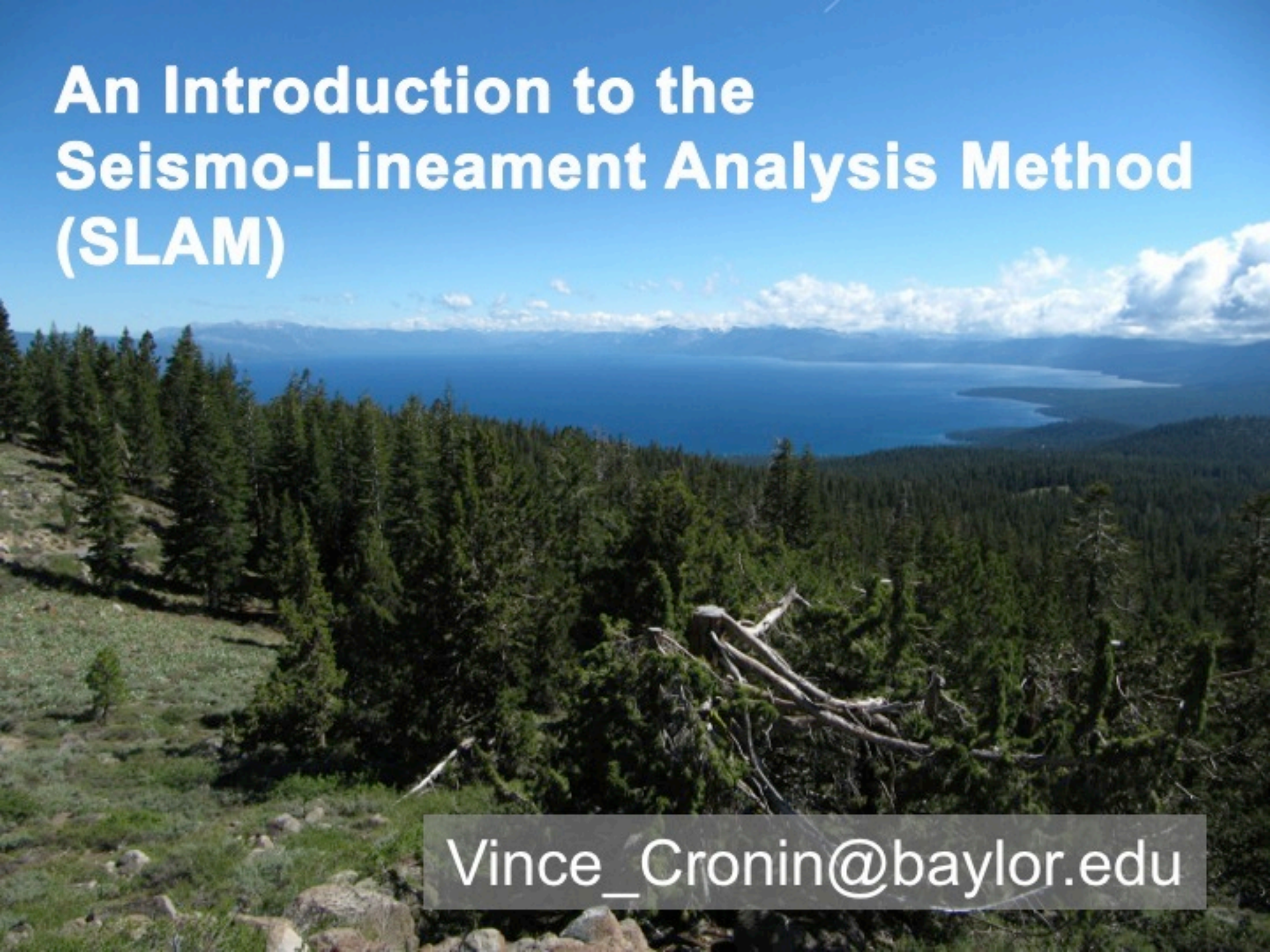
An Introduction to the Seismo-Lineament Analysis Method (SLAM)



Vince_Cronin@baylor.edu

SLAM uses…

SLAM uses…

- earthquake hypocenter and focal mechanism data

SLAM uses…

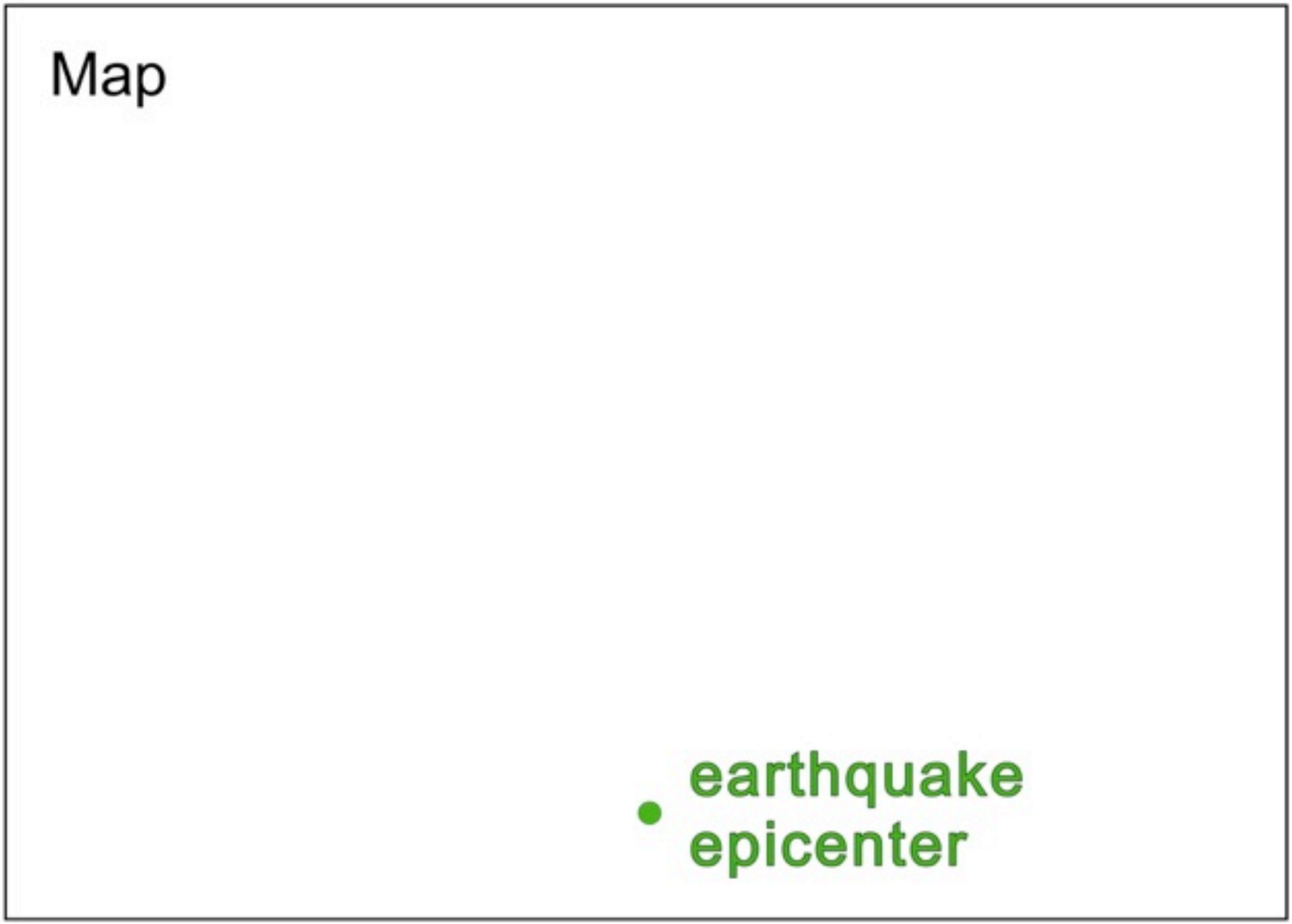
- earthquake hypocenter and focal mechanism data
- hillshade maps derived from digital elevation models

SLAM uses…

- earthquake hypocenter and focal mechanism data
- hillshade maps derived from digital elevation models
- geomorphic analysis

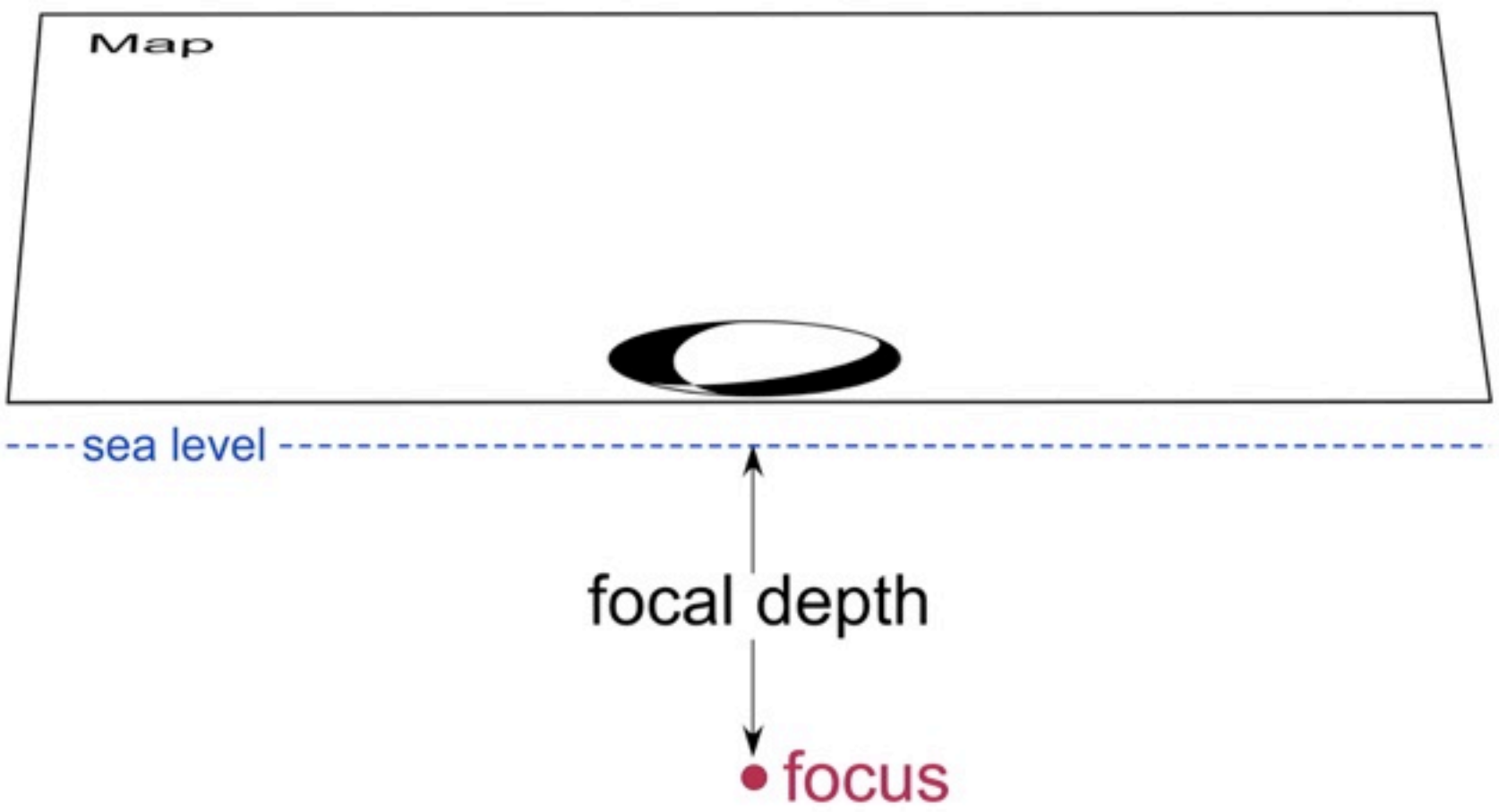
SLAM uses…

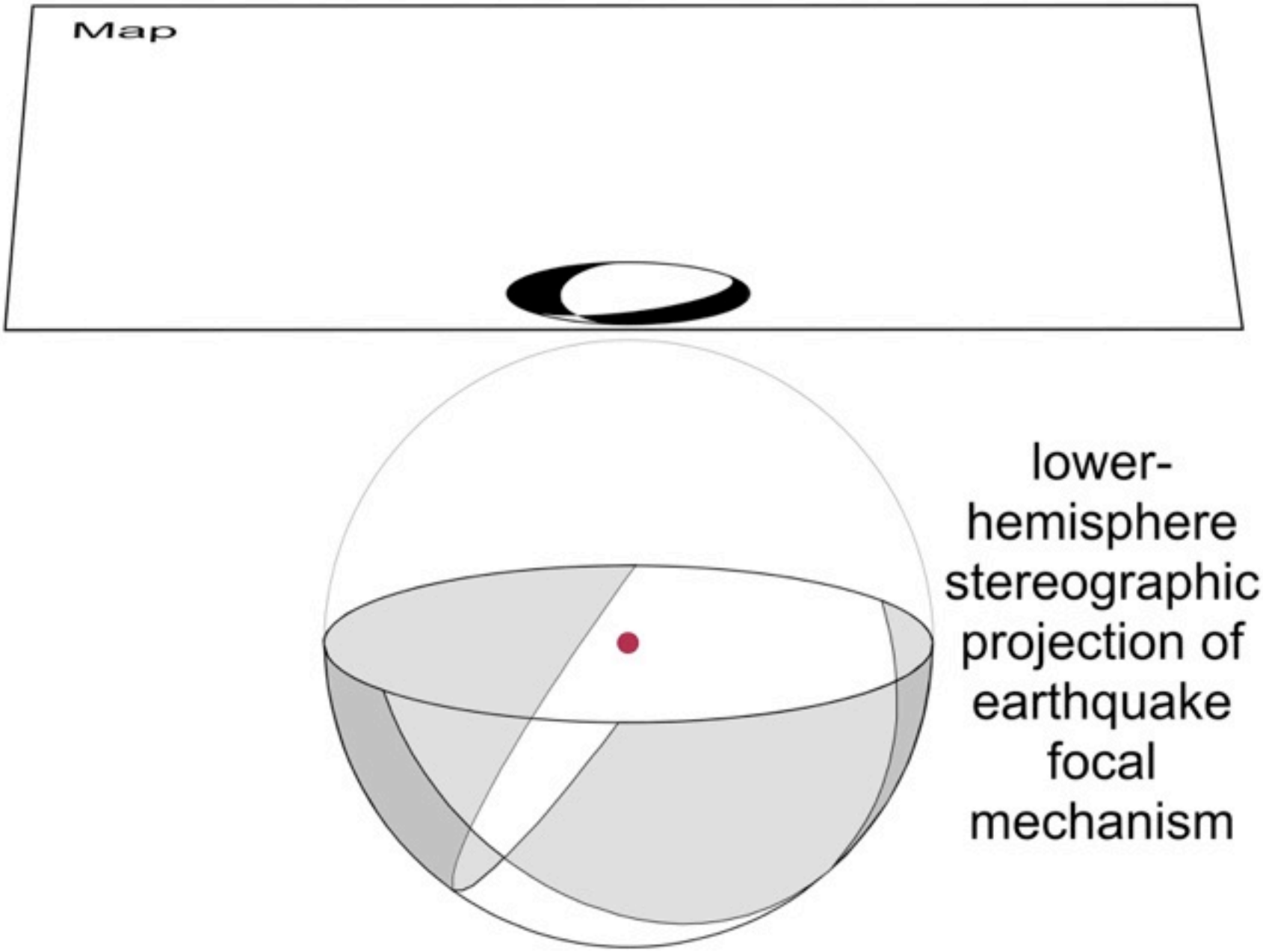
- earthquake hypocenter and focal mechanism data
- hillshade maps derived from digital elevation models
- geomorphic analysis
- geologic field work


Map
earthquake
epicenter

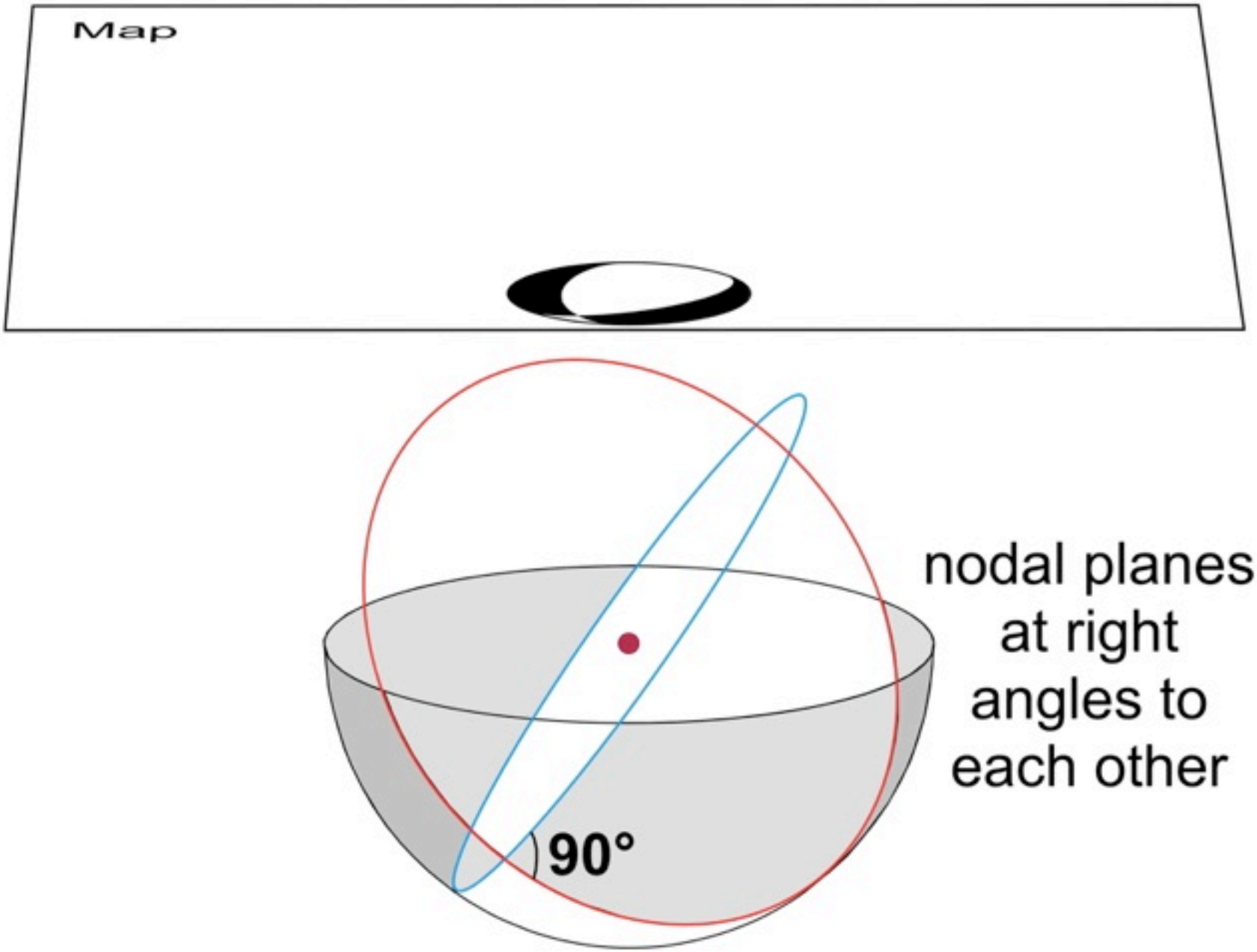
Map

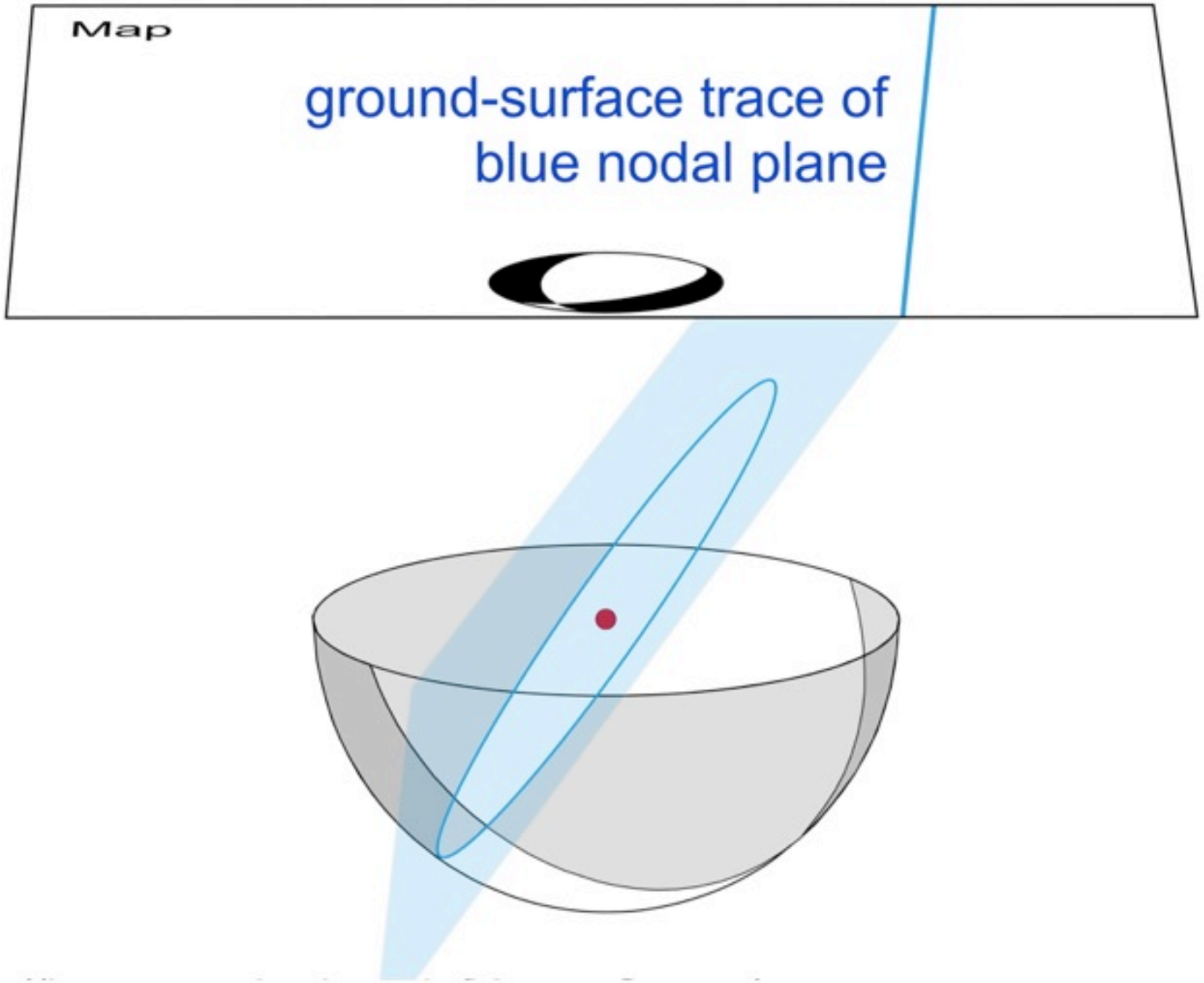
focal mechanism diagram (beachball)

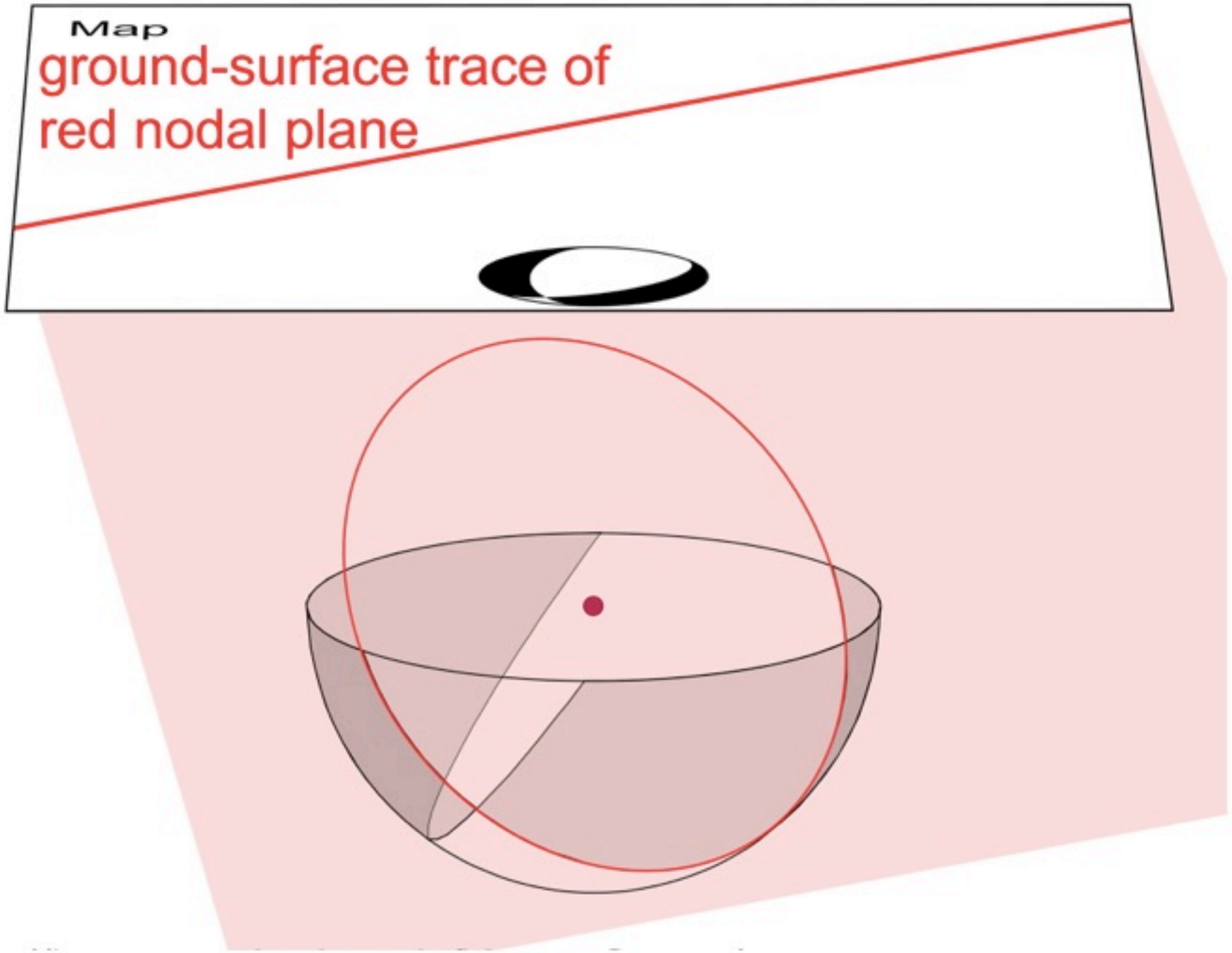

Map
sea level
focal depth
focus

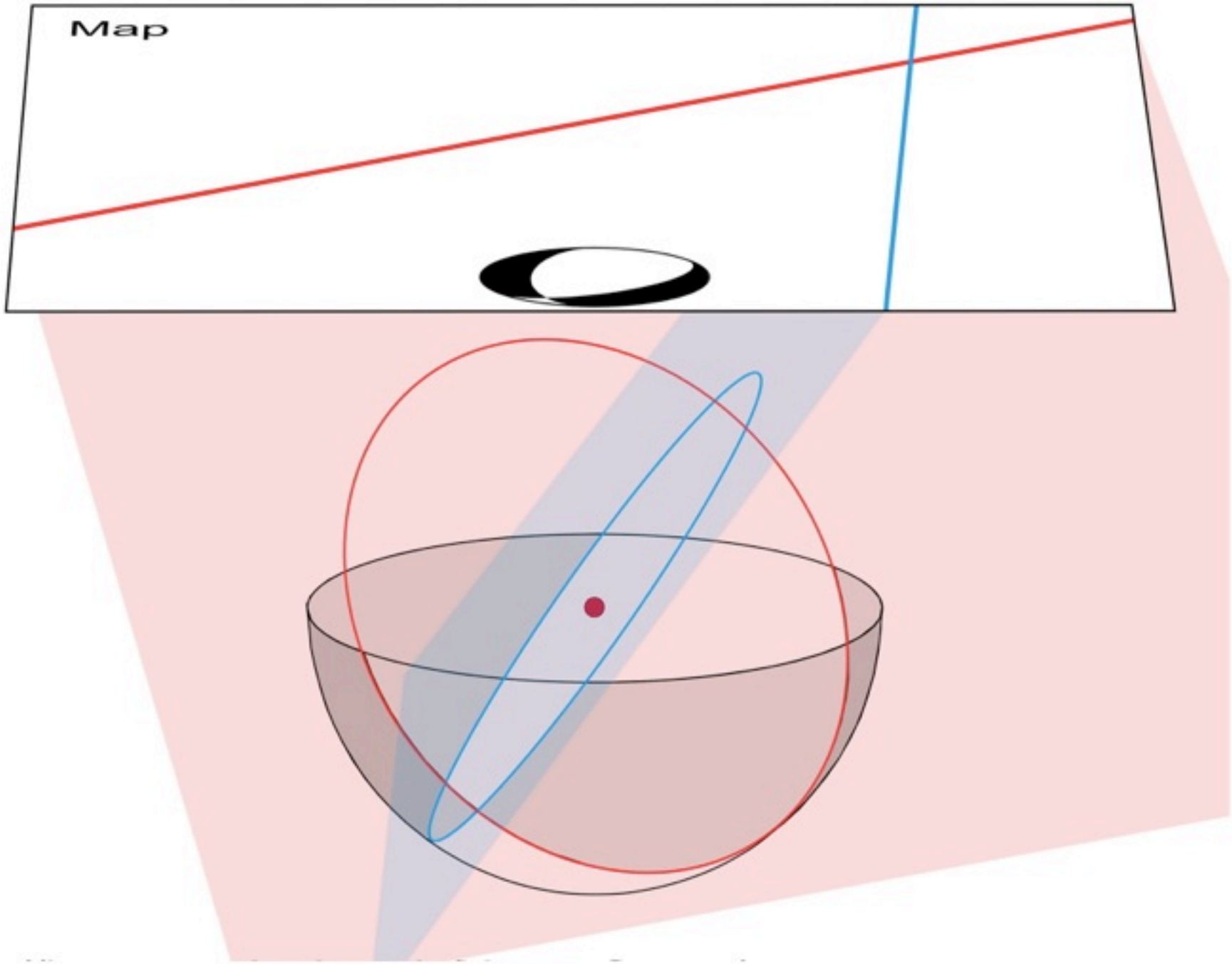


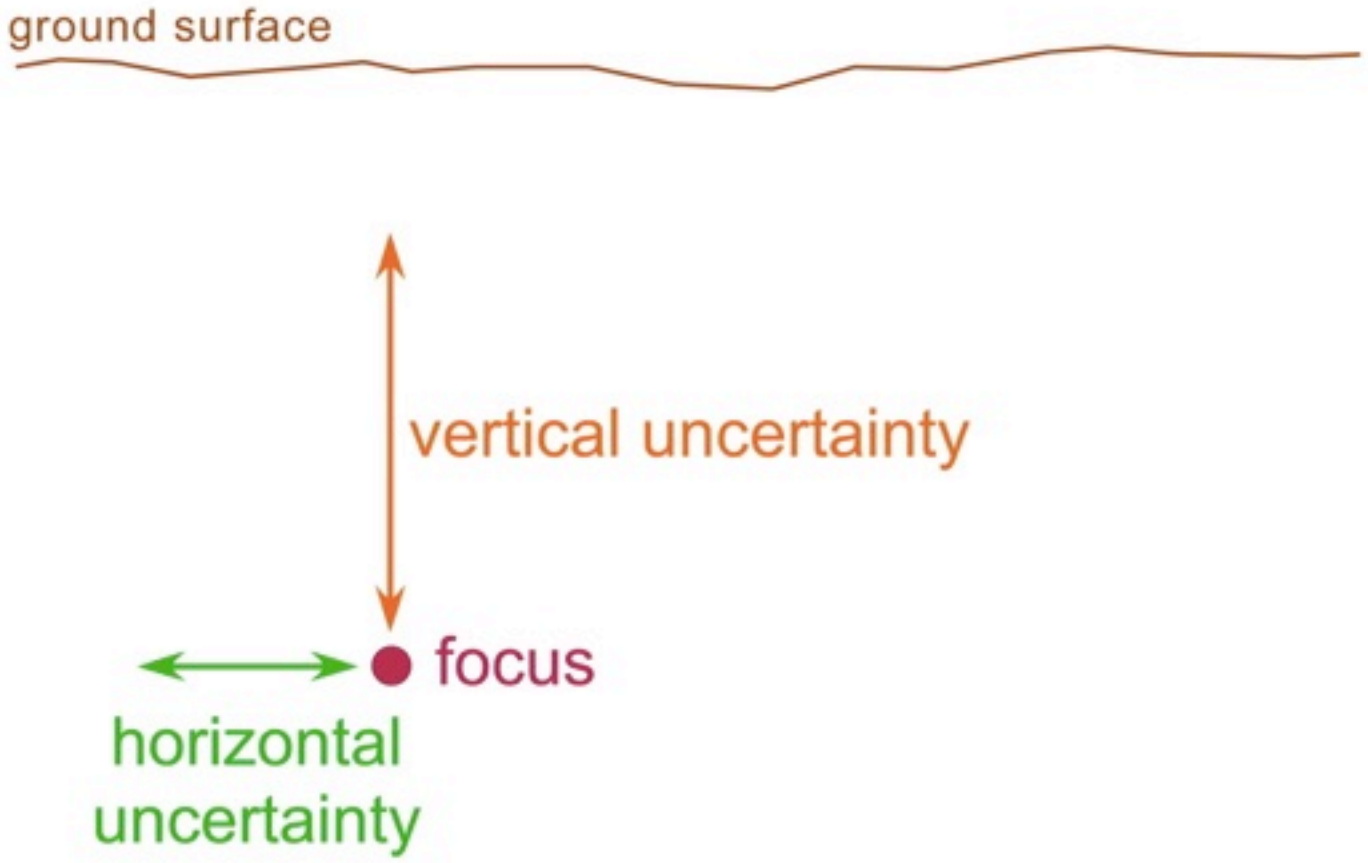
lower-hemisphere stereographic projection of earthquake focal mechanism


Map
90°
nodal planes
at right
angles to
each other

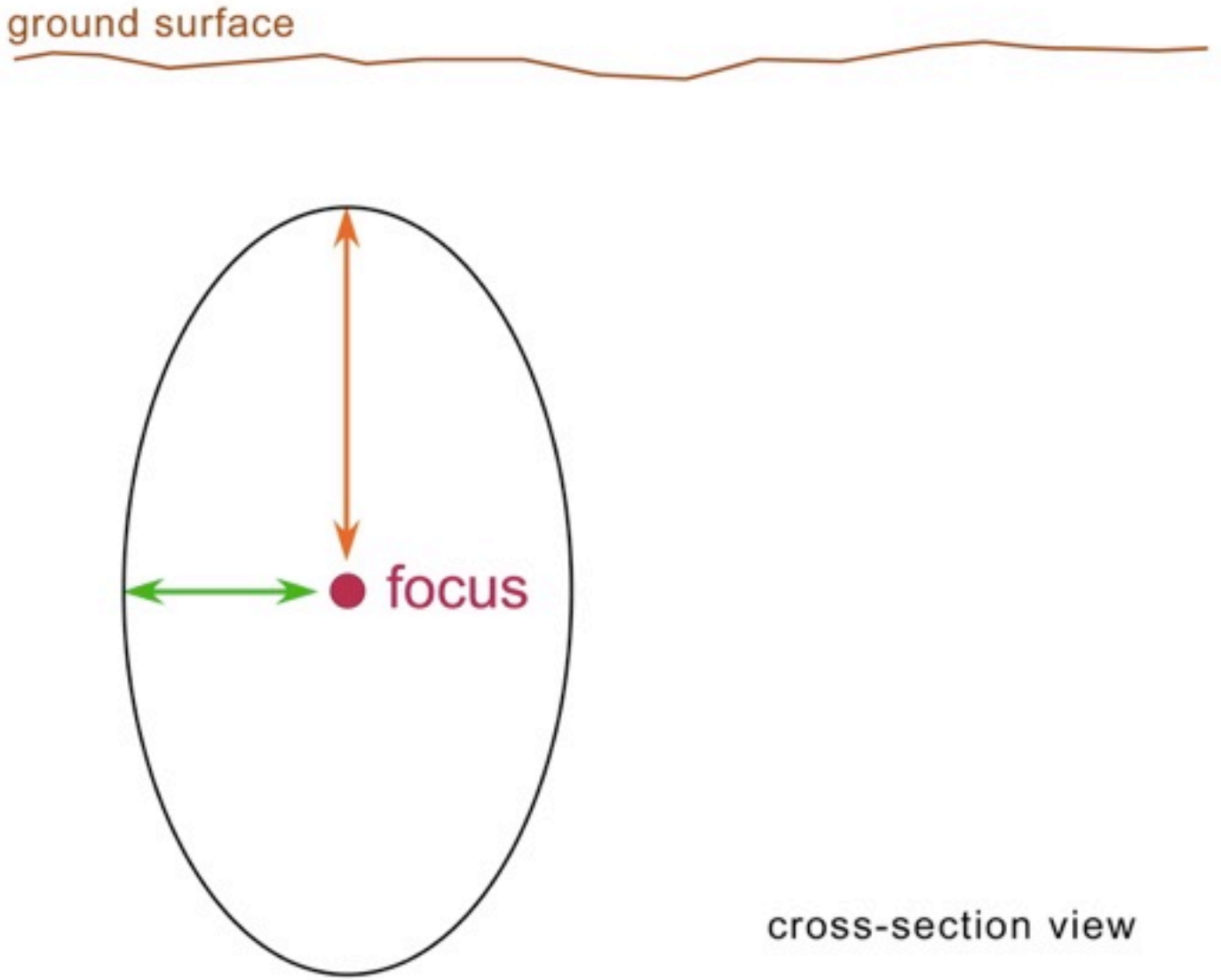

Map
ground-surface trace of
blue nodal plane

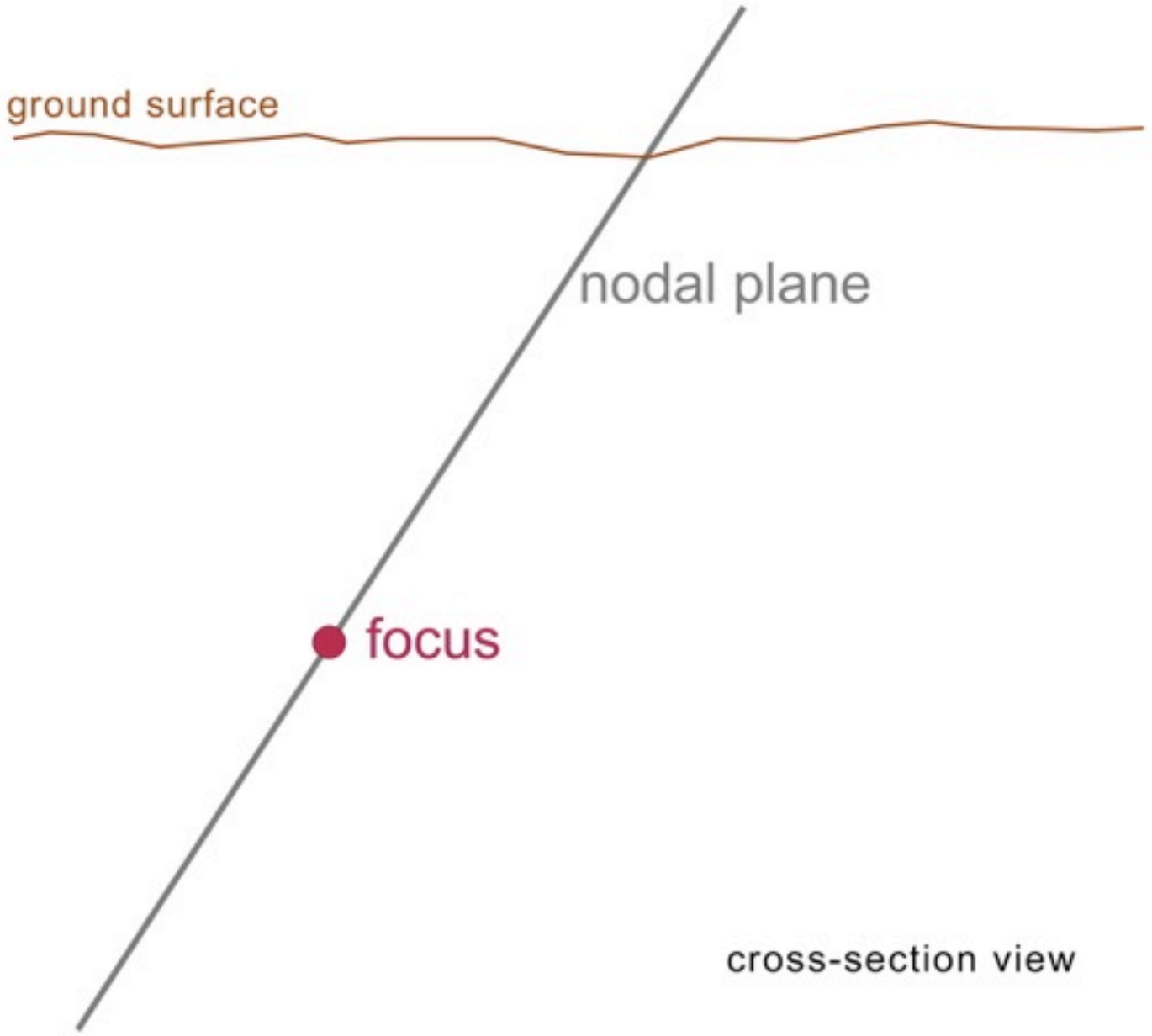

Map
ground-surface trace of
red nodal plane

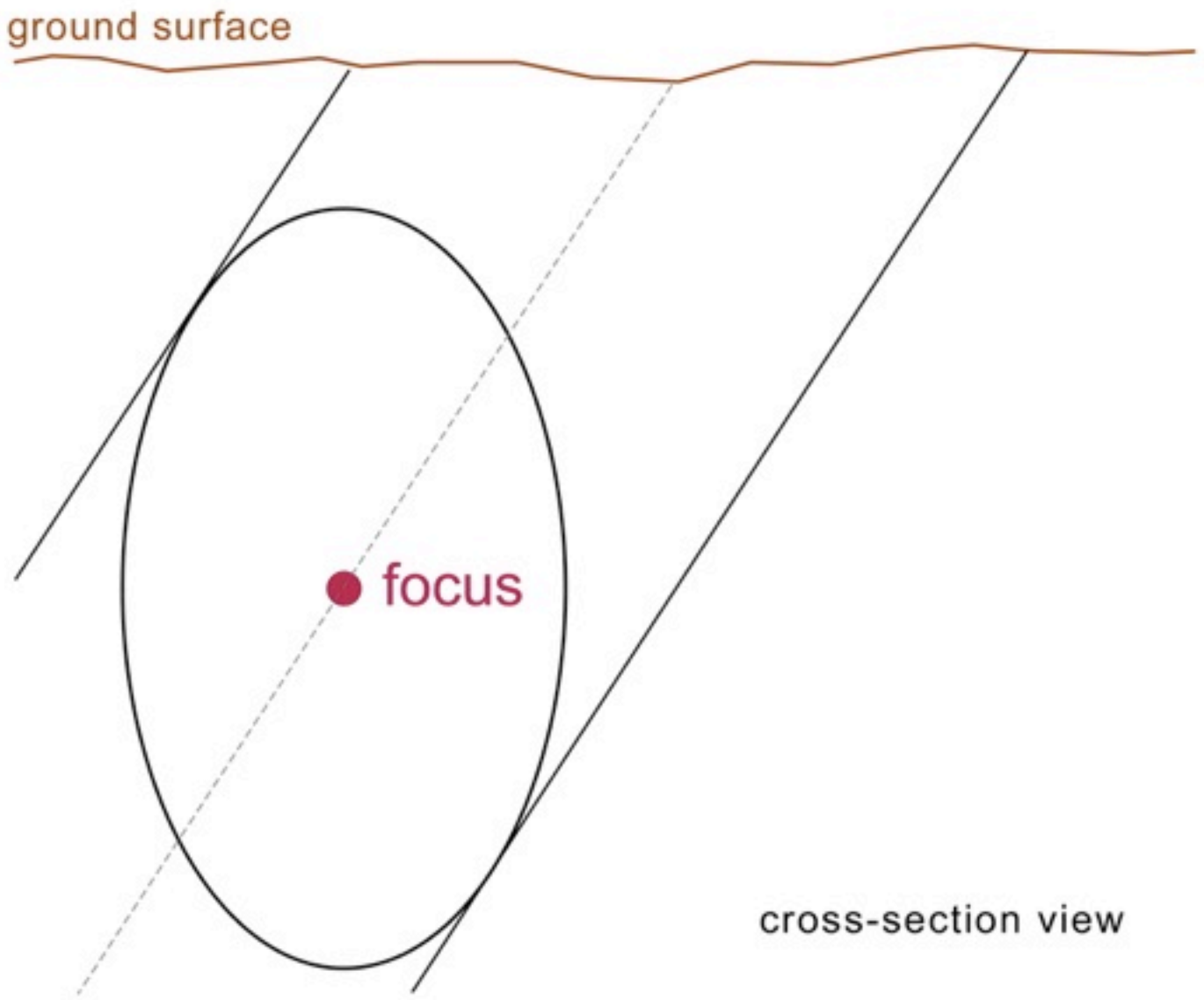

Map

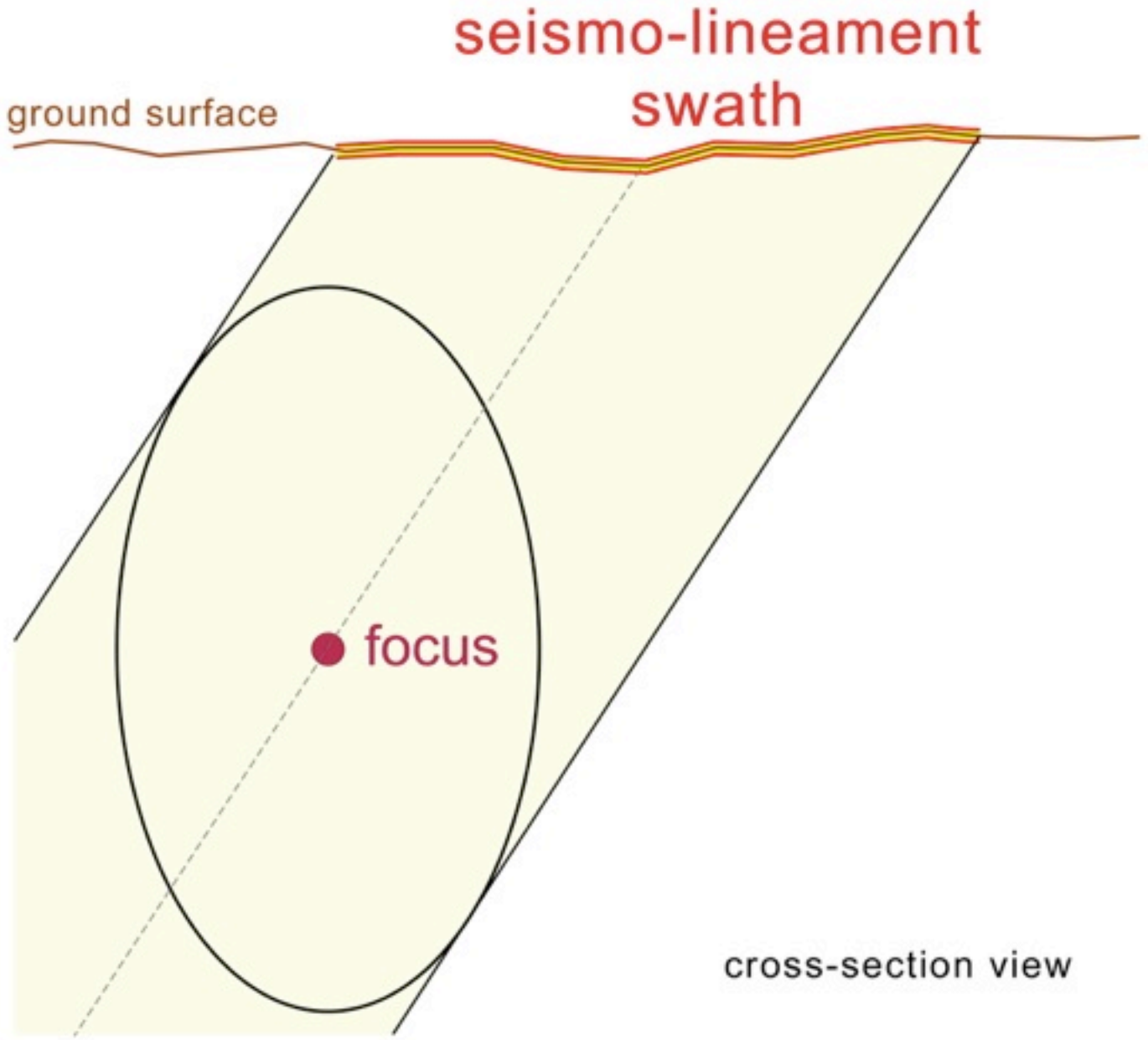


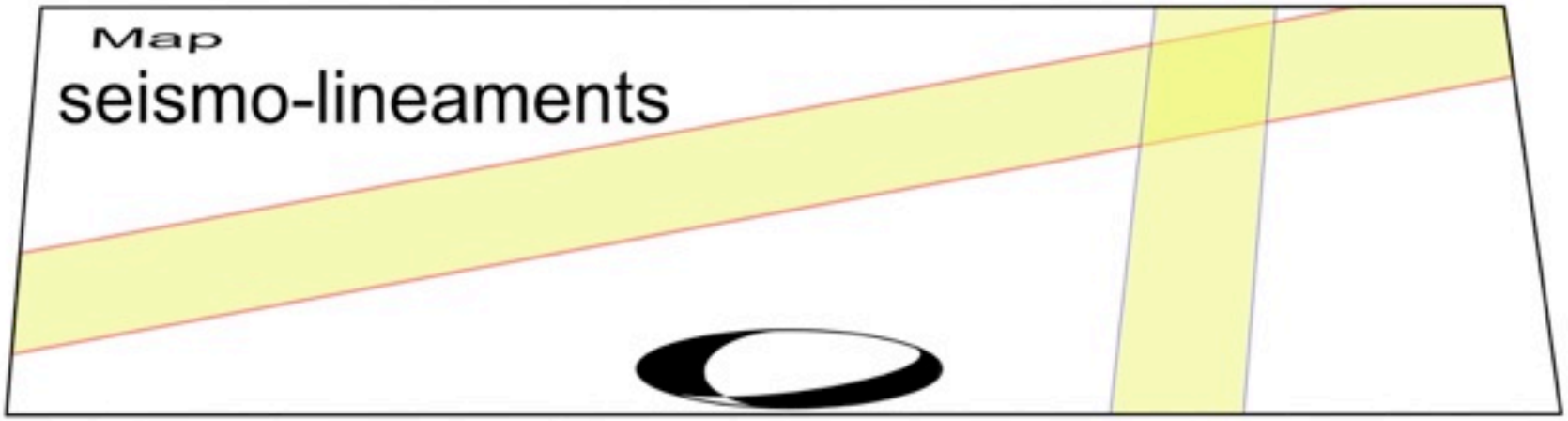
cross-section view

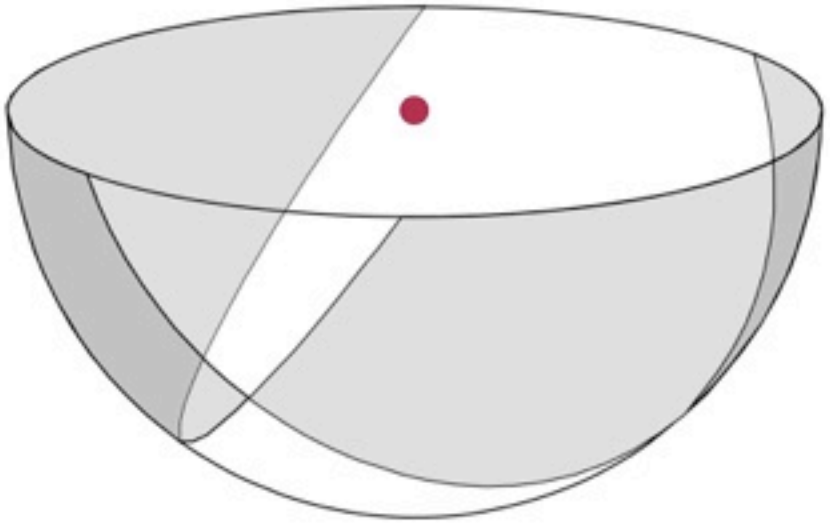

ground surface
focus
cross-section view

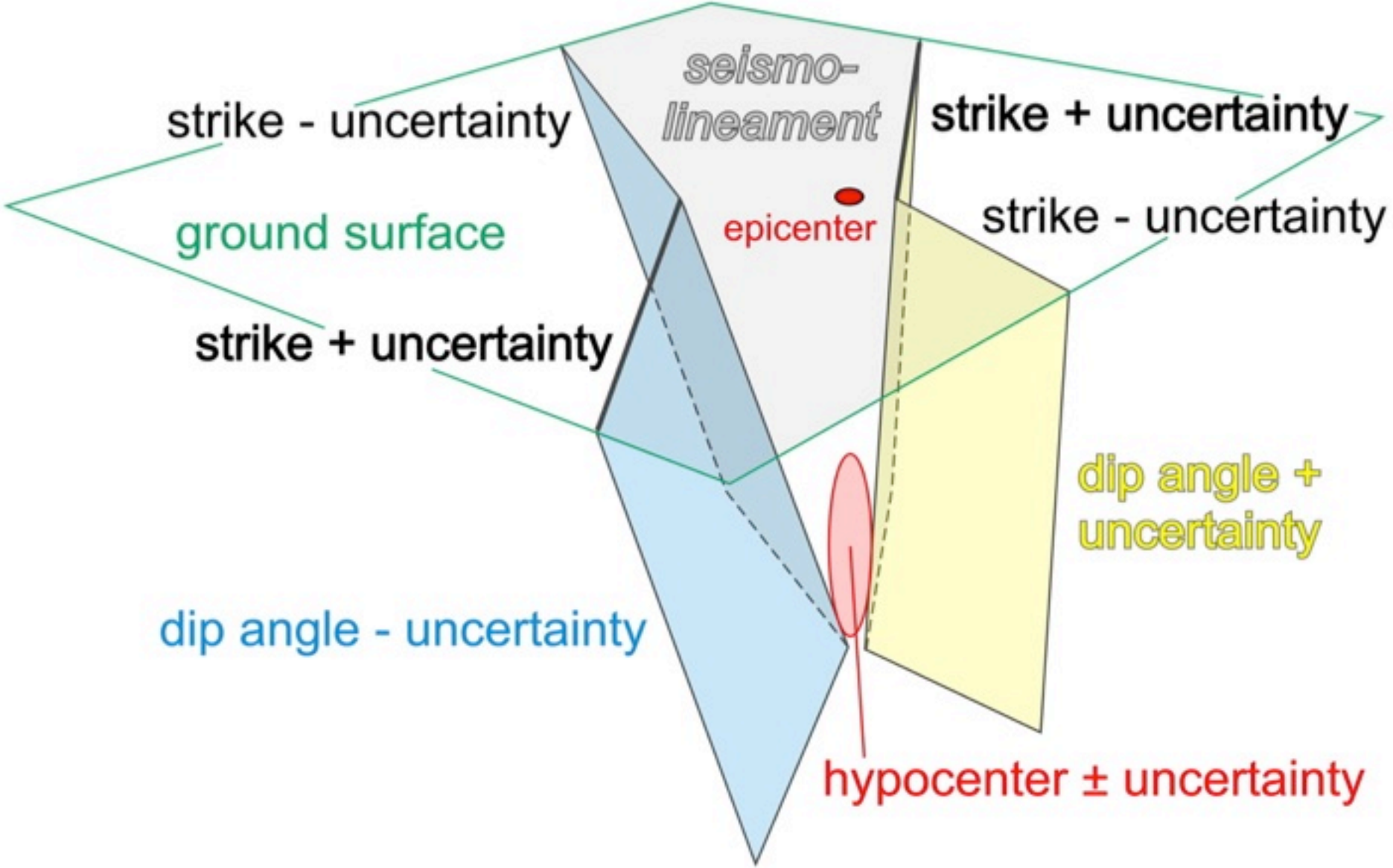

ground surface
nodal plane
focus
cross-section view

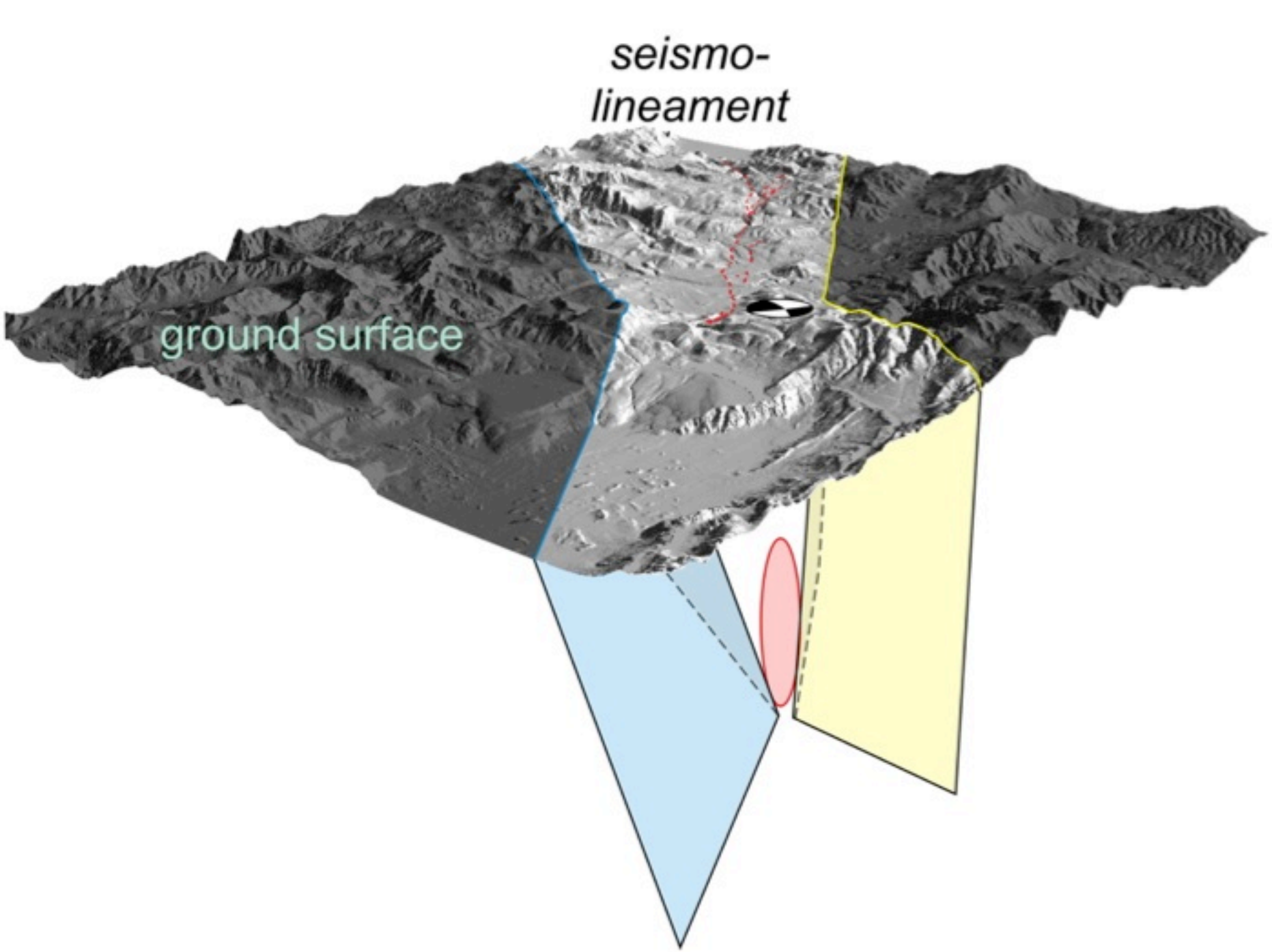

ground surface
focus
cross-section view

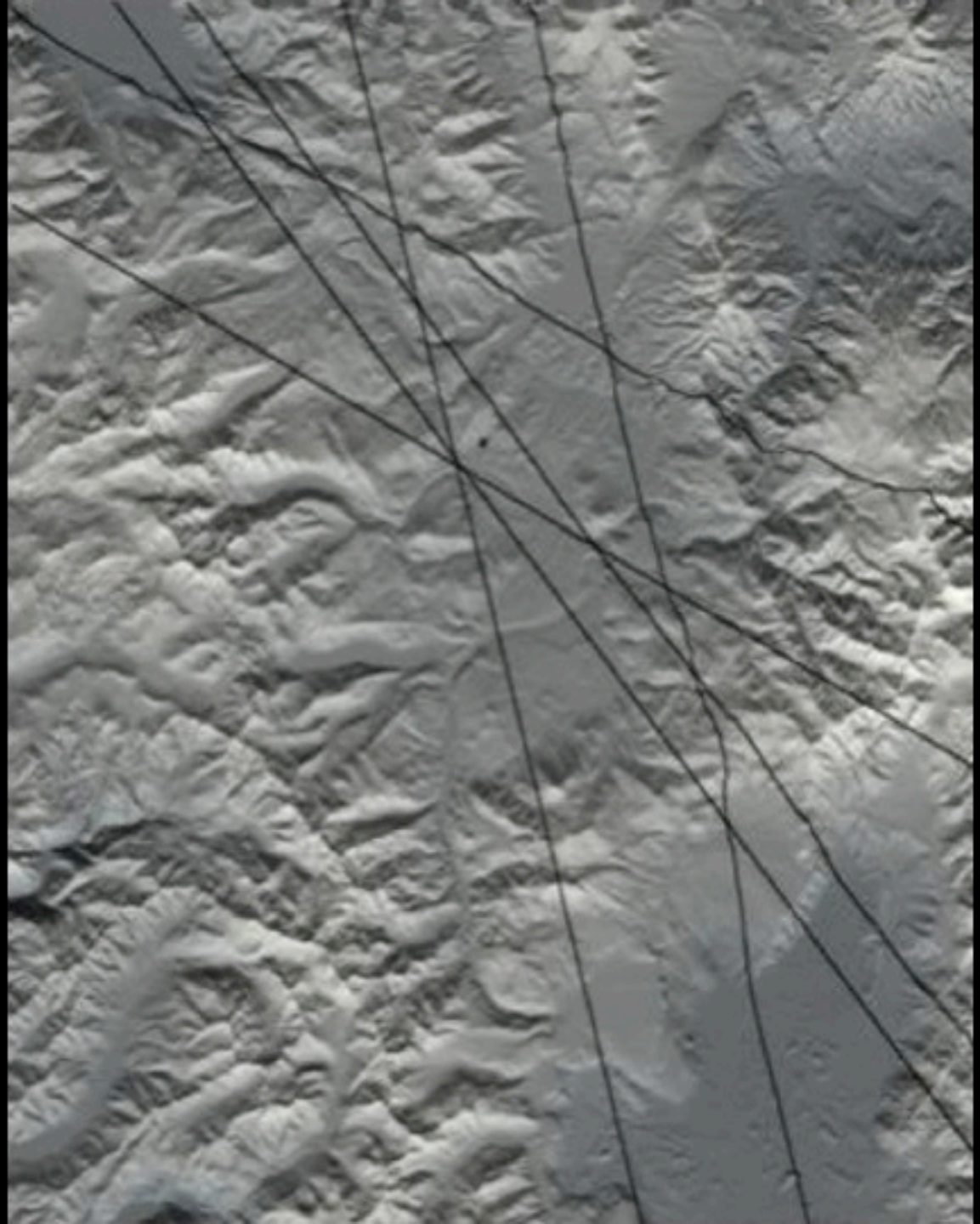

seismo-lineament
swath
ground surface
focus
cross-section view

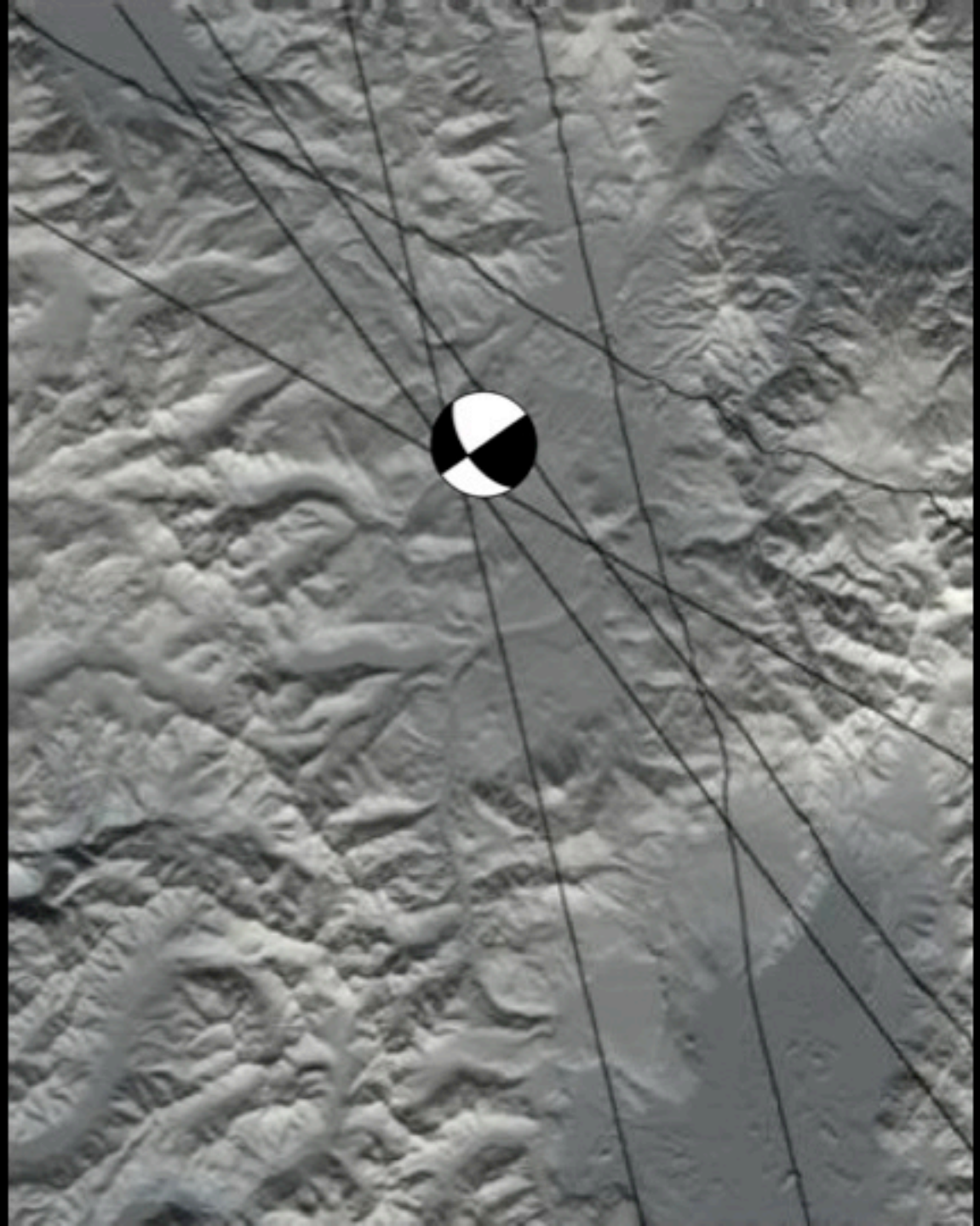

Map
seismo-lineaments

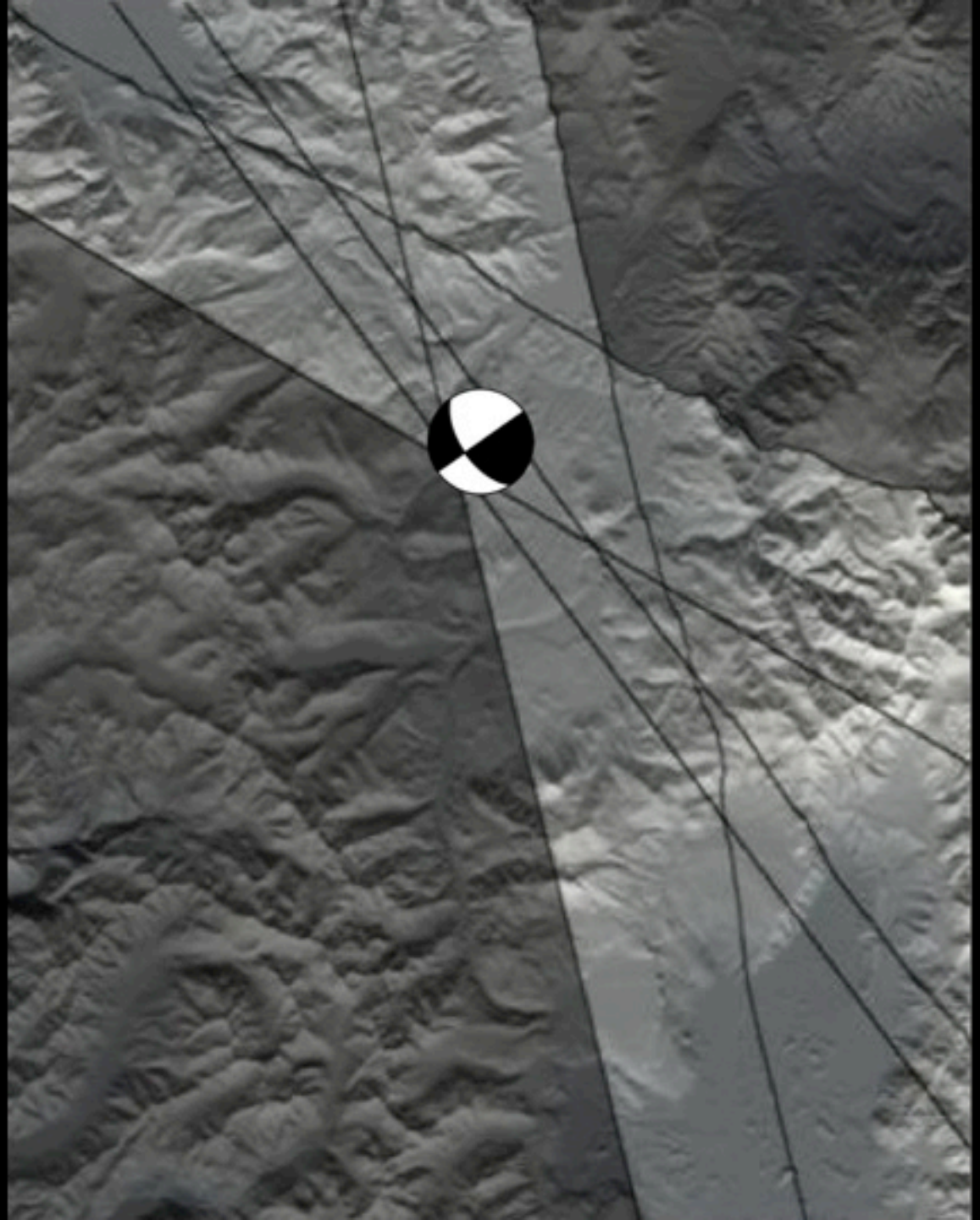


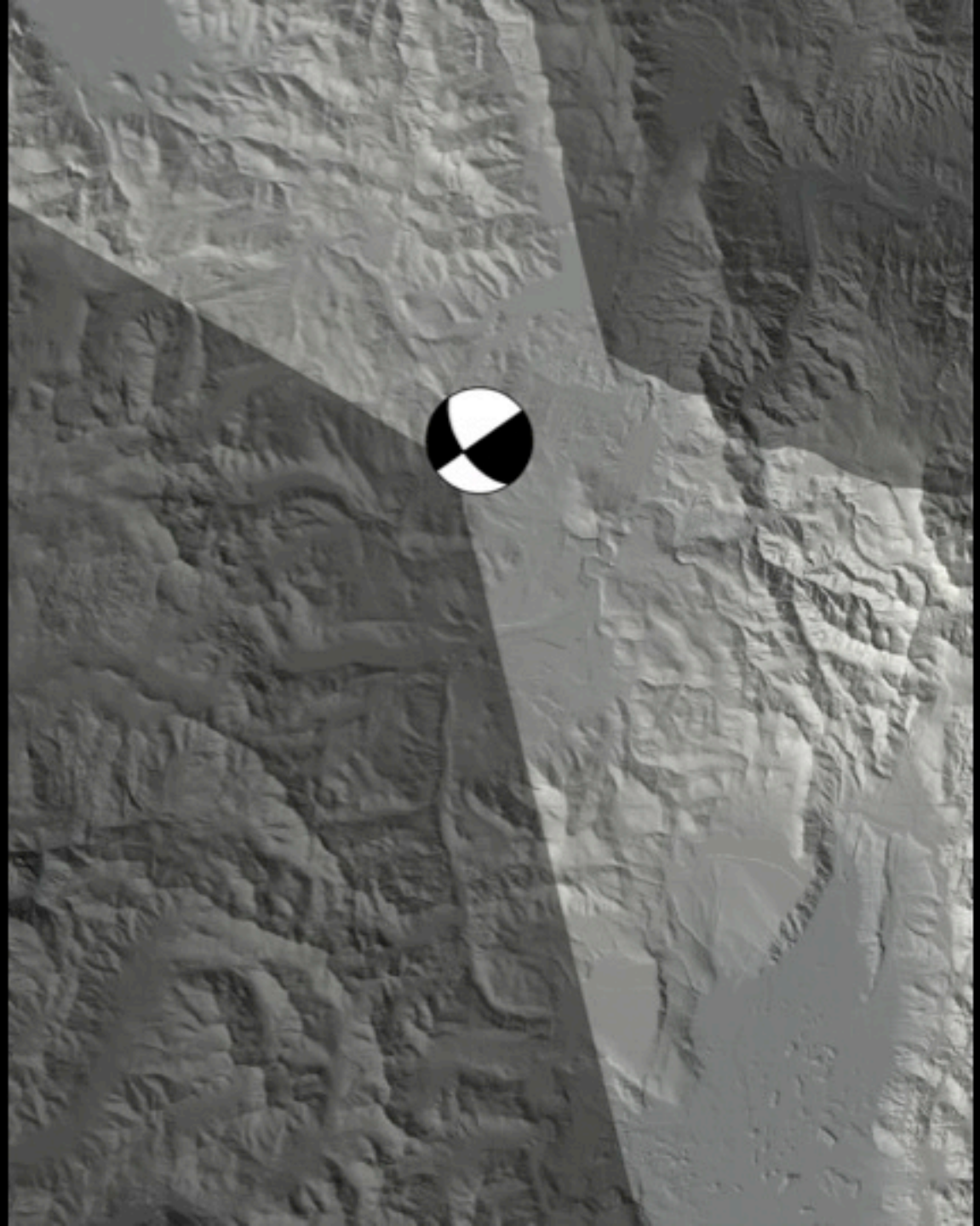

seismo-
lineament
strike - uncertainty
strike + uncertainty
ground surface
epicenter
strike - uncertainty
strike + uncertainty
dip angle +
uncertainty
dip angle - uncertainty
hypocenter ± uncertainty

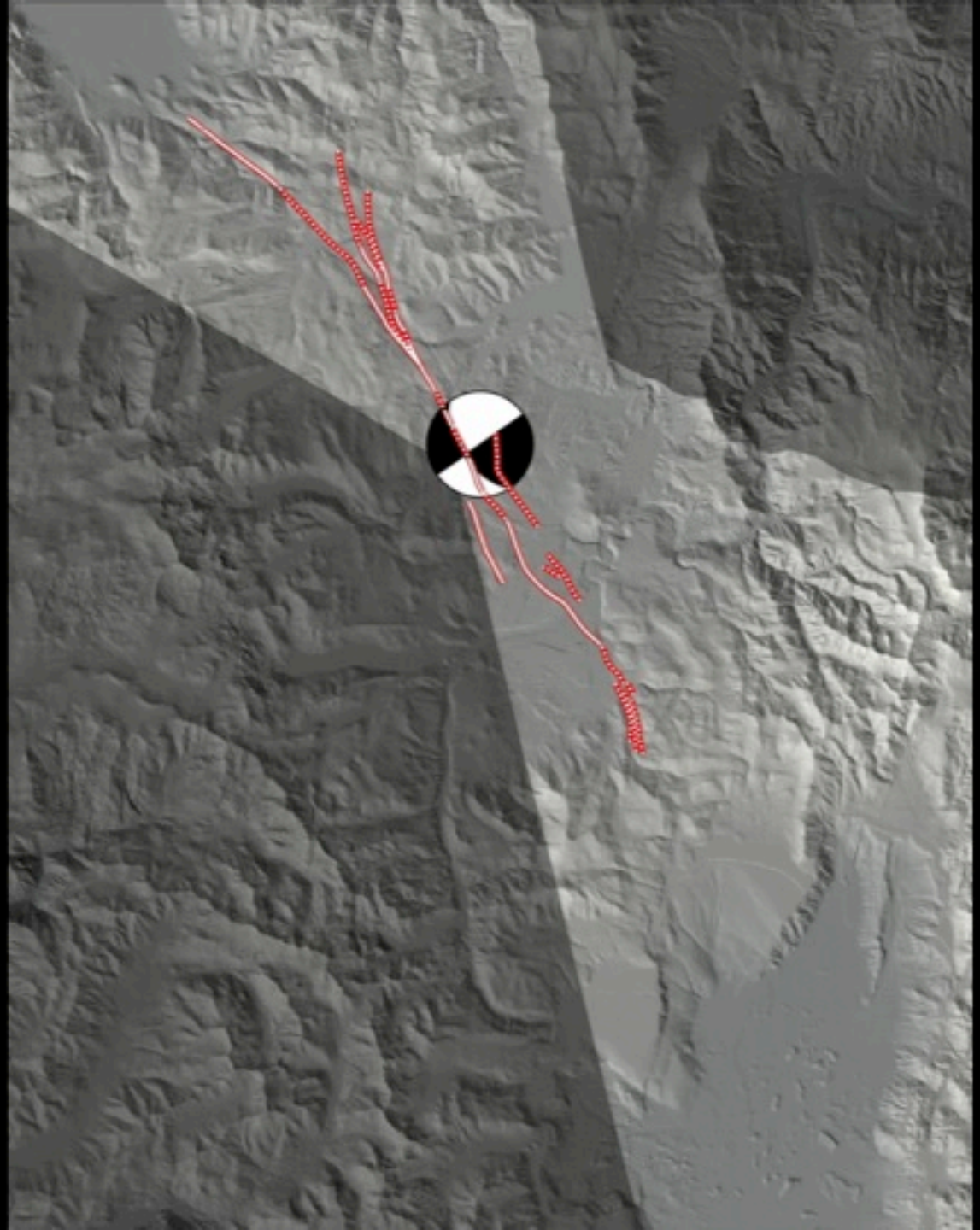

seismo-
lineament
ground surface

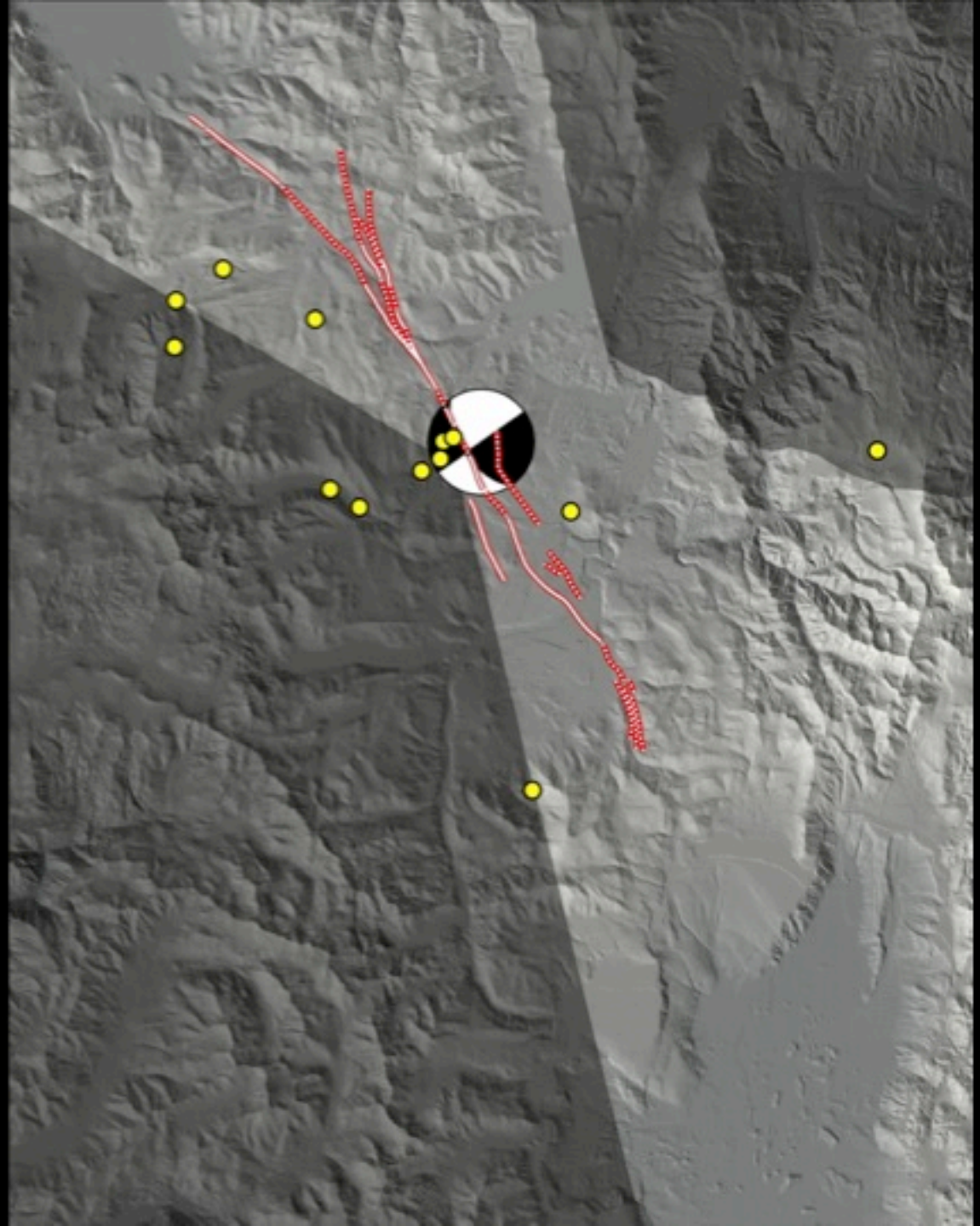




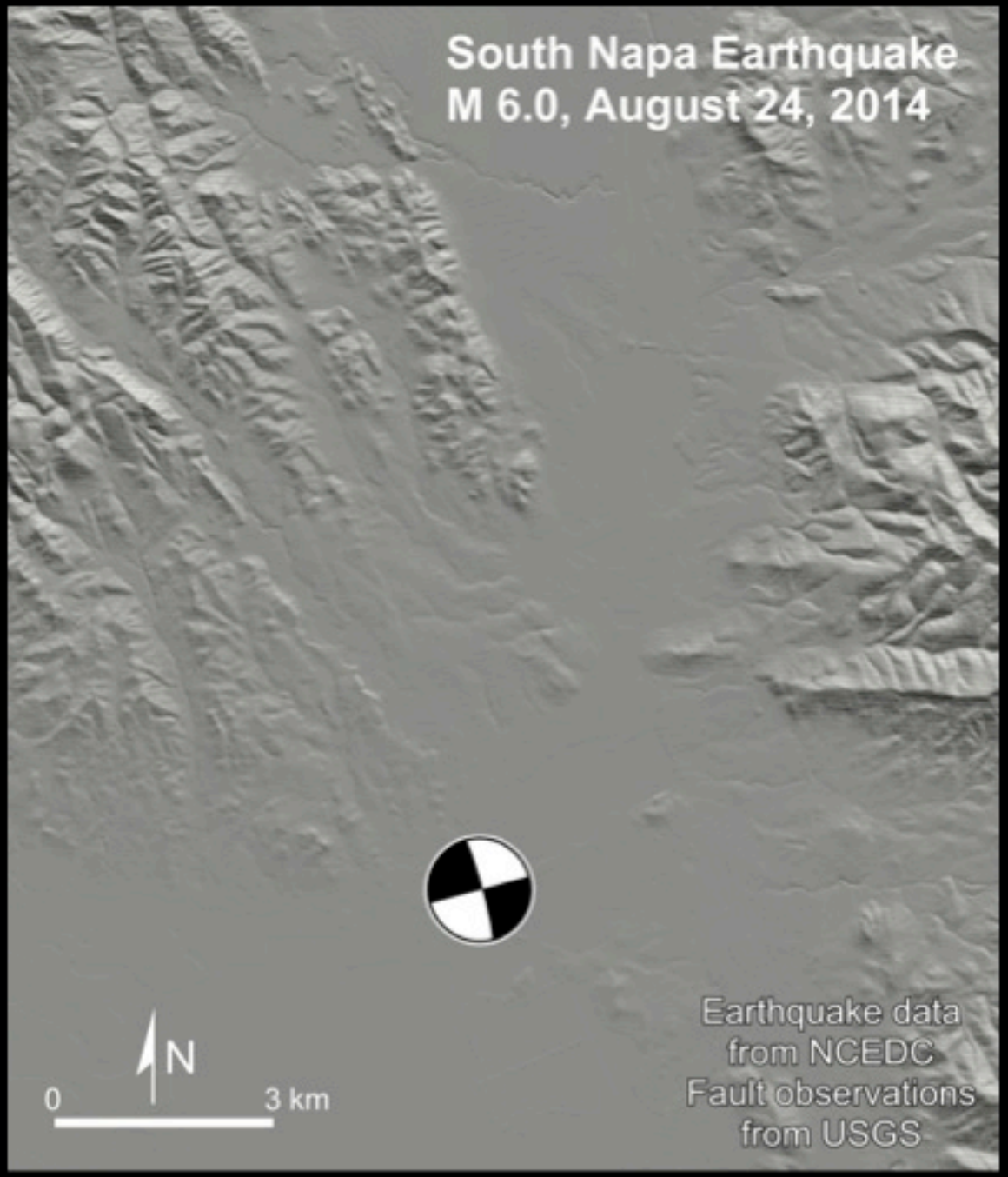




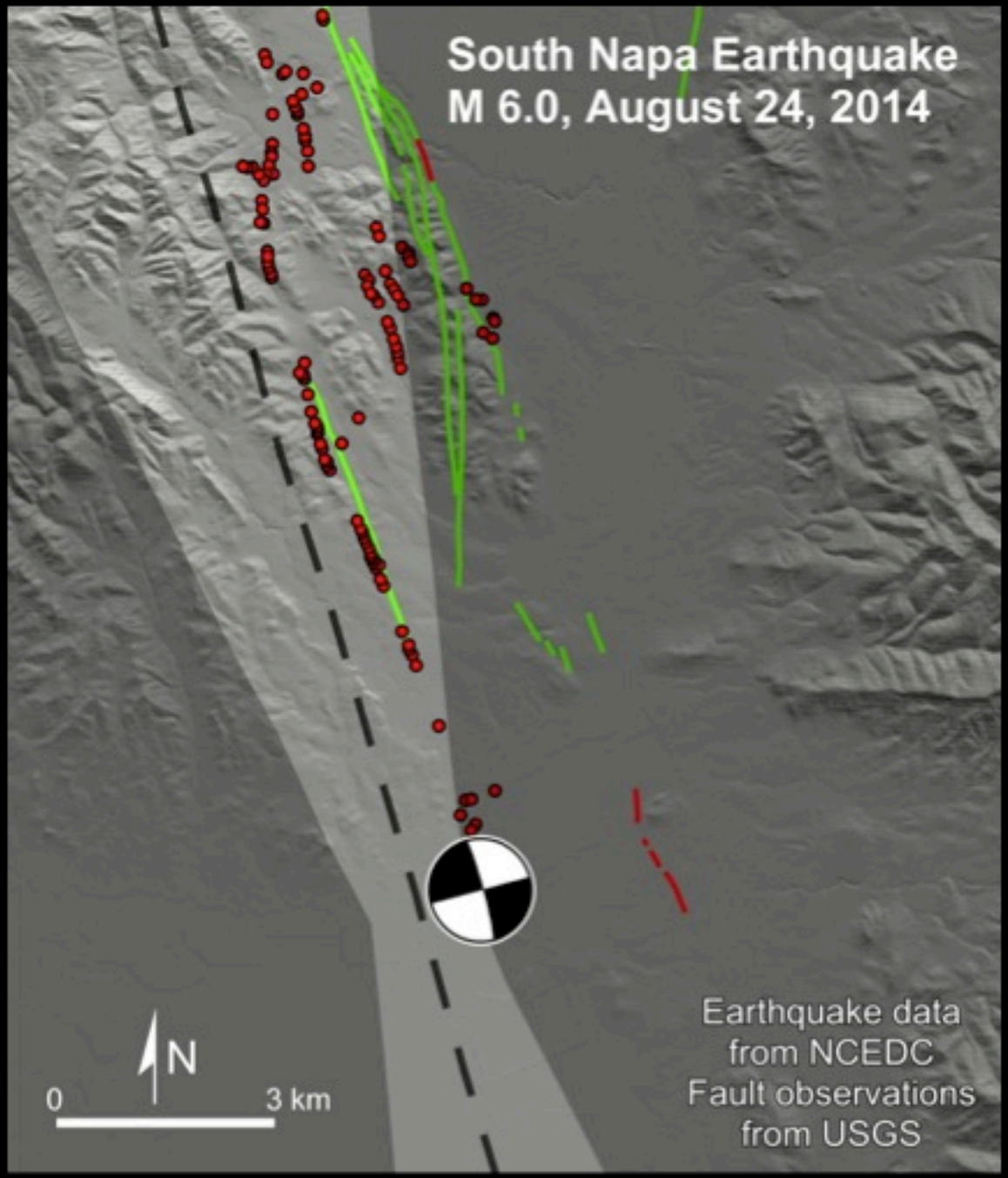




Trivial case: Can we use SLAM to find the fault responsible for the M 6.0 South Napa earthquake of 24 August 2014?

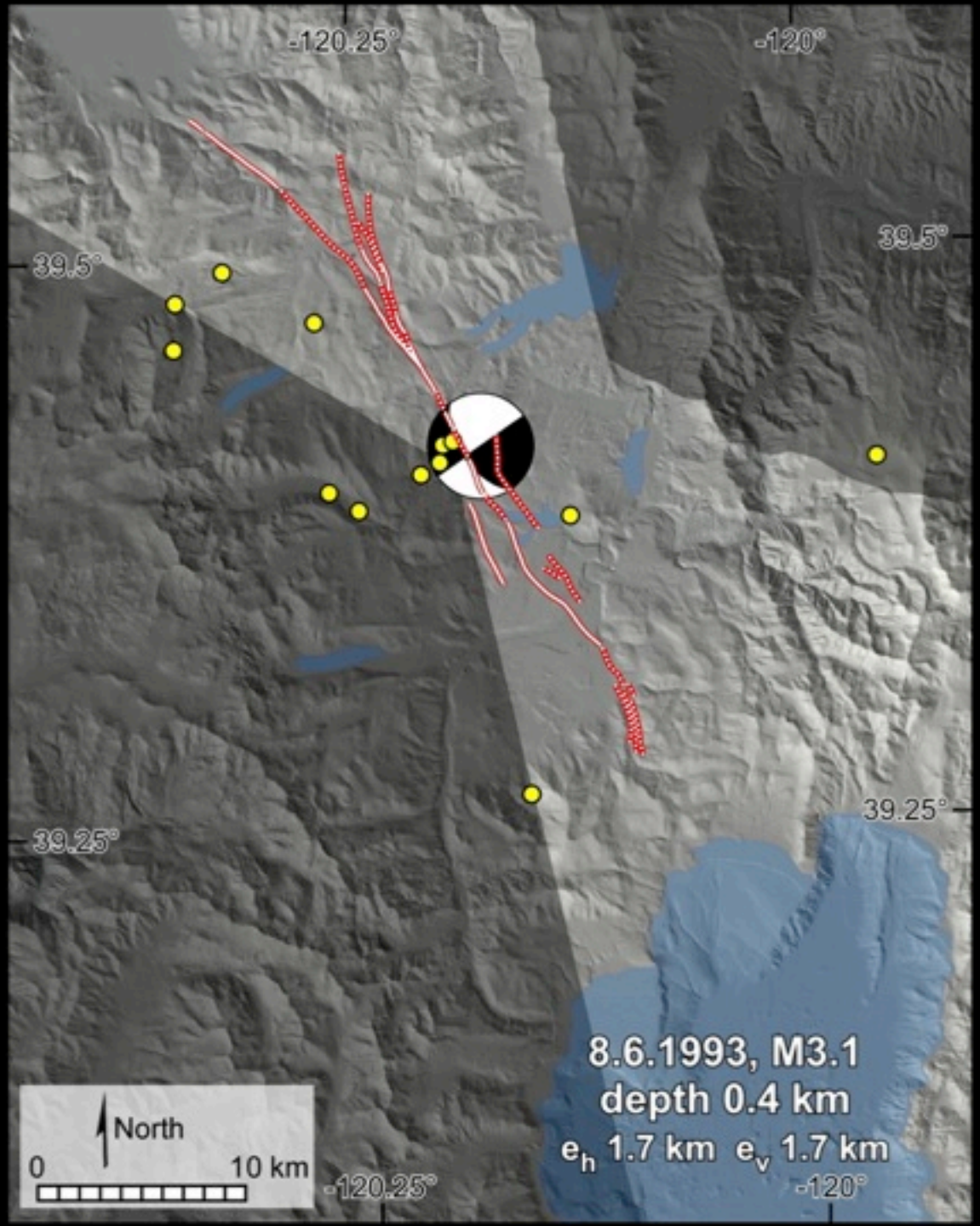

South Napa Earthquake
M 6.0, August 24, 2014
N
0
3 km
Earthquake data
from NCEDC
Fault observations
from USGS

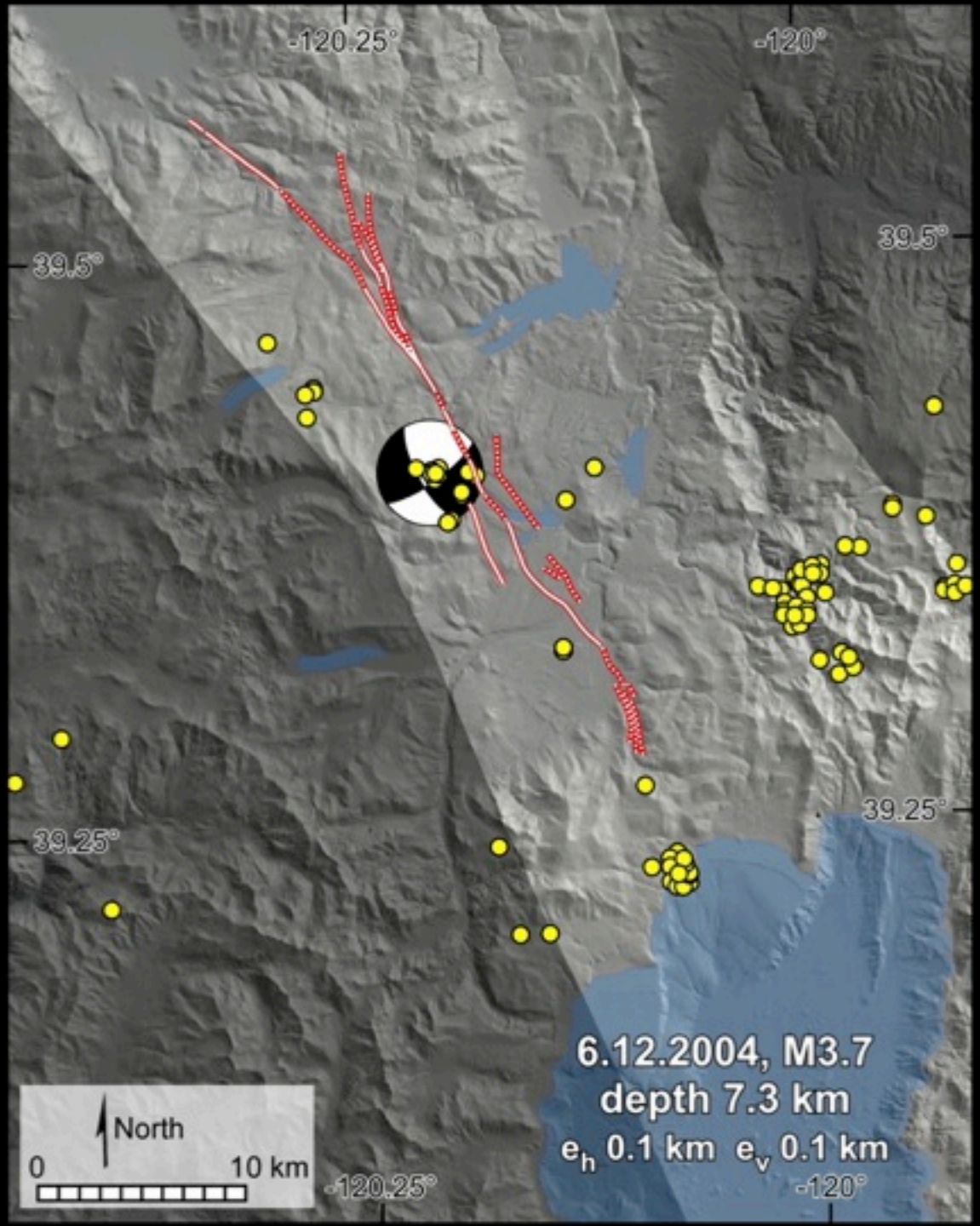
South Napa Earthquake
M 6.0, August 24, 2014
N
0
3 km
Earthquake data
from NCEDC
Fault observations
from USGS

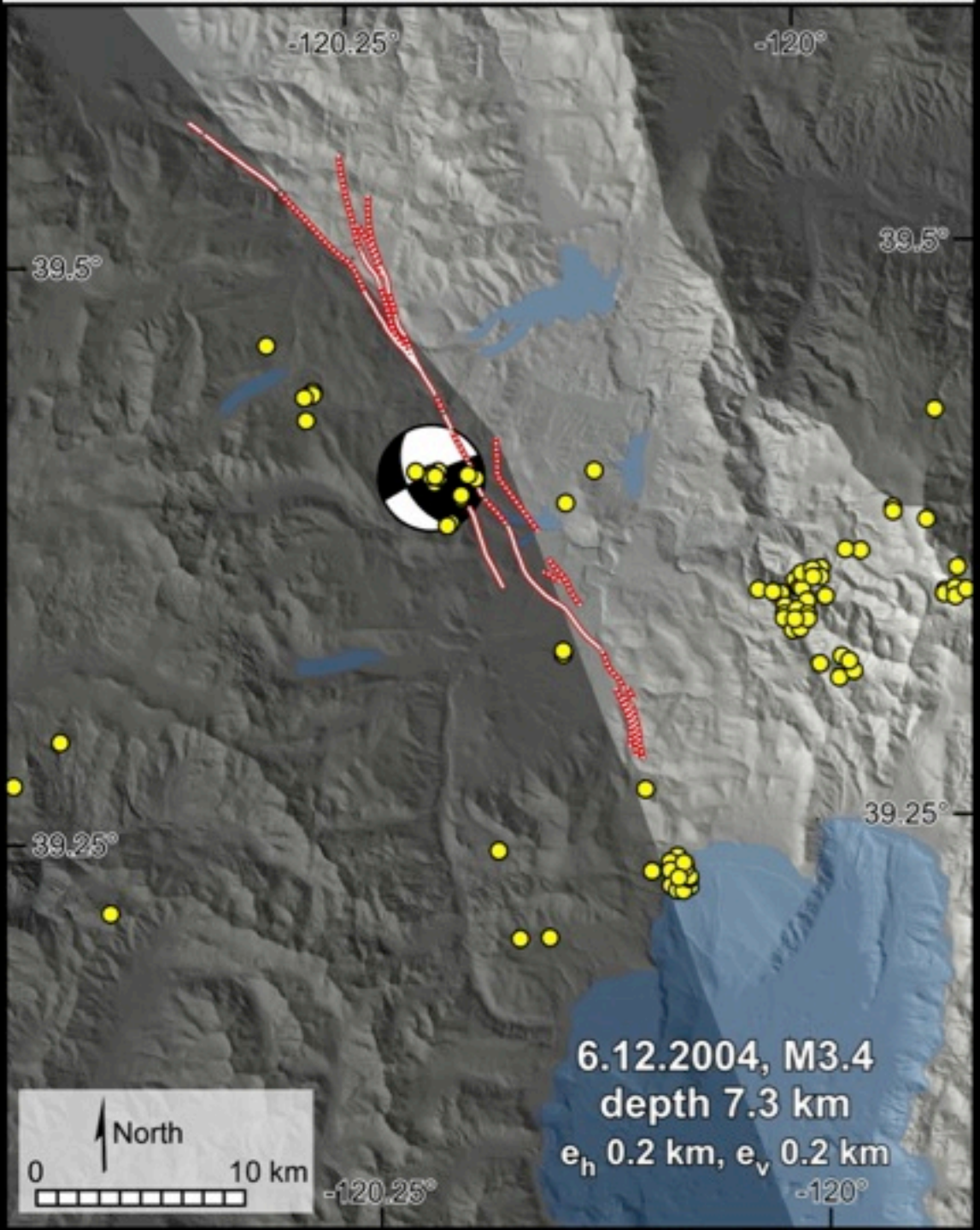

South Napa Earthquake
M 6.0, August 24, 2014
N
0
3 km
Earthquake data
from NCEDC
Fault observations
from USGS

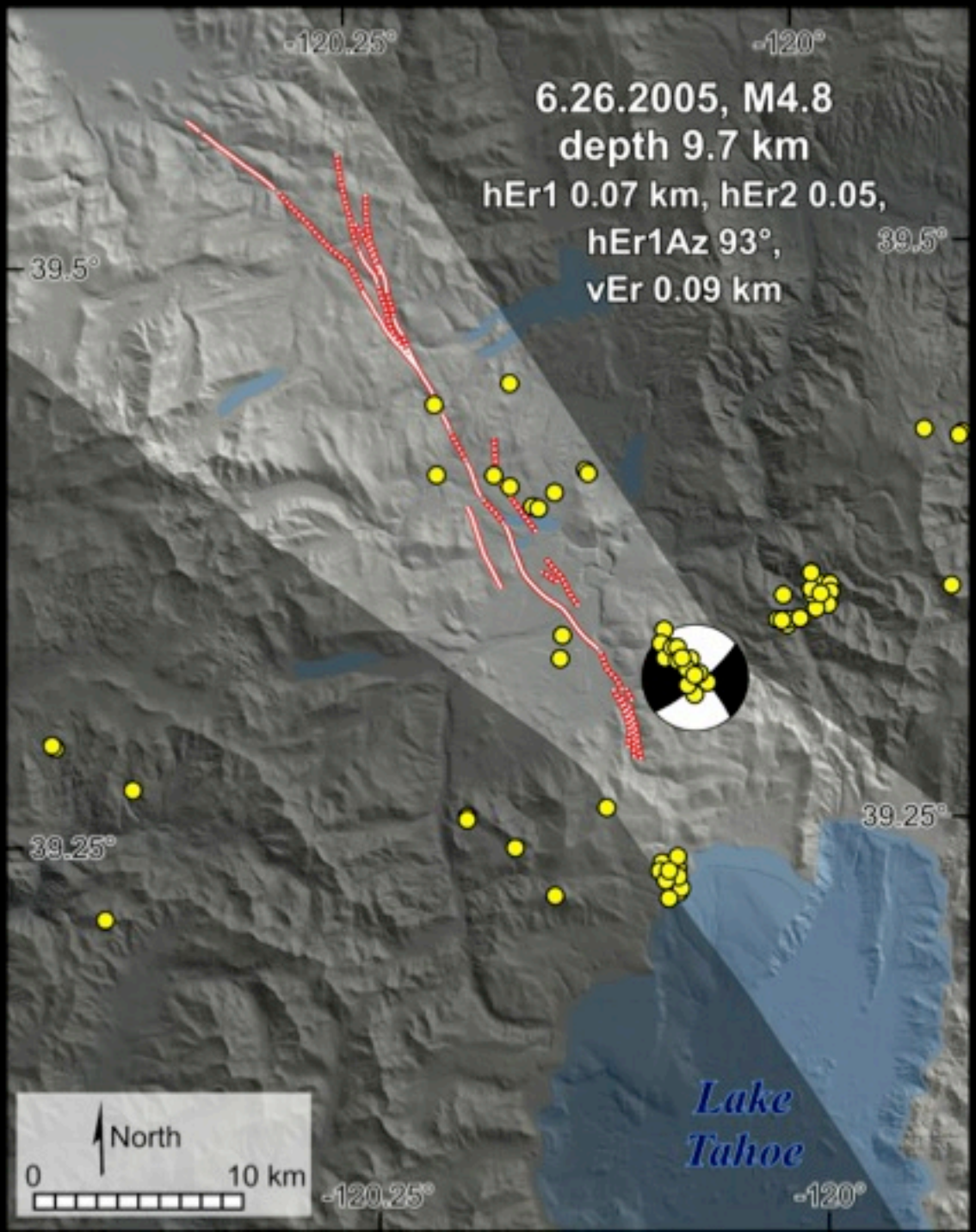
Polaris Fault near Truckee, North Tahoe area, California

- Discovered in 2009
- Right-lateral fault
- Surface trace confirmed with trenches and lidar-based geomorphic analysis
- No reported historic earthquakes


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
8.6.1993, M3.1
depth 0.4 km
e_h 1.7 km e_v 1.7 km
North
0
10 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
North
0
10 km
6.12.2004, M3.7
depth 7.3 km
e_h 0.1 km e_v 0.1 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
6.12.2004, M3.4
depth 7.3 km
e_h 0.2 km, e_v 0.2 km
North
0
10 km
-120.25°
-120°


-120.25°
-120°
6.26.2005, M4.8
depth 9.7 km
hEr1 0.07 km, hEr2 0.05,
hEr1Az 93°,
vEr 0.09 km
39.5°
39.5°
39.25°
39.25°
North
0
10 km
Lake
Tahoe
-120.25°
-120°

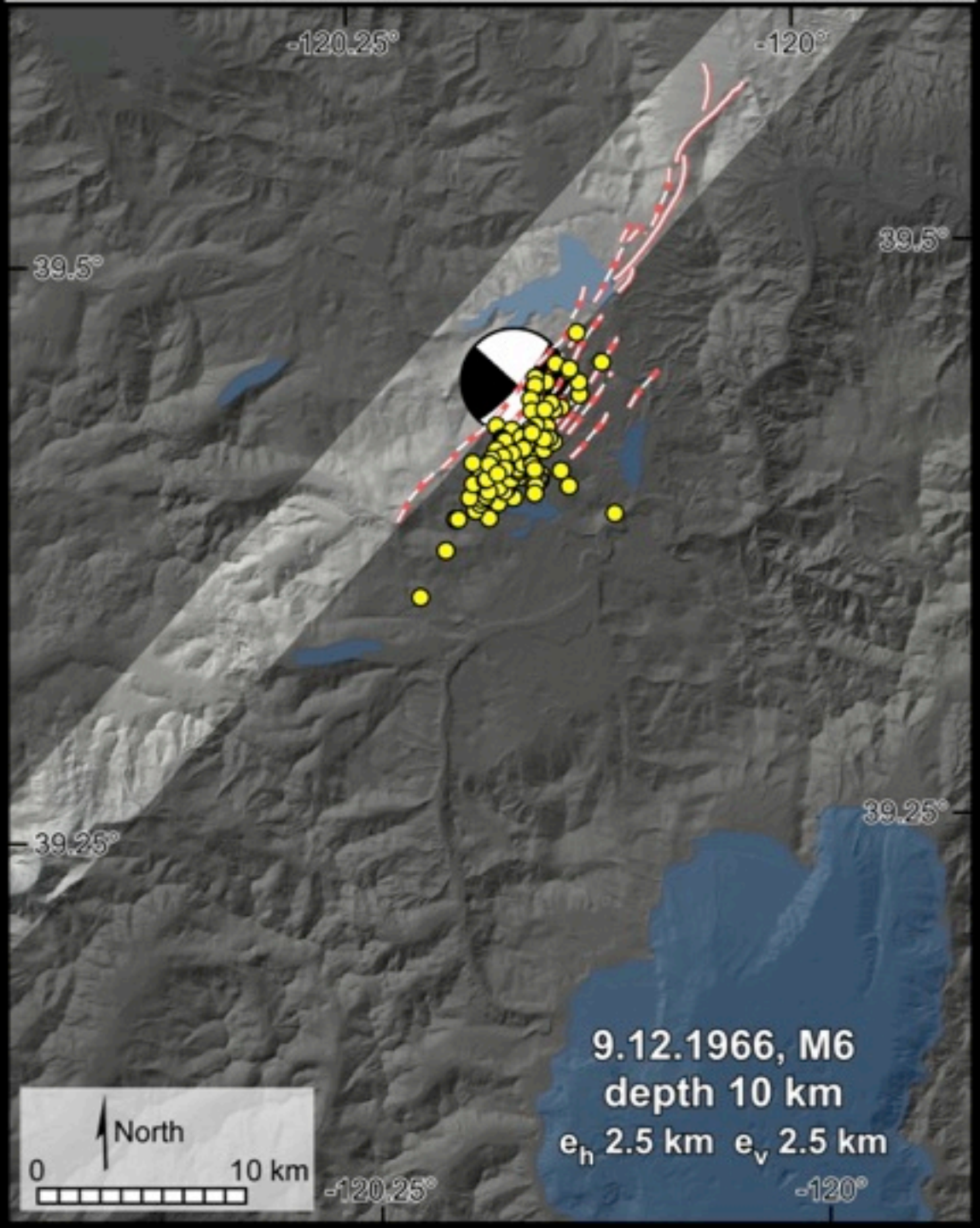
SLAM analysis shows there have been historic earthquakes consistent with displacement along the Polaris Fault.

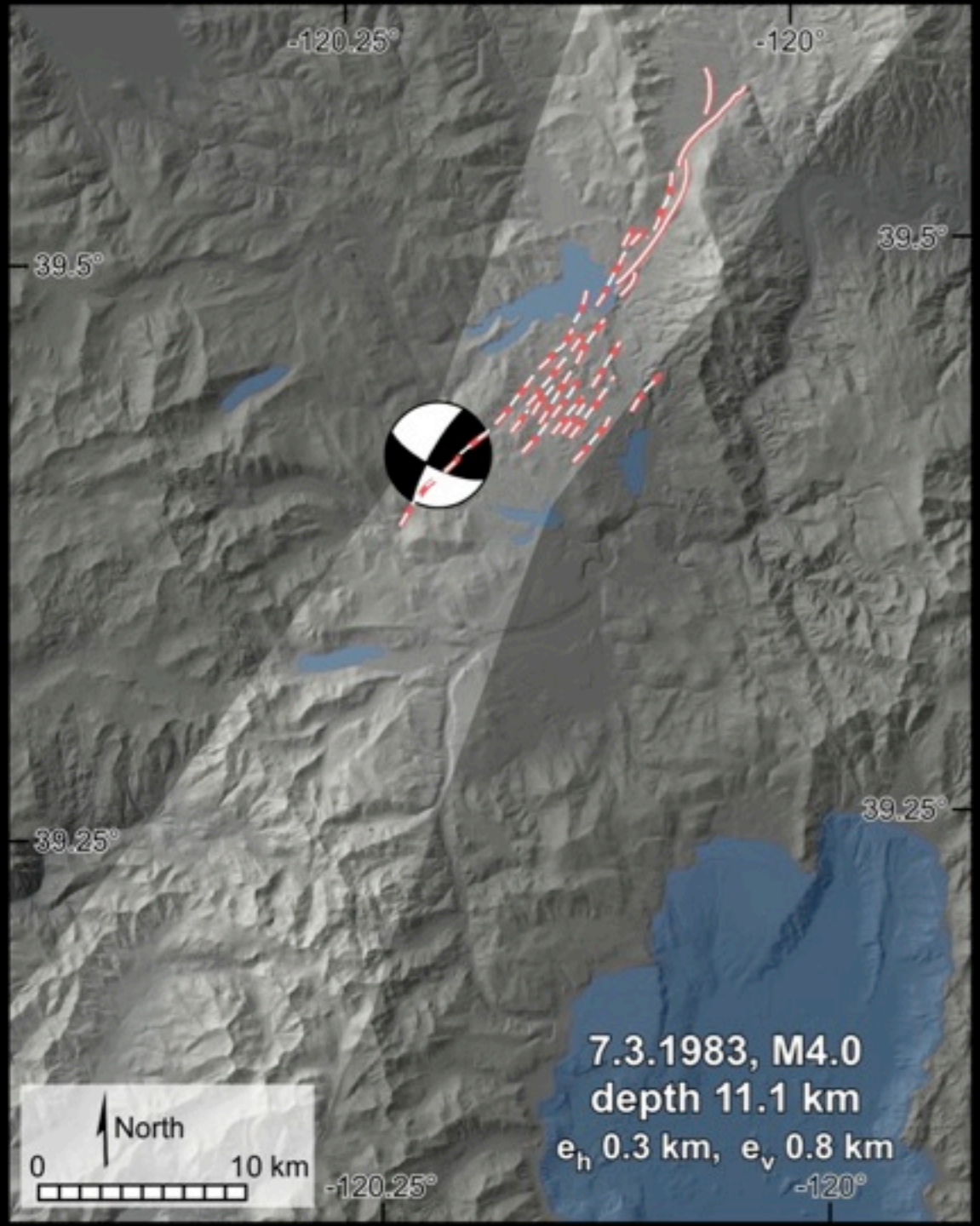
SLAM analysis shows there have been historic earthquakes consistent with displacement along the Polaris Fault.

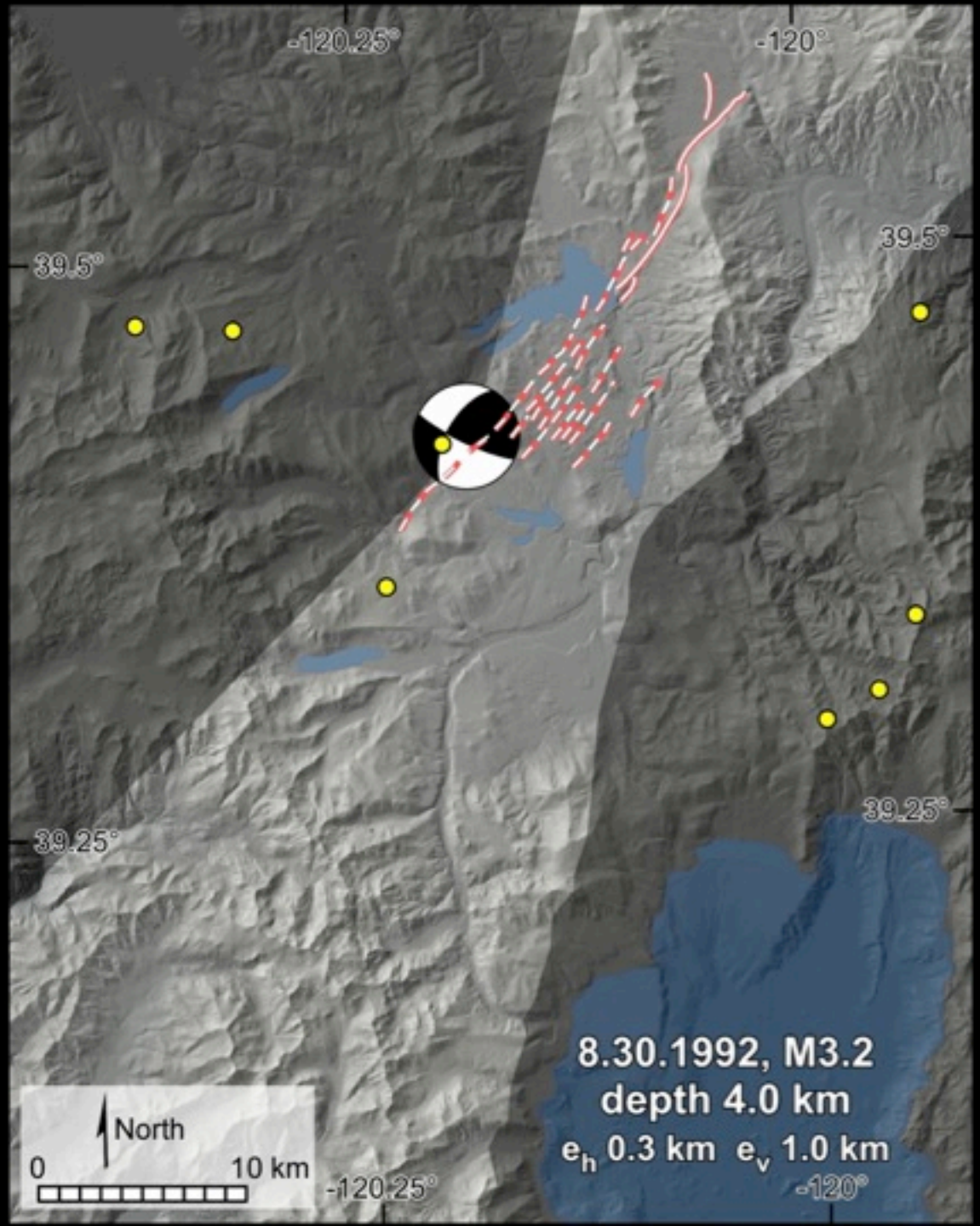
The Polaris Fault extends under and adjacent to Martis Creek Dam and Reservoir.

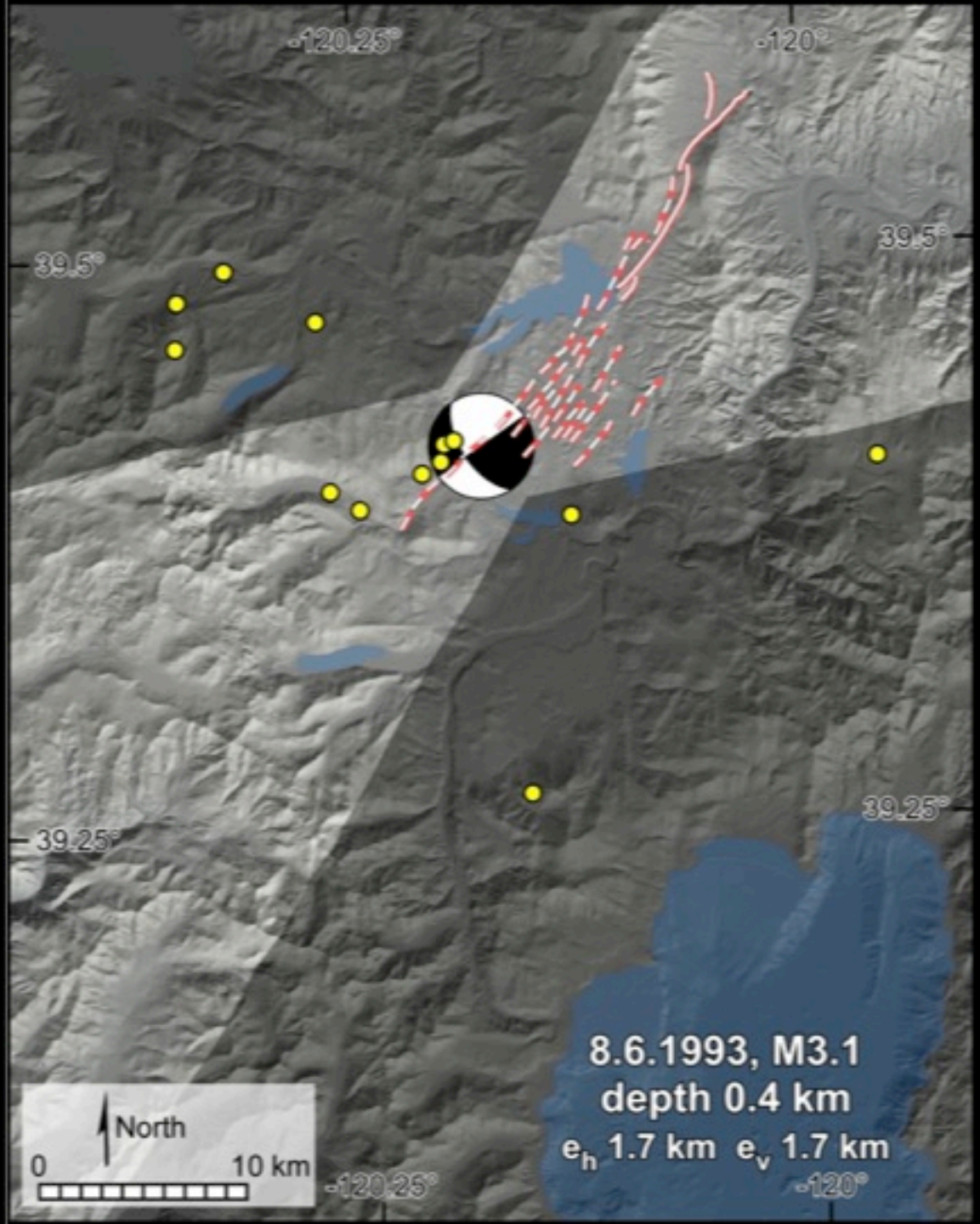
Dog Valley Fault near Truckee, North Tahoe area, California

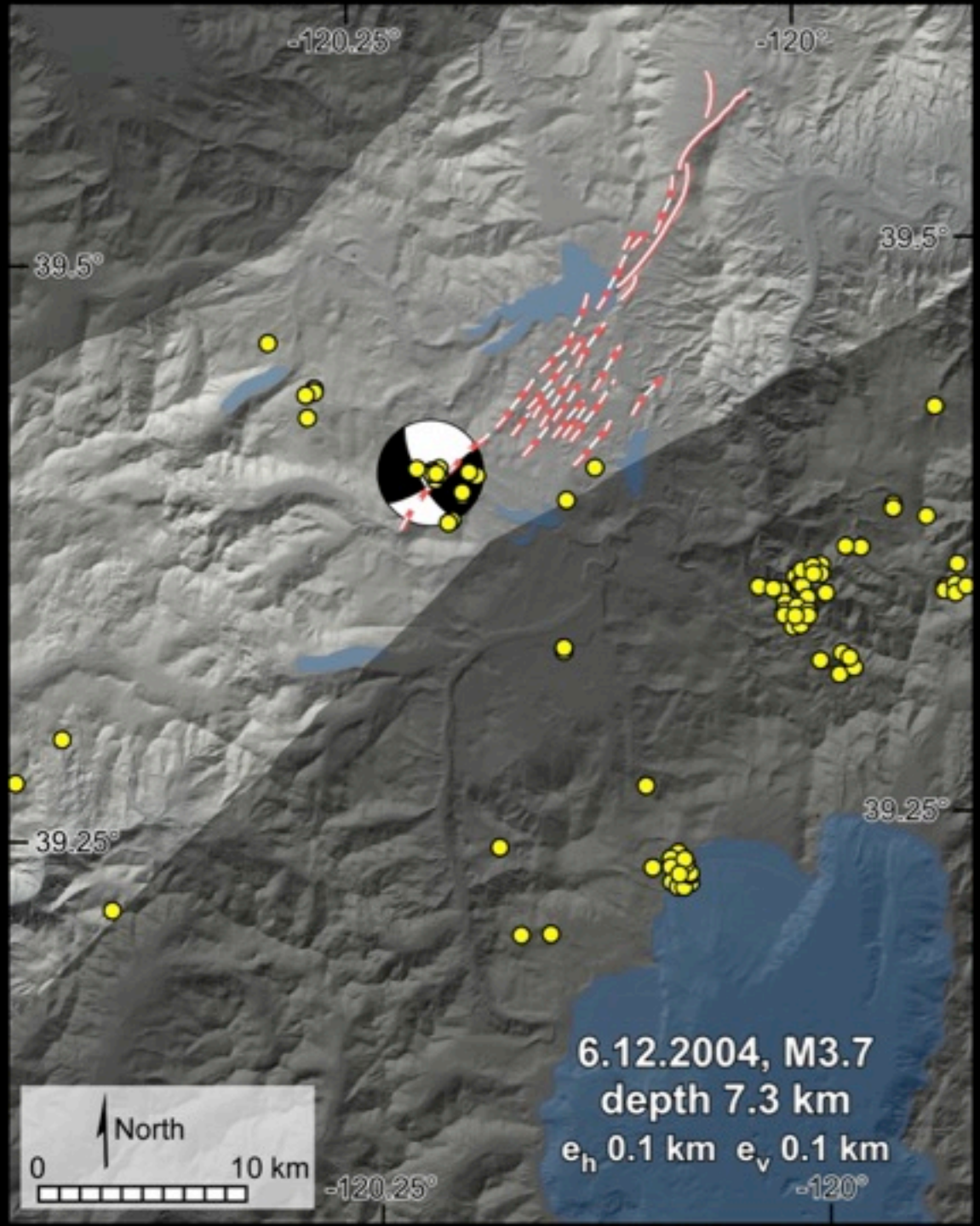
- Generated M_L 6.0 Truckee earthquake of 1966; left-lateral focal mechanism
- Surface trace inferred but not confirmed.

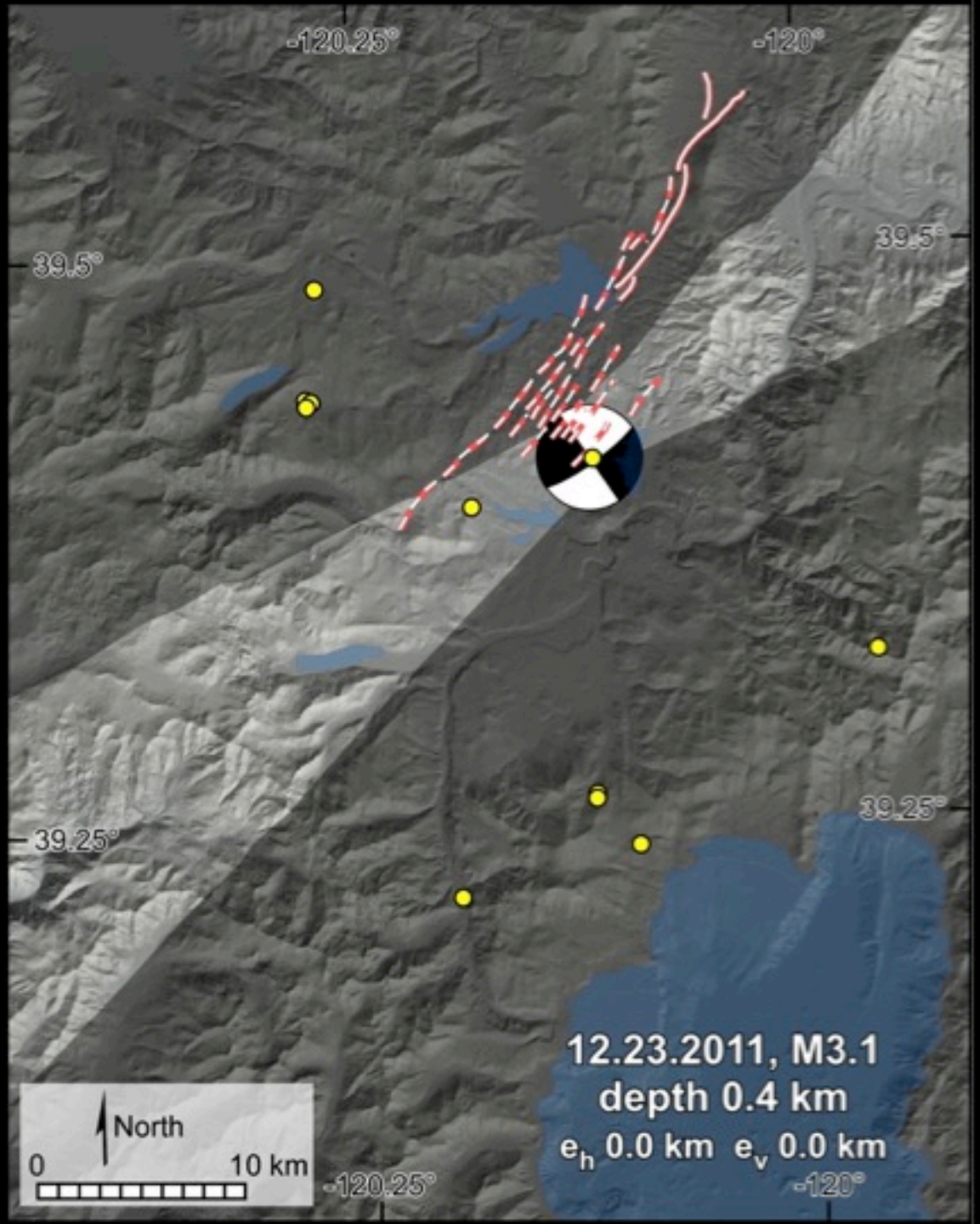

-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
9.12.1966, M6
depth 10 km
e_h 2.5 km e_v 2.5 km
North
0
10 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
North
0
10 km
7.3.1983, M4.0
depth 11.1 km
e_h 0.3 km, e_v 0.8 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
North
0
10 km
8.30.1992, M3.2
depth 4.0 km
e_h 0.3 km e_v 1.0 km
-120.25°
-120°

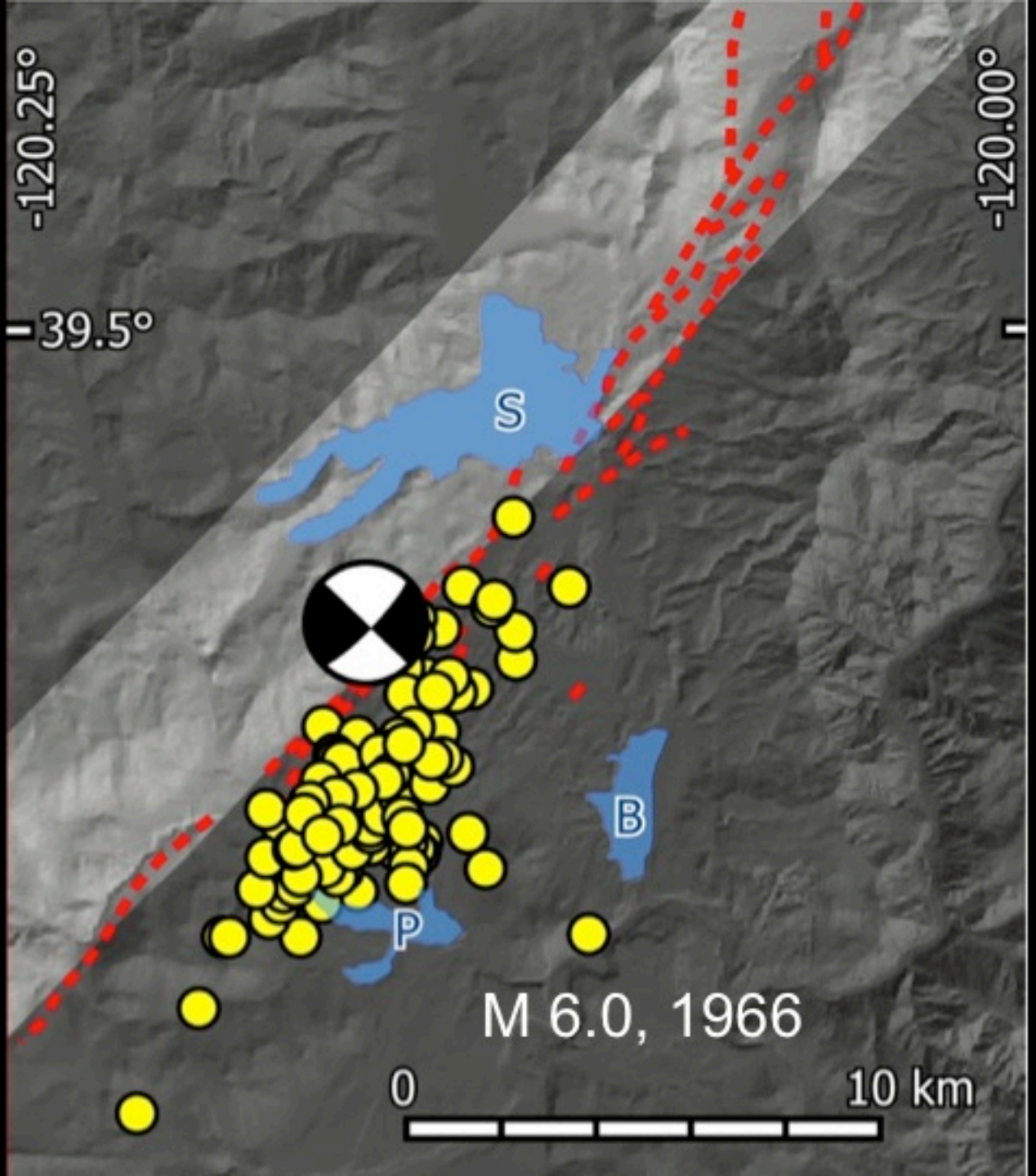

-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
North
0
10 km
8.6.1993, M3.1
depth 0.4 km
e_h 1.7 km e_v 1.7 km
-120.25°
-120°

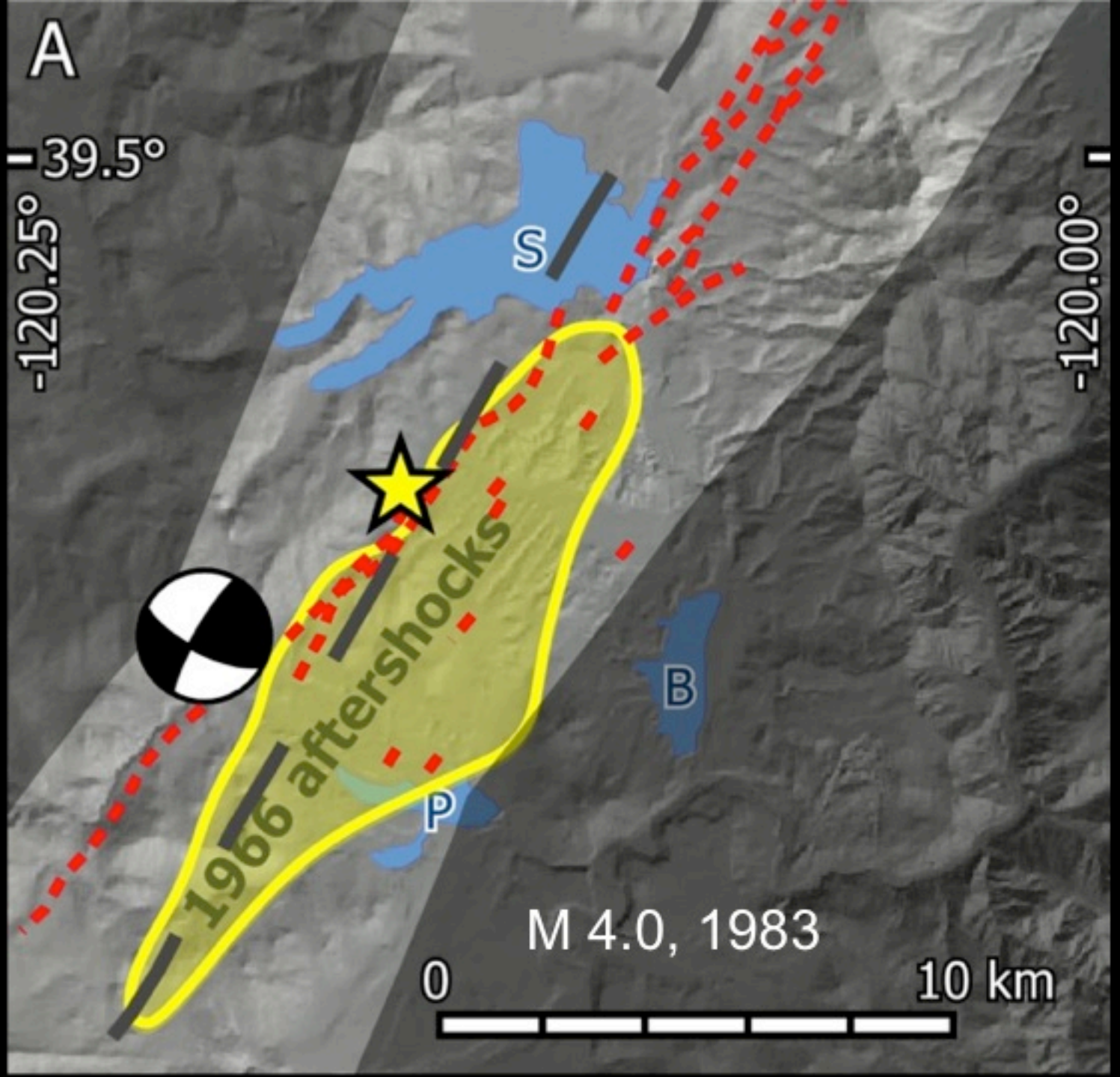

-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
North
0
10 km
6.12.2004, M3.7
depth 7.3 km
e_h 0.1 km e_v 0.1 km
-120.25°
-120°

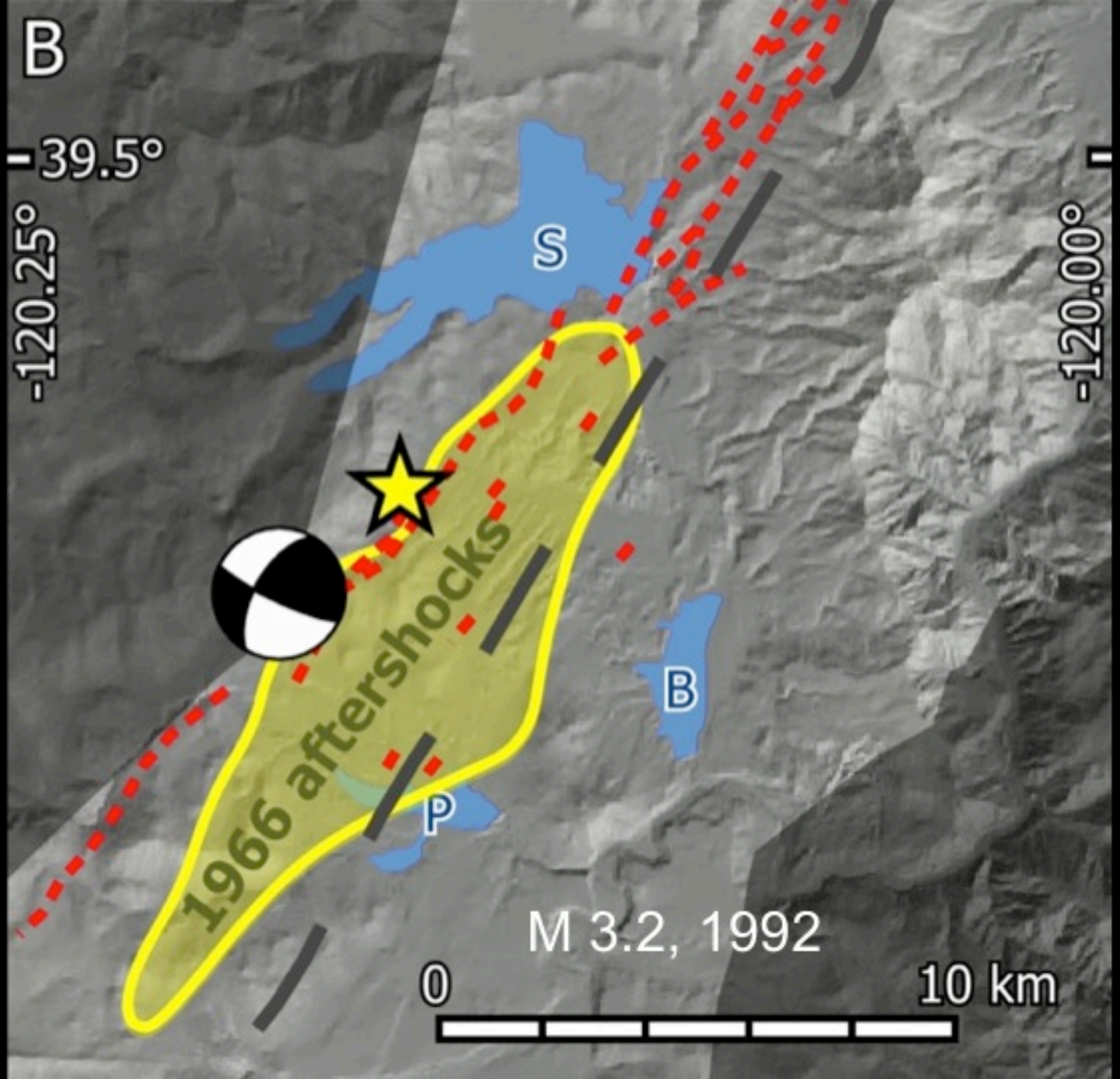

-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
12.23.2011, M3.1
depth 0.4 km
e_h 0.0 km e_v 0.0 km
North
0
10 km
-120.25°
-120°

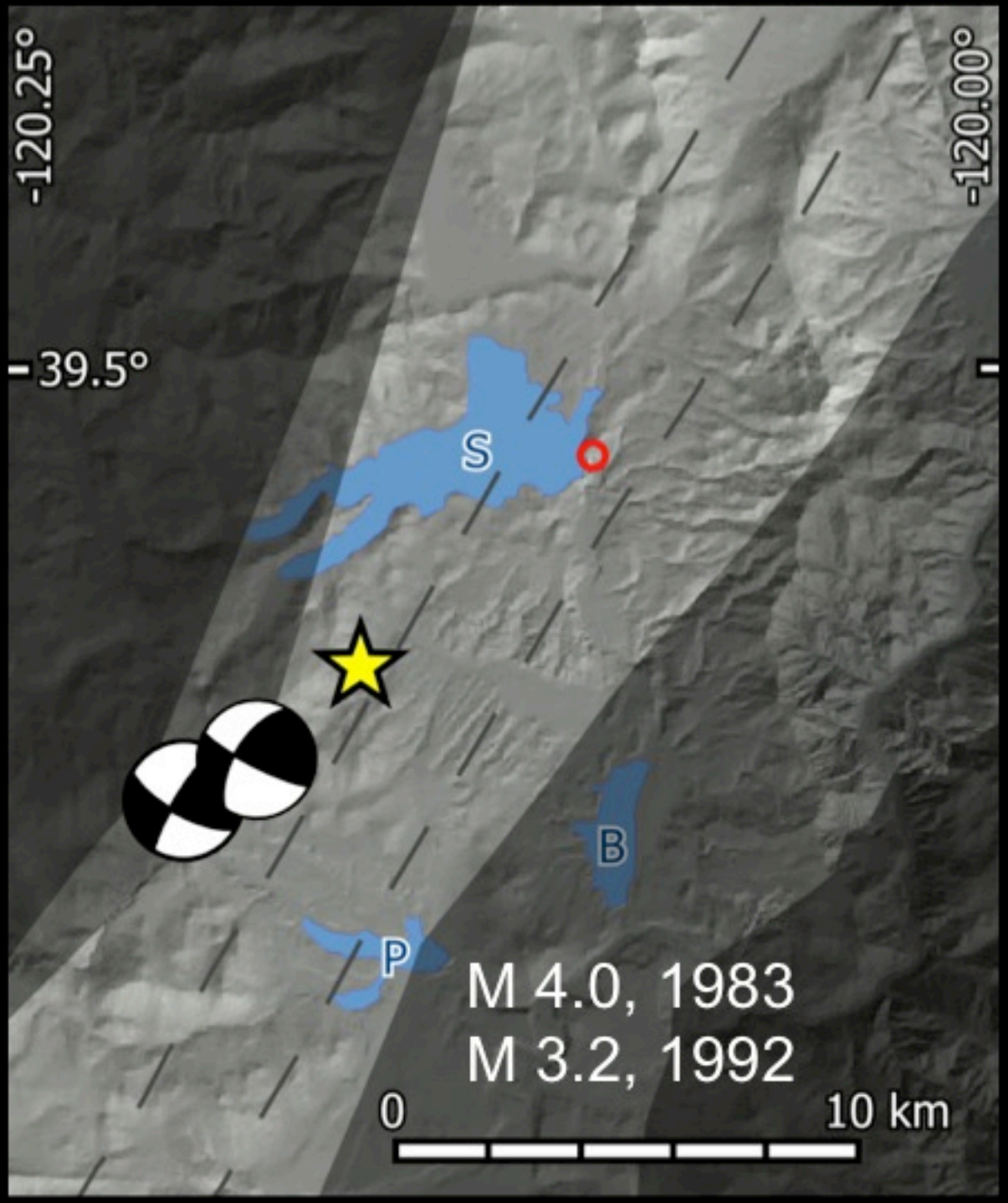
SLAM analysis shows that,
after the M 6.0 Truckee Earthquake
sequence in 1966,
several M 3-4 earthquakes occurred
between 1983 and today that are
consistent with displacement along
the Dog Valley Fault.

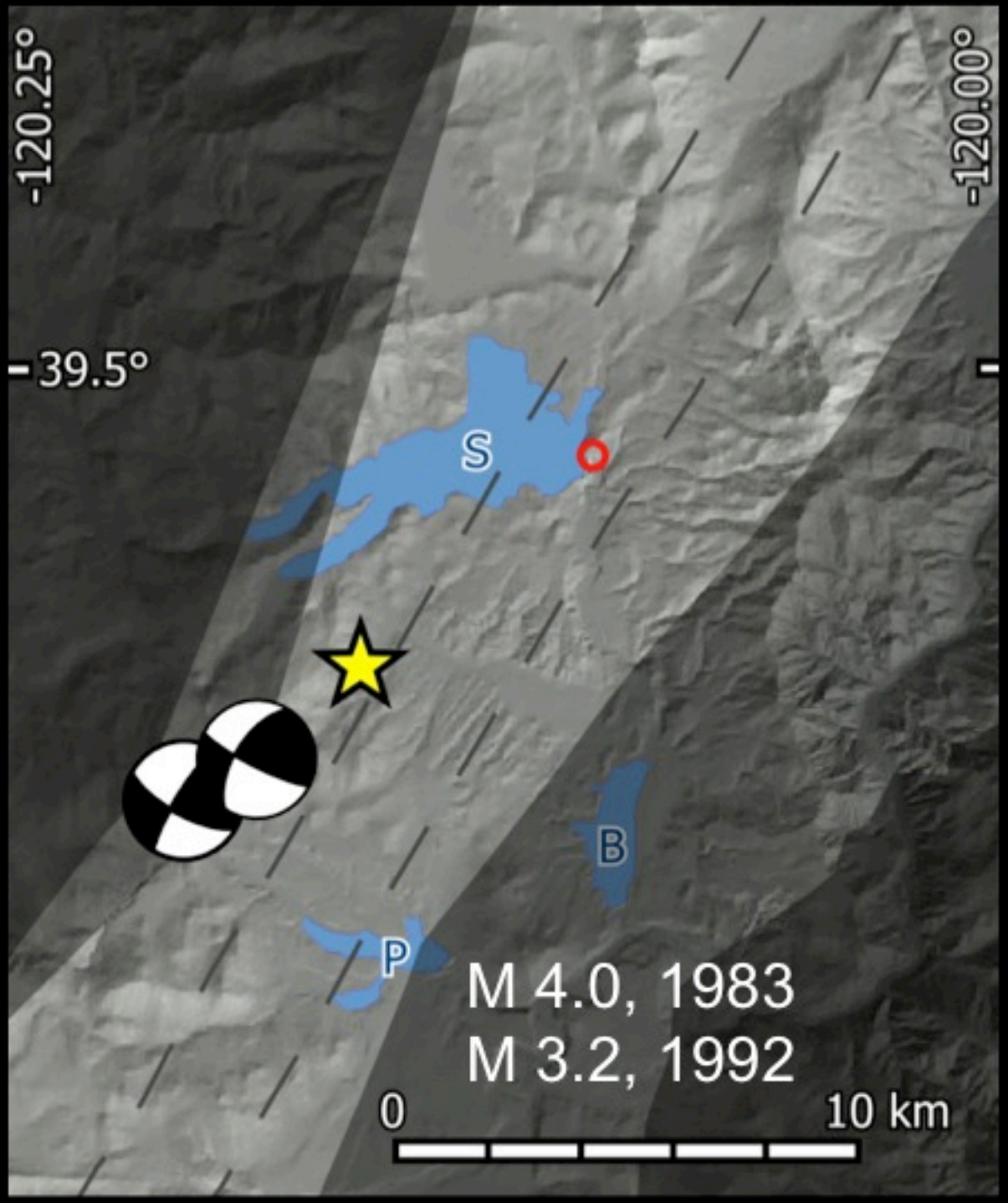
Is the inferred trace of the Dog Valley Fault that is depicted in the Quaternary Fault and Fold Database of the United States accurate?


-120.25°
-120.00°
39.5°
S
B
P
M 6.0, 1966
0
10 km


A
39.5°
-120.25°
-120.00°
S
B
P
1966 aftershocks
M 4.0, 1983
0
10 km


B
39.5°
-120.25°
-120.00°
S
B
P
1966 aftershocks
M 3.2, 1992
0
10 km


-120.25°
-120.00°
39.5°
S
B
P
M 4.0, 1983
M 3.2, 1992
0
10 km


-120.25°
-120.00°
39.5°
S
B
P
M 4.0, 1983
M 3.2, 1992
0
10 km

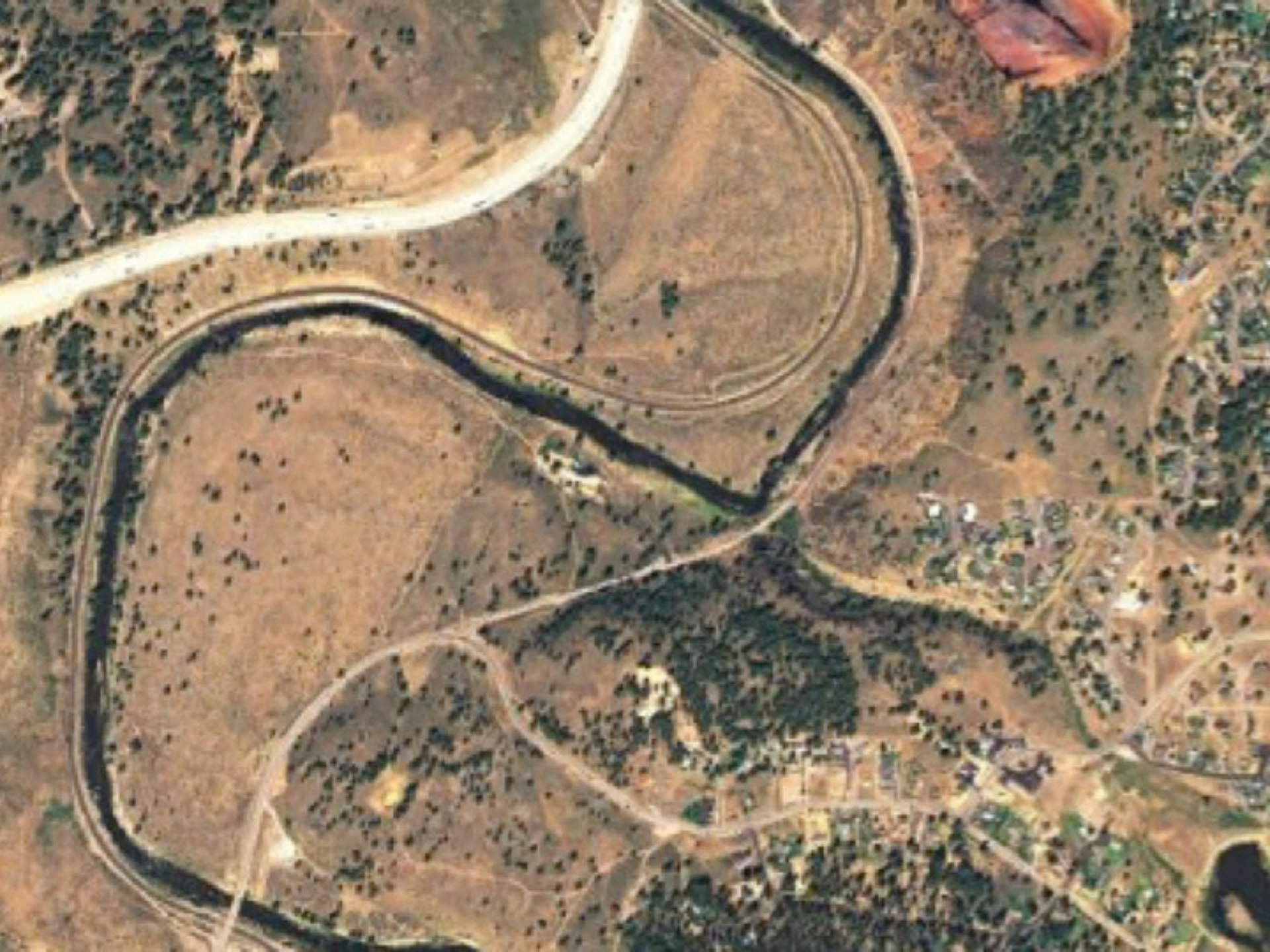
Results from SLAM suggest that the Dog Valley Fault has a different trace than has been inferred in the past,
and that several small-moderate earthquakes have occurred along the DVF since 1966.

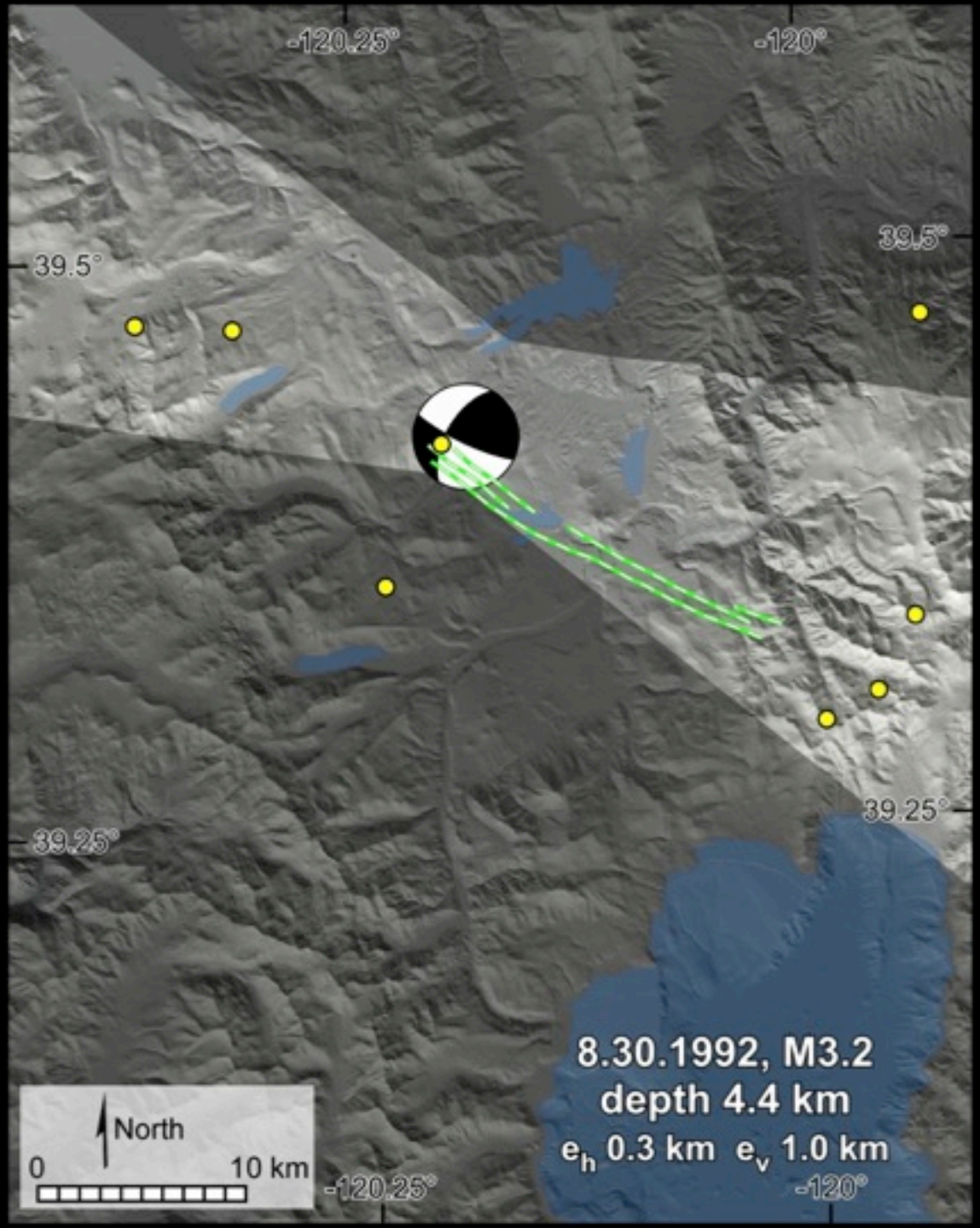
Results from SLAM suggest that the Dog Valley Fault has a different trace than has been inferred in the past, and that several small-moderate earthquakes have occurred along the DVF since 1966.

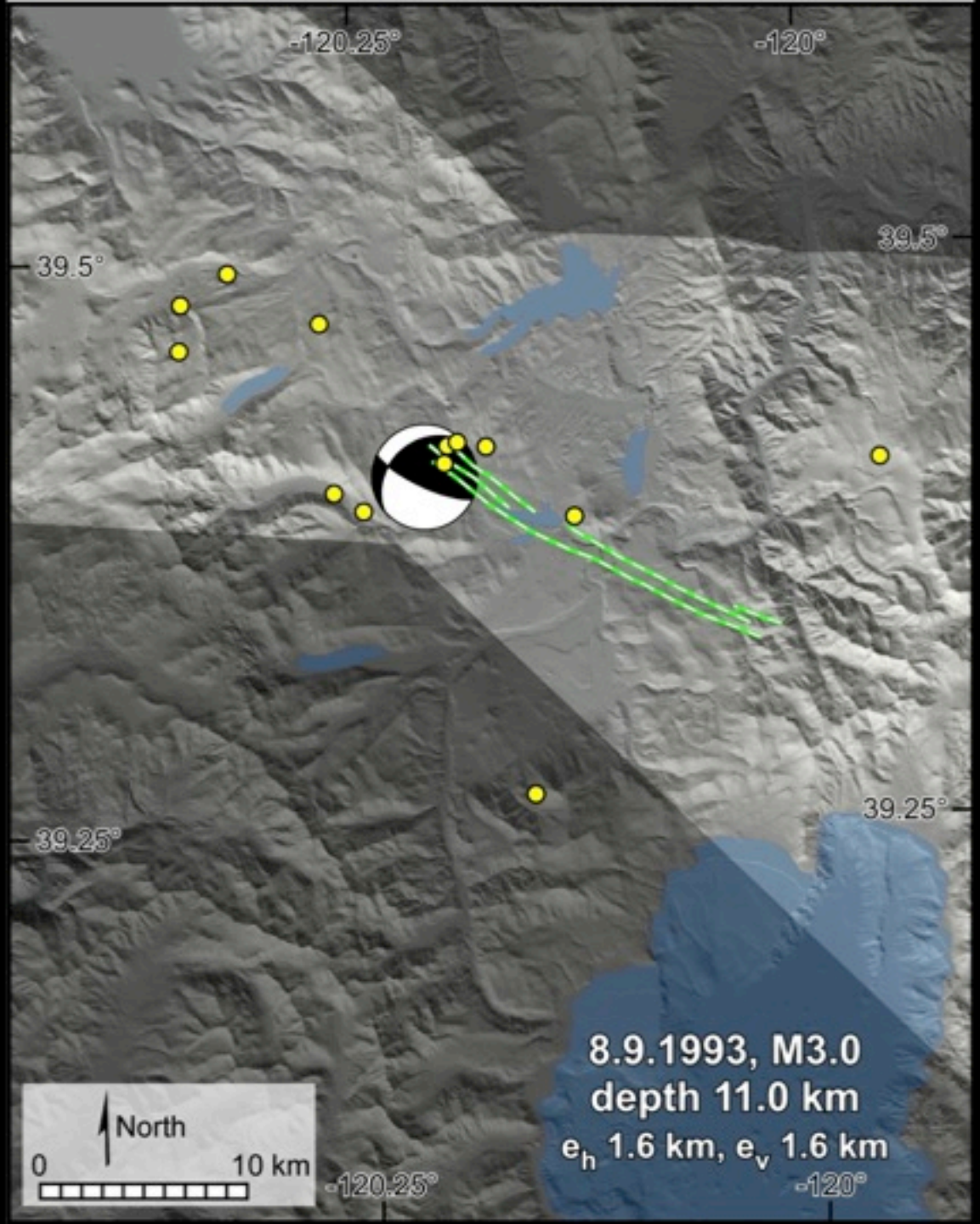
The DVF extends under Stampede Dam and Reservoir.

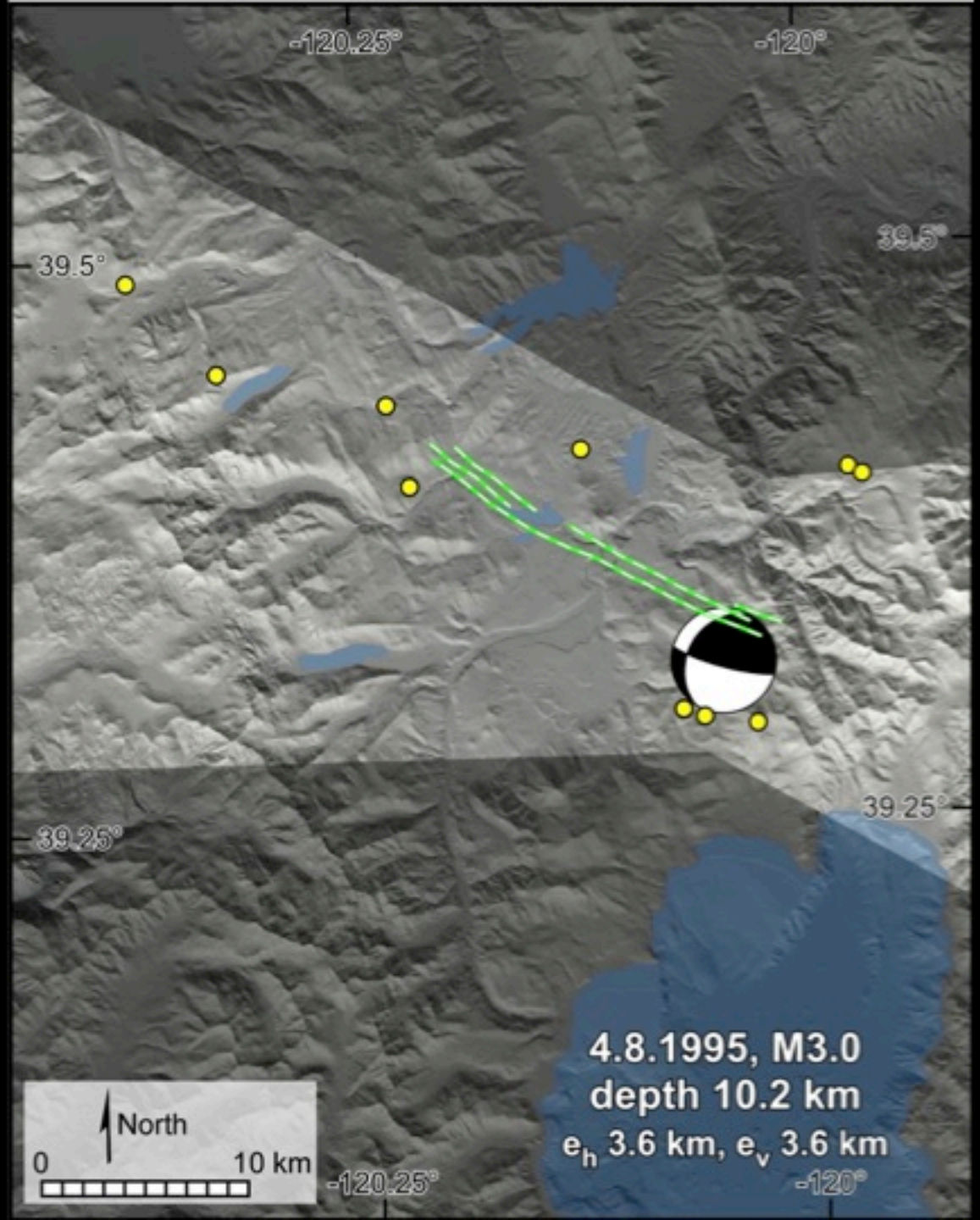
SLAM applied to earthquakes that have not been associated with any known faults

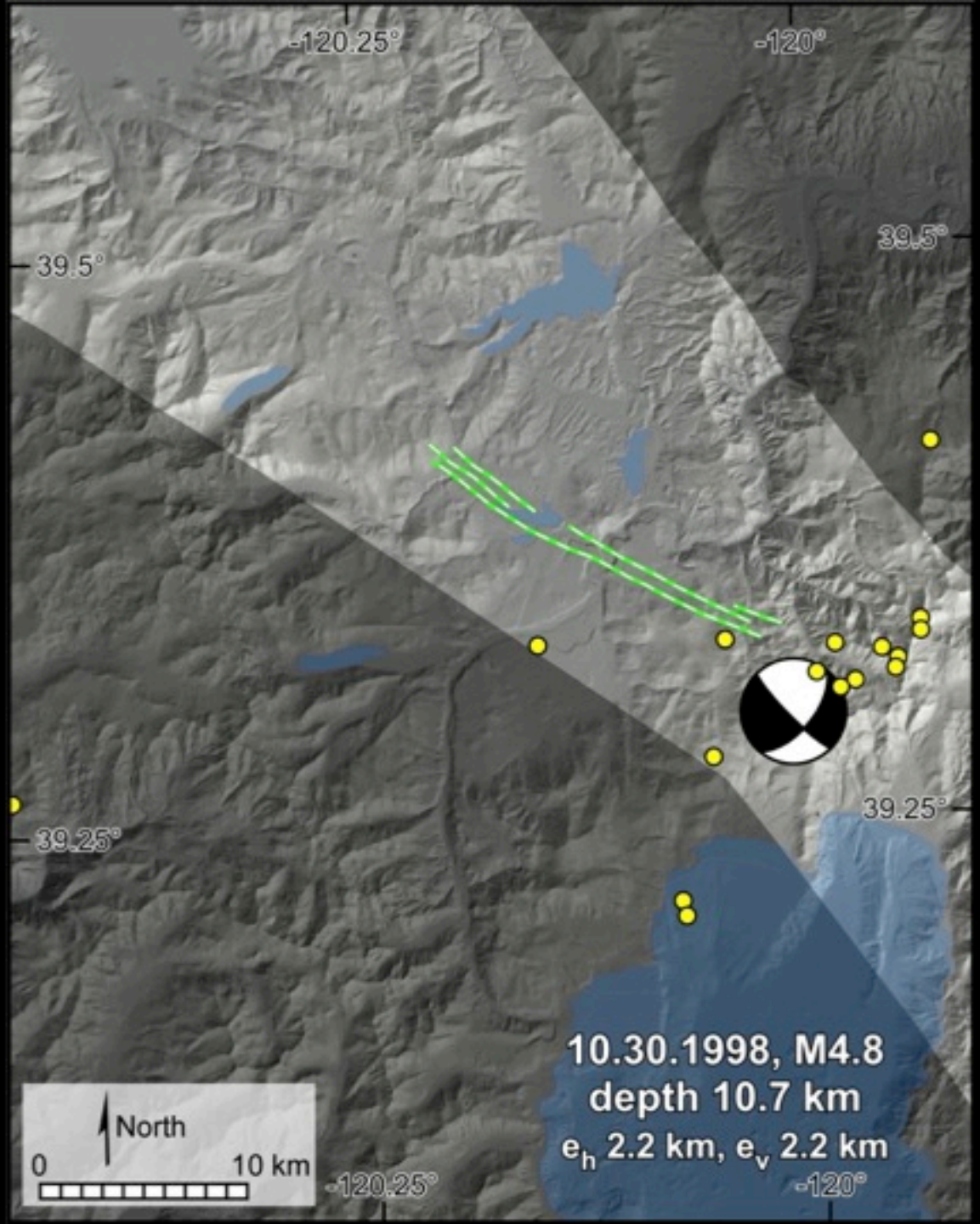
Prosser Creek Trend near Truckee, North Tahoe area, California

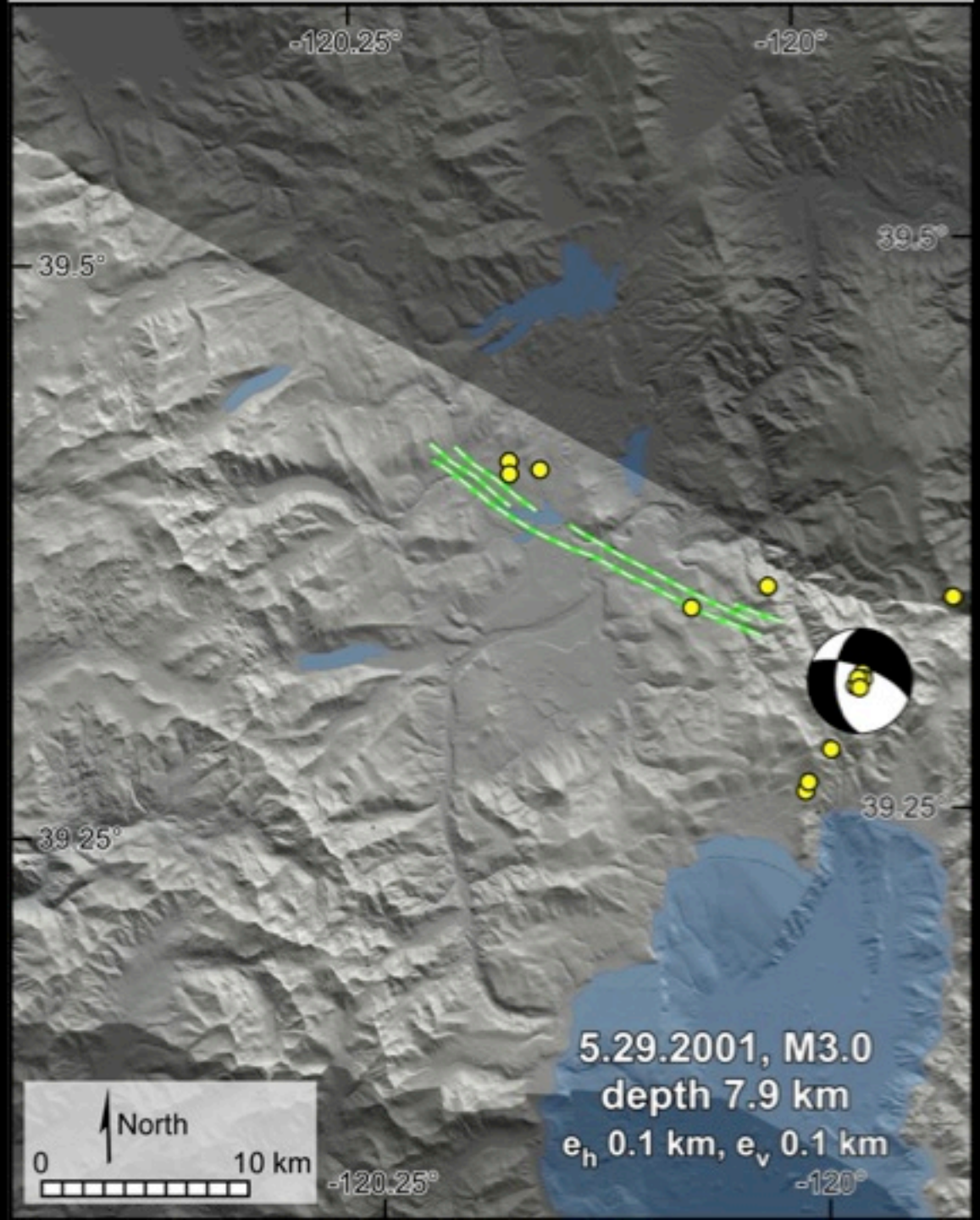


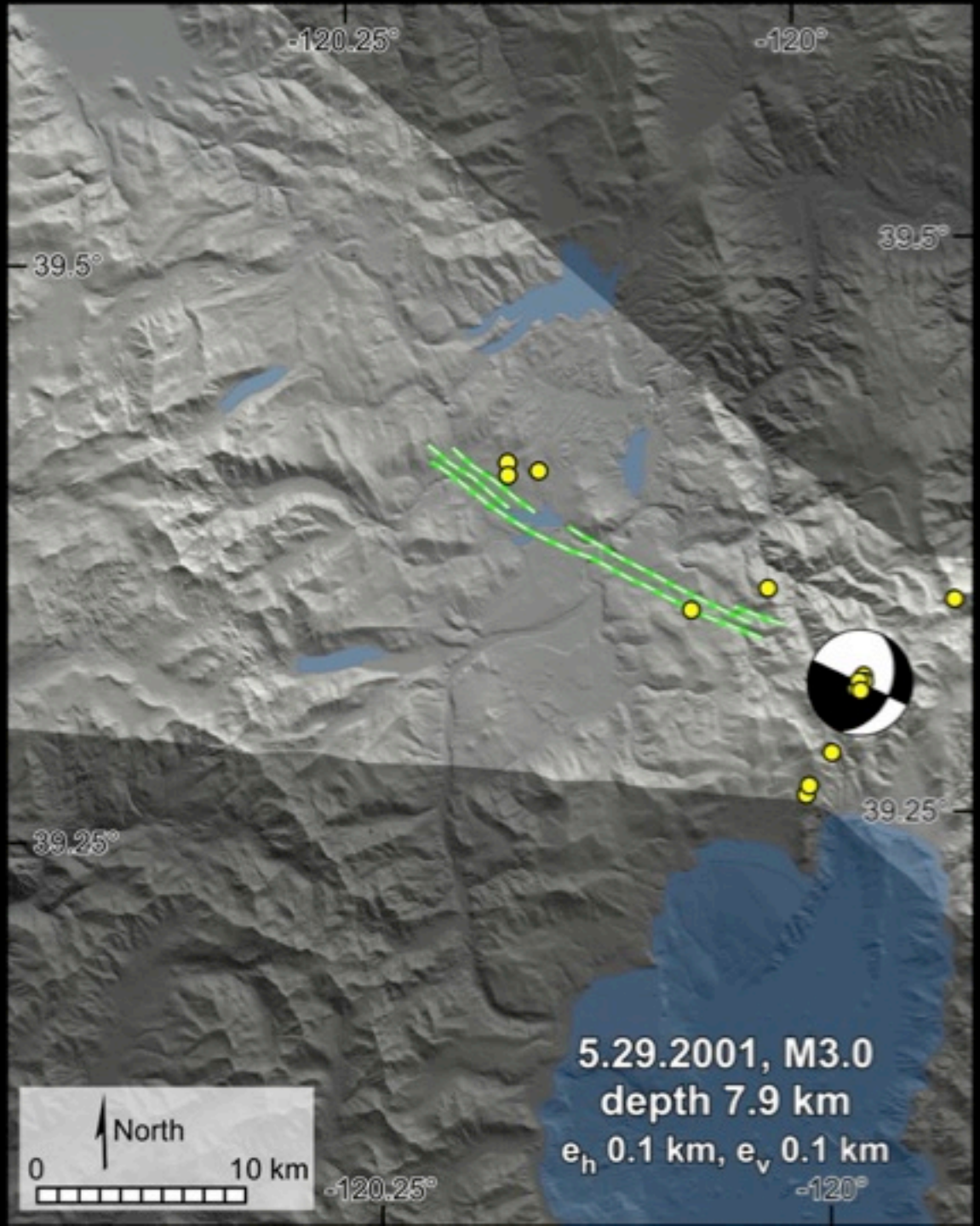

-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
North
0
10 km
8.30.1992, M3.2
depth 4.4 km
e_h 0.3 km e_v 1.0 km
-120.25°
-120°

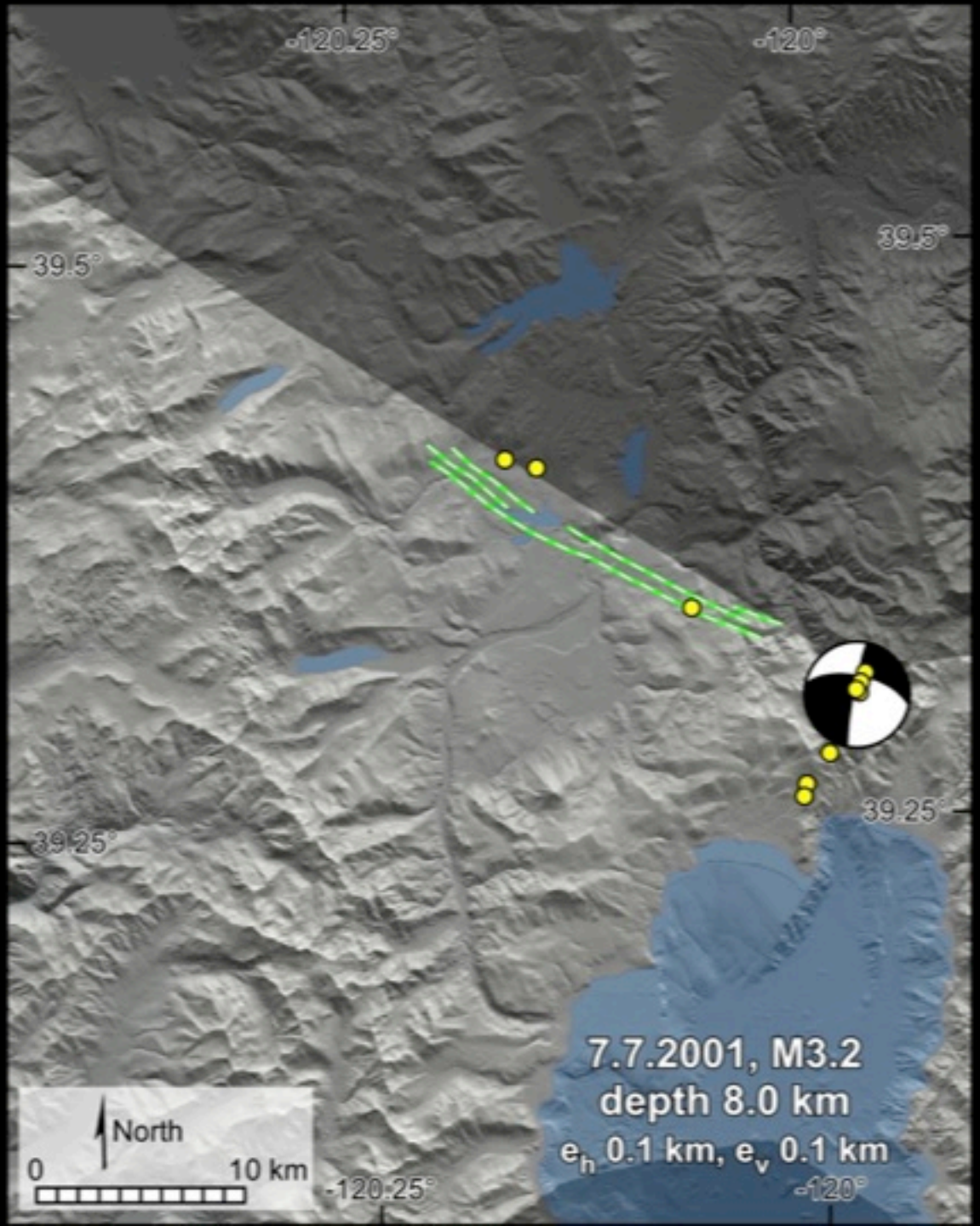

-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
North
0
10 km
8.9.1993, M3.0
depth 11.0 km
e_h 1.6 km, e_v 1.6 km
-120.25°
-120°

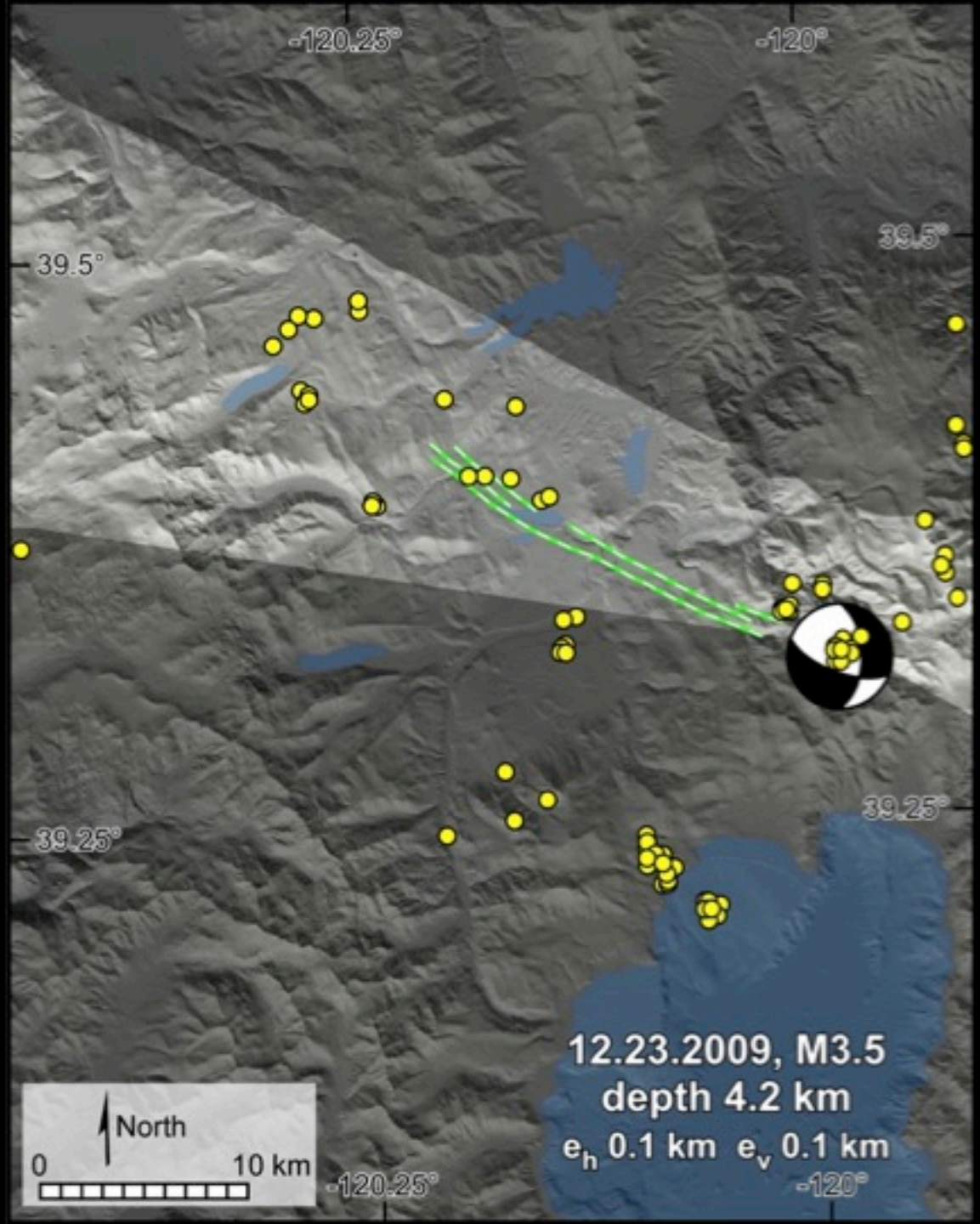

-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
4.8.1995, M3.0
depth 10.2 km
e_h 3.6 km, e_v 3.6 km
North
0
10 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
10.30.1998, M4.8
depth 10.7 km
e_h 2.2 km, e_v 2.2 km
North
0
10 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
North
0
10 km
5.29.2001, M3.0
depth 7.9 km
e_h 0.1 km, e_v 0.1 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
5.29.2001, M3.0
depth 7.9 km
e_h 0.1 km, e_v 0.1 km
North
0
10 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
7.7.2001, M3.2
depth 8.0 km
e_h 0.1 km, e_v 0.1 km
North
0
10 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
12.23.2009, M3.5
depth 4.2 km
e_h 0.1 km e_v 0.1 km
North
0
10 km
-120.25°
-120°

SLAM results suggest that the Prosser Creek Trend might be a right-lateral fault that has generated historic earthquakes.

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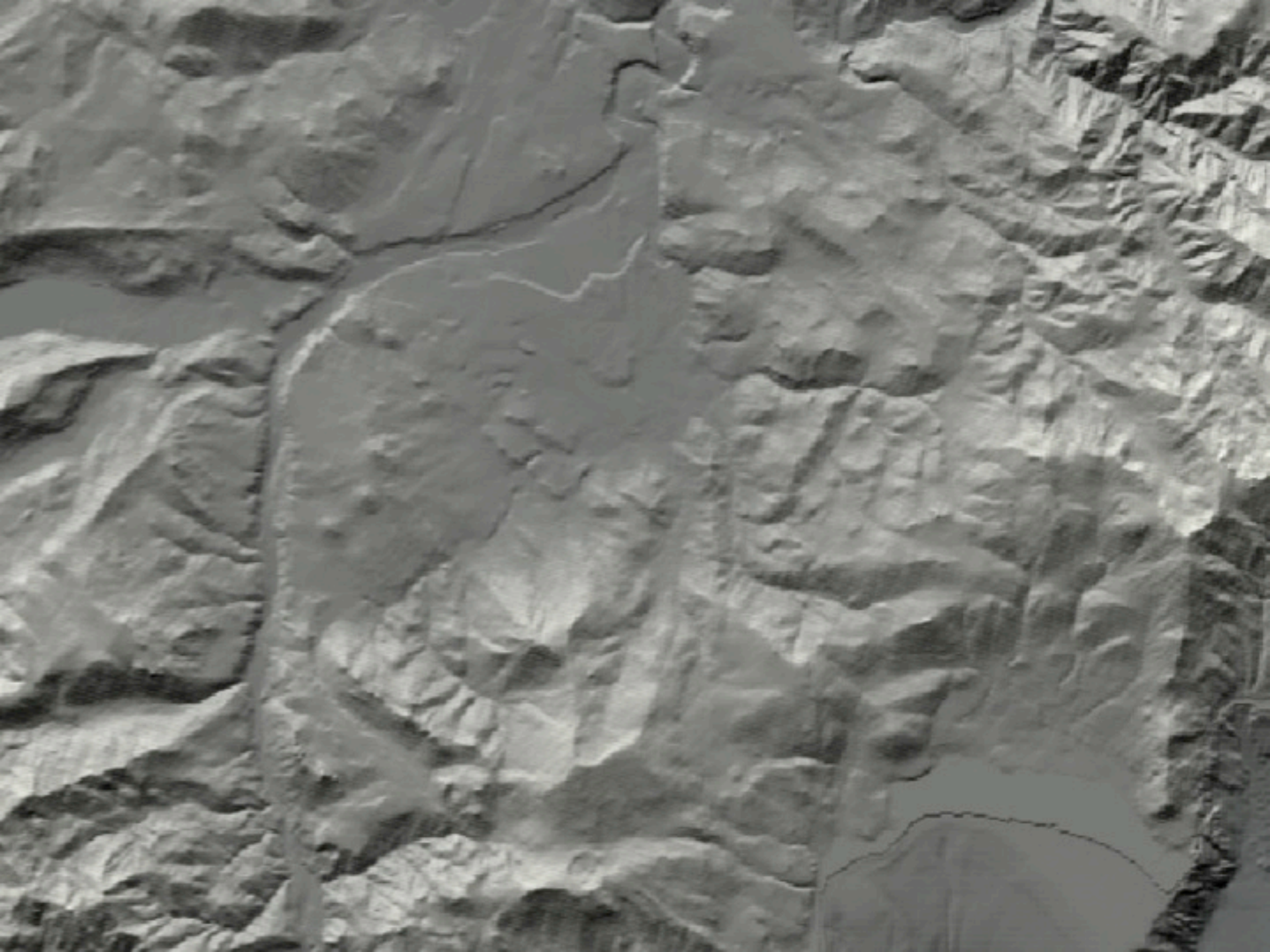
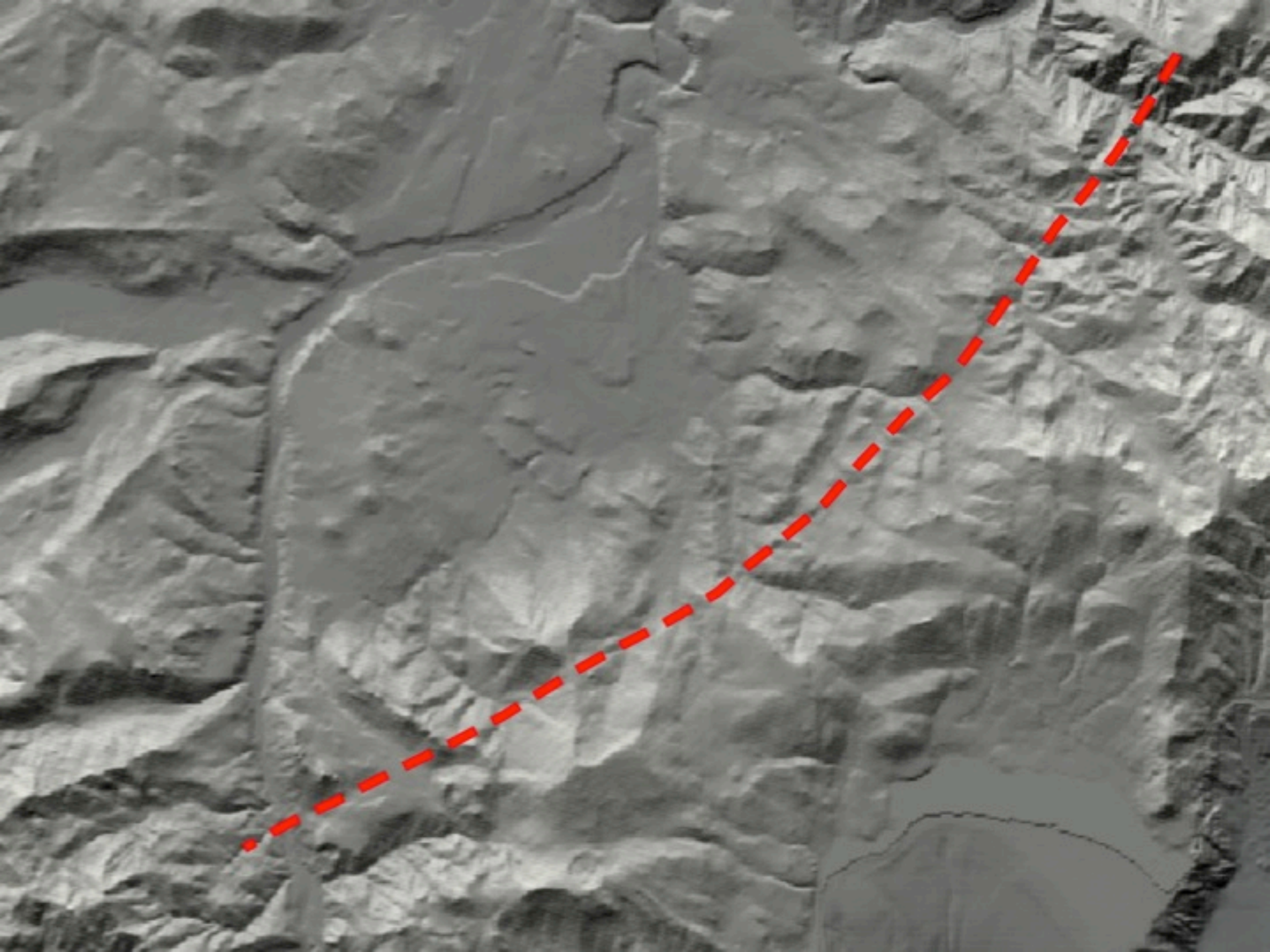
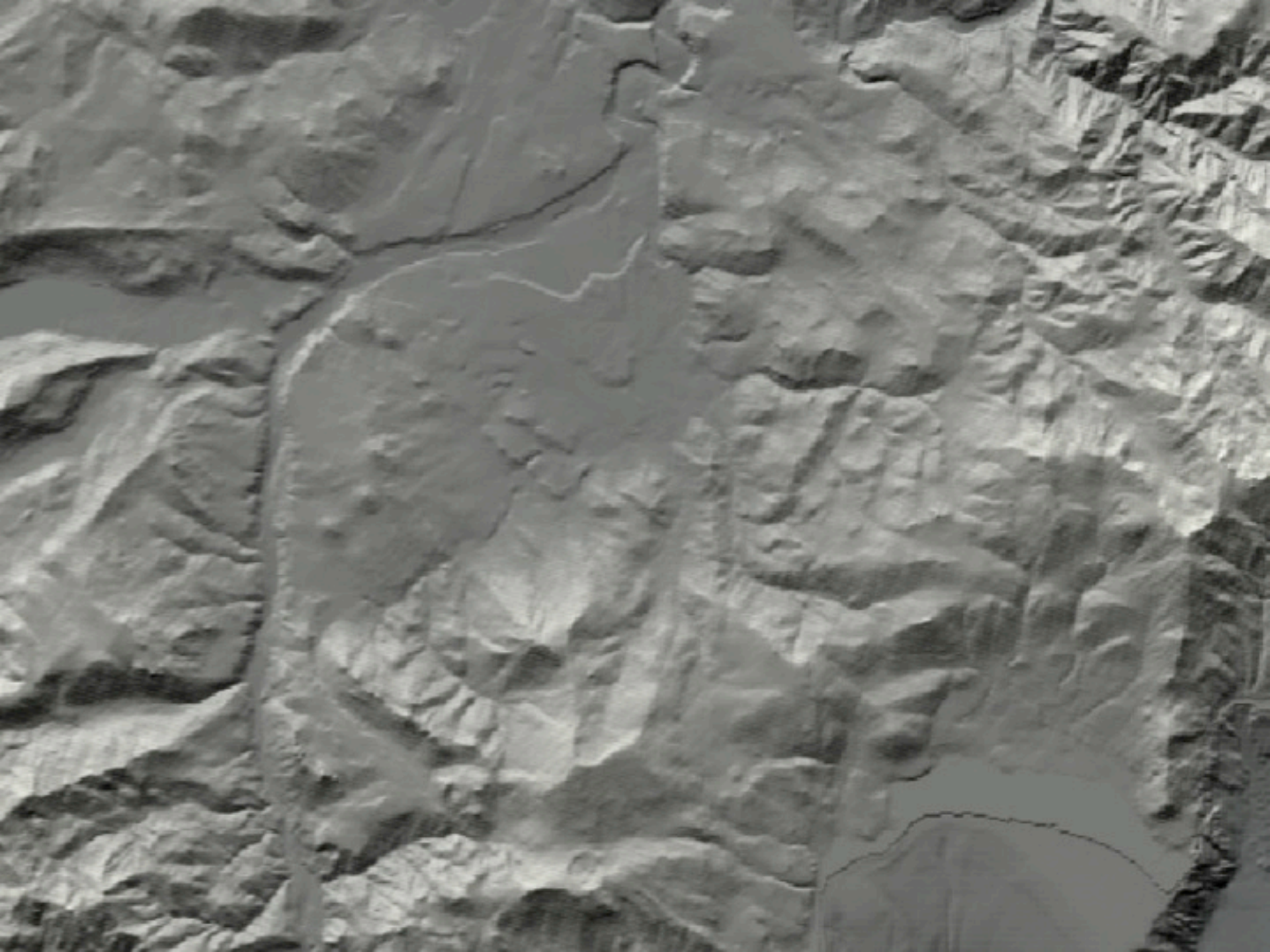
The Prosser Creek Trend extends under Prosser Creek Dam and Reservoir.

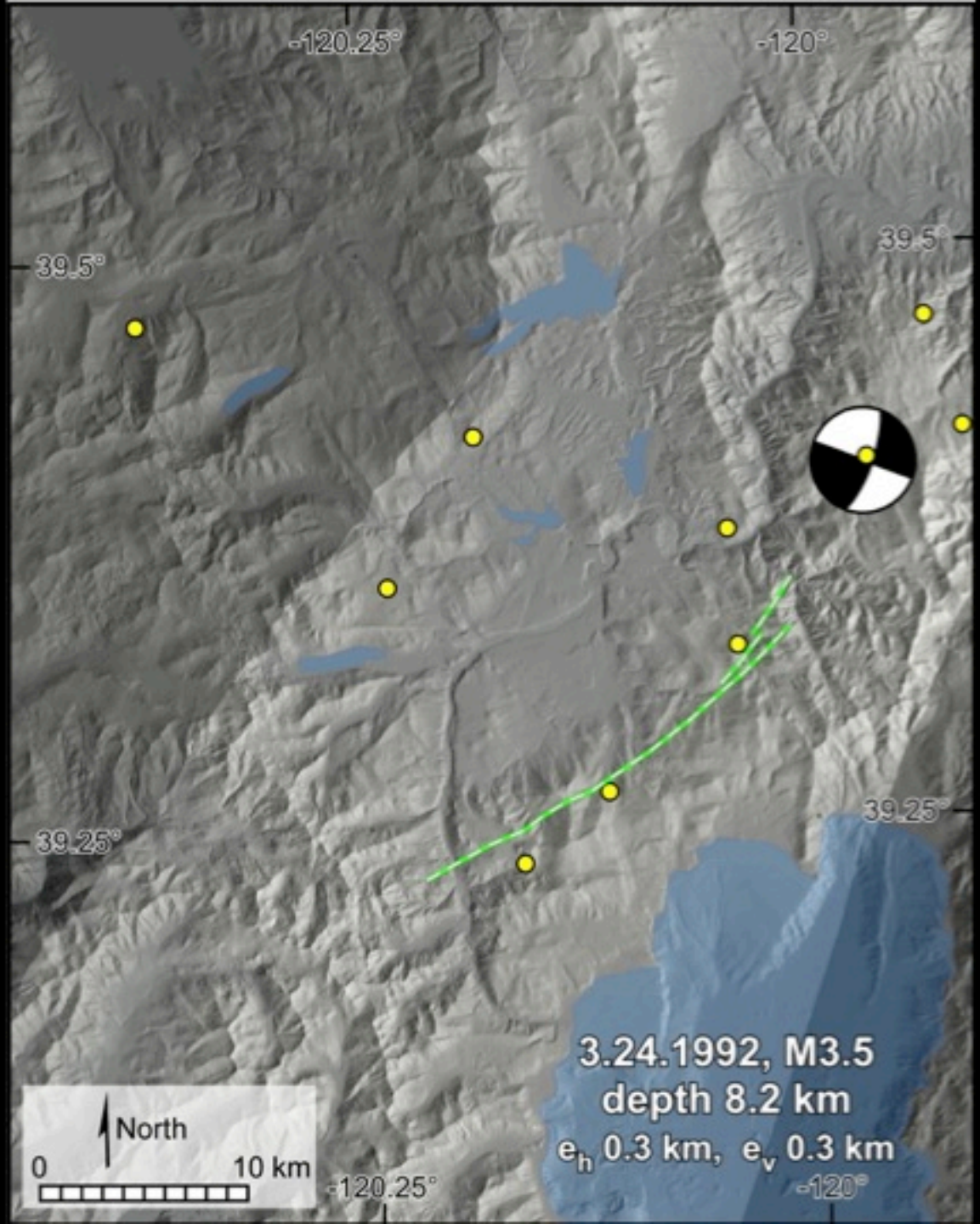
SLAM applied to earthquakes that have not been associated with any known faults

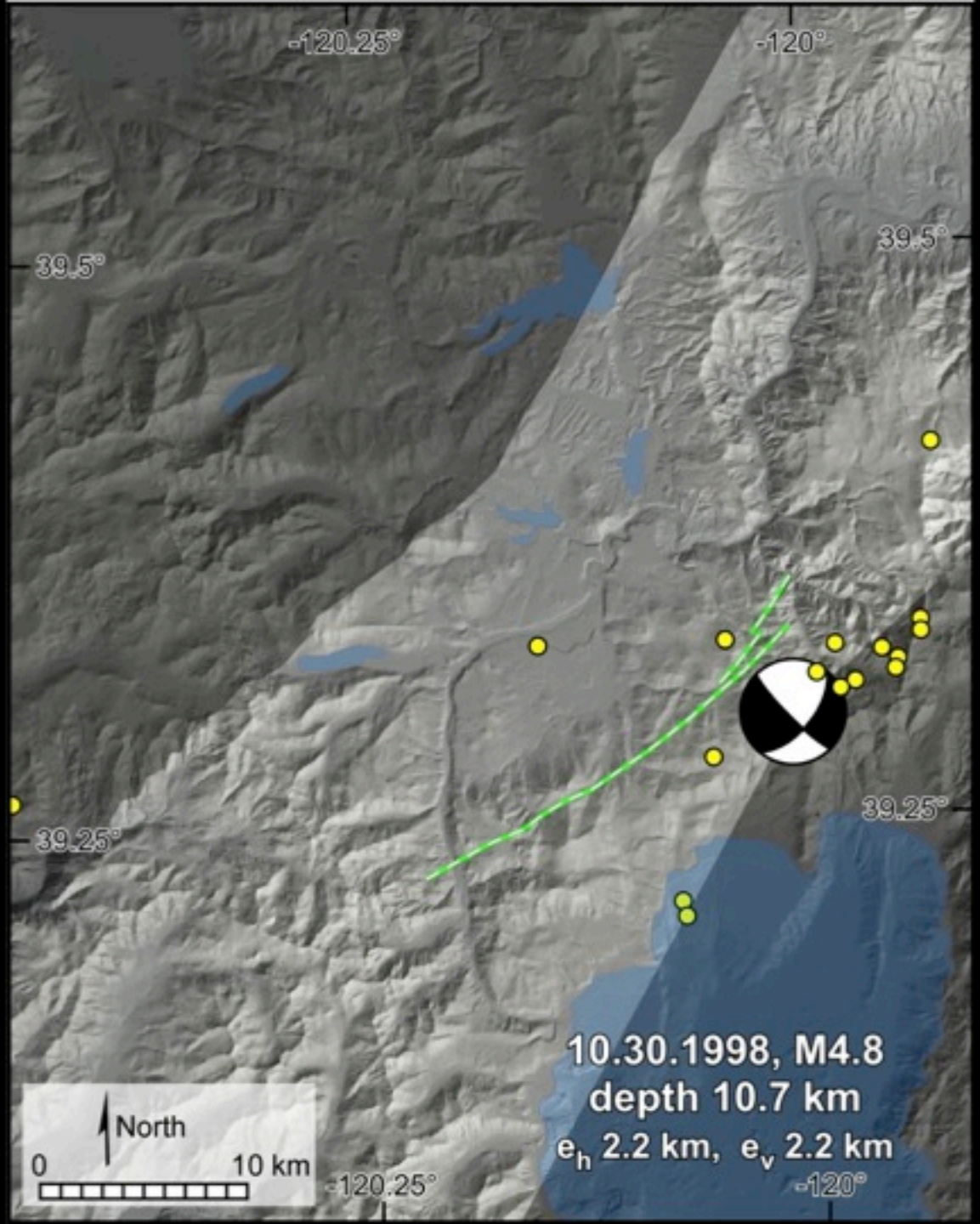
Martis Creek Trend near Truckee, North Tahoe area, California

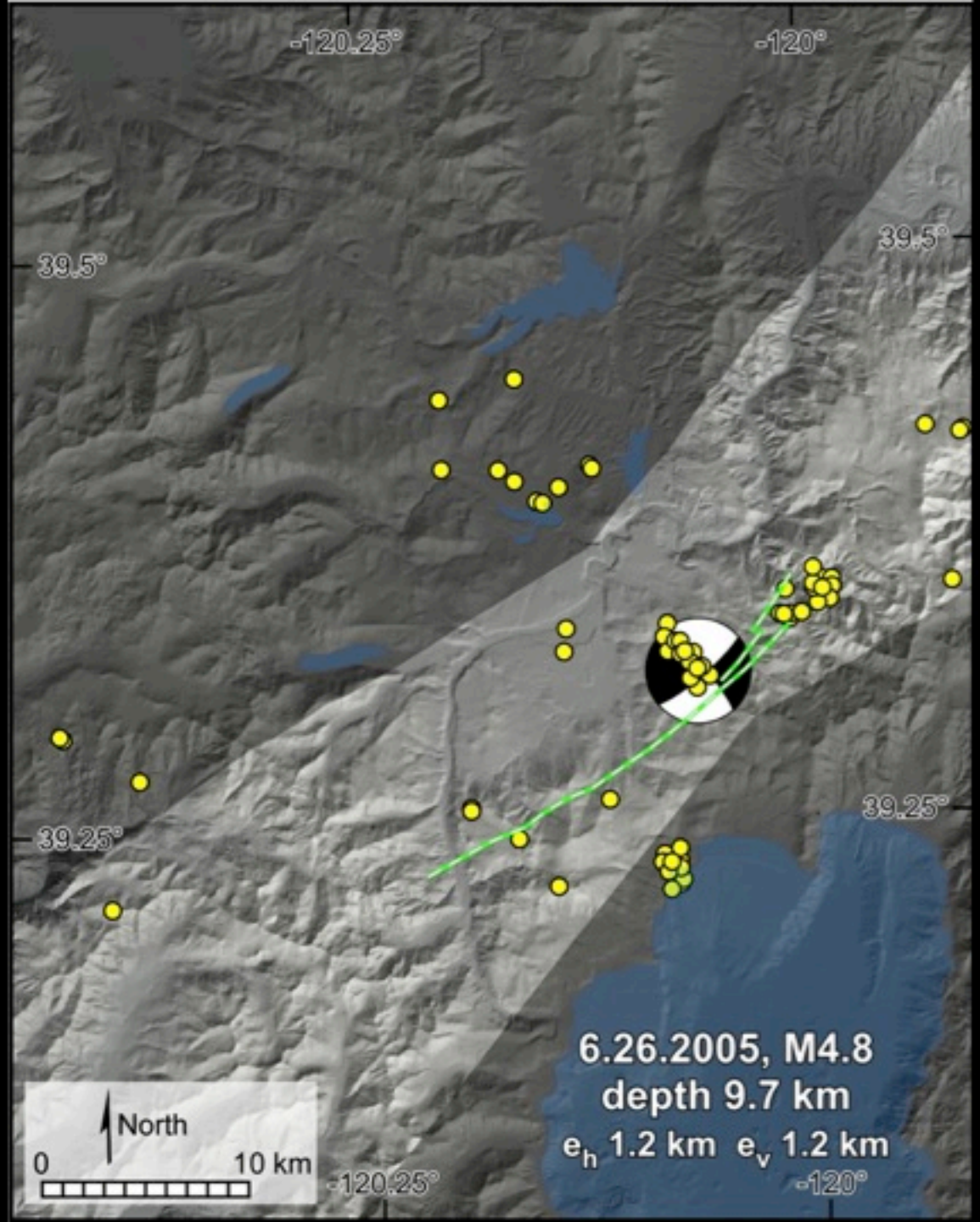


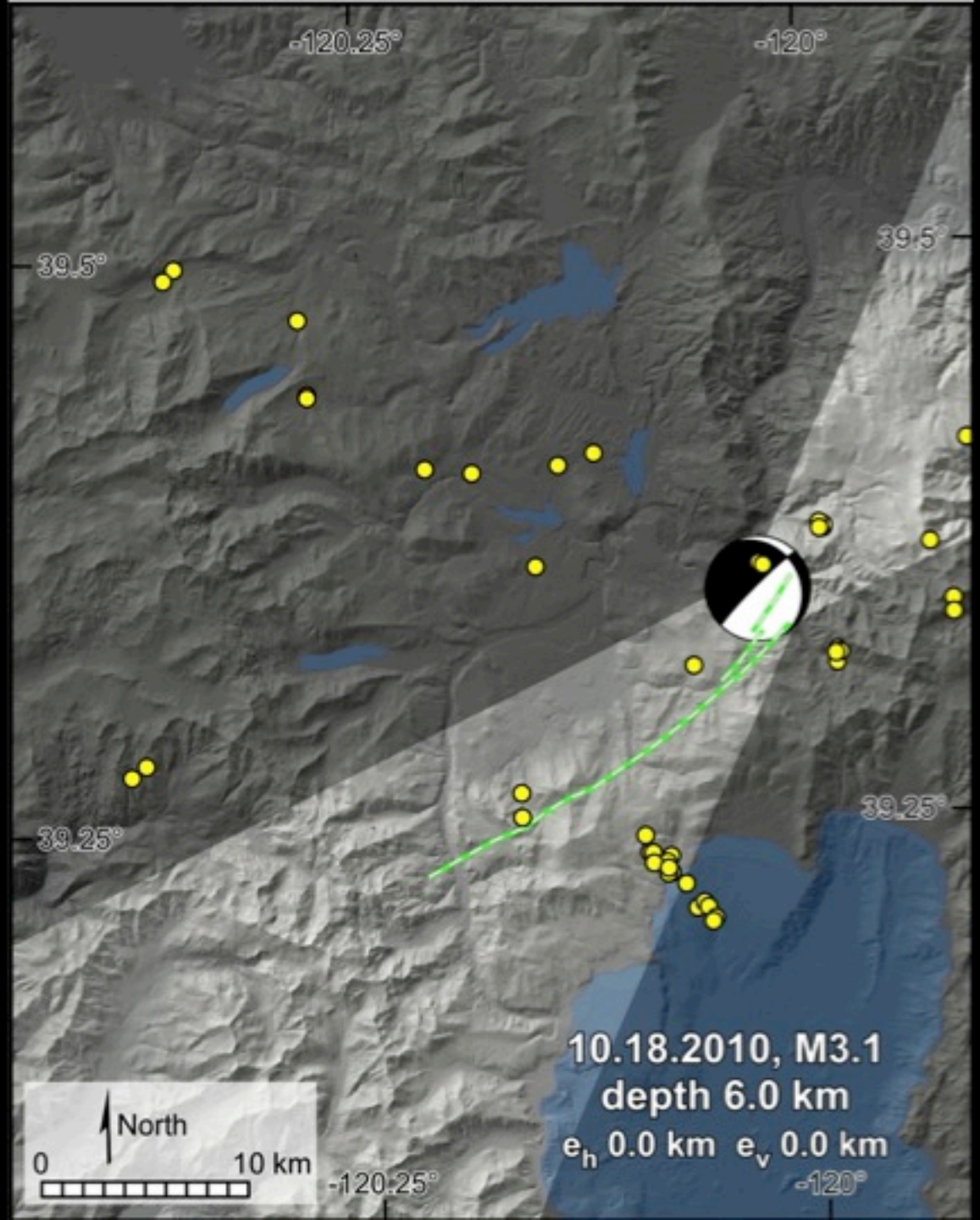





-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
-120.25°
-120°
North
0
10 km
3.24.1992, M3.5
depth 8.2 km
e_h 0.3 km, e_v 0.3 km


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
10.30.1998, M4.8
depth 10.7 km
e_h 2.2 km, e_v 2.2 km
North
0
10 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
North
0
10 km
6.26.2005, M4.8
depth 9.7 km
e_h 1.2 km e_v 1.2 km
-120.25°
-120°


-120.25°
-120°
39.5°
39.5°
39.25°
39.25°
10.18.2010, M3.1
depth 6.0 km
e_h 0.0 km e_v 0.0 km
North
0
10 km
-120.25°
-120°

SLAM results suggest that the Martis Creek Trend might be a left-oblique fault that has generated historic earthquakes.

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The Martis Creek Trend extends through the NorthStar development and is near the towns of Truckee, Tahoe City, and Incline Village.

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- SLAM is only useful for shallow-focus earthquakes (<~30 km depth).
- SLAM is unlikely to be helpful for very gently inclined faults.
- The quality of the seismic data used as input to SLAM is very important.