Earthquake Hazards in Eureka and White Pine Counties

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

Nevada Hazard Mitigation Planning Committee

8 May 2012

Earthquakes in the Eureka region

Earthquakes in Austin and Eureka 1868-1894

- 1st reported event in Austin Nov. 7, 1868; eight more through 1894,
- M 5.5 near Austin March 23,1872, plaster fell in courthouse,
- M 6 south of Austin Nov. 12, 1872, sharp shock.

- April 11, 1872 slight shock Eureka,
- Nov. 8, 1873 quaking last couple of nights, quite a perceptible quiver for several seconds,
- April 2, 1875 severe Eureka M5+.
- Dec. 8, 1881 heavy shock in Eureka

April 2, 1875

~6:00 pm; about 3 secs. Shaking,

"brought to the feet every man, woman, and child in town. Everyone rushed frantically to the streets, and not a few clambered up the hill-sides for safety, fearful that the town was about to be demolished"

Eureka Daily Sentinel 4/2/1875

MMI = VII, Slemmons and others (1965)

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

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.

Age of Latest Fault Rupture

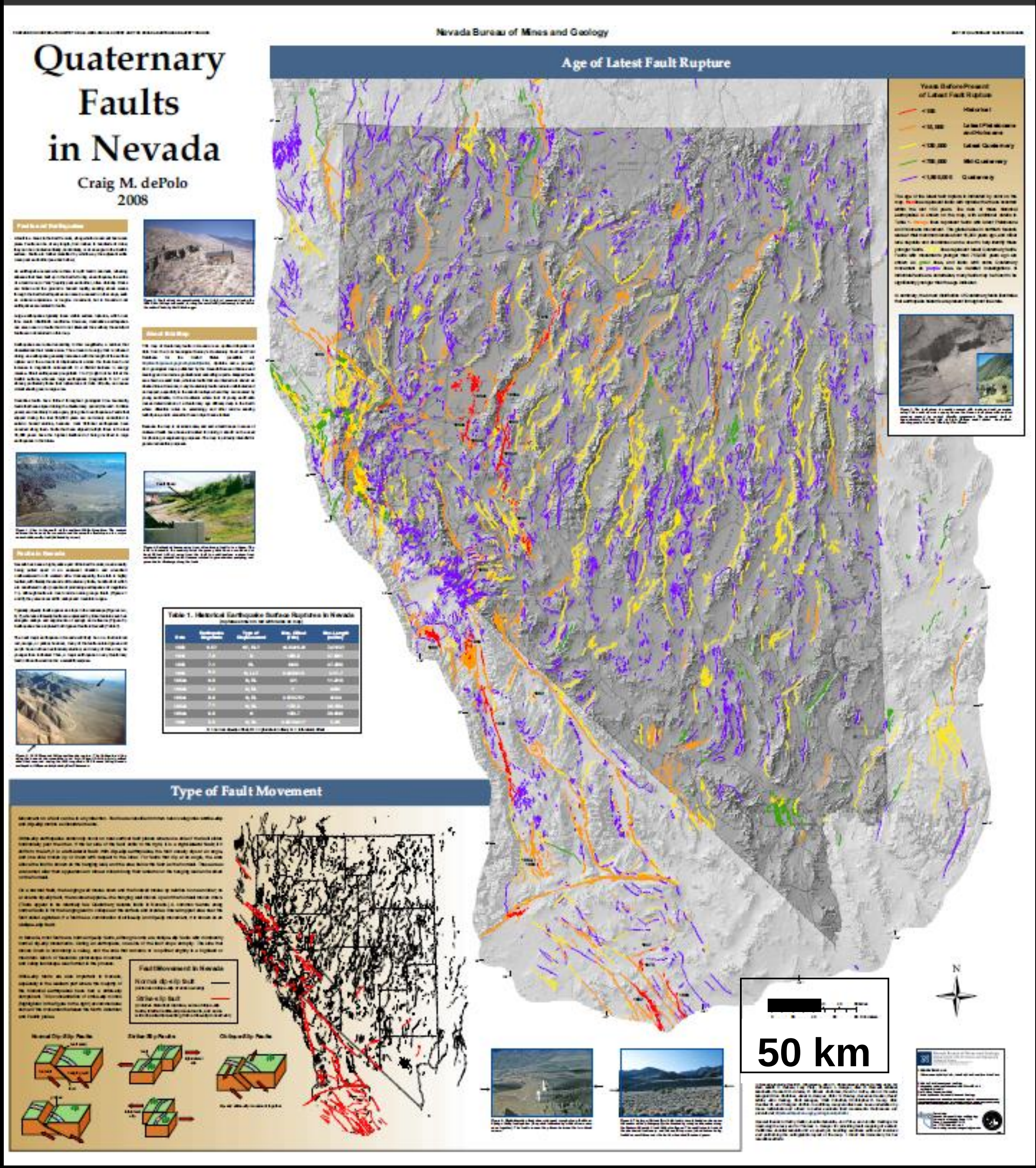
< 150 years (historical)

< 15,000 years

< 130,000 years

< 750,000 years

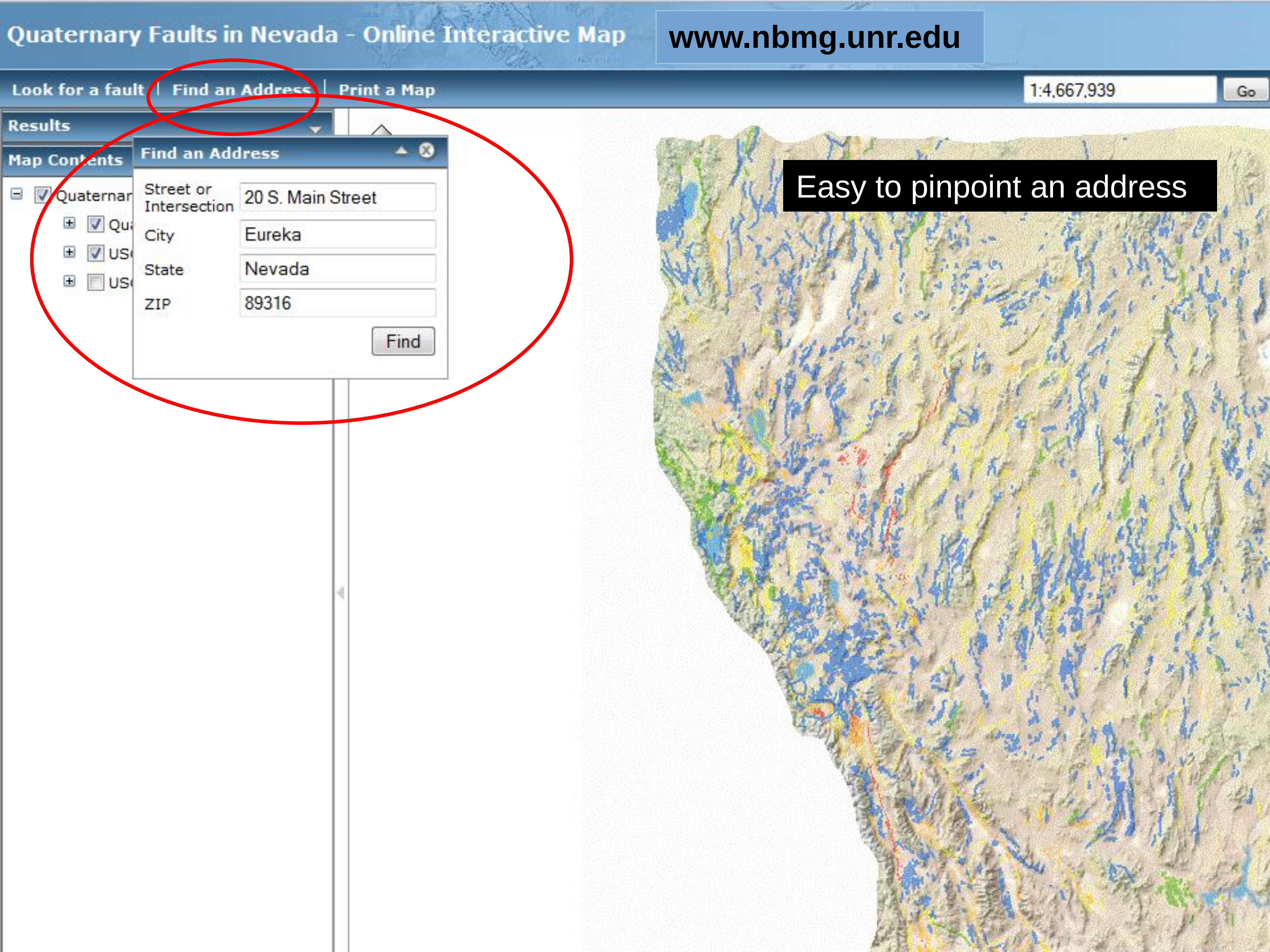
< 1,800,000 years (Quaternary)

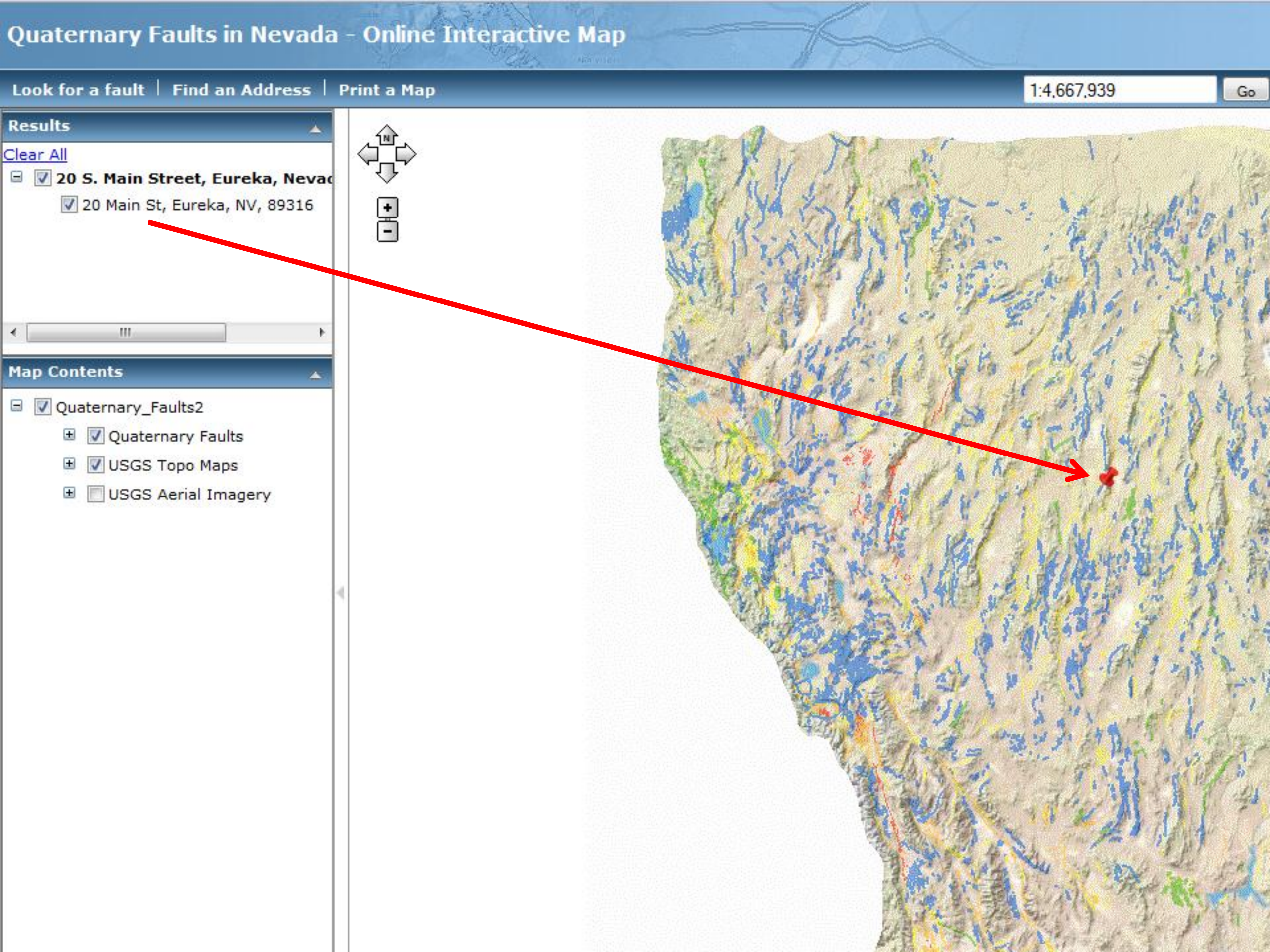


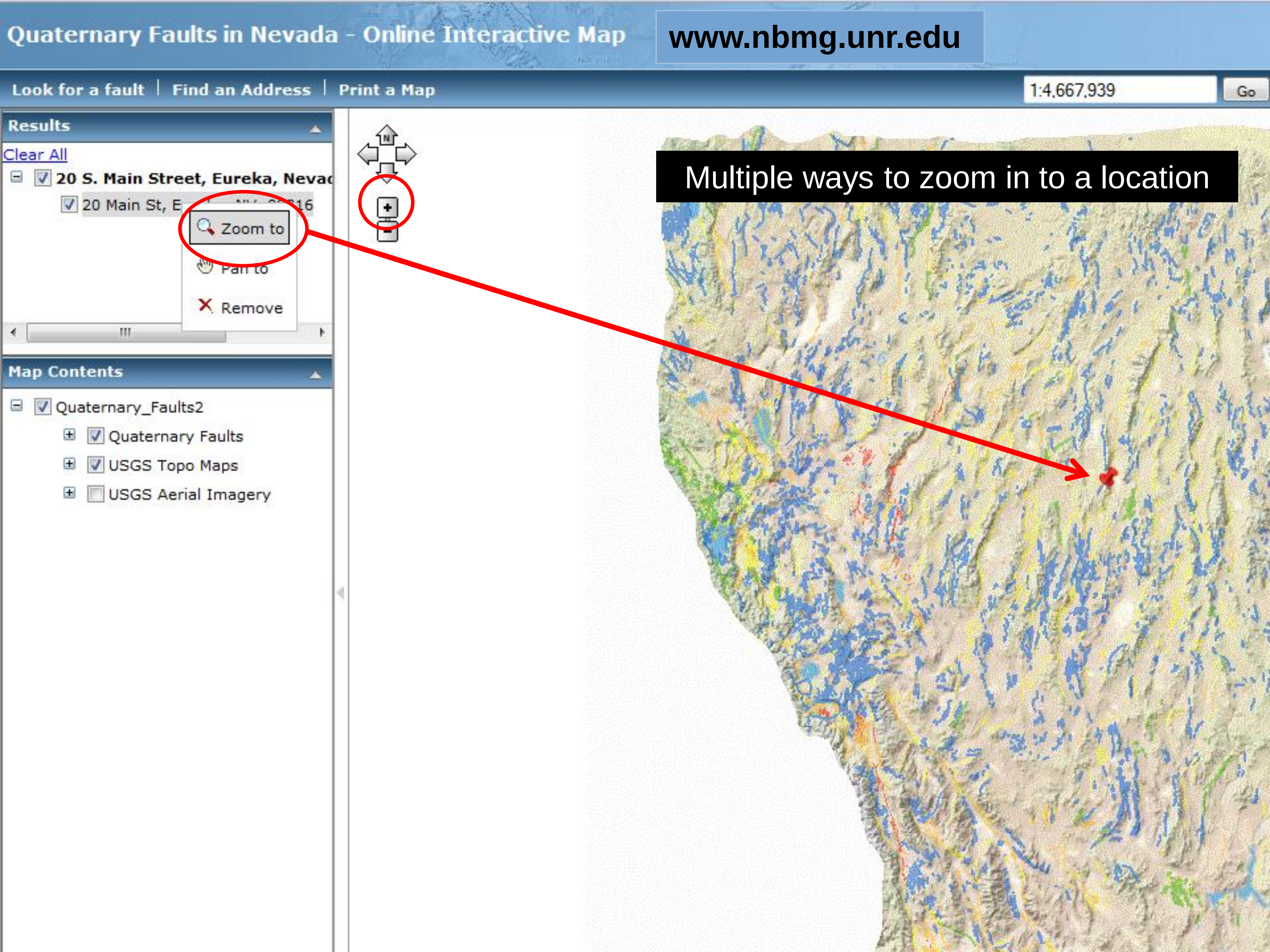
There are active faults nearly everywhere in Nevada.

A magnitude 6.0 earthquake can occur anywhere in Nevada.

www.nbmg.unr.edu


Quaternary Faults in Nevada - Online Interactive Map
www.nbmg.unr.edu
Look for a fault
Find an Address
Print a Map
1:4,667,939
Go
Results
Map Contents
Quaternar
Qu
US
US
Find an Address
Street or Intersection
20 S. Main Street
City
Eureka
State
Nevada
ZIP
89316
Find
Easy to pinpoint an address

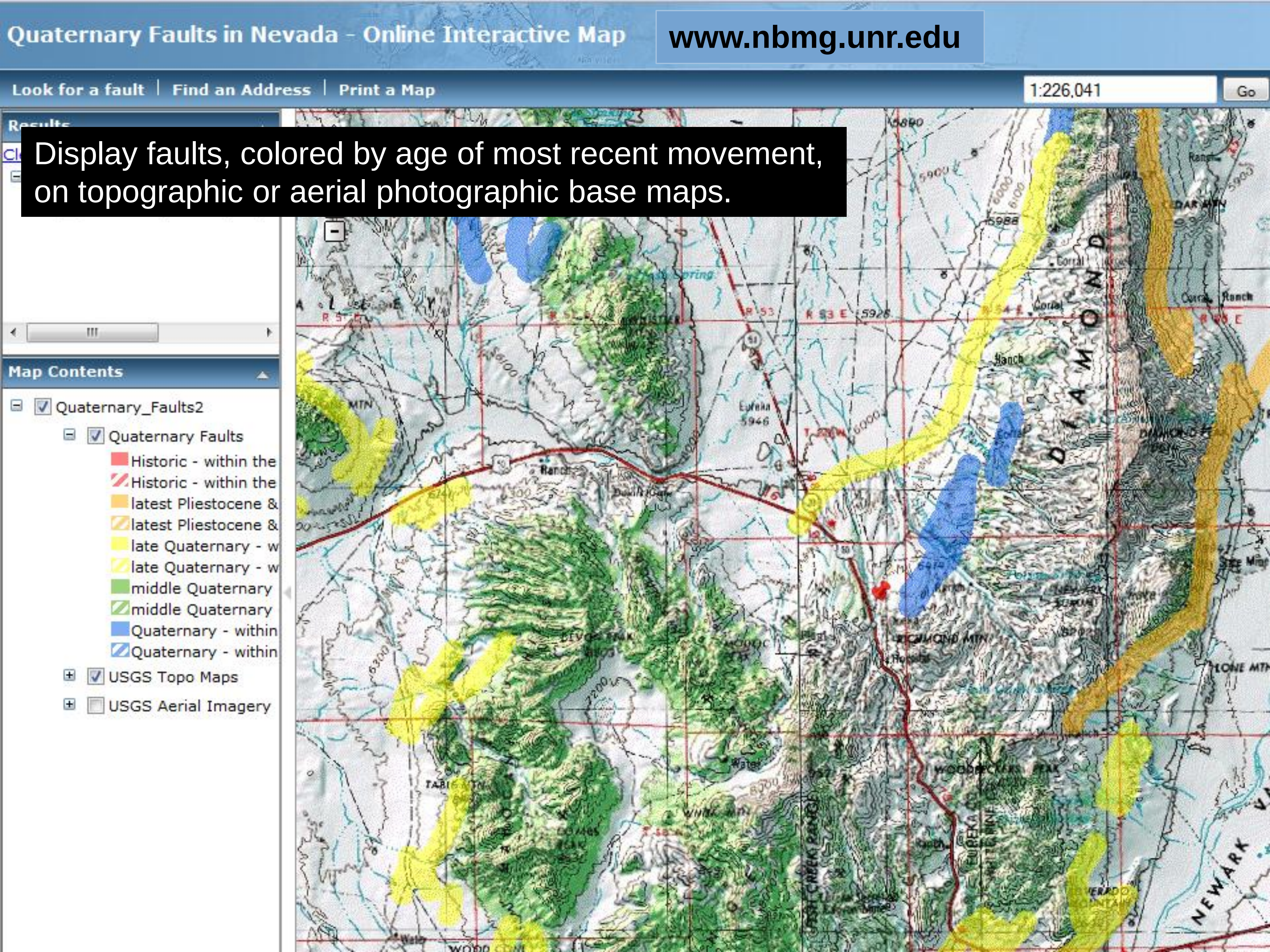

Quaternary Faults in Nevada - Online Interactive Map
Look for a fault
Find an Address
Print a Map
1:4,667,939
Go
Results
Clear All
20 S. Main Street, Eureka, Nevac
20 Main St, Eureka, NV, 89316
Map Contents
Quaternary_Faults2
Quaternary Faults
USGS Topo Maps
USGS Aerial Imagery



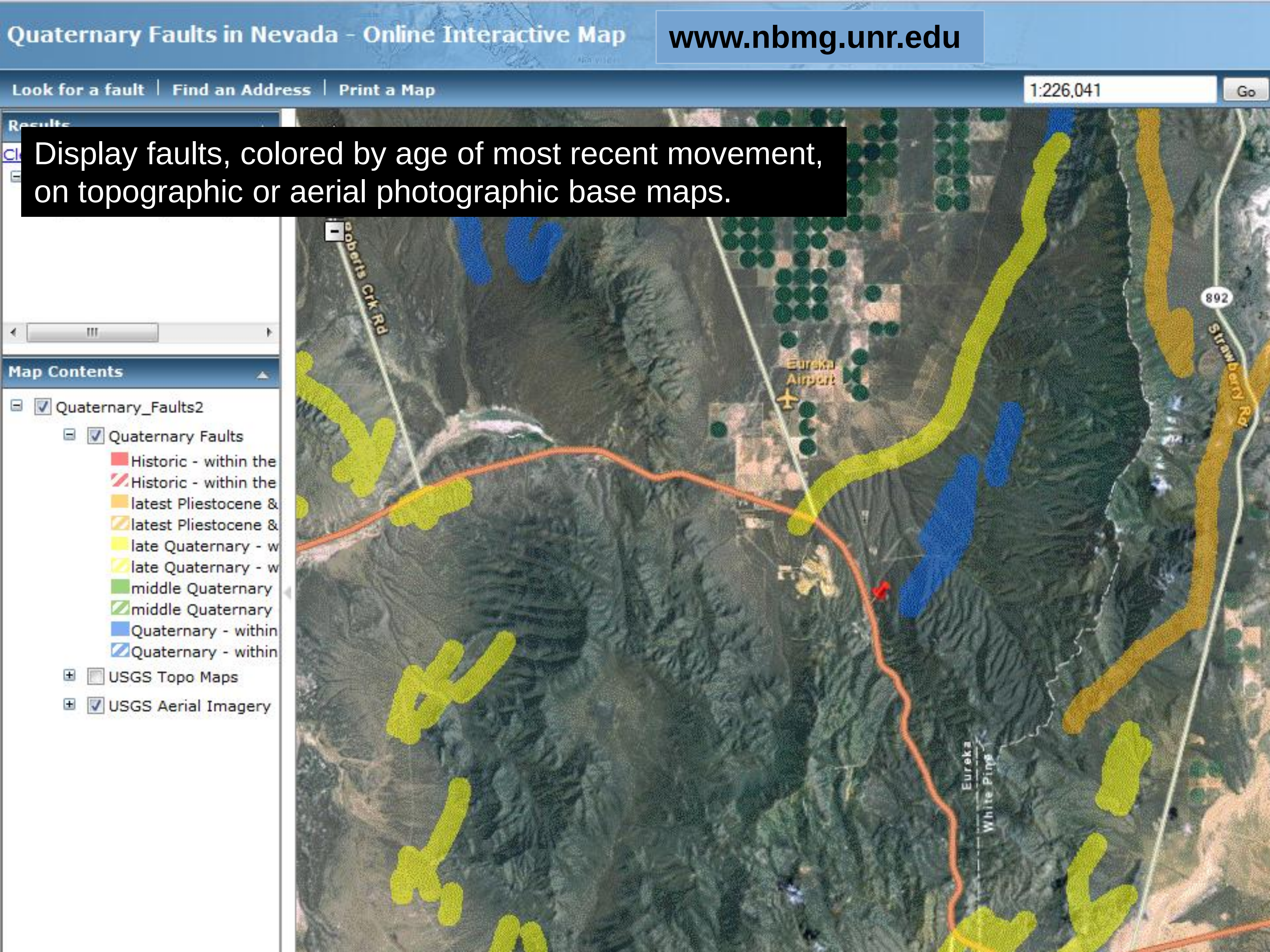
Quaternary Faults in Nevada - Online Interactive Map
www.nbmg.unr.edu
Look for a fault
Find an Address
Print a Map
1:4,667,939
Go
Results
Clear All
20 S. Main Street, Eureka, Nevad
20 Main St, E
Zoom to
Pan to
Remove
Map Contents
Quaternary_Faults2
Quaternary Faults
USGS Topo Maps
USGS Aerial Imagery
Multiple ways to zoom in to a location

www.nbmg.unr.edu

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

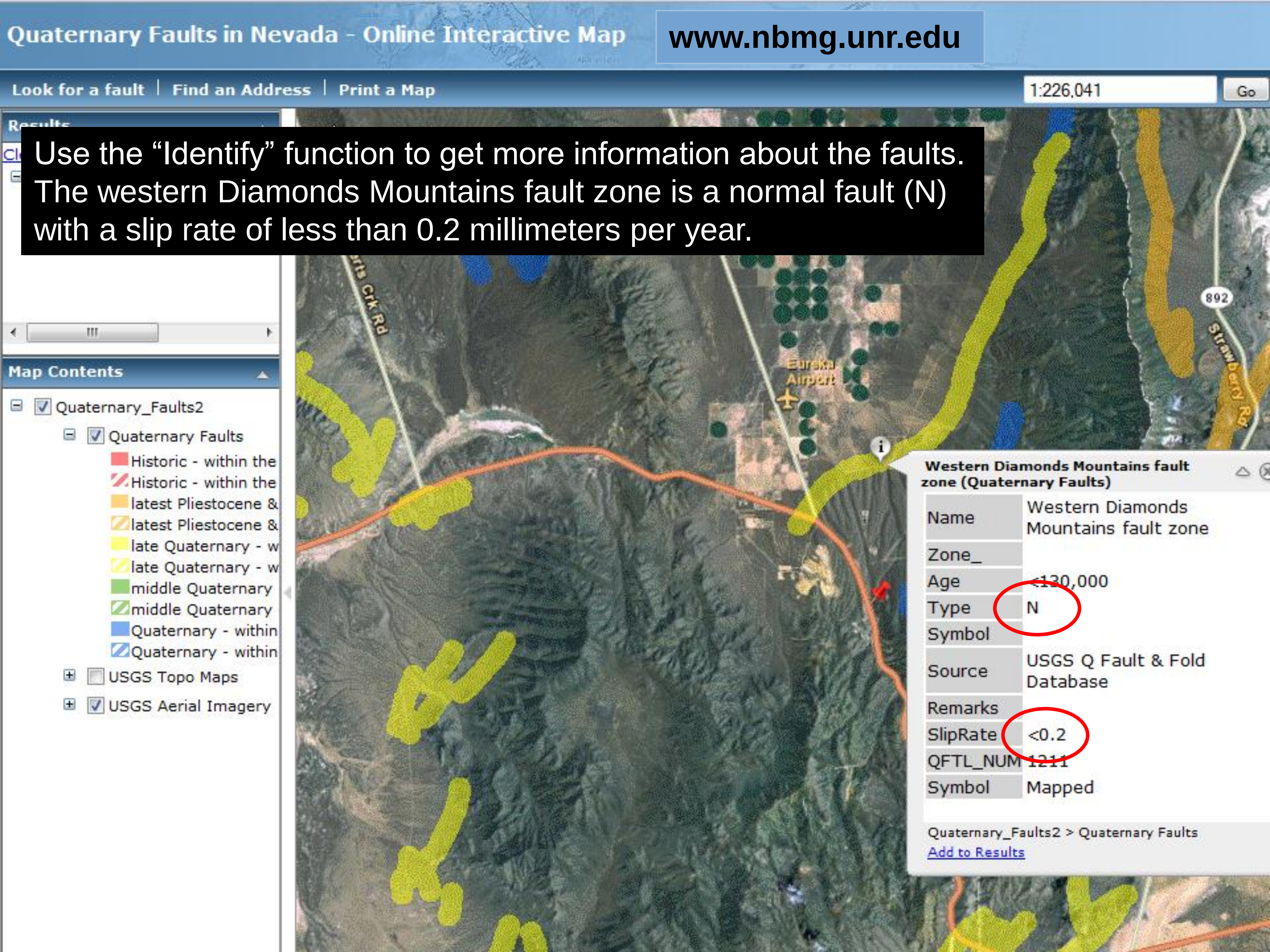


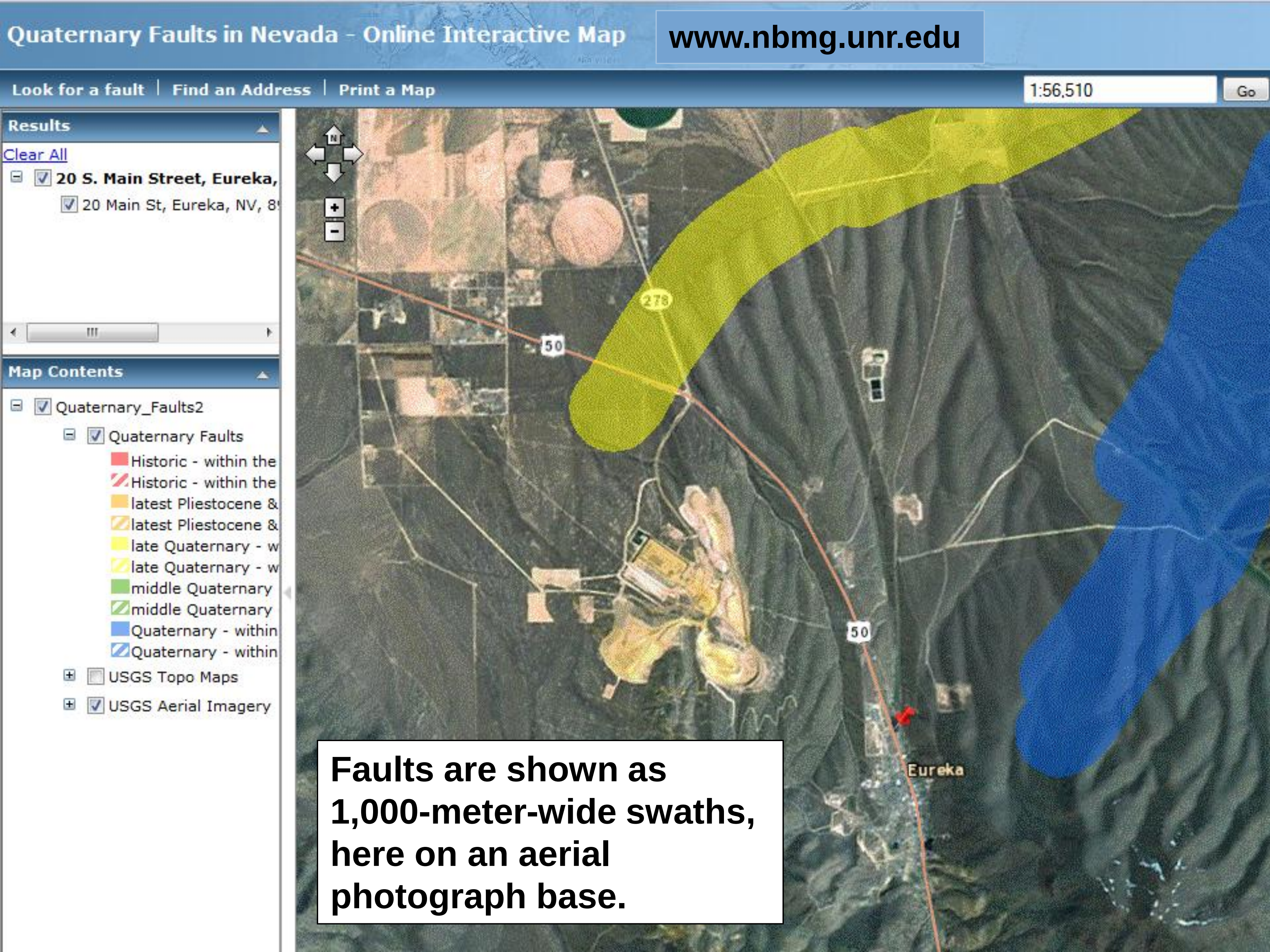
Display faults, colored by age of most recent movement, on topographic or aerial photographic base maps.



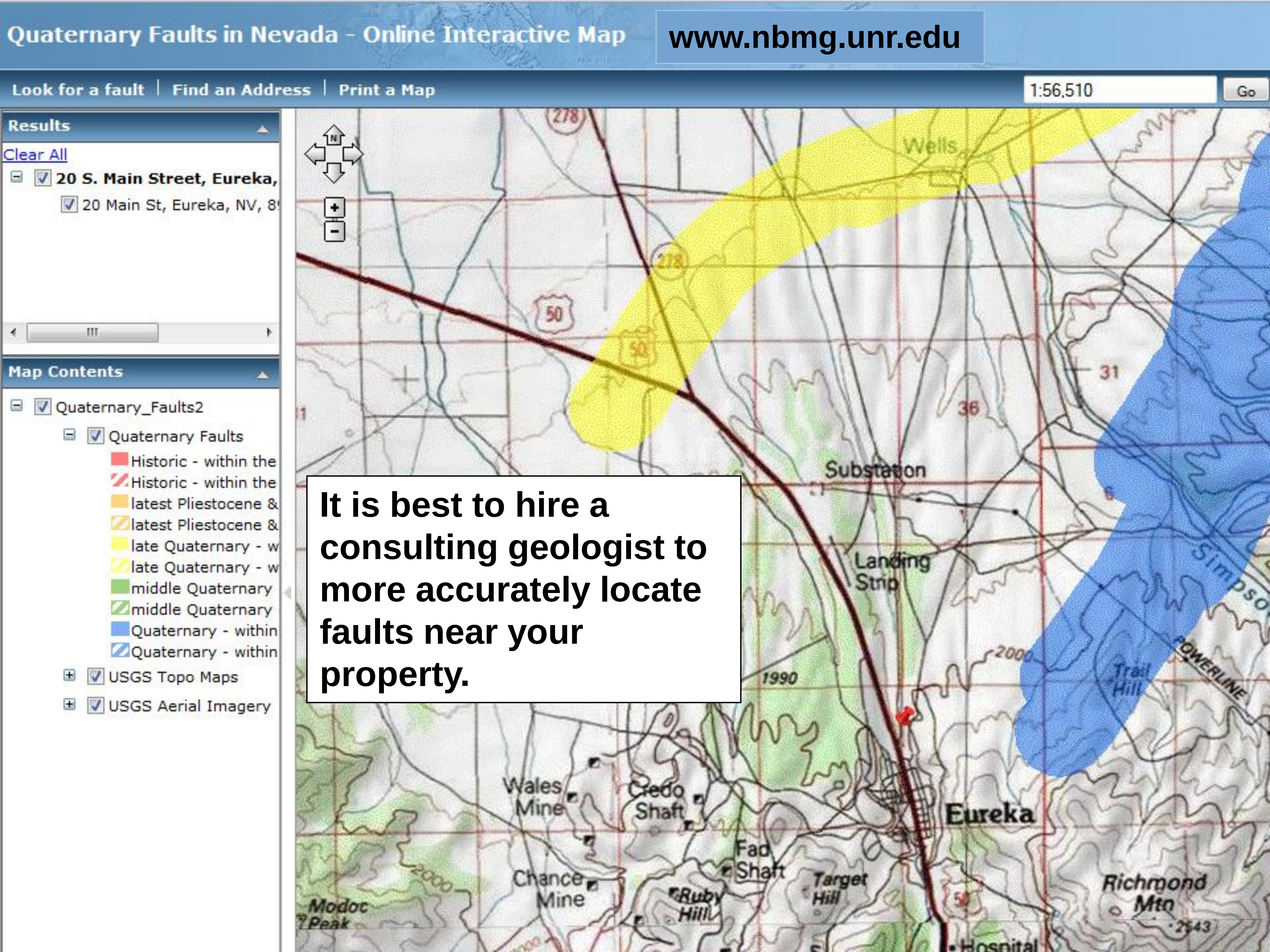
www.nbmg.unr.edu

Use the “Identify” function to get more information about the faults. The western Diamonds Mountains fault zone is a normal fault (N) with a slip rate of less than 0.2 millimeters per year.



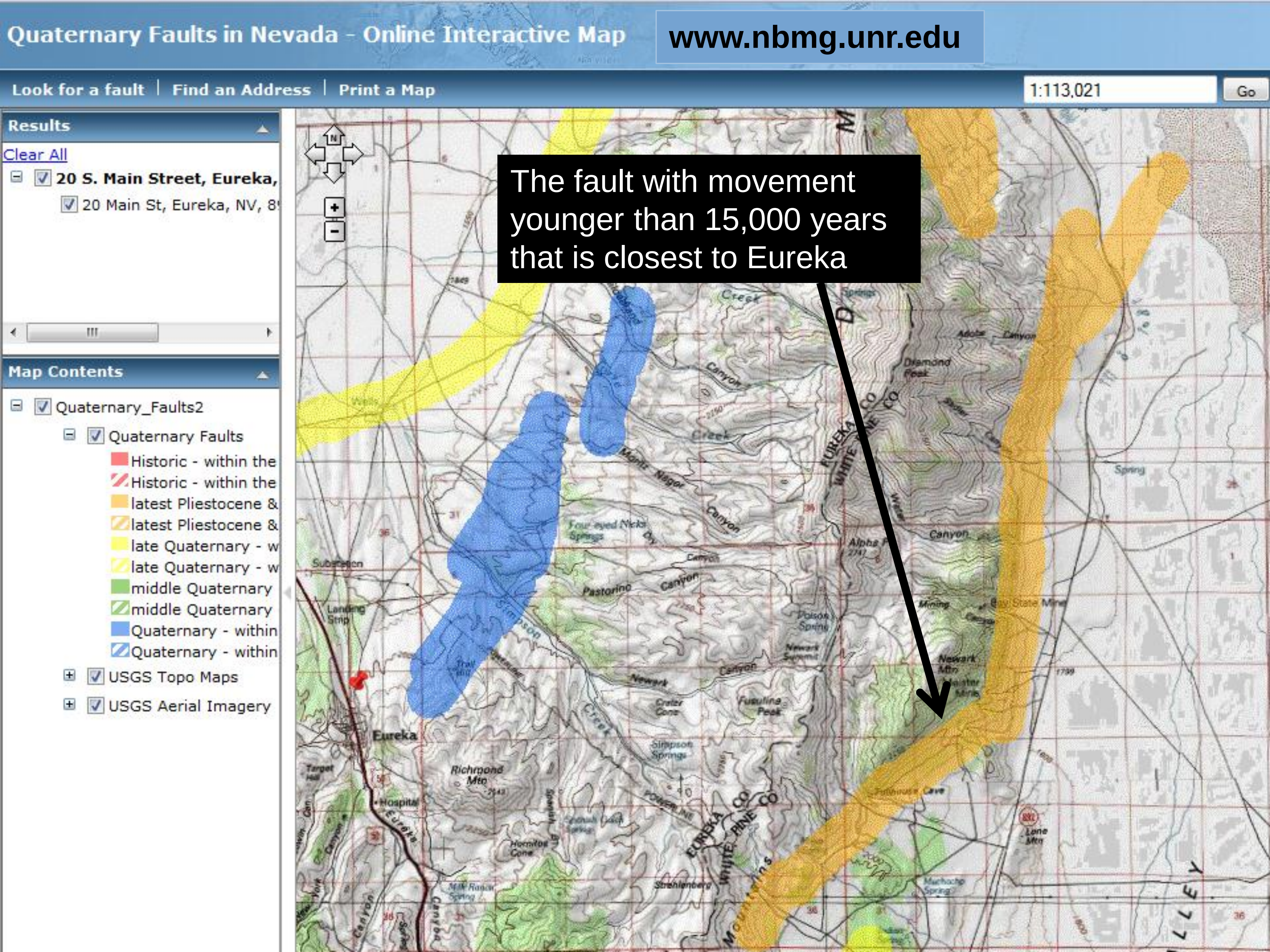


Faults are shown as 1,000-meter-wide swaths, here on an aerial photograph base.

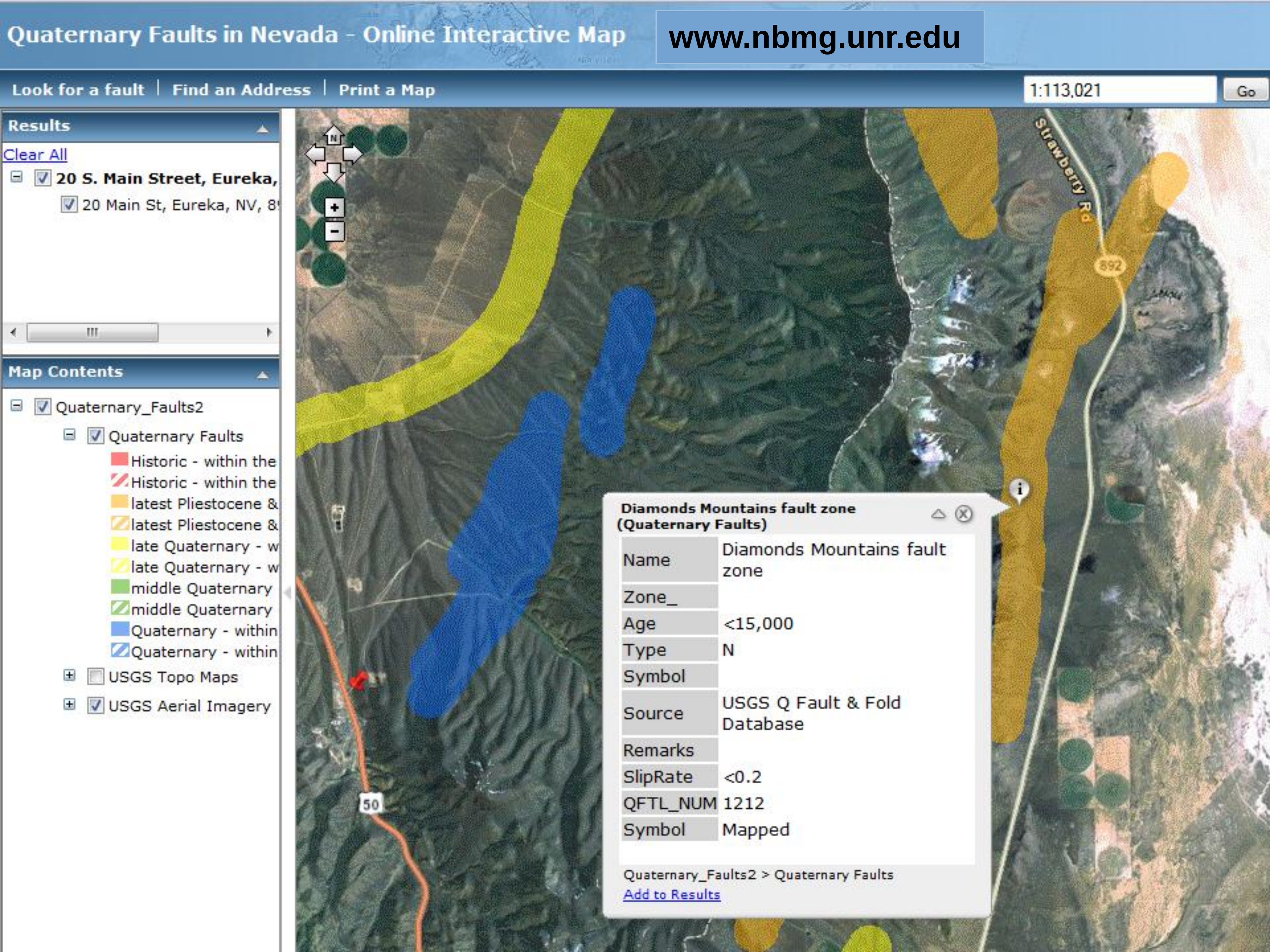


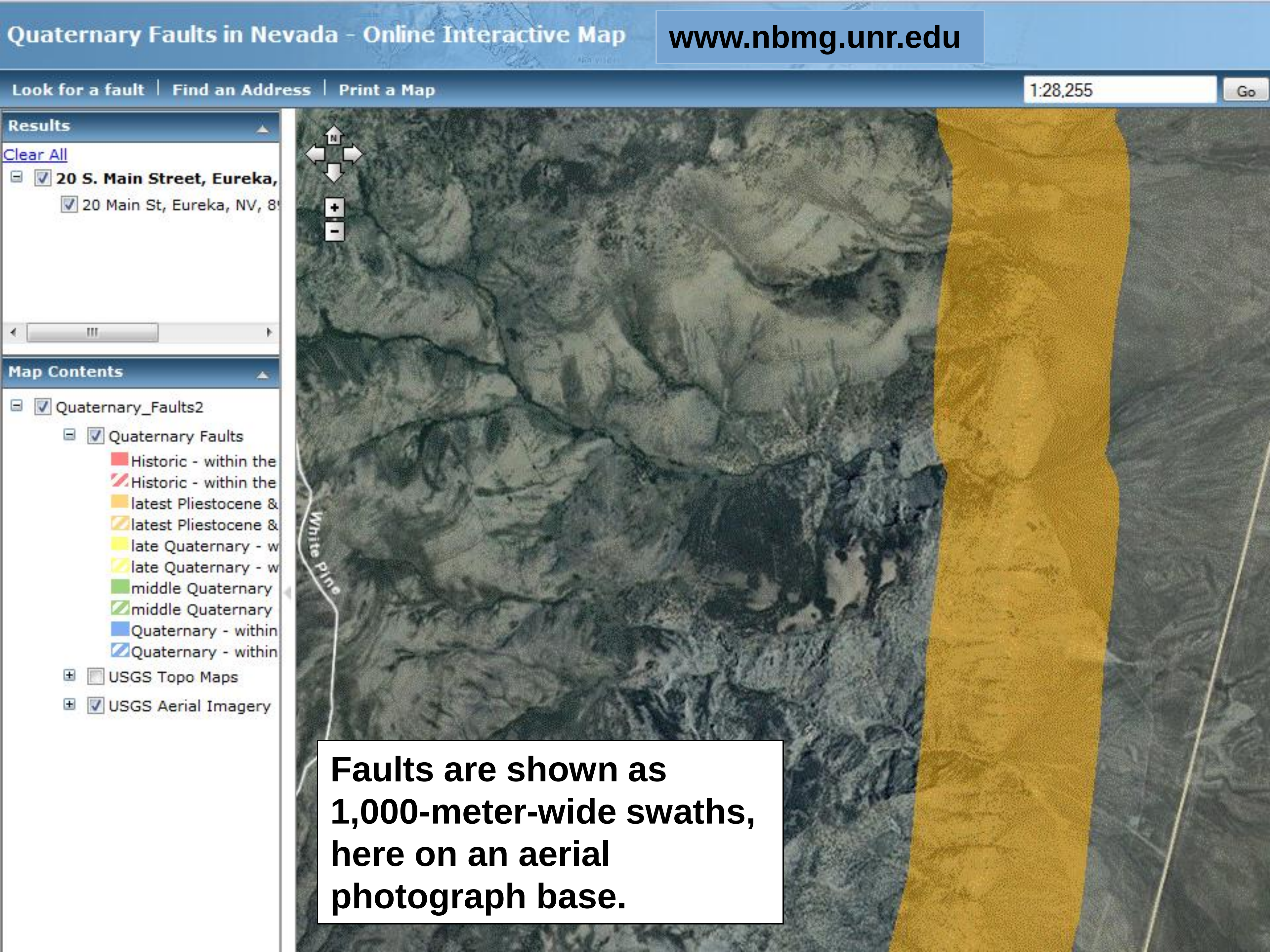
www.nbmg.unr.edu

It is best to hire a consulting geologist to more accurately locate faults near your property.

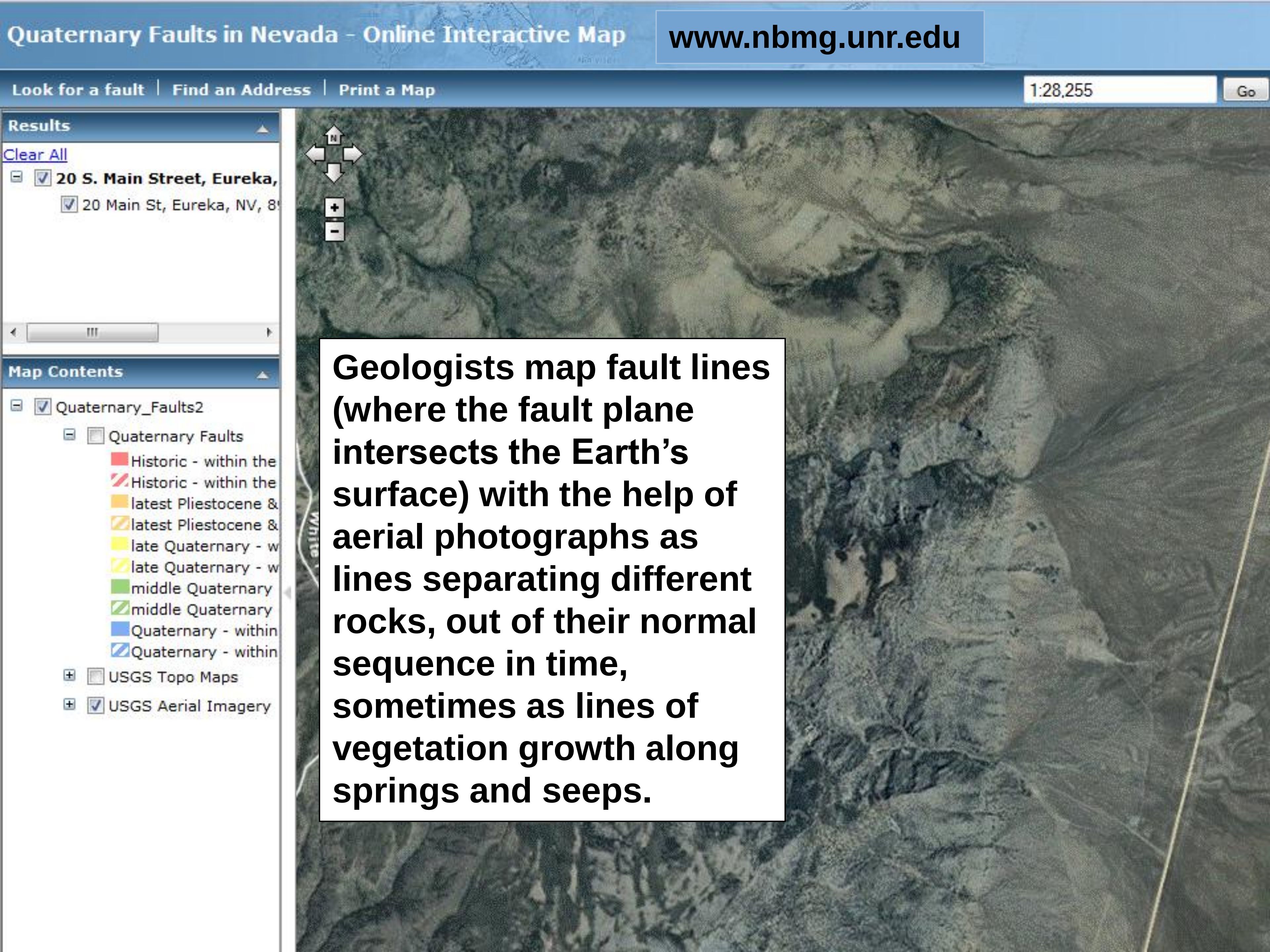


Quaternary Faults in Nevada - Online Interactive Map
www.nbmg.unr.edu
Look for a fault
Find an Address
Print a Map
1:113,021
Go
Results
Clear All
20 S. Main Street, Eureka,
20 Main St, Eureka, NV, 8
Map Contents
Quaternary_Faults2
Quaternary Faults
Historic - within the
Historic - within the
latest Pliestocene &
latest Pliestocene &
late Quaternary - w
late Quaternary - w
middle Quaternary
middle Quaternary
Quaternary - within
Quaternary - within
USGS Topo Maps
USGS Aerial Imagery
The fault with movement younger than 15,000 years that is closest to Eureka
Eureka
Richmond Mtn
Diamond Peak
Newark Mtn
Lone Mtn
EUREKA CO
WHITE PINE CO


Quaternary Faults in Nevada - Online Interactive Map
www.nbmg.unr.edu
Look for a fault | Find an Address | Print a Map
1:113,021
Go
Results
Clear All
20 S. Main Street, Eureka,
20 Main St, Eureka, NV, 8
Map Contents
Quaternary_Faults2
Quaternary Faults
Historic - within the
Historic - within the
latest Pliestocene &
latest Pliestocene &
late Quaternary - w
late Quaternary - w
middle Quaternary
middle Quaternary
Quaternary - within
Quaternary - within
USGS Topo Maps
USGS Aerial Imagery
Strawberry Rd
892
50
Diamonds Mountains fault zone (Quaternary Faults)
Name: Diamonds Mountains fault zone
Zone_
Age: <15,000
Type: N
Symbol
Source: USGS Q Fault & Fold Database
Remarks
SlipRate: <0.2
QFTL_NUM: 1212
Symbol: Mapped
Quaternary_Faults2 > Quaternary Faults
Add to Results

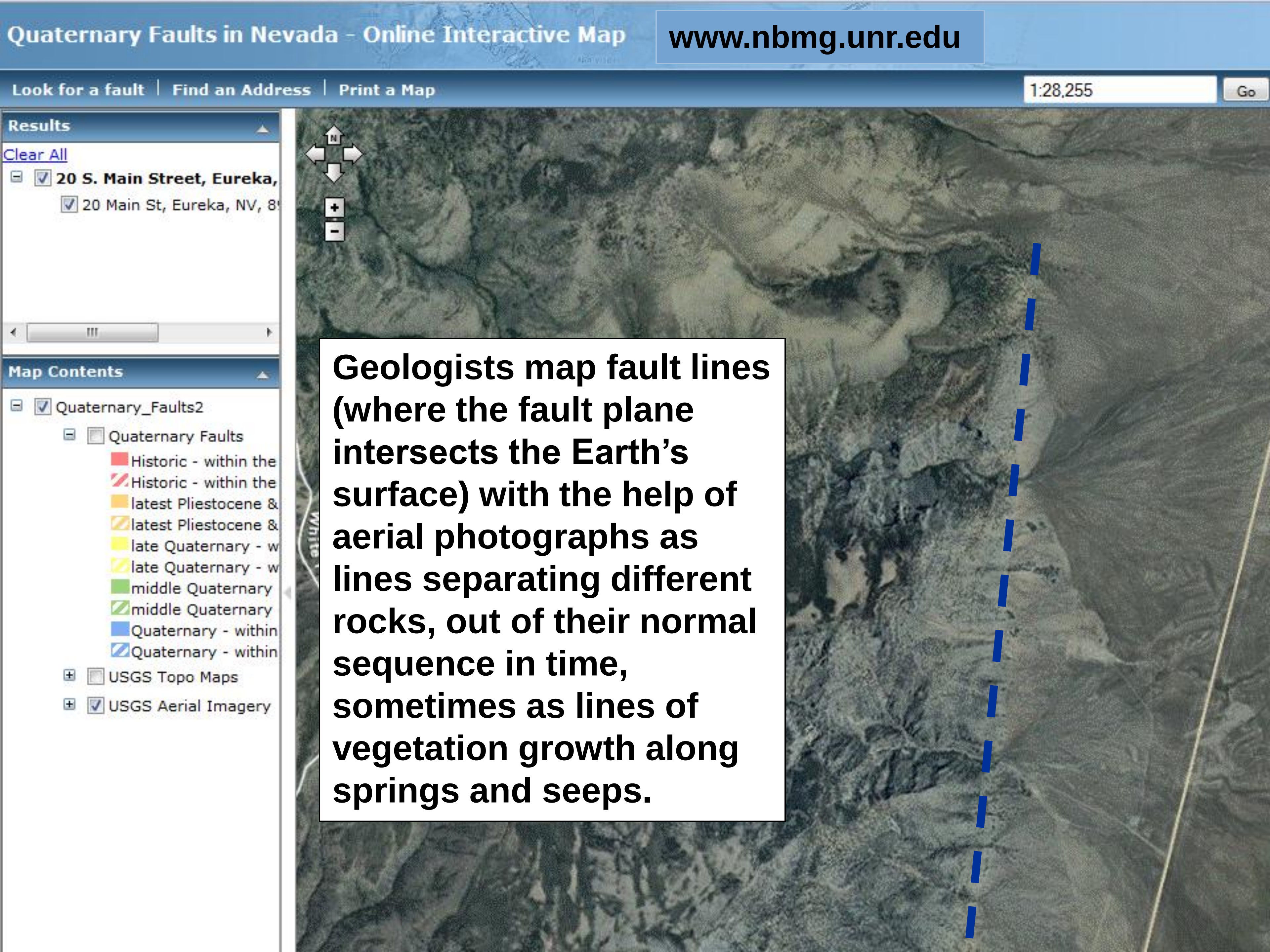


Faults are shown as 1,000-meter-wide swaths, here on an aerial photograph base.



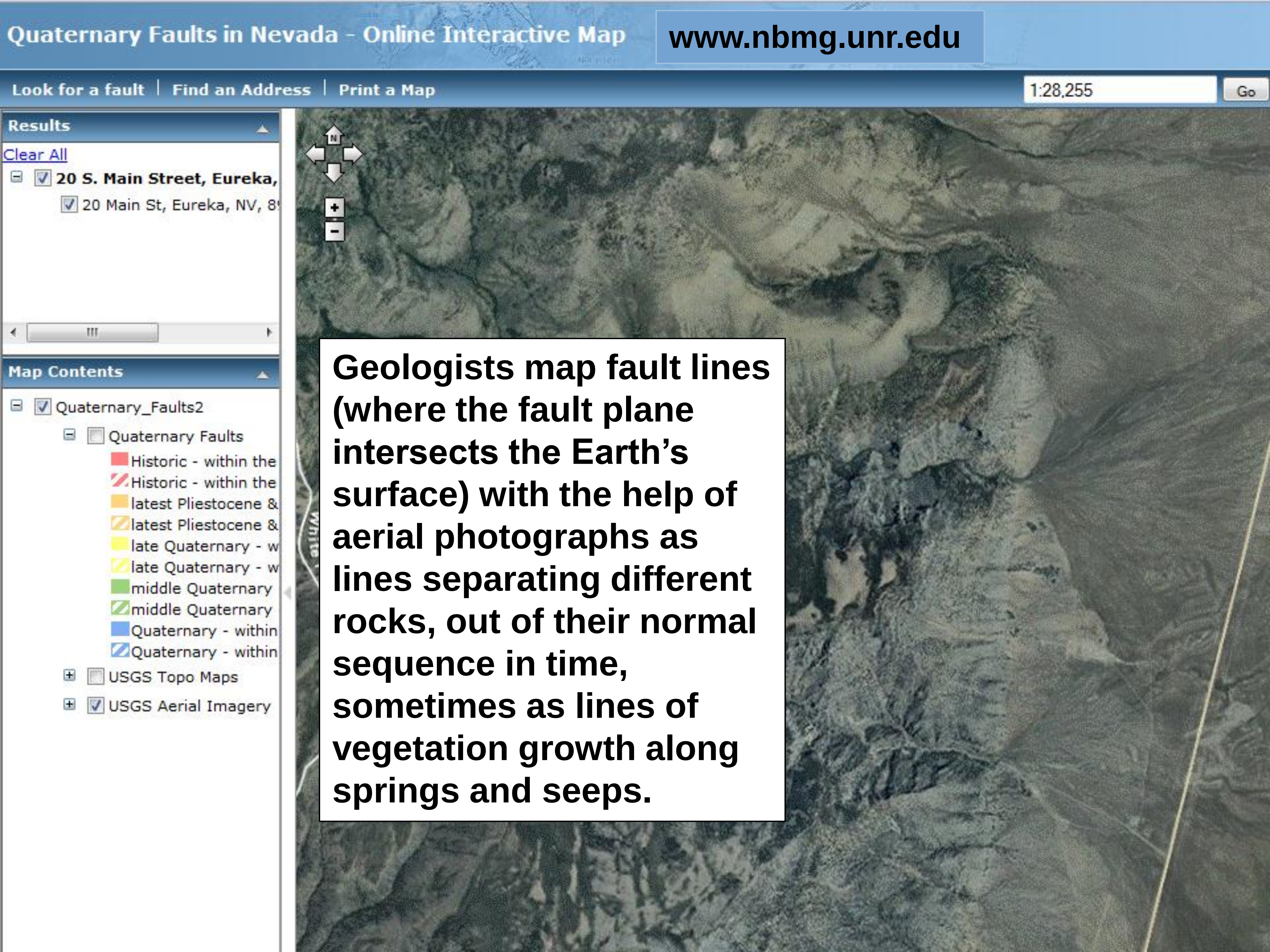
www.nbmg.unr.edu

Geologists map fault lines (where the fault plane intersects the Earth's surface) with the help of aerial photographs as lines separating different rocks, out of their normal sequence in time, sometimes as lines of vegetation growth along springs and seeps.



www.nbmg.unr.edu

Geologists map fault lines (where the fault plane intersects the Earth's surface) with the help of aerial photographs as lines separating different rocks, out of their normal sequence in time, sometimes as lines of vegetation growth along springs and seeps.



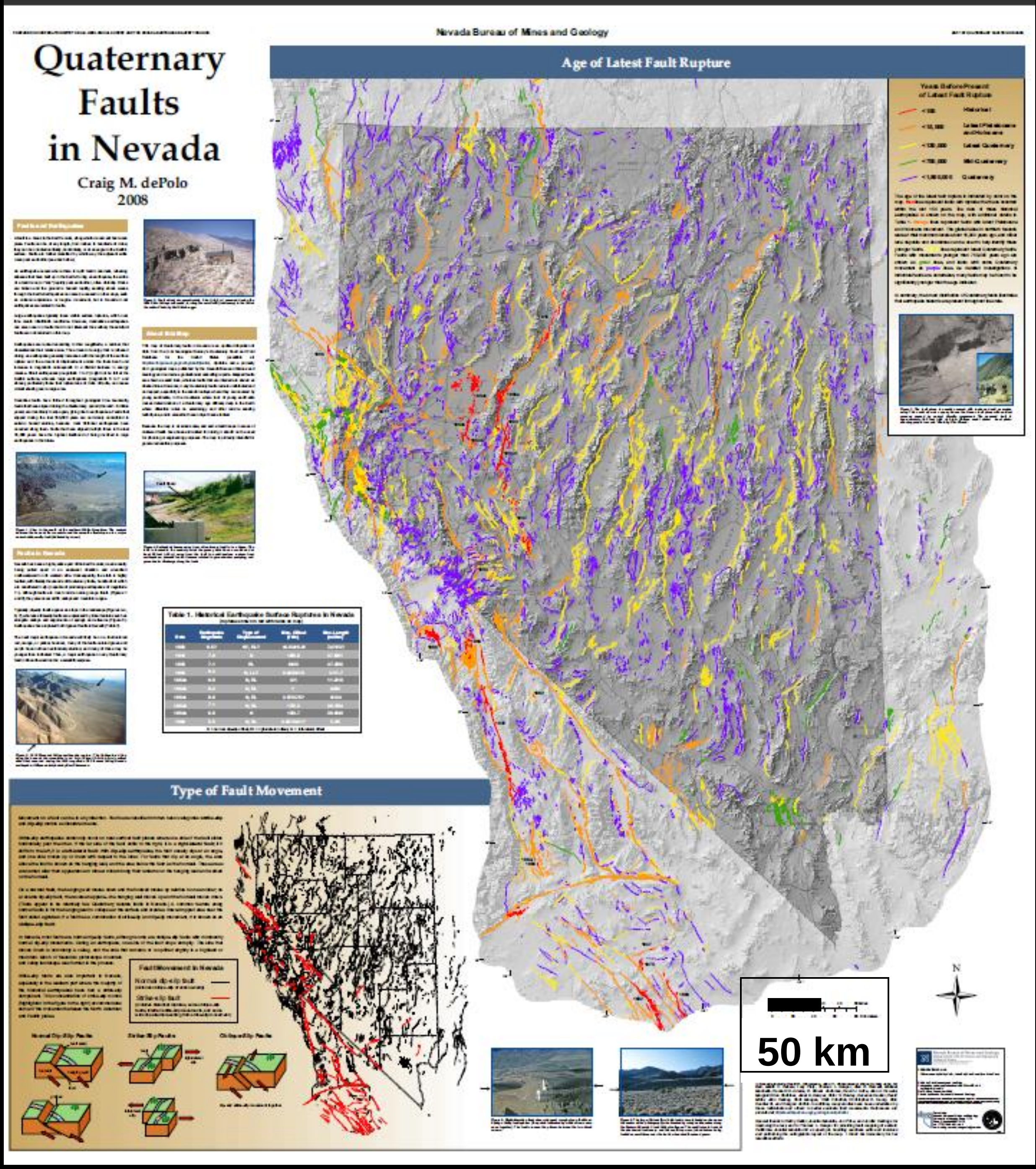
www.nbmg.unr.edu

Geologists map fault lines (where the fault plane intersects the Earth's surface) with the help of aerial photographs as lines separating different rocks, out of their normal sequence in time, sometimes as lines of vegetation growth along springs and seeps.

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

Age of Latest Fault Rupture

< 150 years (historical)

< 15,000 years

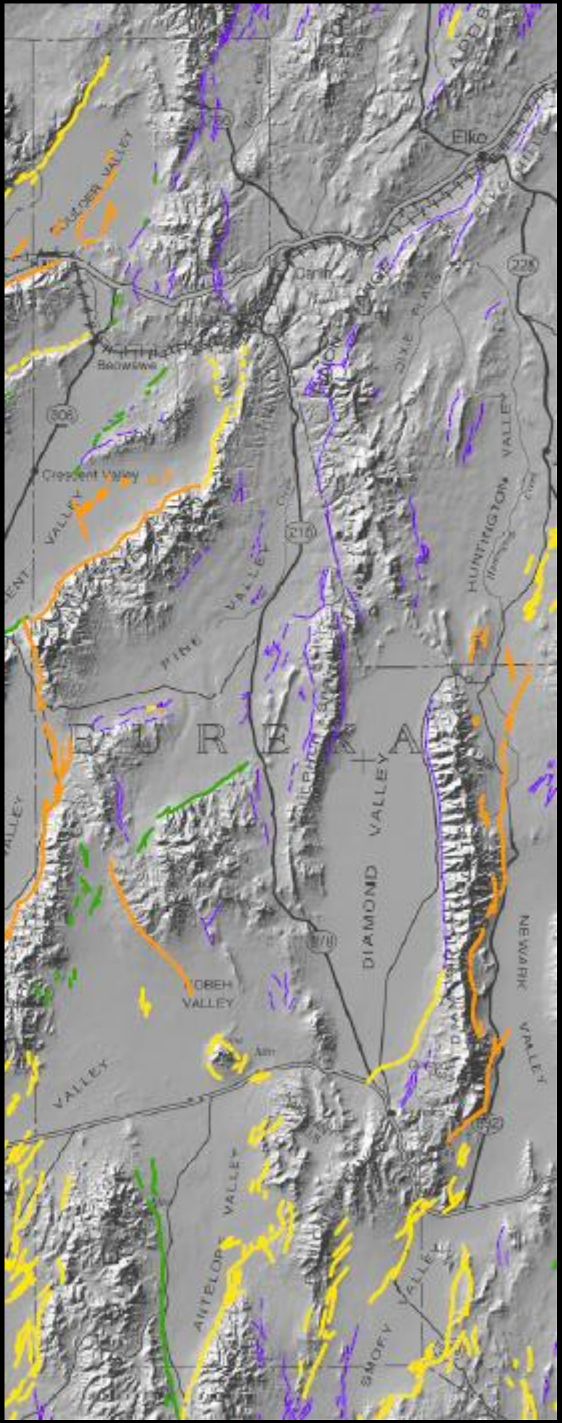
< 130,000 years

< 750,000 years

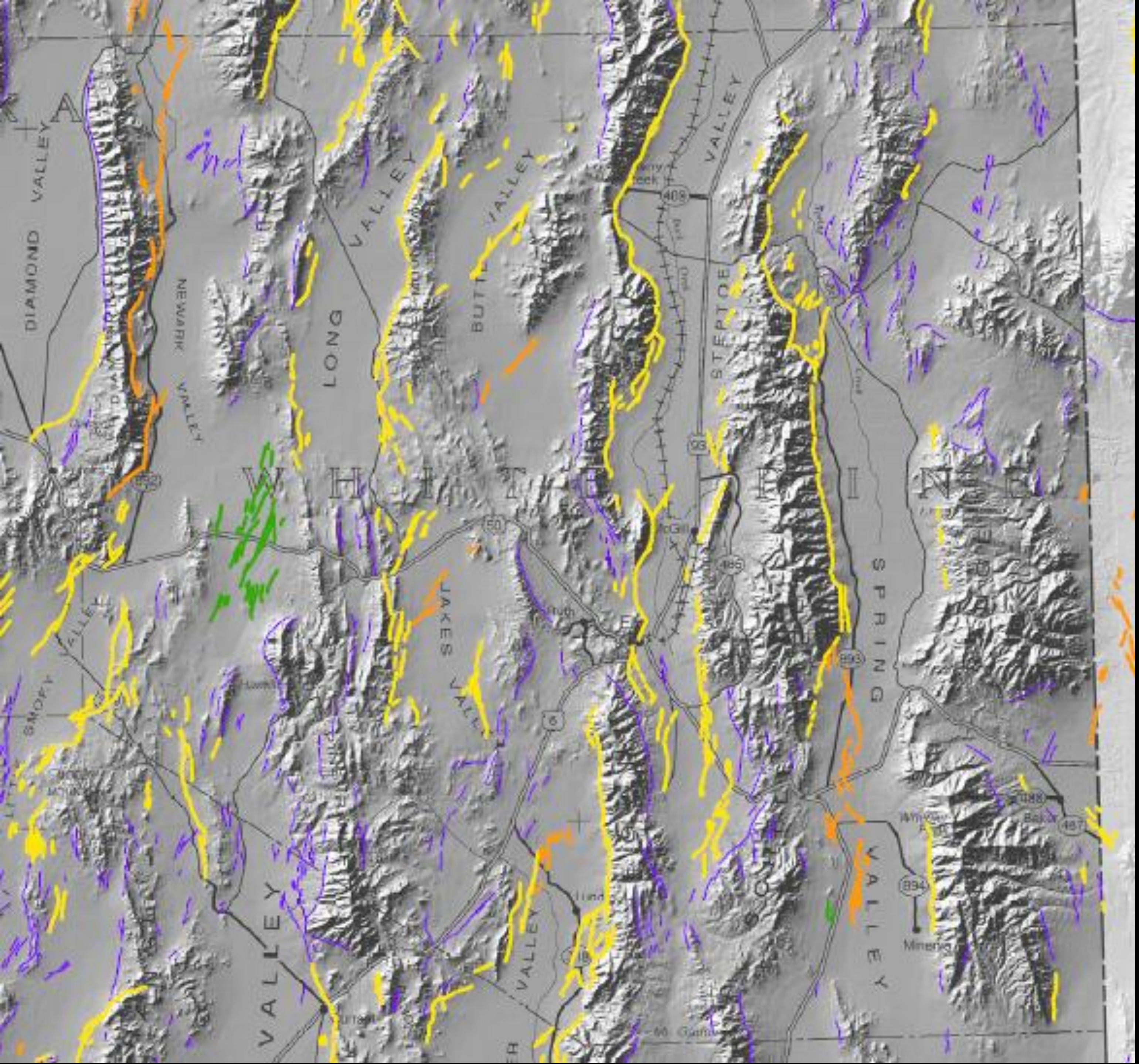
< 1,800,000 years (Quaternary)

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

www.nbmg.unr.edu



Eureka County has its faults.



White Pine County has its faults too.

Quaternary Faults in Nevada - Online Interactive Map

www.nbmg.unr.edu

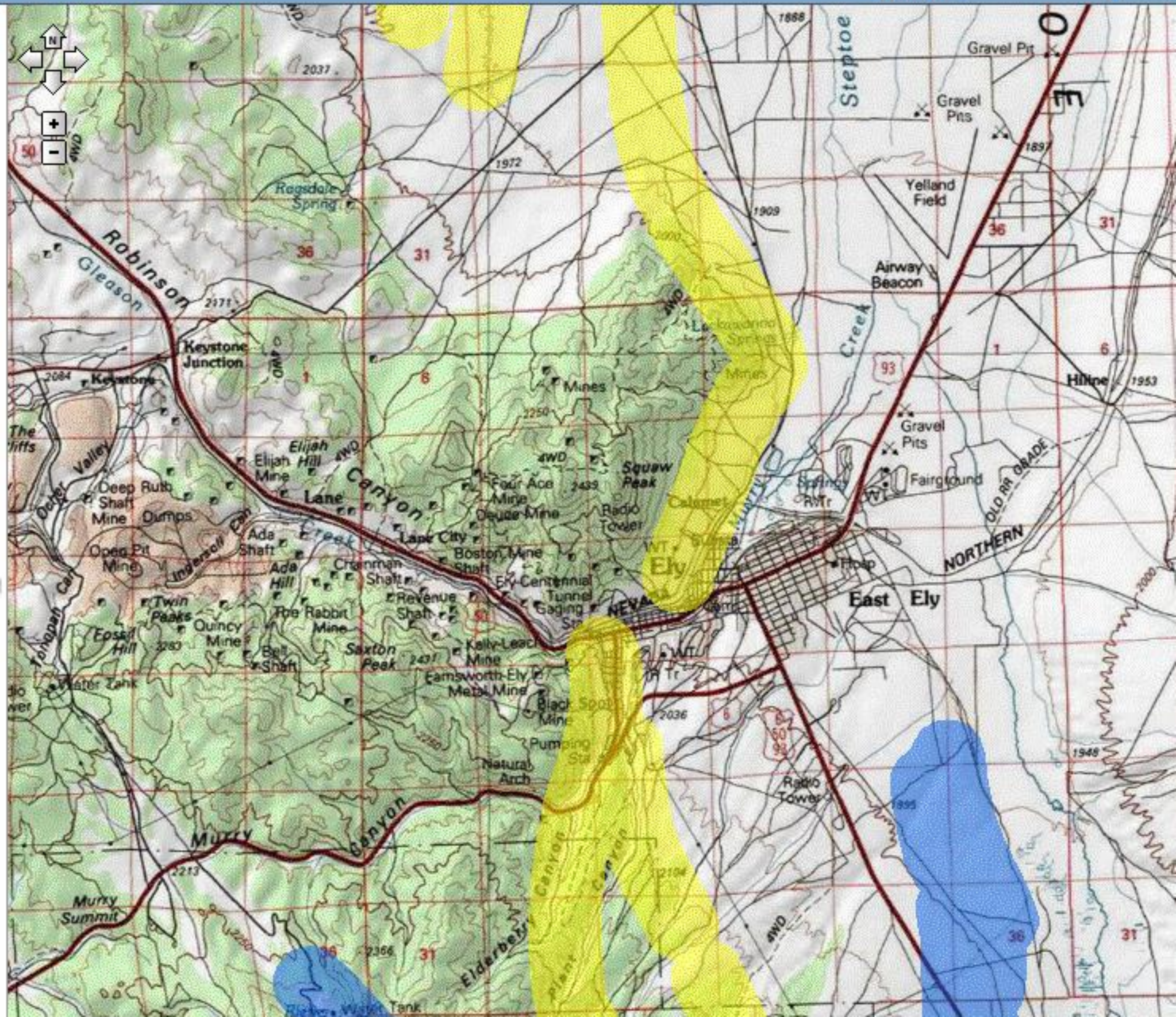
Look for a fault | Find an Address | Print a Map

1:82,042 Go

Results

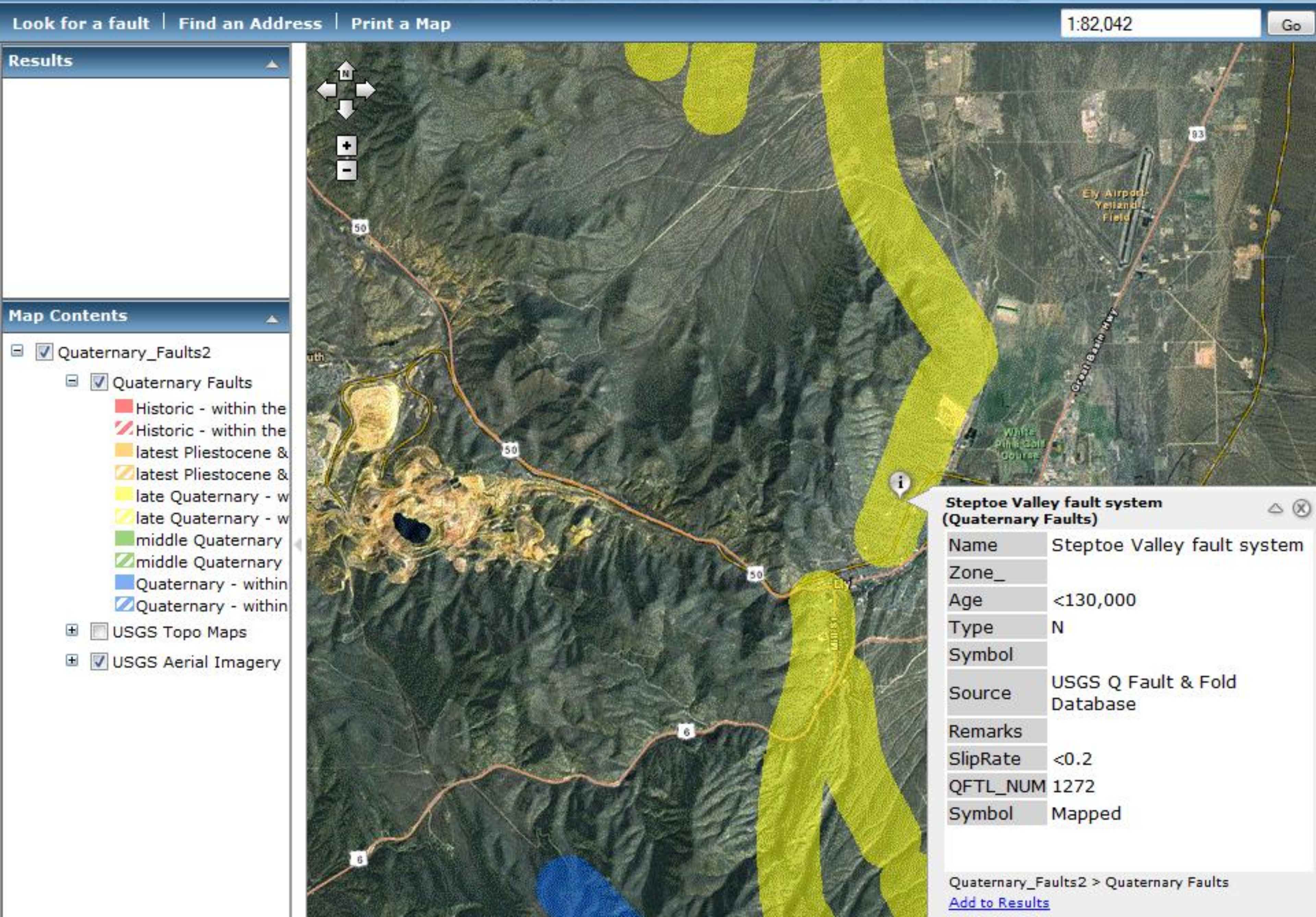
Map Contents

- Quaternary_Faults2
  - Quaternary Faults
    - Historic - within the
    - Historic - within the
    - latest Pliestocene &
    - latest Pliestocene &
    - late Quaternary - w
    - late Quaternary - w
    - middle Quaternary
    - middle Quaternary
    - Quaternary - within
    - Quaternary - within
  - USGS Topo Maps
  - USGS Aerial Imagery



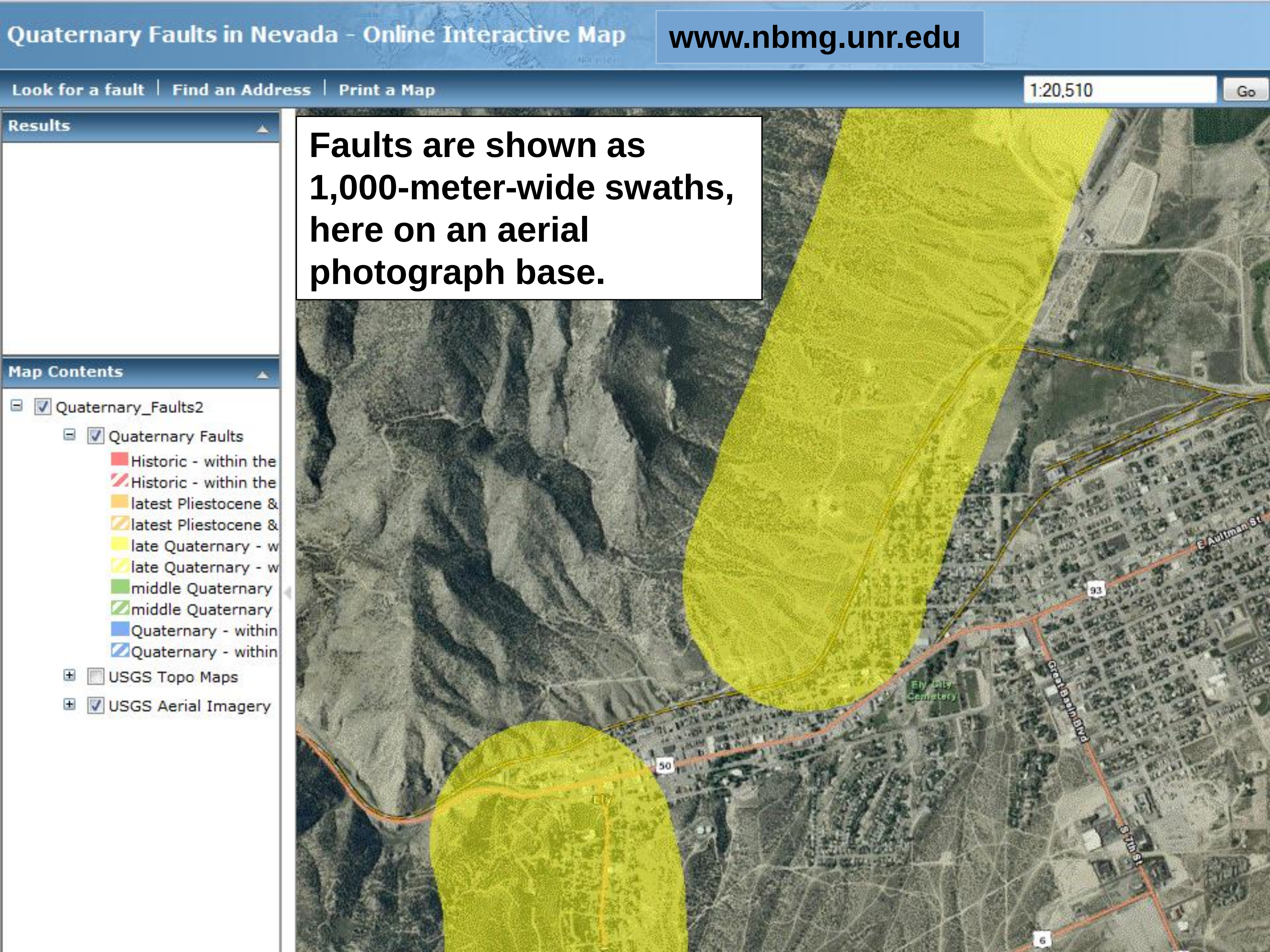
Quaternary Faults in Nevada - Online Interactive Map

www.nbmg.unr.edu



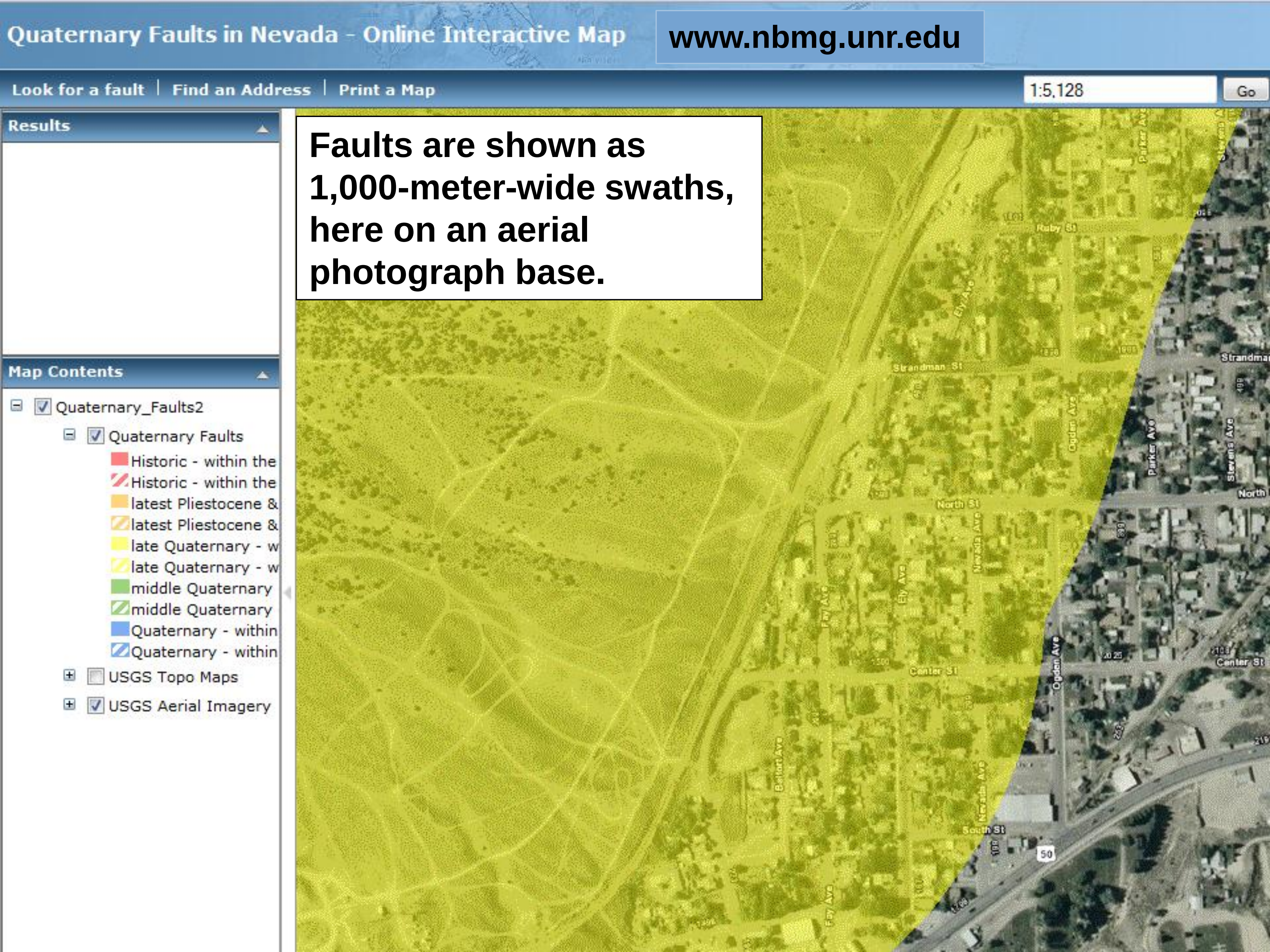
www.nbmg.unr.edu

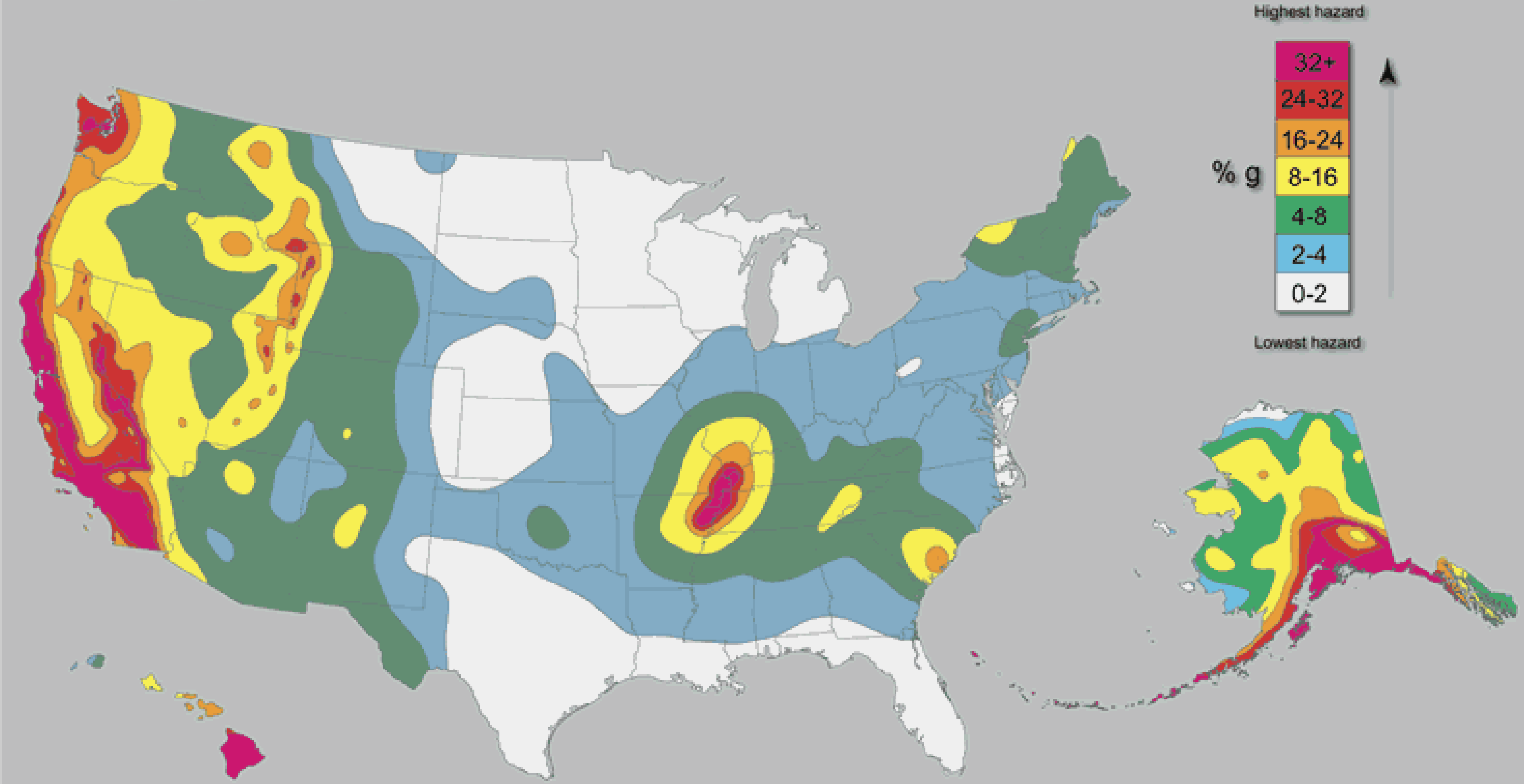
Faults are shown as 1,000-meter-wide swaths, here on an aerial photograph base.



www.nbmg.unr.edu

Faults are shown as 1,000-meter-wide swaths, here on an aerial photograph base.





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

Age of Latest Fault Rupture

< 150 years (historical)

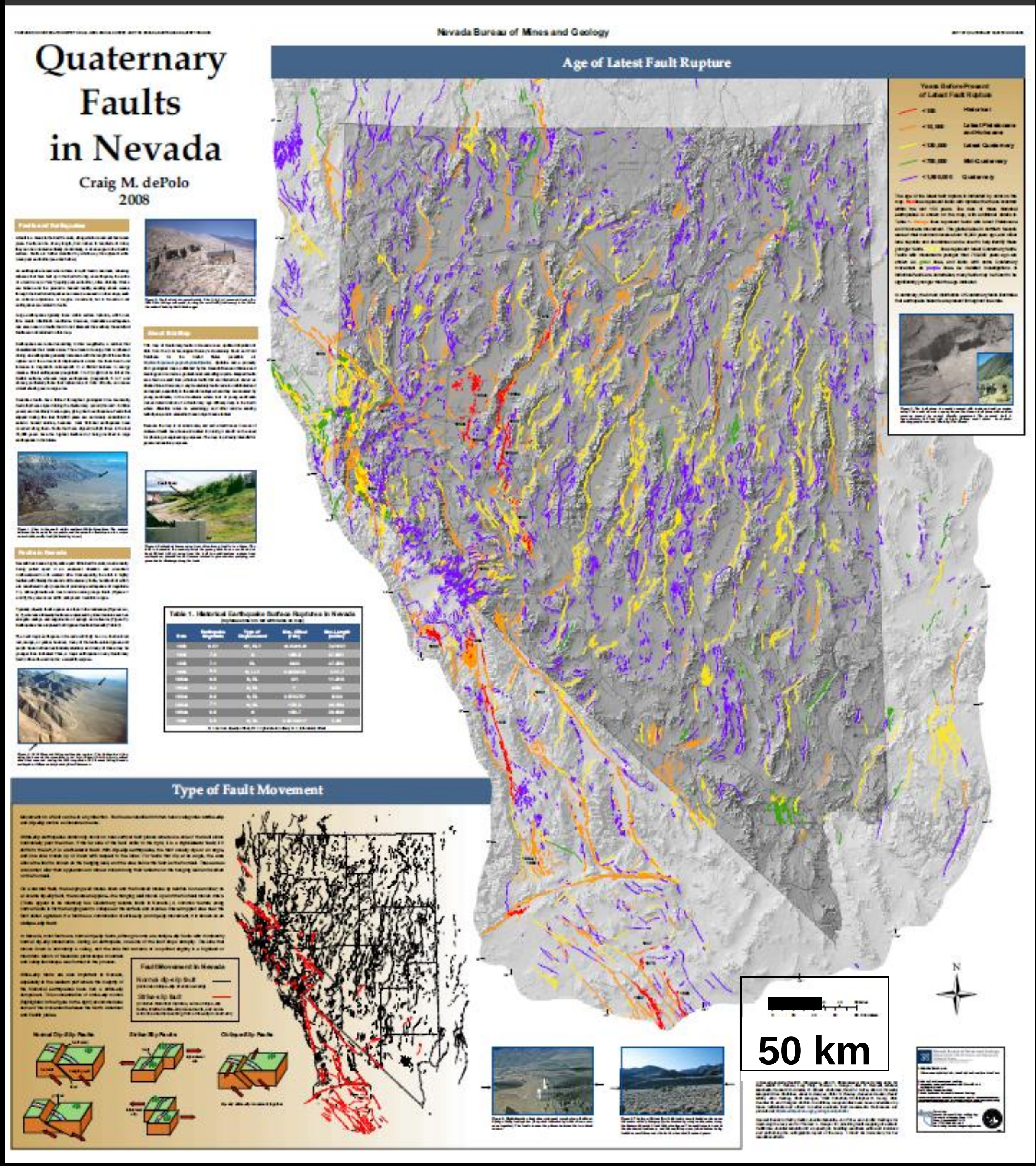
< 15,000 years

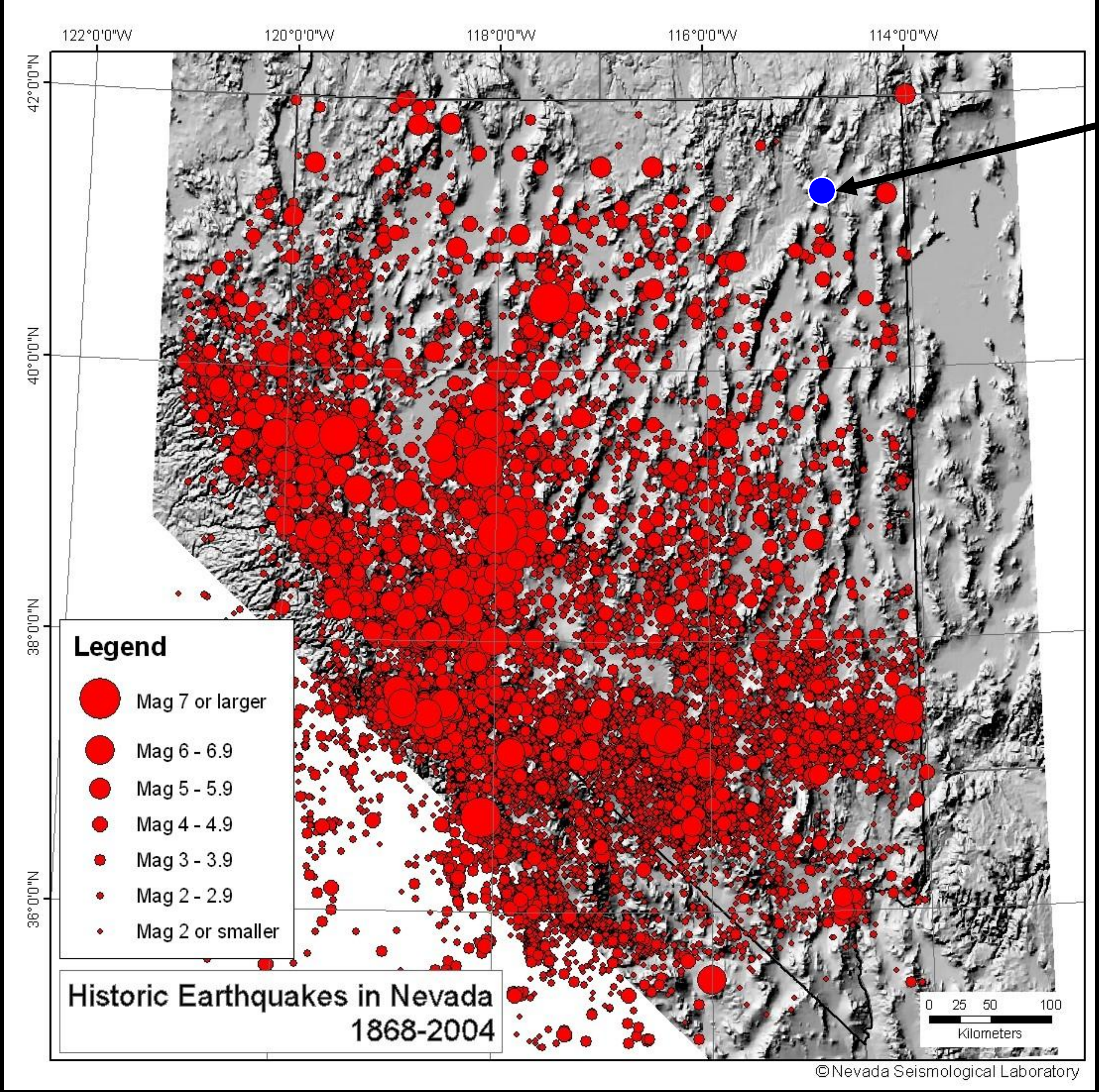
< 130,000 years

< 750,000 years

< 1,800,000 years (Quaternary)

(1) There are active faults nearly everywhere in Nevada, including Eureka and White Pine Counties.



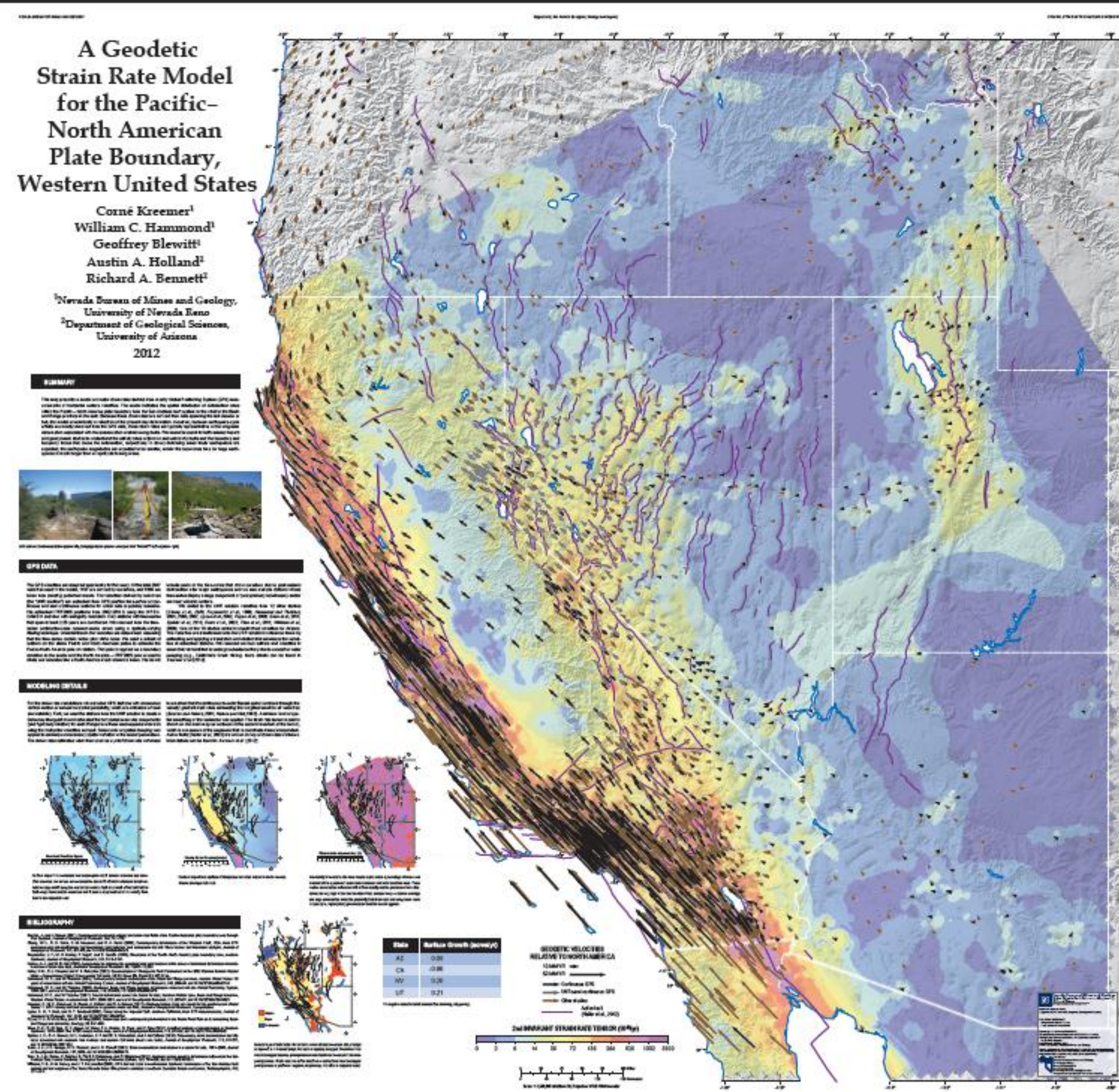


Wells

21 Feb 08

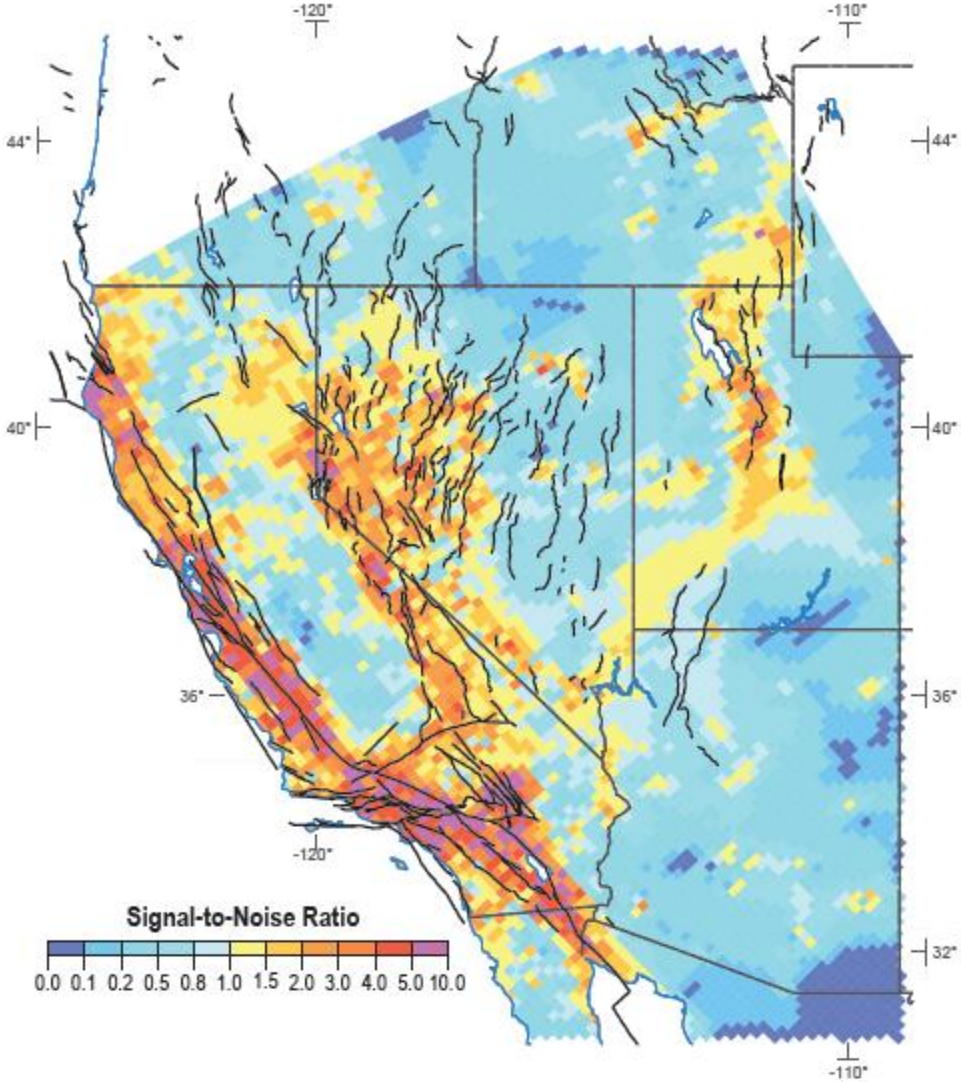
M = 6.0

(2) Earthquakes have occurred throughout Nevada.



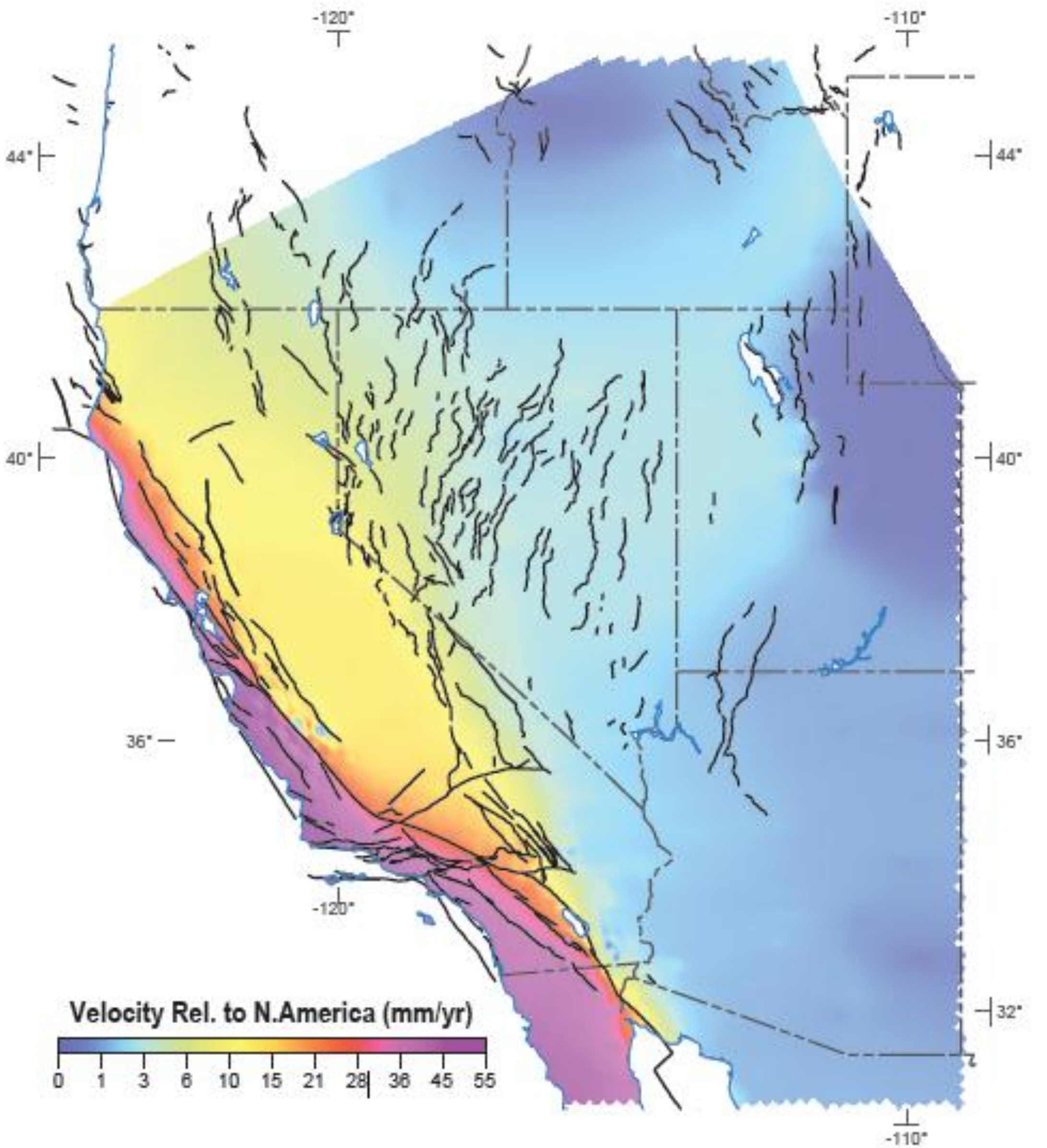
Kreemer et al. (2012)

(3) Geodetic data indicate that the Nevada is gaining about 0.2 acre of area per year through crustal extension, and that western Nevada is accommodating ~20% of the North American-Pacific plate interaction.



Signal-to-noise (SNR) ratio defined as the ratio of second invariant of the strain rate over the a posteriori standard deviation These values are strongly affected by the GPS station density and the precision of velocities. Everywhere where SNR<1 the area could be considered rigid within one standard deviation. Conversely, for areas that the model suggests are nearly rigid and where SNR<1 (e.g., Arizona, eastern Nevada) strain rates may be much more localized (i.e., higher) than the model suggests.

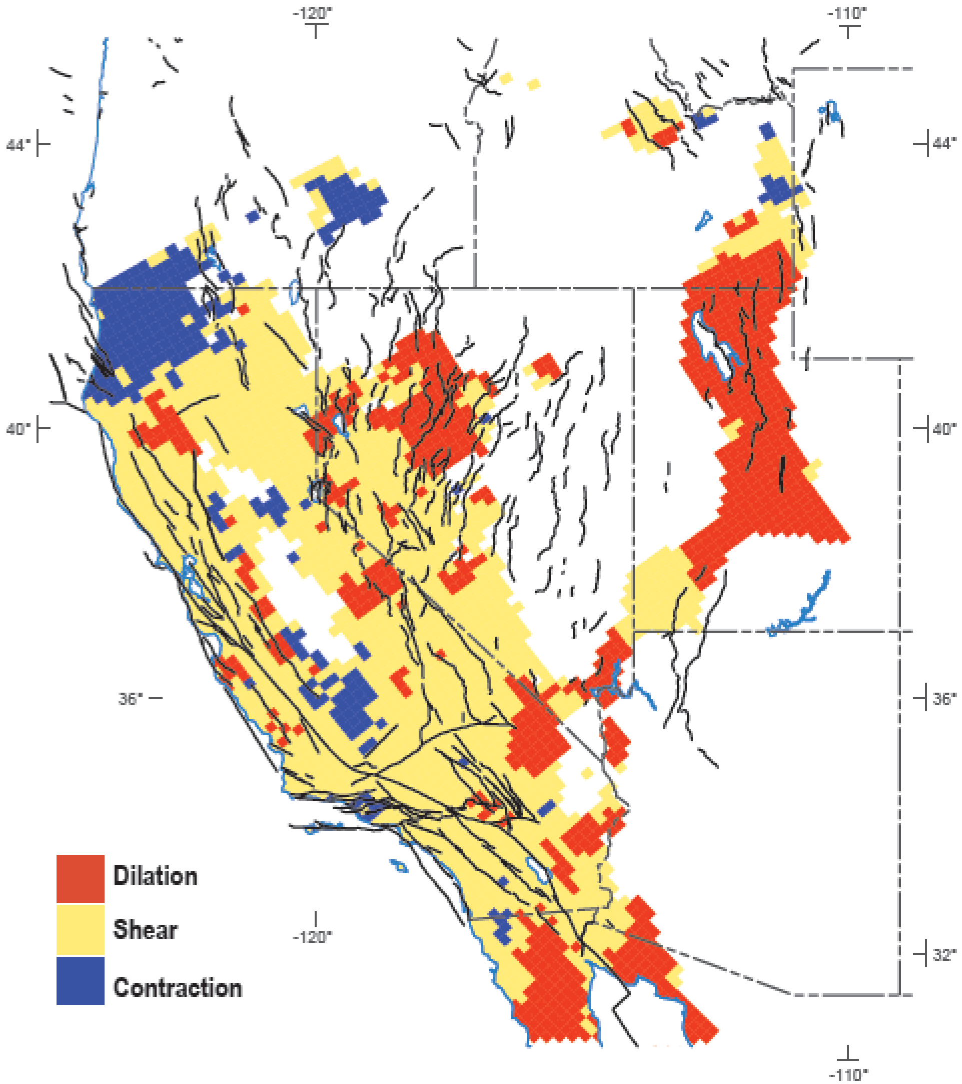
Uncertainty is high in areas with few geodetic GPS data points (areas in blue on this map).



Contour map of the amplitude of interpolated velocities relative to North America. Results are clipped at coast.

West of the San Andreas fault in California, the Pacific Plate is moving northwest relative to the North American Plate.

Kreemer et al. (2012)



General style of deformation for all areas where at least one strain rate principal component is > 6 nanostrain/yr. Results are spatially averaged. We define shear where the largest absolute principal value is less than twice the smallest absolute principal value. If not shear, we define dilatation or contraction when the largest principal value is positive or negative, respectively. Results are clipped at coast.

Western Nevada is accommodating ~20% of the North American-Pacific plate interaction, mostly along right-lateral strike-slip faults and oblique-slip normal faults.

Extension is occurring mostly in western and central Nevada (and along the Wasatch front in Utah) along normal faults.

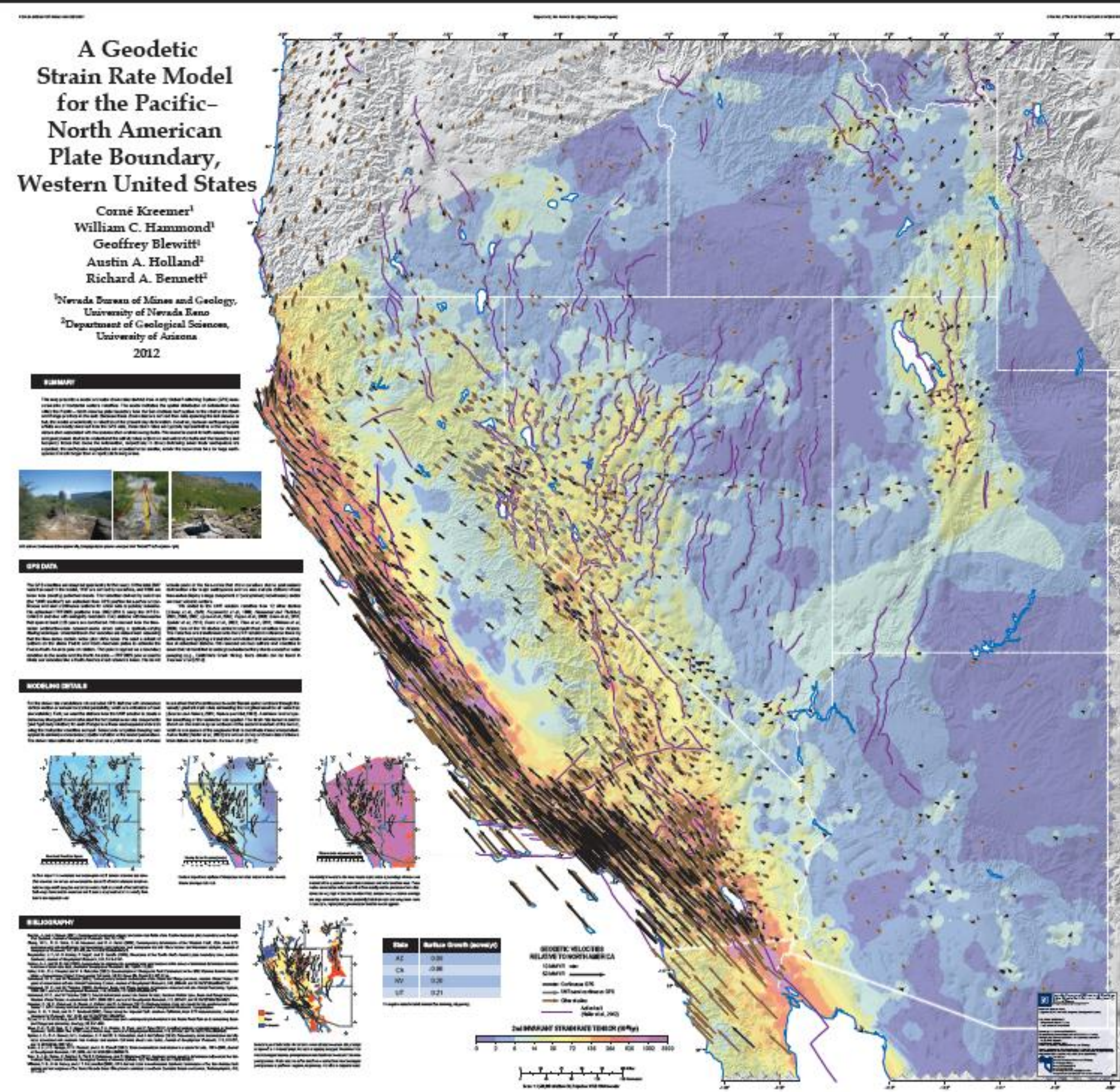
Kreemer et al. (2012)

State	Surface Growth (acres/yr)
AZ	0.08
CA	-0.96
NV	0.20
UT	0.21

The negative value for California indicates shrinking, not growing.

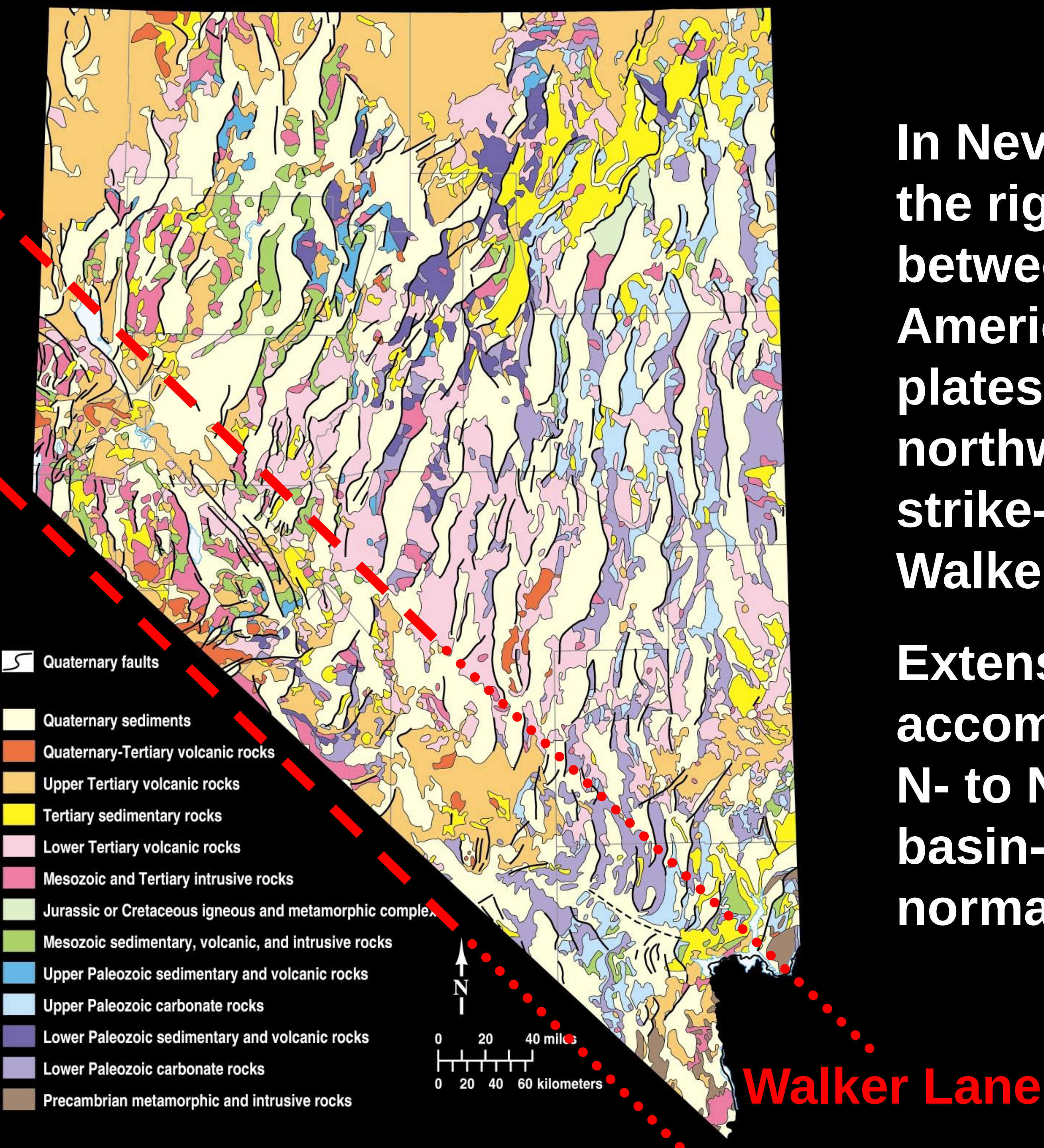
Nevada and Utah are growing.

Kreemer et al. (2012)



Kreemer et al. (2012)

(3) Geodetic data indicate that the Nevada is gaining about 0.2 acre of area per year through crustal extension, and that western Nevada is accommodating ~20% of the North American-Pacific plate interaction.



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.

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
Reno	>90	~80	67	50	12-15
Fallon	80-90	~60	35	20-25	6-8
Las Vegas	40-50	~30	12	4-5	<0.5
Eureka	40-50	~30	10-15	4-6	<0.5
Wells	30-40	~20	9	6	0.5-1
Ely	20-30	~15	4-6	1.5-2	<0.5
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.

nbmg Nevada Bureau of Mines and Geology

University of Nevada, Reno
Statewide • Worldwide

FEMA

U.S. Department of Homeland Security

Nevada Department of Public Safety
Division of Emergency Management

Nevada Earthquake Safety Council

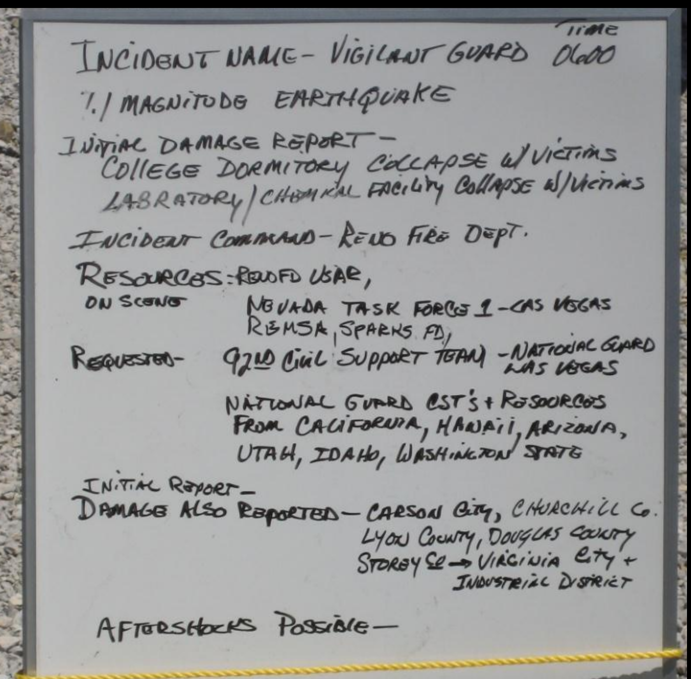
USGS
science for a changing world

Nevada Seismological Laboratory

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

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.



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.

<u>Uncertainties</u> 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 <u>one order of magnitude (a factor of 10)</u>, although experience with urban earthquakes in the US has generally yielded numbers within a factor of 2 or 3 of the actual damages.

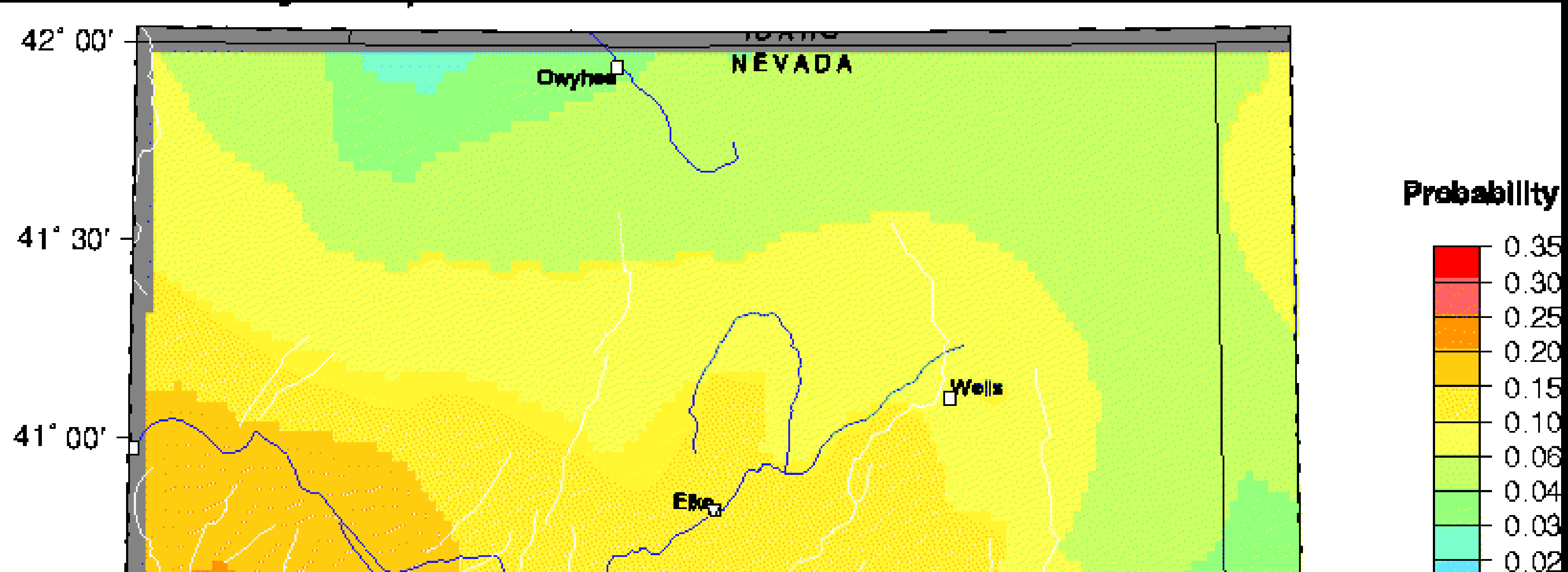
HAZUS estimates for total economic loss from a magnitude 6.0 earthquake and probability of an earthquake of this magnitude or greater occurring within 50 years and within 50 km of the community.

Community	Total Economic Loss	Probability in 50 years within 50 km
Las Vegas	$7.2 billion	12%
Reno	$1.9 billion	67%
Carson City	$650 million	70%
Elko	$160 million	10 to 15%
Fallon	$110 million	35%
Ely	$44 million	4 to 6%
Eureka	$34 million	10 to 15%
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 .

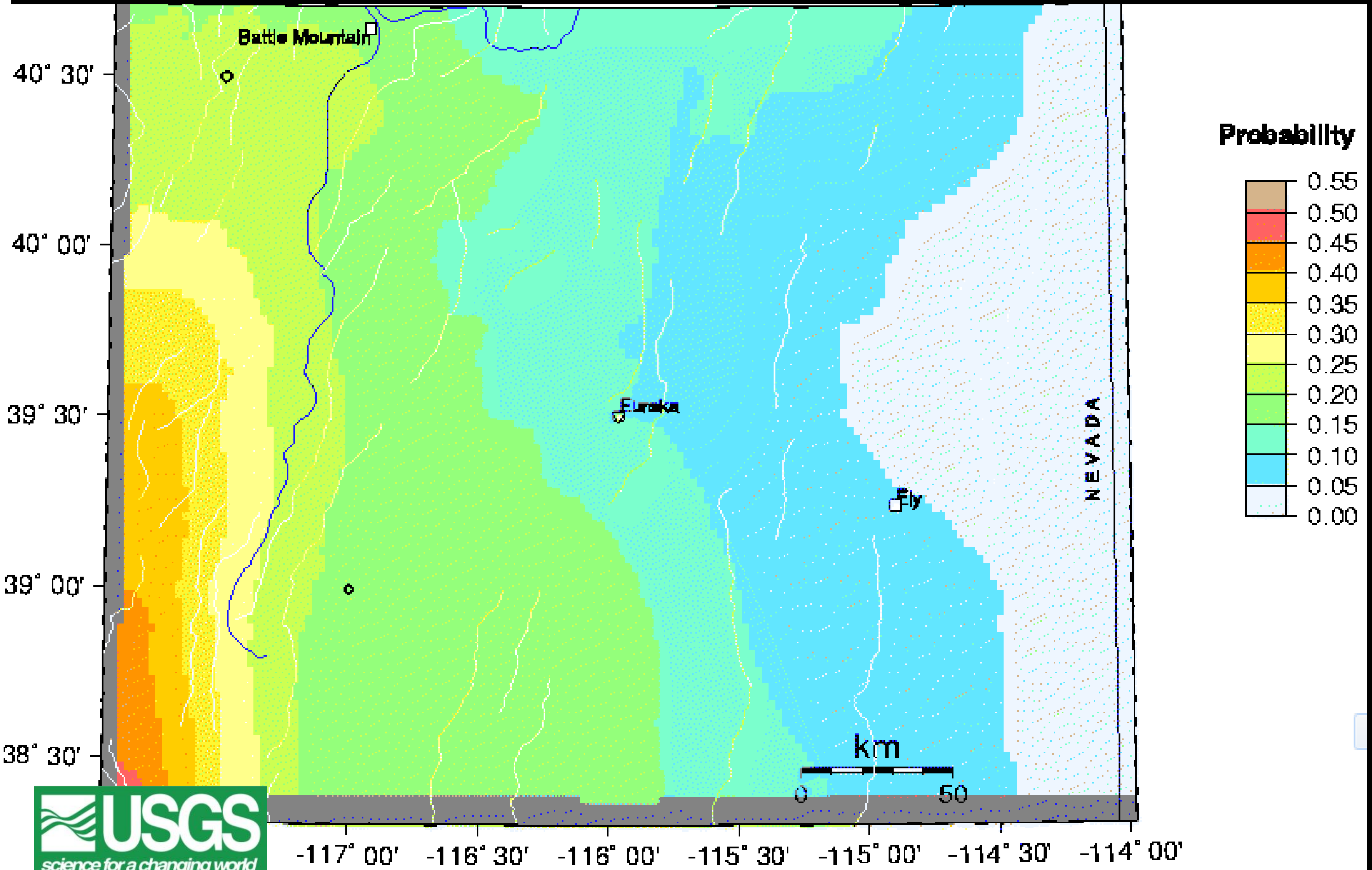
The probability of a magnitude 6.0 earthquake occurring within 50 km of Wells, Nevada within the next 50 years is approximately 9%.

It happened on 21 February 2008.



C. dePolo photo

The probability of a magnitude 6.0 earthquake occurring within 50 km of Eureka within the next 50 years is approximately 10%, about the same as Wells; Ely's probability is approximately 5%.



USGS
science for a changing world

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. (Make a plan; assemble a kit; stay informed.)

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

C. Mitigate nonstructural risks.

San Marin Hotel, an unreinforced masonry building (URM) that collapsed during the Wells, Nevada earthquake

front and west side

before the 21 February 2008 magnitude 6.0 earthquake

after the earthquake

front

back

See http://www.nbmg.unr.edu/Pubs/sp/sp36/

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

Definition of potential unreinforced masonry (URM) buildings in Nevada:

buildings listed by County Assessors or State Public Works as built before 1974 with brick, stone, or block masonry structure.

Caution: This is a preliminary study based on data provided by the County Assessors and the State of Nevada. We know there are errors in the database:

- **URMs missed - not recorded as masonry structures**
- **URMs missed – ones on federal or Indian lands**
- **URMs counted due to wrong building type in the database**
- **Wrong locations due to poor address coding**
- **Misidentifications due to lack of construction date**
- **Buildings that may have been seismically retrofitted**
- **Buildings that have been removed.**

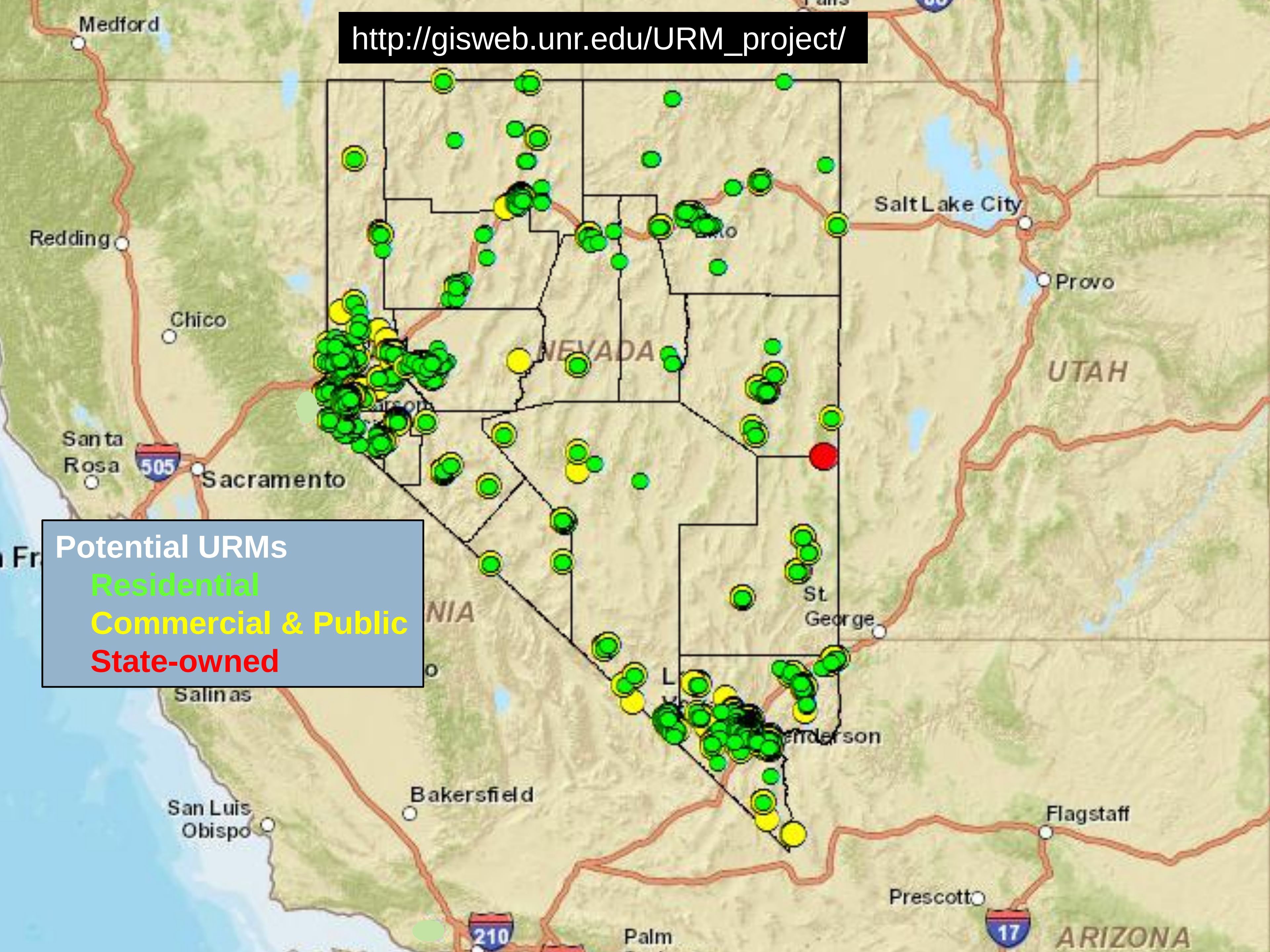
Recommendation 1 (draft): Jurisdictions (cities, counties, state) should use this County Assessors' data to follow up with on-the-ground inspections and checks of building plans. Individuals should determine if their buildings are URMs. Everyone should recognize that some URMs are missing from the database and that some buildings listed are actually adequately reinforced.

Potential URMs in Nevada – totals*

7,354	Residential
16,145	Commercial & Public (city and county)
98	State-owned
23,597	TOTAL*

* The total does not include buildings owned by the federal government.

http://gisweb.unr.edu/URM_project/



http://gisweb.unr.edu/URM_project/
Potential URMs
Residential
Commercial & Public
State-owned
Medford
Redding
Chico
Santa Rosa
505
Sacramento
NEVADA
Salt Lake City
Provo
UTAH
St George
Salinas
Bakersfield
San Luis Obispo
Flagstaff
Prescott
17
210
Palm
ARIZONA

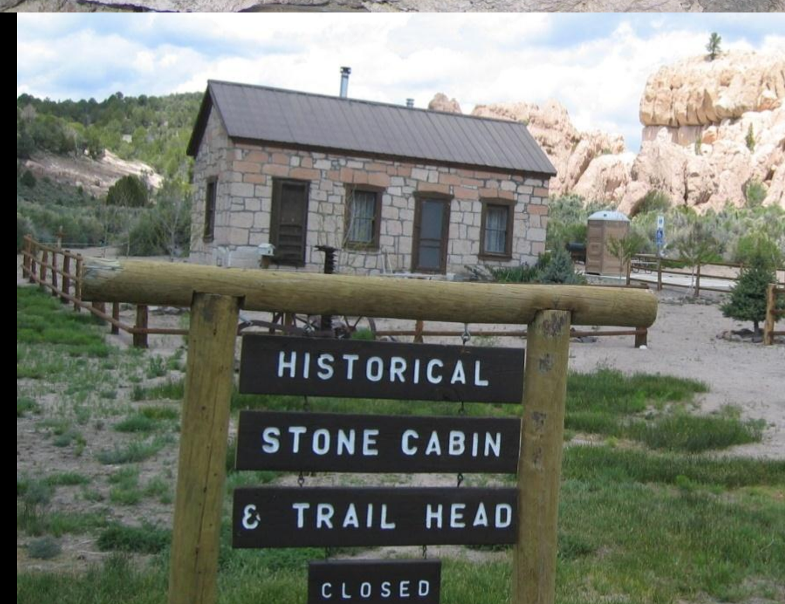
Observations:

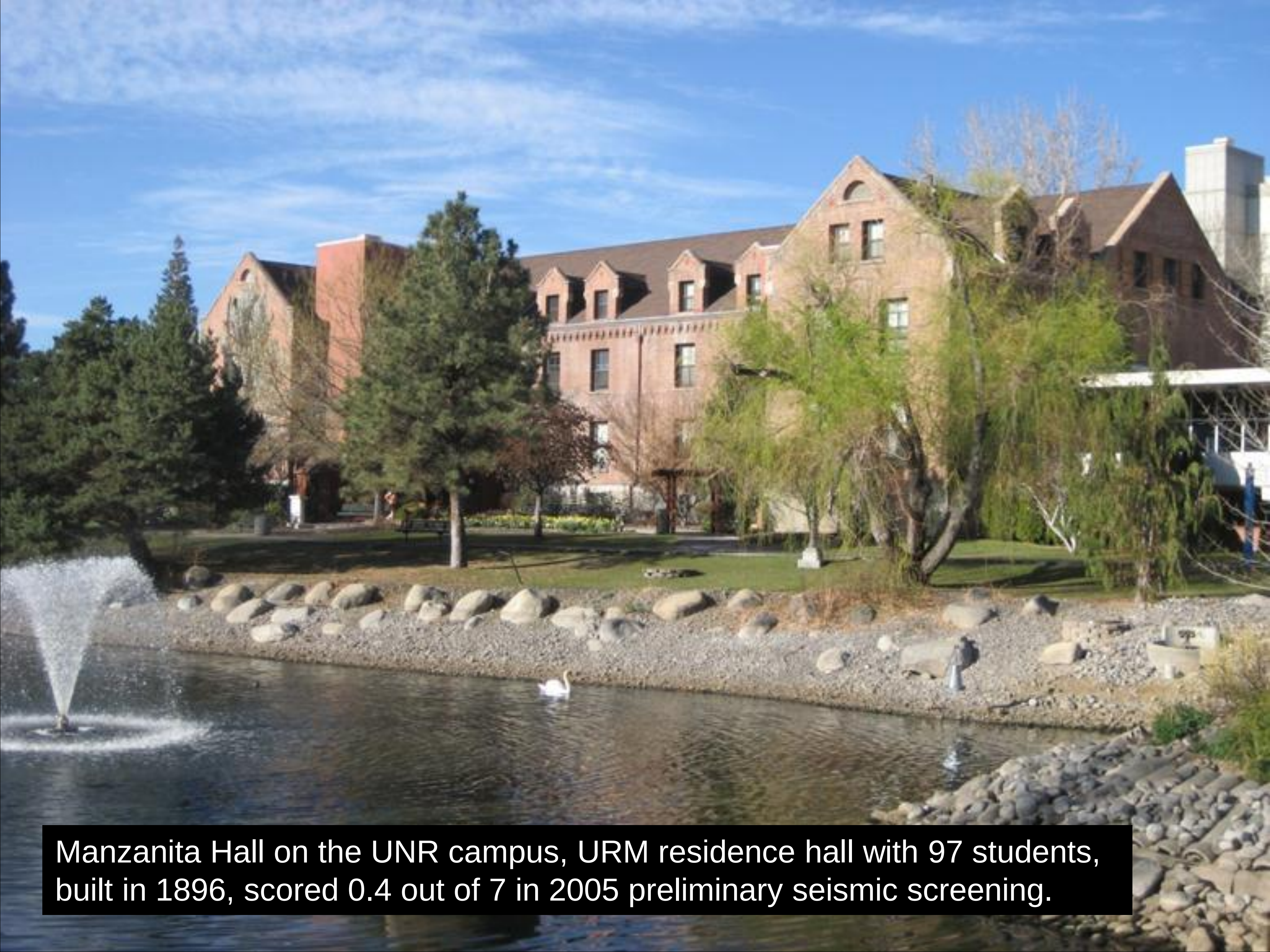
Because URMs are mostly 50+ years old, many have deteriorated and need maintenance. Some may have been damaged from shaking during previous distant or small earthquakes.

Many of the potential URMs in Nevada are historical buildings. Many are concentrated in downtown business districts and along thoroughfares. Experience from recent earthquakes demonstrates that collapse of these buildings or their facades not only can cause deaths and injuries but also disrupt emergency vehicles during earthquake response and slow business recovery in the weeks and months after the earthquake.

Historical stone cabin, built in the 1870s with blocks of tuff from nearby outcrops, Spring Valley State Park, Lincoln County.

Potential injuries to people are minimized by preventing visitors from going inside.





Manzanita Hall on the UNR campus, URM residence hall with 97 students, built in 1896, scored 0.4 out of 7 in 2005 preliminary seismic screening.


URM d
Identify
URM: YES
Building_N: LINCOLN HALL
Match_type: A
ARC_ZIP: 89557-
Zip: 89557-
Shape: Point
City: Reno
Dept_: NSHE
ARC_State: NV
Status: M
NV_State_URM_Buildings
County: Washoe
F16:
Score: 84
SubAgency:
ARC_City: Reno
X: -119.820801
F17:
Address: 1664 N. Virginia St.
State: NV
Y: 39.547041
F15:
Square_Fee: 28298
Agency:
Potential URMs
Residential
Commercial & Public
State-owned
400 m
1000 ft

Lincoln Hall on the UNR campus, URM residence hall with 73 students, built in 1896, scored 0.8 out of 7 in 2005 preliminary seismic screening.

Building in downtown Reno

Building in downtown Reno


CHEVROLET
LUMINA

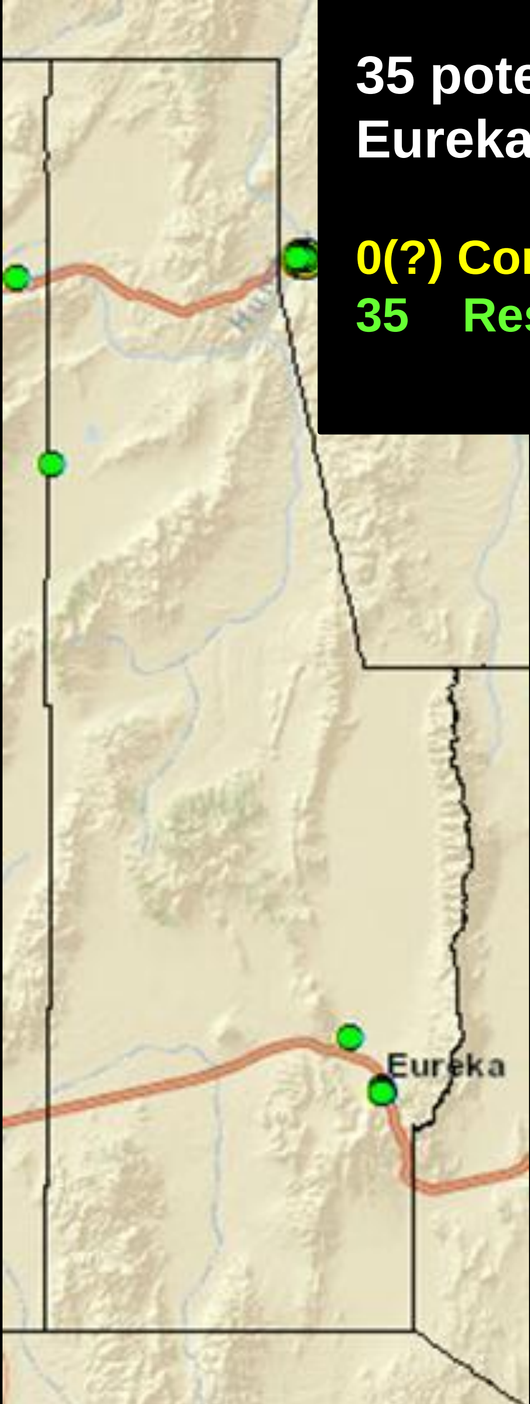
Building in downtown Reno

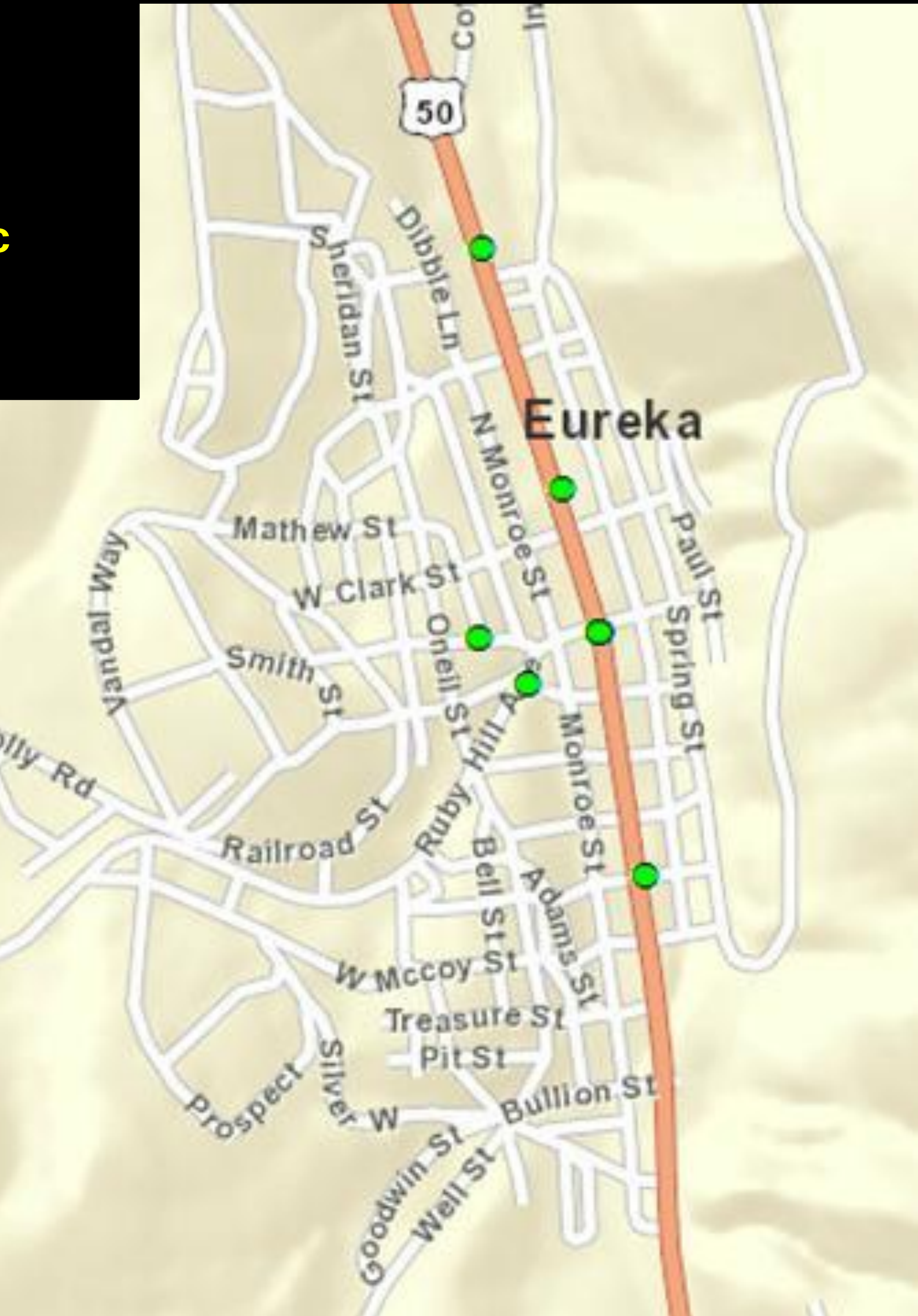
Building in downtown Reno

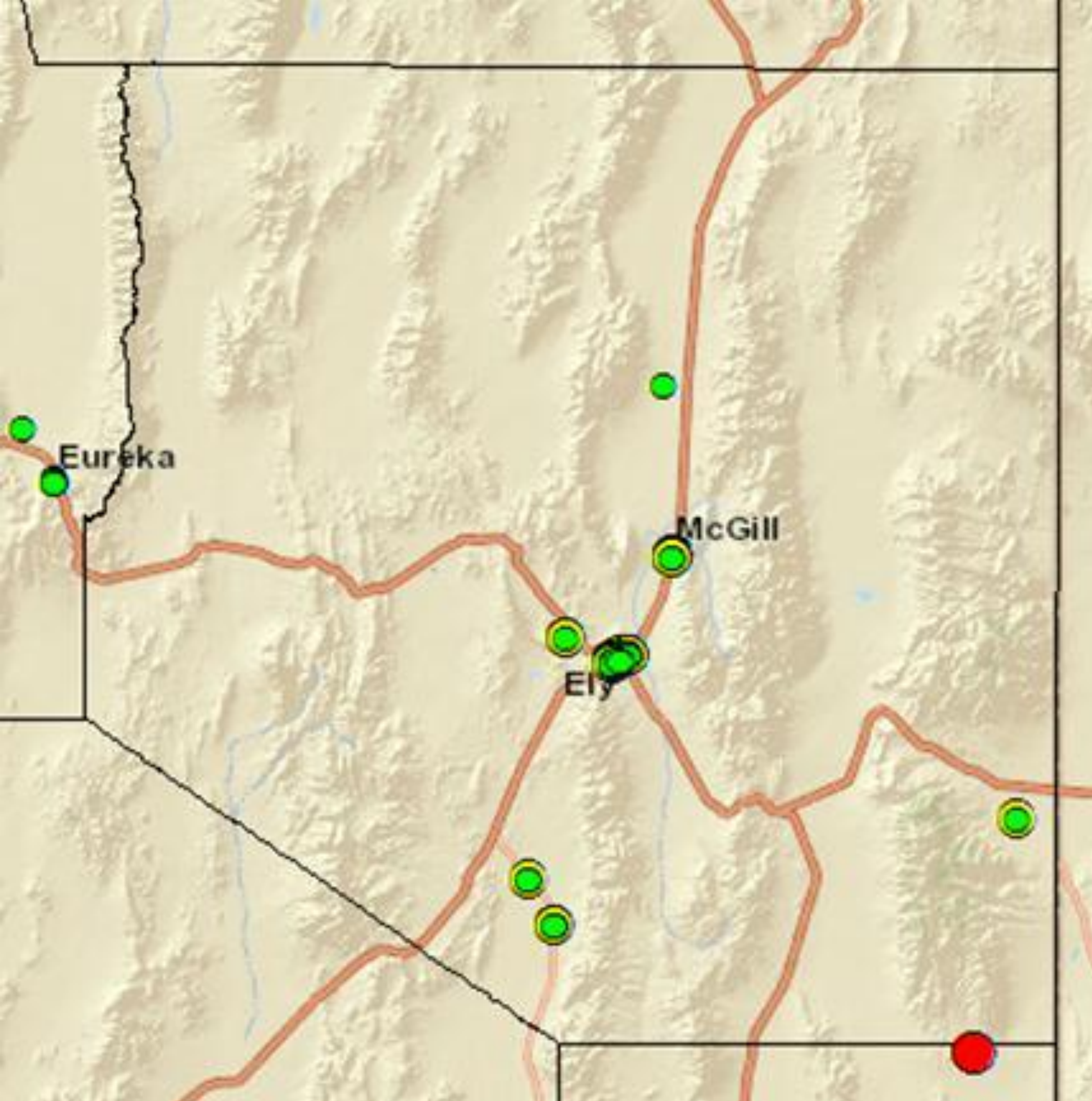
35 potential URMs in Eureka County

0(?) Commercial & public

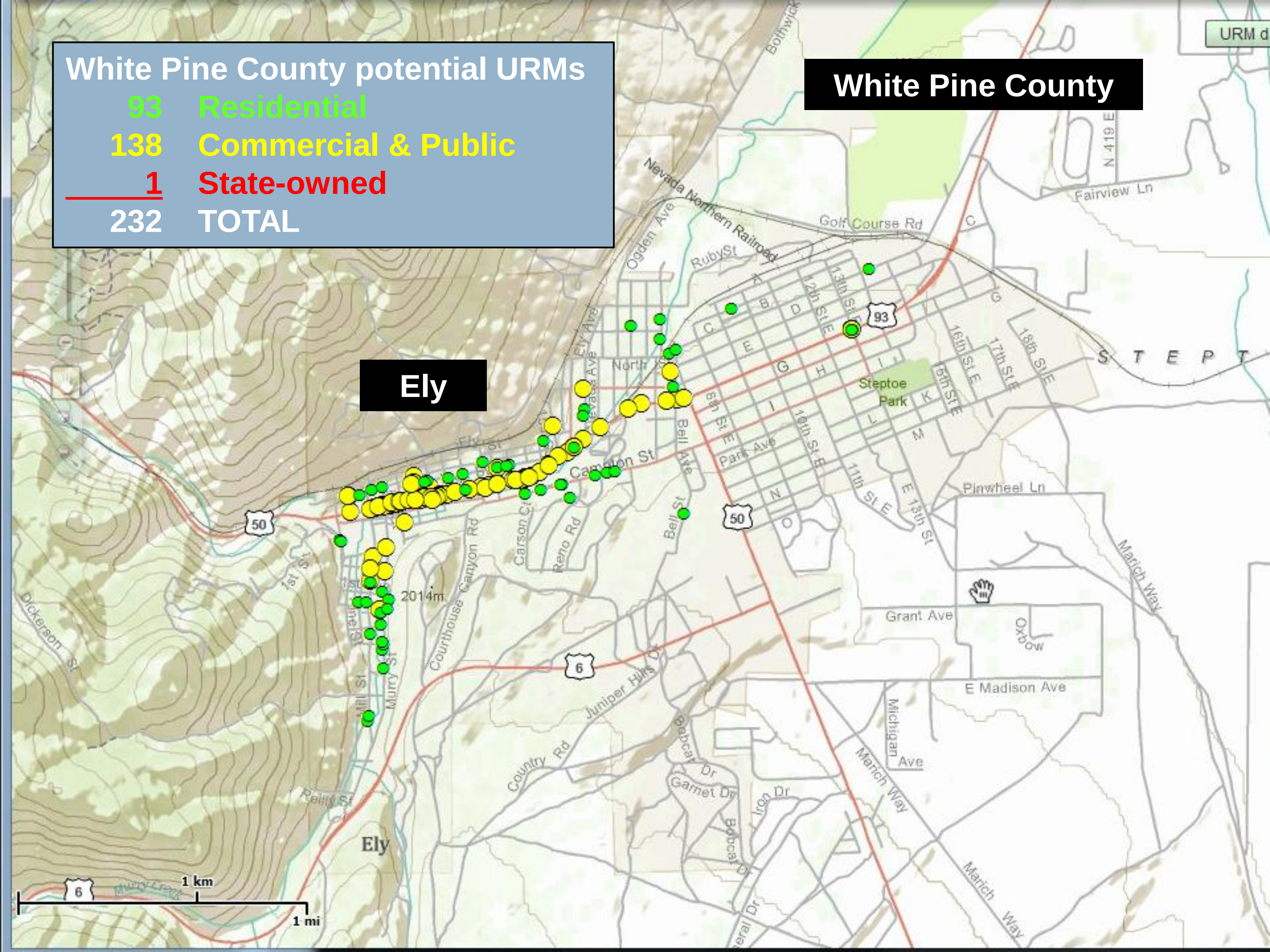
35 Residential







232 potential URMs in White Pine County



White Pine County potential URMs
93 Residential
138 Commercial & Public
1 State-owned
232 TOTAL
White Pine County
Ely
URM d
Nevada Northern Railroad
Golf Course Rd
Fairview Ln
Steptoe Park
Camp
Pinwheel Ln
Grant Ave
E Madison Ave
Juniper Hills Dr
Country Rd
Courthouse Canyon Rd
Michigan Ave
Marich Way
Garnet Dr
Iron Dr
Bobcat Dr
Oxbow
Carson Ct
Reno Rd
Bell Ave
Park Ave
Ogden Ave
Ruby St
Ely Ave
North
Mill St
Murry St
Dickerson St
Reilly St
Bothwick
N 419 E
S T E P T
2014m
1 km
1 mi
Ely

Recommendation 2 (draft): Jurisdictions should work toward seismically retrofitting URMs or removing them from human occupancy. **They can take advantage of opportunities for federal funding for mitigation. Buildings should be brought up to current code when remodeling. They can learn from what other jurisdictions have done successfully, such as providing incentives for individuals and businesses to retrofit URMs or replace them with new buildings.**

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

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

Thank you!

And thanks to 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.