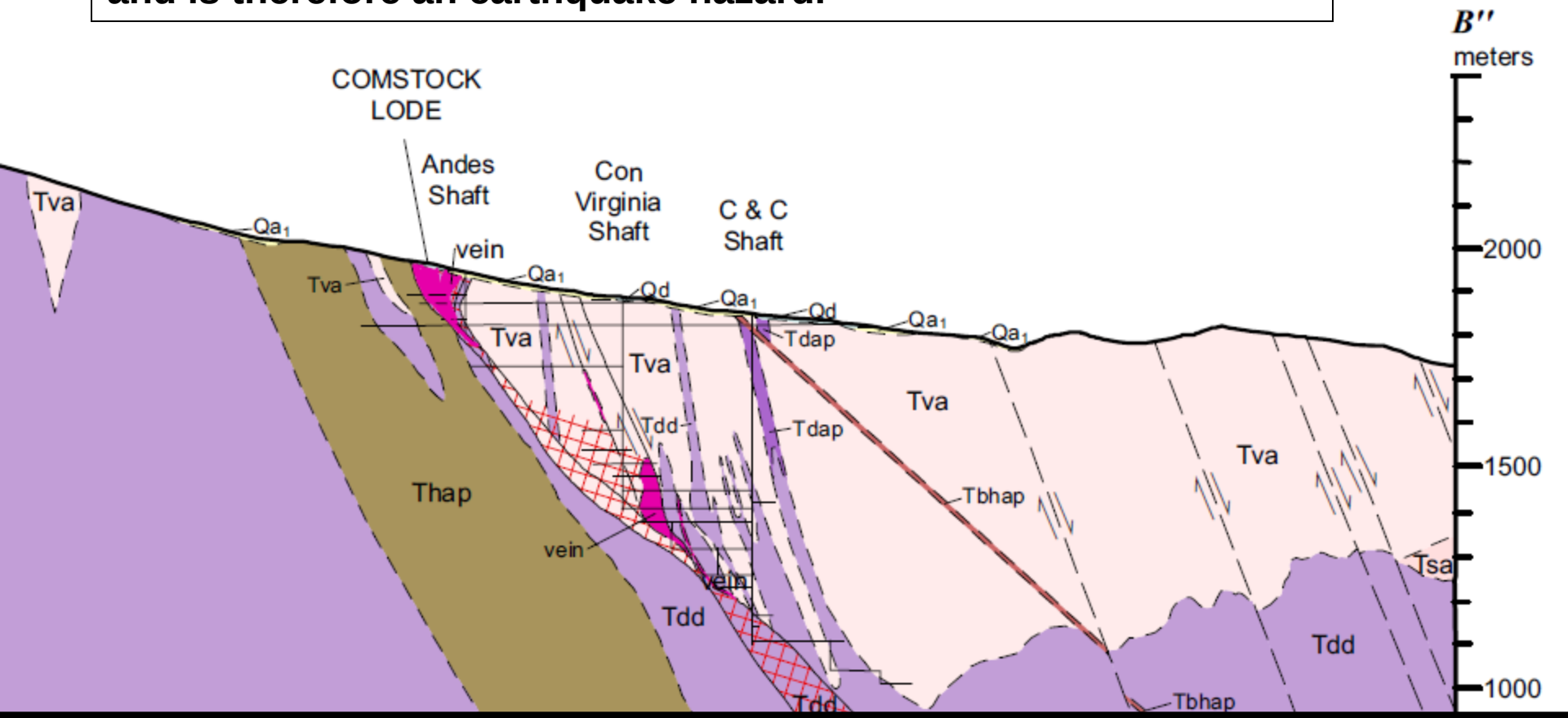

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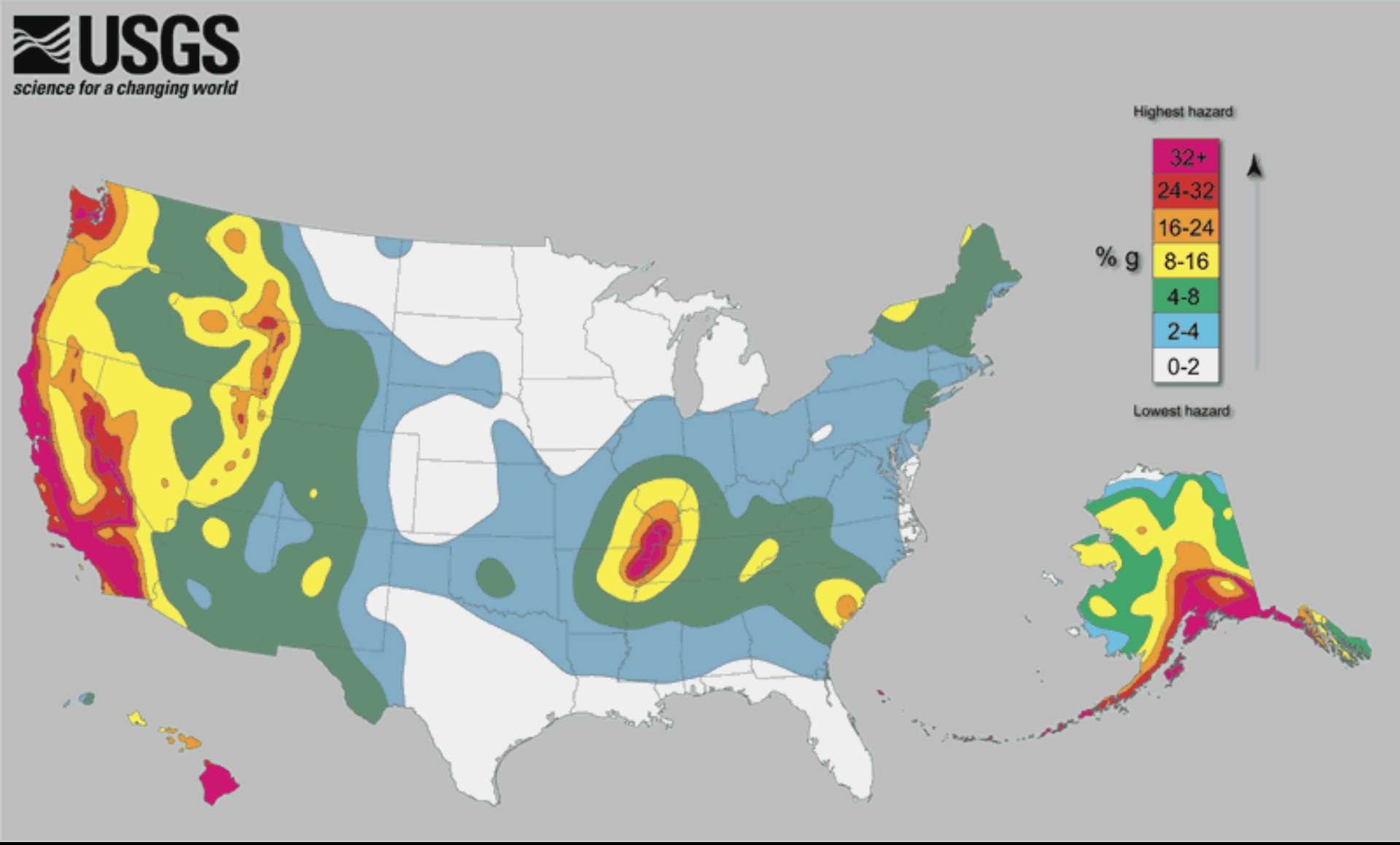
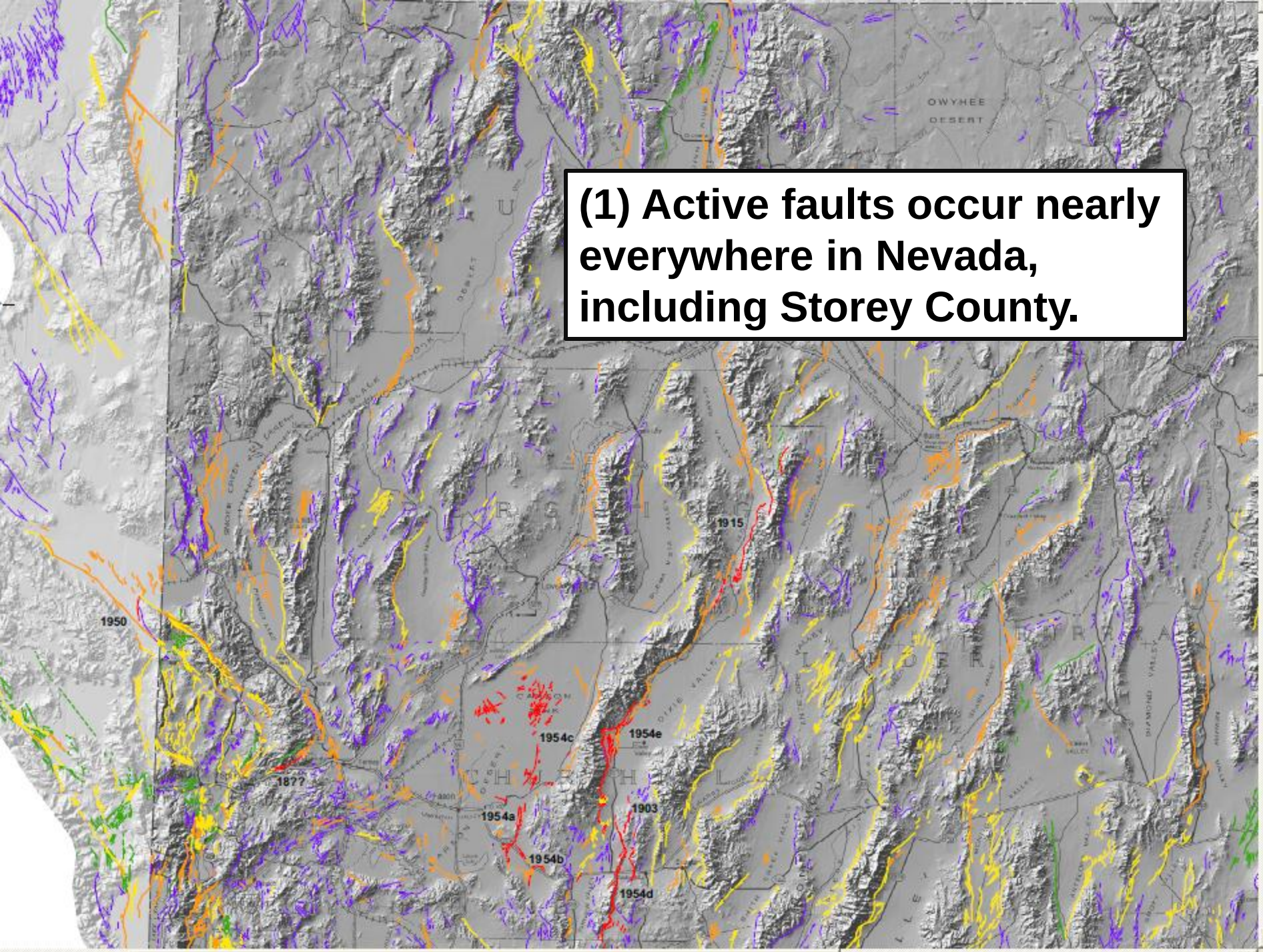


The USGS integrates (1) fault, (2) earthquake, and (3) geodetic data into its probabilistic seismic hazard analysis.


(1) Active faults occur nearly everywhere in Nevada, including Storey County.
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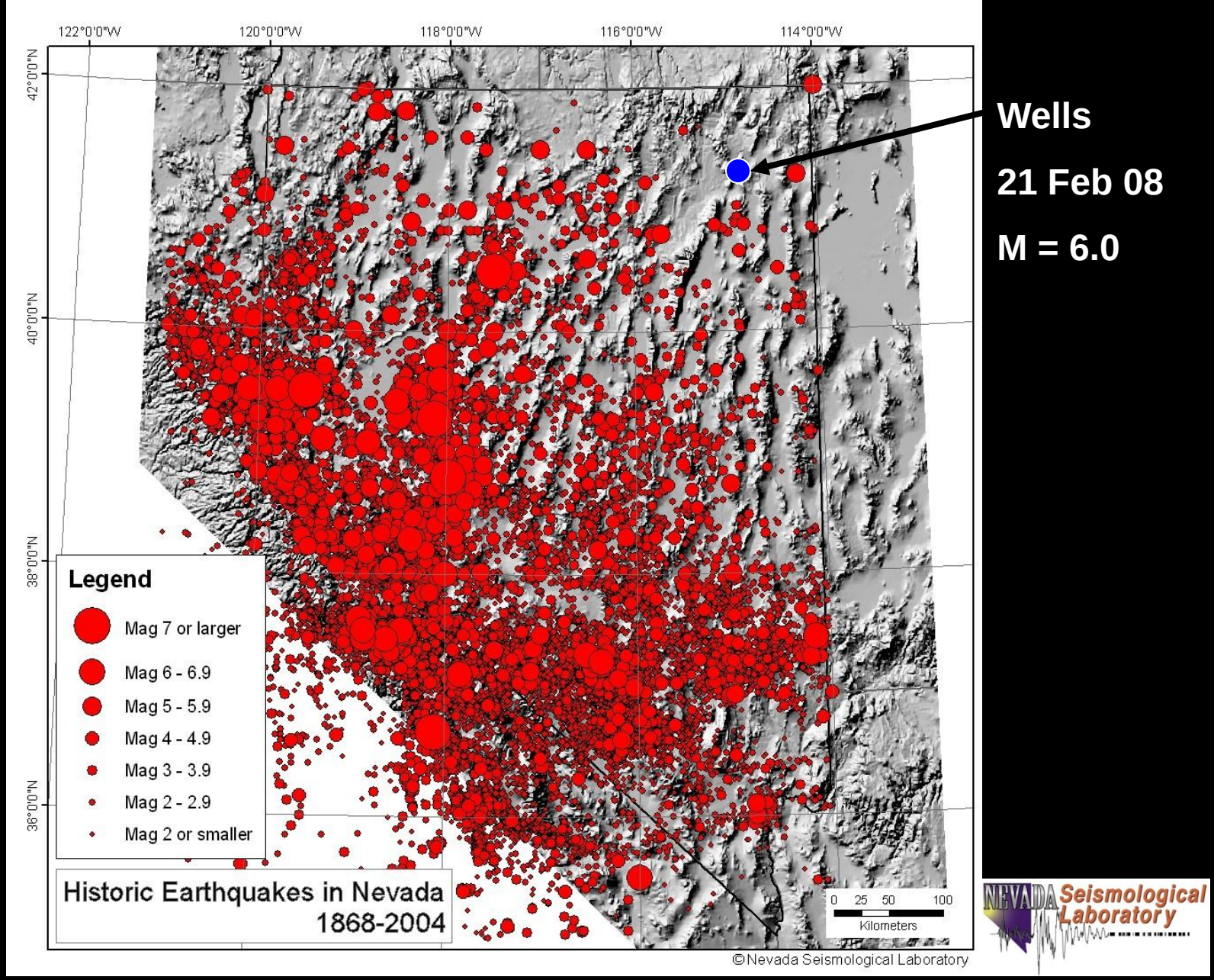
1954b
1954d



(2) Earthquakes have occurred throughout Nevada.

Historical Earthquakes close to Virginia City

March 15, 1860: Magnitude 7.0, perhaps on the Olinghouse fault – caused goods to be shaken from shelves and general panic in Carson City.

May 29, 1868: Magnitude 6.0, preceded by foreshocks 14 and 5 minutes before the main shock – may have been a foreshock of the 6.7 earthquake 17 months later – at Virginia City, brick buildings were cracked; some bricks shaken down, and plaster fell in nearly all brick buildings.

December 26, 1869: Magnitude 6.7 – seriously damaged masonry walls in Virginia City and Washoe City, and caused some damage in communities of the Sierra Nevada foothills in California

December 27, 1869: Magnitude 6.1, aftershock, 8 hours later

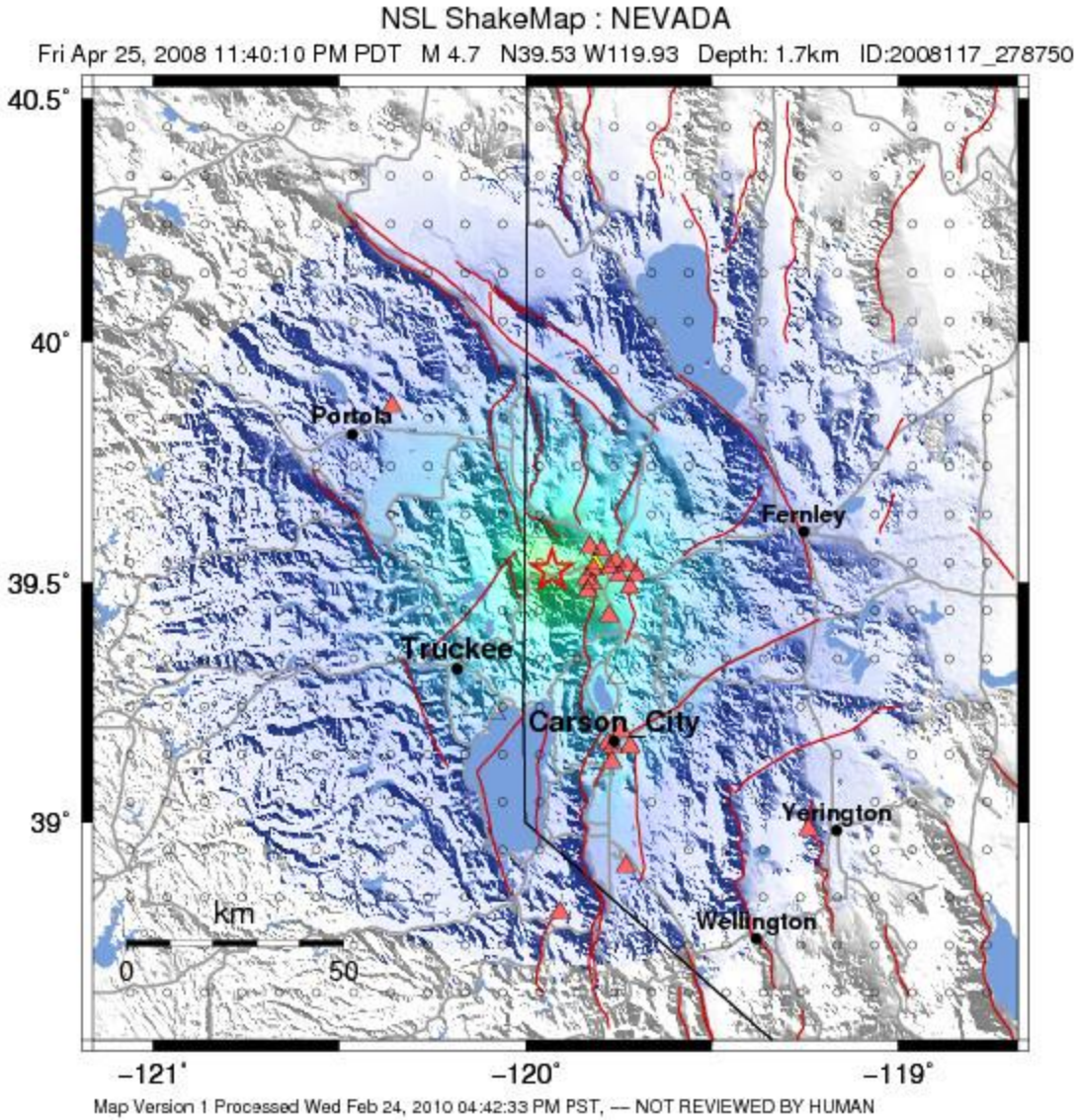
April 24, 1914: Magnitude 6.4, probably near Fernley or Wadsworth

June 25, 1933: Magnitude 6.0, near Wabuska – knocked down several chimneys and damaged the Catholic Church in Virginia City

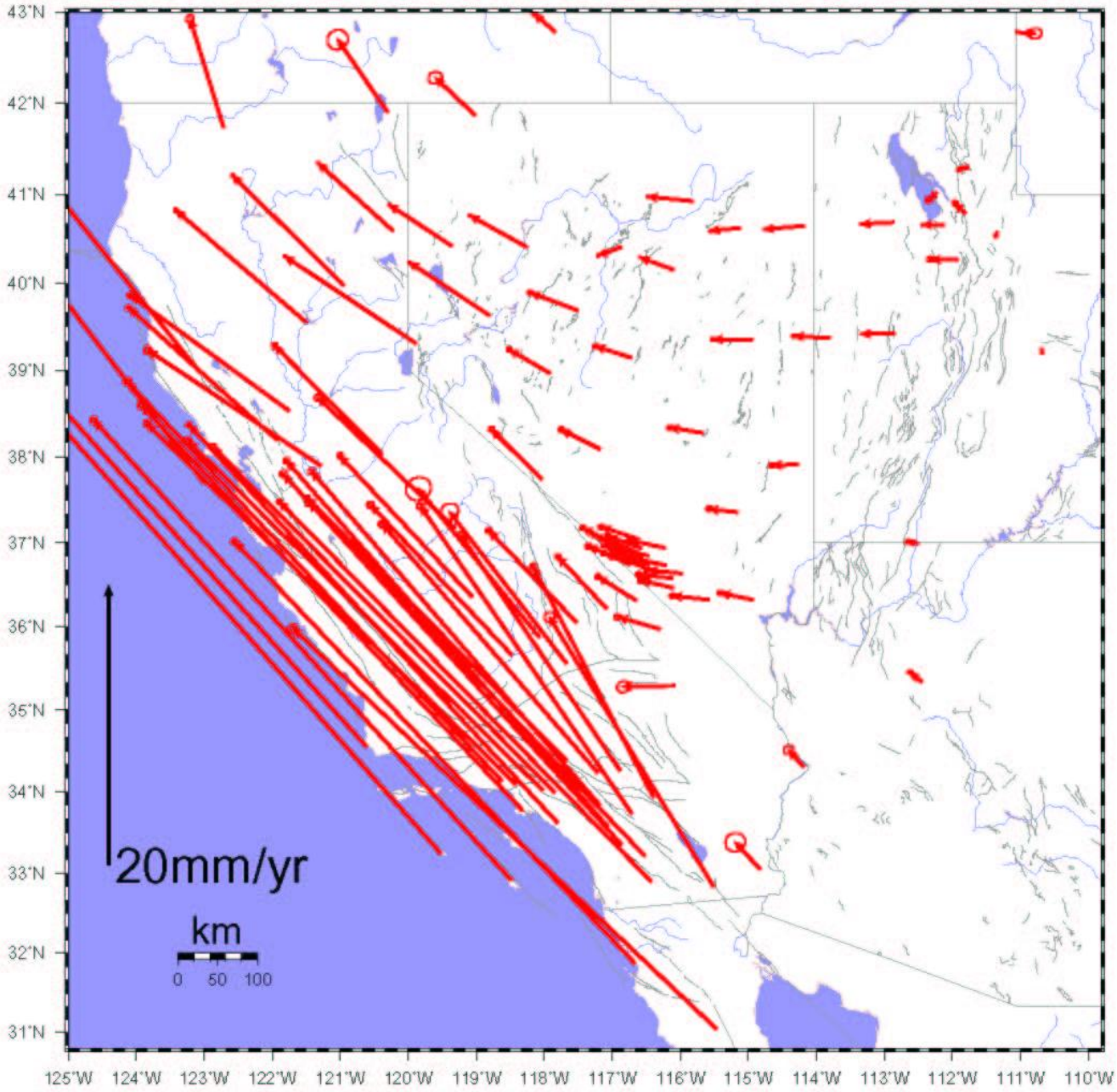
Source: NBMG Special Publication 20 and references therein.

Today, the Nevada Seismological Laboratory and the USGS produce ShakeMaps after a significant earthquake.

NEVADA Seismological Laboratory



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17–1.4*	*1.4–3.9*	*3.9–9.2*	*9.2–18*	18–34	34–65	65–124	>124
PEAK VEL.(cm/s)	<0.1	0.1–1.1	1.1–3.4	3.4–8.1	*8.1–16*	*16–31*	*31–60*	*60–116*	*>116*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+



(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)

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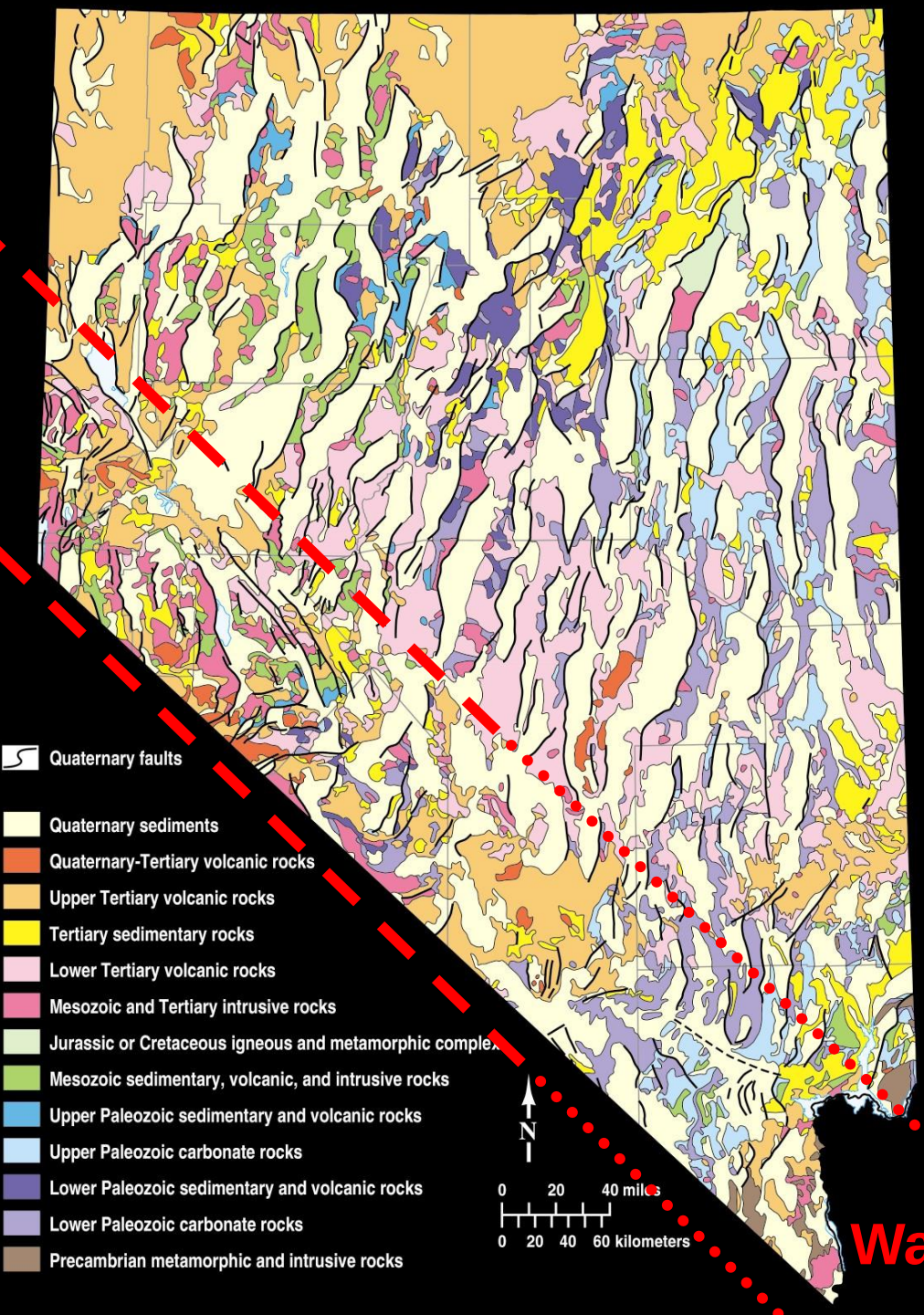

In Nevada, much of the right-lateral shear between the North American and Pacific plates occurs along northwest-striking strike-slip faults of the Walker Lane.

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

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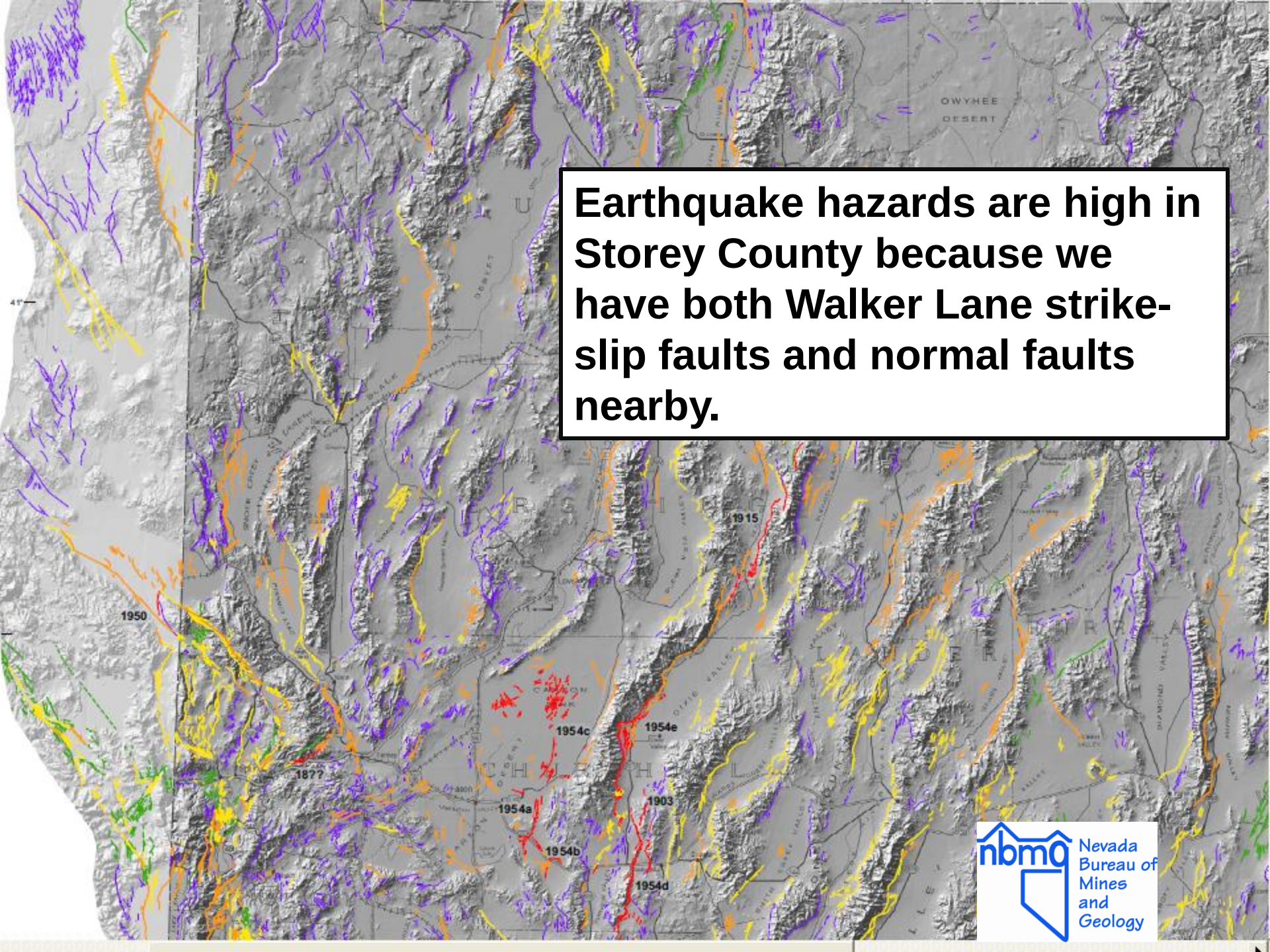
Earthquake hazards are high in Storey County because we have both Walker Lane strike-slip faults and normal faults nearby.
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1915
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1954c
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nbmg
Nevada Bureau of Mines and Geology

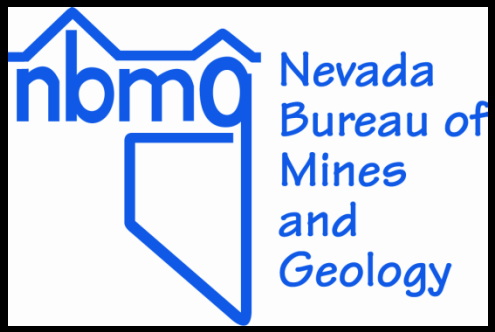
The hazard: expressed in terms of probability of an earthquake of a given magnitude occurring within 50 years and within 50 km of the community.

	% Probability of magnitude greater than or equal to magnitude				
Community	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
Virginia City	>90	~80	70	50	12-15
Reno	>90	~80	67	50	12-15
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.

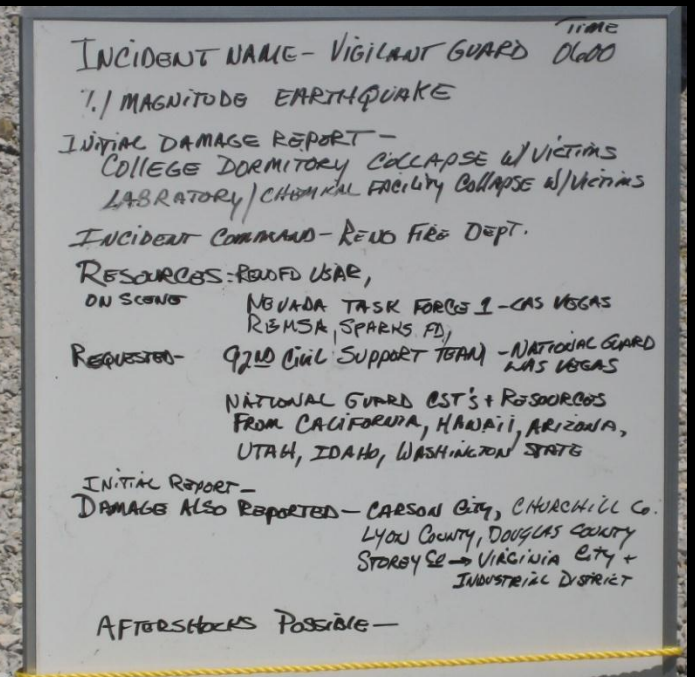
Earthquake faults occur throughout Nevada, and potential losses from earthquakes are high for many communities.

NBMG Open-File Report 09-8, *Estimated Losses from Earthquakes near Nevada Communities*, demonstrates that the consequences of earthquakes can be huge in Nevada, particularly if individuals are not prepared.



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.

These loss estimates are useful in hazard-mitigation planning, in building scenarios for emergency response and recovery exercises, and in helping emergency managers and the Governor make decisions on official disaster declarations after an actual earthquake.



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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.

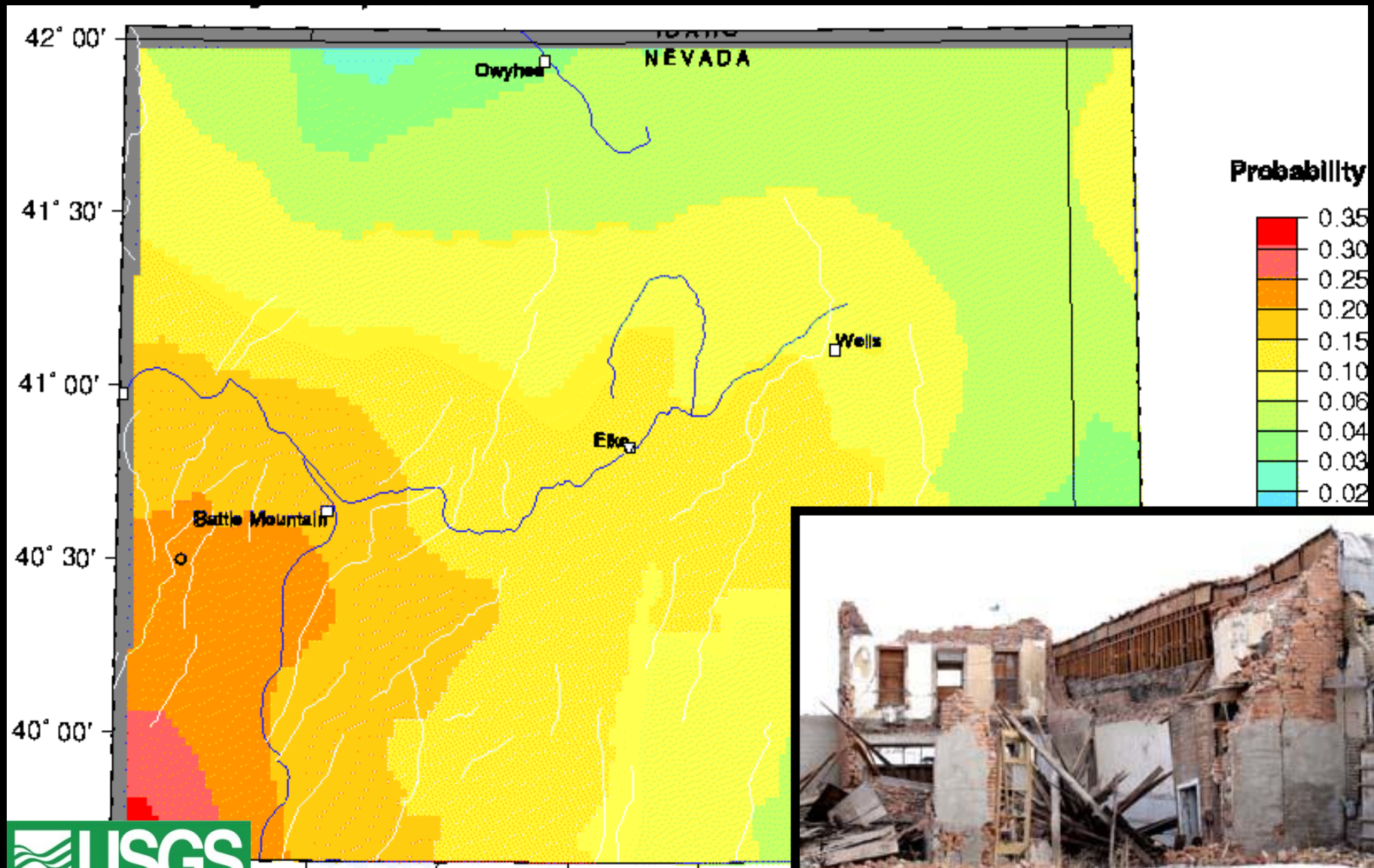
Uncertainties in the location of epicenters, depths, and magnitude, when combined with changing population and uncertainties in local effects (soil and rock types, assumptions about attenuation, basin geometry, liquefaction potential, and directivity), make loss estimates generally consistent within 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.

Community	Total Economic Loss	Probability in 50 years within 50 km
Las Vegas	$7.2 billion	12%
Reno	$1.9 billion	67%
Carson City	$510 million	60 to 70%
Virginia City	$490 million	70%
Elko	$160 million	10 to 15%
Fallon	$110 million	35%
Wells	$30 million	9%

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

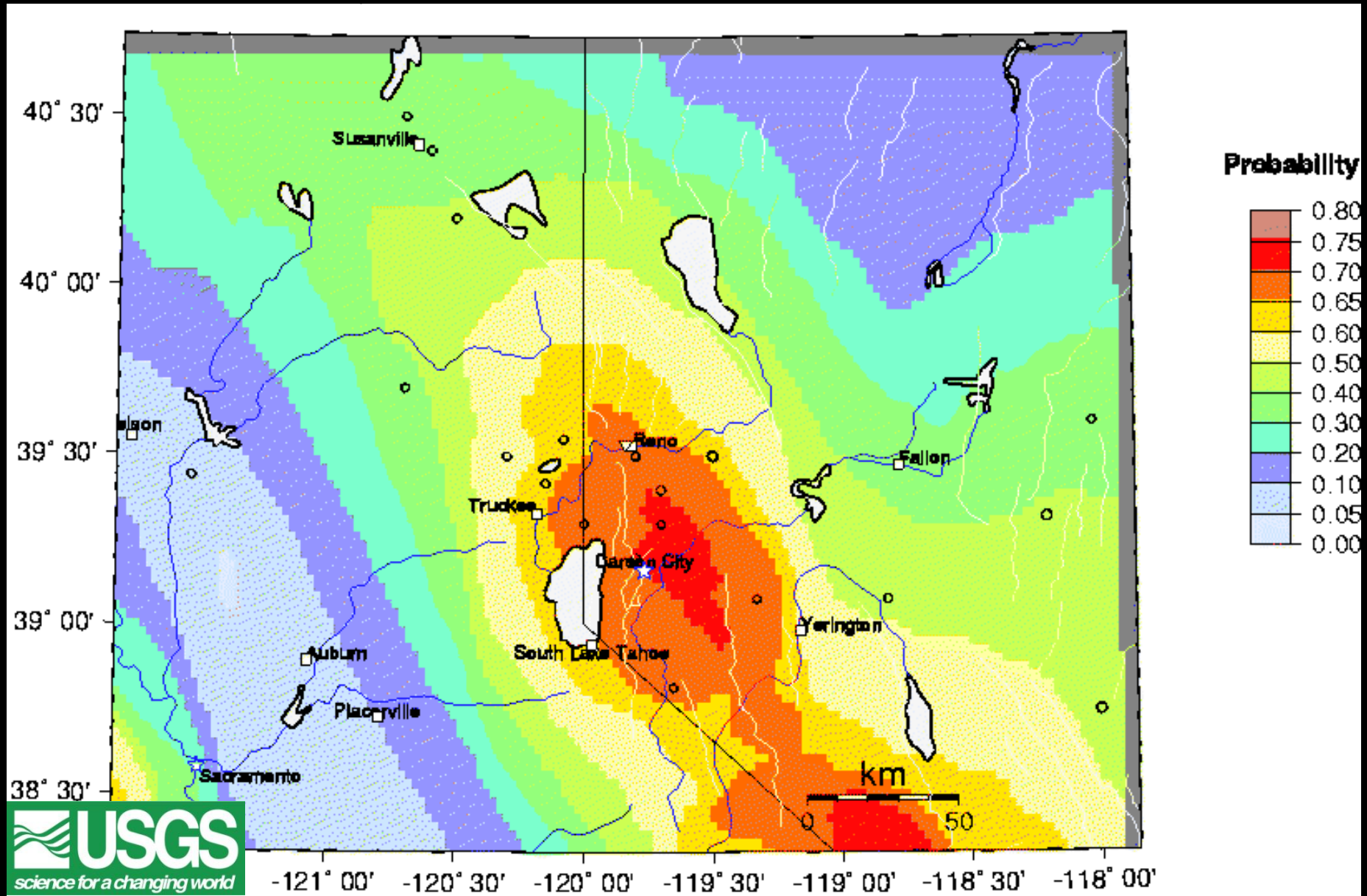
The probability of a magnitude 6.0 earthquake occurring within 50 km of Wells, Nevada within the next 50 years is approximately 9%.
It happened on 21 February 2008.



C. dePolo photo

USGS science for a changing world

The probability of a magnitude 6.0 earthquake occurring within 50 km of Virginia City within the next 50 years is approximately 70%, 7.8 times higher than for Wells.



USGS science for a changing world

HAZUS loss-estimation model results for Virginia City earthquake scenarios (all counties affected)

	Magnitude				
	5.0	5.5	6.0	6.5	7.0
Total Dollar Loss	$39M	$140M	$490M	$1.5B	$3.4B
# Buildings with major damage	20	110	740	3,000	7,700
# People needing shelter	1	9	46	240	680
# People needing hospital care	1	4	21	120	430
# Fatalities	none	1	4	29	110
Probability in 50 years	>90%	~80%	70%	50%	12-15%

HAZUS loss-estimation model results for Virginia City earthquake scenarios (Storey County only)

	Magnitude				
	5.0	5.5	6.0	6.5	7.0
Total Dollar Loss	$7M	$16M	$33M	$62M	$83M
# Buildings with major damage	3	17	110	230	320
# People needing shelter	none	none	1	4	6
# People needing hospital care	none	none	1	4	7
# Fatalities	none	none	none	1	2
Probability in 50 years	>90%	~80%	70%	50%	12-15%

HAZUS loss-estimation model results for Virginia City earthquake scenarios (all counties affected)

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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.

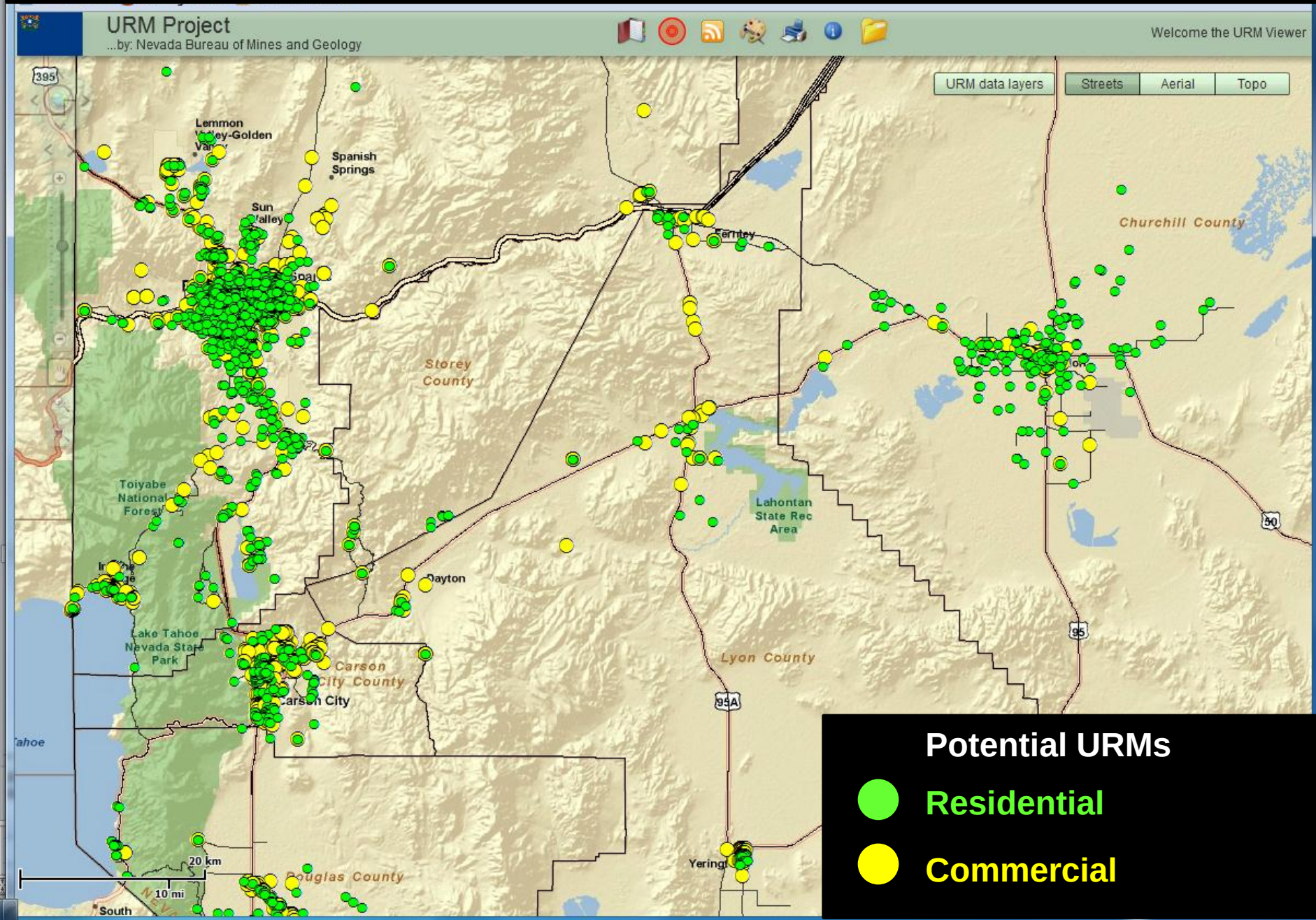
C. Mitigate nonstructural risks.

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

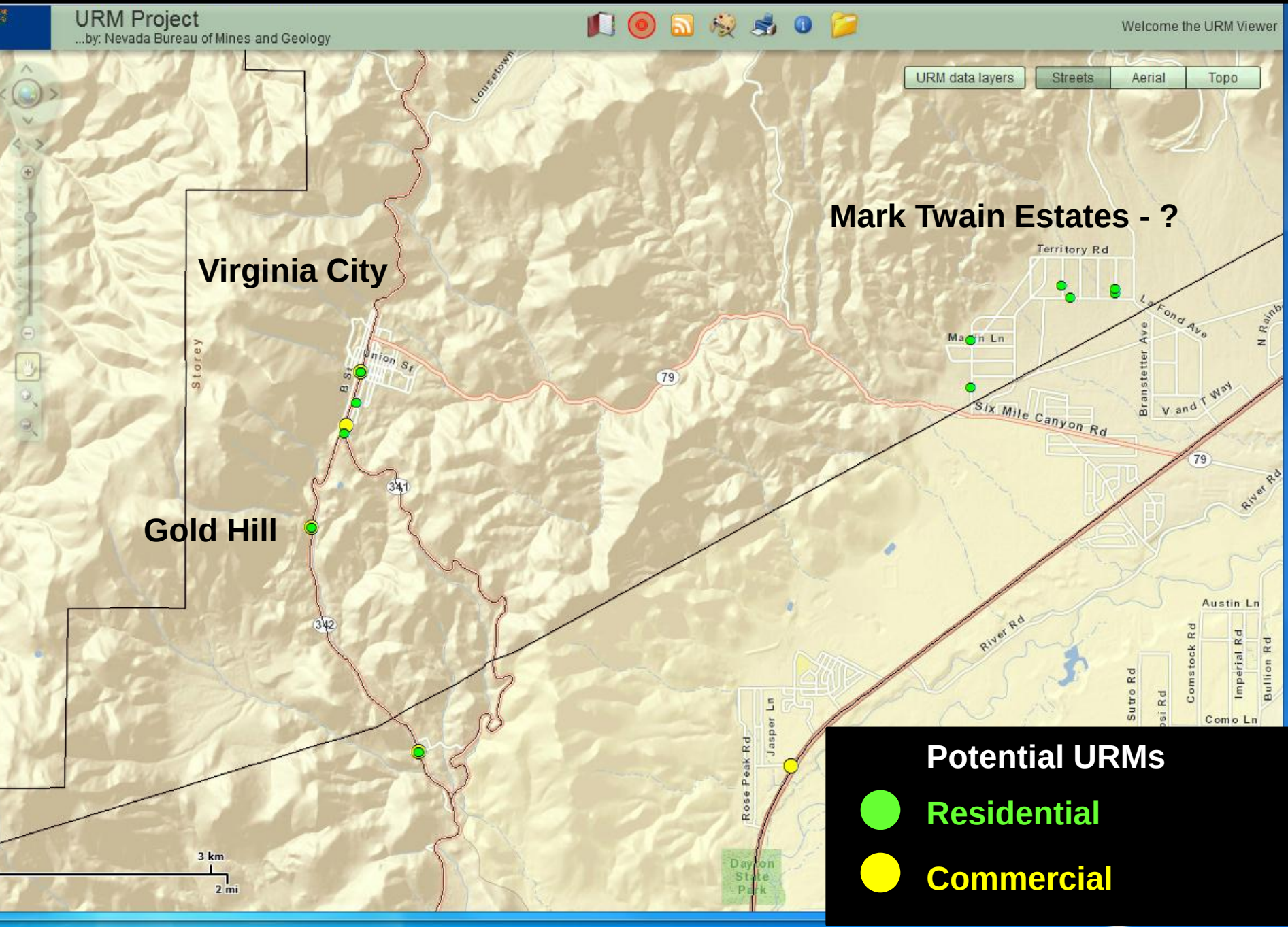
View from back, 20 May 2009

View from front, 20 May 2009

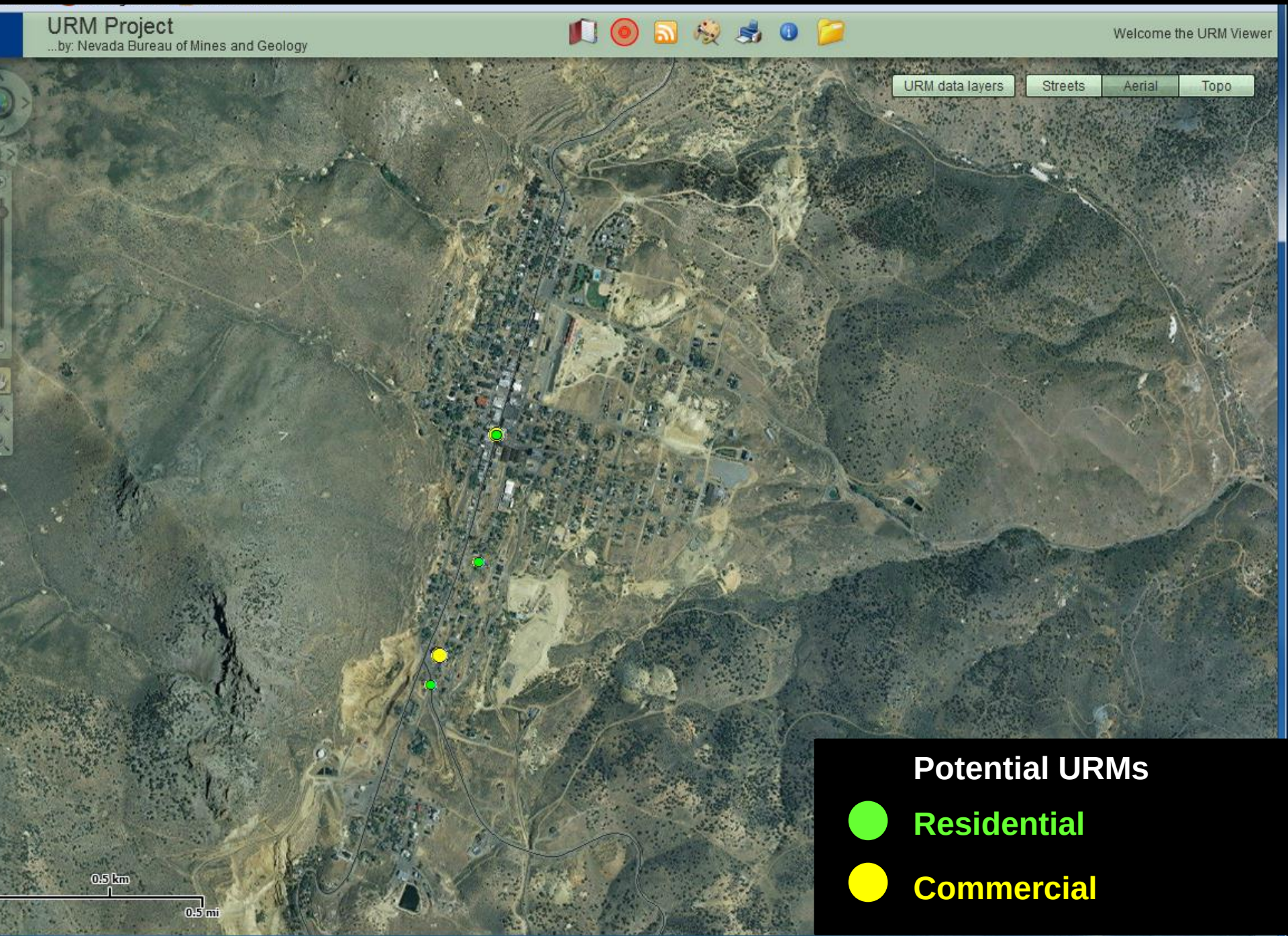
County assessors supplied locations of potential URMs, based on type and age of buildings.



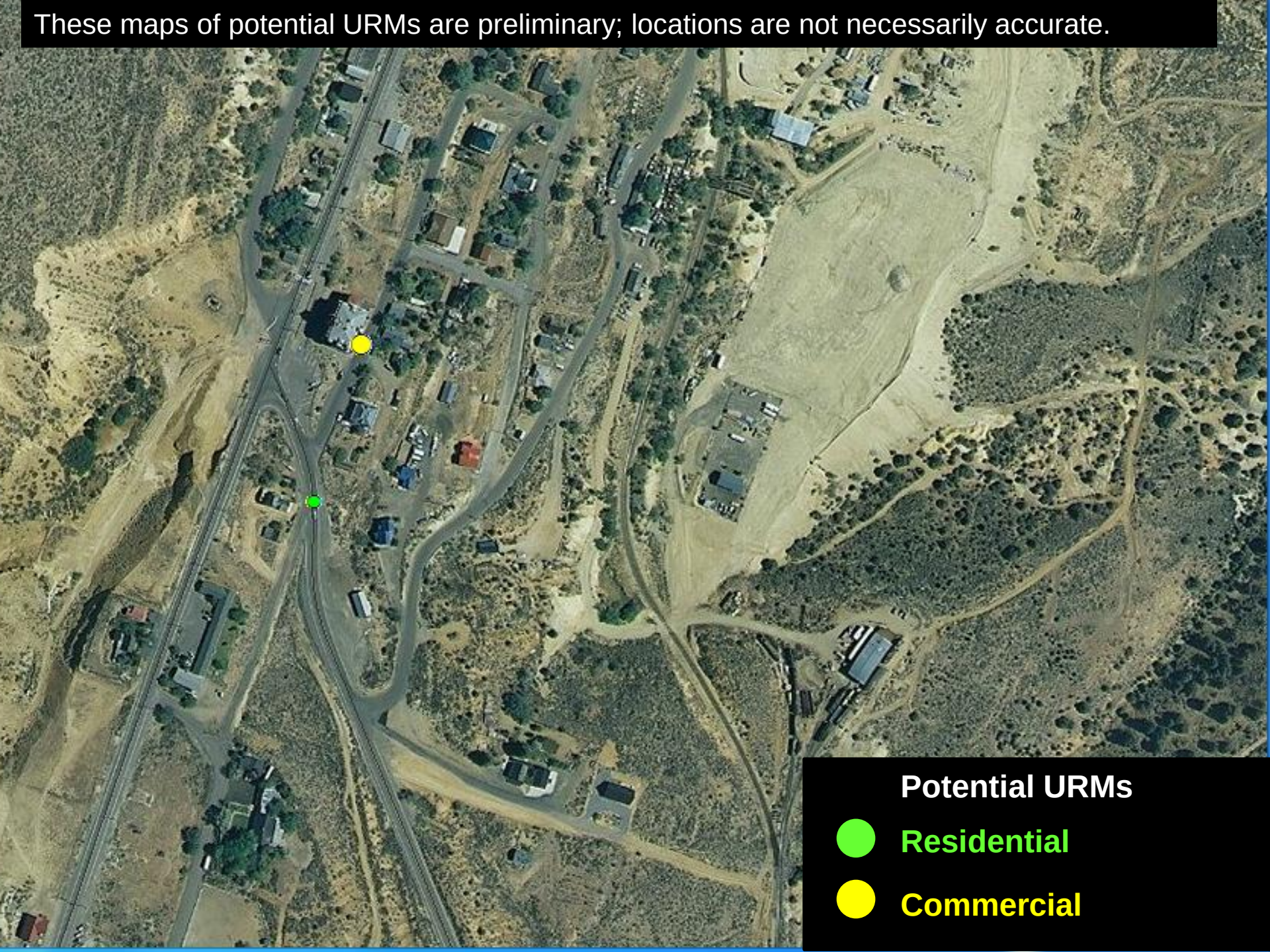
These maps of potential URMs are preliminary; locations are not necessarily accurate.

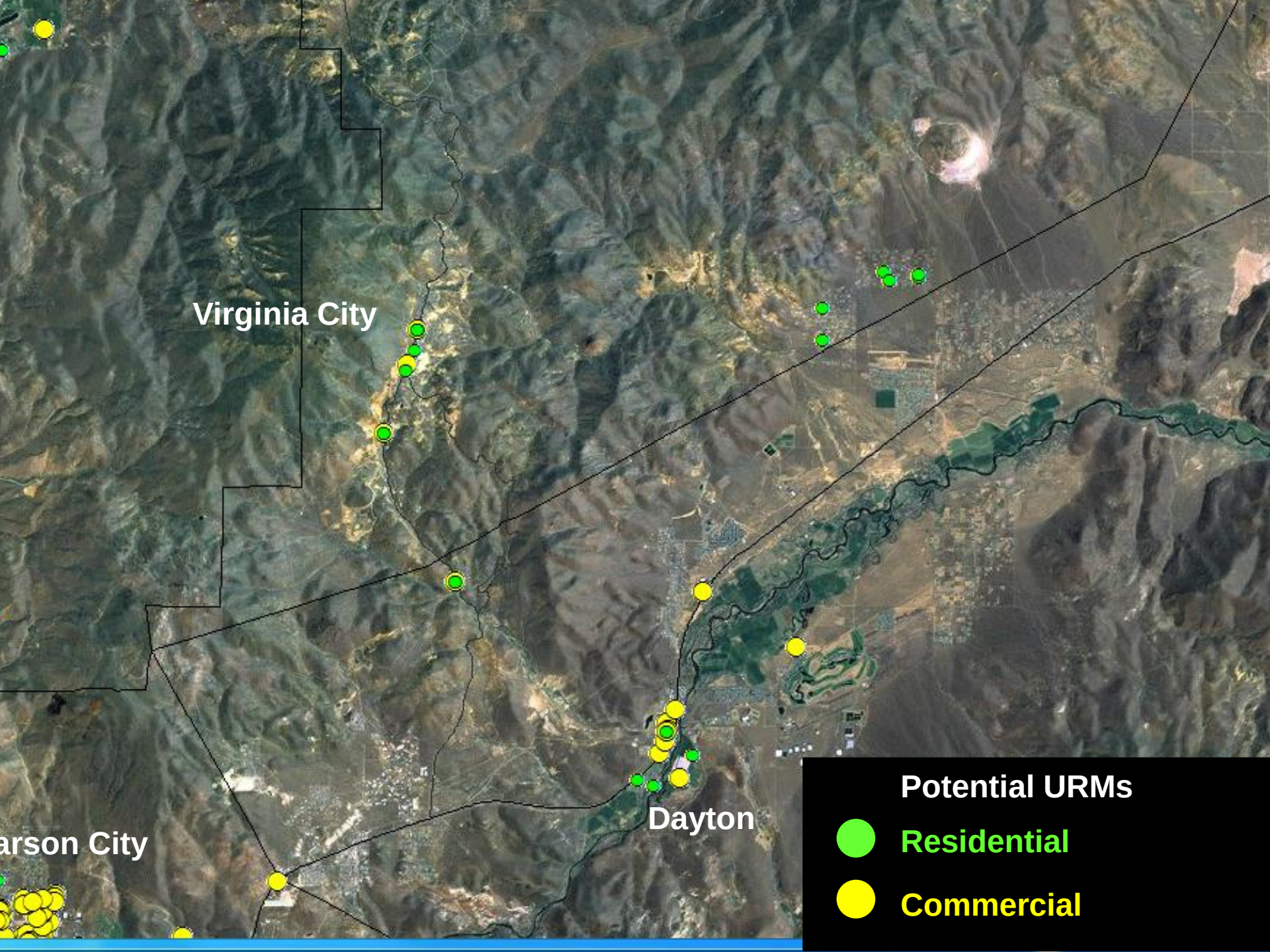


These maps of potential URMs are preliminary; locations are not necessarily accurate.



These maps of potential URMs are preliminary; locations are not necessarily accurate.




Virginia City
Dayton
arson City
Potential URMs
Residential
Commercial

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

Washoe County EOC, 30 September 2007 – computers secure

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
2175 Raggio Parkway, Reno, NV 89512

Cuttings from oil, gas, and geothermal exploration and production wells
6 May 2009

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


RIDG-U-RAK®
Seismic Base Isolation System
Patent No's. 7,249,442 & 7,263,806

4 May 2009

Thank you!

And thanks to Craig dePolo, Gary Johnson, Christine Ballard, Heather Armeno, Irene Seeley, Linda D. Goar, and Jordan T. Hastings for their work on the open-file reports (OF 09-8 and 09-9), which are available as online documents at www.nbmg.unr.edu.

From there, go to online documents at http://www.nbmg.unr.edu/dox/dox.htm, then scroll down to OF 09-8 or 09-9. Link to the fault map from OF 09-9.

nbmg Nevada Bureau of Mines and Geology

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FEMA

Nevada Department of Public Safety
Division of Emergency Management

Nevada Earthquake Safety Council

USGS
science for a changing world

NEVADA Seismological Laboratory

THE GREAT SEAL OF THE STATE OF NEVADA
ALL FOR OUR COUNTRY

Large earthquakes can cluster in time and location.

Large historical earthquakes in 1954-1959 near Fallon, preceded by a possible large earthquake in 1852

Date	Magnitude	Near
1852?	7.3	Fallon
July 6, 1954 (a)	6.6	Rainbow Mtn.
11 hours later (b)	6.0	Fourmile Flat
August 24, 1954 (c)	6.8	Stillwater
December 16, 1954 (d)	7.1	Fairview Peak
4 minutes later (e)	6.8	Dixie Valley
March 23, 1959	6.3	Dixie Valley

On the basis of historical seismic records, the Nevada Seismological Laboratory estimates that

there is a 2% probability that a given earthquake is a foreshock of an earthquake with a magnitude 1 unit higher within the next 10 days, and that

there is a 5% probability that a given earthquake is a foreshock of an earthquake with a magnitude 0.5 unit higher within the next 10 days.