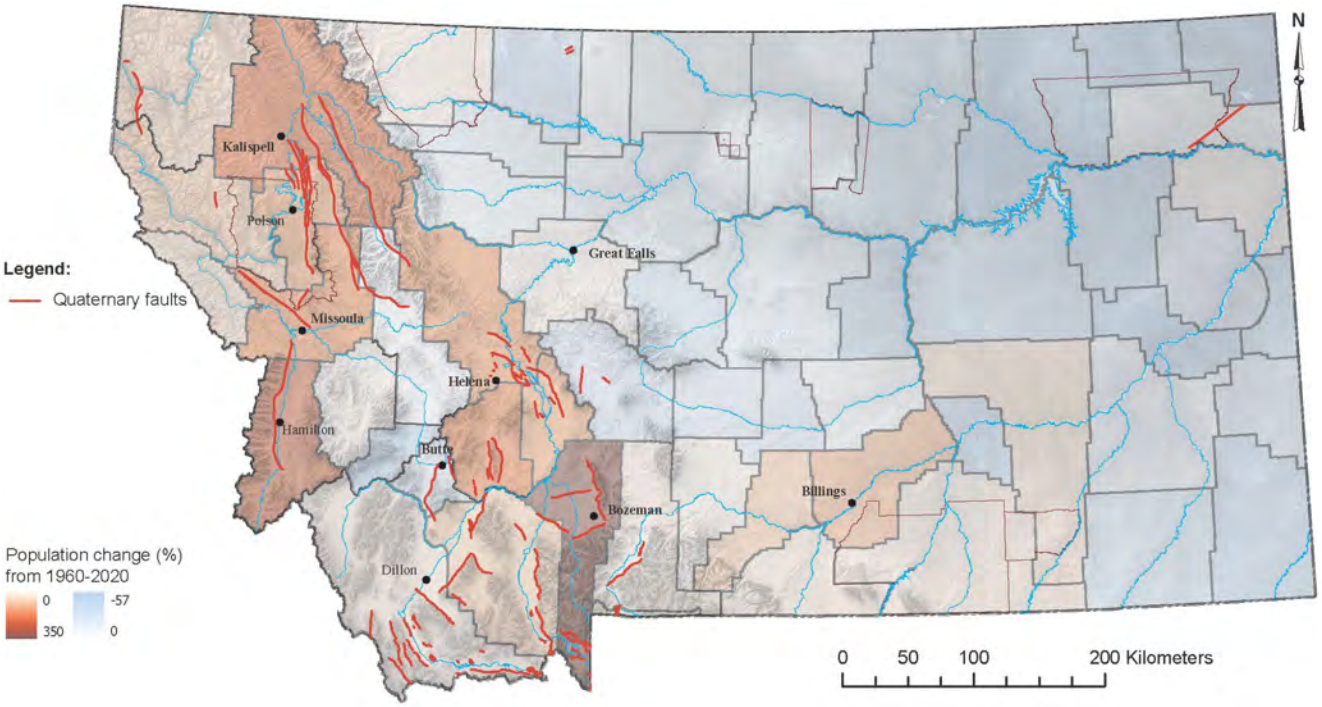
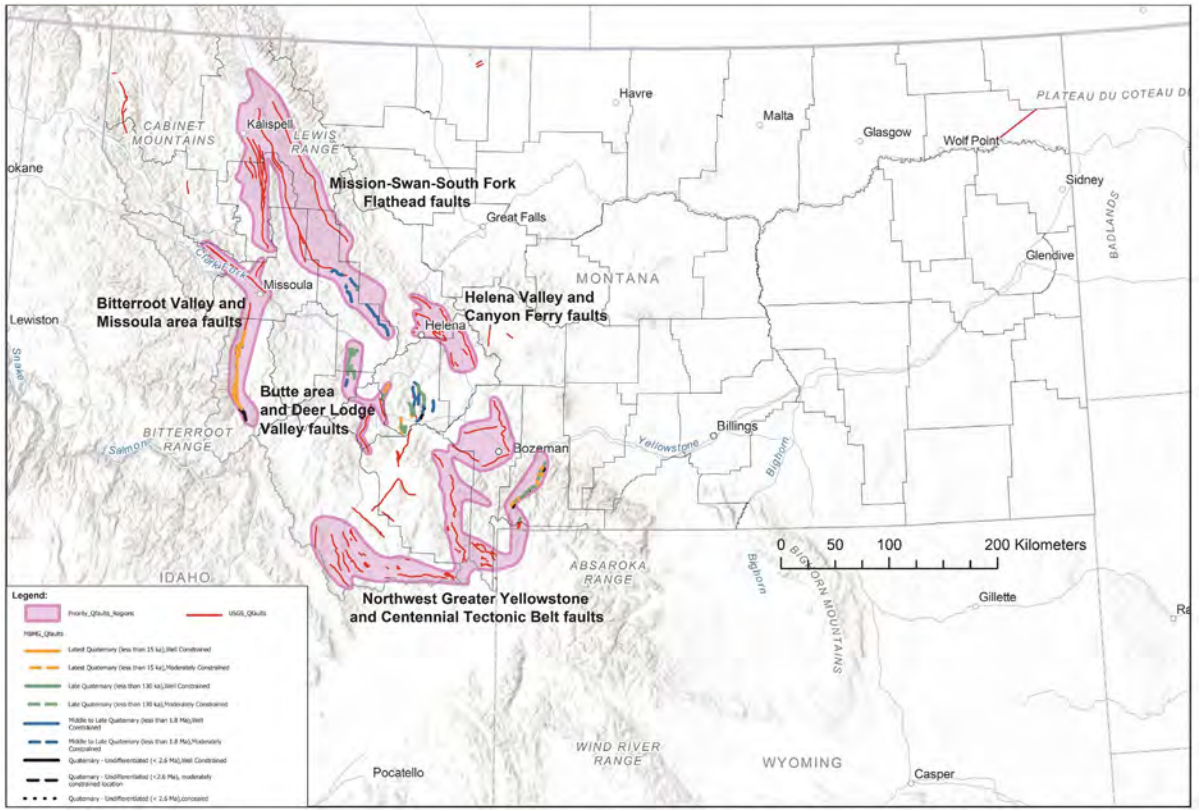
2025 Montana Geohazards Workshop
Kalispell – May 8-9, 2025

Workshop Day 2 (May 9) Presentations

Kalispell Region Quaternary faults – Top 5 Priority Areas (Mission, Swan Valley, South Fork Flathead faults)

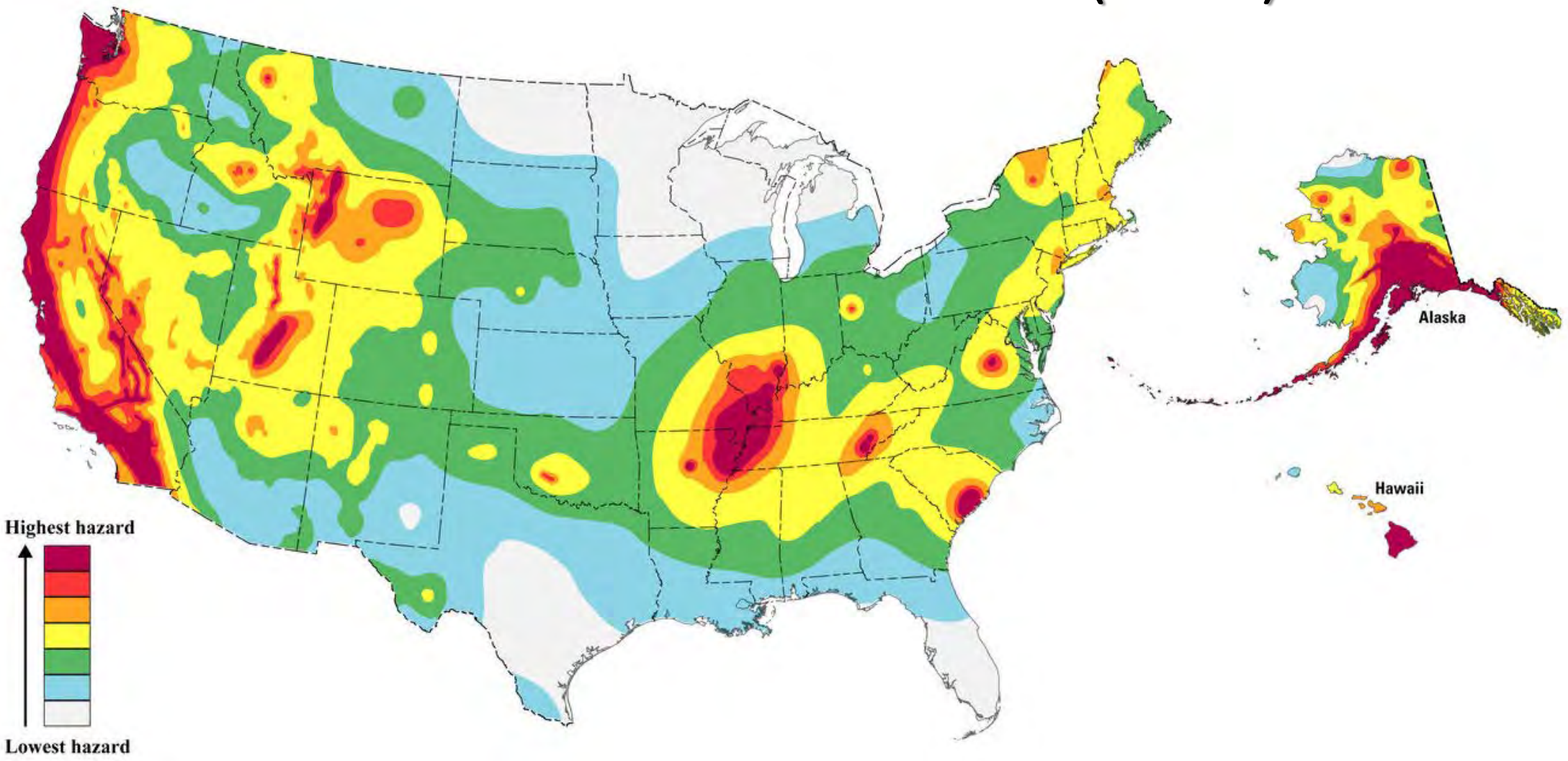




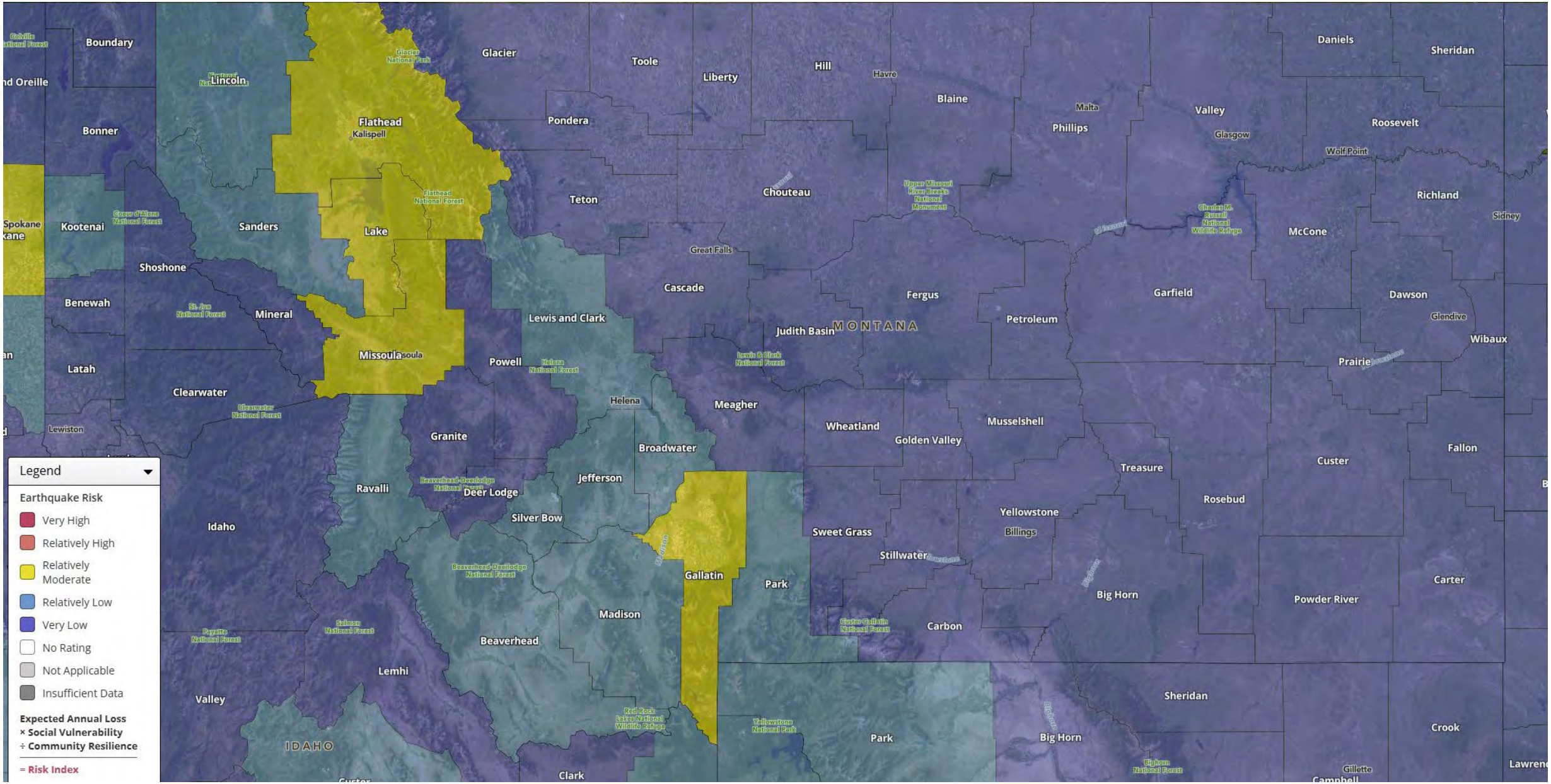
Justification/Criteria: High hazard-High risk faults near the populated Mission and Flathead valleys.

- Need to better characterize fault trace location (southern and northern extents, including beneath Flathead Lake section), fault activity, fault slip rates, paleoseismic parameters, and site-specific seismic investigations of reservoirs, hydroelectric dams, and critical infrastructure.
- Only the Mission fault is included in the National Seismic Hazard Model.

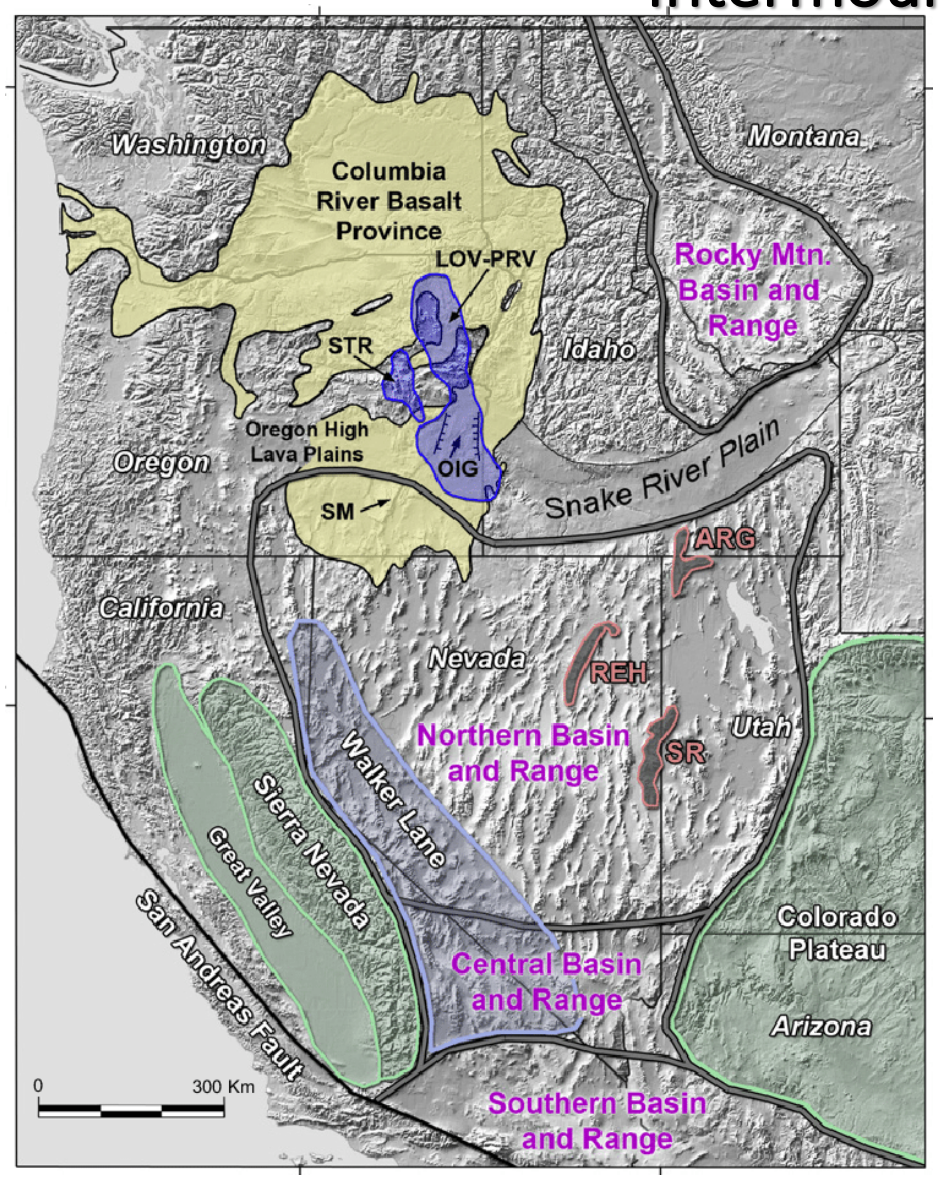
Earthquake Hazard map from the 2023 update of the National Seismic Hazard Model (NSHM)



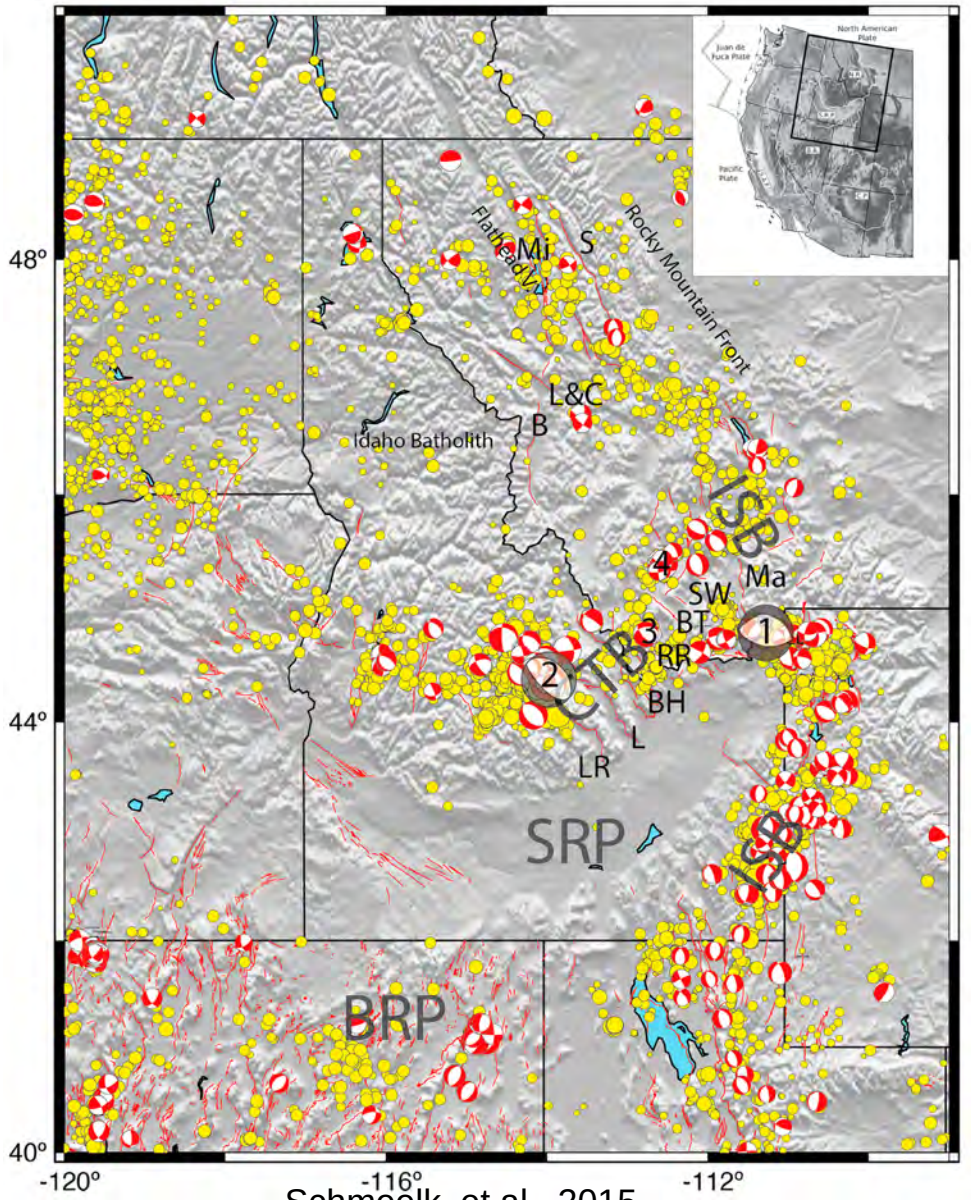
FEMA National Seismic Risk – MT Earthquake Risk



Regional setting of the Northern Rockies Basin and Range and Intermountain Seismic Belt

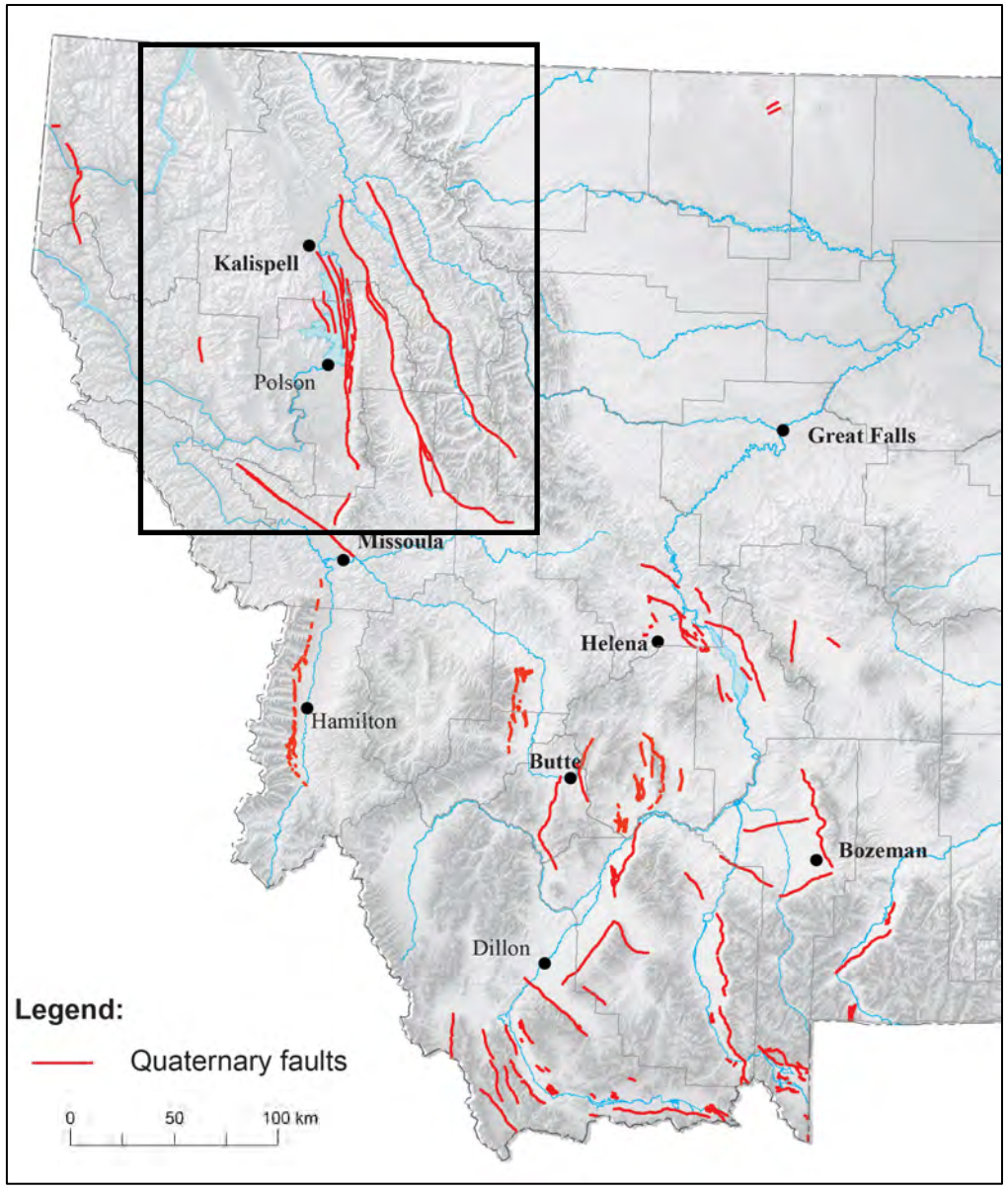


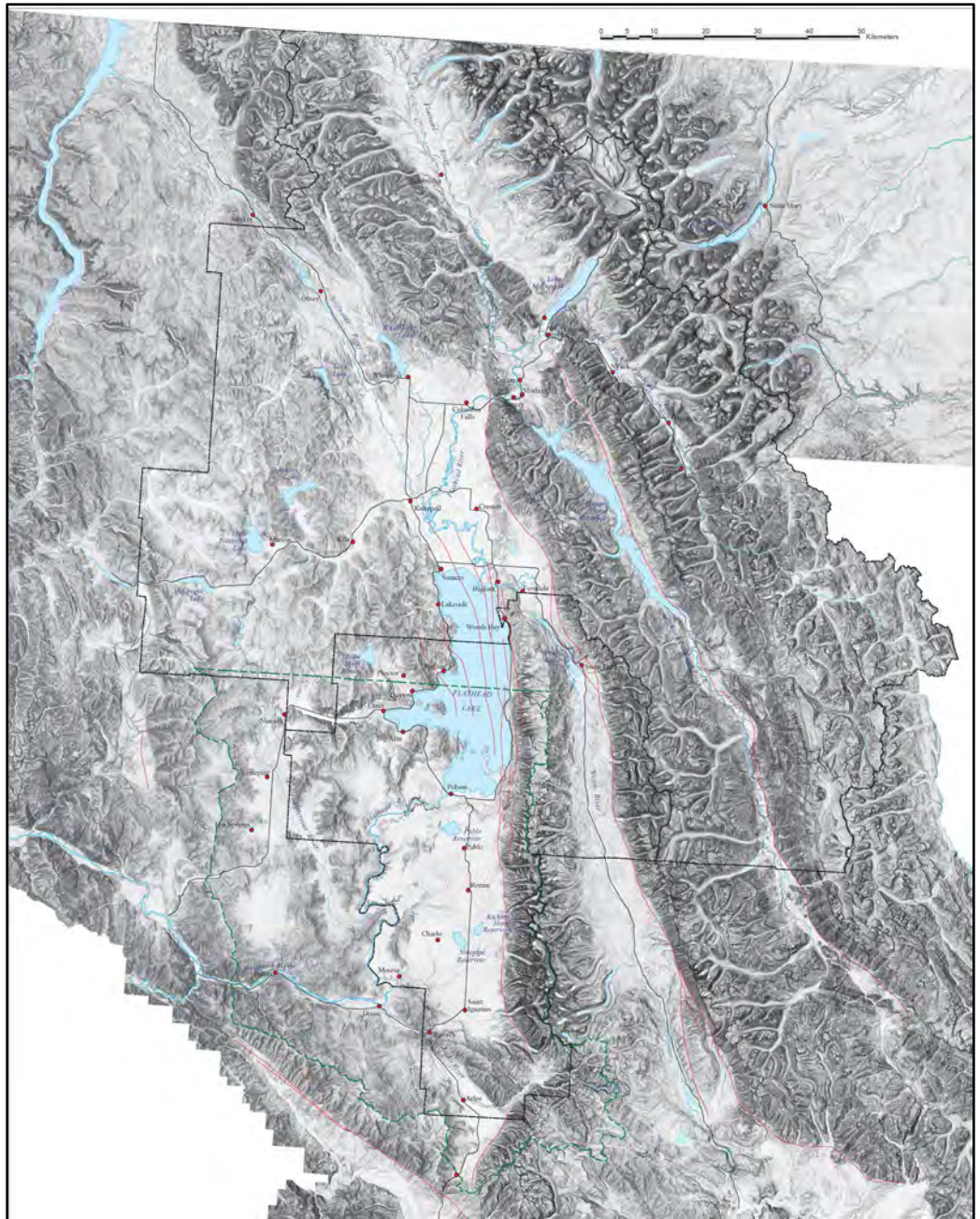
Camp, et al., 2015

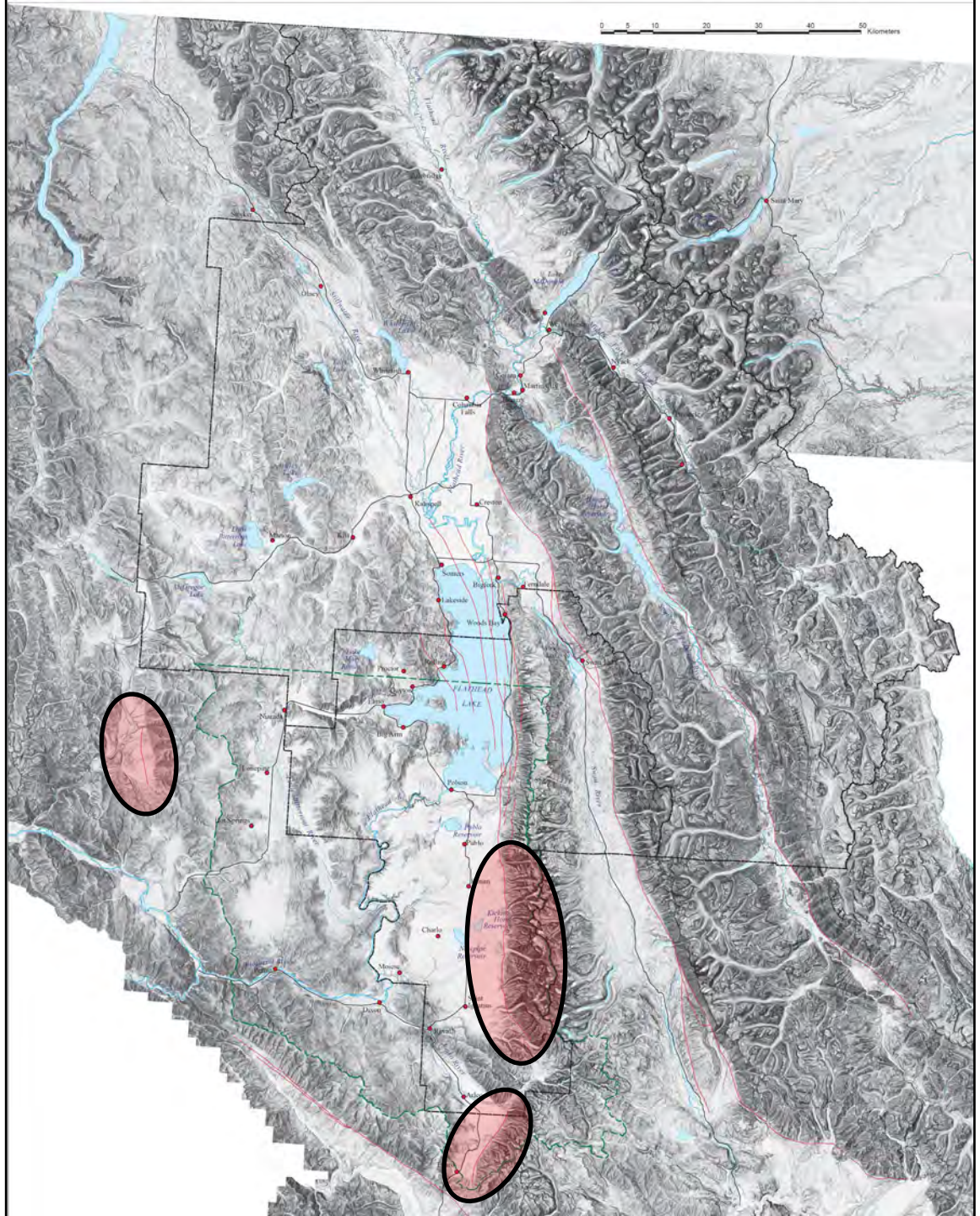


Schmeelk, et al., 2015

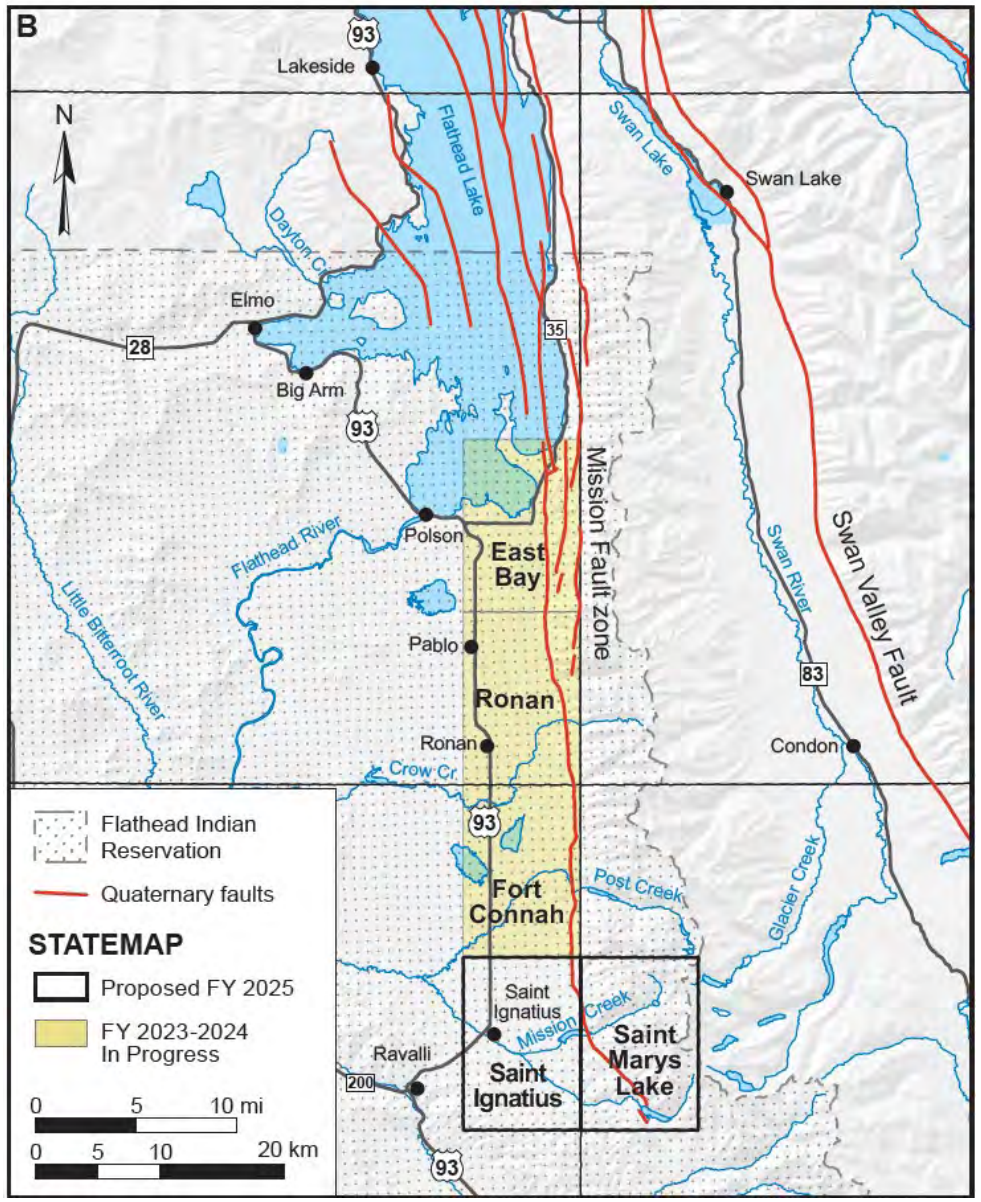
Kalispell Region Quaternary faults

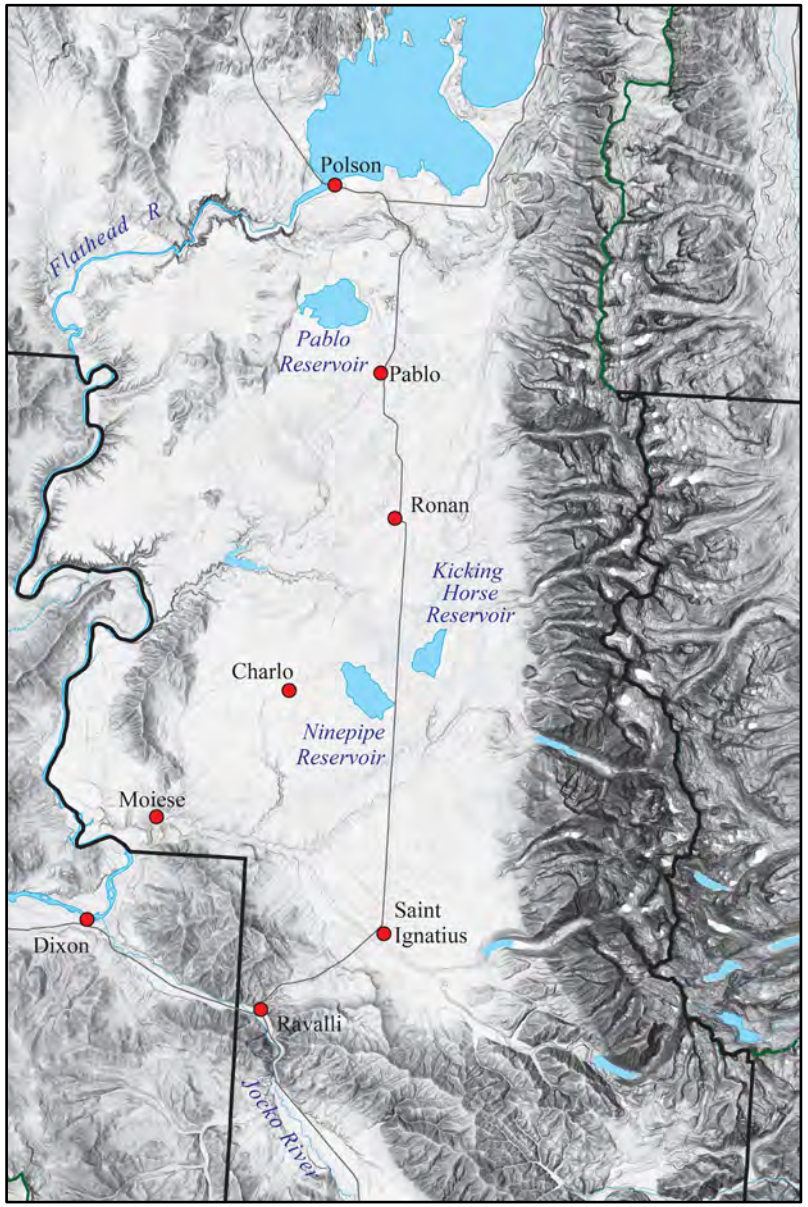


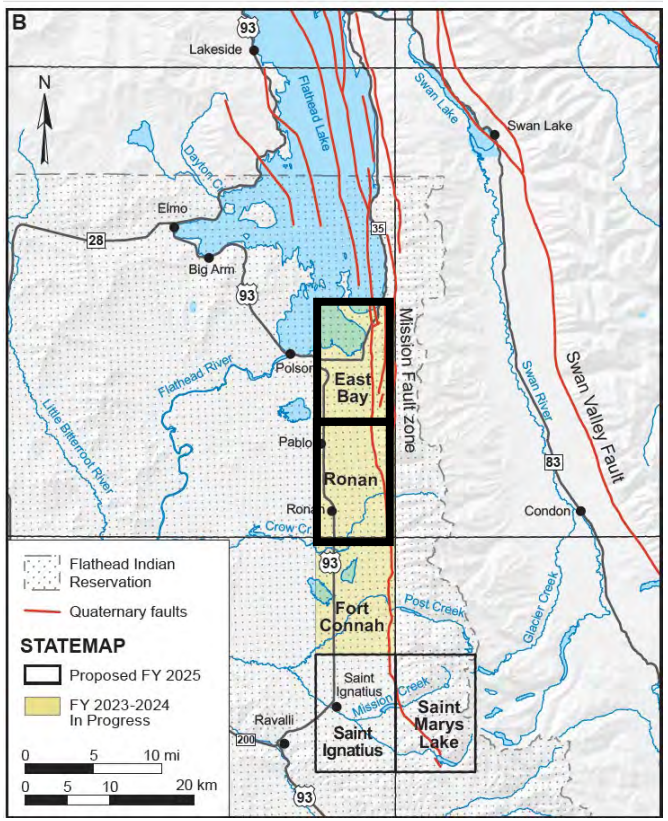



0 5 10 20 30 40 50 Kilometers
Stryker
Saint Mary
Saint Mary Lake
Lake McDonald
Olney
Whitefish
Columbia Falls
Coram
Martin City
Hungry Horse
Hungry Horse Reservoir
Kalispell
Creston
Marion
Kila
Somers
Bigfork
Ferndale
Lakeside
Woods Bay
Swan Lake
Proctor
Rollins
Dayton
Elmo
Big Arm
FLATHEAD LAKE
Polson
Pablo
Pablo Reservoir
Ronan
Kicking Horse Reservoir
Charlo
Ninepipe Reservoir
Mission
Saint Ignatius
Dixon
Ravalli
Arlee
Flathead River
Swan River
0 4.25 8.5 17 Kilometers

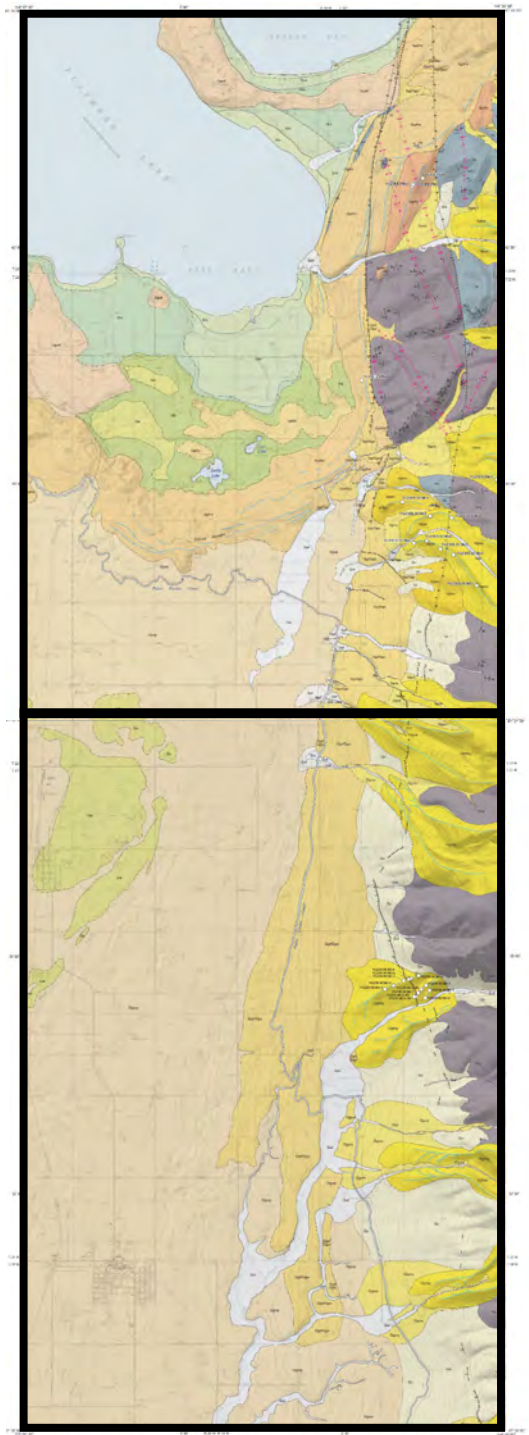
STATEMAP Polson Project
Geological Mapping of the Mission fault

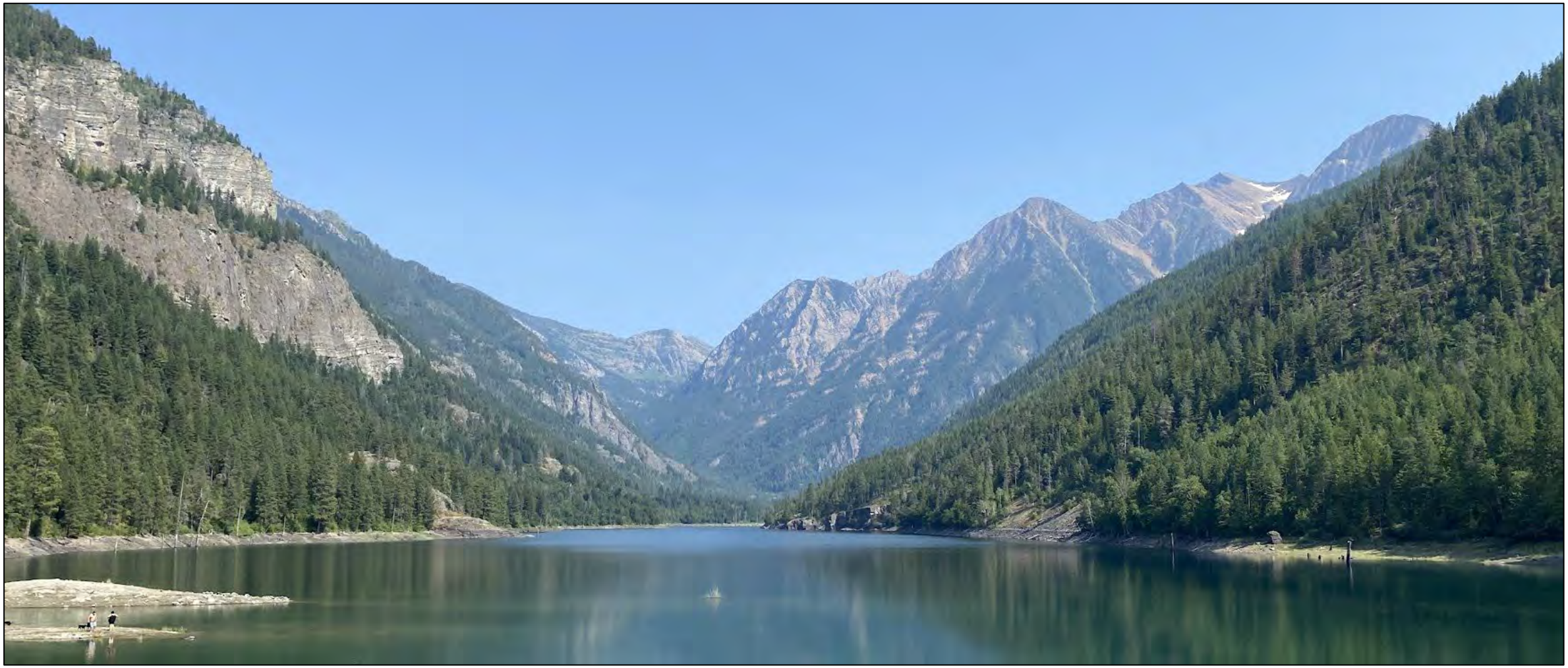


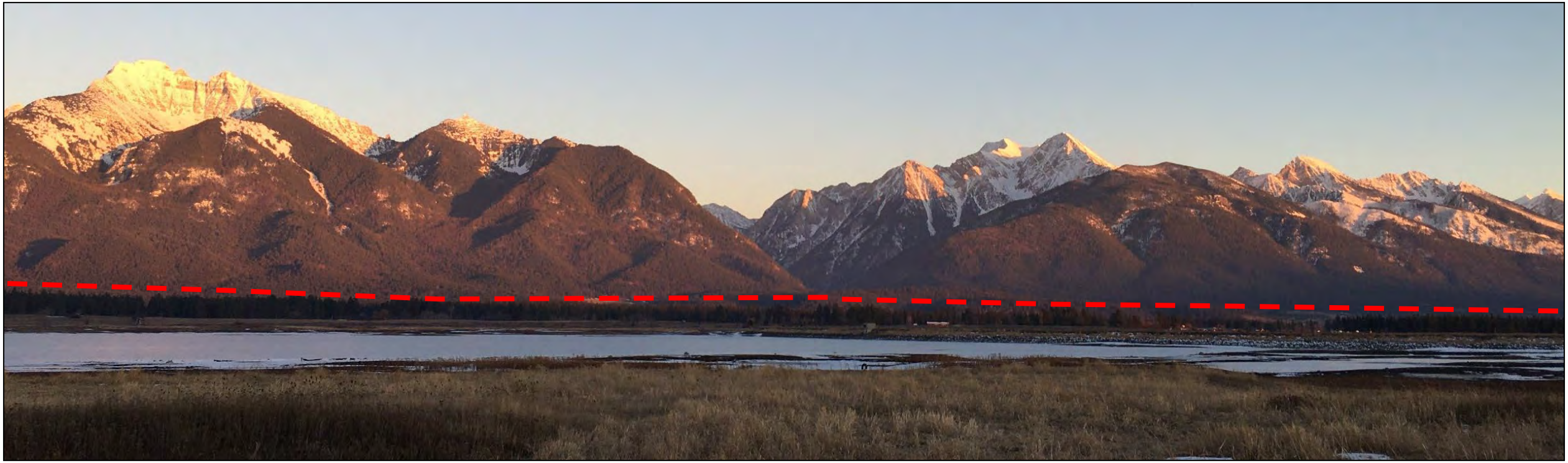


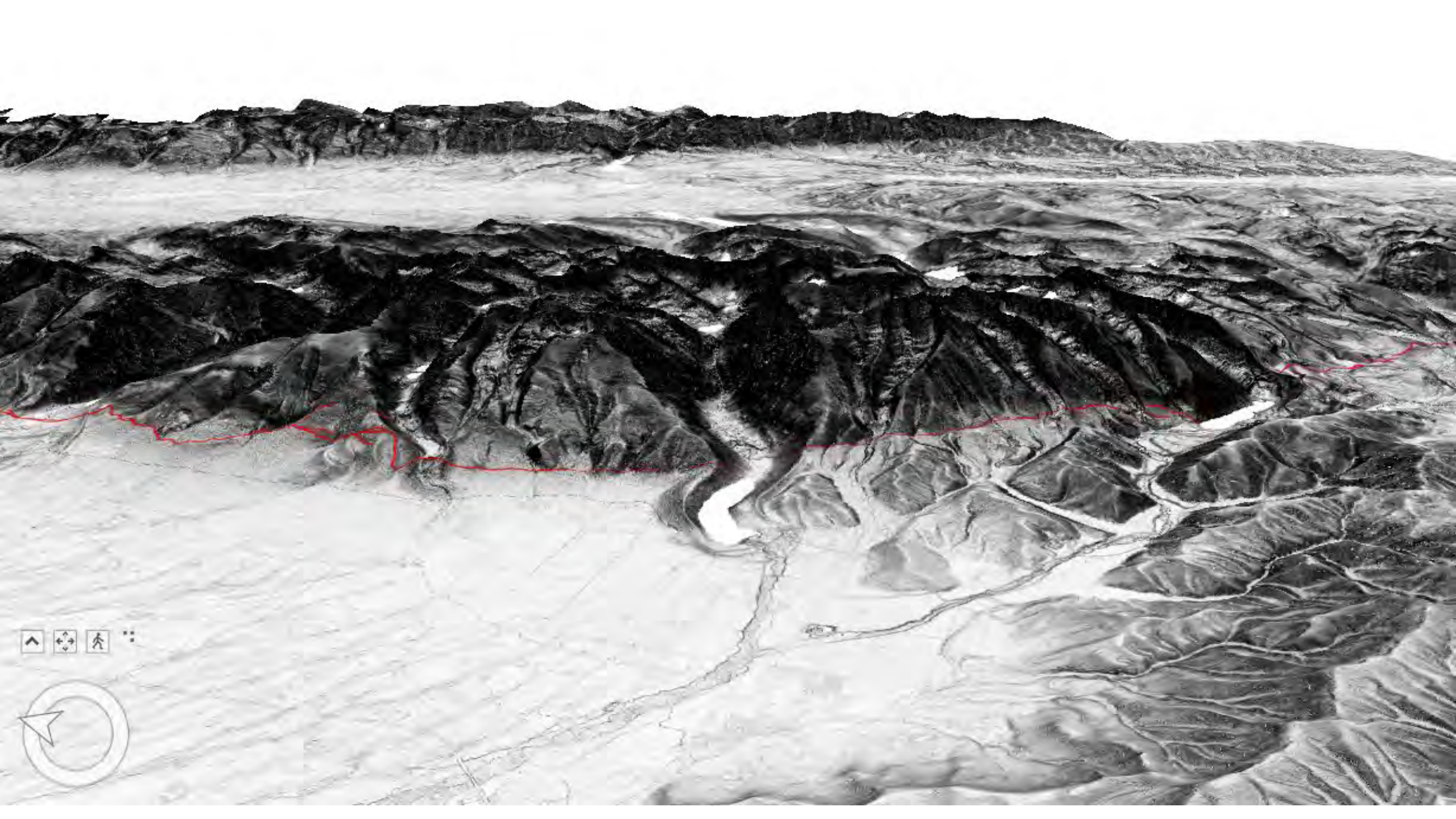

B
N
Lakeside
93
Flathead Lake
Swan Lake
Swan Lake
Dayton Creek
Elmo
28
35
Big Arm
93
Mission Fault zone
Swan River
Swan Valley Fault
Polson
East Bay
Flathead River
Little Bitterroot River
Pablo
Ronan
Ronan
Crow Creek
83
Condon
93
Flathead Indian Reservation
Quaternary faults
STATEMAP
Proposed FY 2025
FY 2023-2024 In Progress
0 5 10 mi
0 5 10 20 km
Fort Connah
Post Creek
Glacier Creek
Saint Ignatius
Mission Creek
Saint Marys Lake
Ravalli
200
Saint Ignatius
93


Polson
Pablo Reservoir
Pablo
Ronan
Kicking

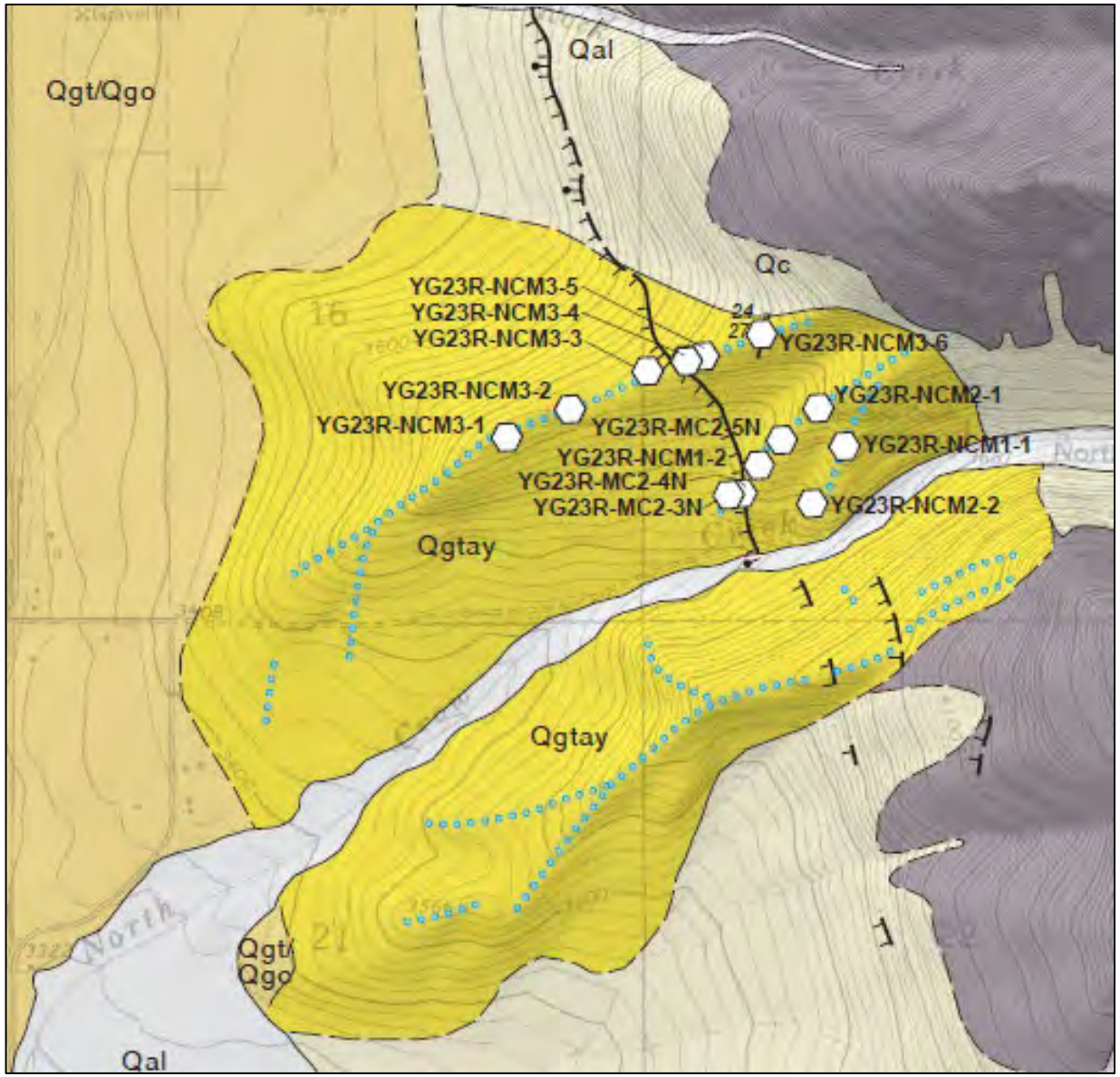


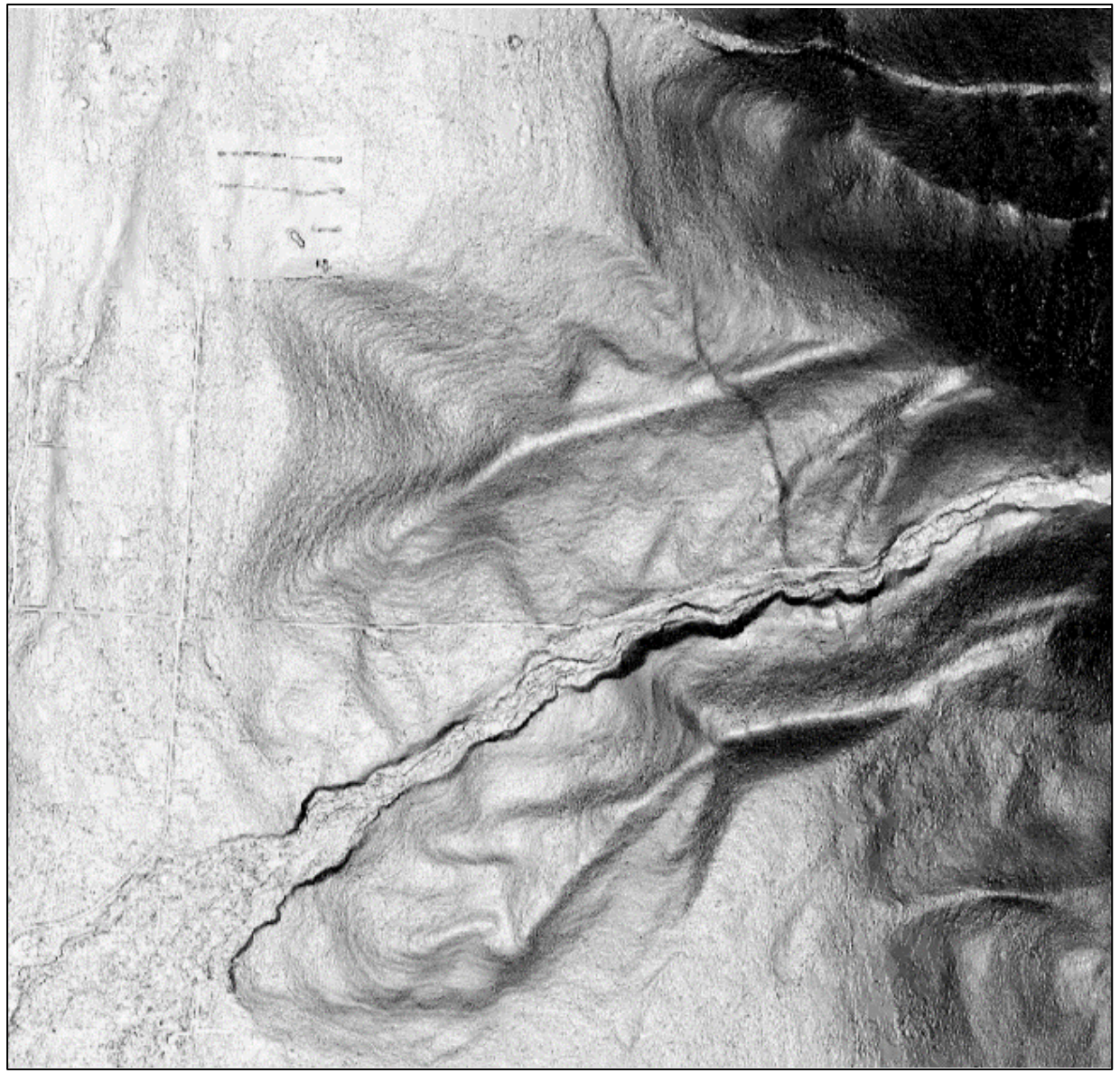


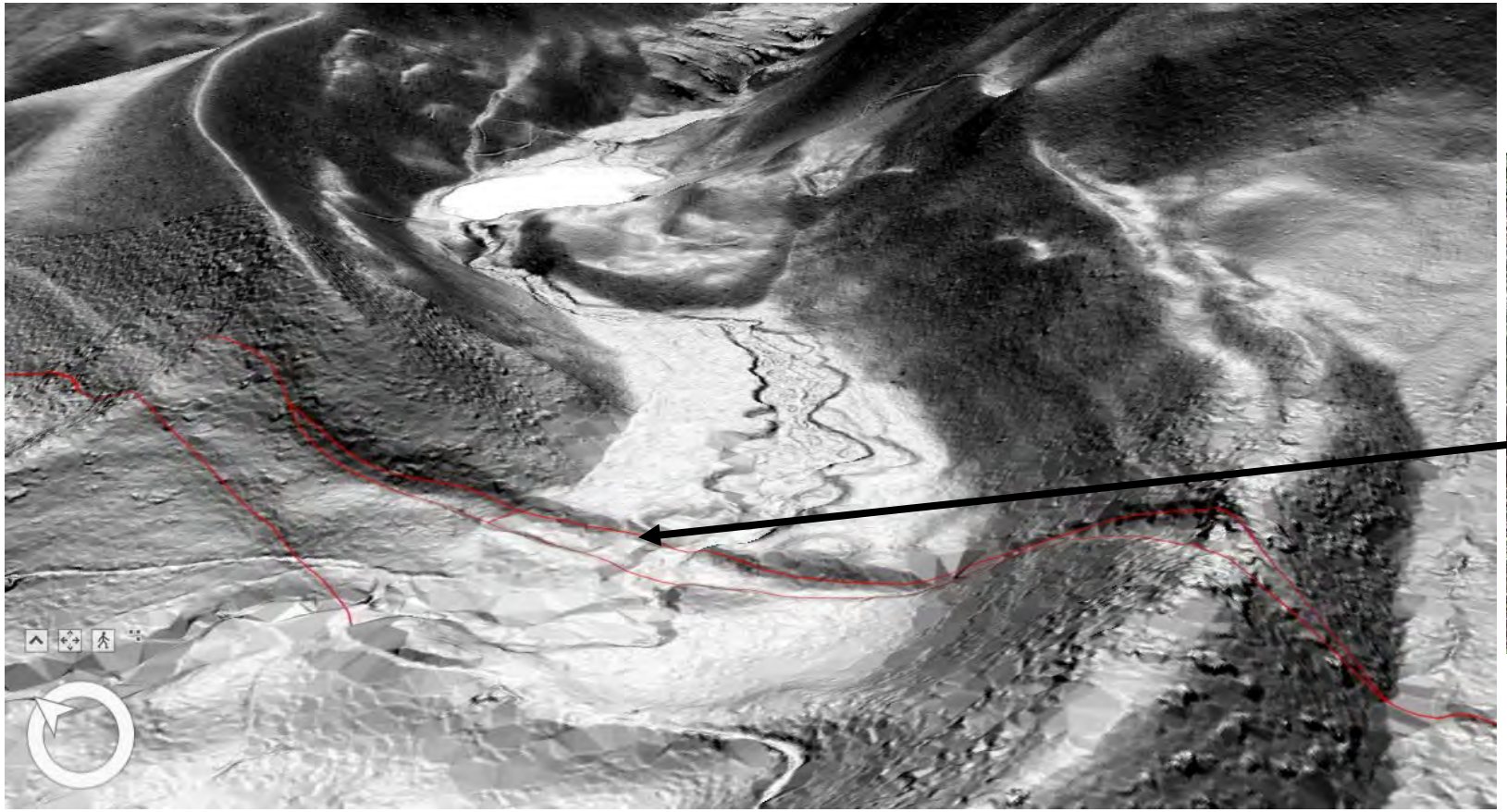




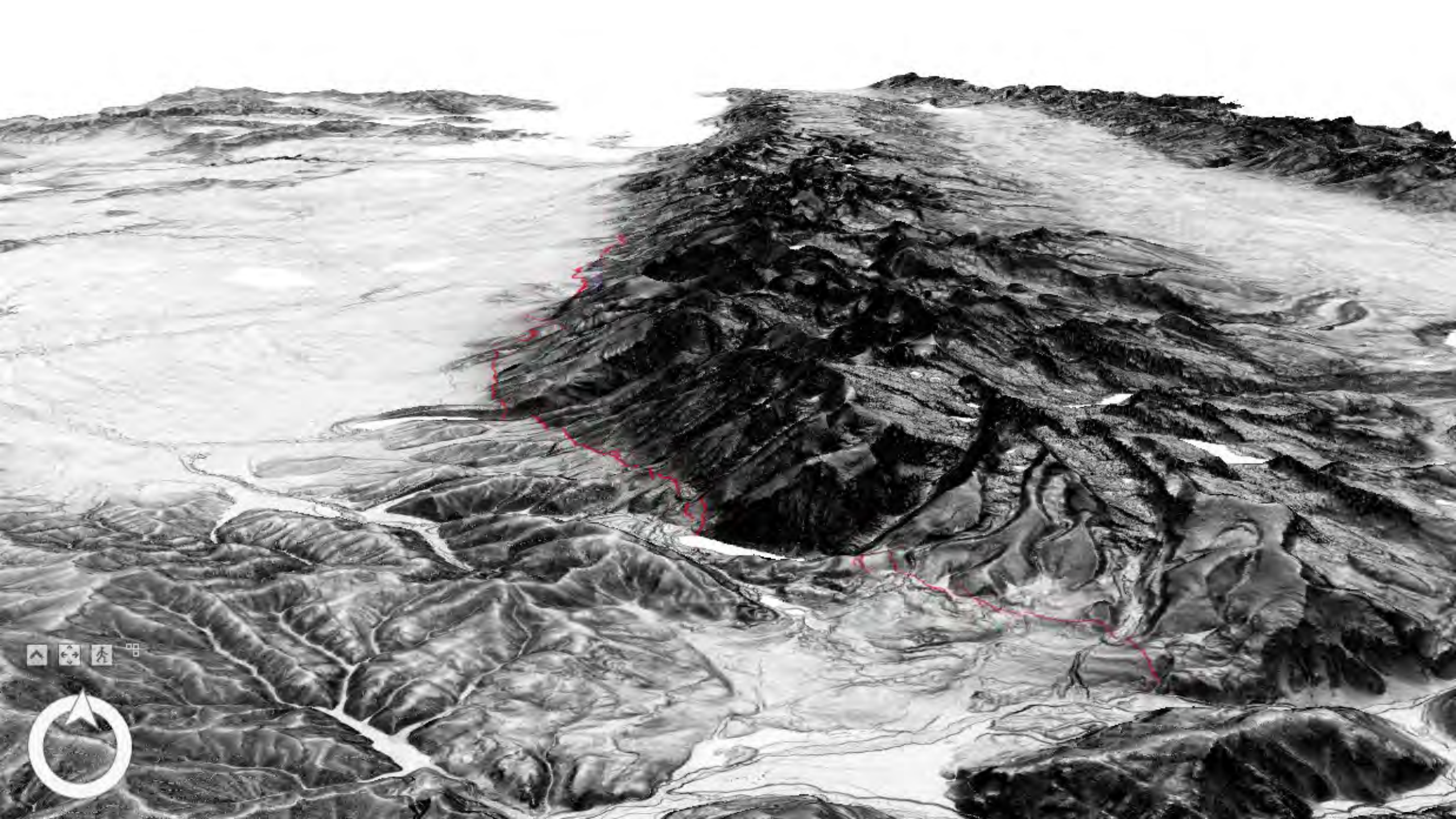
Mission fault – Fault activity, slip rates, geochronology, glacial history

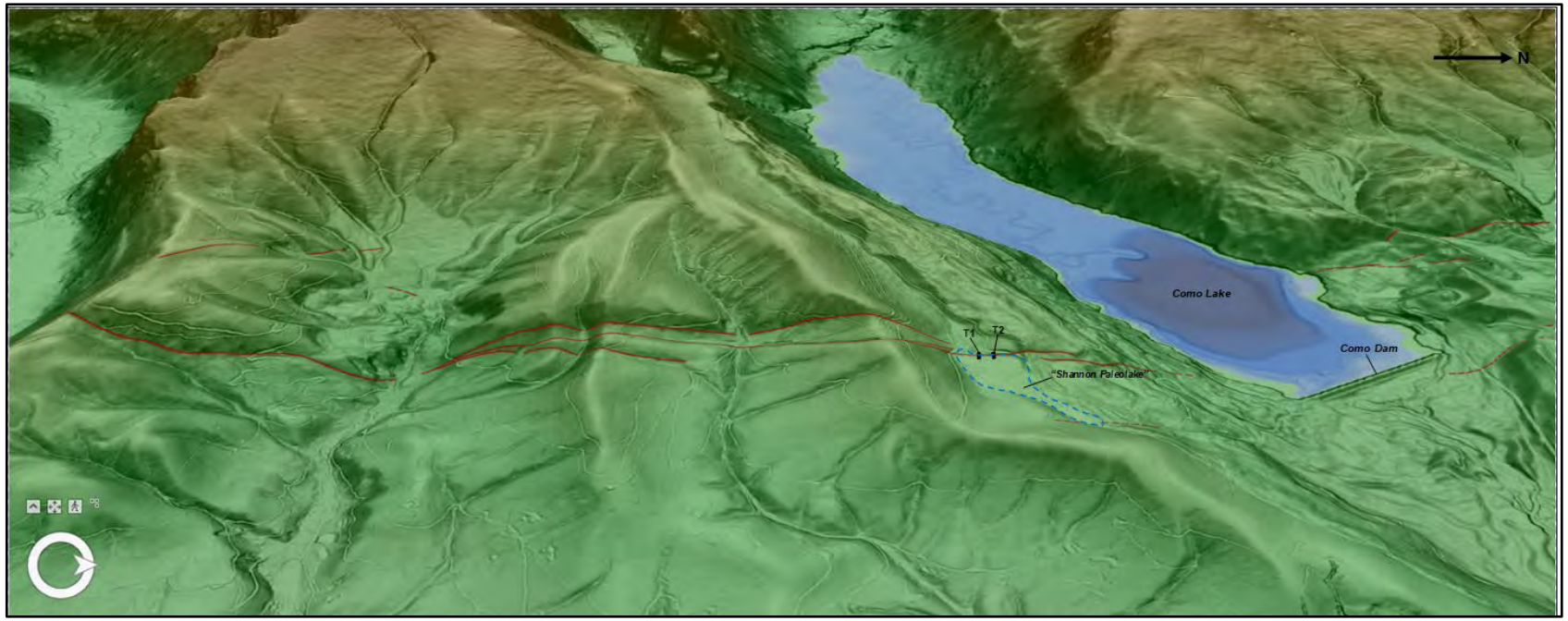




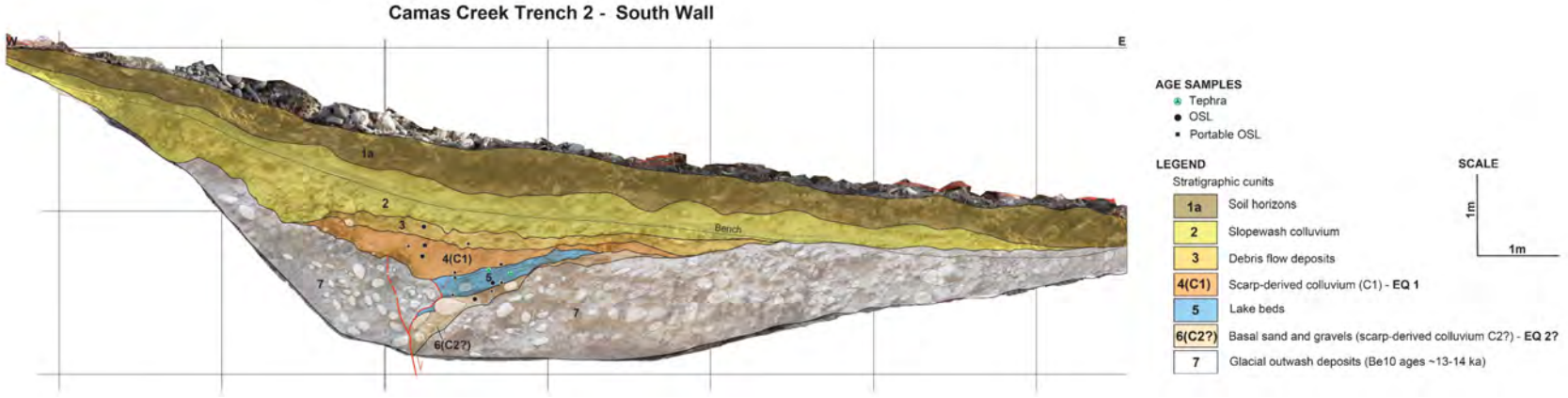


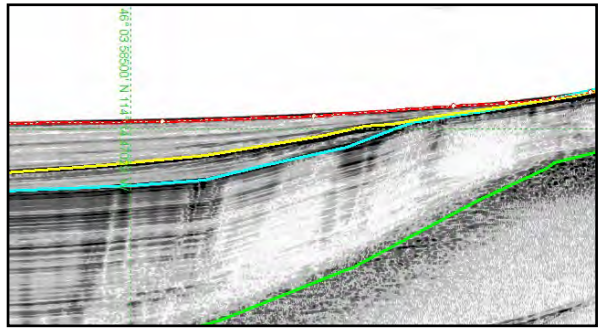
Cosmogenic ^{10}Be dating on boulders in glacial deposits




N
Como Lake
Como Dam
T1
T2
"Shannon Paleolake"


STANLEY

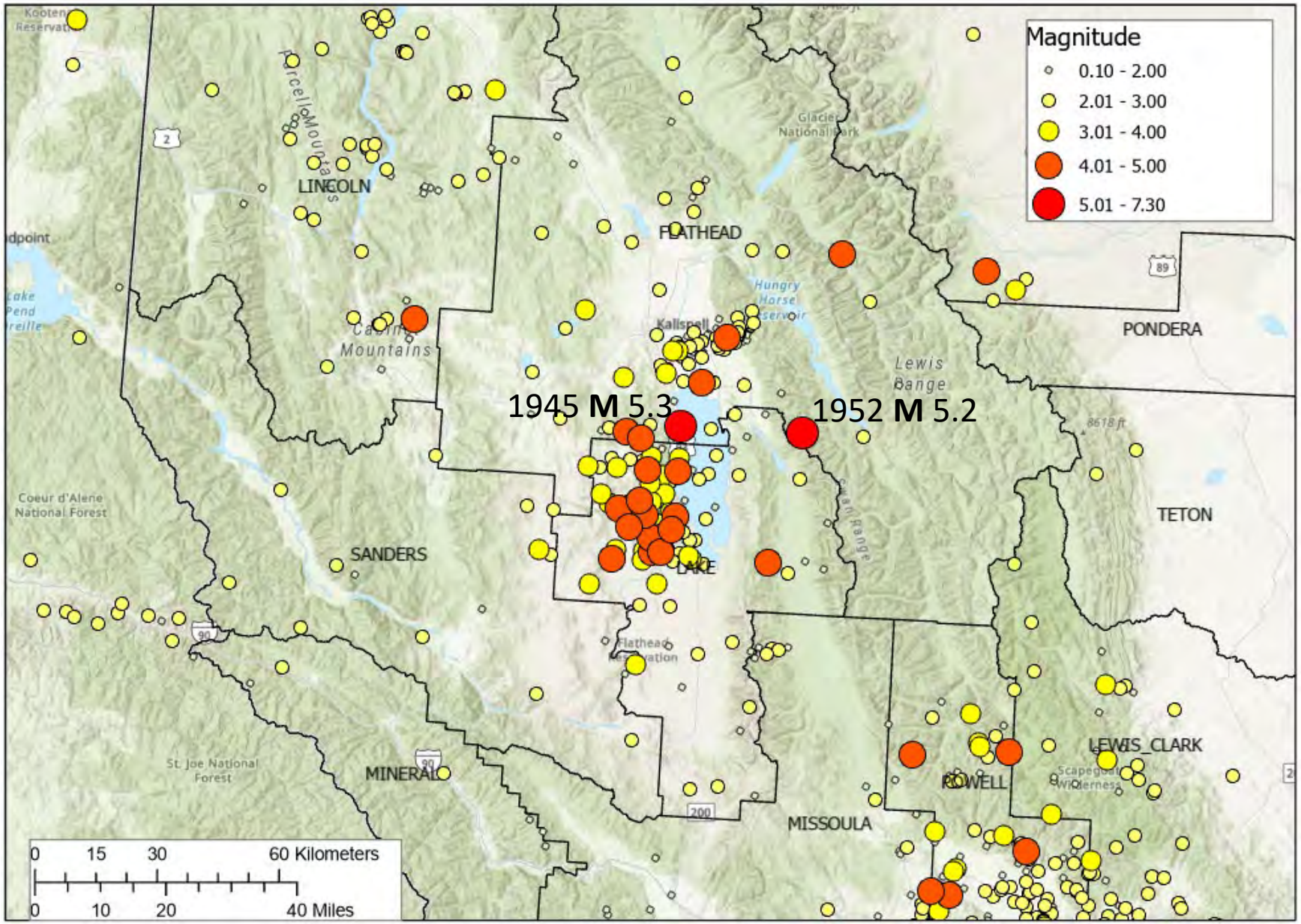

Camas Creek Trench 2 - South Wall
W
E
1a
2
3
4(C1)
5
7
Bench
6(C2?)
AGE SAMPLES
Tephra
OSL
Portable OSL
LEGEND
Stratigraphic cunits
1a Soil horizons
2 Slopewash colluvium
3 Debris flow deposits
4(C1) Scarp-derived colluvium (C1) - EQ 1
5 Lake beds
6(C2?) Basal sand and gravels (scarp-derived colluvium C2?) - EQ 2?
7 Glacial outwash deposits (Be10 ages ~13-14 ka)
SCALE
1m
1m



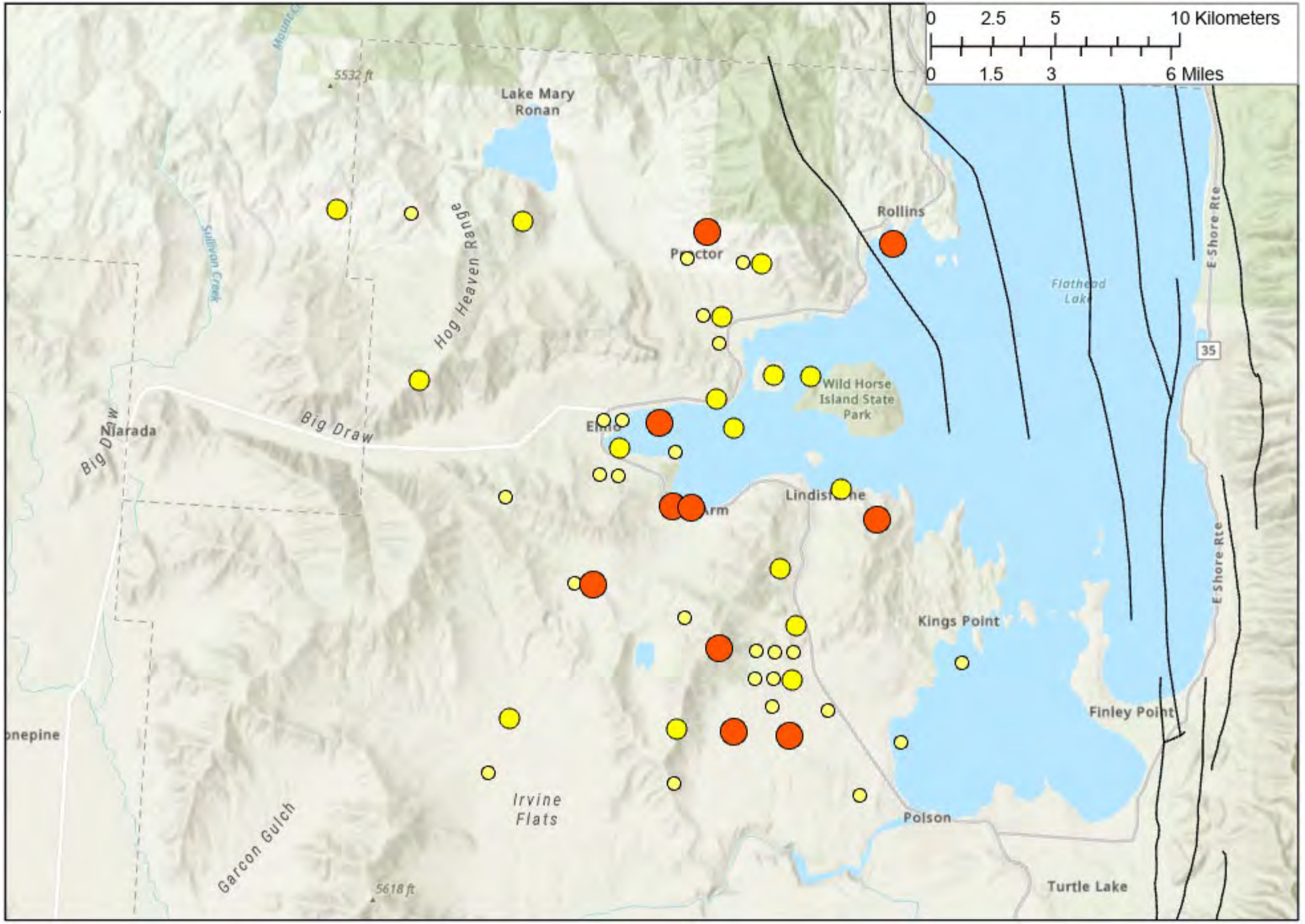

Thank you

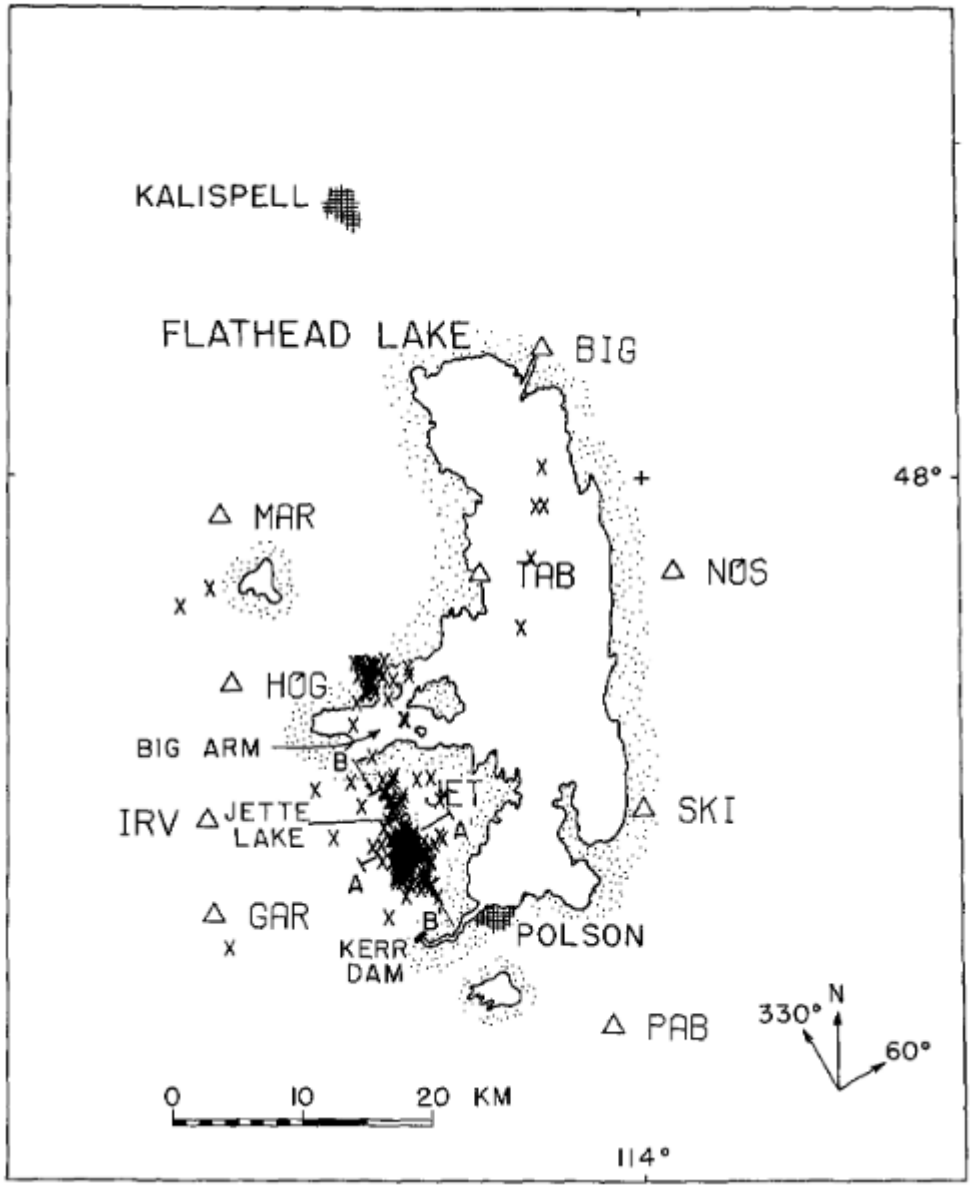
Kalispell/Mission Valley Region Seismicity

Earthquakes 1805 - 1981



Big Arm swarm 1969-1971
303 earthquakes reported
16 with M ≥ 4.0
Largest M 4.7





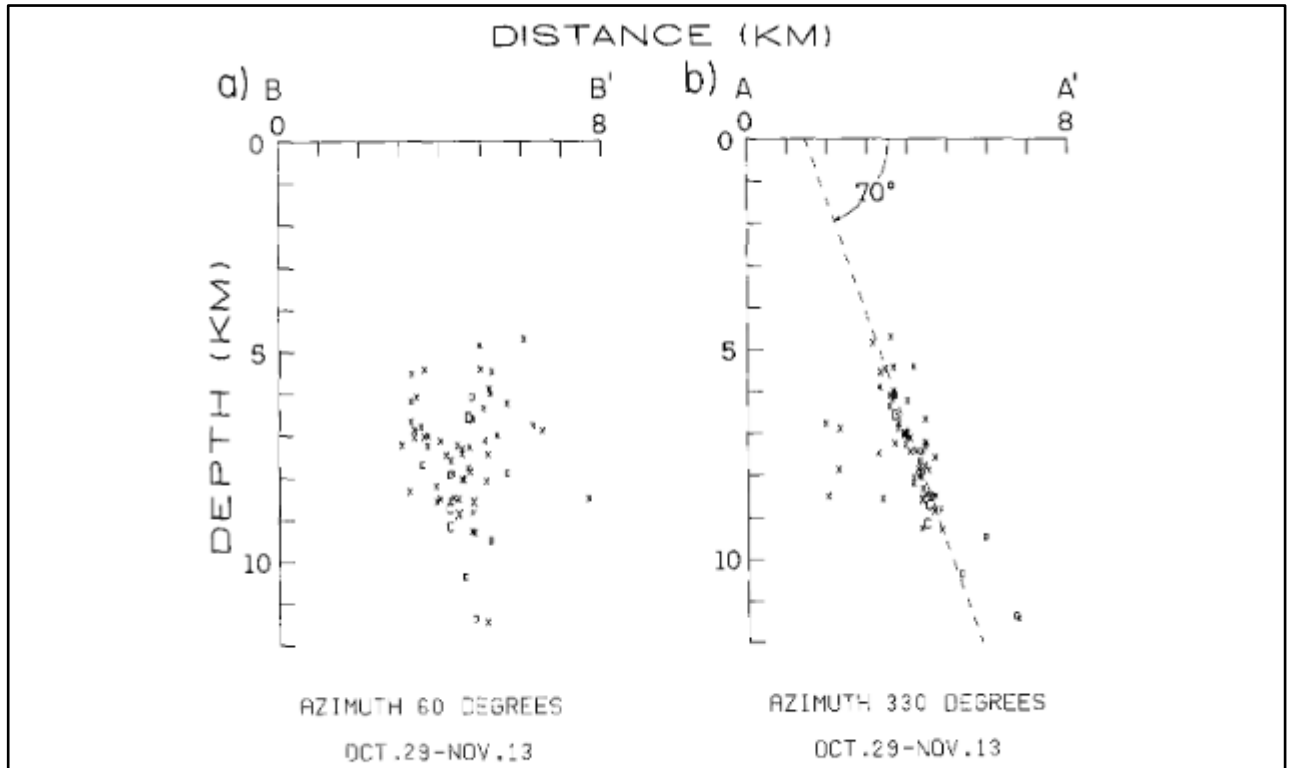
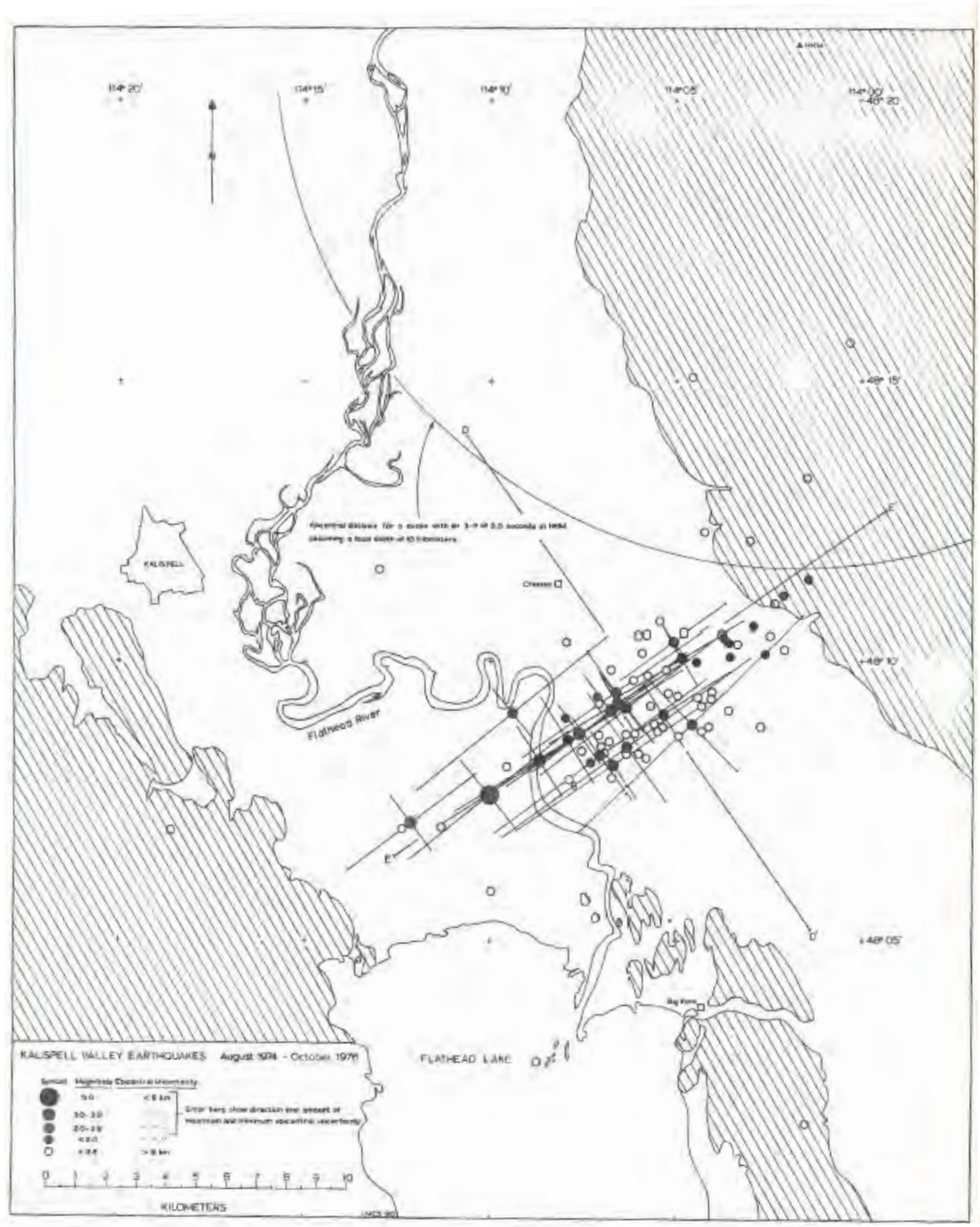


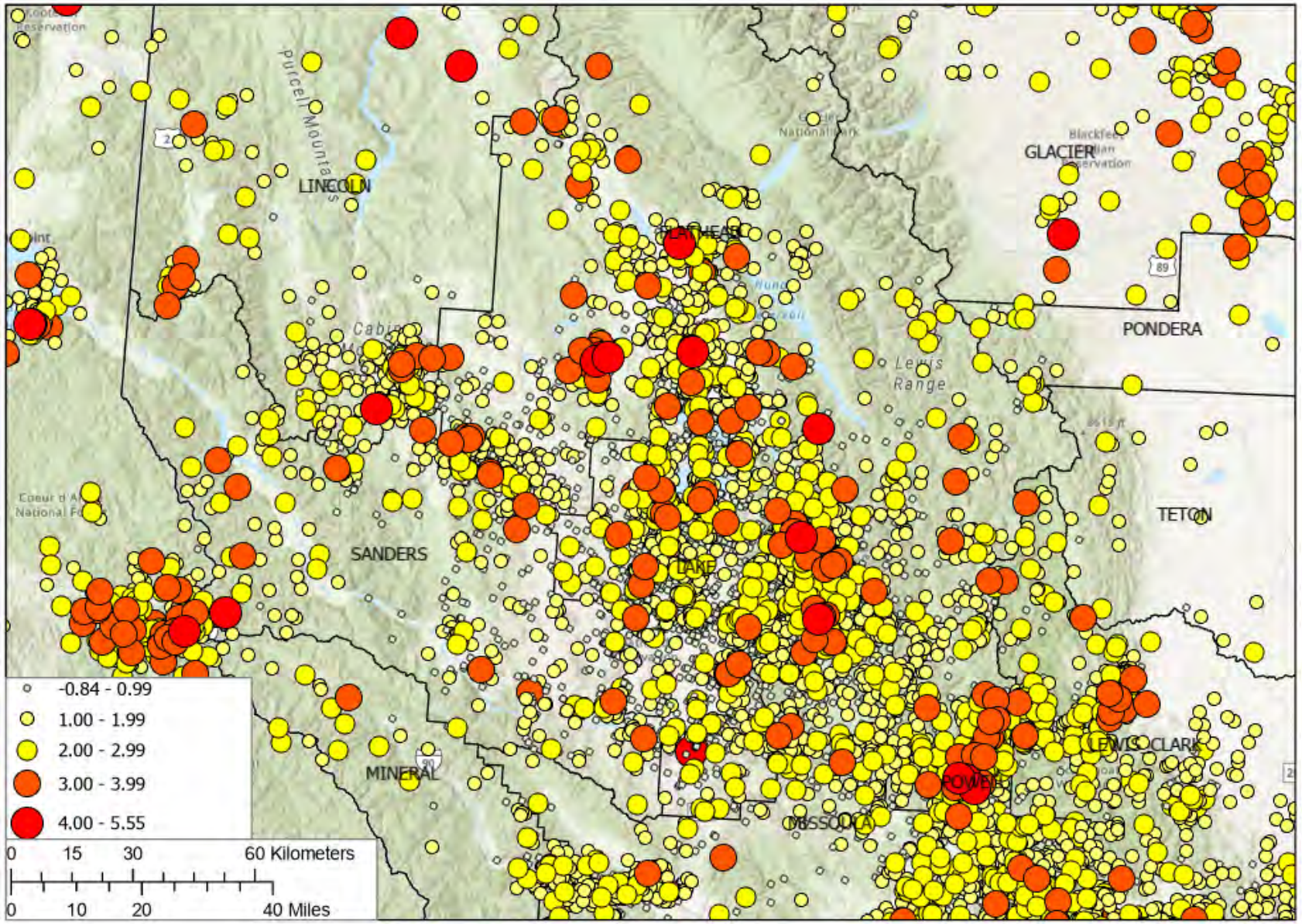
FIG. 7. Cross sections of Flathead Lake earthquake hypocenters for October 29–November 13. (a) Azimuth of 60° and (b) Azimuth of 330°.

259 earthquakes in 50 days, Oct 13 – Nov 27, 1971
Stevenson, 1976



Stickney, 1980

Earthquakes 1982 - Present



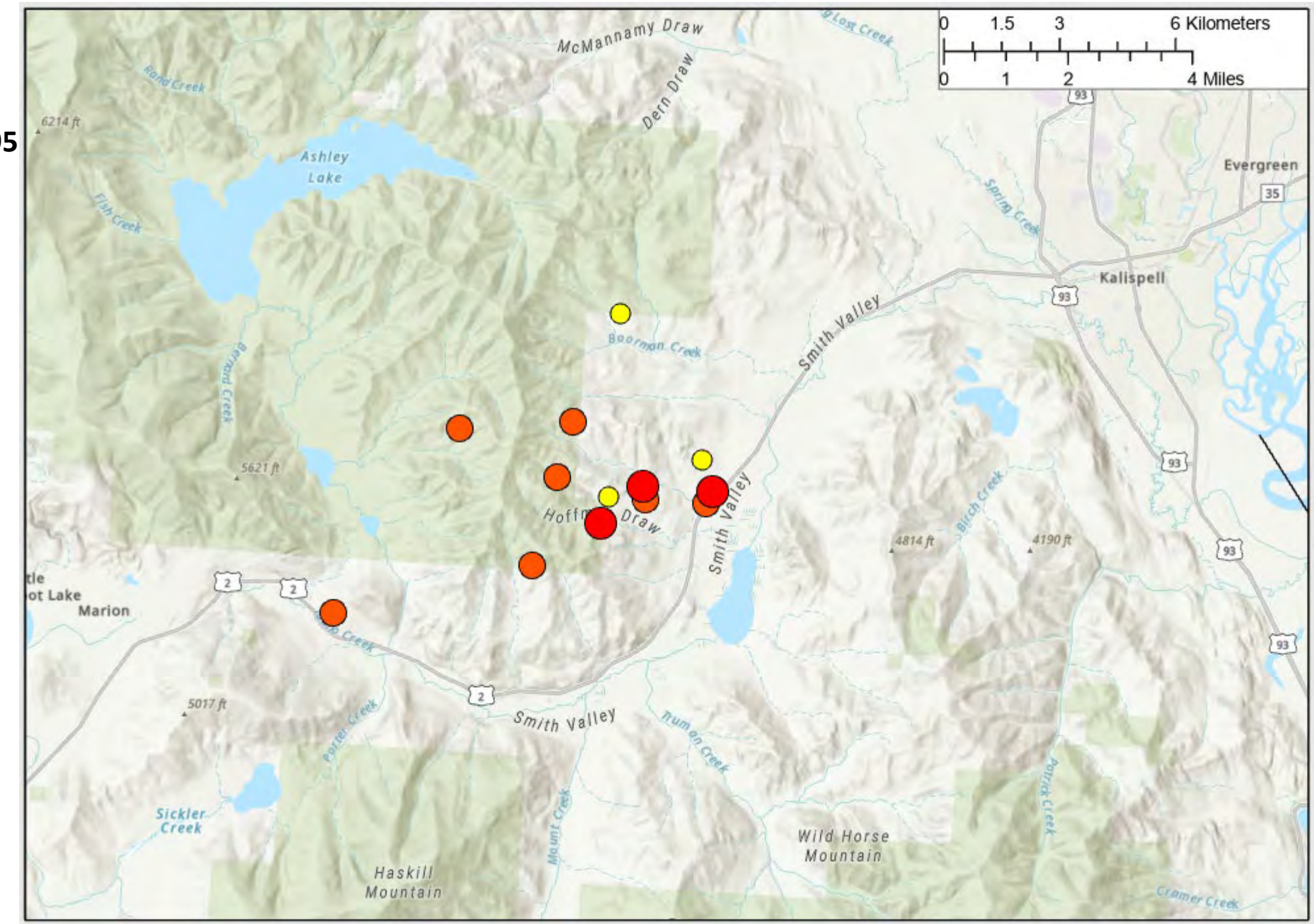
Kila Swarm 5/2 – 6/30/95

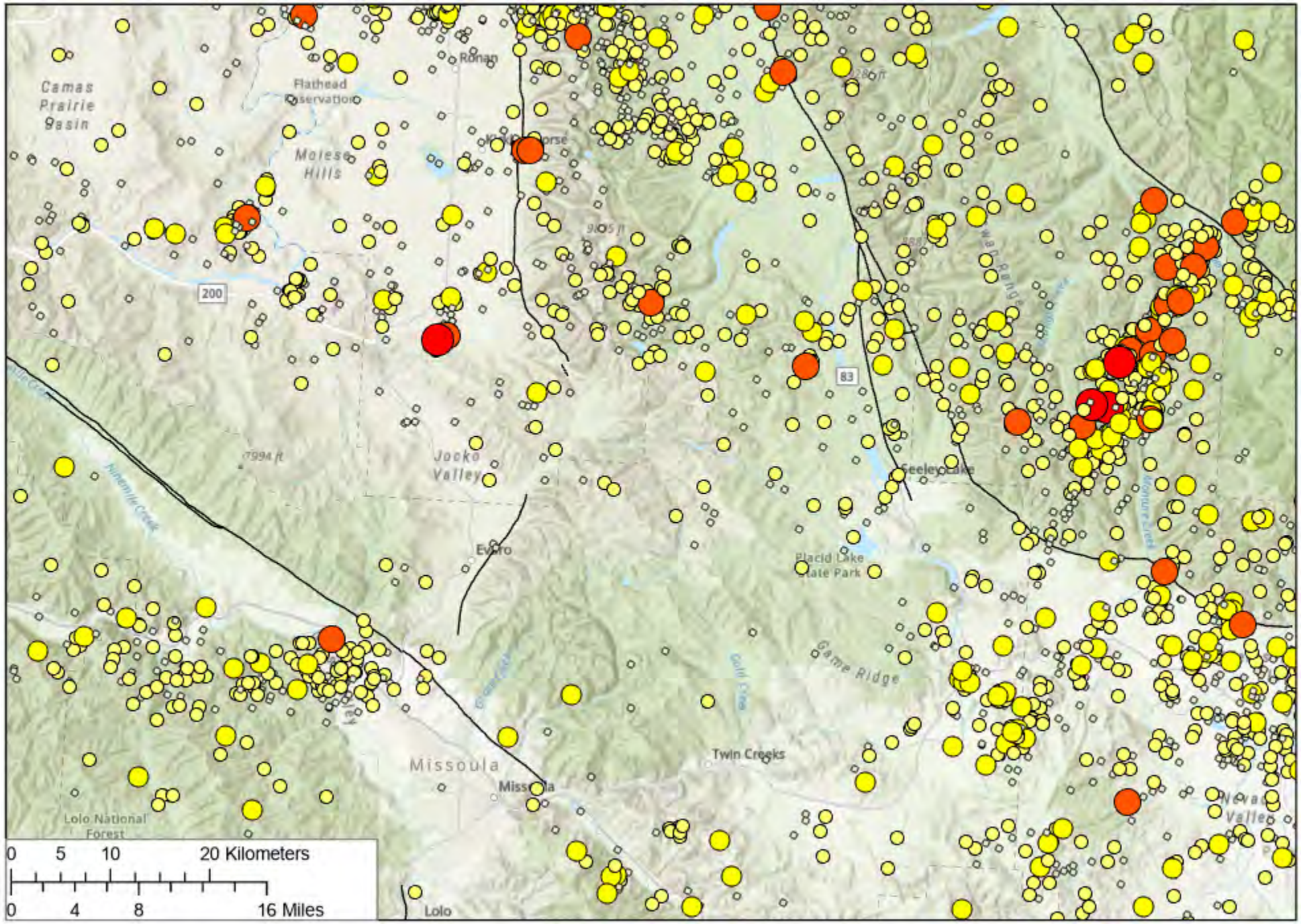
15 quakes

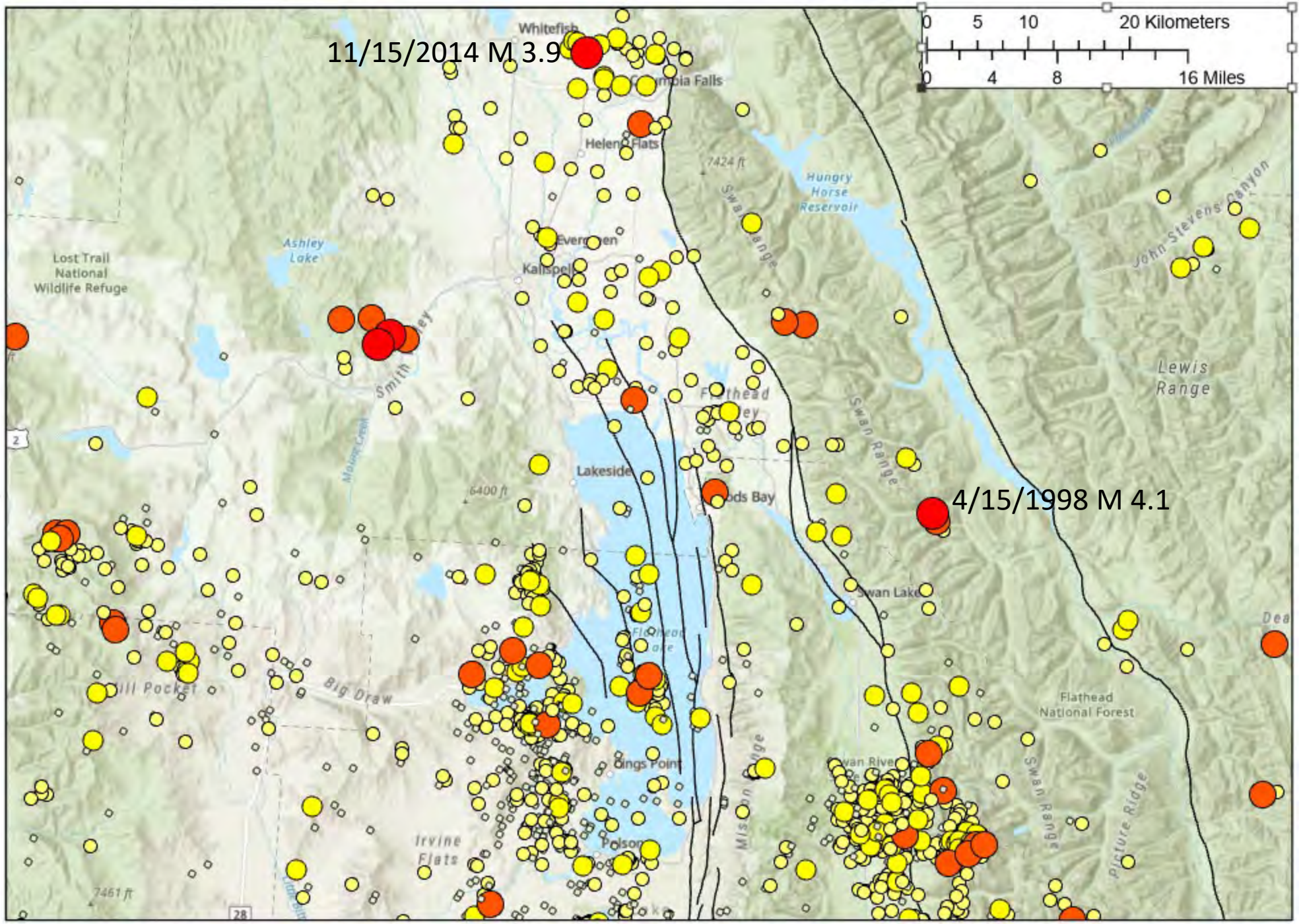
3 quakes M 4.0 – 4.4

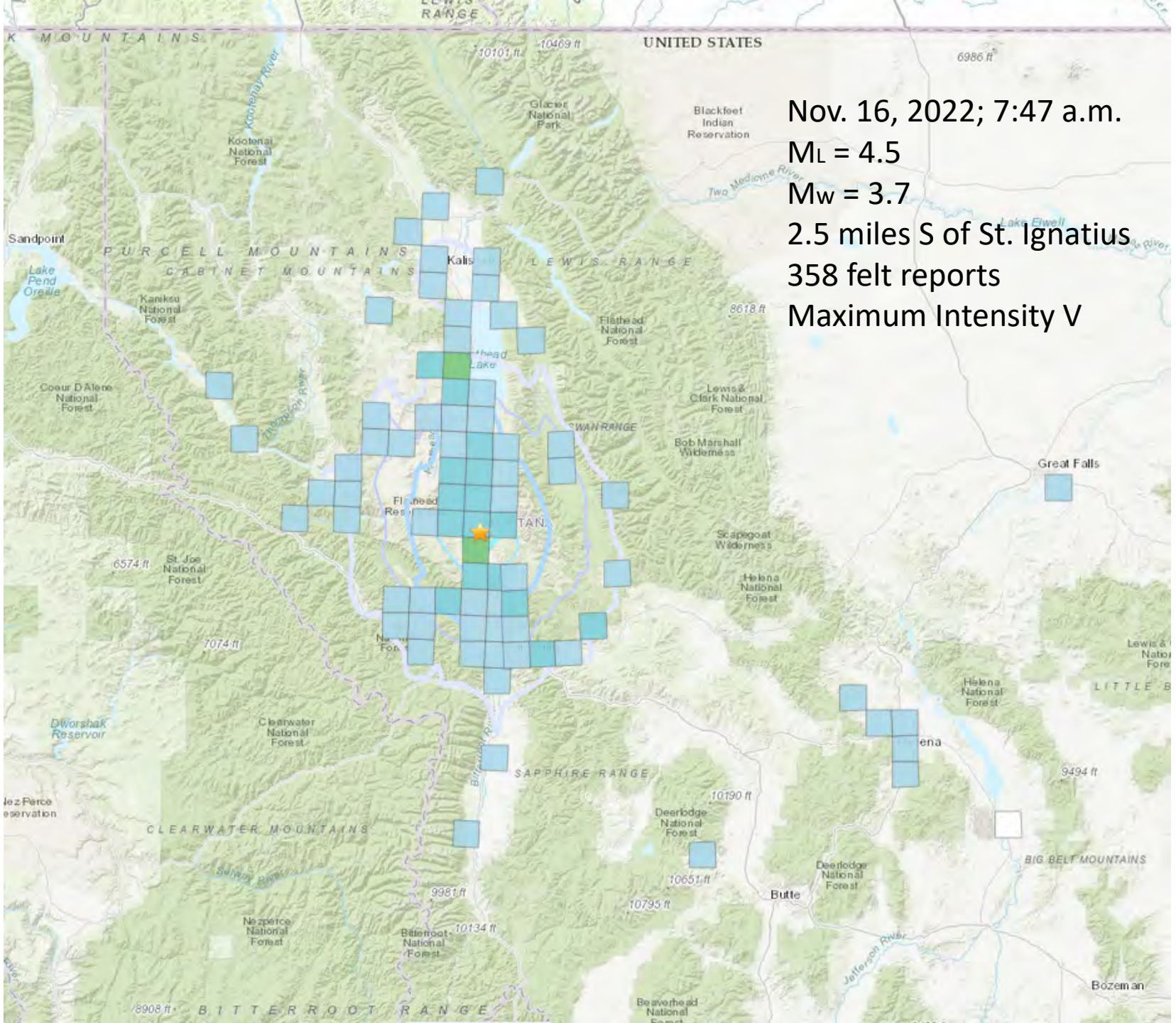
7 quakes M 3.1 – 3.8

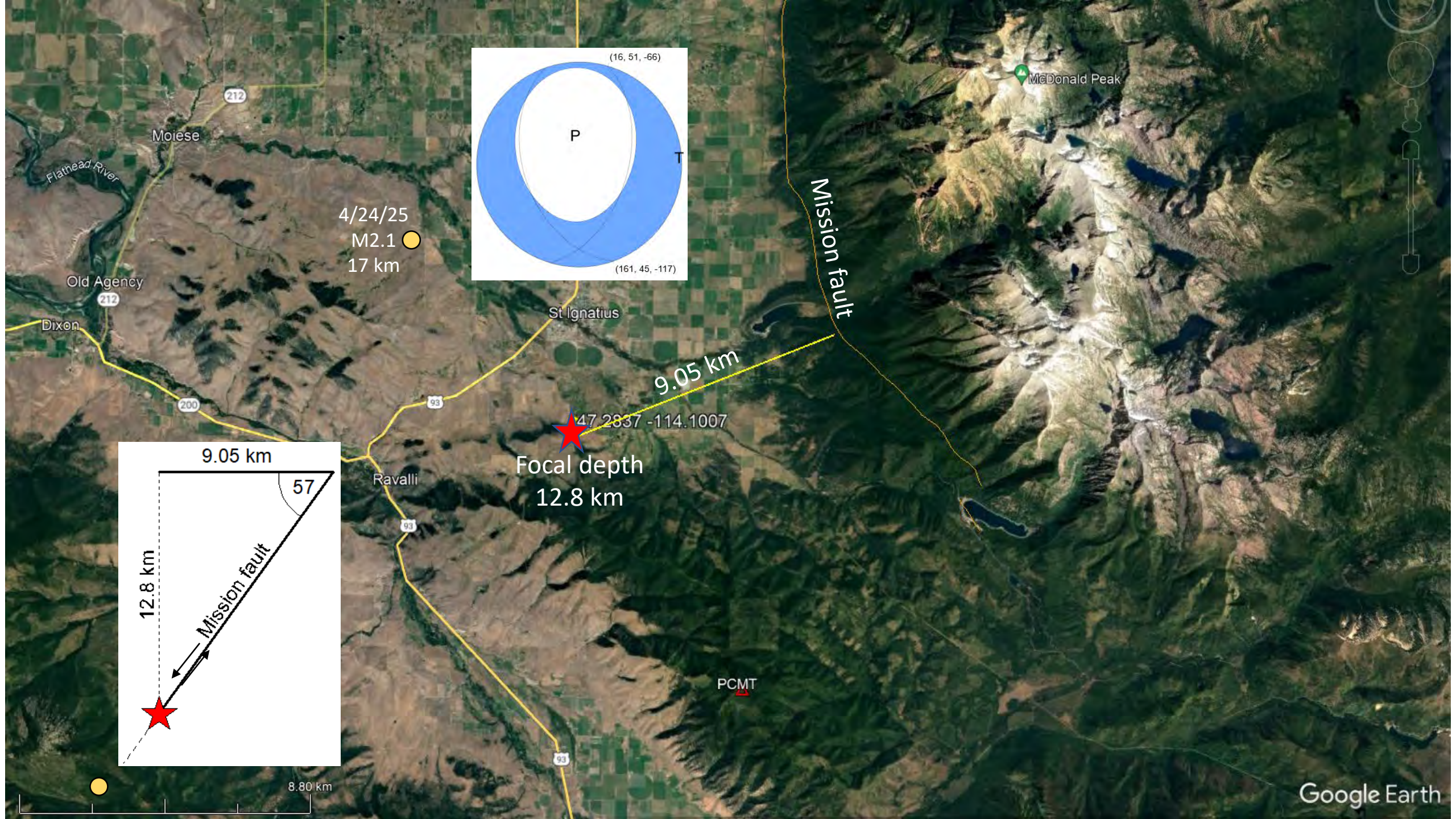
Strongly felt by local residents

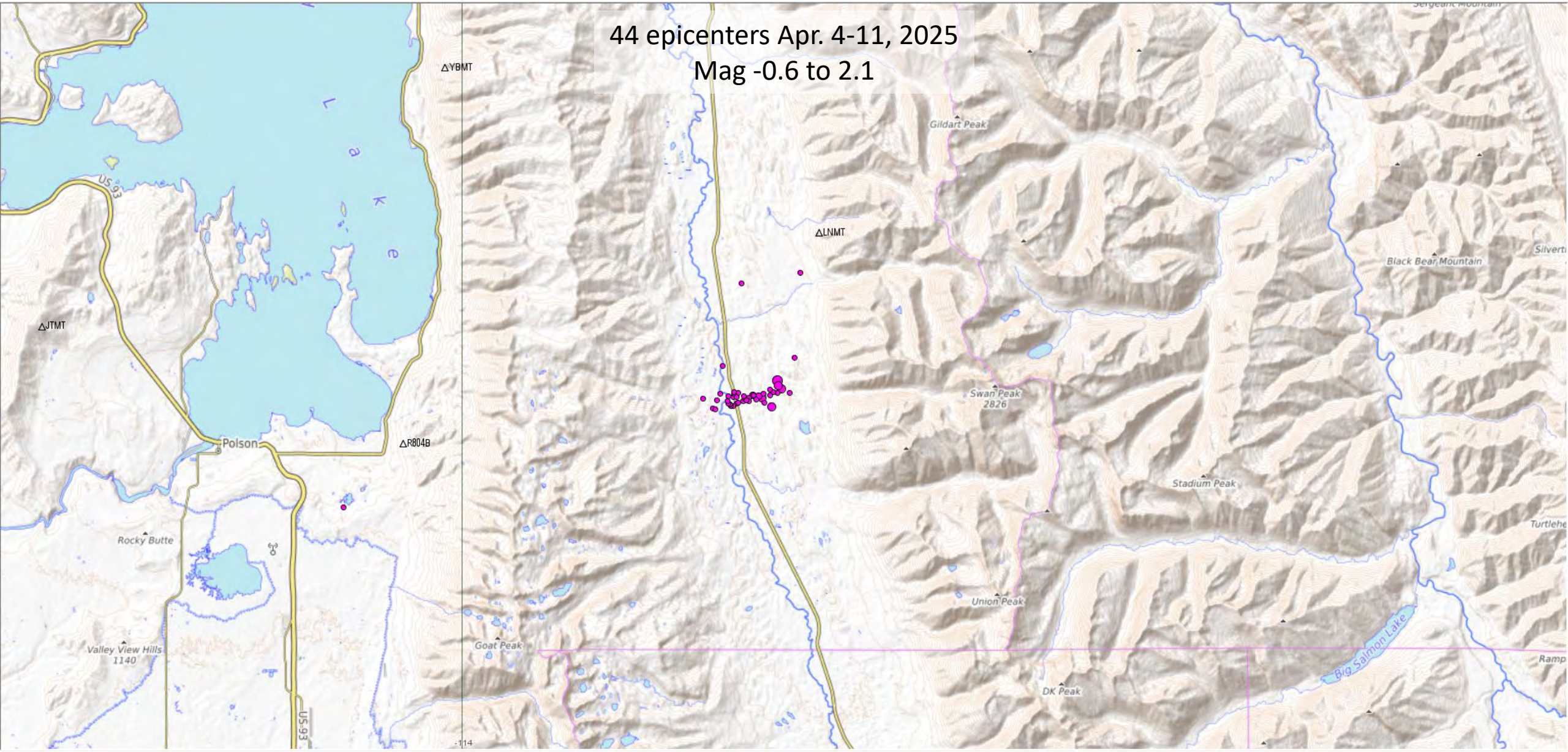


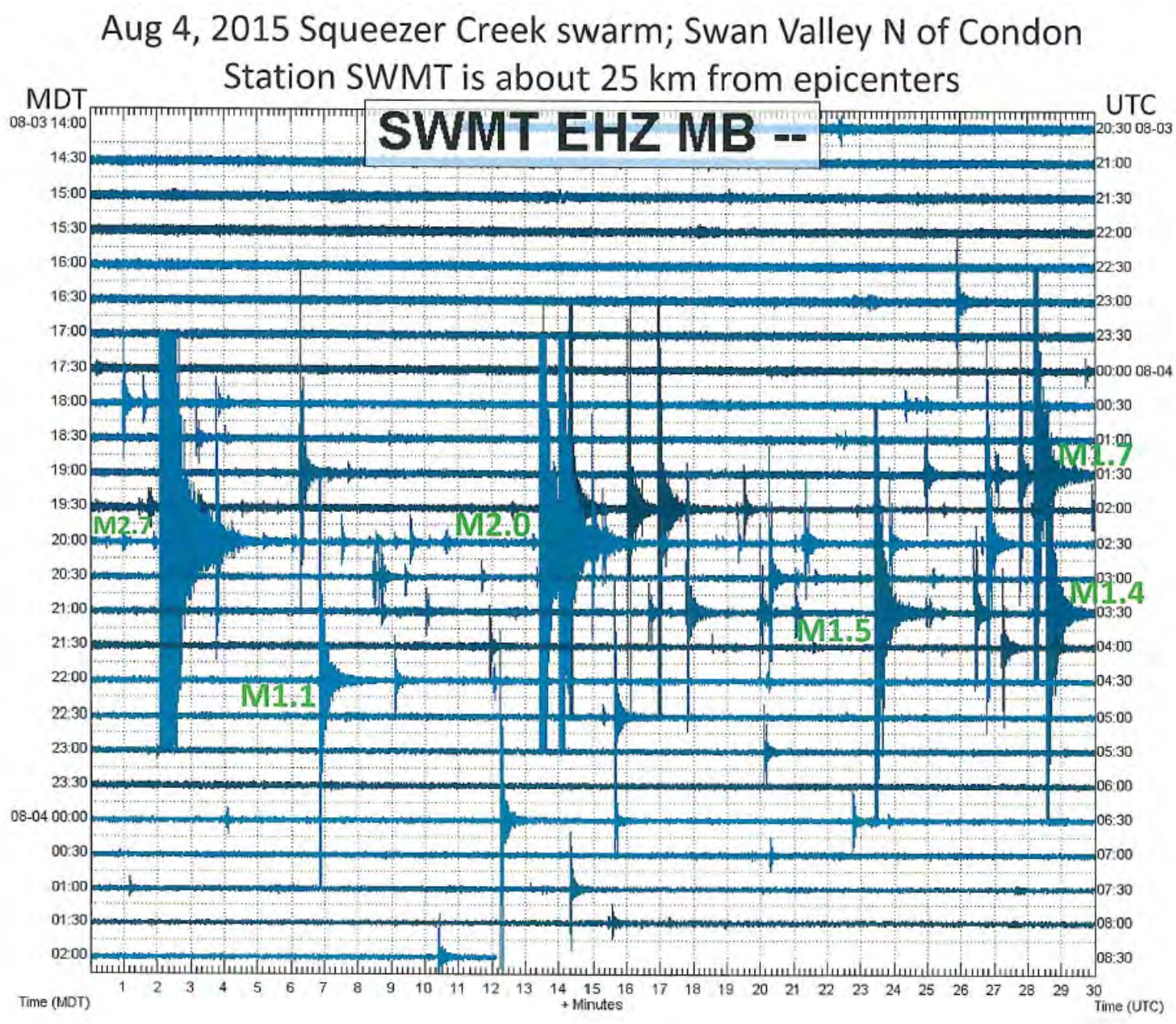

Camas Prairie Basin
Flathead Reservation
Moiese Hills
Jocko Valley
Evaro
Missoula
Lolo National Forest
Lolo
Twin Creeks
Game Ridge
Placid Lake State Park
Seeley Lake
200
83
0 5 10 20 Kilometers
0 4 8 16 Miles


11/15/2014 M 3.9
4/15/1998 M 4.1
0 5 10 20 Kilometers
0 4 8 16 Miles
Whitefish
Columbia Falls
Helena Flats
7424 ft
Hungry Horse Reservoir
Swan Range
John Stevens Canyon
Lewis Range
Ashley Lake
Lost Trail National Wildlife Refuge
Evergreen
Kalispell
Smith
Mount Creek
Flathead Valley
Swan Range
Lakeside
6400 ft
Woods Bay
Swan Lake
Flathead Lake
Big Draw
Flathead National Forest
Kings Point
Swan River
Mission Range
Swan Range
Picture Ridge
Irvine Flats
Polson
7461 ft
2
28


Nov. 16, 2022; 7:47 a.m.
ML = 4.5
Mw = 3.7
2.5 miles S of St. Ignatius
358 felt reports
Maximum Intensity V
UNITED STATES
Sandpoint
Kalispell
Great Falls
Butte
Bozeman
PURCELL MOUNTAINS
CABINET MOUNTAINS
LEWIS RANGE
SAPPHIRE RANGE
CLEARWATER MOUNTAINS
BITTERROOT RANGE
BIG BELT MOUNTAINS
Glacier National Park
Blackfeet Indian Reservation
Kootenai National Forest
Kaniksu National Forest
Flathead National Forest
Lewis & Clark National Forest
Bob Marshall Wilderness
Scapegoat Wilderness
Helena National Forest
Coeur D'Alene National Forest
St Joe National Forest
Clearwater National Forest
Nezperce National Forest
Bitterroot National Forest
Deerlodge National Forest
Beaverhead National Forest
Lake Pend Oreille
Flathead Lake
Dworshak Reservoir
Kootenay River
Clark Fork River
Blackfoot River
Jefferson River
Lake Elwell
10101 ft
10469 ft
6986 ft
8618 ft
6574 ft
7074 ft
9494 ft
10190 ft
10651 ft
10795 ft
9981 ft
10134 ft
8908 ft


(16, 51, -66)
P
T
(161, 45, -117)
4/24/25
M2.1
17 km
Moiese
Flathead River
Old Agency
Dixon
St Ignatius
Ravalli
McDonald Peak
Mission fault
9.05 km
47.2837 -114.1007
Focal depth
12.8 km
PCMT
9.05 km
57
12.8 km
Mission fault
8.80 km
Google Earth


44 epicenters Apr. 4-11, 2025
Mag -0.6 to 2.1
Lake
US 93
Polson
Rocky Butte
Valley View Hills
1140
US 93
△YBMT
△LNMT
△JTMT
△R804B
Gildart Peak
Black Bear Mountain
Swan Peak
2826
Stadium Peak
Union Peak
Goat Peak
DK Peak
Big Salmon Lake
114


Aug 4, 2015 Squeezer Creek swarm; Swan Valley N of Condon
Station SWMT is about 25 km from epicenters
SWMT EHZ MB --
MDT
UTC
08-03 14:00
14:30
15:00
15:30
16:00
16:30
17:00
17:30
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
08-04 00:00
00:30
01:00
01:30
02:00
20:30 08-03
21:00
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22:00
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23:00
23:30
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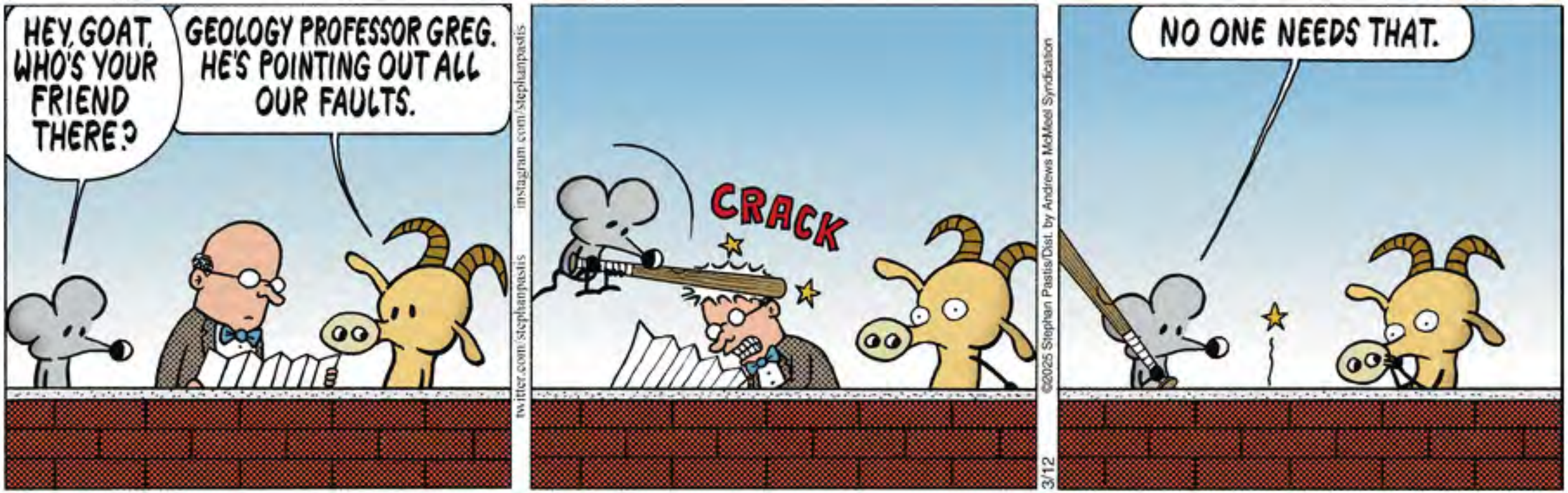
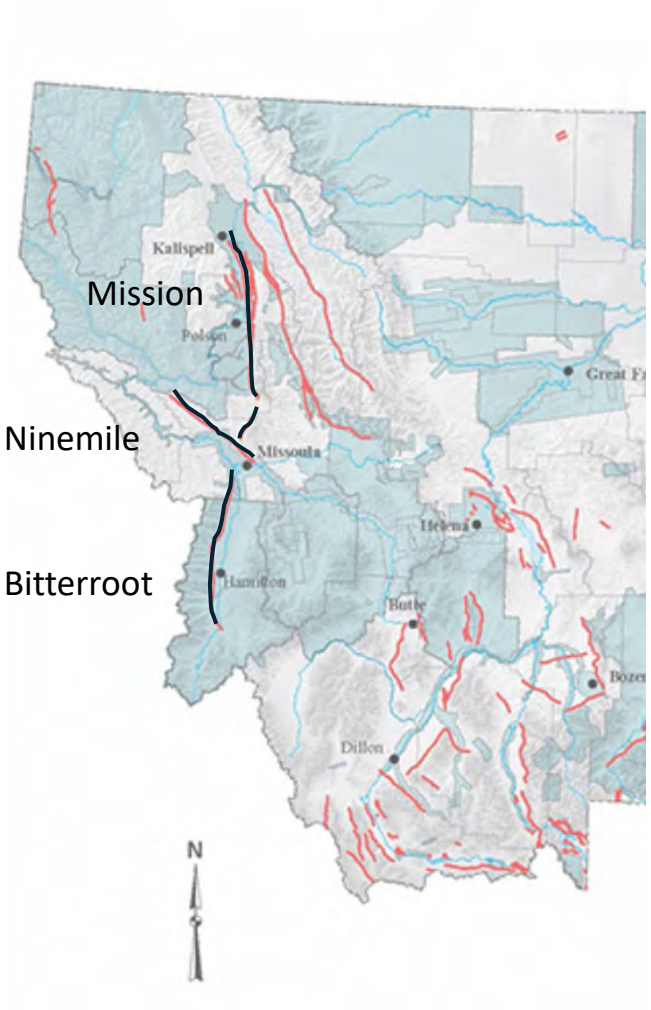
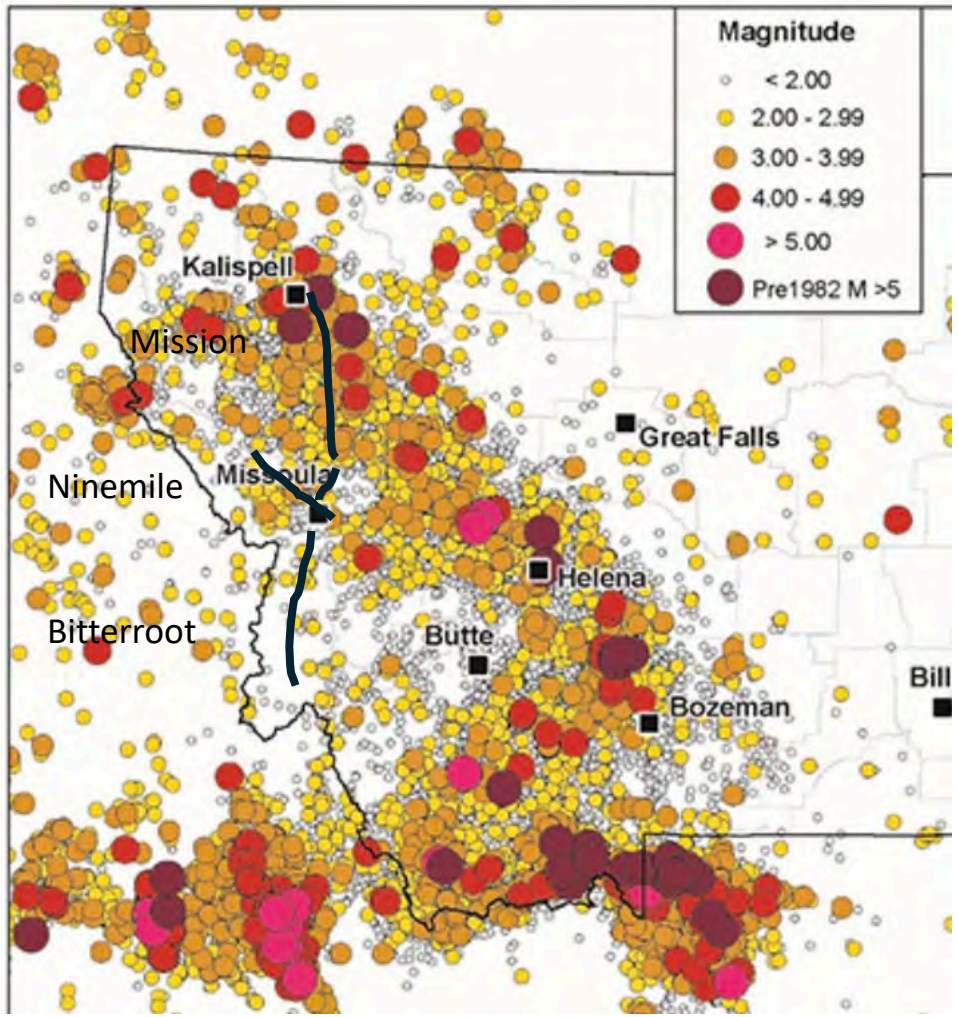
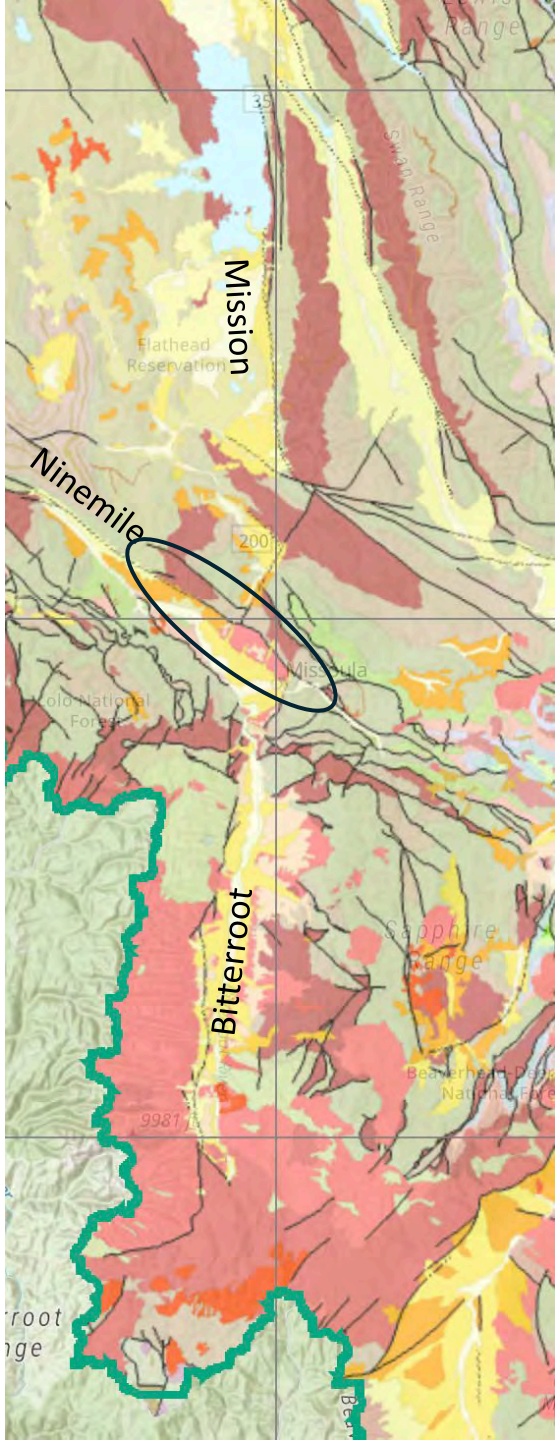
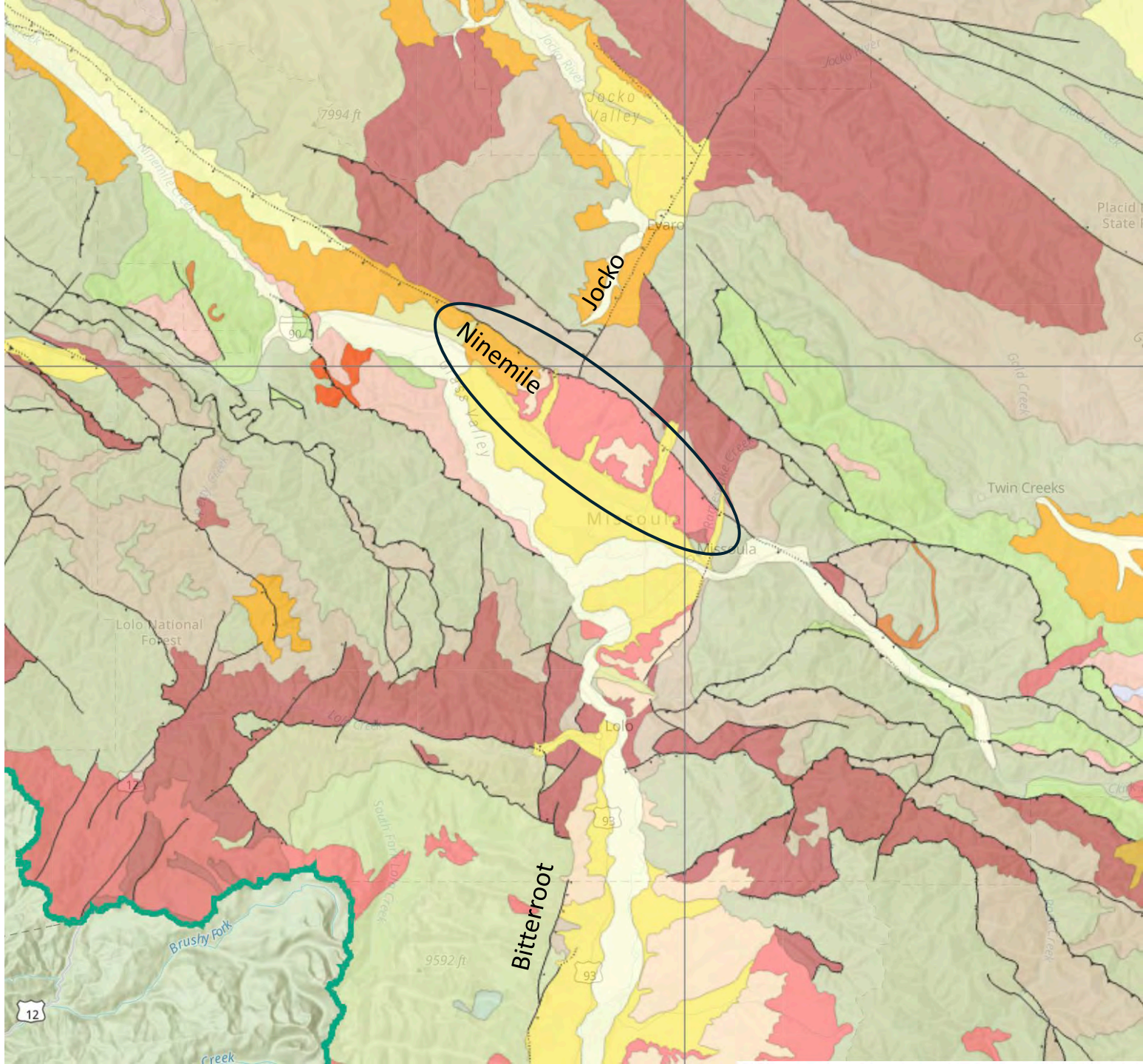
06:30
07:00
07:30
08:00
08:30
M2.7
M2.0
M1.7
M1.4
M1.5
M1.1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Time (MDT)
+ Minutes
Time (UTC)

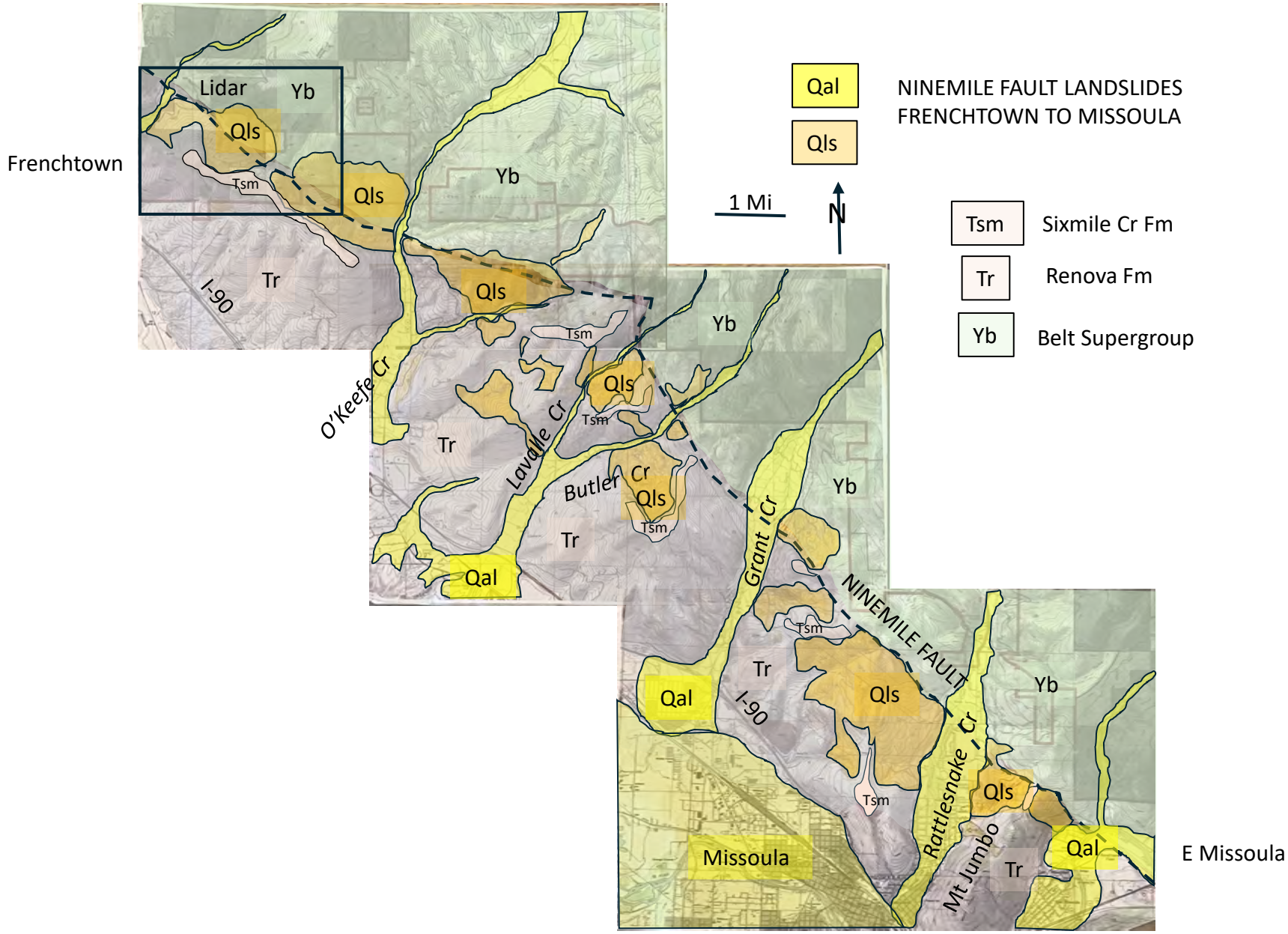

HEY, GOAT, WHO'S YOUR FRIEND THERE?
GEOLOGY PROFESSOR GREG. HE'S POINTING OUT ALL OUR FAULTS.
twitter.com/stephanpastis
instagram.com/stephanpastis
CRACK
3/12
©2025 Stephan Pastis/Dist. by Andrews McMeel Syndication
NO ONE NEEDS THAT.


Kalispell
Mission
Polson
Missoula
Ninemile
Helena
Bitterroot
Hamilton
Butte
Dillon
N


Magnitude
< 2.00
2.00 - 2.99
3.00 - 3.99
4.00 - 4.99
> 5.00
Pre1982 M >5
Kalispell
Mission
Great Falls
Missoula
Ninemile
Helena
Bitterroot
Butte
Bozeman

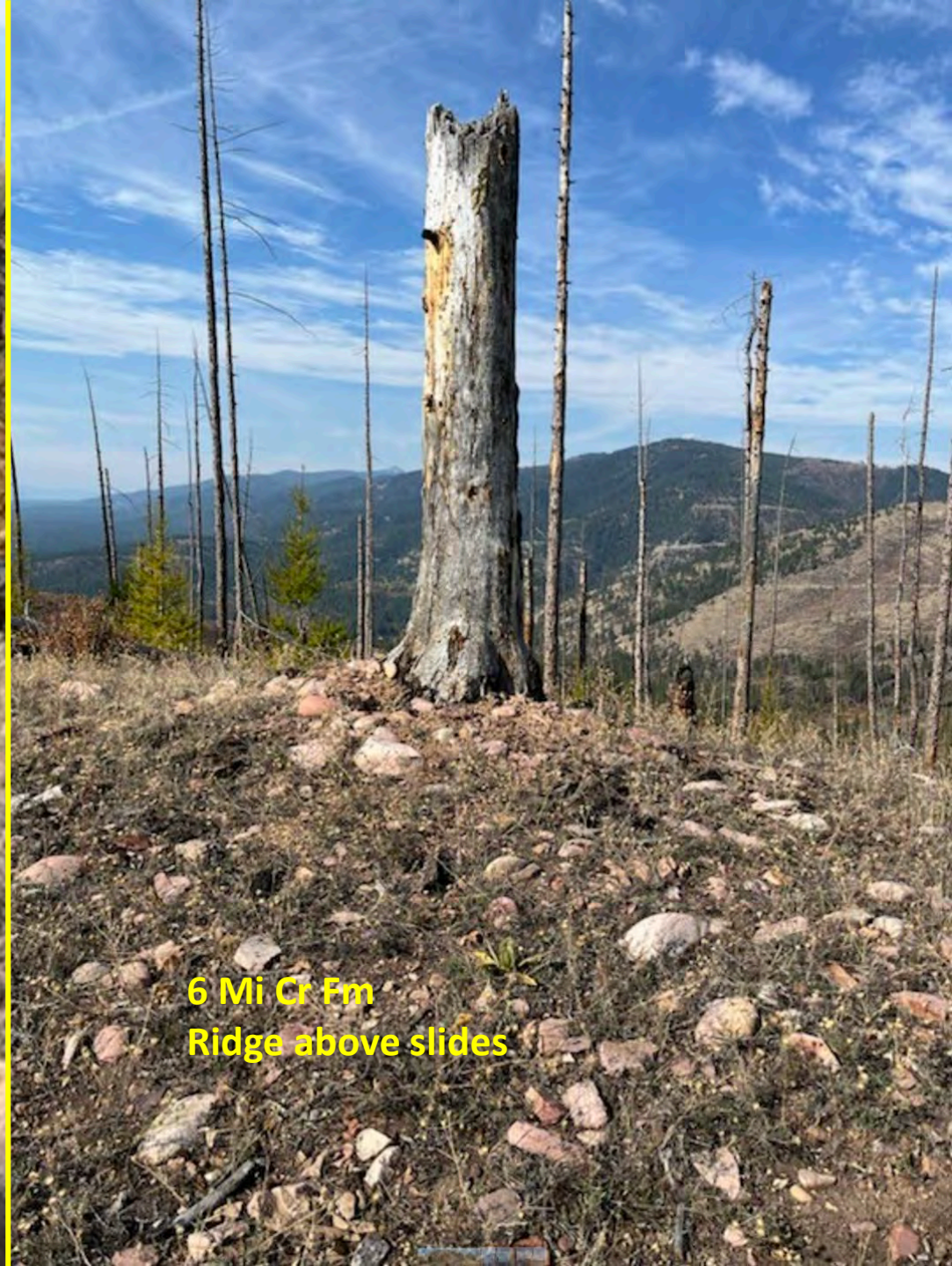

Mission
Ninemile
Bitterroot

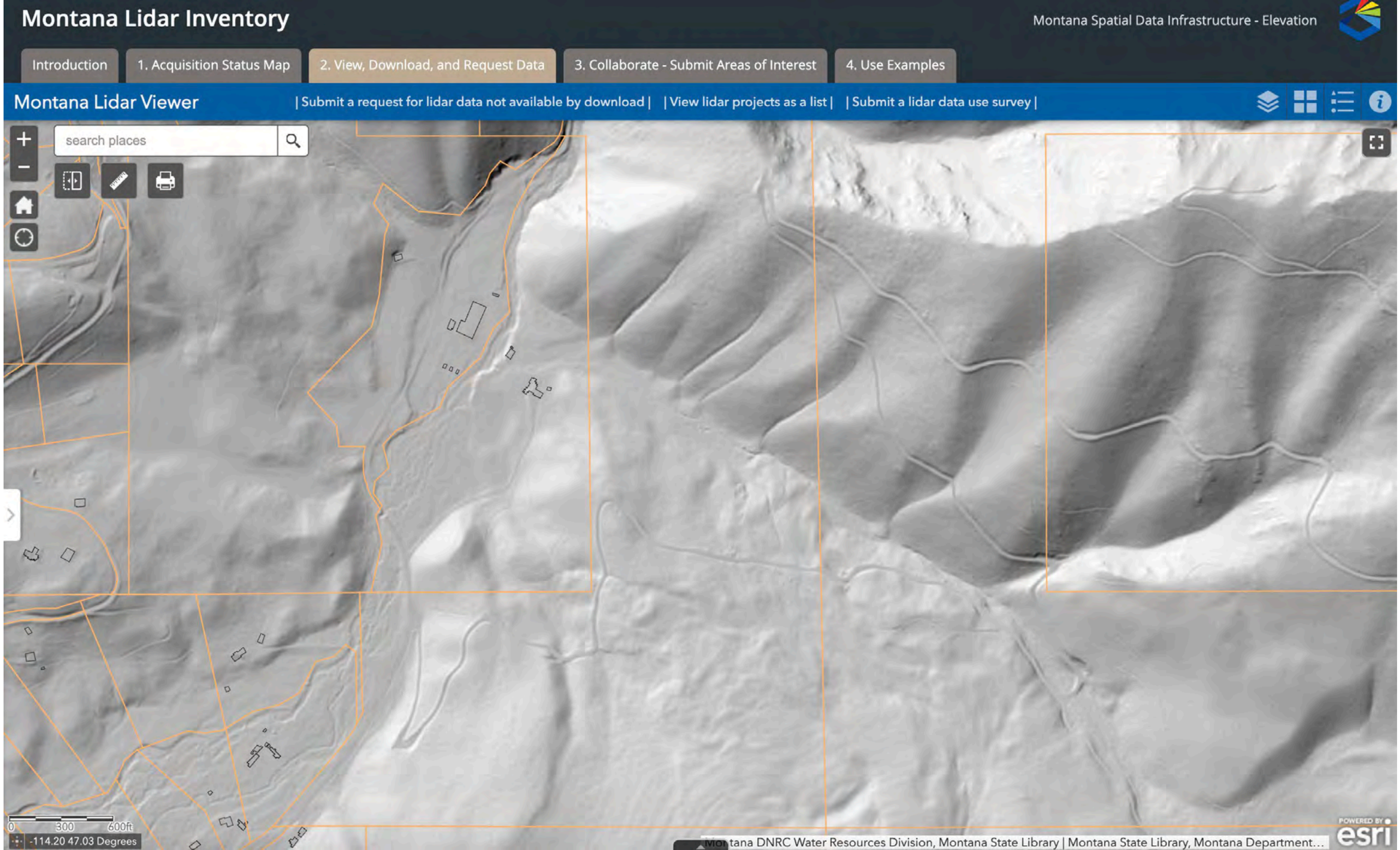

Jocko
Ninemile
Bitterroot
Missoula
Lolo
Twin Creeks
Lolo National Forest
Brushy Fork


Frenchtown
Lidar
Yb
Qls
Tsm
Qls
Yb
Tr
I-90
Qls
Tsm
Yb
O'Keefe Cr
Qls
Tsm
Tr
Lavalle Cr
Butler Cr
Qls
Tsm
Tr
Qal
Grant Cr
Yb
NINEMILE FAULT
Tsm
Tr
Qal
I-90
Qls
Yb
Rattlesnake Cr
Qls
Tsm
Missoula
Mt Jumbo
Tr
Qal
Qal
Qls
1 Mi
N
NINEMILE FAULT LANDSLIDES
FRENCHTOWN TO MISSOULA
Tsm
Sixmile Cr Fm
Tr
Renova Fm
Yb
Belt Supergroup
E Missoula

Lavalle Creek
HW tilted Renova
View SE

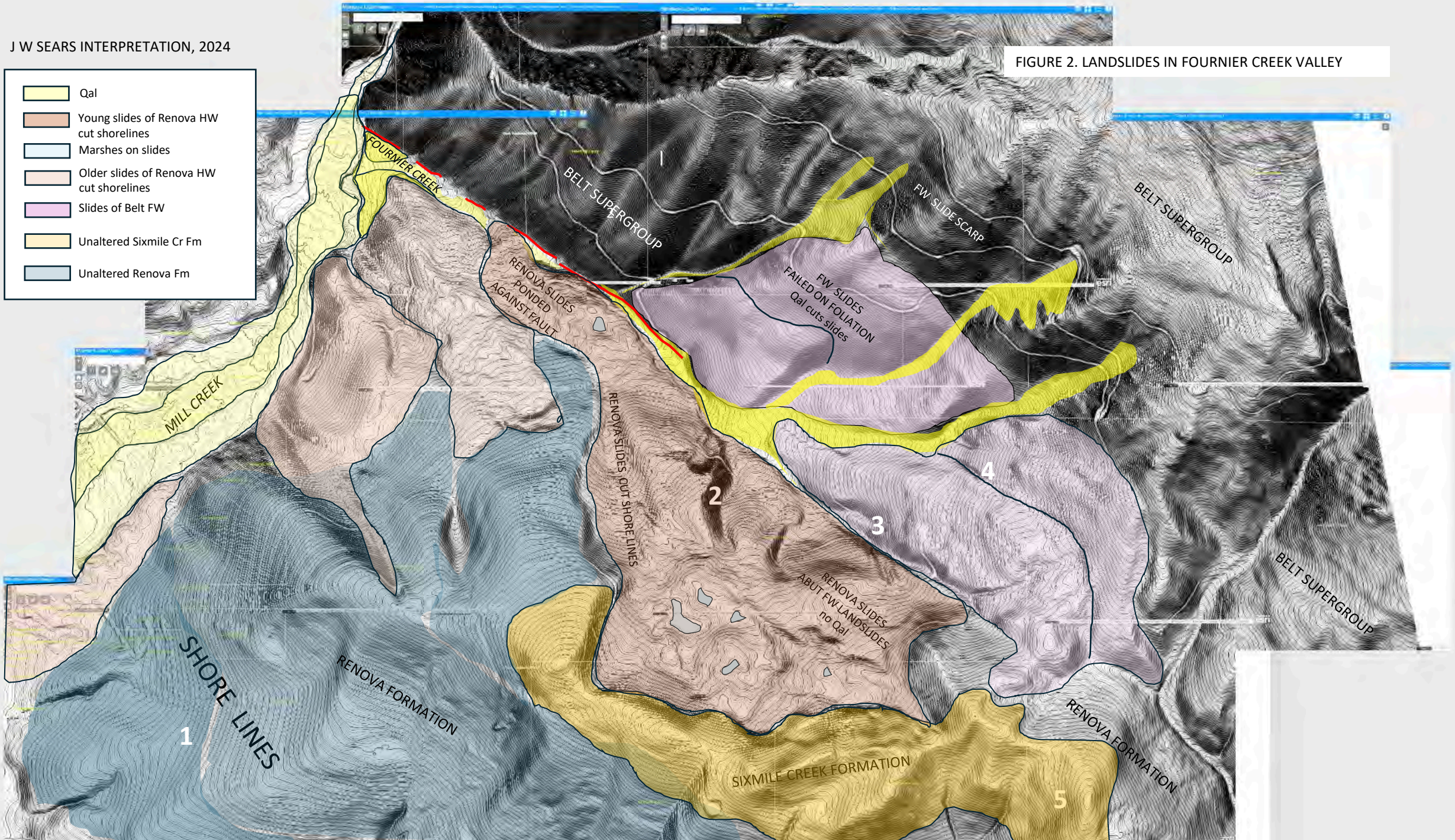

6 Mi Cr Fm
Ridge above slides


6 Mi Cr Fm
Ridge above slides

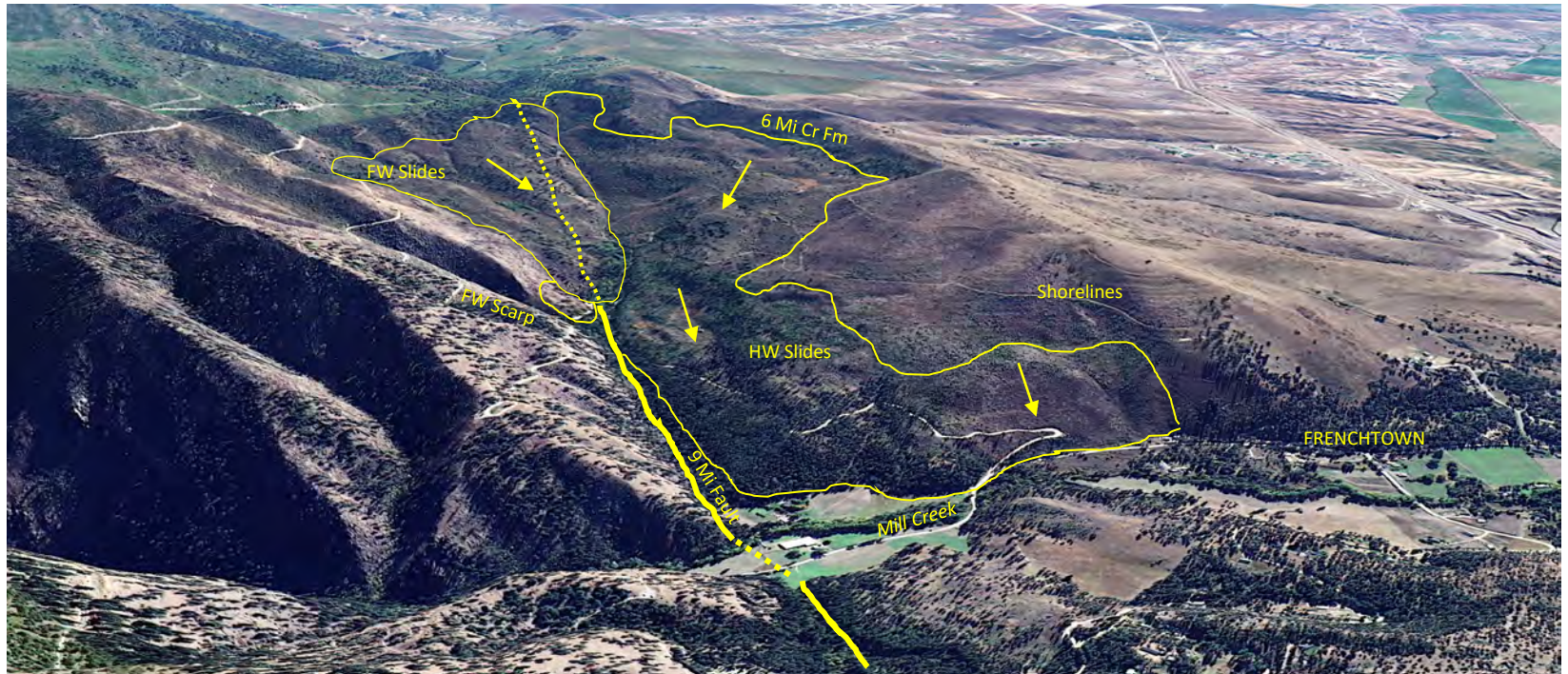

Montana Lidar Inventory
Montana Spatial Data Infrastructure - Elevation
Introduction
1. Acquisition Status Map
2. View, Download, and Request Data
3. Collaborate - Submit Areas of Interest
4. Use Examples
Montana Lidar Viewer
| Submit a request for lidar data not available by download |
| View lidar projects as a list |
| Submit a lidar data use survey |
search places
0
300
600ft
-114.20 47.03 Degrees
tana DNRC Water Resources Division, Montana State Library | Montana State Library, Montana Department…
POWERED BY esri

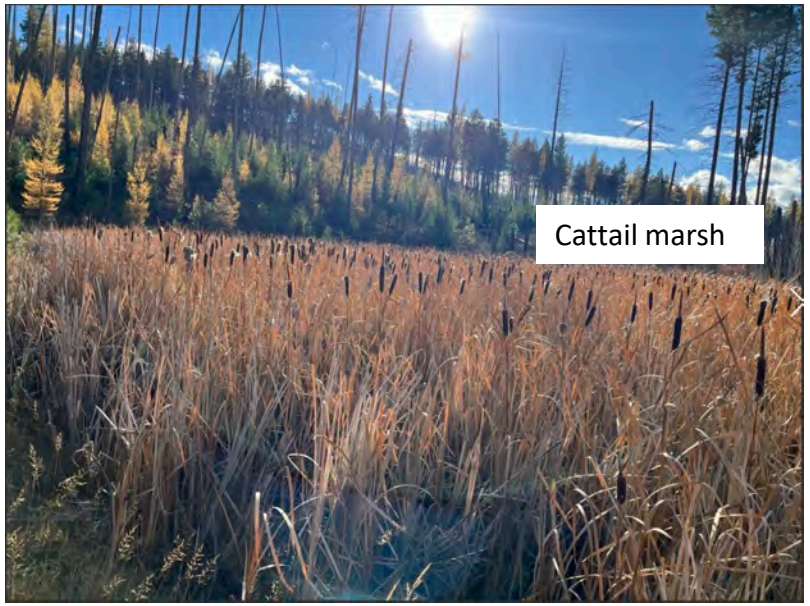
J W SEARS INTERPRETATION, 2024

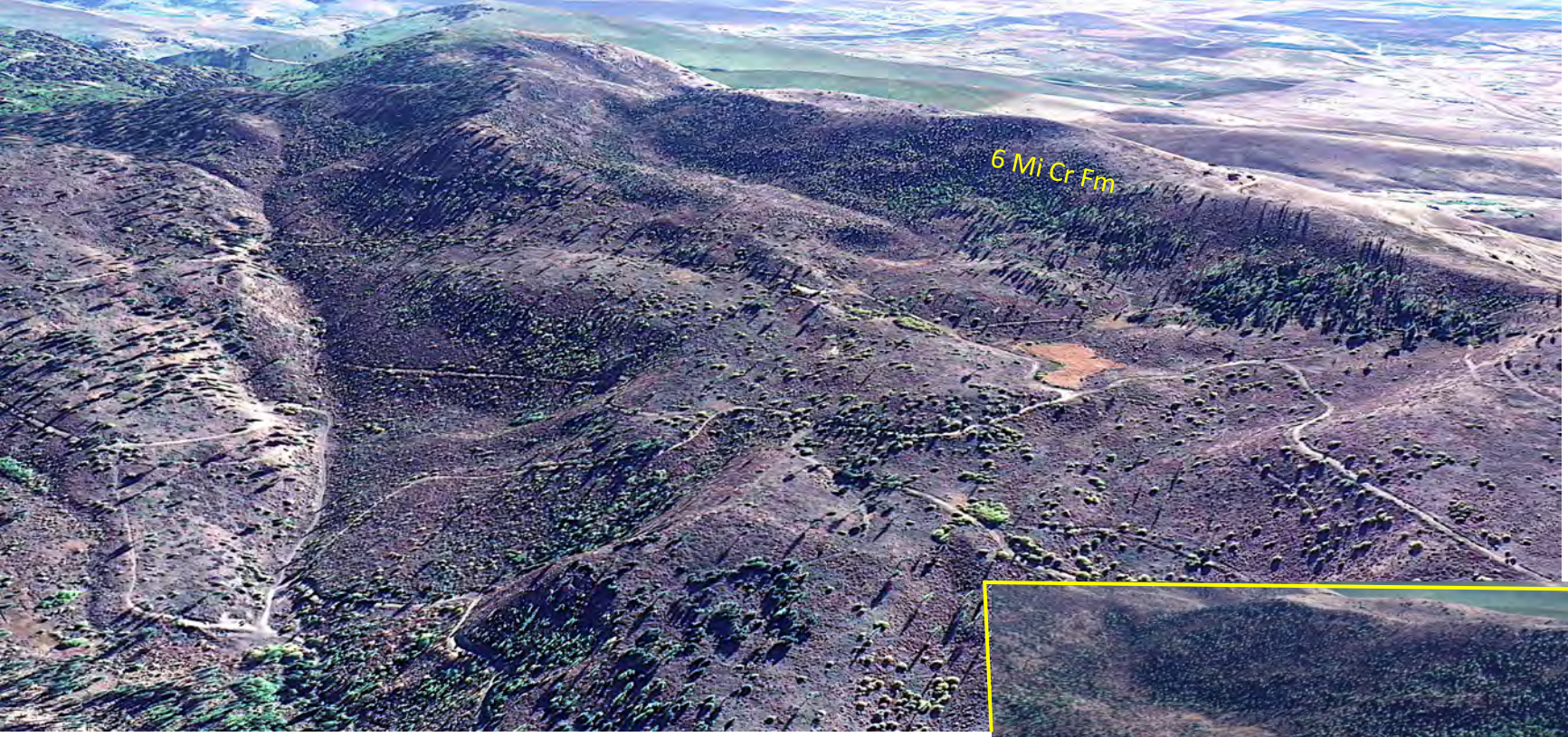
FIGURE 2. LANDSLIDES IN FOURNIER CREEK VALLEY



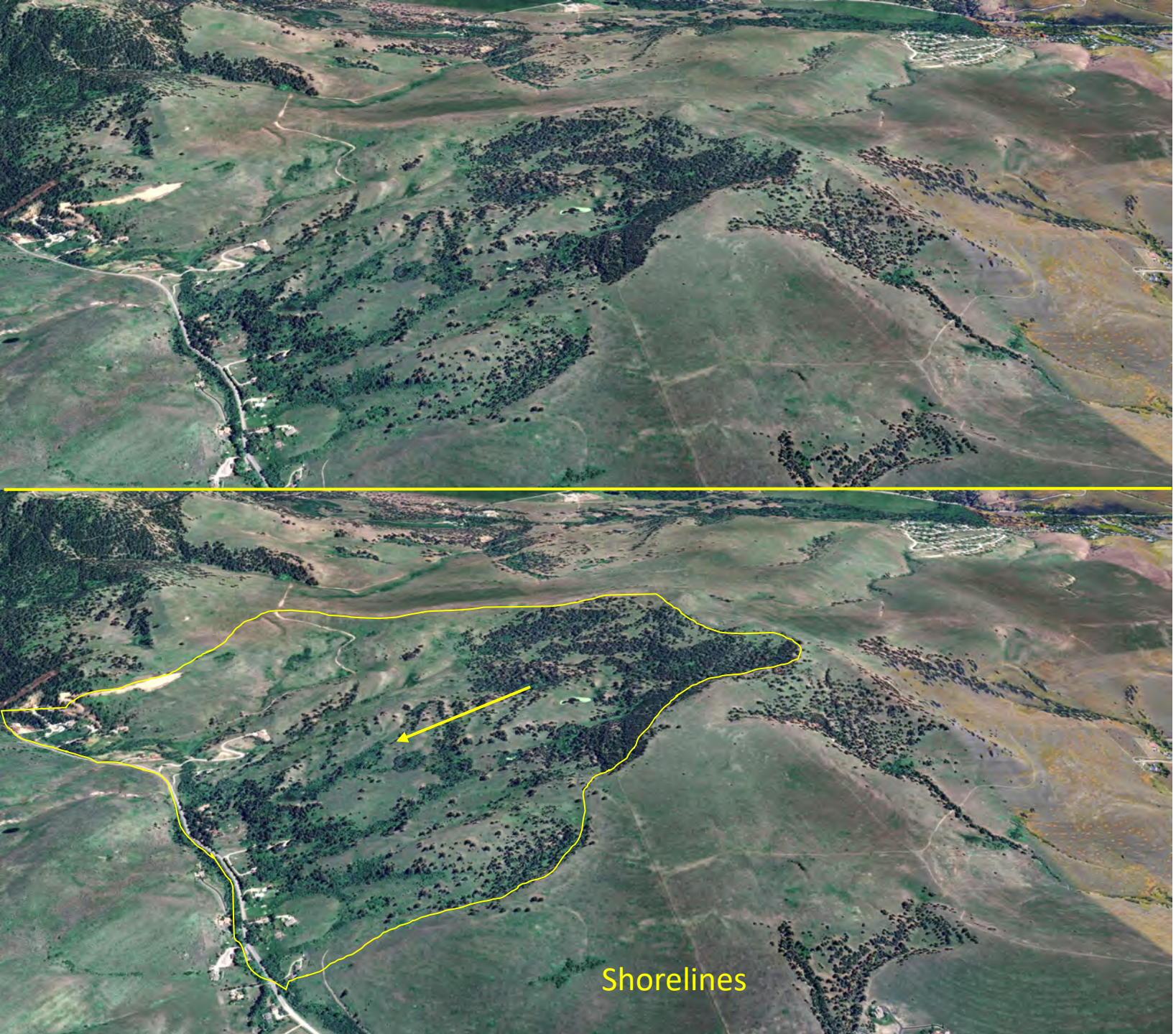
9 Mile Fault at Mill Creek
Near Frenchtown
View SE



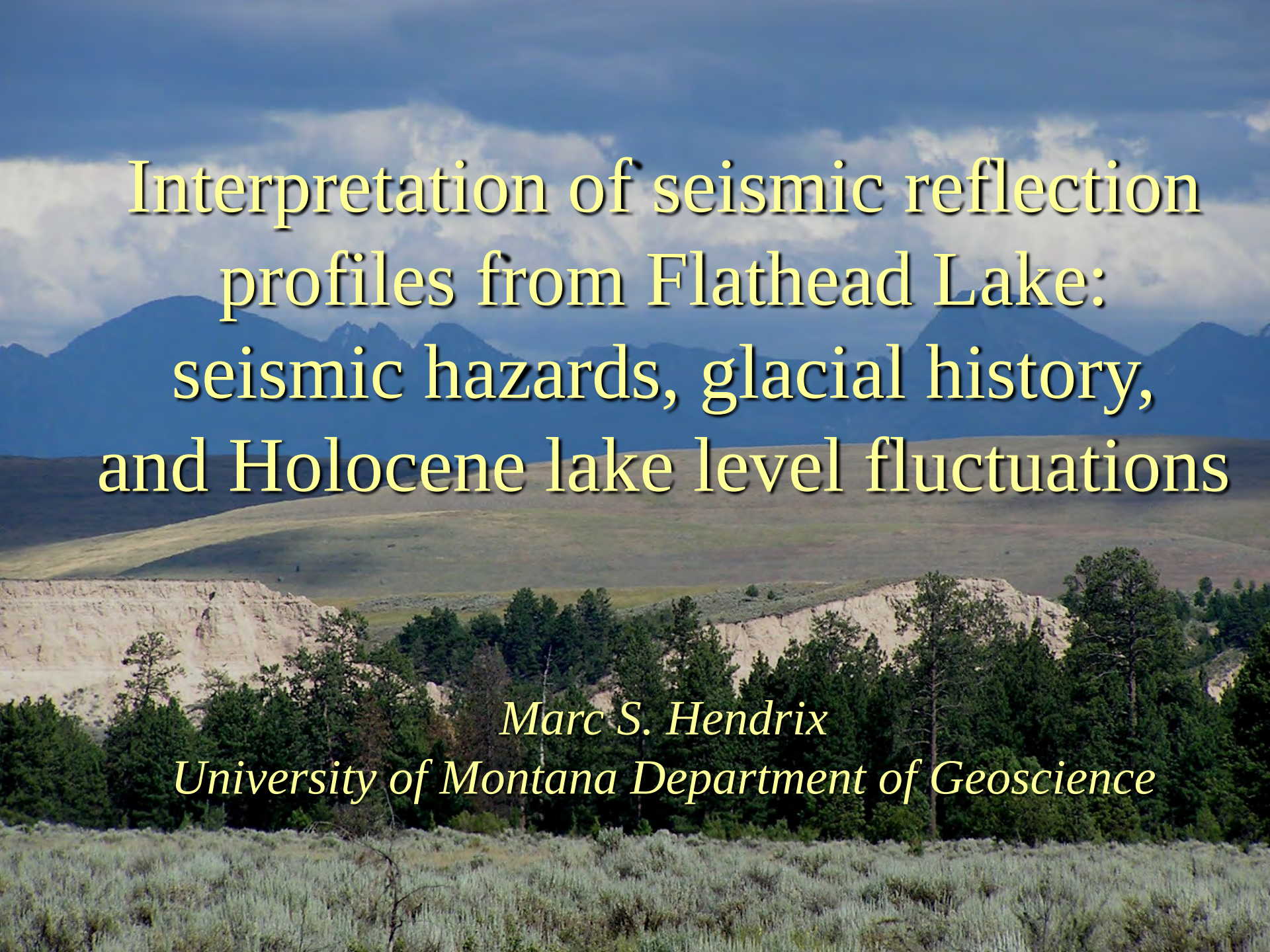




Detail of cattail marshes
HW slides

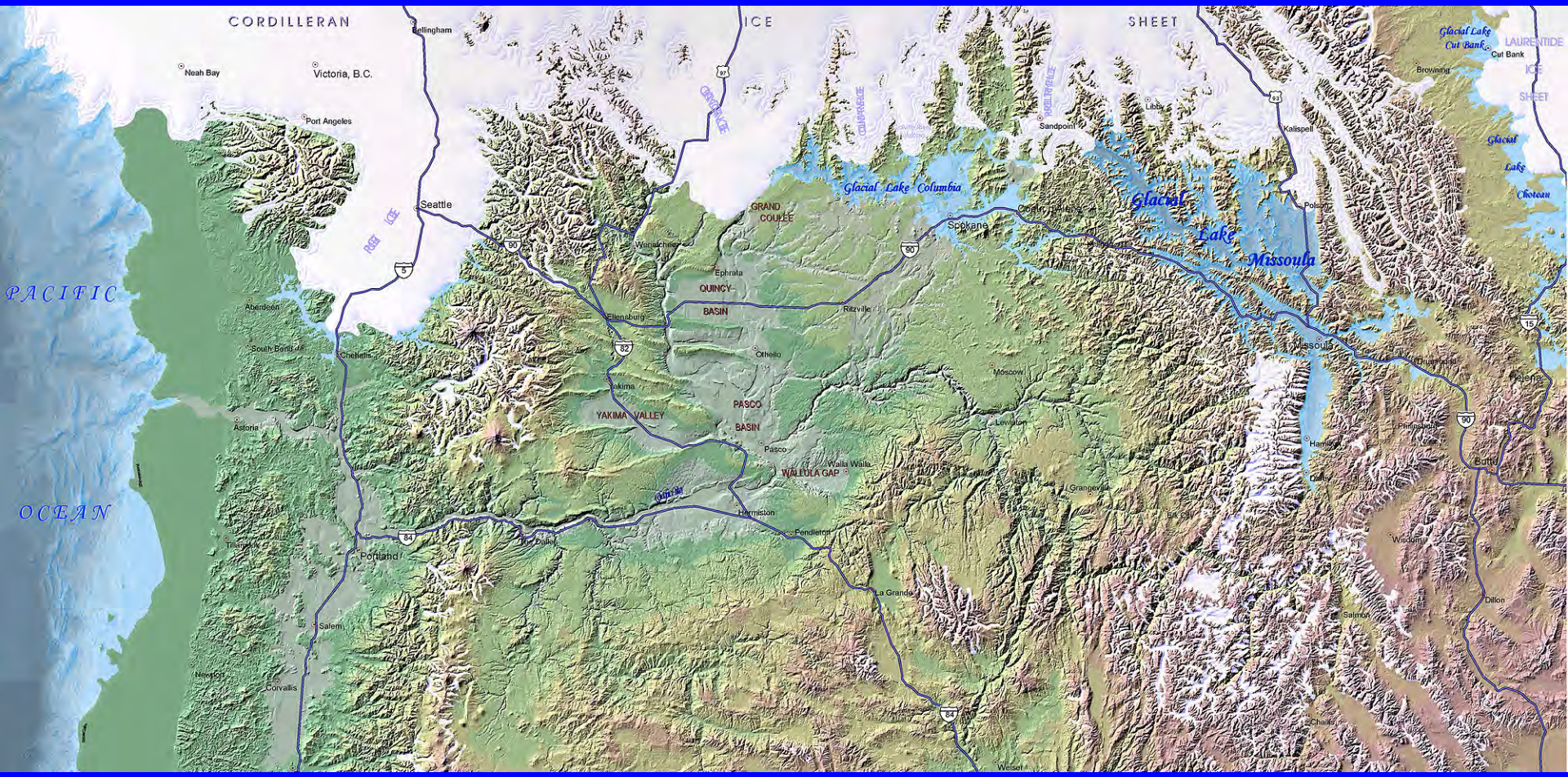


Butler Creek
HW Slide
View E



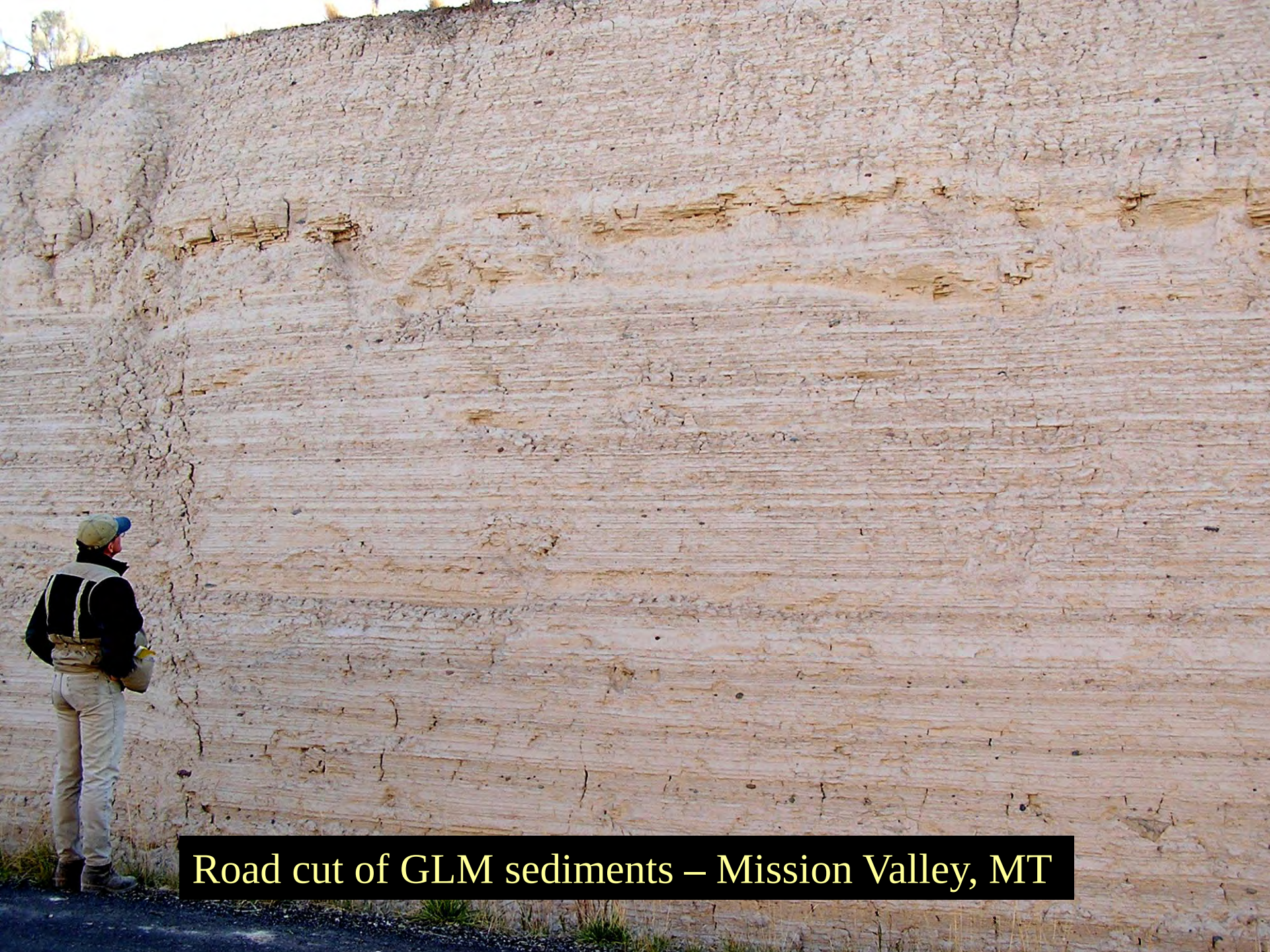
Interpretation of seismic reflection profiles from Flathead Lake: seismic hazards, glacial history, and Holocene lake level fluctuations

Marc S. Hendrix
University of Montana Department of Geoscience

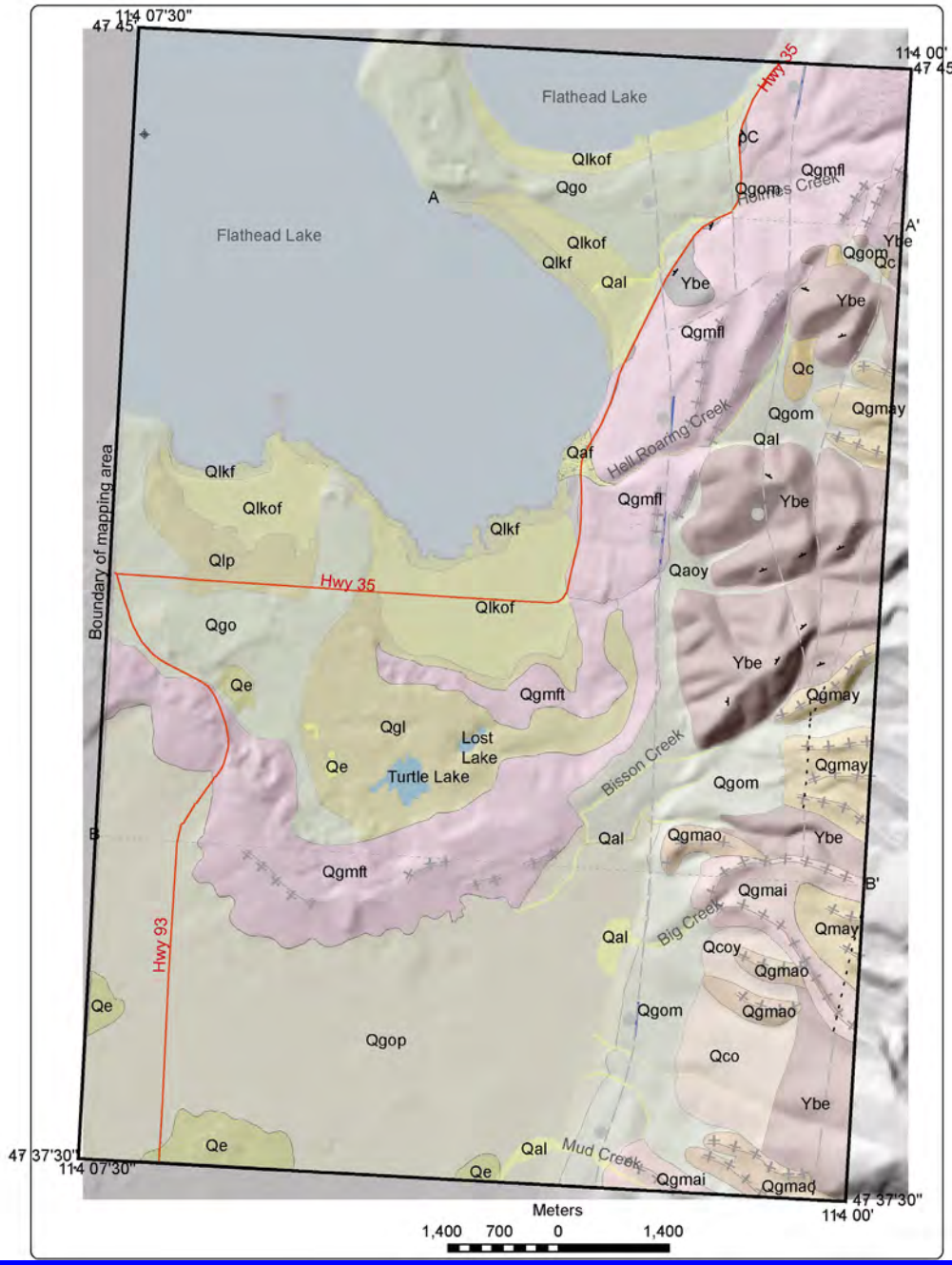


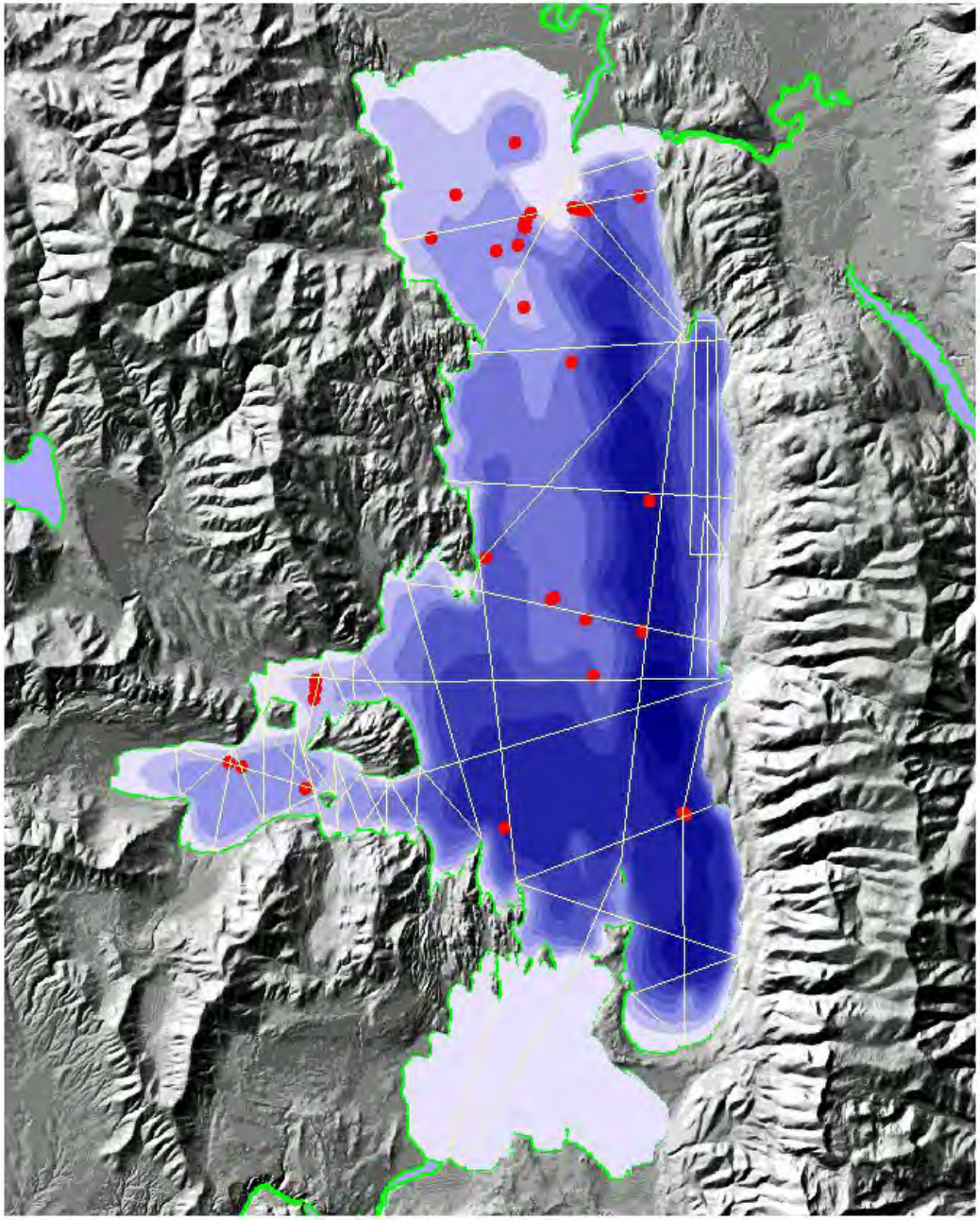
Data provided by USFS

Artificially-exposed GLM sediments -- Polson, MT



Road cut of GLM sediments – Mission Valley, MT


114 07'30"
47 45'
114 00'
47 45'
Flathead Lake
Flathead Lake
Hwy 35
Qc
Qlkof
Qgo
Qgom
Qgmfl
Horns Creek
A
A'
Qlkof
Qlkf
Qal
Ybe
Qgom
Qc
Ybe
Qgmfl
Qc
Qgom
Qgmay
Qal
Hell Roaring Creek
Qaf
Qlkf
Qlkof
Qgmfl
Ybe
Qlkf
Qlp
Hwy 35
Qaoy
Qlkof
Qgo
Ybe
Qe
Qgmft
Qgmay
Qgl
Lost
Lake
Qe
Turtle Lake
Bisson Creek
Qgmay
Qgom
B
Qal
Qgmao
Ybe
Qgmft
Qgmai
B'
Hwy 93
Qal
Big Creek
Qmay
Qcoy
Qgmao
Qe
Qgom
Qgmao
Qgop
Qco
Ybe
Qe
Qal
Mud Creek
Qgmai
Qgmao
Qe
Boundary of mapping area
47 37'30"
114 07'30"
47 37'30"
114 00'
Meters
1,400 700 0 1,400

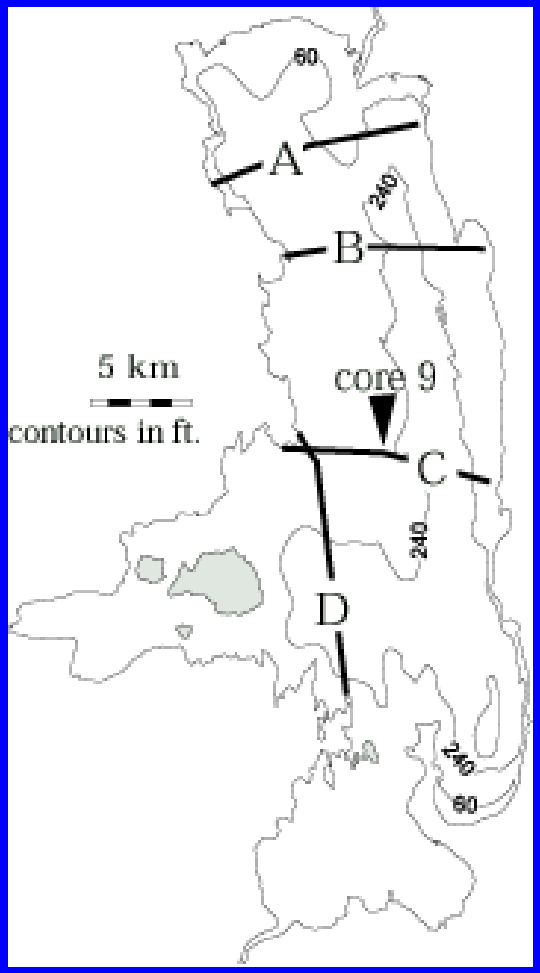


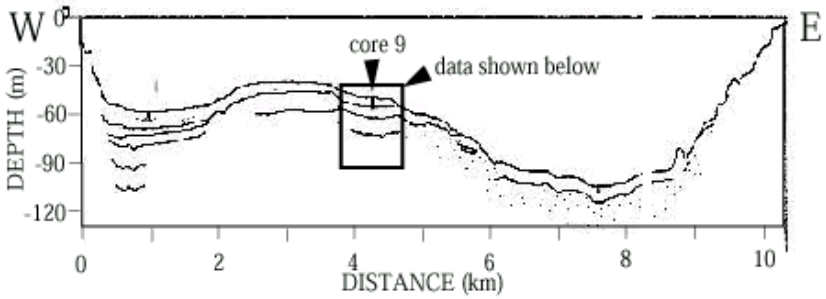
10 km

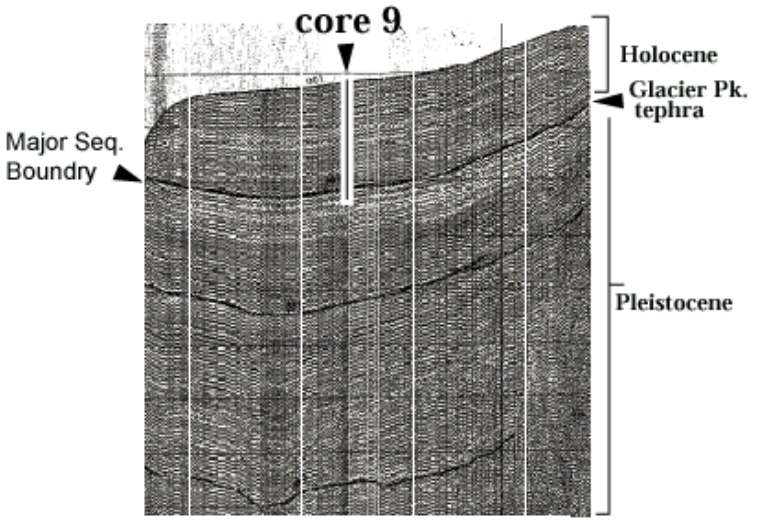

CAROLINA
SKIFF 19

Kullenberg coring apparatus

Excellent Late Pleistocene - Holocene record

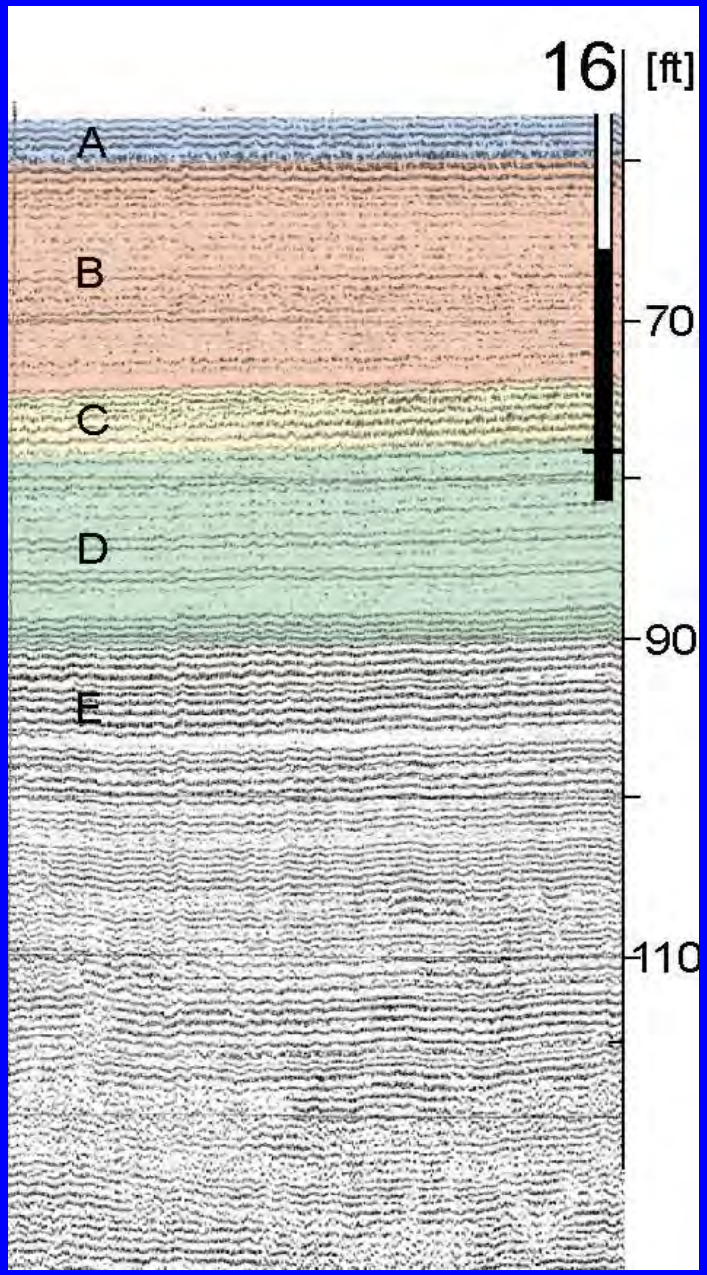


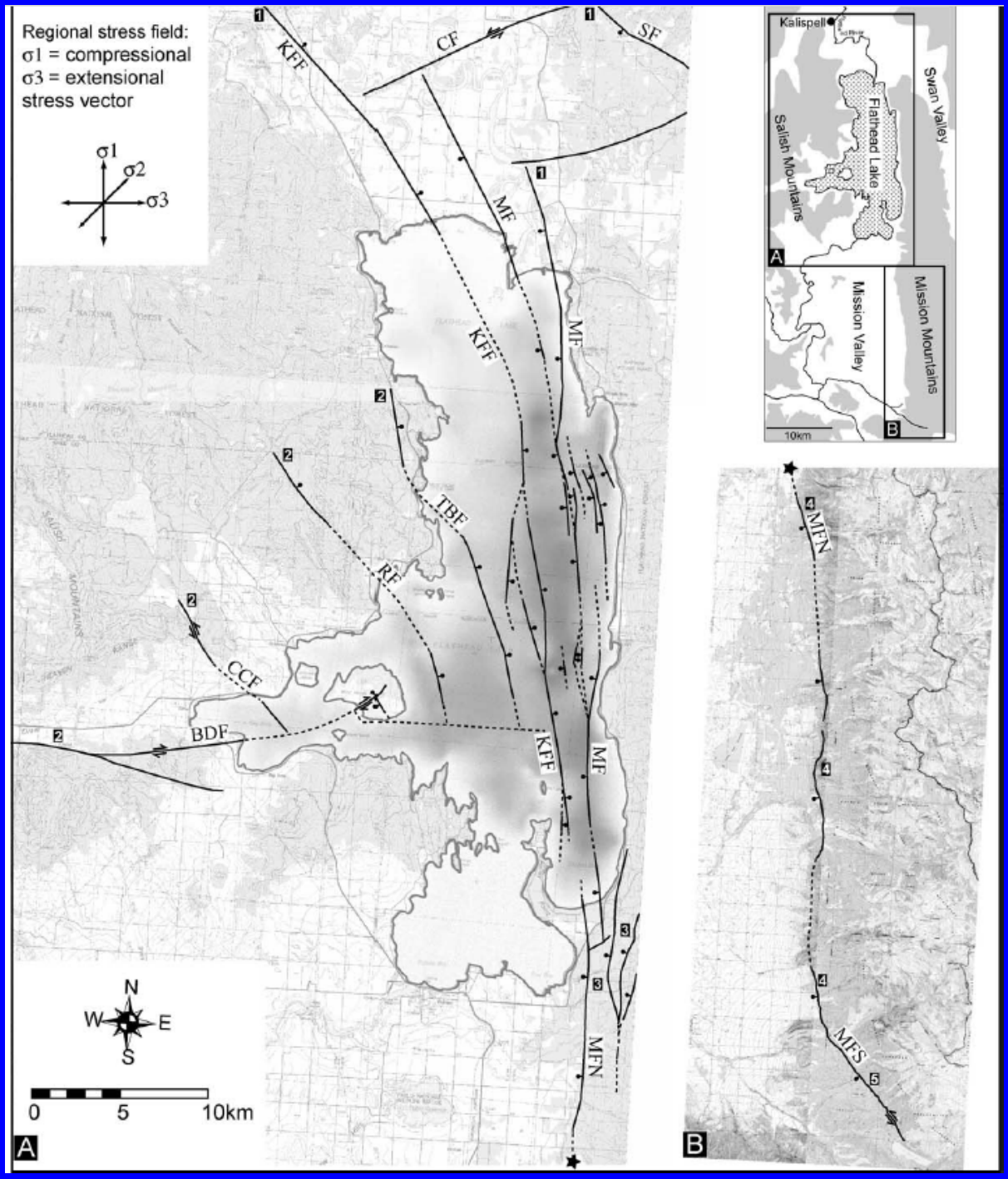


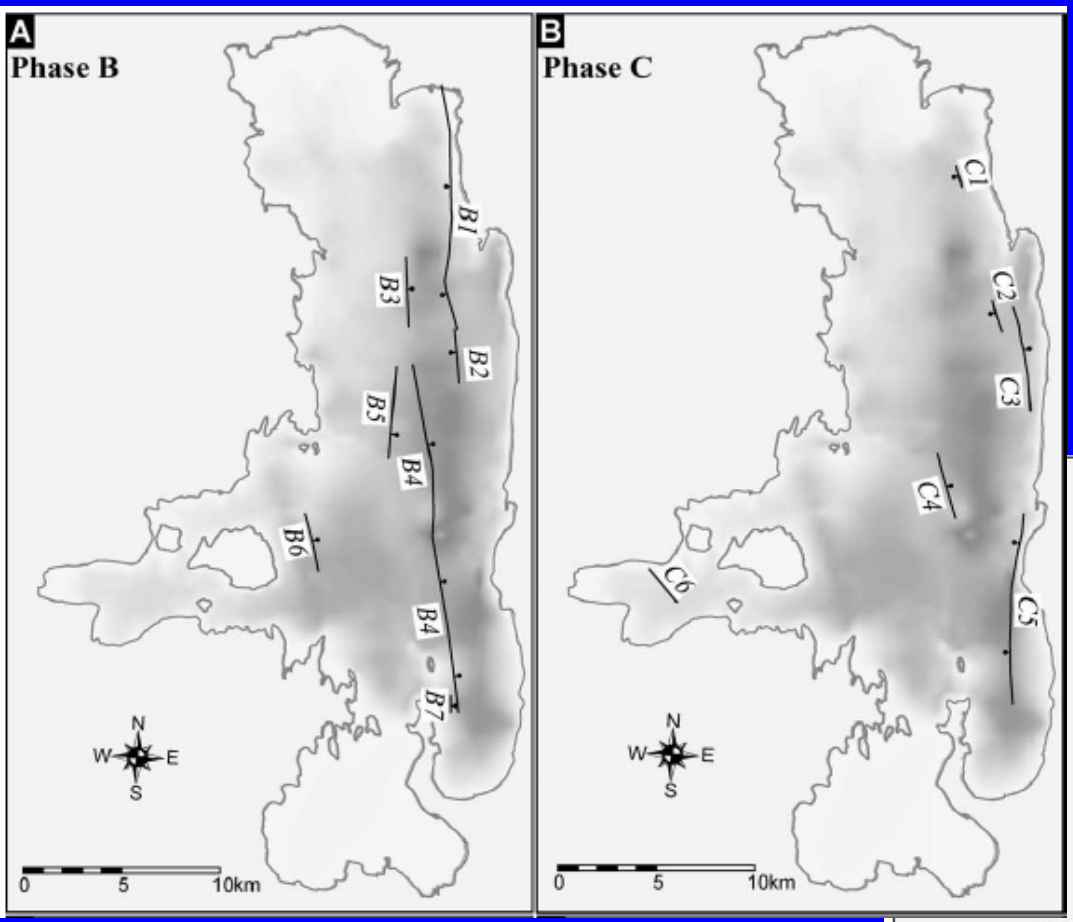


Unpublished 3.5 kHz seismic data and interpretations from Flathead Lake (Kogan 1980)

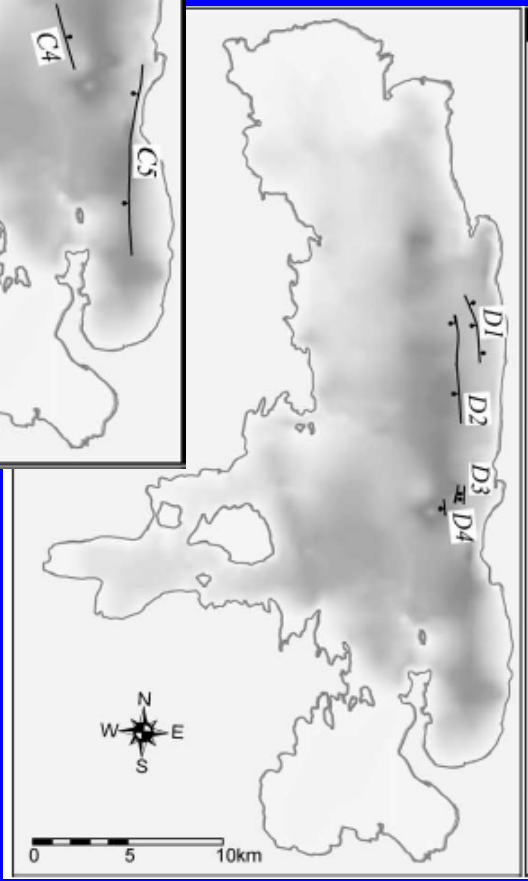
Seismic facies

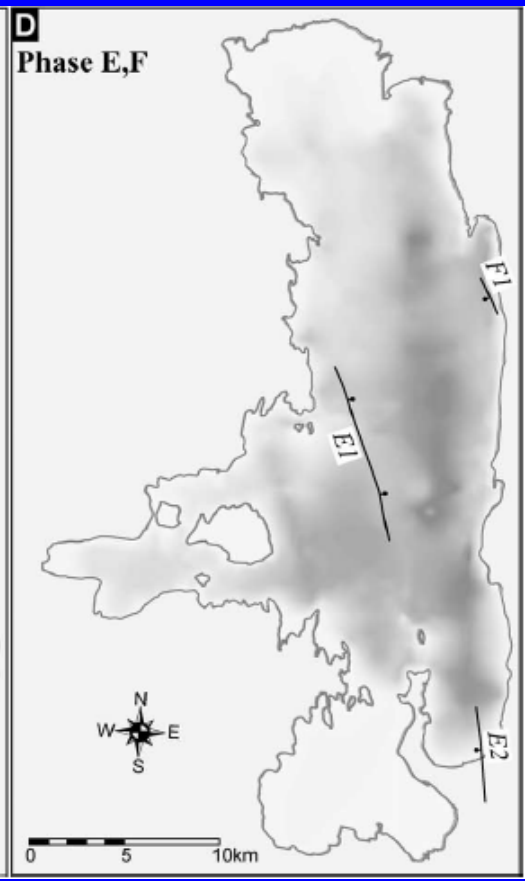


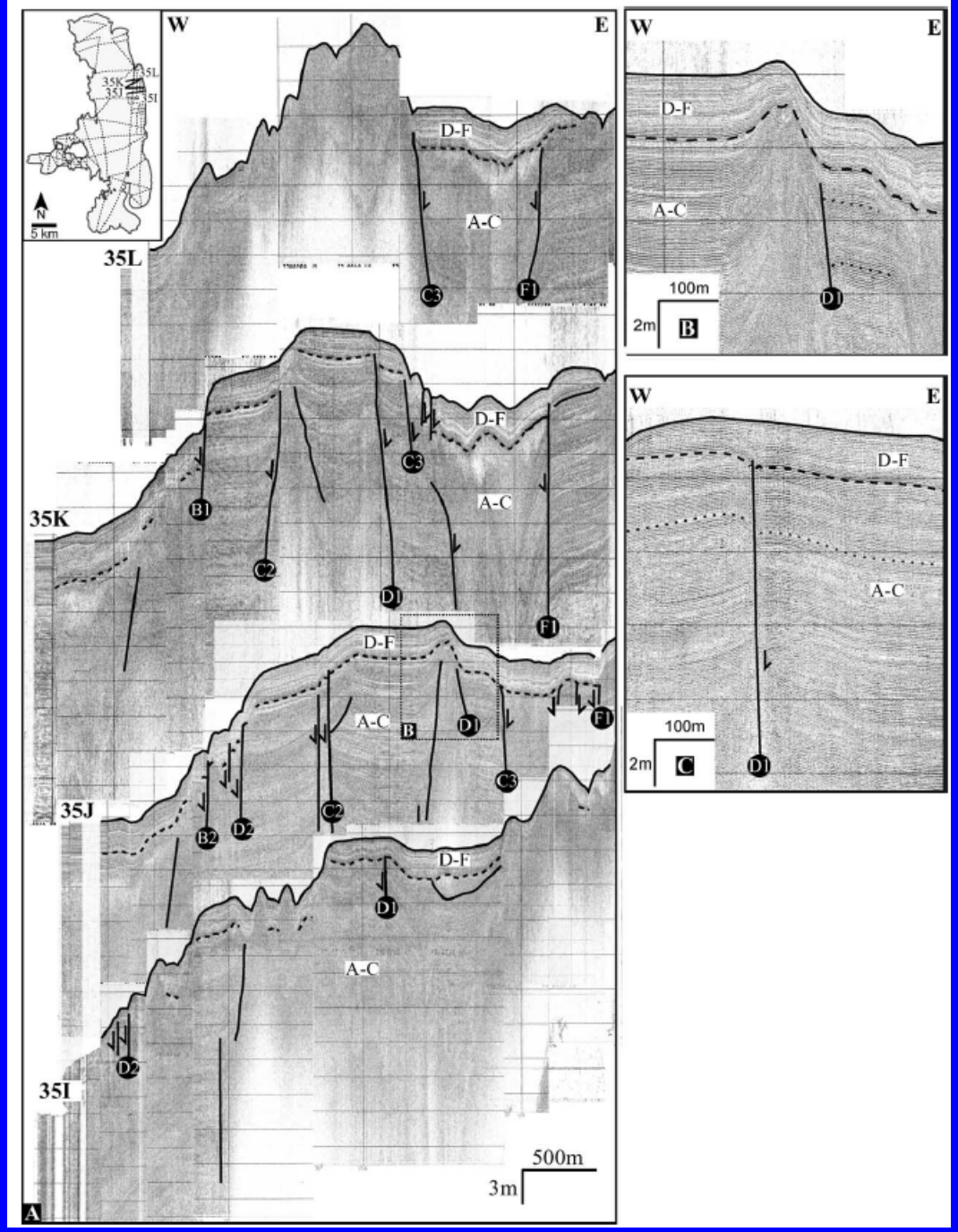

Regional stress field:
σ1 = compressional
σ3 = extensional
stress vector
σ1
σ2
σ3
KFF
CF
SF
MF
TBF
RF
CCF
BDF
MFN
MFS
N
W
E
S
0
5
10km
A
B
Kalispell
Swan Valley
Flathead Lake
Salish Mountains
Mission Valley
Mission Mountains
10km

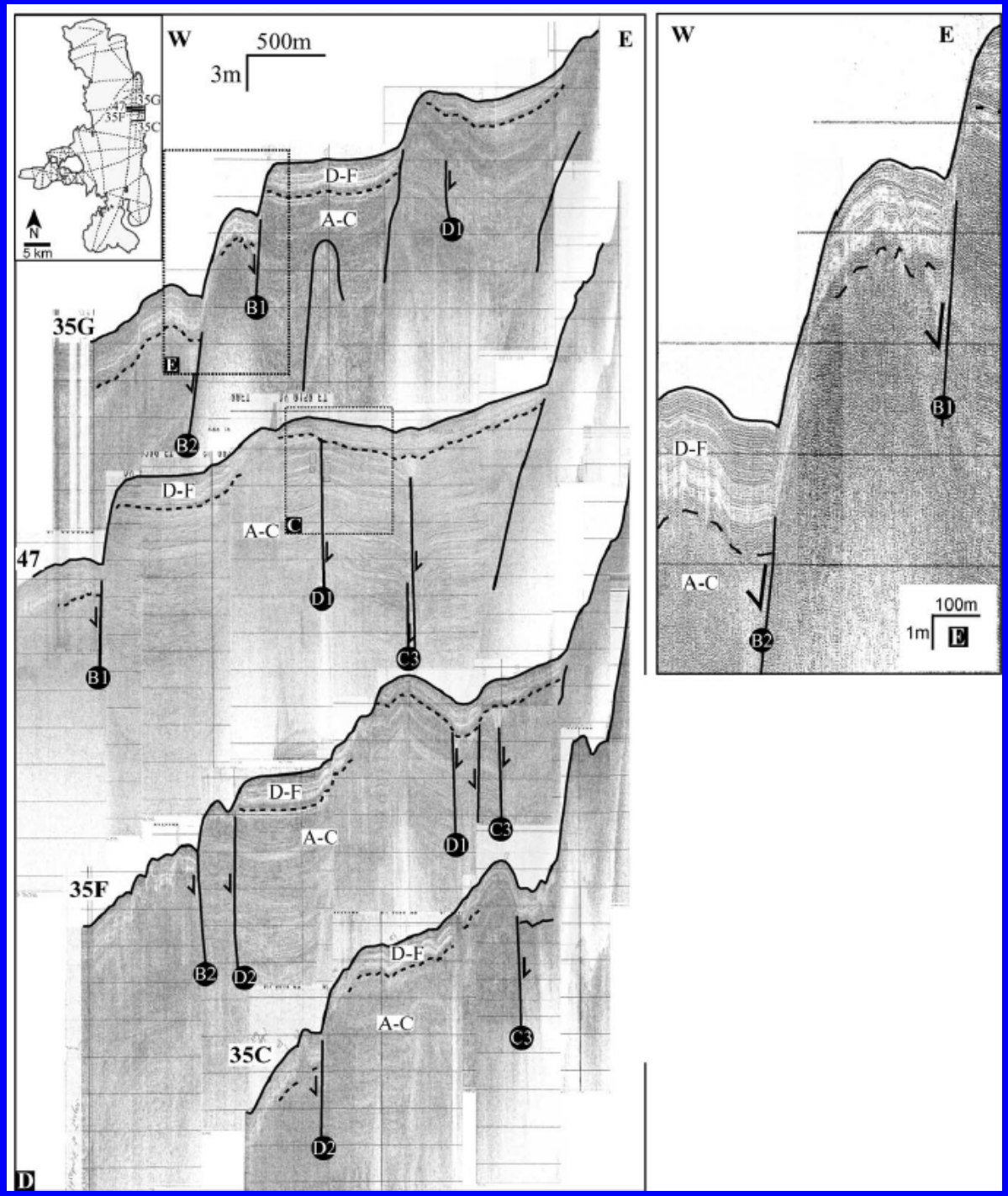

A
Phase B
B1
B2
B3
B4
B5
B6
B4
B7
N
W
E
S
0
5
10km

B
Phase C
C1
C2
C3
C4
C5
C6
N
W
E
S
0
5
10km


D1
D2
D3
D4
N
W
E
S
0
5
10km

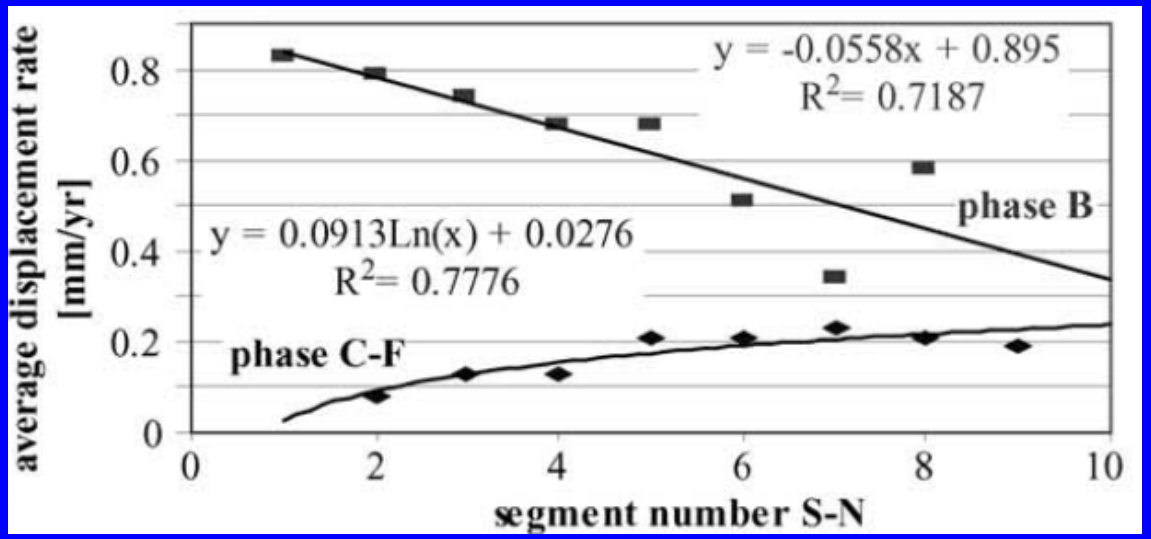

D
Phase E,F
F1
E1
E2
N
W
E
S
0
5
10km

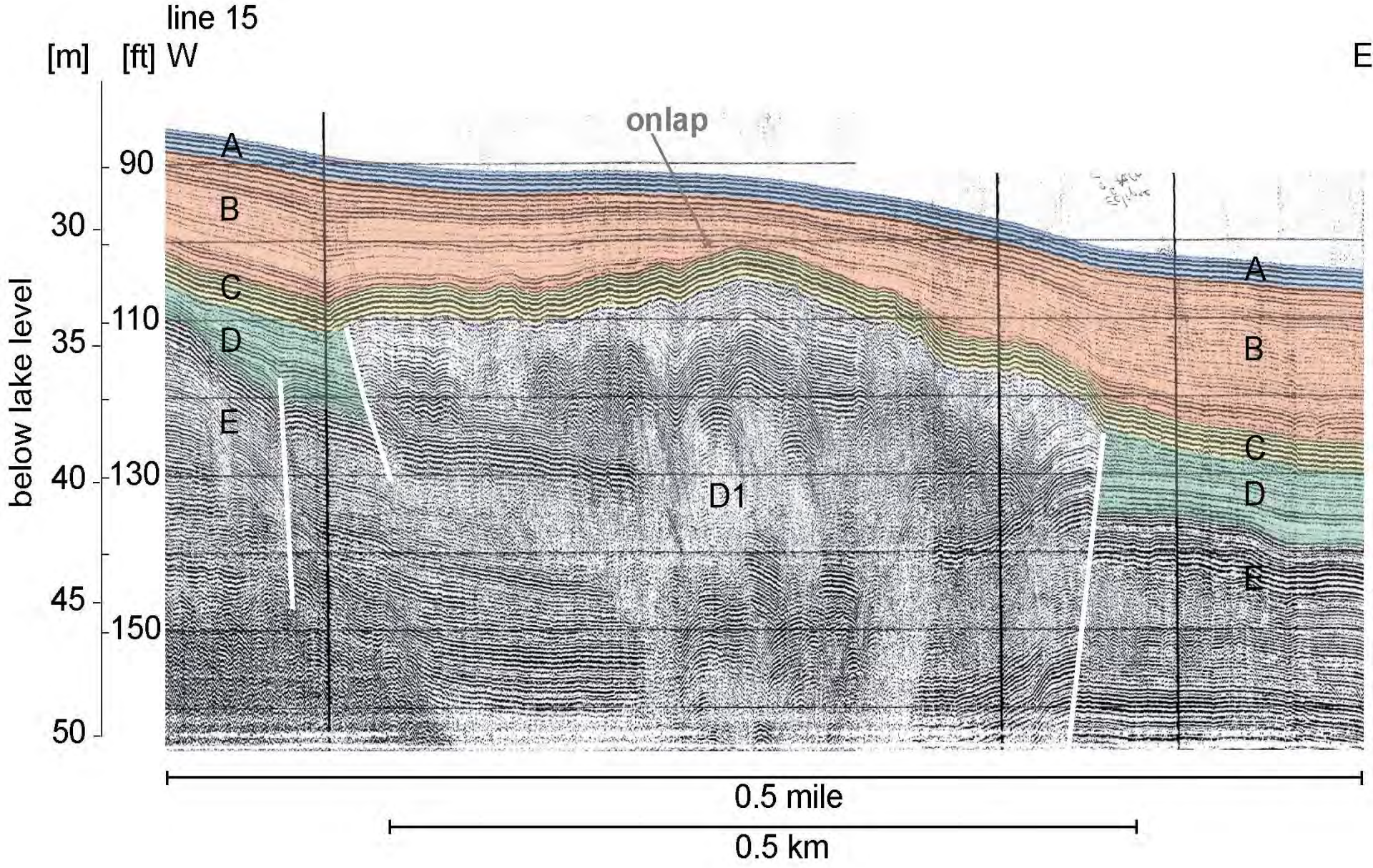

W
E
35L
35K
35J
35I
D-F
A-C
C3
F1
B1
C2
D1
B2
D2
B
500m
3m
A
100m
2m
B
C

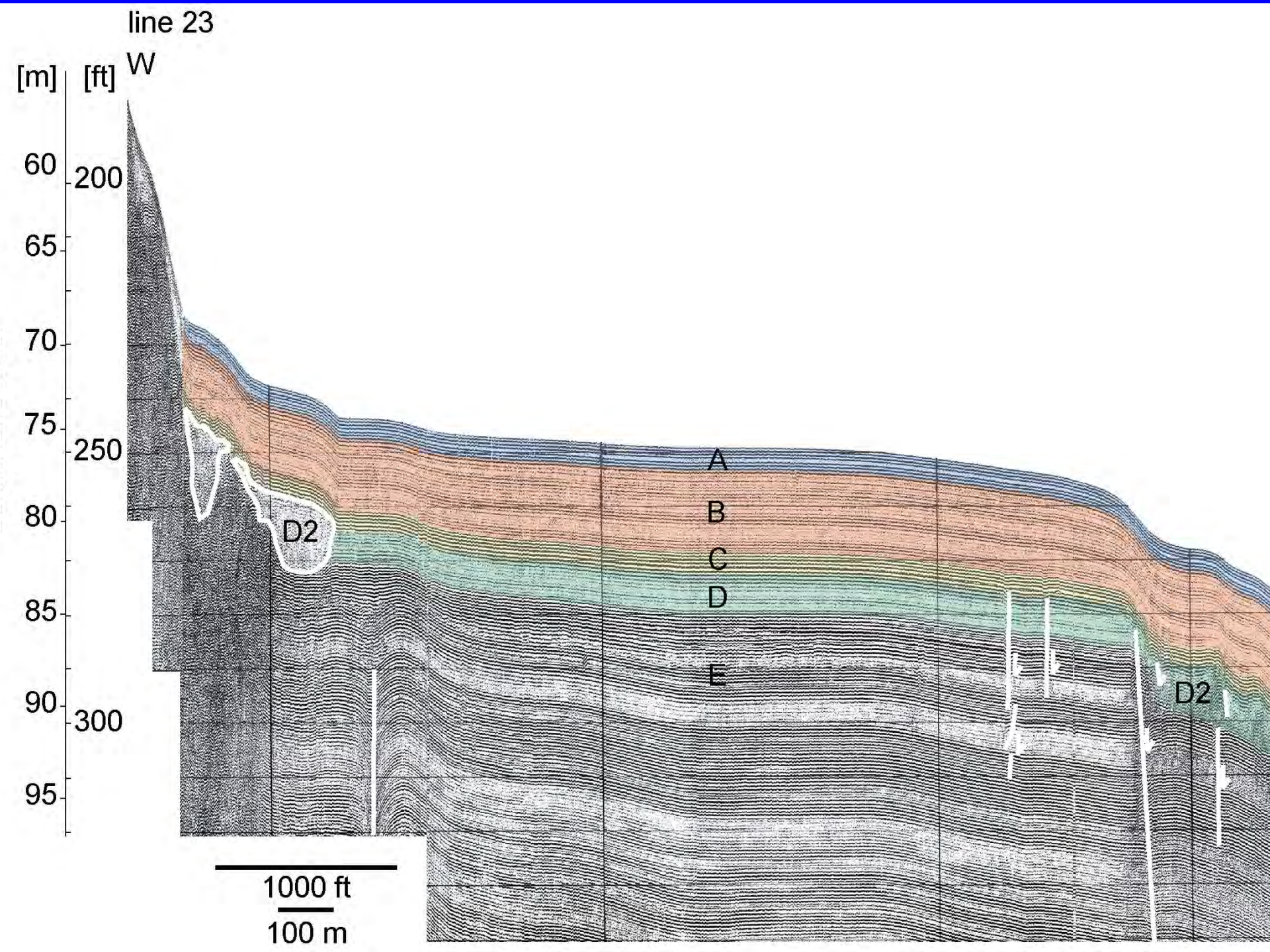

W
E
500m
3m
35G
35F
35C
N
5 km
D-F
A-C
B1
B2
D1
C3
D2
47
E
C
D
100m
1m

Fault name	Segment name	Observed along seismic line	Dip direction	Youngest units offset (age of displacement)	Offset [m] (seismic unit offset), scarp	Displacement rates [mm/yr]	Fault geometry (strike, length, slip)	Southern Mission Fault	
								Activity phases [cal yr BP]	Displacement rate [mm/yr]
MF	B1	18, 20, 21, 30, 35G, 35K, 47	W	B?	*4.3–7.3*	*0.3–0.6*	165–185° southern segment, 170° northern segment, 20 km, normal	~15,000, 12,500–12,600	1.13–1.33, ?
MF	B2	35F, 35G, 35J	W	B?	2.7 (C–D)		176°, 2.9 km, normal		
KFF	B3	21, 47	E						
KFF	B4	6, 17, 23, 24, 28	E	B?	6.1–14.3	0.4–1.1	~350°; 17.5 km, normal		
KFF	B5	28, 30	E	C (13,000–14,000)	1.8–3.3 (upper B)	0.13–0.28	5–358°, 10.9 km, normal		
RF	B6	6, 17	E	lowest C (13,000–14,000)	0.5–0.6 (upper B)	0.03–0.05	355°, 3.2 km		
KFF	B7	24	E	lowest C (13,000–14,000)			3°, 2.3 km long, normal slip		
MF	C1	18	W	C (~10,000)	0.8 (C)	0.19	Normal	10,000–10,300	?
MF	C2	35J, 35K	W	C–D (~10,000)	0.4 (C–D)	0.04	178°, 1.6 km, normal		
MF	C3	35J, 35K, 35L, 35C, 35F, 47	E	C (~10,000)	4.3 (C–D)	0.43	223° southern part, 233° northern part, 2.5 km, normal		
KFF	C4	28	E	C, lowest D (~10,000)			357°, 1.3 km, normal		
MF	C5	6, 23, 27	W	C (~10,000)	1.8 (upper B)	0.13	177–194°, 9.4 km, normal		
CCF	C6	15	S–S	C (~10,000)			Strike–slip		
MF	D1	35I	W	lowest D (~8000)	0.5–0.8 (upper B)	0.03–0.06	352° southern segment, 336° northern segment, 3.8 km, oblique normal		
		35F, 35J, 35K, 47	E						
MF	D2	35C, 35F, 35I, 35J	W	D (~8000)	2.7 (C–D)		155–174°, 4.5 km, normal	7500–7900	0.25–0.4
MF	D3	6, 17	W	D (~7600)	0.7–1.9 (D)	0.09–0.25	194°, 1.9 km, normal		
MF	D4	6	W	D (~7500)	3.3 (D)	0.44	Normal		
TBF	E1	6, 17, 28	E	D, lowest E (5,000–6000)	0.5–1.1 (upper B)	0.09–0.23	340–350°, 7 km, normal		
MF	E2	25	W	lowest E (~5000)	0.4 (D–E)		176°, 5.3 km (2.2 onshore), normal		
MF	F1	35J, 35L, 35K	W	E–F (~1600)	0.7 (C–D)	0.47	155°, 2.5 km, normal		

segment number	displacement rate phase C-F [mm/yr]	fault scarp height phase B faults [m]	displacement rate phase B [mm/yr] (13kyr - 15ky
10	n/a		n/a
9	**0.19**		n/a
8	*0.21*	**8.5**	**0.60 - 0.56**
7	**0.23**	**5**	**0.36 - 0.33**
6	**0.21**		*0.53 - 0.50*
5	**0.21**	**10**	**0.71 - 0.66**
4	**0.13**	**10**	**0.71 - 0.66**
3	**0.13**		*0.76 - 0.71*
2	**0.08**		*0.81 - 0.76*
1	n/a	**12**	**0.86 - 0.80**




line 15
[m] [ft] W
E
onlap
A
B
C
D
E
D1
A
B
C
D
E
90
110
130
150
30
35
40
45
50
below lake level
0.5 mile
0.5 km


line 23
W
[m]
[ft]
60
200
65
70
75
250
80
85
90
300
95
D2
A
B
C
D
E
D2
1000 ft
100 m

Acknowledgements

Collaborators/ co-PI's:

J. N. Moore, M. Sperazza, M. Hofmann, G. Timmerman, A. Bondurant,

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L. Smith – Montana Bureau of Mines and Geology

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C. Whitlock –Montana State University

M. Shapley, C. Whitkopp – Linmological Research Center

C. Fuller, R. Forester – USGS

Funding:

NSF-Earth Systems History Program

USGS-EDMAP Program

NSF-EPSCOR


Thank you!

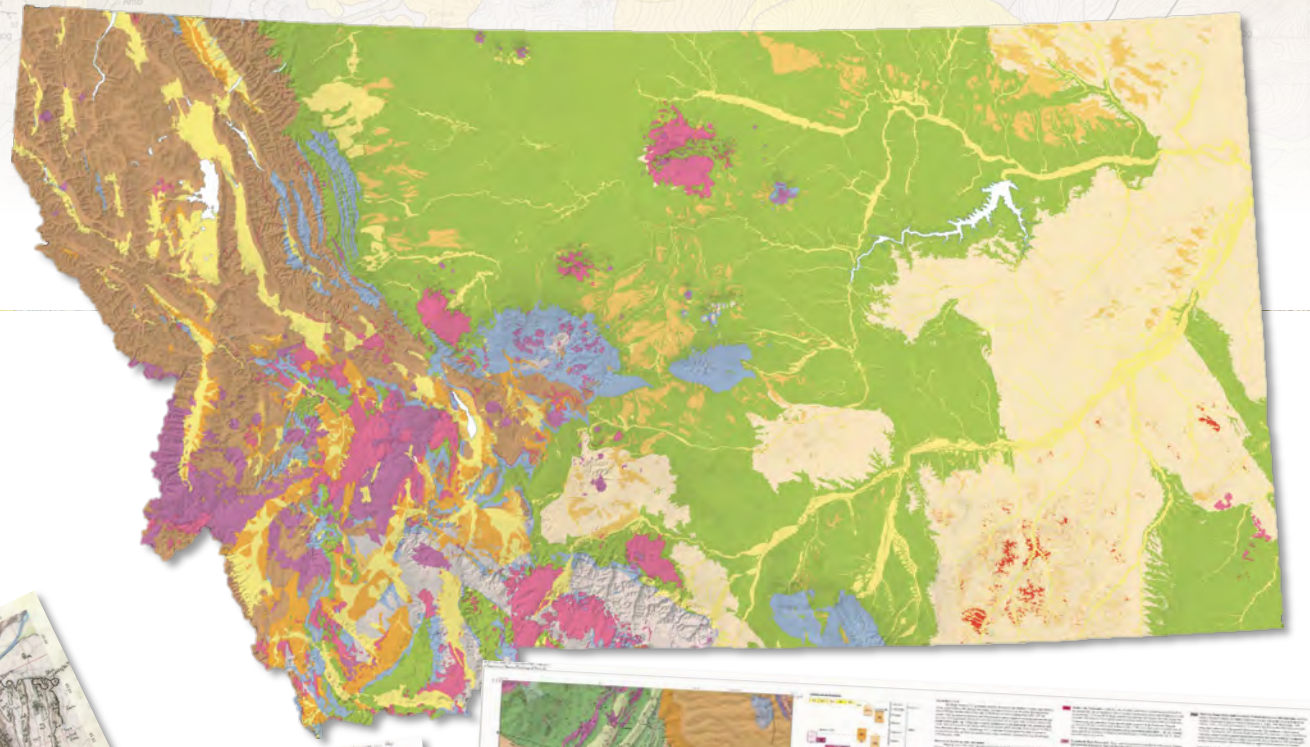
Geologic mapping in northwestern Montana

Implications for geologic hazards

Stuart Parker

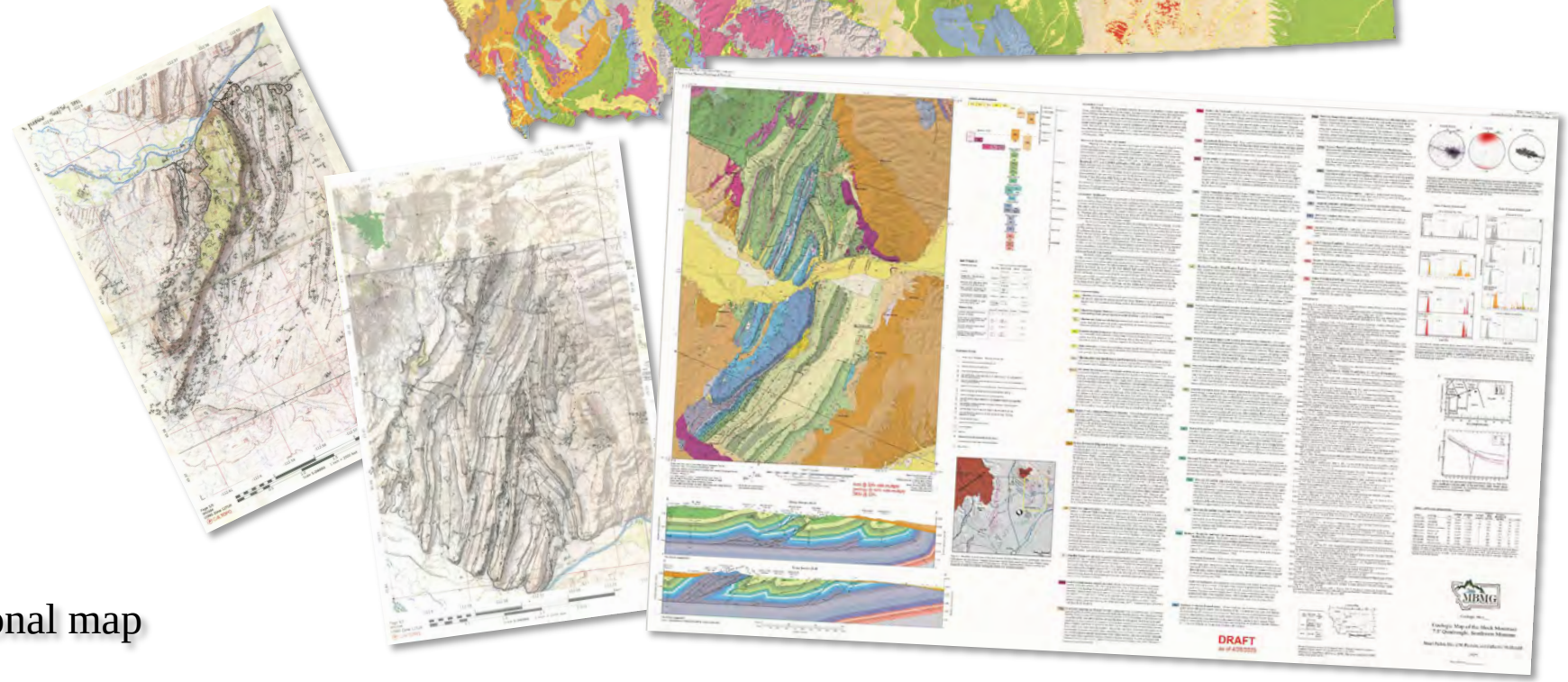
MBMG
Montana Bureau of Mines and Geology

STATEMAP program



Goal 1: Uniform Geologic Map Coverage

Goal 2: Specific Focus Maps



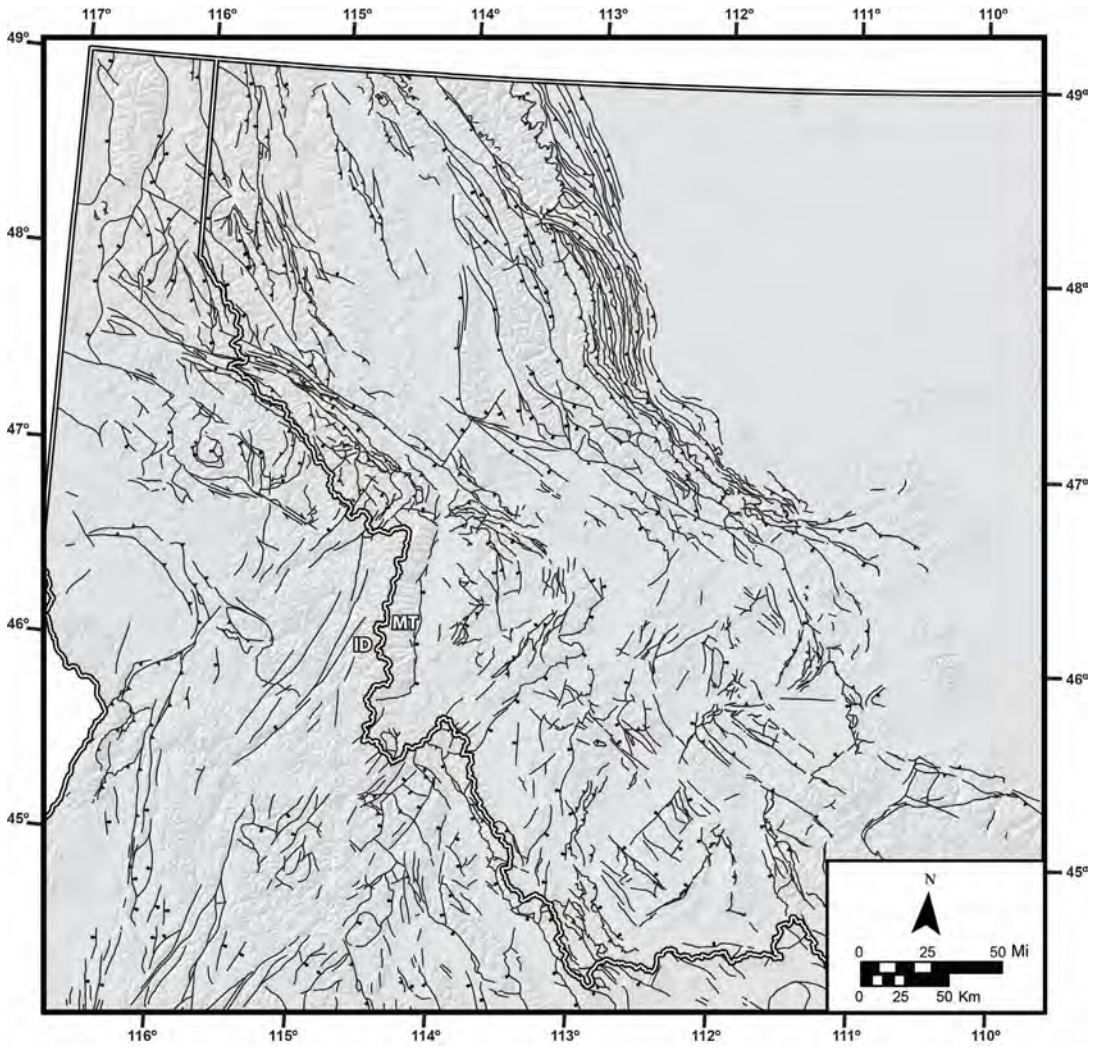
Staff

- 8 mappers
- GIS Specialist
- Cartographer
- Lab Manager

Products

- Paper maps
- GIS databases
- Seamless state map
- USGS seamless national map

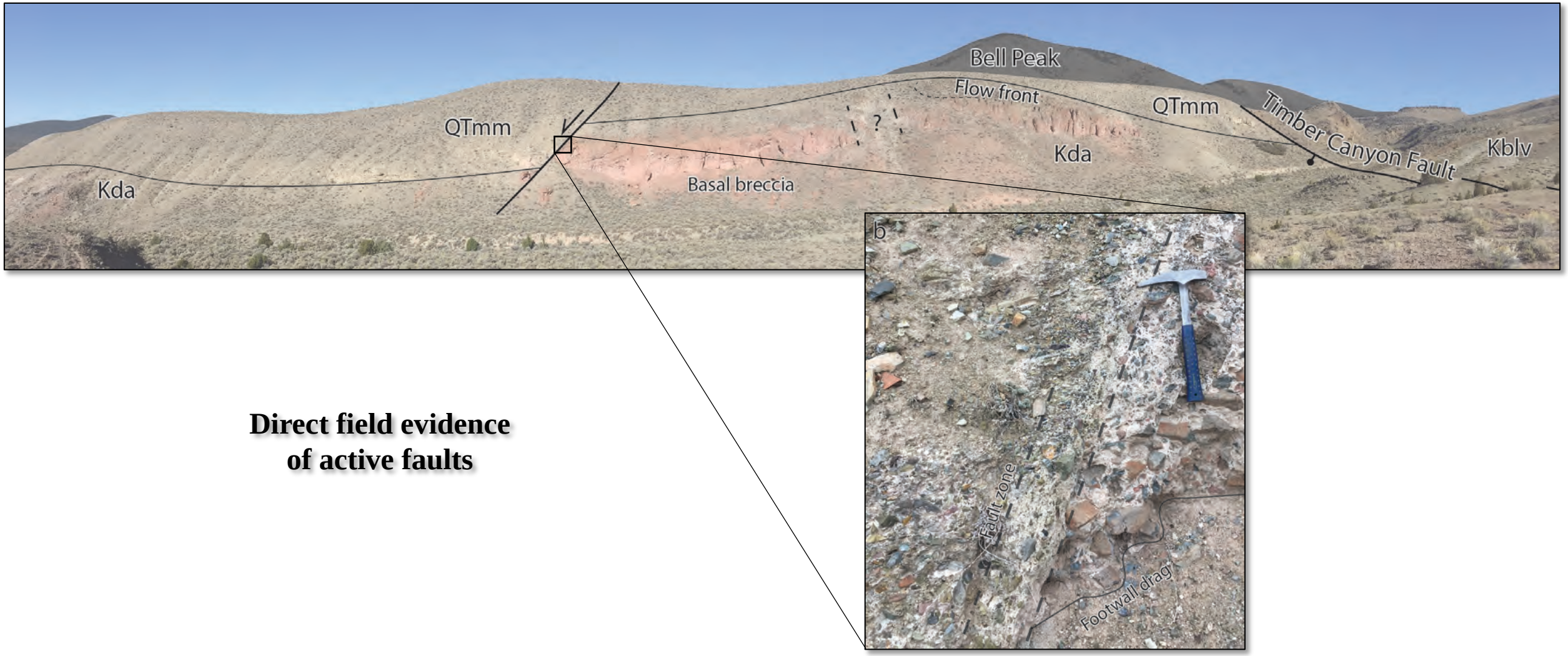
From faults to hazards



- Constantly updating fault mapping
- Which ones are large?
- Which ones are active?

Where are the hazards?

In Southwestern Montana…



Direct field evidence of active faults

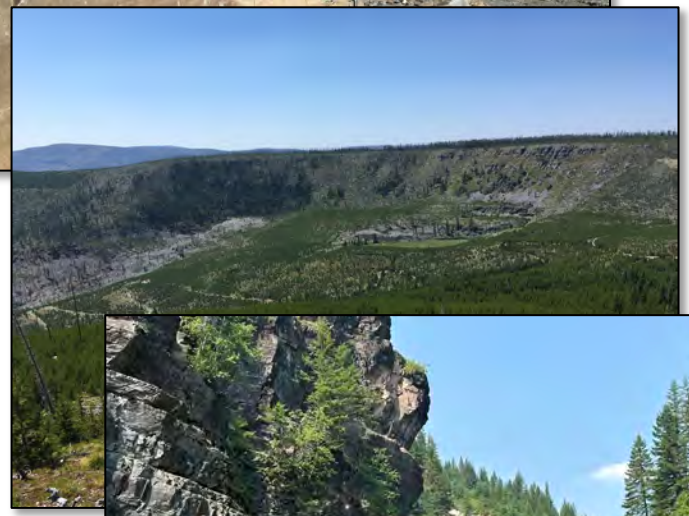
In Northwestern Montana…

Limited field evidence…

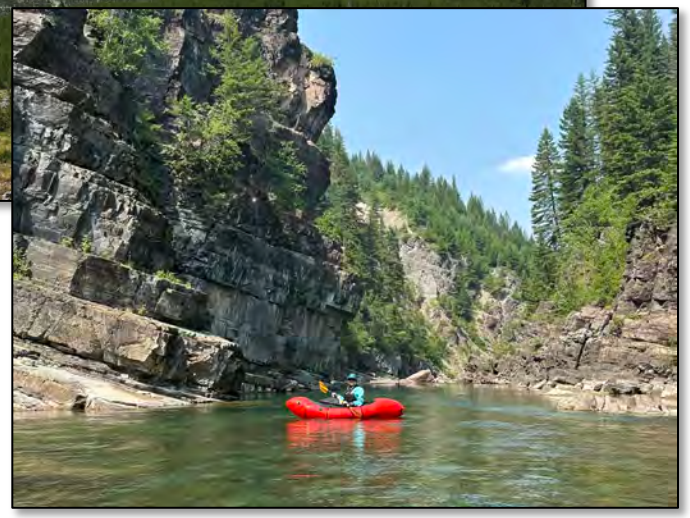
unrecognized hazards

Exposures in Northwestern Montana

roadcuts and quarries



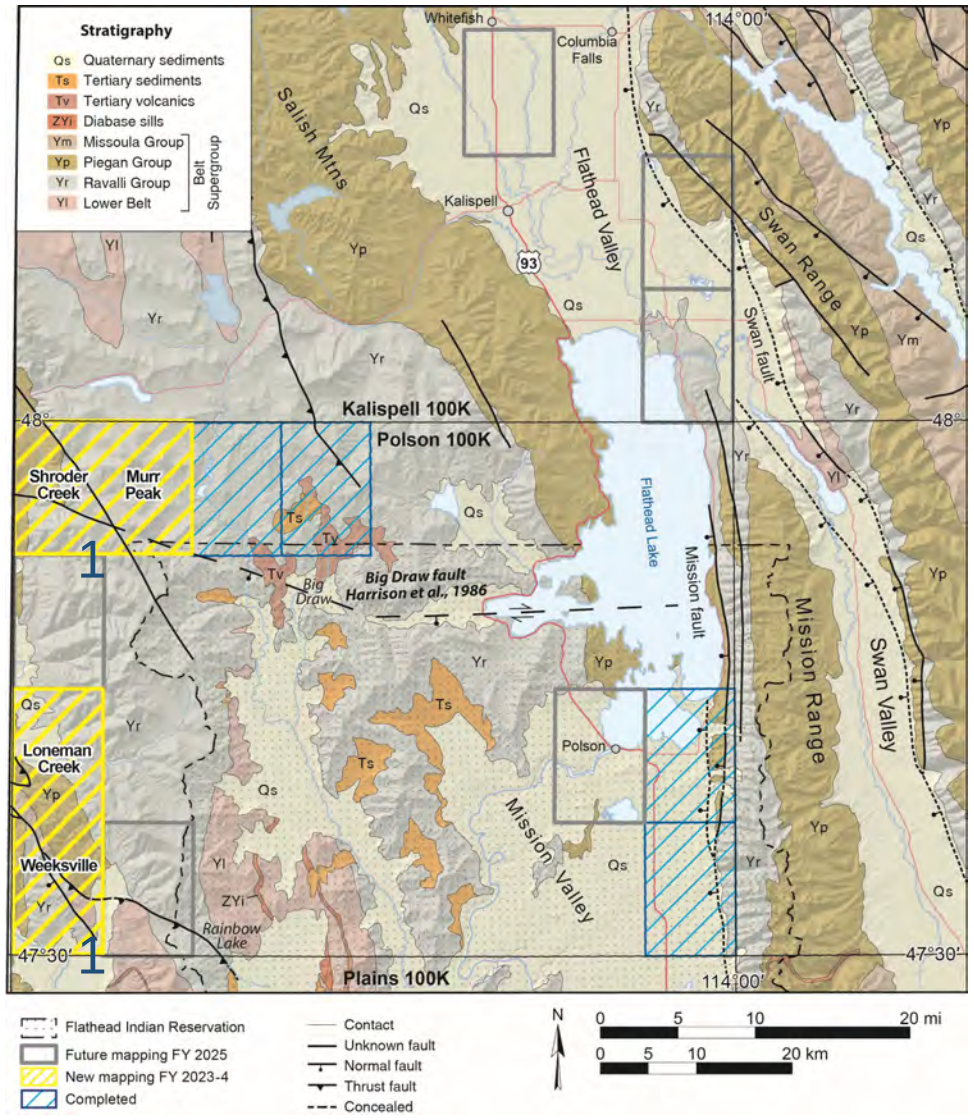
cirques and ridgelines

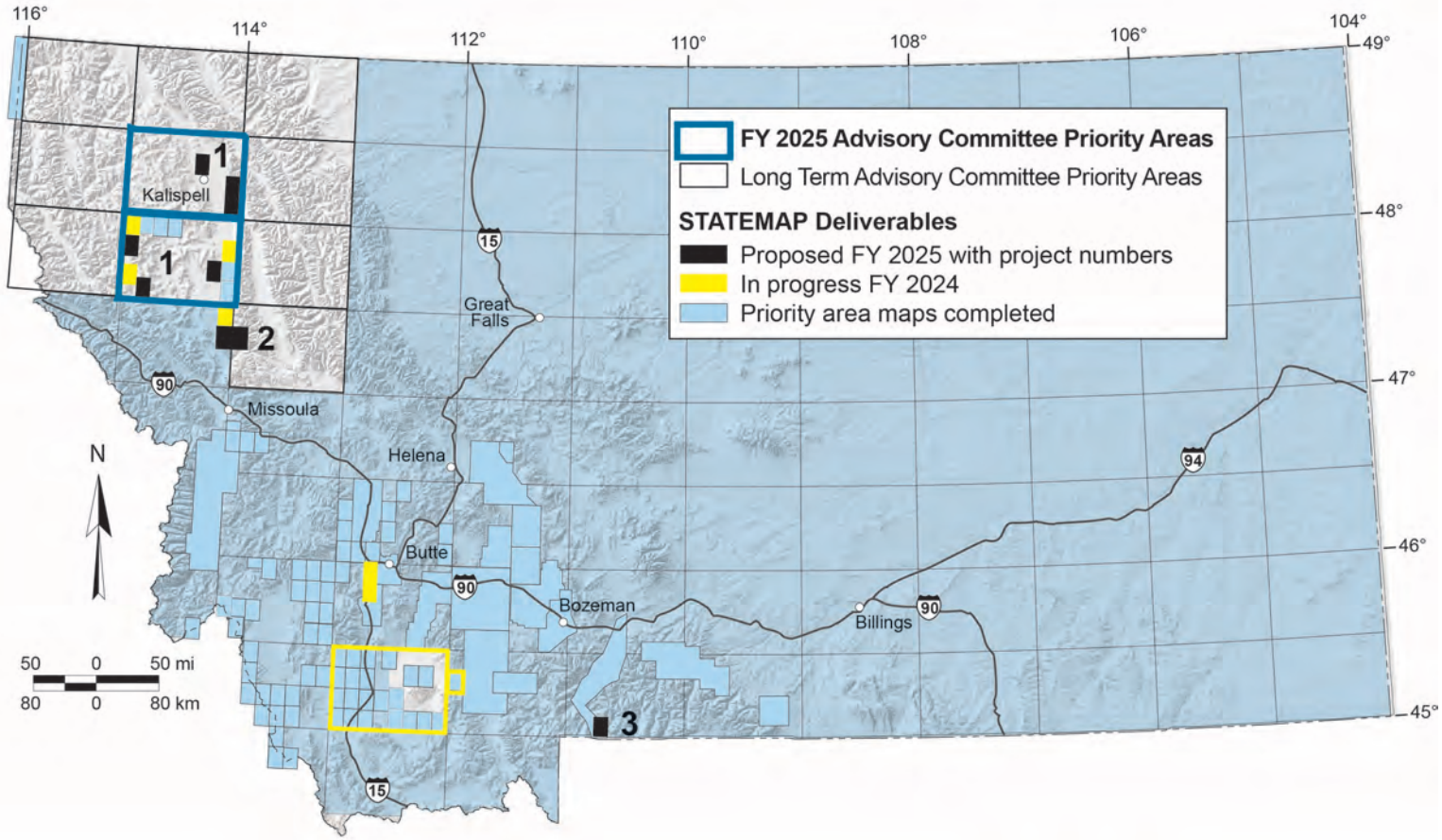


river canyons

…and Lidar

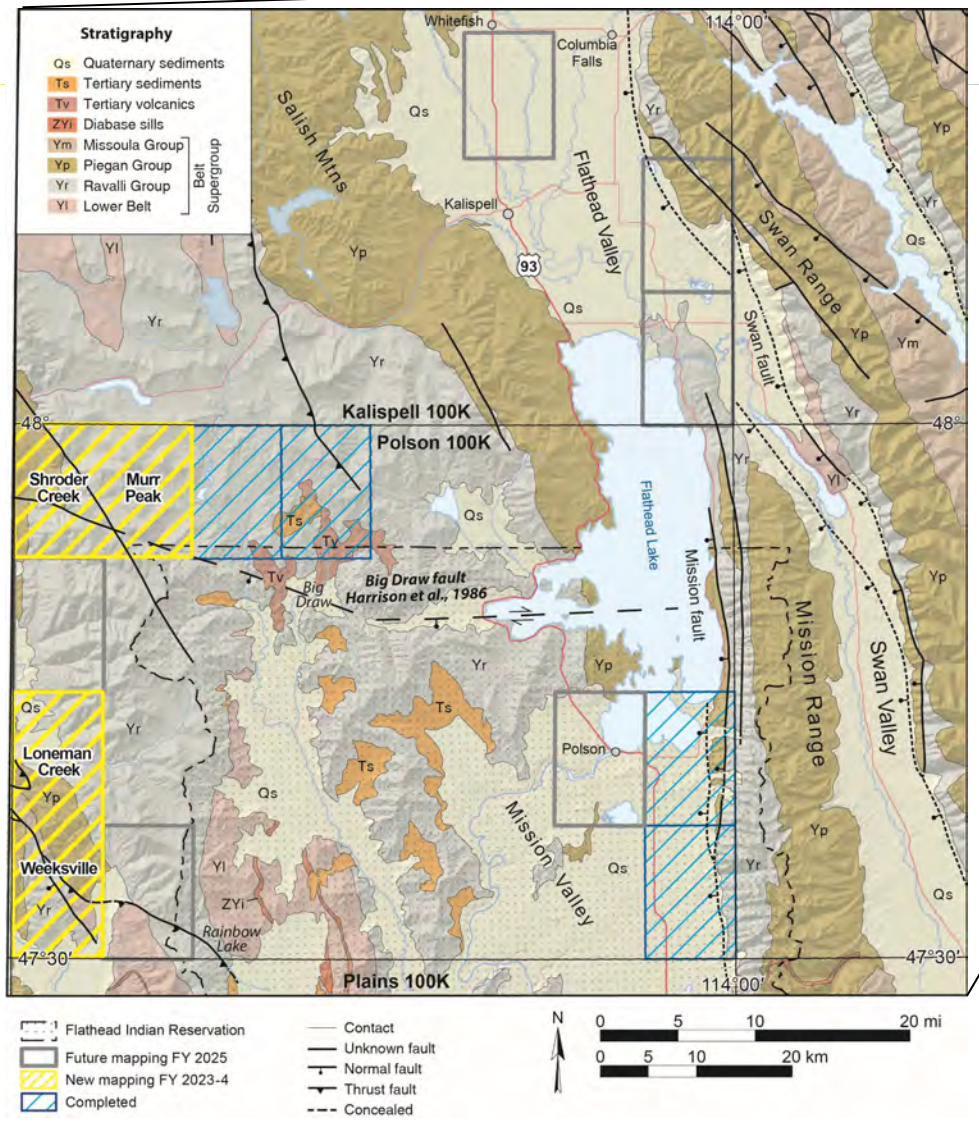
Current and ongoing mapping

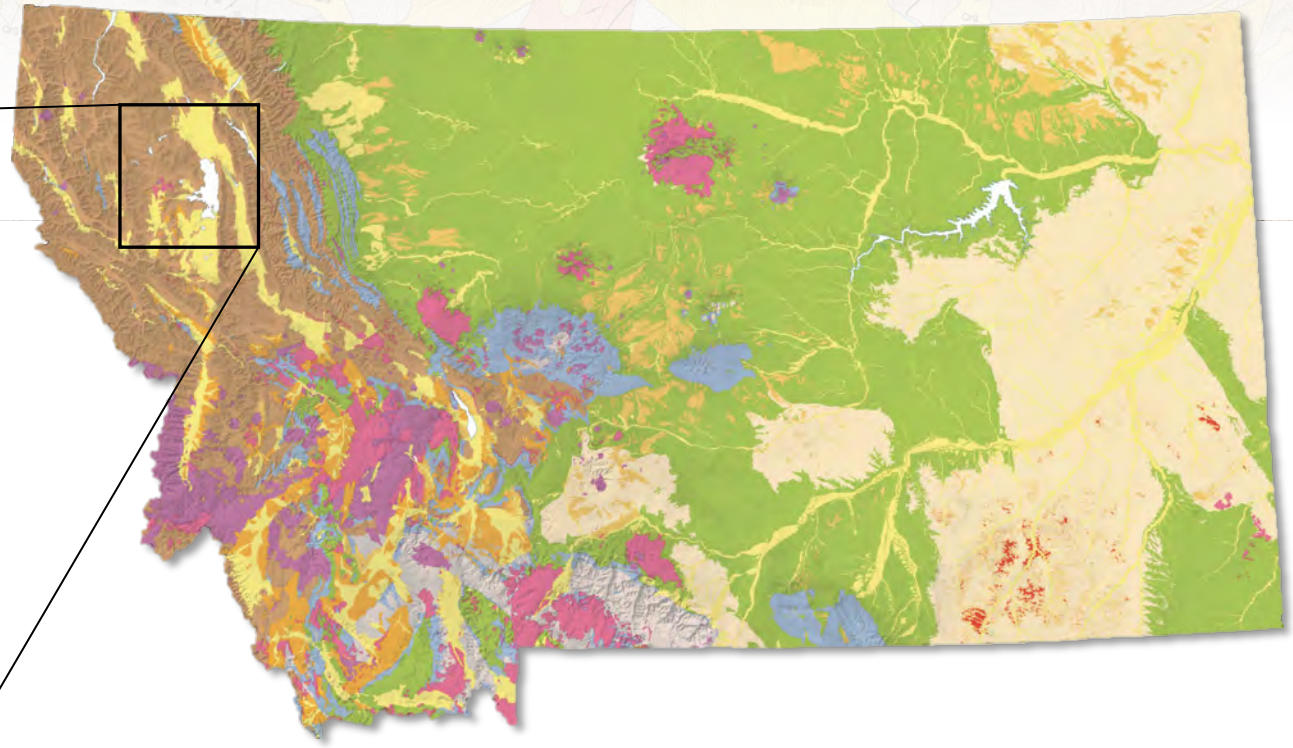




1) Polson 30' x 60', and Kalispell 30' x 60'
2) Mission Fault
3) Gardiner

Geologic background



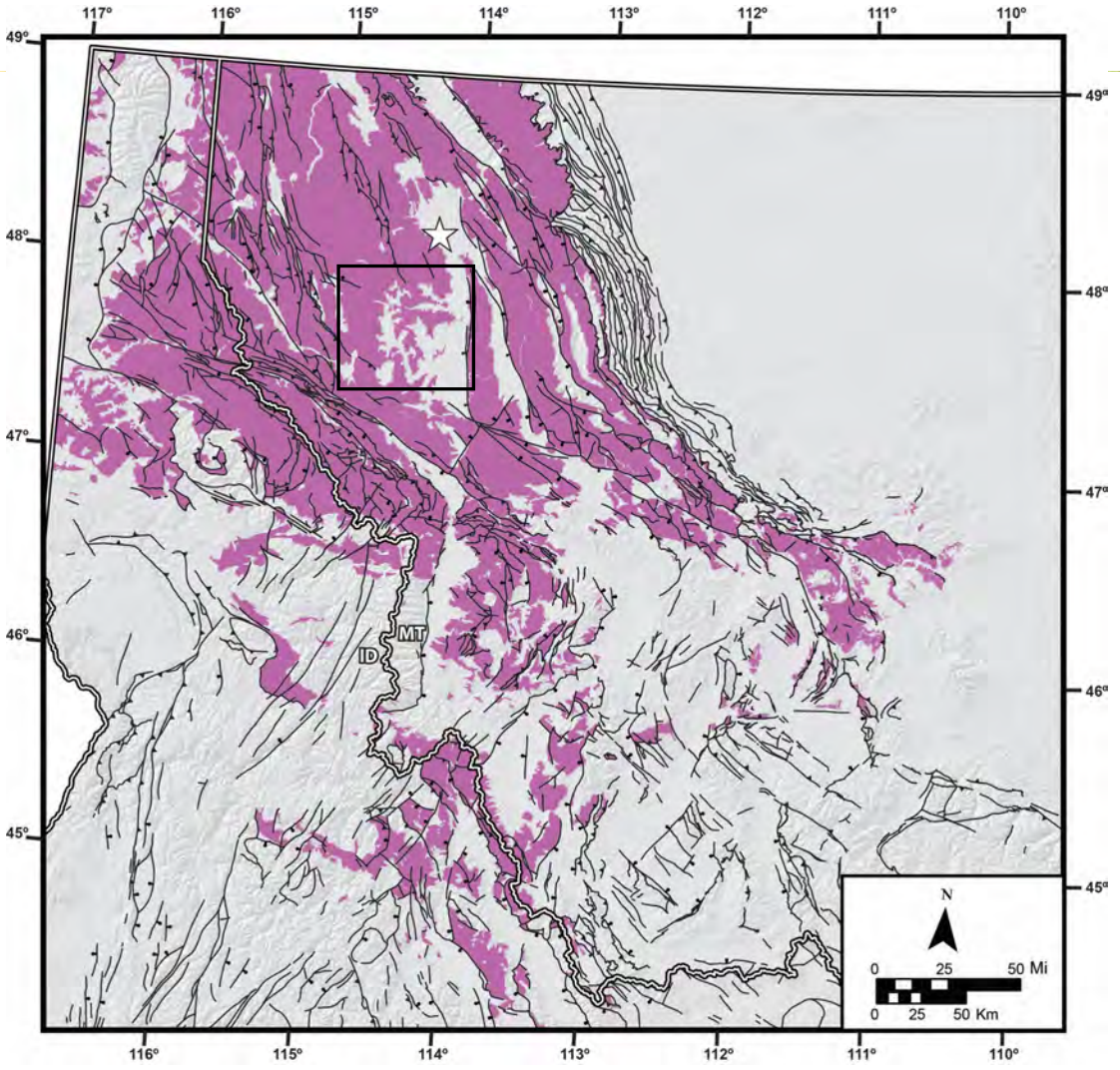


Two key units

1) Precambrian ~1.5 Ga Belt Supergroup

2) Glacial deposits

Belt Supergroup

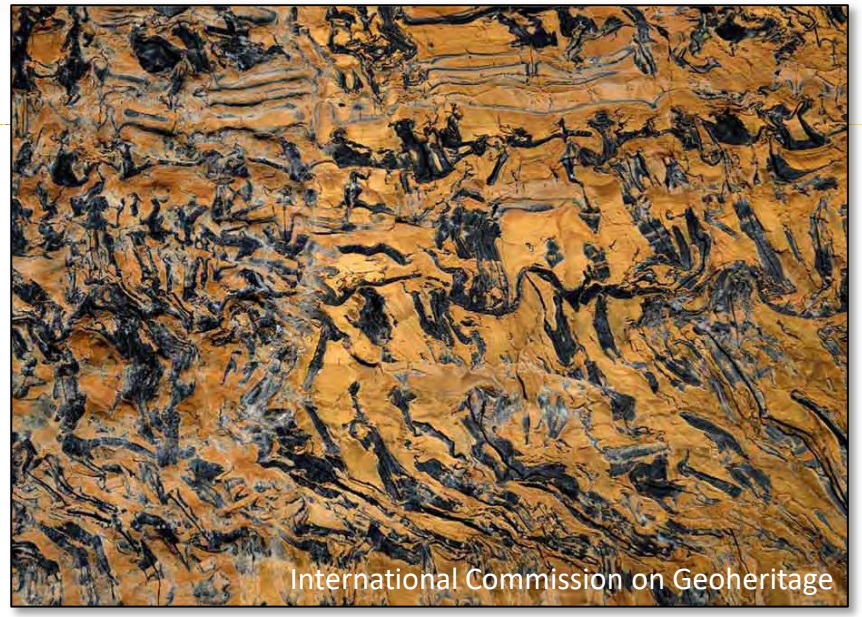


- Up to ~ 18 km (~60,000 ft) thick

- Widespread throughout northwestern Montana

- Exposed in Glacier National Park

Belt Supergroup (for nerds)

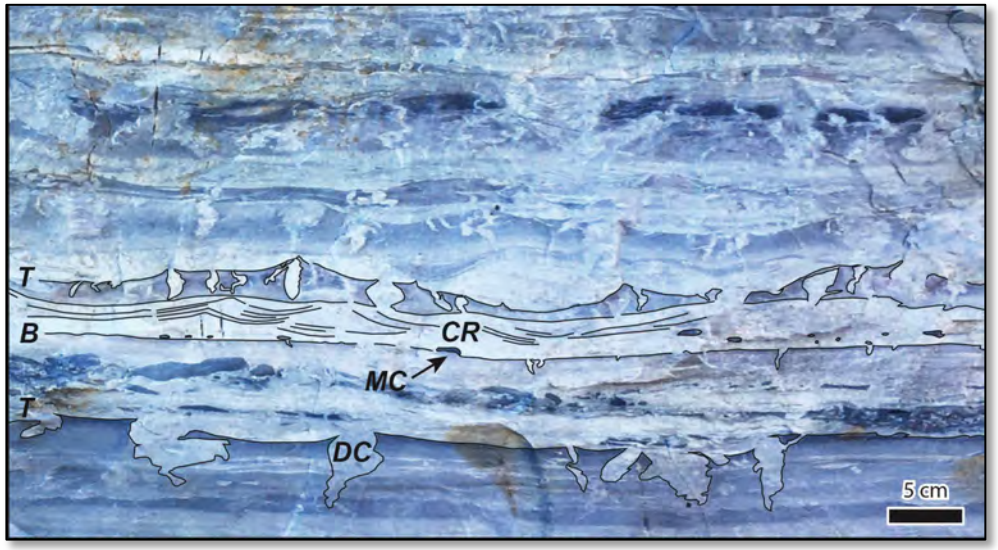


-stromatolites (algal mats)

-molartooth structure (biotic gas escape)

-mudcracks

-individual storm deposits



Record of day to day conditions 1.5 billion years ago

Belt Supergroup (for engineers)

Cliff at knickpoint in non-jointed outcrop

Unstable blocks in jointed outcrop

-homogenous quartz

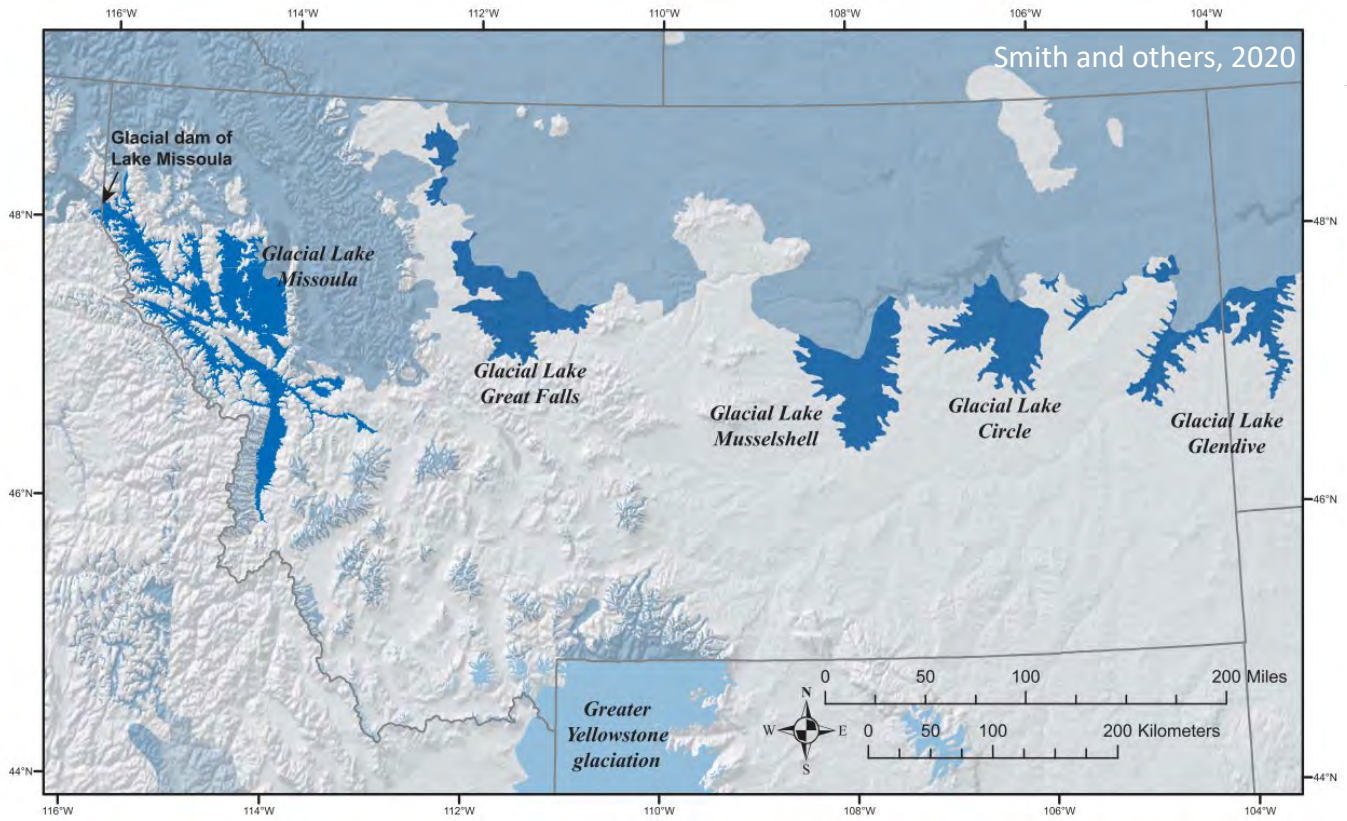
-strong

-brittle

-cliff former (intact)

-topples where jointed

Glacial deposits

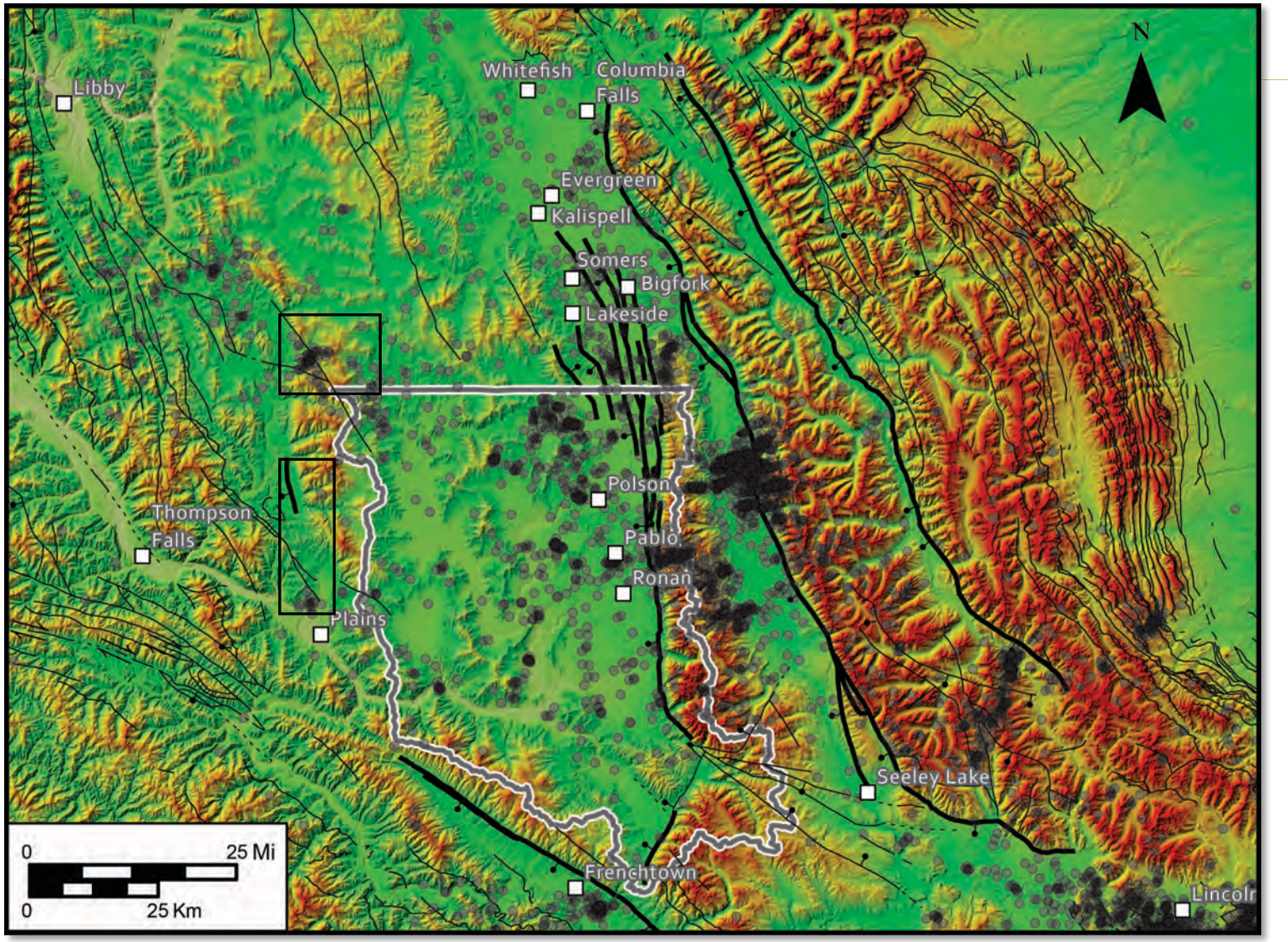


glacial deposits

lake deposits

- young markers, constrain slip rates on faults
  - weak (landslides, liquefaction, settling)

Hazardous faults?



-active normal faults bound high topography

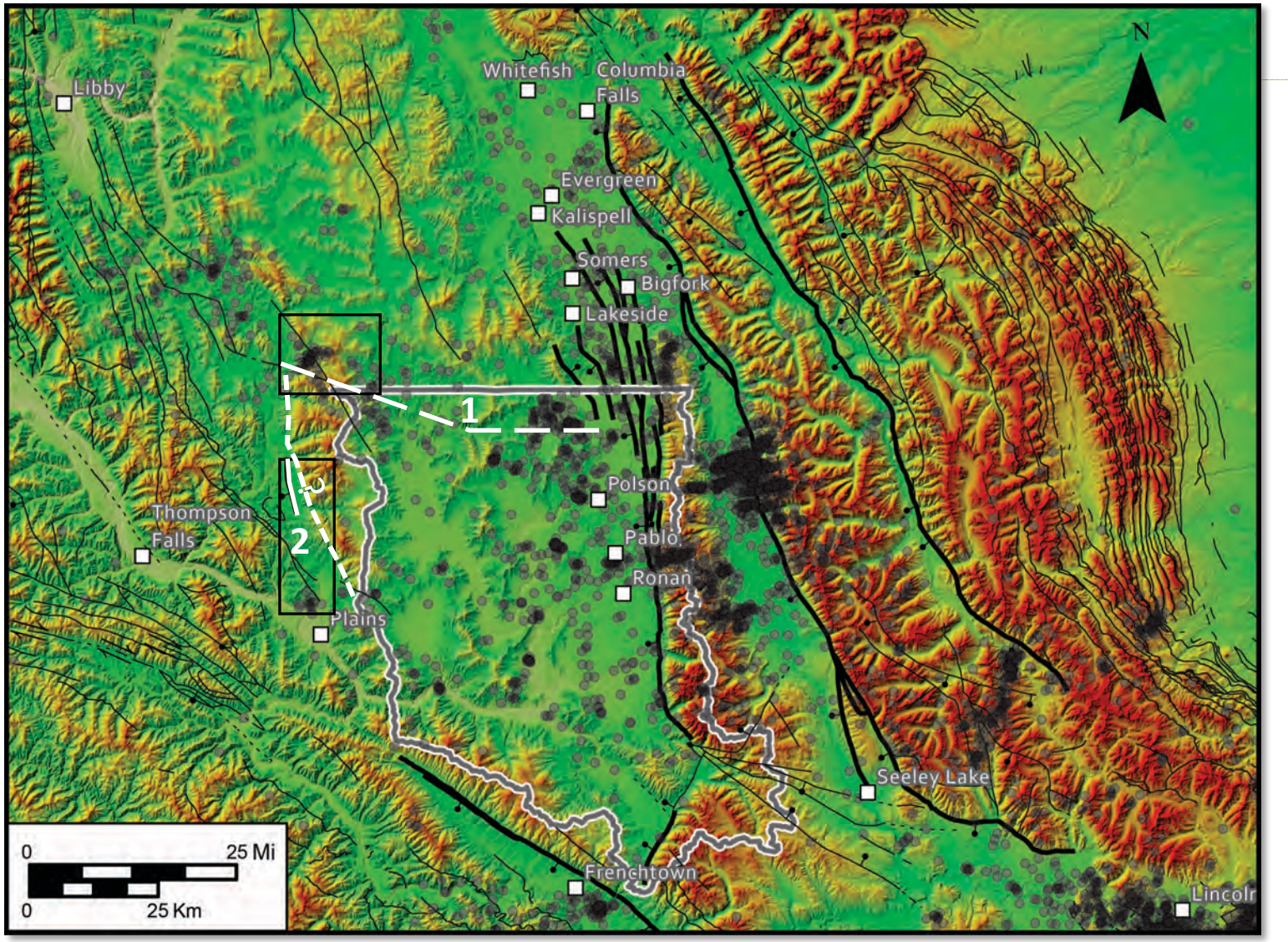
-seismicity is widespread

-apparent lack of mapped faults in study area

Major hazards in the Missions, Swan, etc.

…are there active faults in the Salish Mountains?

Potentially hazardous faults

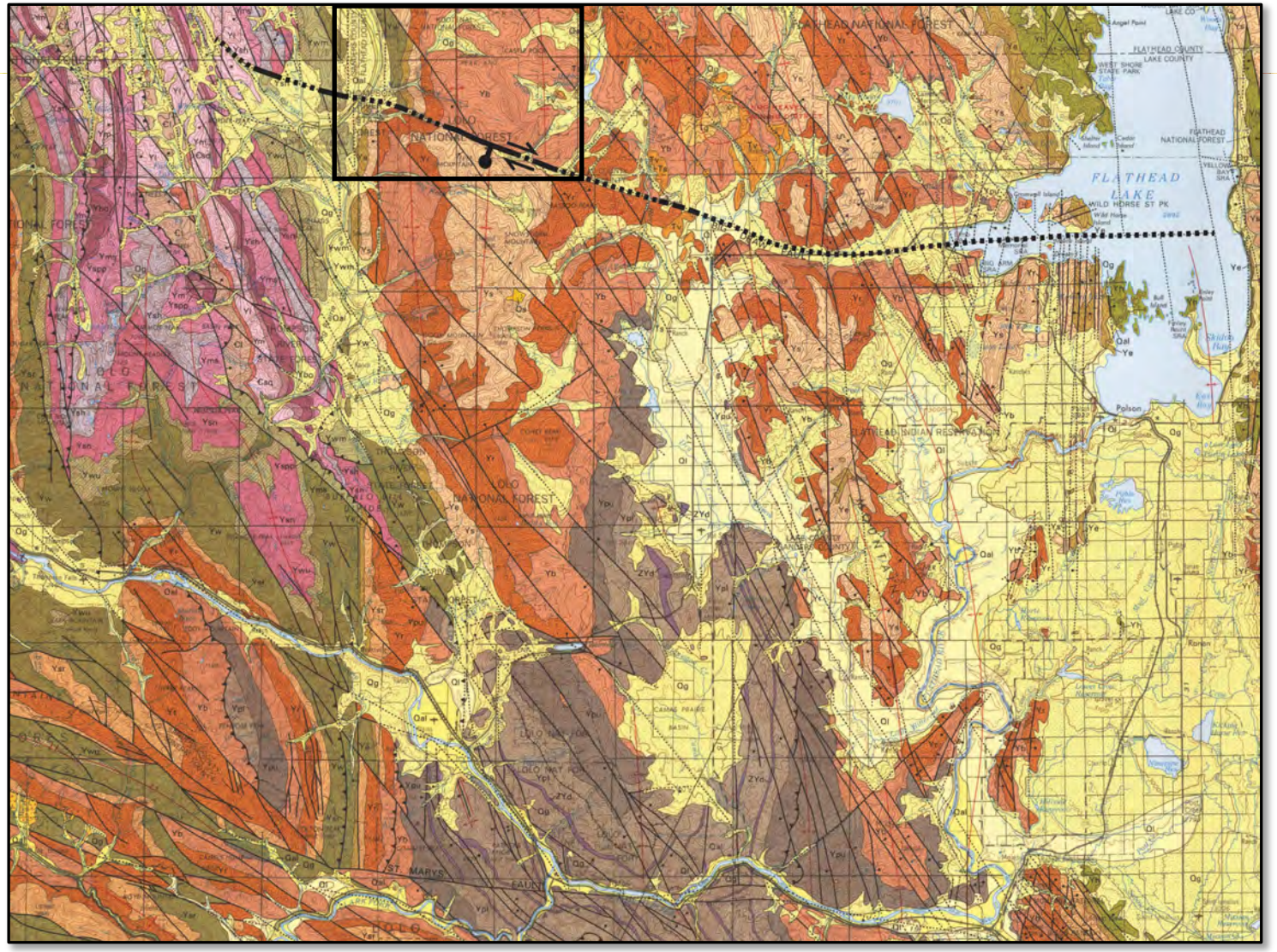


1) Big Draw fault

2) Thompson Valley fault

Big Draw fault

Wallace 1° x 2° quad
(Harrison et al., 1986)



Page (1963)

– Original mapping, M.S. thesis

Johns and others (1963)

- Shroder Creek fault
- road cut exposure of damage zone
- topographic liniment, trends ~110°
- right-lateral, N-side down normal

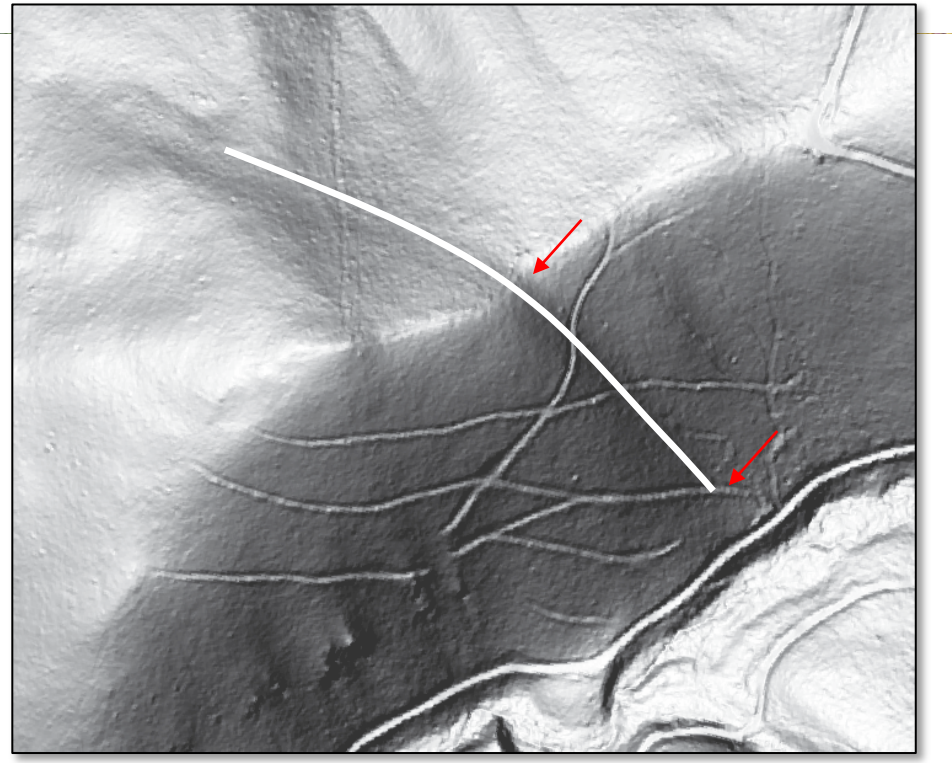
LaPoint (1971)

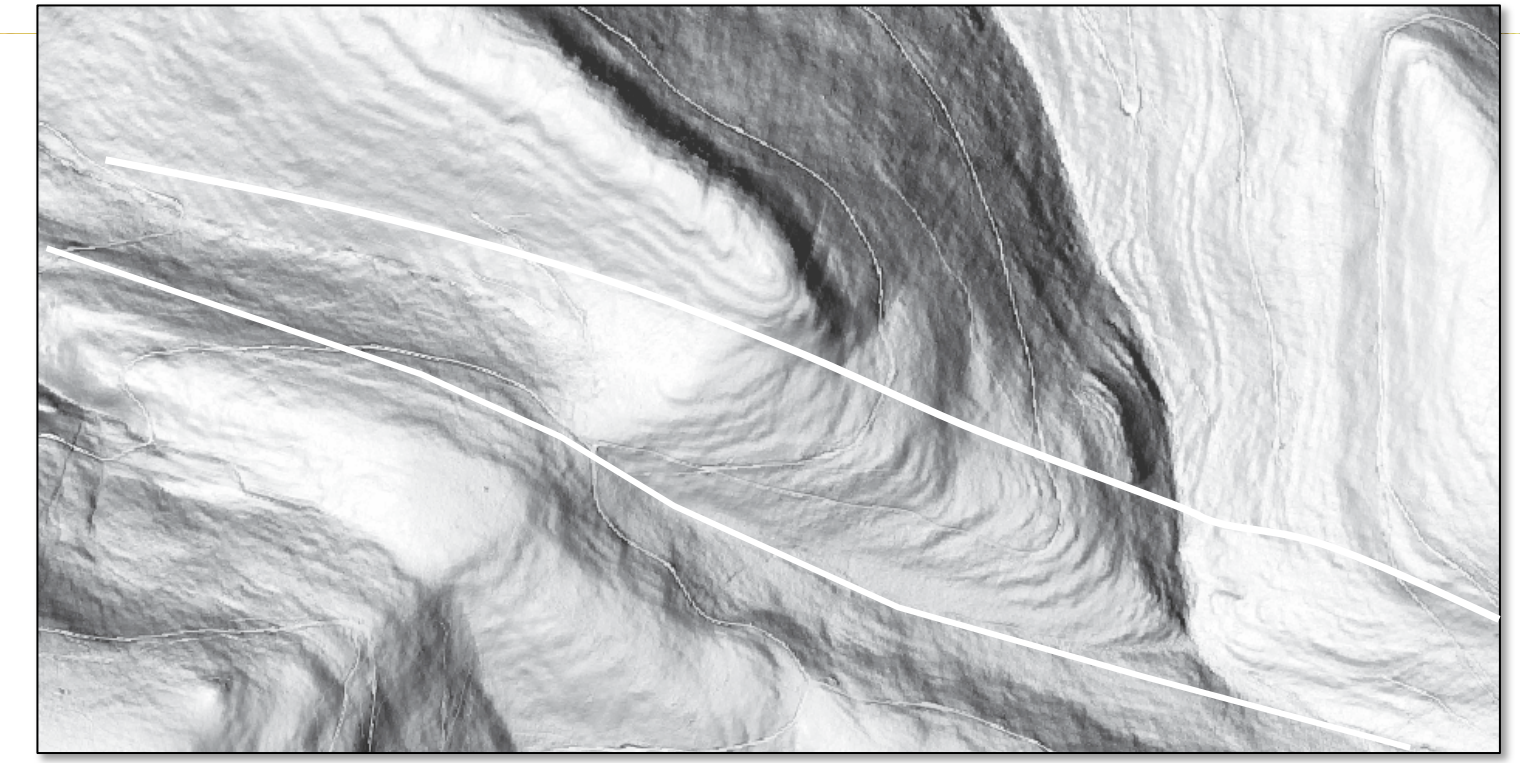
- Big Draw fault
- 090° topographic liniments in Big Draw
- gravity survey
- deep, narrow valley
- right-lateral, S-side down normal
- connected to Shroder Creek fault

Harrison et al. (1986)

- reference LaPoint's interpretation
- active (8 km offset), in Flathead Lake

Direct evidence of Shroder Creek fault

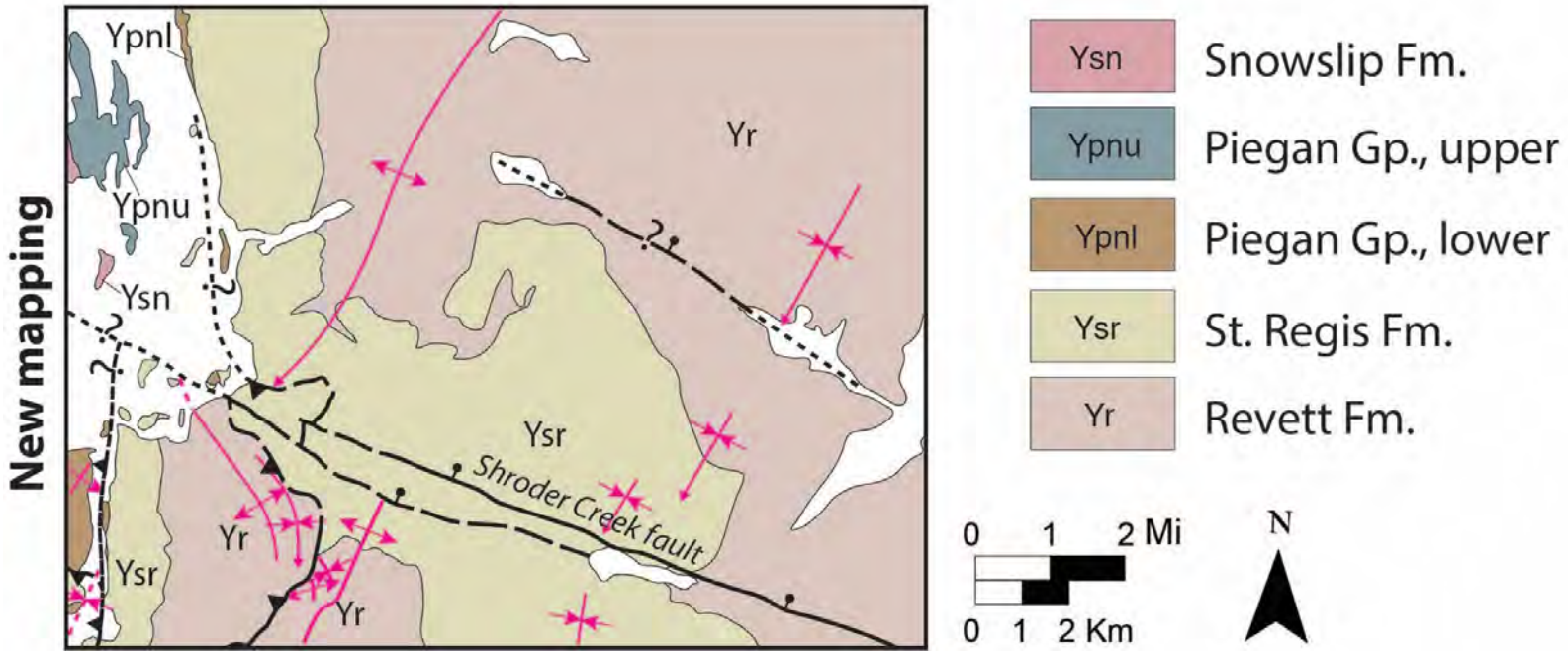




- numerous bedrock liniments

- iron staining and brecciation along trace

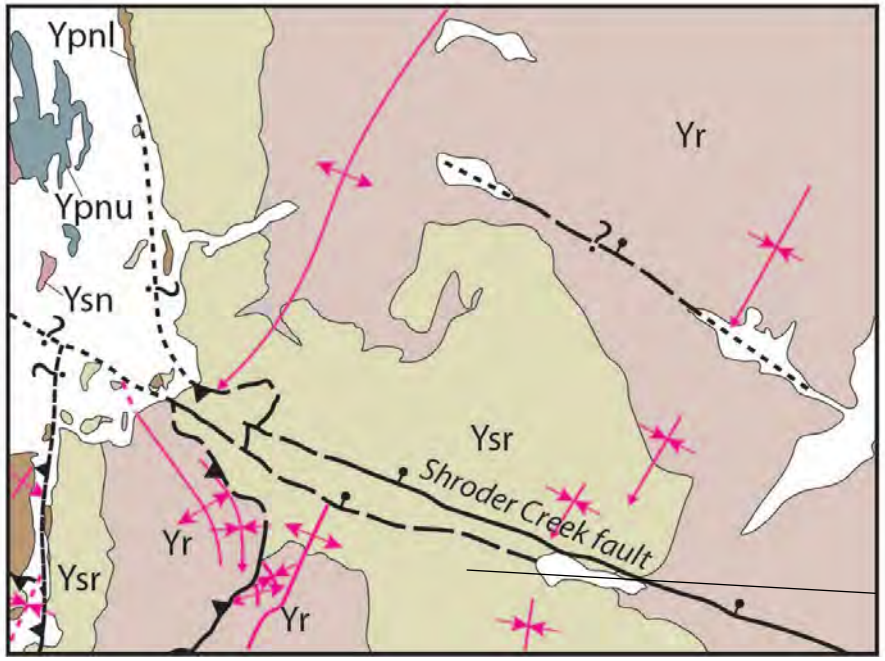
Indirect evidence of Shroder Creek fault



- folded bedding (roll-over anticline)
- offset stratigraphy
- offset older thrust
- offset older anticline

Indirect evidence of Shroder Creek fault

New mapping



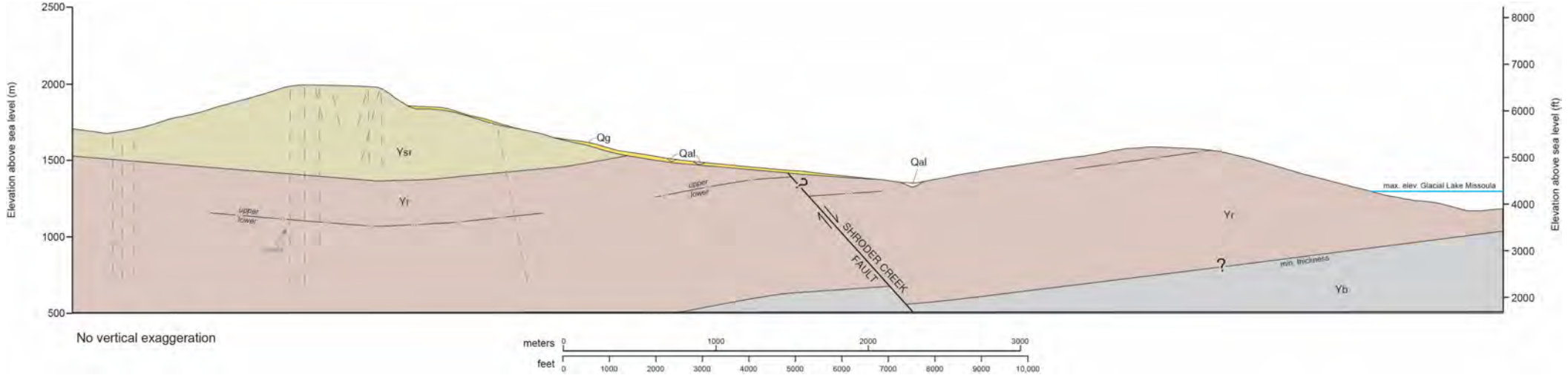
Ysn Snowslip Fm.
Ypnu Piegan Gp., upper
Ypnl Piegan Gp., lower
Ysr St. Regis Fm.
Yr Revett Fm.

0 1 2 Mi
0 1 2 Km

N

consistent with <500' of down-to-NNE normal faulting

negligible oblique component!



Improved mapping

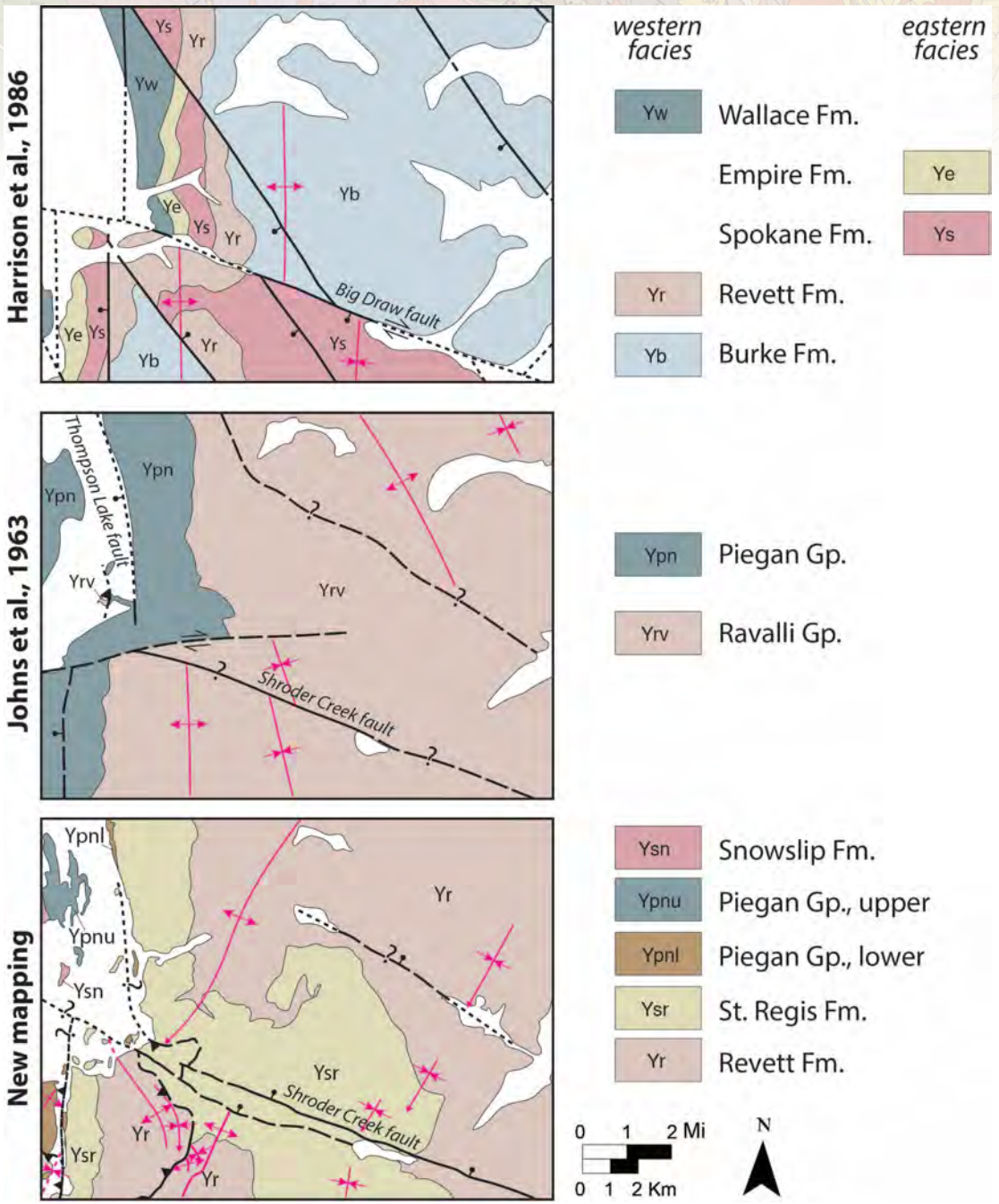
Ferricrete
(old alluvium/colluvium)

Basalt lava flow

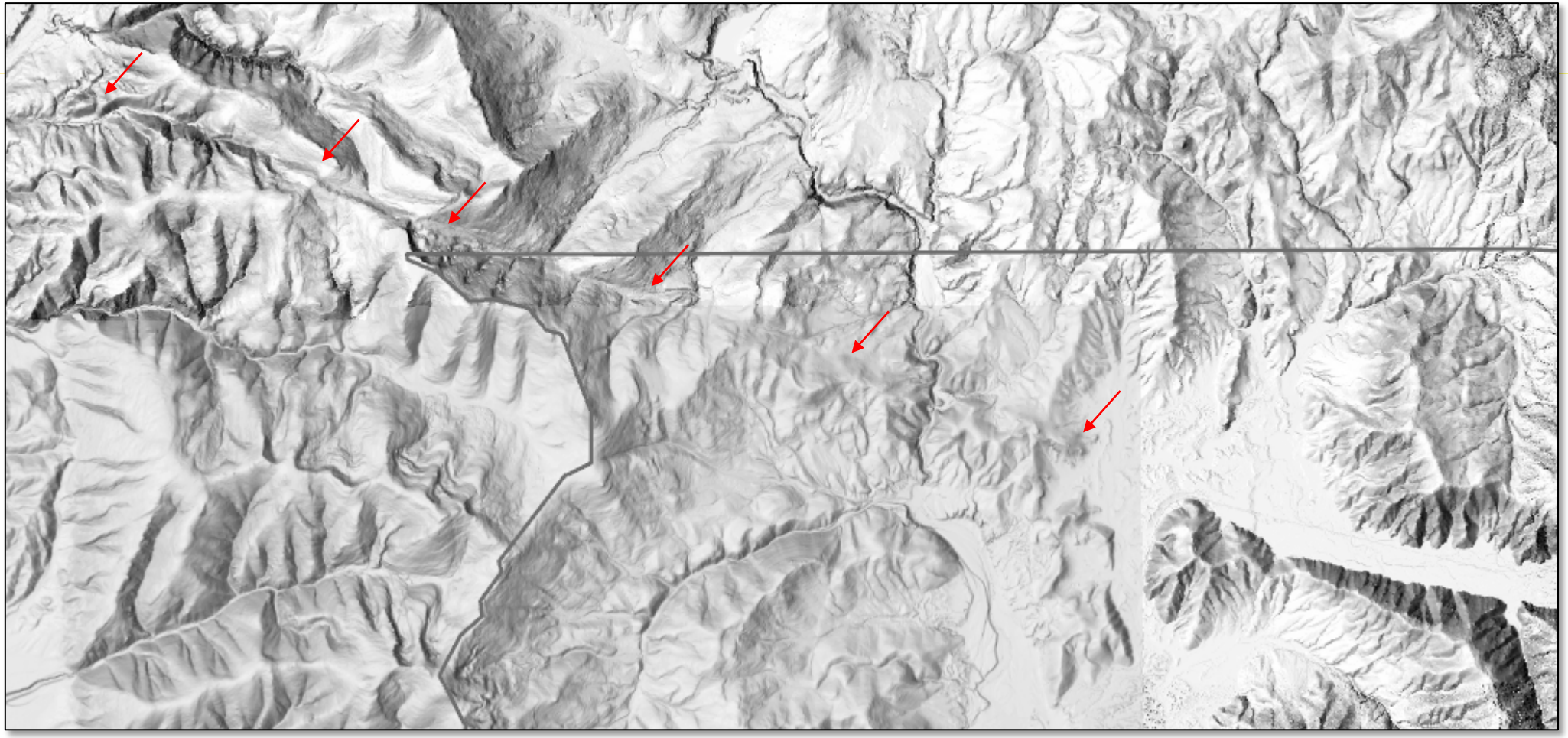
- Shroder Creek fault is small normal fault system

- does not cut quaternary

- old landscape (Oligocene, ~30 Ma)



Where does the Shroder Creek fault go?

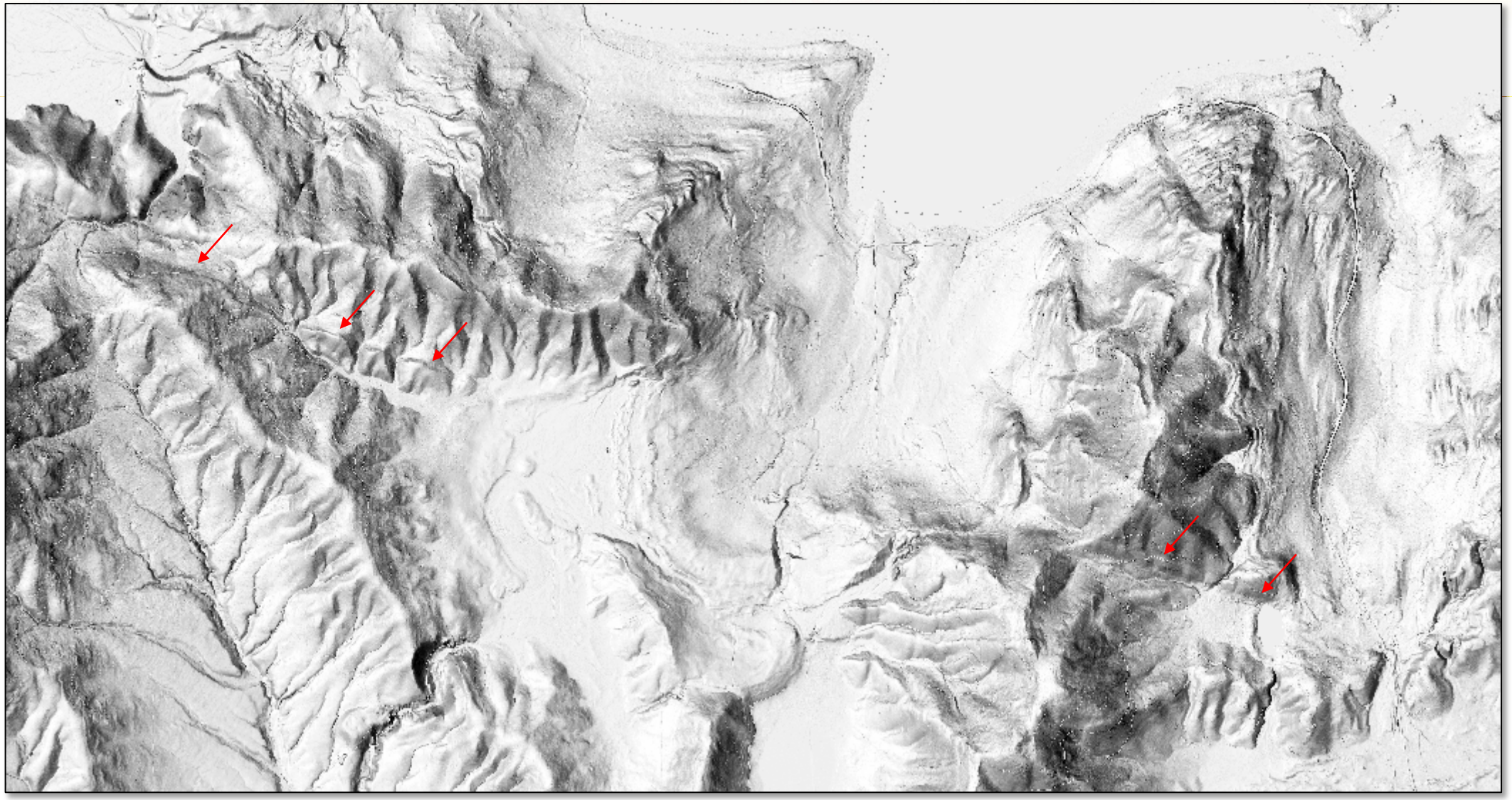


- traced for 26 km (16 mi)

- disappears beneath Big Draw

next slide

Continuation of Shroder Creek fault?



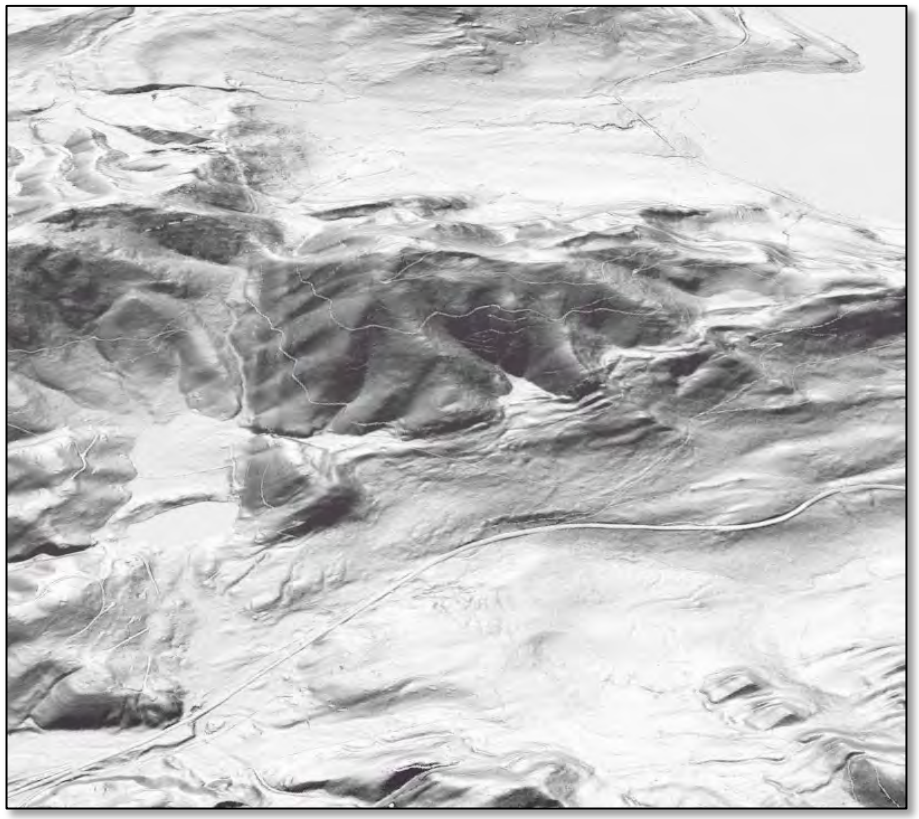
-liniment continues east of Big Draw

-covered by glacial deposits

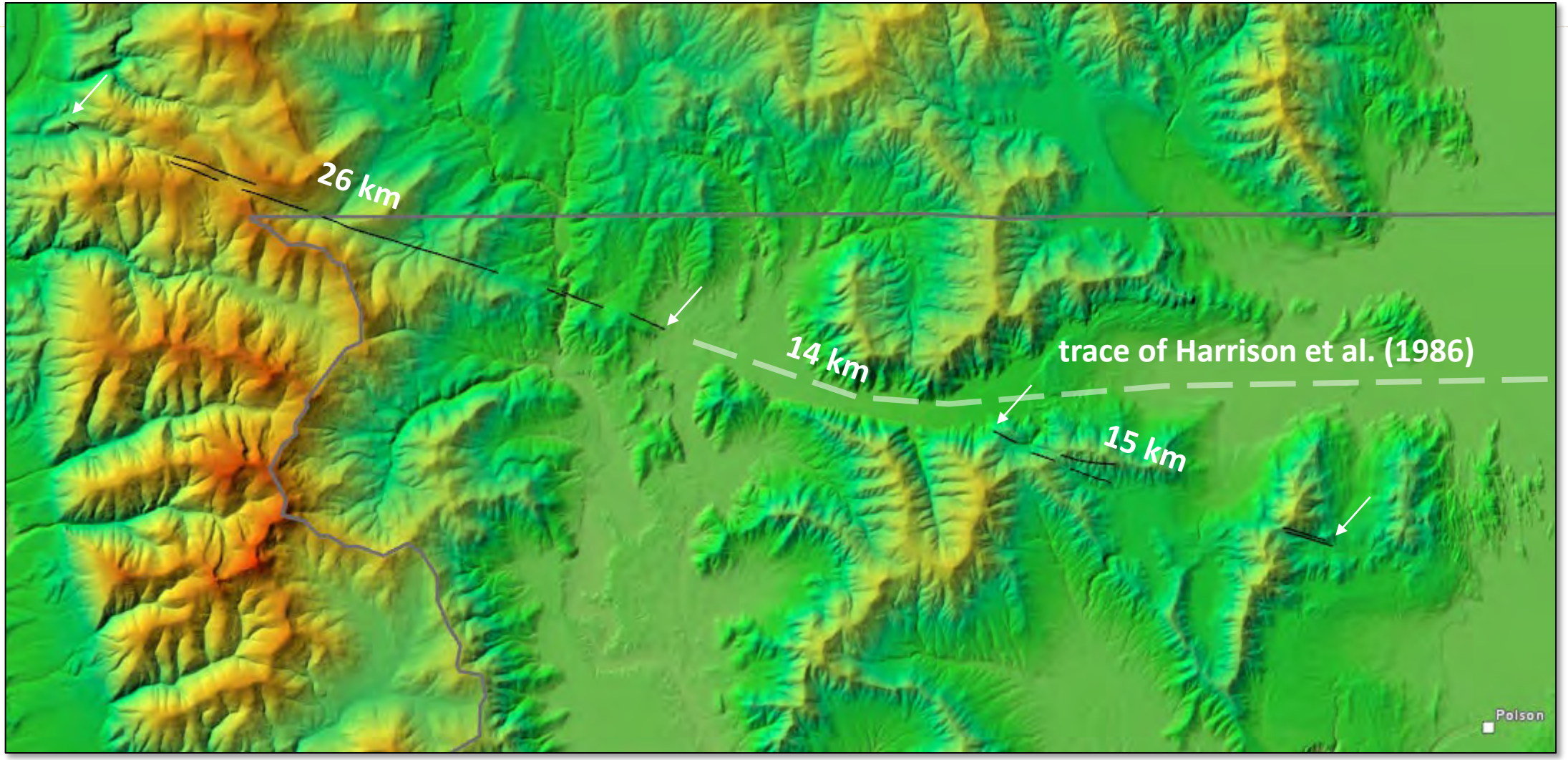
Is it active?

- Pleistocene shorelines are not cut by fault

- Glacial deposits cover fault



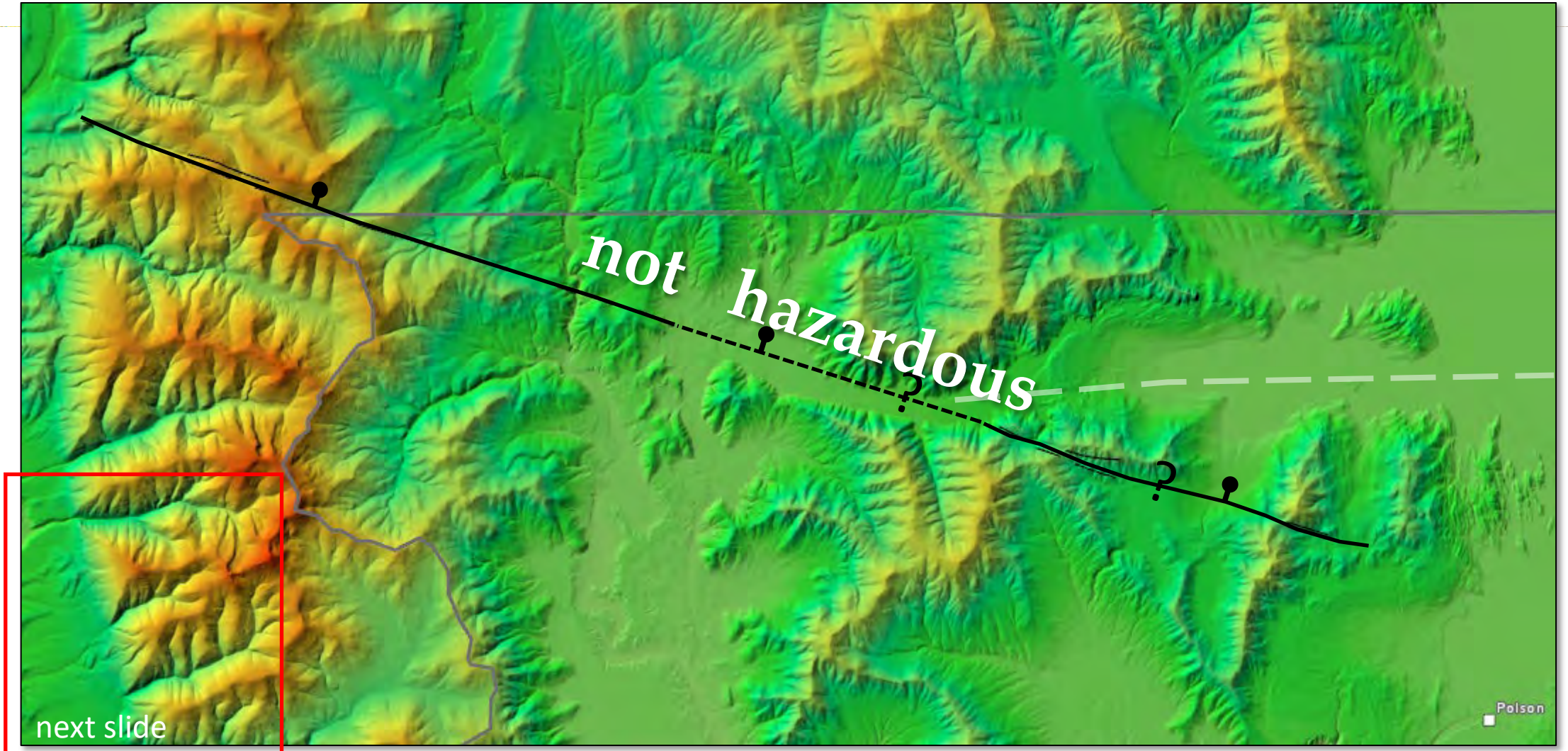
Continuation of Shroder Creek fault?



55 km trace?

(34 mi)

Proposed Shroder Creek fault



Thompson Valley fault

USGS Quaternary fault and fold database

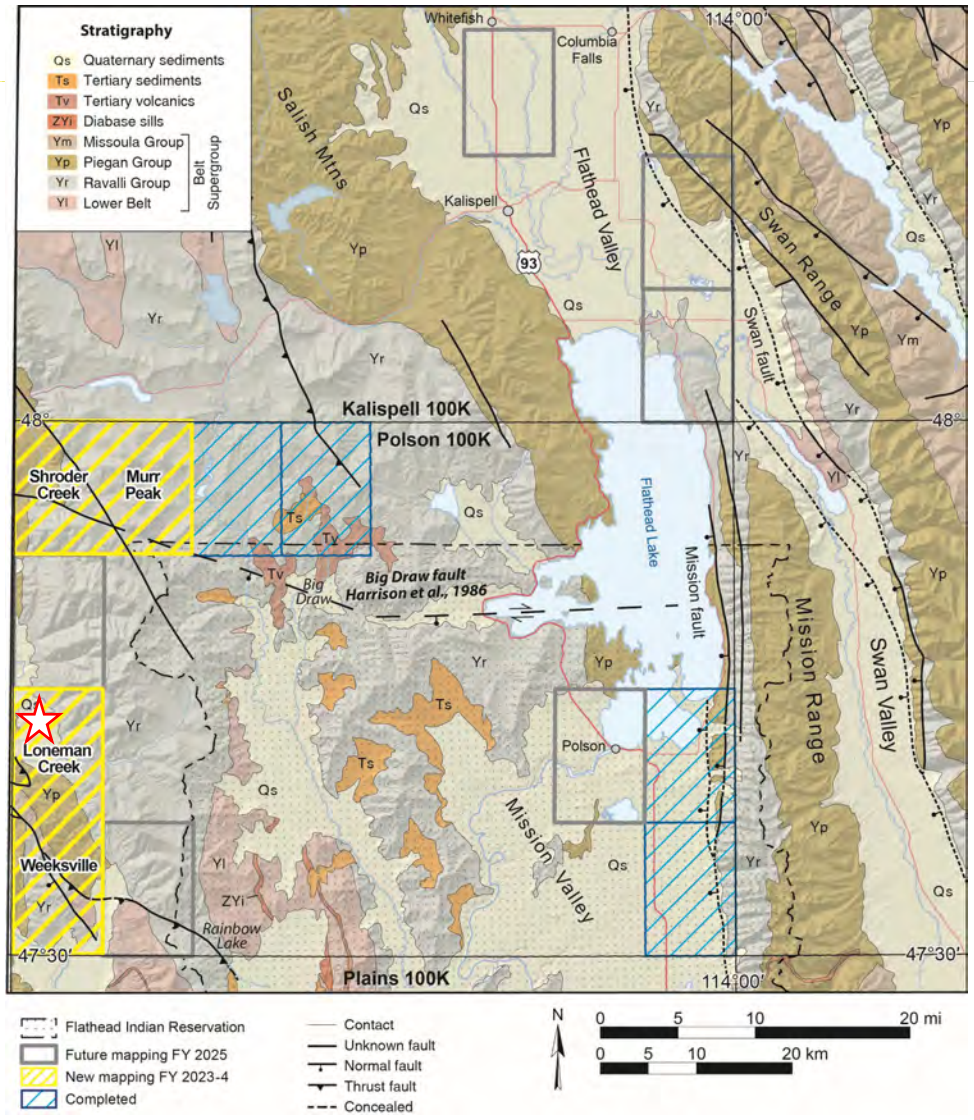
Ostenaa et al., 1990

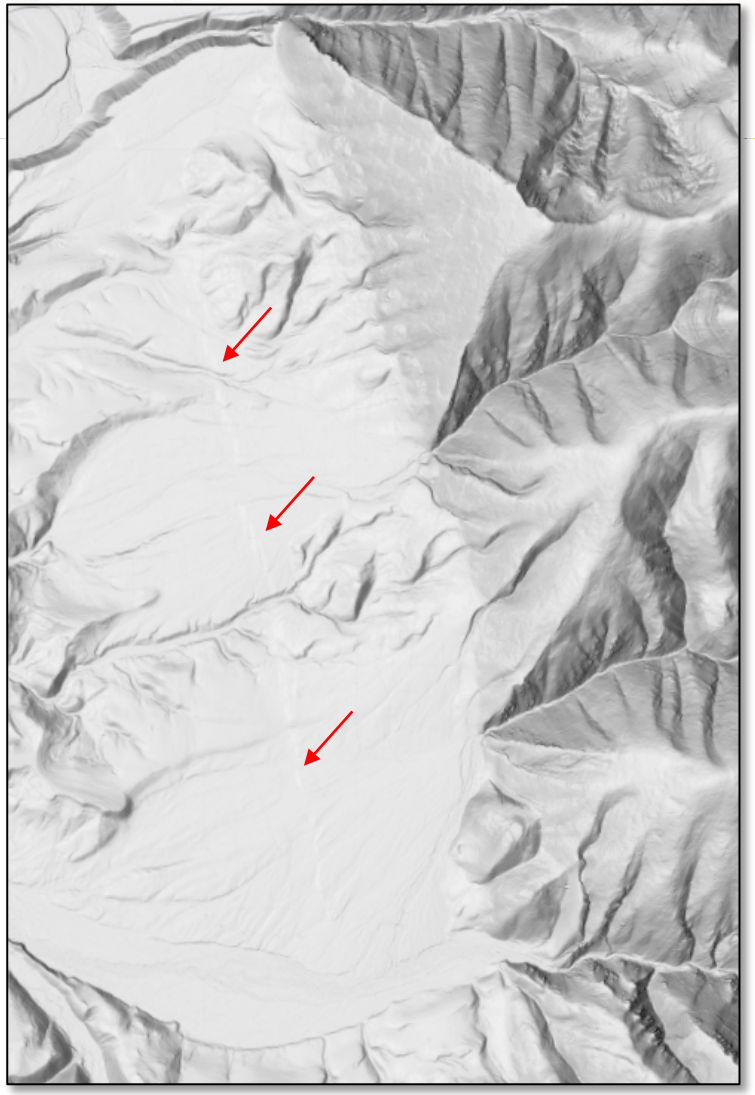
- U.S. Bureau of Rec seismotectonic study
- hard to find study
- constraints unknown

USGS Quaternary fault and fold database

- well constrained trace
- active normal fault (latest Quaternary)

Thompson Valley fault





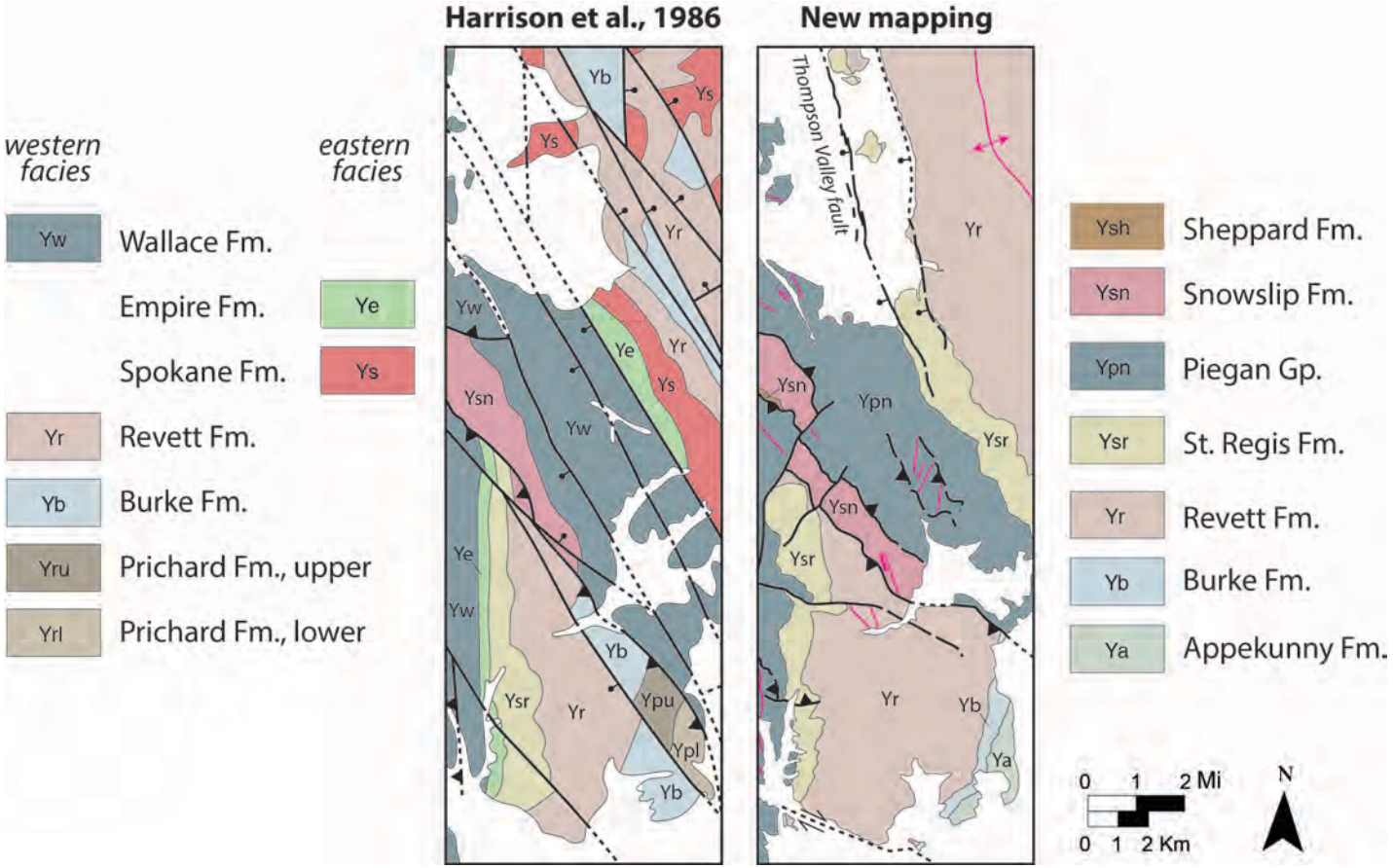
-scarp cuts alluvium in valley

-sharp range front

active range-bounding fault?

Larger unrecognized hazard next door?

Mapping results



- general fault reduction

- Thompson Valley fault traced for ~ 11 km (7 mi)

- range-bounding fault: inferred, concealed

Inconclusive results

- range front is defined by dip slope

-valley is shallow, and exhumed

..suggests old landscape

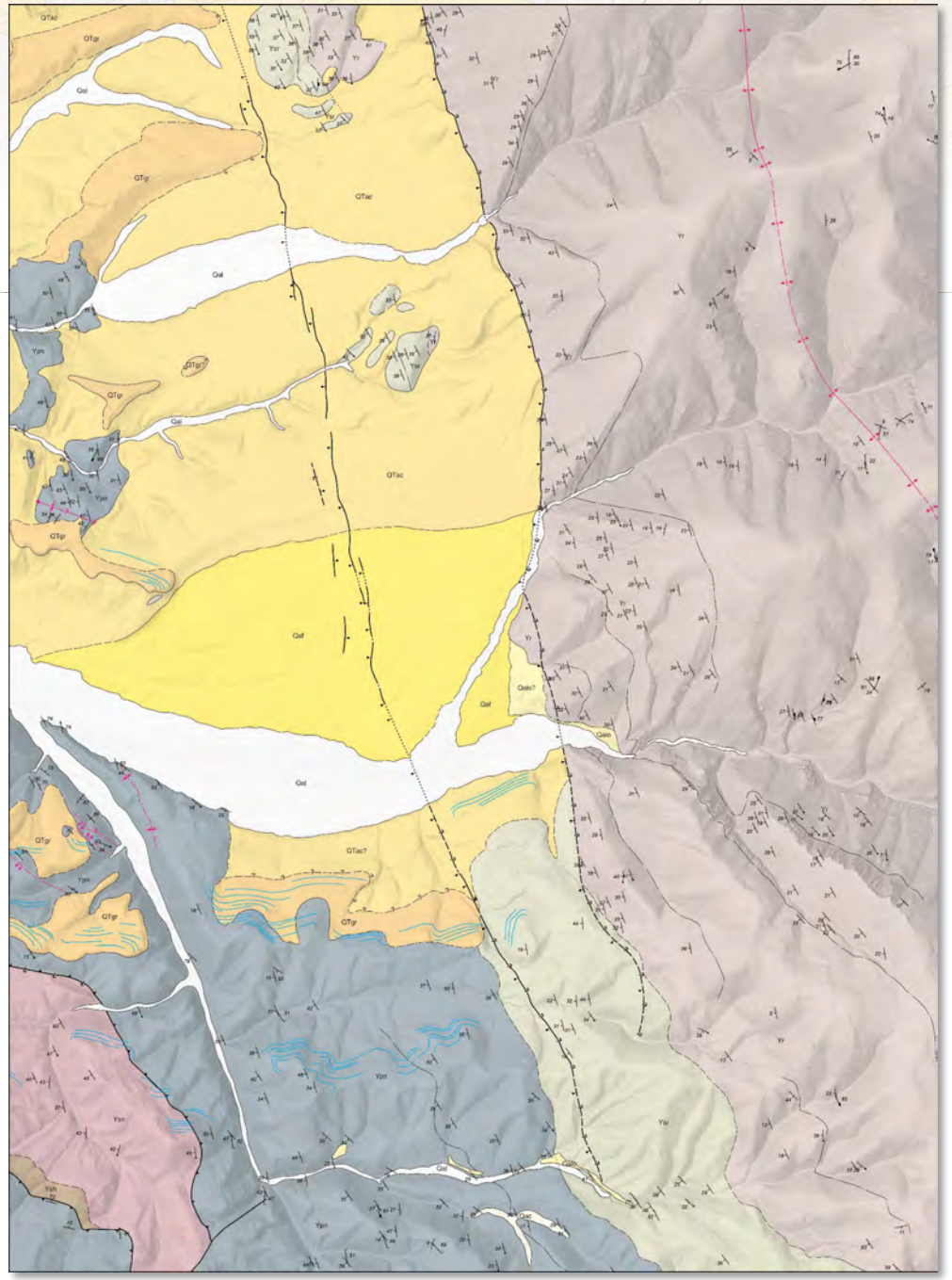
…low strain rates or inactive range front fault

- scarps cut Quaternary fan

- stratigraphic position of range front changes along strike

…demonstrates active faulting in valley

…suggests range front is fault controlled



Thompson Valley fault system

-evidence of active fault in valley

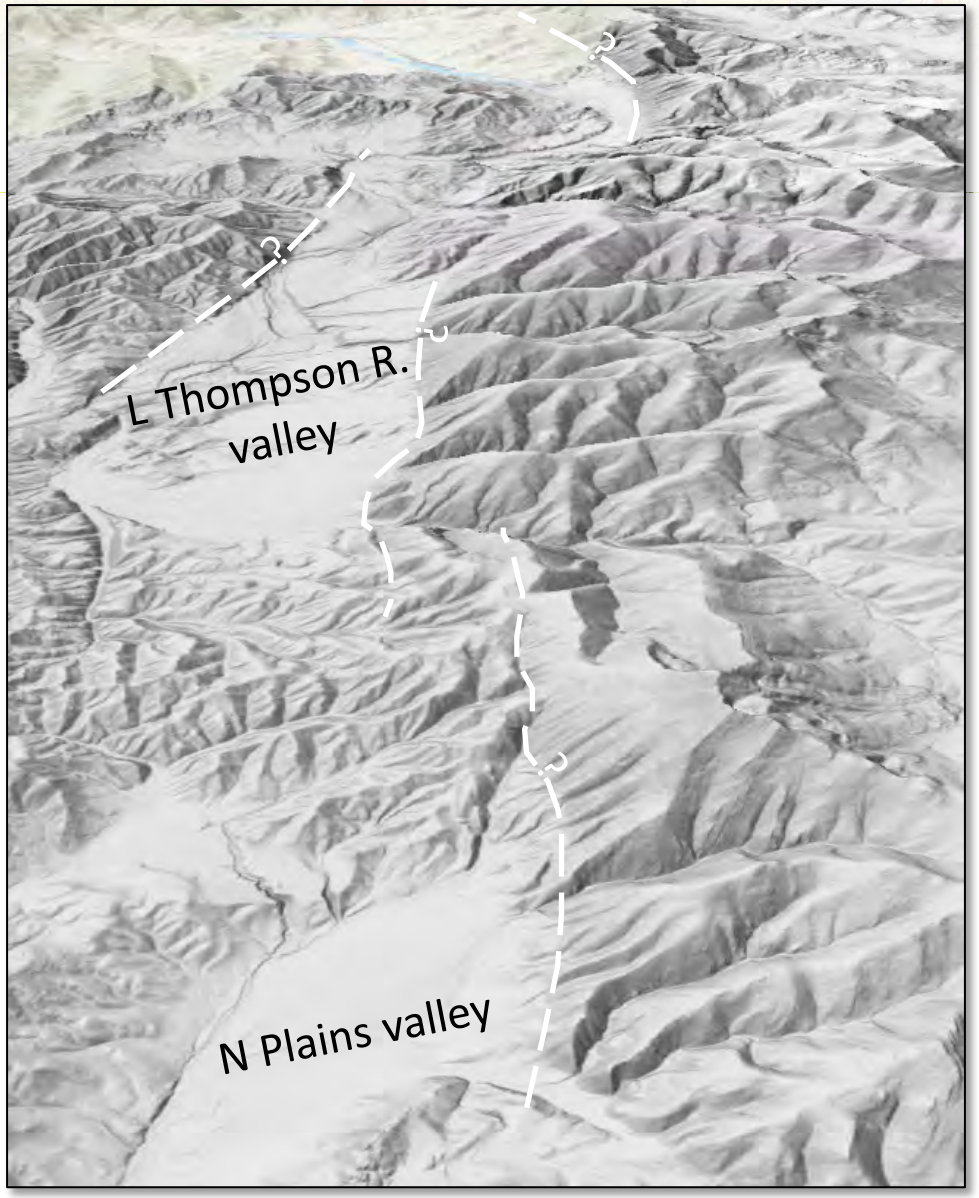
- no direct evidence of larger range-bounding normal fault

- potentially up to 60 km (34 mi) long fault system

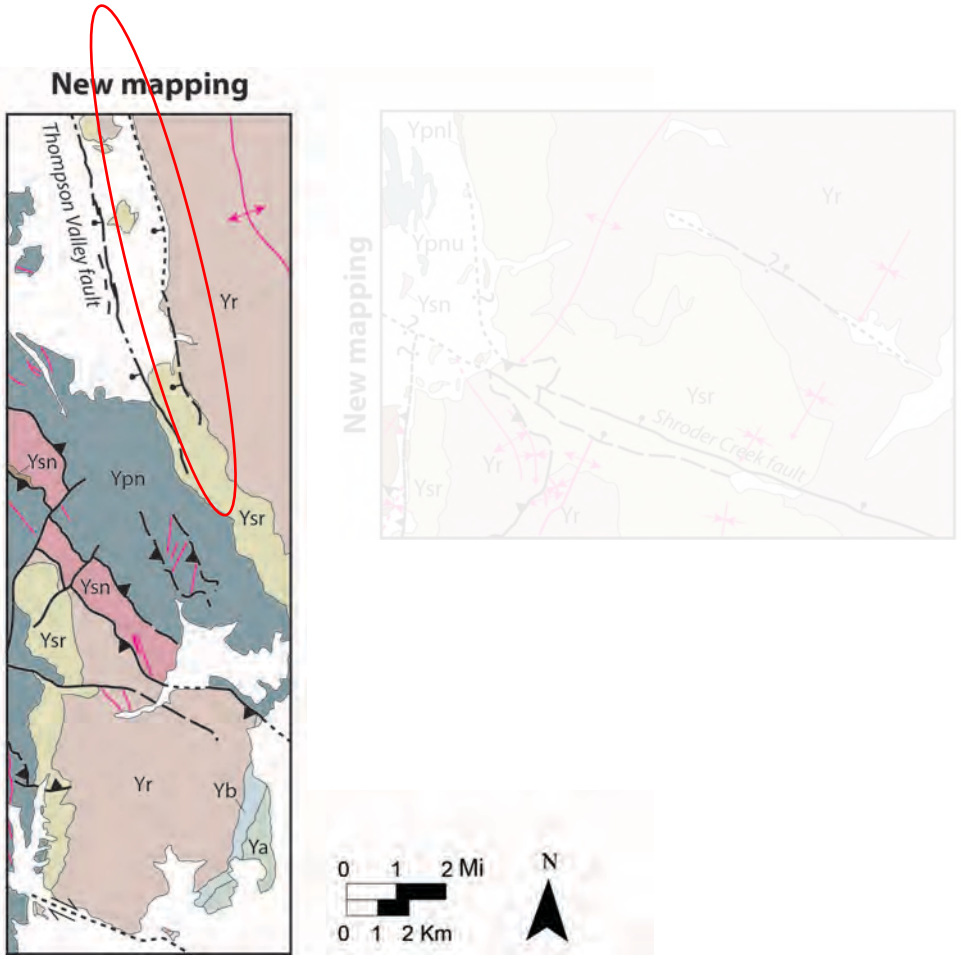
Are modern valleys relics?

Or…

Is this an active fault system?



Preliminary conclusions



Big Draw fault

not hazardous

- weak evidence for active E-W segment into Flathead lake

Shroder Creek fault

not hazardous

- may be up to 55 km (34 mi) long normal fault
- not likely active

Thompson Valley fault

potentially hazardous

- active 11 km long splay in valley
- valley is likely fault bounded (poorly constrained)
- fault system could be up to 60 km (37 mi) long

Are bounding faults active or not?

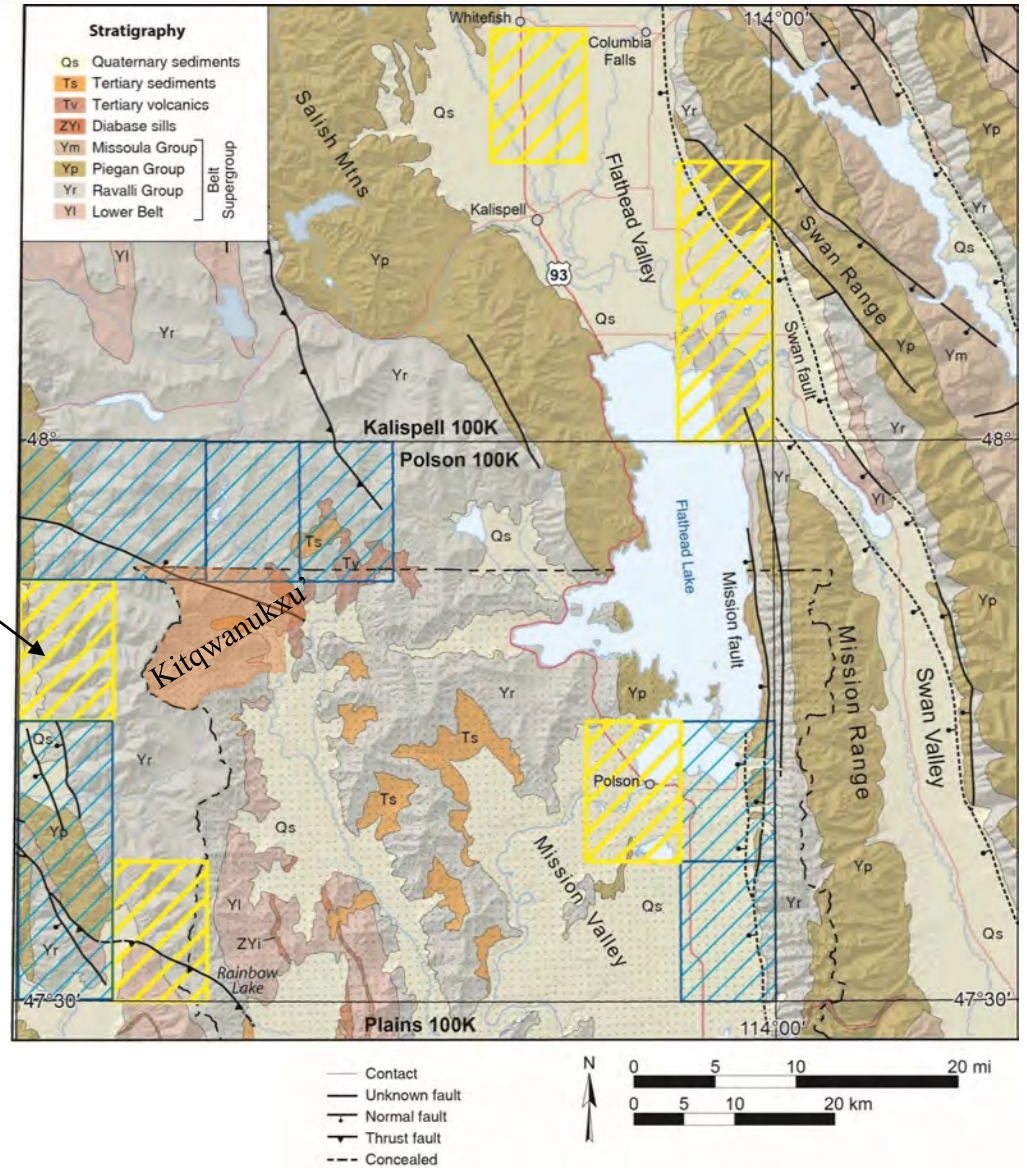
Future work

- map continuation of Thompson Valley fault

- continue mapping in Polson 30' x 60' quadrangle

- begin mapping in Kalispell 30' x 60' quadrangle

FY 2026 mapping

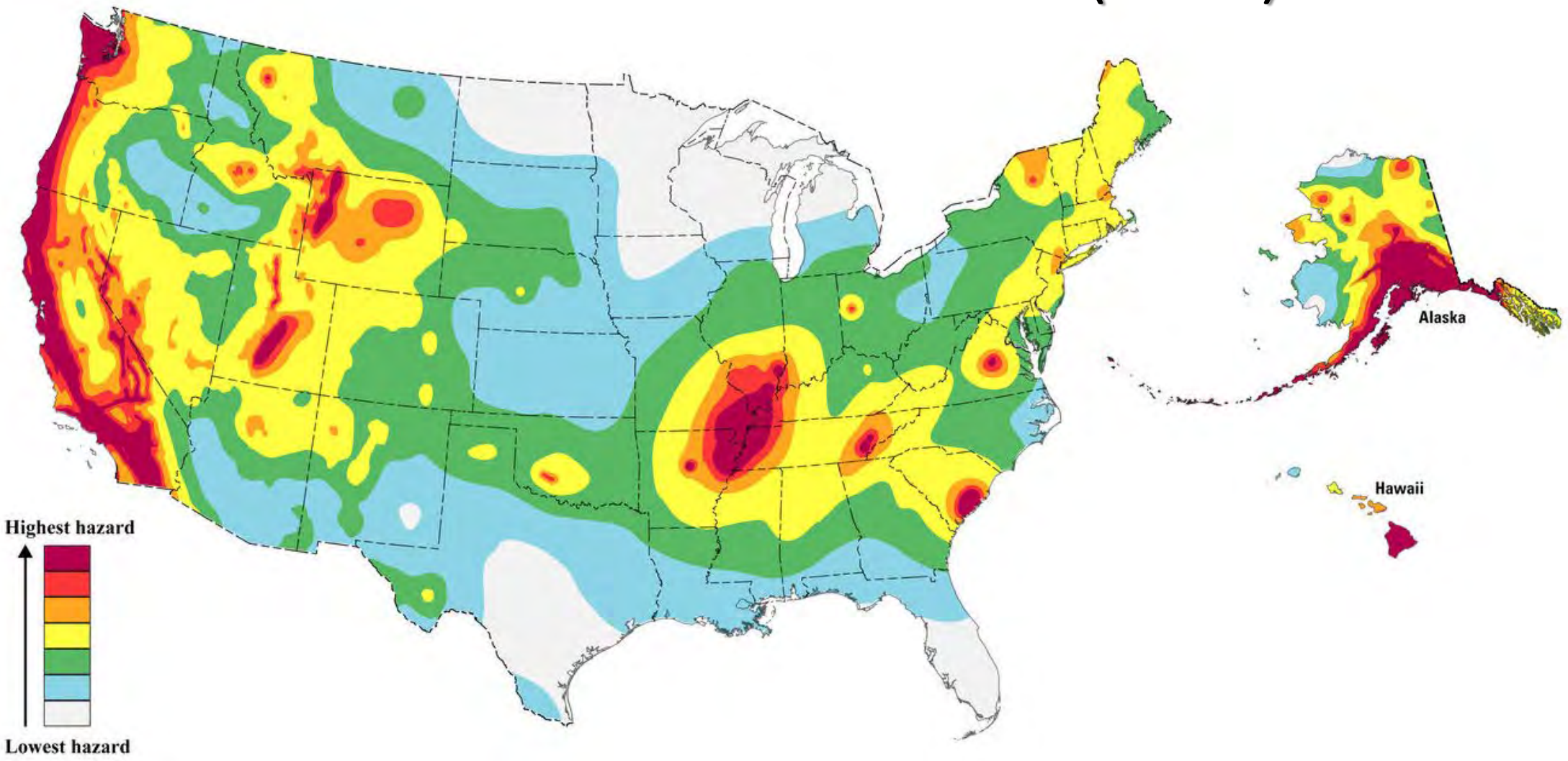


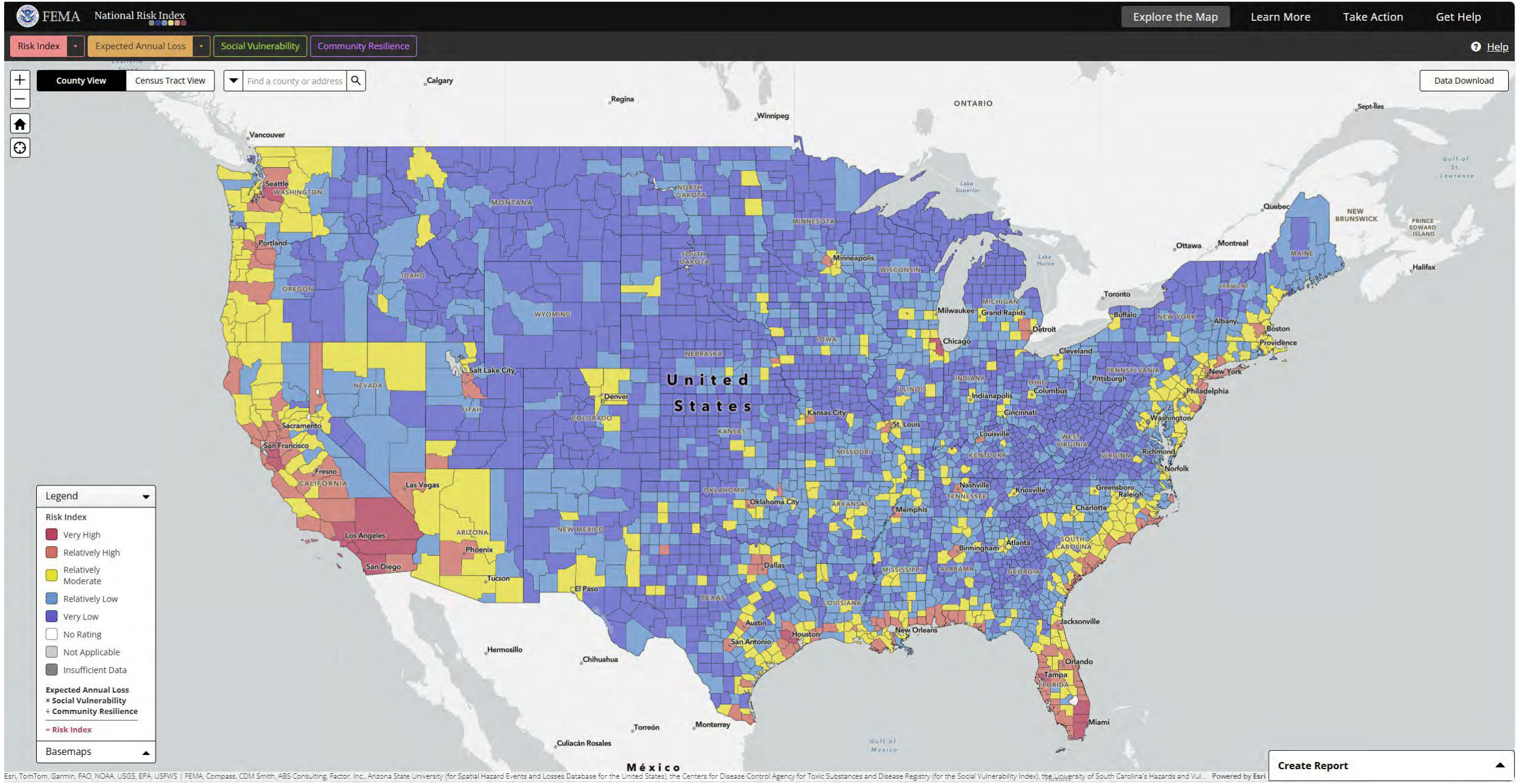
Earthquake Risk in Flathead and Mission Valleys

Yann Gavillot
Montana Bureau of Mines and Geology

2025 Montana Geohazards Workshop: Kalispell May 8-9, 2025

Earthquake Hazard map from the 2023 update of the National Seismic Hazard Model (NSHM)

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Take Action
Get Help
Risk Index
Expected Annual Loss
Social Vulnerability
Community Resilience
Help
County View
Census Tract View
Find a county or address
Data Download
Legend
Risk Index
Very High
Relatively High
Relatively Moderate
Relatively Low
Very Low
No Rating
Not Applicable
Insufficient Data
Expected Annual Loss
× Social Vulnerability
÷ Community Resilience
= Risk Index
Basemaps
Create Report
United States
México
Seattle
Portland
Vancouver
Salt Lake City
Denver
Sacramento
San Francisco
Fresno
Las Vegas
Los Angeles
San Diego
Phoenix
Tucson
El Paso
Dallas
Houston
San Antonio
Austin
Oklahoma City
Kansas City
Minneapolis
Chicago
Milwaukee
Detroit
Cleveland
Pittsburgh
Columbus
Indianapolis
Cincinnati
St. Louis
Memphis
Louisville
Nashville
Atlanta
Birmingham
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Jacksonville
Orlando
Tampa
Miami
Charlotte
Raleigh
Greensboro
Richmond
Norfolk
Washington
Philadelphia
New York
Albany
Buffalo
Boston
Providence
Toronto
Ottawa
Montreal
Quebec
Halifax
Sept-Îles
Winnipeg
Regina
Calgary
Hermosillo
Chihuahua
Torreón
Monterrey
Culiacán Rosales
Gulf of Mexico
Lake Superior
Lake Huron
Gulf of St. Lawrence
ONTARIO
NEW BRUNSWICK
PRINCE EDWARD ISLAND
MAINE
VERMONT
NEW YORK
PENNSYLVANIA
WEST VIRGINIA
VIRGINIA
KENTUCKY
TENNESSEE
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
LOUISIANA
ARKANSAS
MISSOURI
IOWA
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MICHIGAN
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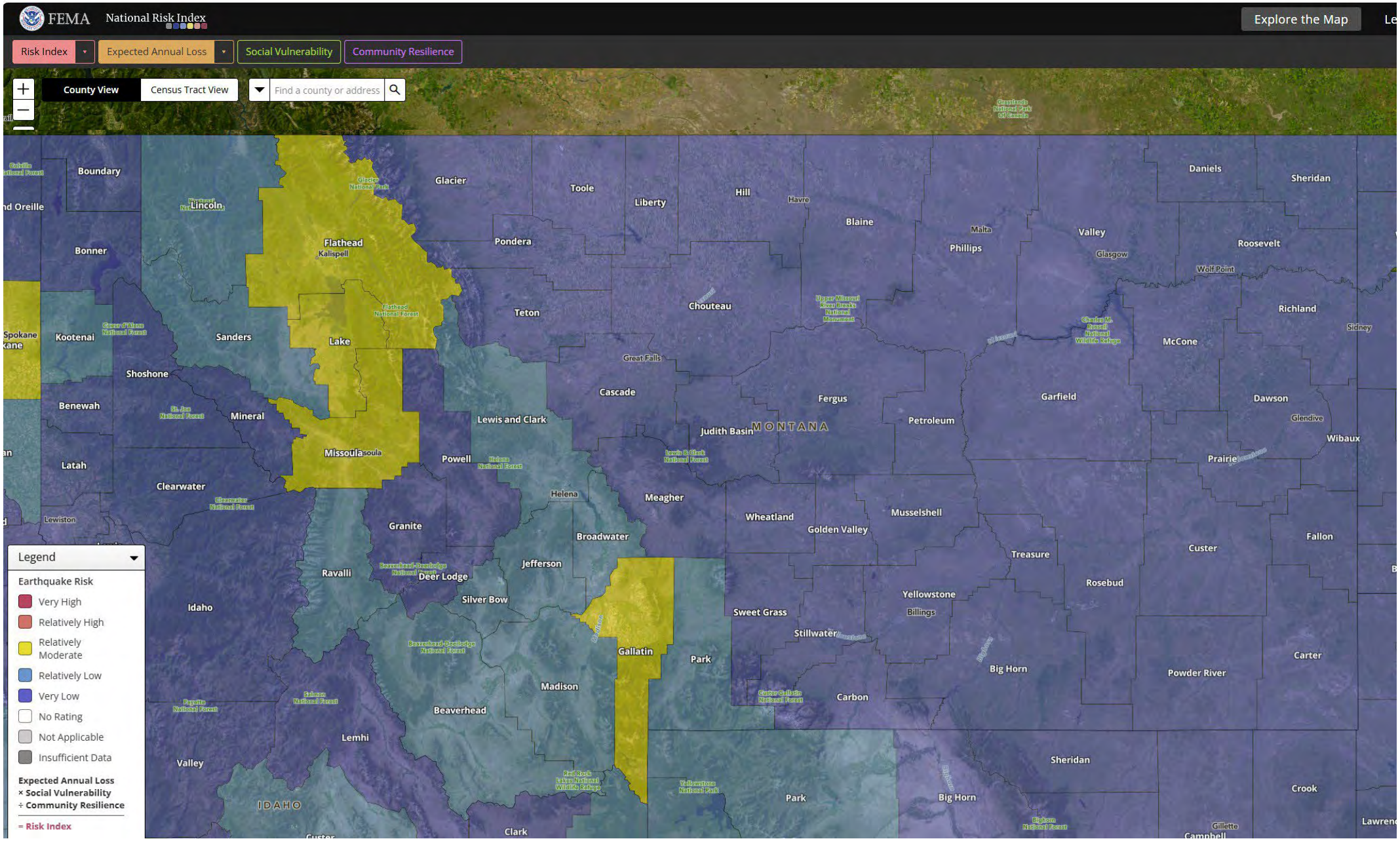
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
NEW MEXICO
ARIZONA
COLORADO
UTAH
NEVADA
WYOMING
MONTANA
IDAHO
OREGON
CALIFORNIA
NORTH DAKOTA
SOUTH DAKOTA
WASHINGTON
FLORIDA
Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS | FEMA, Compass, CDM Smith, ABS Consulting, Factor, Inc., Arizona State University (for Spatial Hazard Events and Losses Database for the United States), the Centers for Disease Control Agency for Toxic Substances and Disease Registry (for the Social Vulnerability Index), the University of South Carolina's Hazards and Vul...
Powered by Esri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Relatively Moderate
Relatively Low
Very Low
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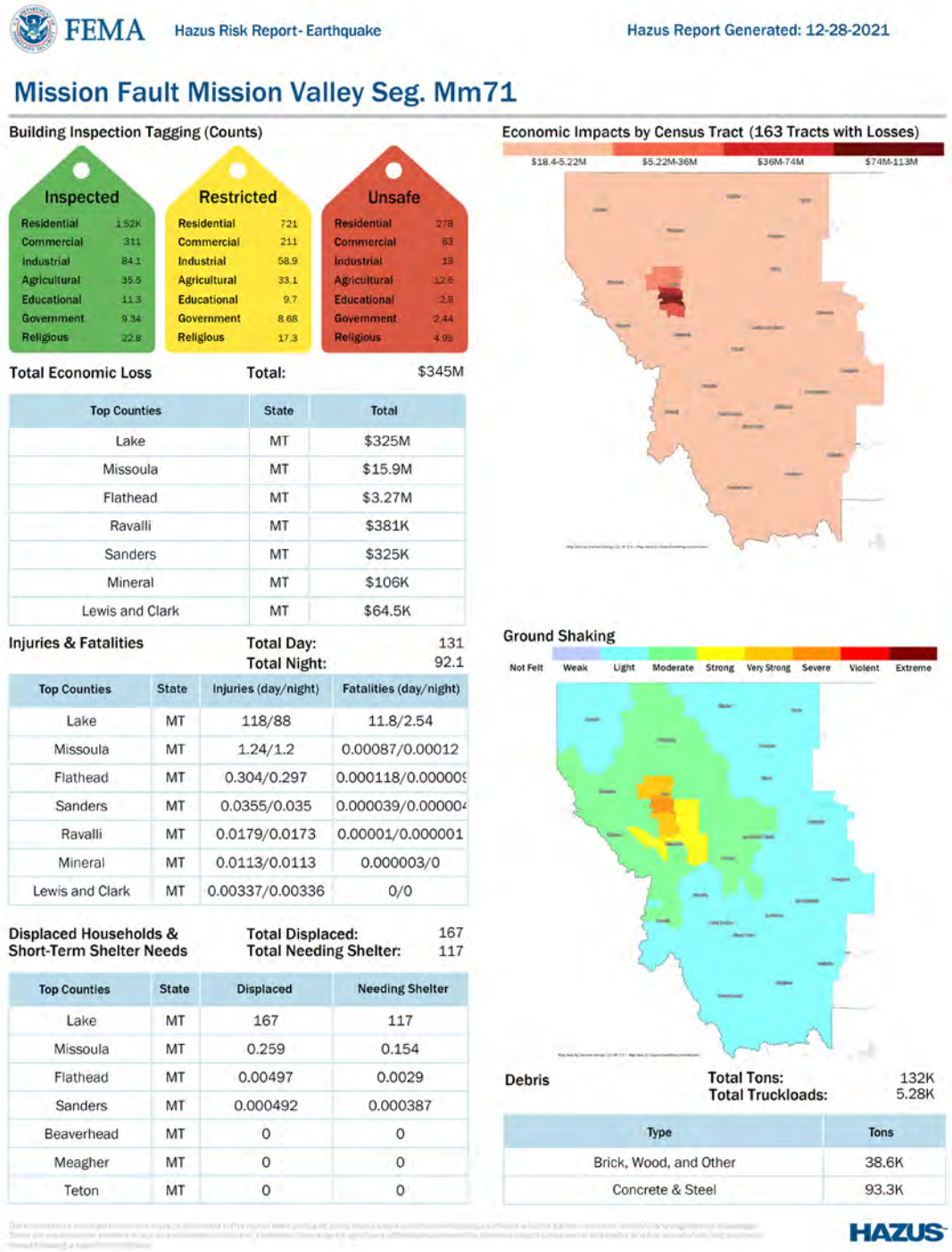
Not Applicable
Insufficient Data
Expected Annual Loss × Social Vulnerability ÷ Community Resilience
= Risk Index
MONTANA
IDAHO
Boundary
Bonner
Kootenai
Shoshone
Benewah
Latah
Clearwater
Lewiston
Idaho
Valley
Lemhi
Ravalli
Granite
Missoula
Mineral
Sanders
Lake
Flathead
Kalispell
Lincoln
Pondera
Glacier
Toole
Liberty
Hill
Havre
Blaine
Phillips
Malta
Valley
Glasgow
Daniels
Sheridan
Roosevelt
Wolf Point
Richland
Sidney
McCone
Garfield
Dawson
Glendive
Wibaux
Prairie
Fallon
Custer
Rosebud
Powder River
Carter
Big Horn
Carbon
Yellowstone
Billings
Stillwater
Sweet Grass
Treasure
Golden Valley
Musselshell
Wheatland
Meagher
Broadwater
Jefferson
Deer Lodge
Silver Bow
Gallatin
Park
Madison
Beaverhead
Powell
Lewis and Clark
Helena
Cascade
Great Falls
Teton
Chouteau
Fergus
Judith Basin
Petroleum
Crook
Lawrence
Clark
Custer
Gillette
Campbell

Earthquake

Rank	Community	State	Risk Index Rating	Risk Index Score	National Percentile
1	Flathead County	MT	Relatively Moderate	95.83	0 100
2	Gallatin County	MT	Relatively Moderate	93.95	0 100
3	Missoula County	MT	Relatively Moderate	93.86	0 100
4	Lake County	MT	Relatively Moderate	93.76	0 100
5	Lewis and Clark County	MT	Relatively Low	87.08	0 100
6	Silver Bow County	MT	Relatively Low	86.35	0 100
7	Beaverhead County	MT	Relatively Low	79.48	0 100
8	Madison County	MT	Relatively Low	79.03	0 100
9	Ravalli County	MT	Relatively Low	75.82	0 100
10	Lincoln County	MT	Relatively Low	70.92	0 100
11	Park County	MT	Relatively Low	70.79	0 100
12	Sanders County	MT	Relatively Low	67.26	0 100
13	Cascade County	MT	Very Low	64.33	0 100
14	Yellowstone County	MT	Very Low	59.62	0 100
15	Carbon County	MT	Very Low	39.2	0 100
16	Big Horn County	MT	Very Low	22.27	0 100
17	Custer County	MT	Very Low	12.25	0 100
18	Roosevelt County	MT	Very Low	9.1	0 100
19	Richland County	MT	Very Low	6.62	0 100
20	Valley County	MT	Very Low	5.95	0 100

36 lower-risk communities were omitted from this report. **View the list †**

- ***Mission and Flathead Valleys (Kalispell Region)***
  - Mission fault: Hazus report for M7.1; **Total economic Loss = $345 million; total injuries = 131/92 (Day/night).** https://hazards.fema.gov/hazus-loss-library/details?id=245&sort=a-z



FEMA Hazus Risk Report- Earthquake — Hazus Report Generated: 12-28-2021

Mission Fault Mission Valley Seg. Mm71

Building Inspection Tagging (Counts)

Inspected		Restricted		Unsafe	
Residential	1.52K	Residential	721	Residential	278
Commercial	311	Commercial	211	Commercial	83
Industrial	84.1	Industrial	58.9	Industrial	19
Agricultural	35.5	Agricultural	33.1	Agricultural	12.6
Educational	11.3	Educational	9.7	Educational	2.9
Government	9.34	Government	8.68	Government	2.44
Religious	22.8	Religious	17.3	Religious	4.95

Total Economic Loss — **Total:** $345M

Top Counties	State	Total
Lake	MT	$325M
Missoula	MT	$15.9M
Flathead	MT	$3.27M
Ravalli	MT	$381K
Sanders	MT	$325K
Mineral	MT	$106K
Lewis and Clark	MT	$64.5K

Injuries & Fatalities — **Total Day:** 131 — **Total Night:** 92.1

Top Counties	State	Injuries (day/night)	Fatalities (day/night)
Lake	MT	118/88	11.8/2.54
Missoula	MT	1.24/1.2	0.00087/0.00012
Flathead	MT	0.304/0.297	0.000118/0.000009
Sanders	MT	0.0355/0.035	0.000039/0.000004
Ravalli	MT	0.0179/0.0173	0.00001/0.000001
Mineral	MT	0.0113/0.0113	0.000003/0
Lewis and Clark	MT	0.00337/0.00336	0/0

Displaced Households & Short-Term Shelter Needs — **Total Displaced:** 167 — **Total Needing Shelter:** 117

Top Counties	State	Displaced	Needing Shelter
Lake	MT	167	117
Missoula	MT	0.259	0.154
Flathead	MT	0.00497	0.0029
Sanders	MT	0.000492	0.000387
Beaverhead	MT	0	0
Meagher	MT	0	0
Teton	MT	0	0

Economic Impacts by Census Tract (163 Tracts with Losses)

$18.4-5.22M | $5.22M-36M | $36M-74M | $74M-113M

Ground Shaking

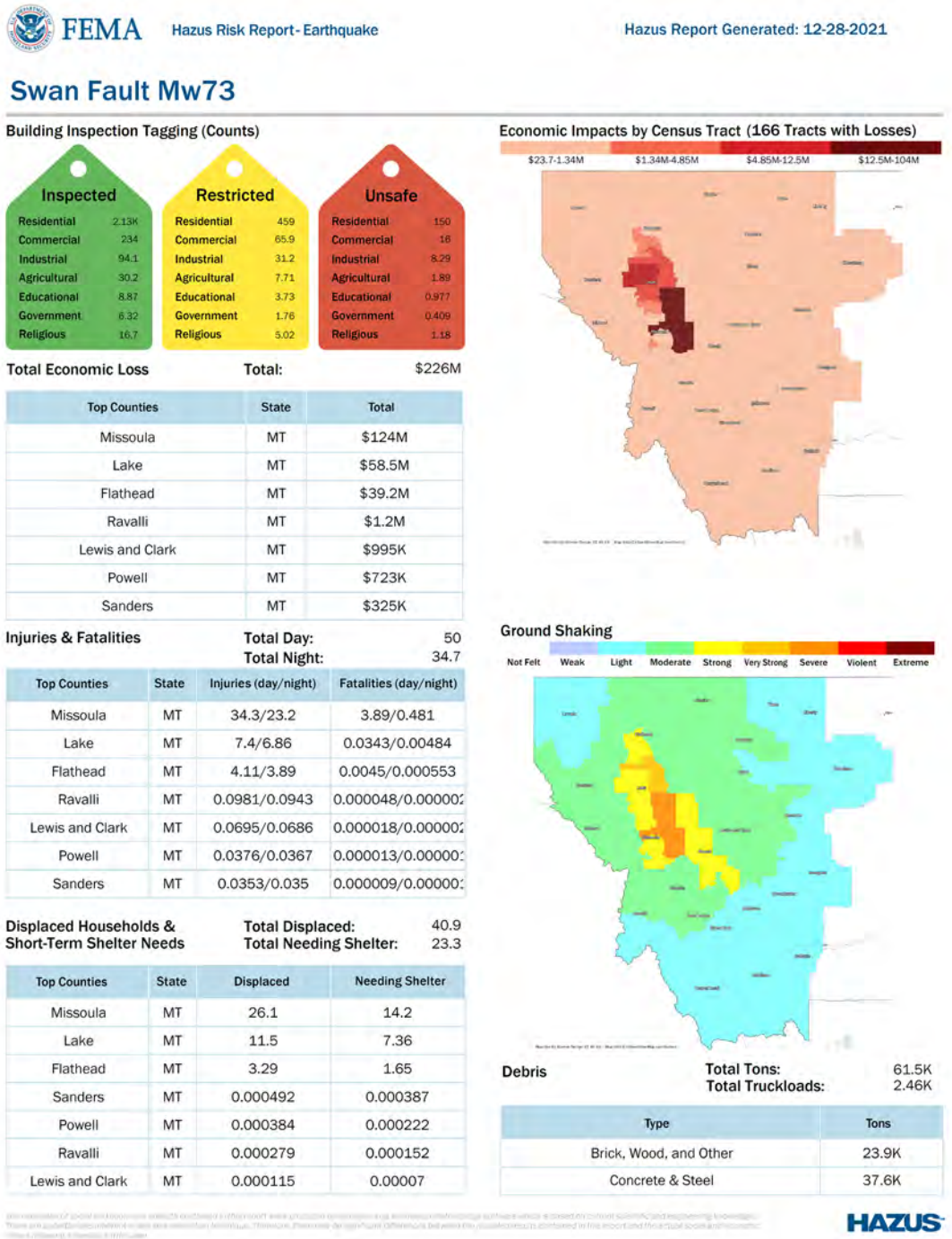
Not Felt | Weak | Light | Moderate | Strong | Very Strong | Severe | Violent | Extreme

Debris — **Total Tons:** 132K — **Total Truckloads:** 5.28K

Type	Tons
Brick, Wood, and Other	38.6K
Concrete & Steel	93.3K

HAZUS

- Swan Valley fault: Hazus report for M7.3; **Total economic Loss = $226 million**; **total injuries = 50/34.7 (Day/night).** https://hazards.fema.gov/hazus-loss-library/details?id=277&sort=a-z



FEMA Hazus Risk Report- Earthquake — Hazus Report Generated: 12-28-2021

Swan Fault Mw73

Building Inspection Tagging (Counts)

Inspected		Restricted		Unsafe	
Residential	2.13K	Residential	459	Residential	150
Commercial	234	Commercial	65.9	Commercial	18
Industrial	94.1	Industrial	31.2	Industrial	8.29
Agricultural	30.2	Agricultural	7.71	Agricultural	1.89
Educational	8.87	Educational	3.73	Educational	0.977
Government	6.32	Government	1.76	Government	0.409
Religious	16.7	Religious	5.02	Religious	1.18

Total Economic Loss — **Total:** $226M

Top Counties	State	Total
Missoula	MT	$124M
Lake	MT	$58.5M
Flathead	MT	$39.2M
Ravalli	MT	$1.2M
Lewis and Clark	MT	$995K
Powell	MT	$723K
Sanders	MT	$325K

Injuries & Fatalities — **Total Day:** 50 — **Total Night:** 34.7

Top Counties	State	Injuries (day/night)	Fatalities (day/night)
Missoula	MT	34.3/23.2	3.89/0.481
Lake	MT	7.4/6.86	0.0343/0.00484
Flathead	MT	4.11/3.89	0.0045/0.000553
Ravalli	MT	0.0981/0.0943	0.000048/0.00000
Lewis and Clark	MT	0.0695/0.0686	0.000018/0.00000
Powell	MT	0.0376/0.0367	0.000013/0.00000
Sanders	MT	0.0353/0.035	0.000009/0.00000

Displaced Households & Short-Term Shelter Needs — **Total Displaced:** 40.9 — **Total Needing Shelter:** 23.3

Top Counties	State	Displaced	Needing Shelter
Missoula	MT	26.1	14.2
Lake	MT	11.5	7.36
Flathead	MT	3.29	1.65
Sanders	MT	0.000492	0.000387
Powell	MT	0.000384	0.000222
Ravalli	MT	0.000279	0.000152
Lewis and Clark	MT	0.000115	0.00007

Economic Impacts by Census Tract (166 Tracts with Losses)

$23.7-1.34M | $1.34M-4.85M | $4.85M-12.5M | $12.5M-104M

Ground Shaking

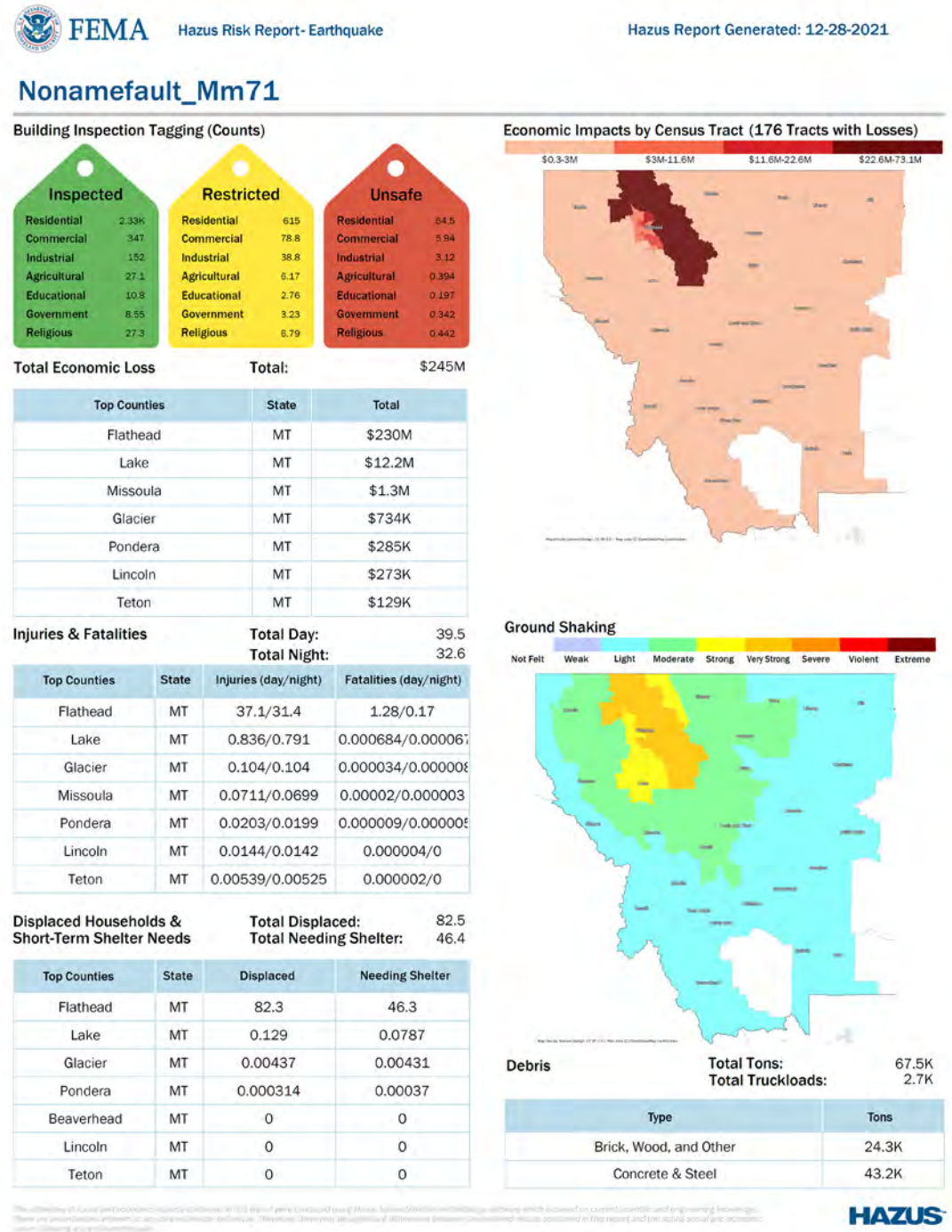
Not Felt | Weak | Light | Moderate | Strong | Very Strong | Severe | Violent | Extreme

Debris — **Total Tons:** 61.5K — **Total Truckloads:** 2.46K

Type	Tons
Brick, Wood, and Other	23.9K
Concrete & Steel	37.6K

HAZUS

- South Fork Flathead fault: Hazus report for M7.1; **Total economic Loss = $245 million**; **total injuries = 39.5/32.6 (Day/night).** https://hazards.fema.gov/hazus-loss-library/details?id=251&sort=a-z



FEMA Hazus Risk Report- Earthquake — Hazus Report Generated: 12-28-2021

Nonamefault_Mm71

Building Inspection Tagging (Counts)

	Inspected	Restricted	Unsafe
Residential	2.33K	615	84.5
Commercial	347	78.8	5.94
Industrial	152	38.8	3.12
Agricultural	27.1	6.17	0.394
Educational	10.8	2.76	0.197
Government	8.55	3.23	0.342
Religious	27.3	6.79	0.442

Total Economic Loss — Total: $245M

Top Counties	State	Total
Flathead	MT	$230M
Lake	MT	$12.2M
Missoula	MT	$1.3M
Glacier	MT	$734K
Pondera	MT	$285K
Lincoln	MT	$273K
Teton	MT	$129K

Injuries & Fatalities — Total Day: 39.5; Total Night: 32.6

Top Counties	State	Injuries (day/night)	Fatalities (day/night)
Flathead	MT	37.1/31.4	1.28/0.17
Lake	MT	0.836/0.791	0.000684/0.000067
Glacier	MT	0.104/0.104	0.000034/0.000008
Missoula	MT	0.0711/0.0699	0.00002/0.000003
Pondera	MT	0.0203/0.0199	0.000009/0.000005
Lincoln	MT	0.0144/0.0142	0.000004/0
Teton	MT	0.00539/0.00525	0.000002/0

Displaced Households & Short-Term Shelter Needs — Total Displaced: 82.5; Total Needing Shelter: 46.4

Top Counties	State	Displaced	Needing Shelter
Flathead	MT	82.3	46.3
Lake	MT	0.129	0.0787
Glacier	MT	0.00437	0.00431
Pondera	MT	0.000314	0.00037
Beaverhead	MT	0	0
Lincoln	MT	0	0
Teton	MT	0	0

Economic Impacts by Census Tract (176 Tracts with Losses)

Ground Shaking

Debris — Total Tons: 67.5K; Total Truckloads: 2.7K

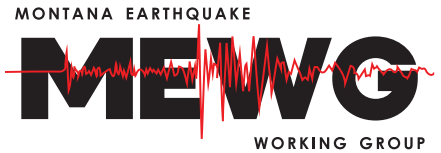
Type	Tons
Brick, Wood, and Other	24.3K
Concrete & Steel	43.2K

HAZUS

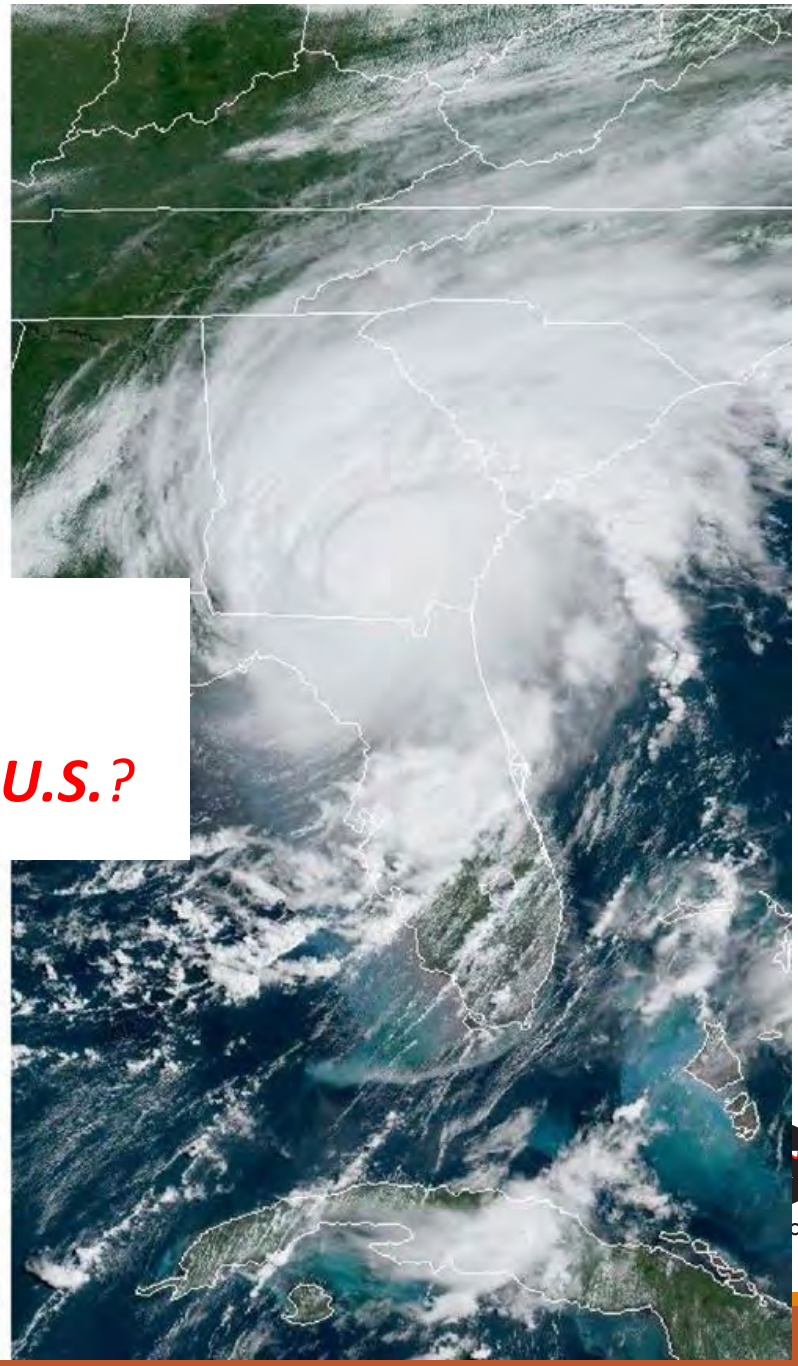
Disaster Resilience in our Flathead Valley

ANNA LANG OFSTAD

Perceptions of Risk vs. Reality



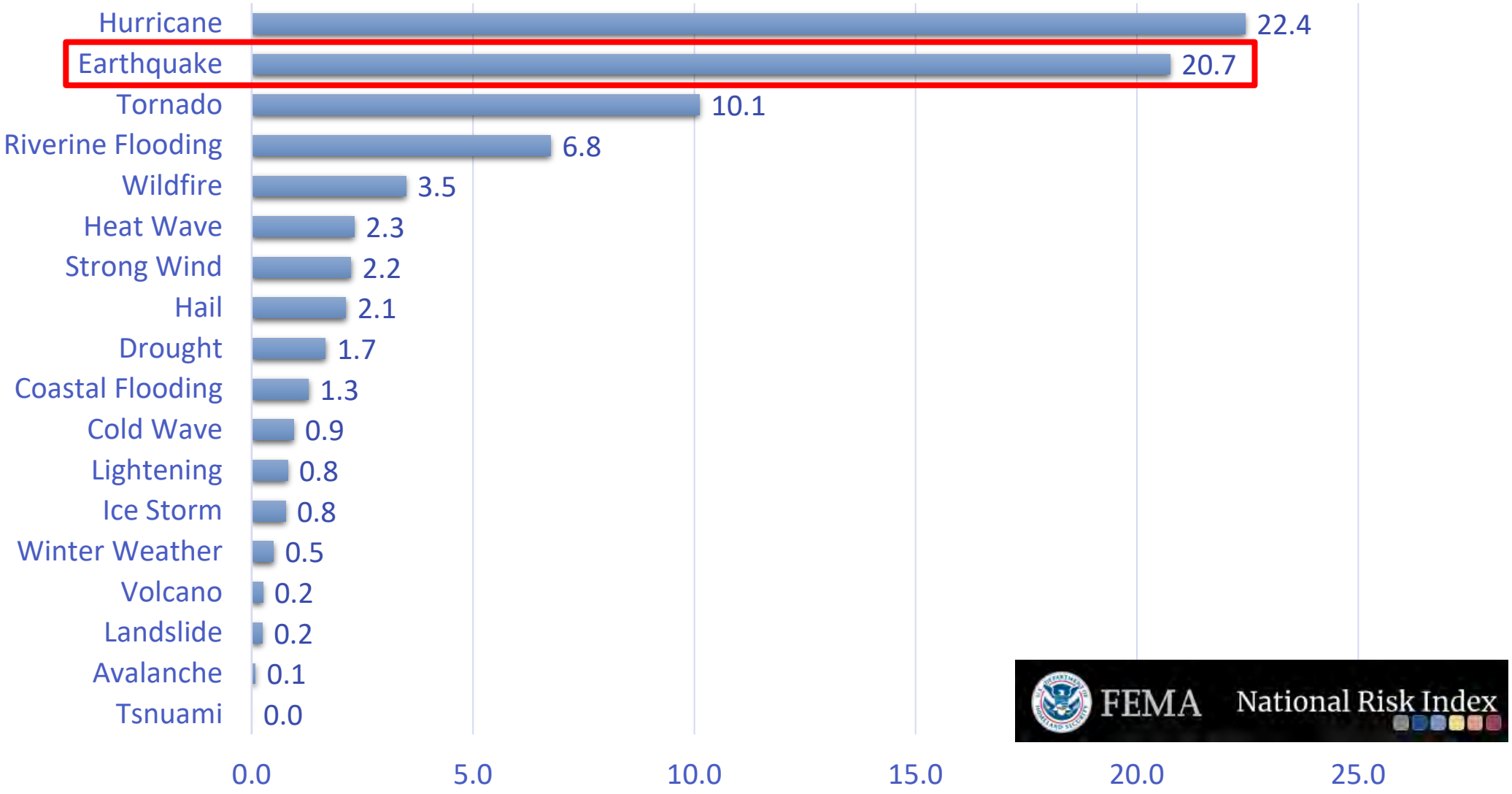




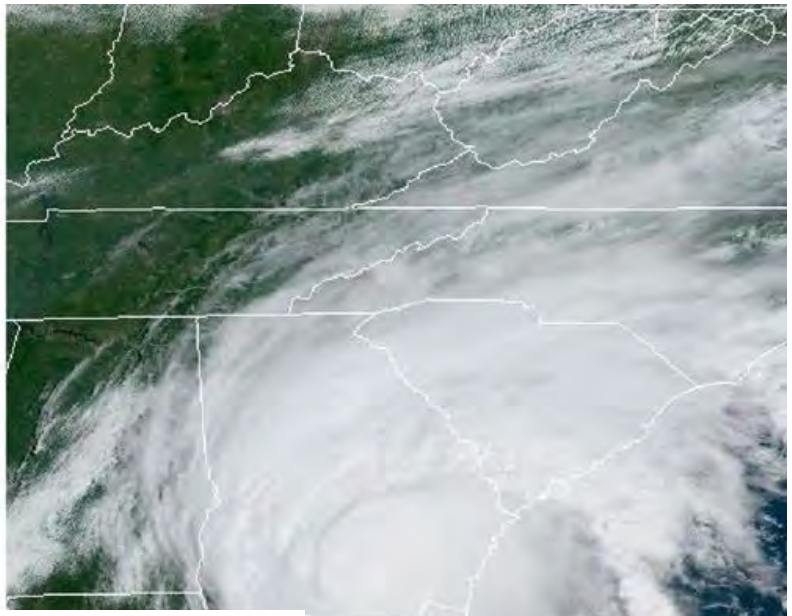
Quiz time!

*What's the biggest disaster threat to the **U.S.**?*

Estimated Annualized Losses by Hazard (USD Billion)

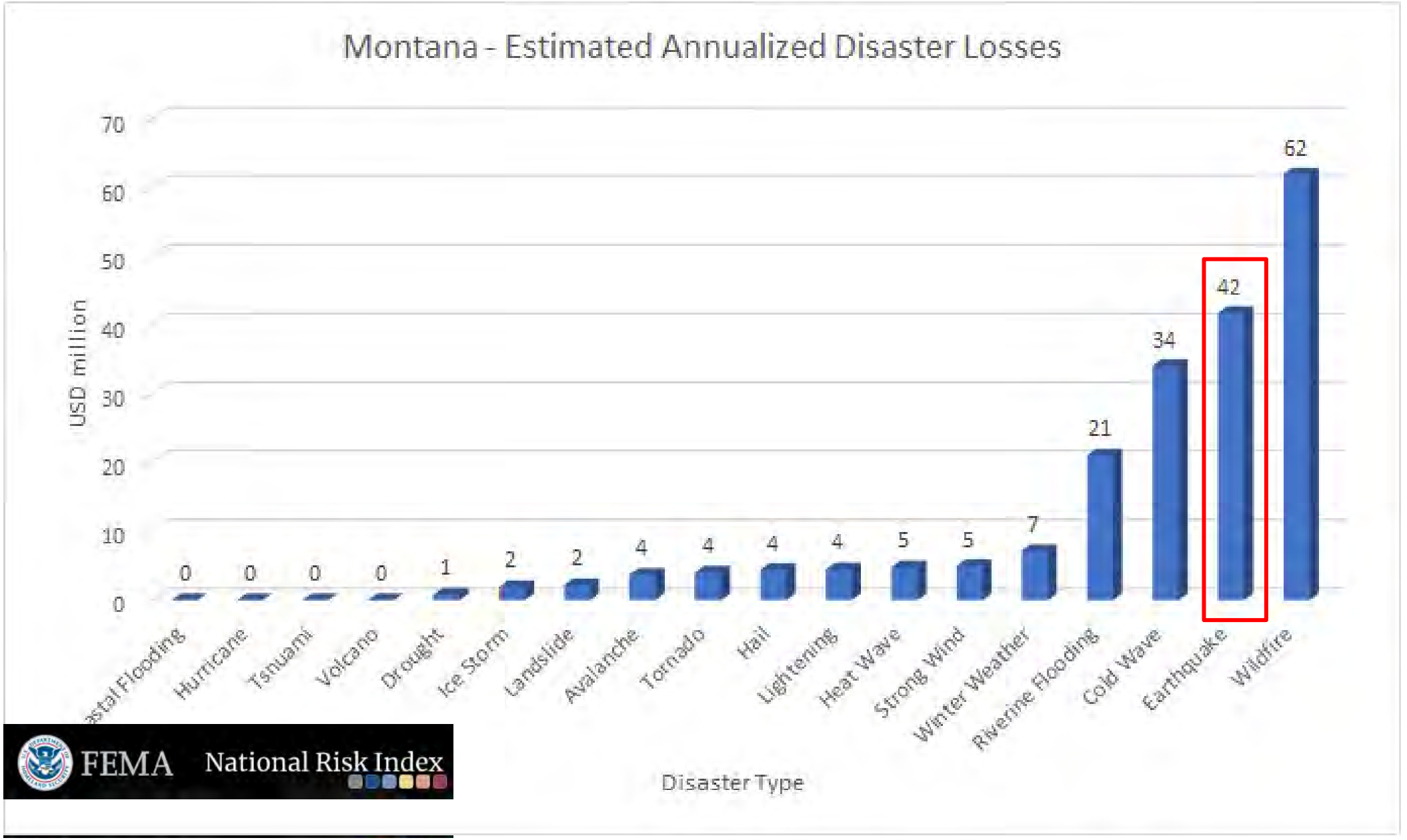






*What's the biggest disaster threat to **Montana**?*

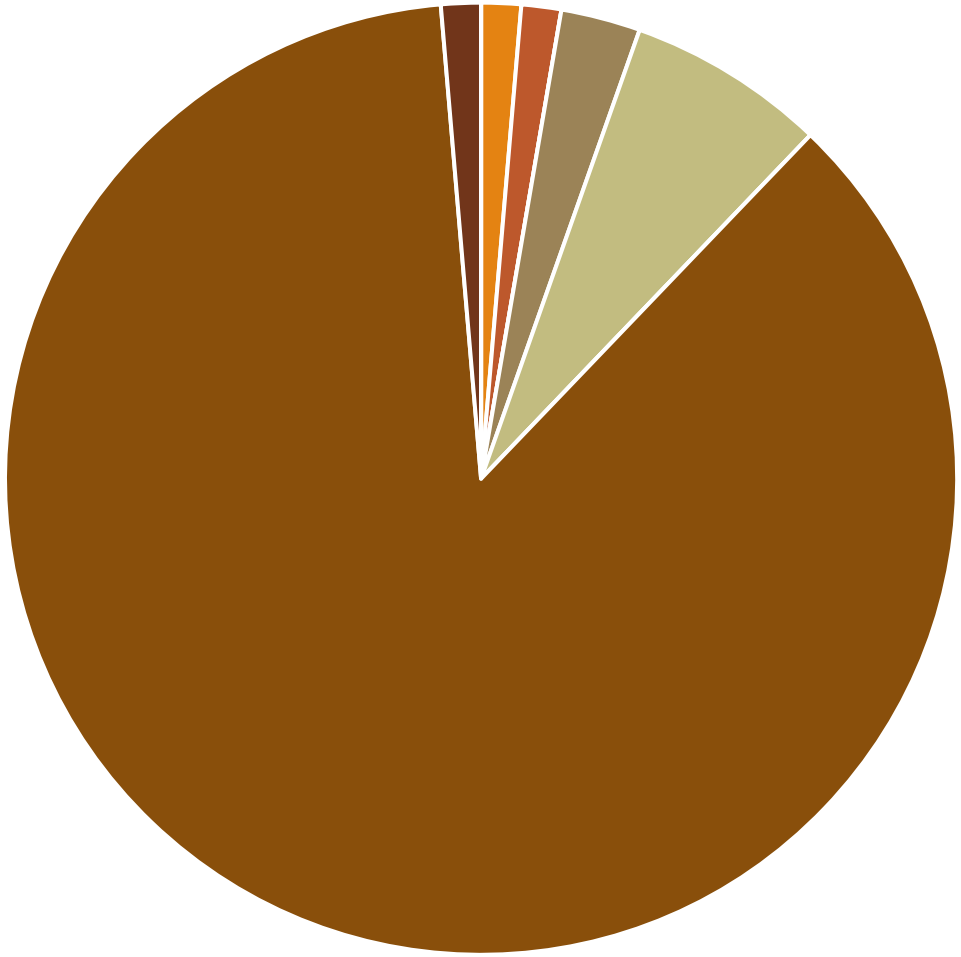



Montana - Estimated Annualized Disaster Losses
USD million
70
60
50
40
30
20
10
0
0
0
0
0
1
2
2
4
4
4
4
5
5
7
21
34
42
62
estal Flooding
Hurricane
Tsunami
Volcano
Drought
Ice Storm
Landslide
Avalanche
Tornado
Hail
Lightening
Heat Wave
Strong Wind
Winter Weather
Riverine Flooding
Cold Wave
Earthquake
Wildfire
Disaster Type
FEMA
National Risk Index




What is the most likely (probable) natural or manmade disaster to hit the ***Flathead Valley****?*

What do you think is the most likely (probable) natural or manmade disaster to hit the Flathead Valley?



- Earthquake 1
- Severe Convection Storm (Wind/Hail) 1
- Hurricane 0
- Flooding 2
- Severe Winter Weather 5
- Tornado 0
- Wildfire 64
- Terrorism on Key Infrastructure 1
- Pandemic/Epidemic 0
- Chemical Spills 0
- Nuclear Explosion 0

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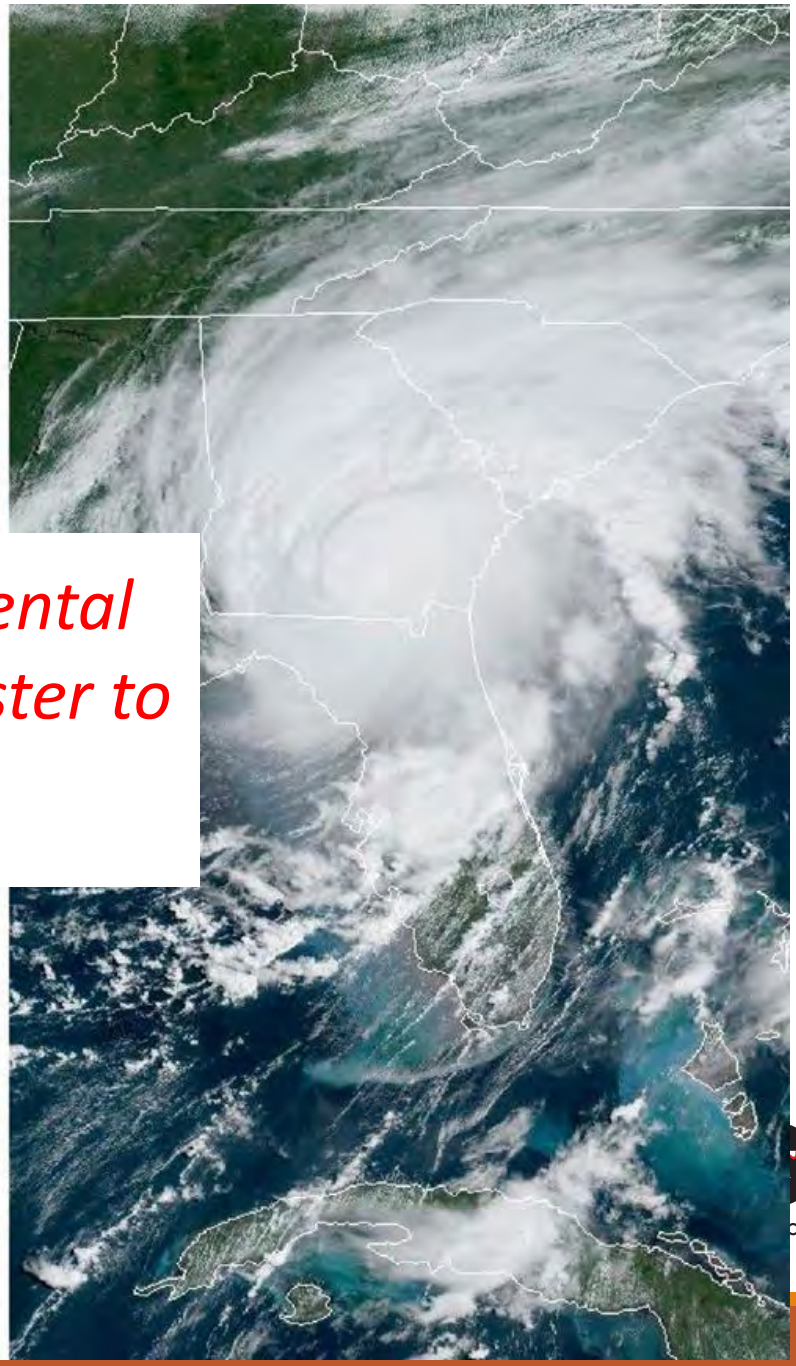
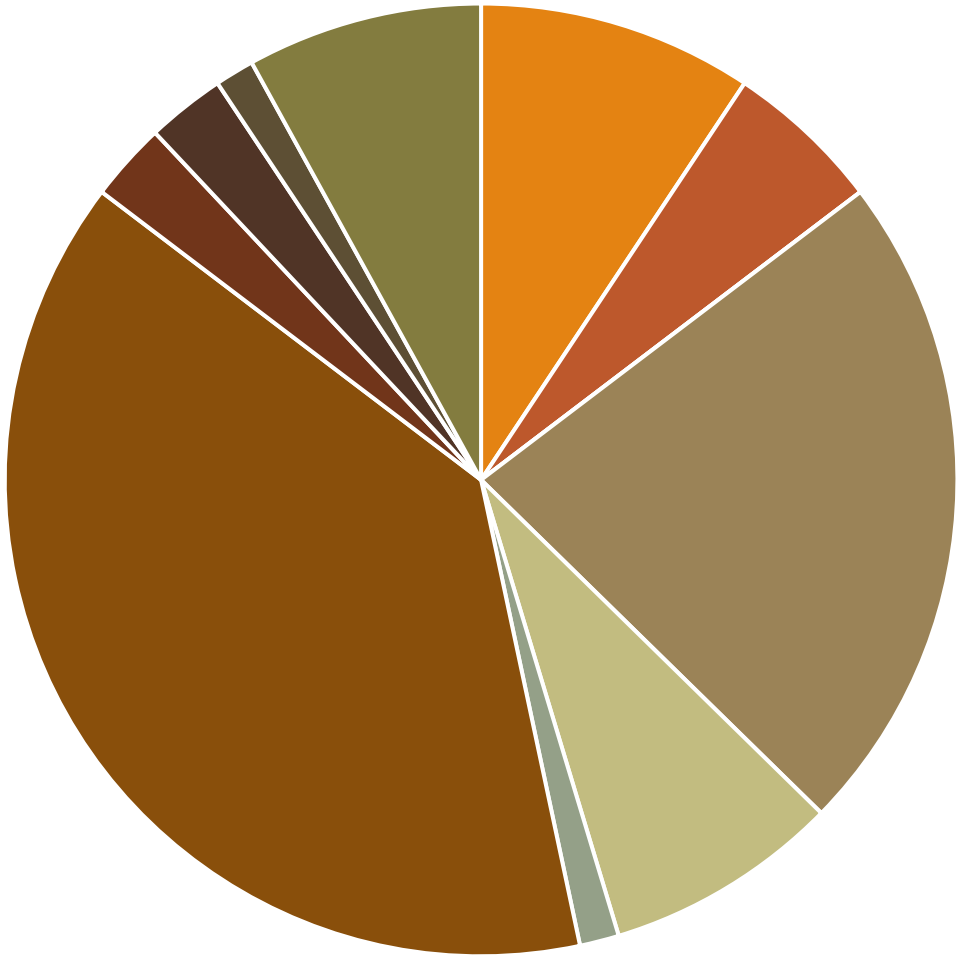


*Which would be the most detrimental (severe) natural or manmade disaster to impact the **Flathead Valley**?*

Which would be the most detrimental (severe) natural or manmade disaster to impact the Flathead Valley?



- Earthquake 7
- Severe Convection Storm (Wind/Hail) 4
- Hurricane 0
- Flooding 17
- Severe Winter Weather 6
- Tornado 1
- Wildfire 29
- Terrorism on Key Infrastructure 2
- Pandemic/Epidemic 2
- Chemical Spills 1
- Nuclear Explosion 6

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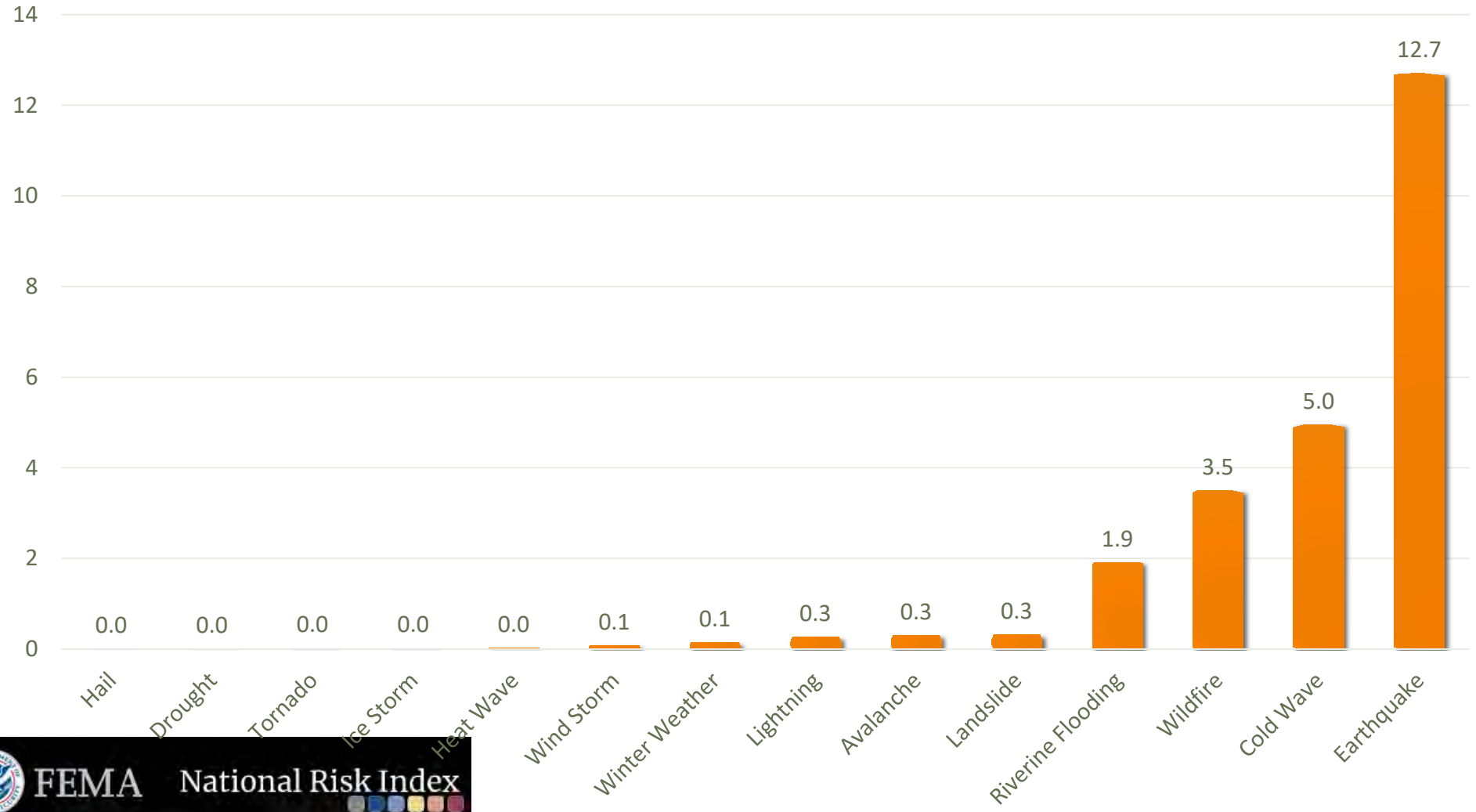
Estimated Annualized Disaster Losses in Flathead County (USD Million)



FEMA National Risk Index

Disaster Impacts on Community

Immediate Physical Impacts

- Damage to lifelines & infrastructure
- Broken gas lines
- Fire following earthquake
- Debris blocking & removal
- Deaths & injuries
- Overburdened first responders

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Disaster Impacts on Community

Social & Psychological Impacts

- Sociodemographic - disruption of social networks & household routines
- Psychosocial - cognitive impairment, anxiety, depression, grief, substance abuse, ritualistic behavior
- Physical - fatigue, sleep, physical pathology
- Sociopolitical - rise of social activism, political disruption
- Temporary & permanent relocation
- Longer term reduction of tax revenue

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Disaster Impacts on Community

Recovery

- Lack of post-disaster inspection protocols – how do you know if your building is safe?
- Closed schools & childcare centers
- Downtime of essential facilities: hospitals, EM, dialysis centers, grocery stores, gas stations
- Loss and damage to places of community & cultural significance
- Businesses closed - costly/timely repairs
- Little to no capacity to repair adequately

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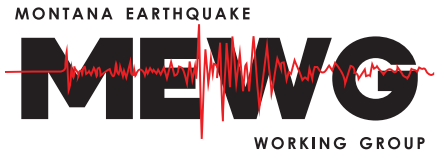
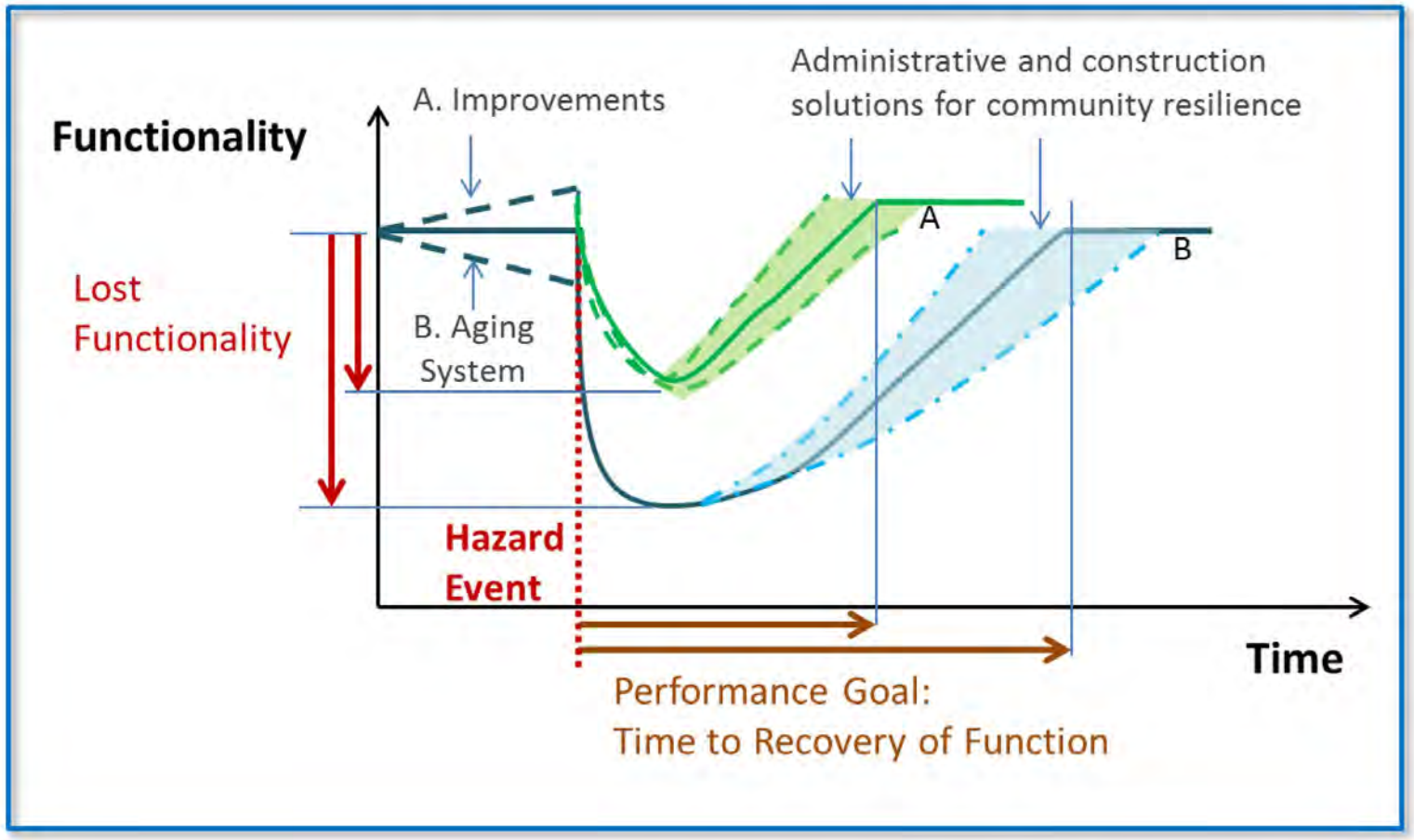
What is Community Resilience?

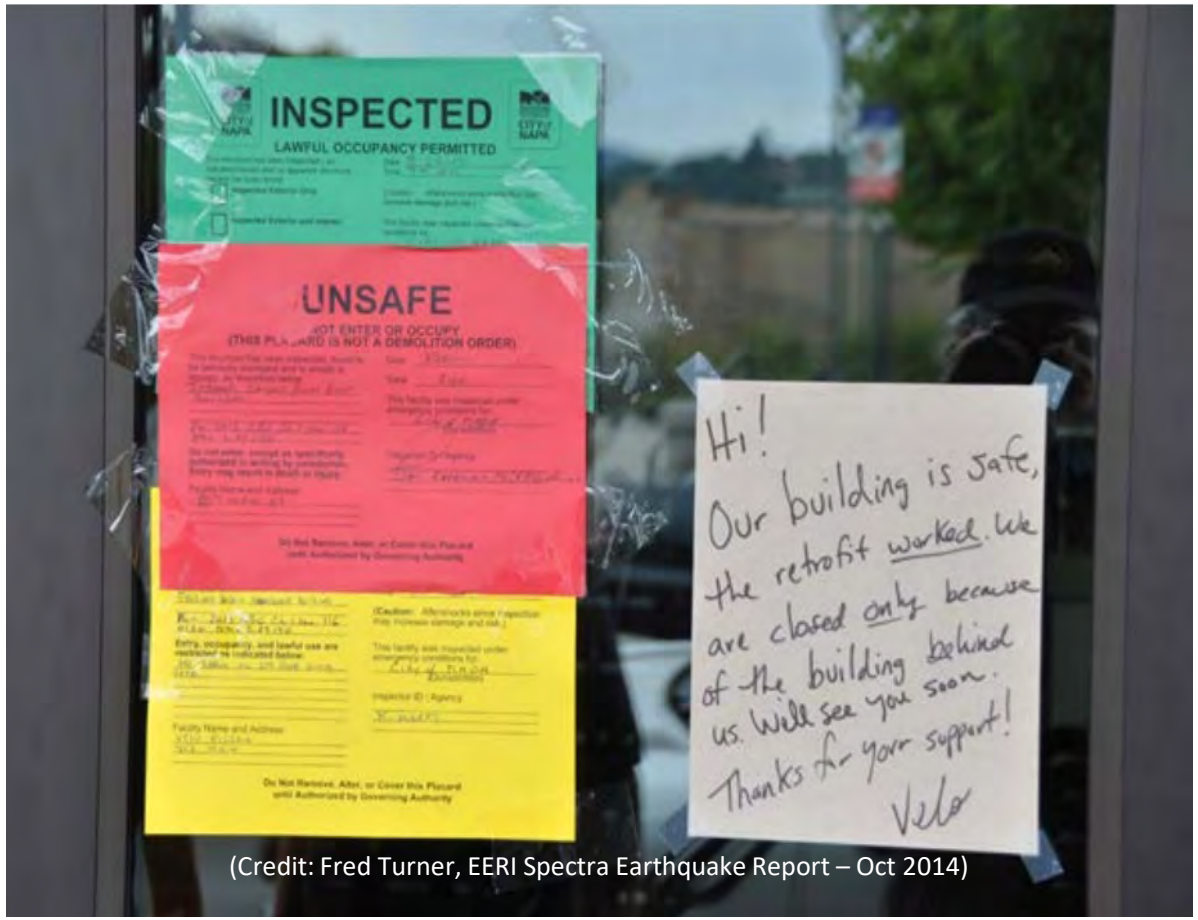


Functionality, Recovery & Resilience



Community Resilience Planning Guide for Buildings and Infrastructure Systems. National Institute of Standards and Technology, 2015.

Defining Resilience



(Credit: Fred Turner, EERI Spectra Earthquake Report – Oct 2014)

"The ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies."
[Obama, B.H. (2011). Presidential Policy Directive 8: National Preparedness]

Resilience is an attribute of the community, not buildings.

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Defining Resilience

Community resilience is the ability of **groups** (e.g., schools, households, businesses) to recover functionality in a timely fashion following a disruptive event, and for the buildings that those groups reside in to recover functionality.

Affected by:

- The strength and adaptability of social, institutional and economic networks
- Environmental damage and social inequality
- Pre-disaster mitigation measures, including physical risk reduction and emergency response capacity

Resilience is NOT sustainability, LEED, GREEN, though they can be in alignment

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Resilience is an attribute of the community…
and the built environment facilitate our communities.

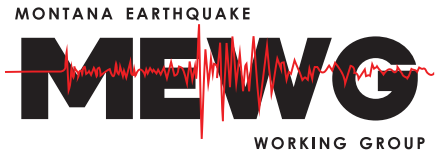
Essential Community Functions & Services

The <u>social functions</u> of a community define the functional requirements of a community's buildings and infrastructure systems.

The goal is to restore a building sufficiently enough (and within a reasonable timeframe) to regain those essential functions that support community resilience.

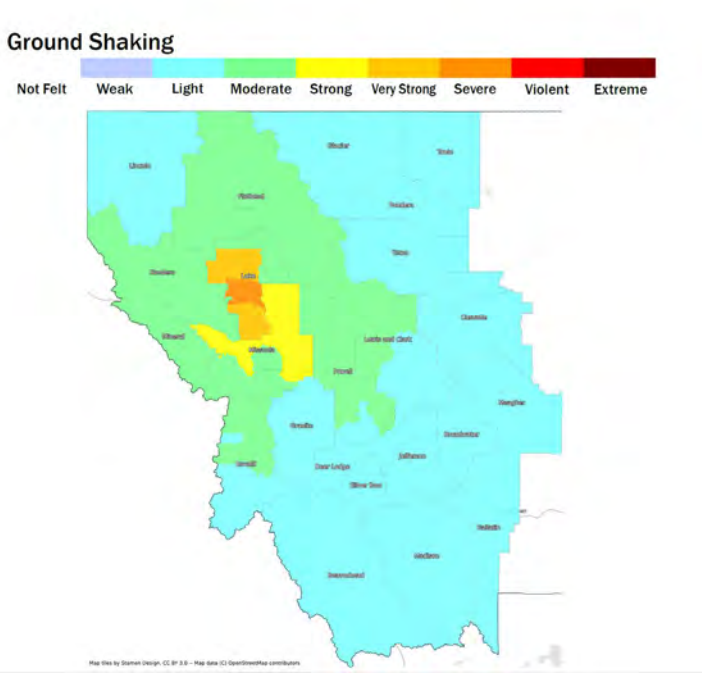
Community Resilience Planning Guide for Buildings and Infrastructure Systems. National Institute of Standards and Technology, 2015.

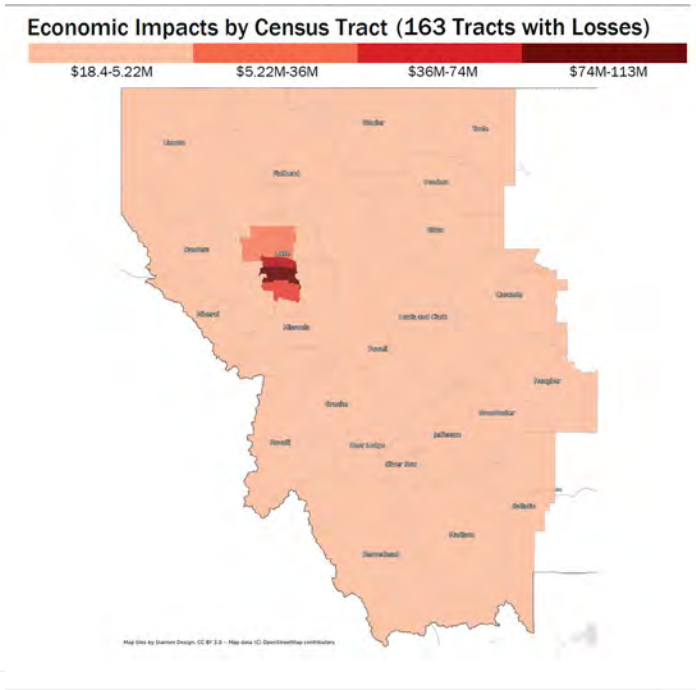
The Scenario



The Scenario: Mission Fault

- Modeled Magnitude 7.1
- Total Economic Losses: **$345 million**
  - Lake County: $325 million
  - Missoula County: $15.9 million
  - Flathead County: $3.27 million
- Total Injuries (day/night): 120/90
- Total fatalities (day/night): 11.8/2.54
- Total Displaced: 167
- Total Needing Shelter: 117
- Total Debris: 132,000 tons





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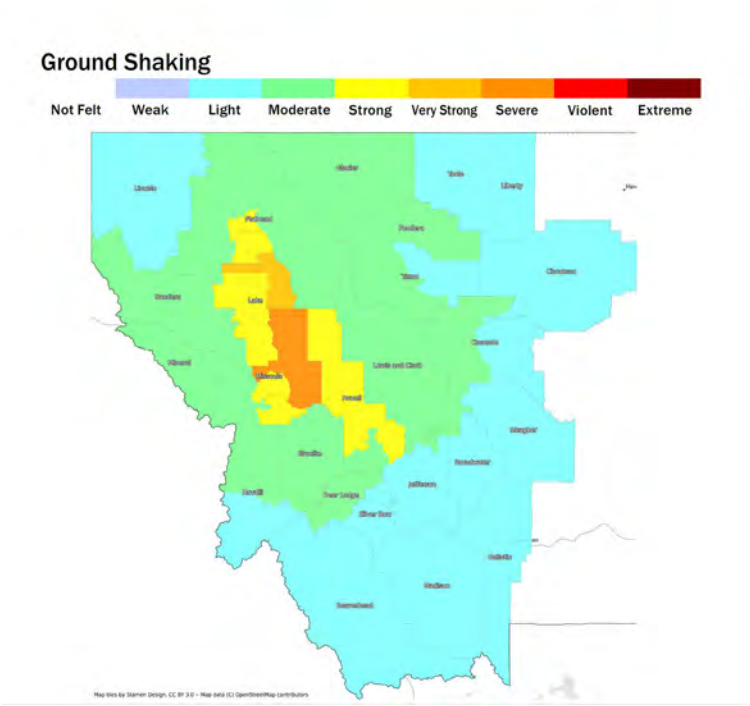
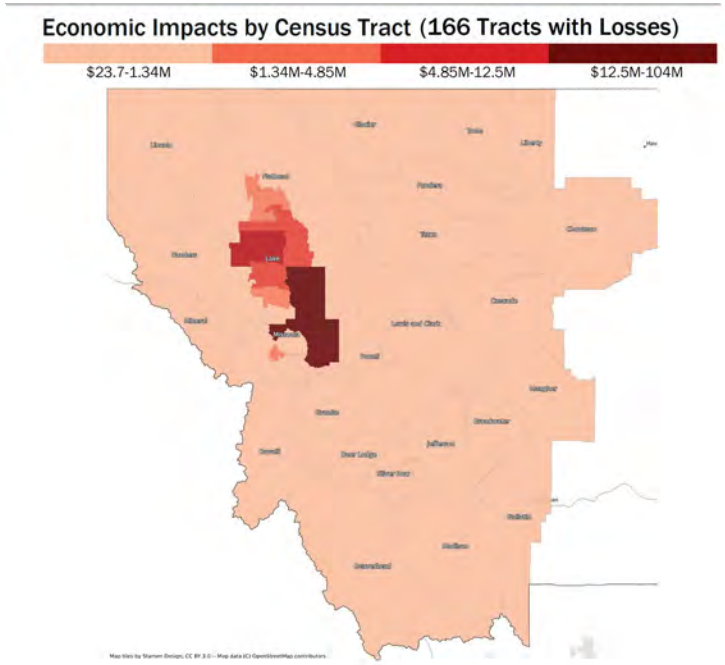
The Scenario: Swan Valley Fault

- Modeled Magnitude 7.3
- Total Economic Losses: **$226 million**
  - Missoula County: $124 million
  - Lake County: $58.5 million
  - Flathead County: $39.2 million
- Total Injuries (day/night): 46/34
- Total fatalities (day/night): 4/1
- Total Displaced: 41
- Total Needing Shelter: 23
- Total Debris: 61,500 tons





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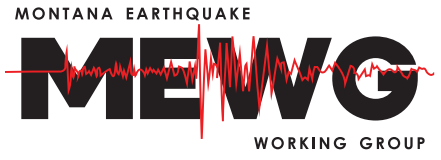
https://youtu.be/8WmWzuYeY64?feature=shared

Let’s Talk About It



Immediate

Fire Following Earthquake (FFE)

Frederic Larson, The Chronicle
https://www.sfgate.com/news/article/S-F-leaders-ignore-weak-buildings-quake-risk-3208142.php

Firefighters extinguish a blaze in the Marina District in San Francisco, days after the Loma Prieta earthquake. *(Jonathan Nourok/AFP/Getty Images)*

Collapse of the link span at Tower E9 of the San Francisco Oakland Bay Bridge due to inadequate seat lengths and anchor bolts (Gary Weber/AFP/Getty Images).

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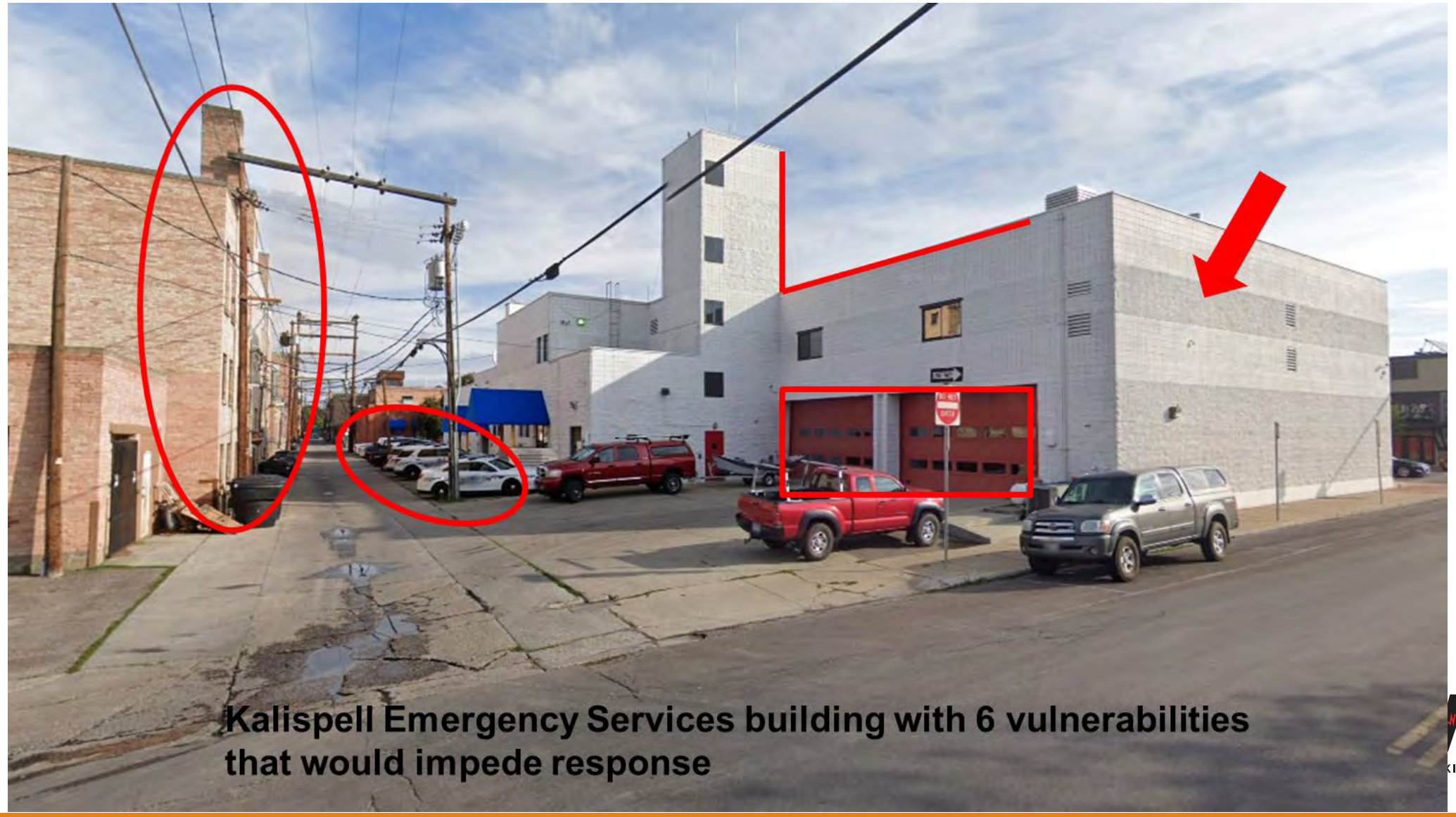
Kalispell Emergency Services building with 6 vulnerabilities
that would impede response

Immediate

Community functions that provide essential and urgent safety and survival needs.

police stations

fire stations

EMS/ critical transportation services (ambulance)

jails/prisons

facilities for natural gas pumping, production and consumer distribution; eg, gas stations, propane "stores"

emergency communication facilities

internet - server farms, facilities, data centers

acute care hospitals & supporting facilities

acute care supporting facilities (eg, HVAC, mechanical, gas supply)

emergency departments

elder care/nursing home/dependent care facility

emergency shelter

Days and Weeks

https://www.vosizneias.com/122965/2013/01/31/new-york-state-to-provide-free-inspections-to-sandy-victims/

Fred Turn, CSSC

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Days & Weeks

Community functions that provide safety, survival, basic well-being, and essential everyday needs and prevent the escalation of adverse disaster consequences.

water infrastructure facilities

wastewater treatment infrastructure

pharmacies

dialysis centers

temporary housing and facilities; temporary structures (eg, tents, tent structures, event structures)

airport

grocery stores

emergency supply - warehouse, storage (food, water, PPE)

multi-family housing (5+ units)

multi-family housing (2-5 units)

vet - urgent care for domestic animals

religious - (facilities that seek to provide emergency shelter and services, including food)

2 Months

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2 Months

Community functions that provide basic human needs, self- and group preservation, and that sustain short- and long-term economic, educational, and governance activities and services.

sewer system facilities

general outpatient (not captured - e.g., chemical dependencies)

medical clinics

public transportation facilities

railroad facilities - maintenance yards

single-family housing

banking/finance

K-12 schools, including private and religious

childcare/daycare - private and religious

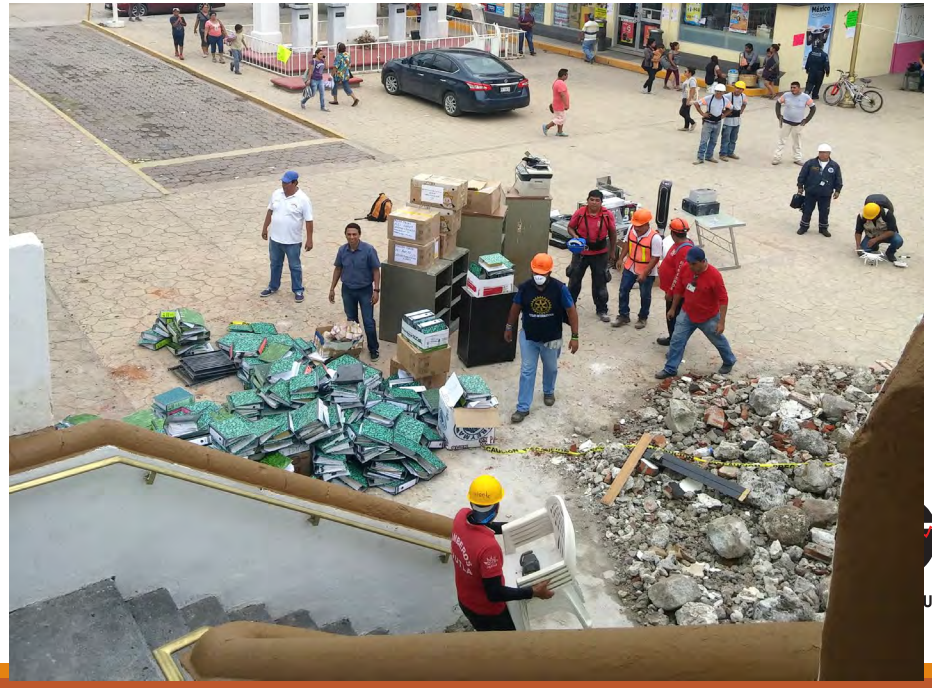
essential gov't function buildings

commercial (small businesses; retail)

social services, community & elder centers (neighborhood support services)

libraries

6 Months



https://www.undp.org/turkiye/publications/Six-months-after-the-earthquakes-in-Turkiye

6 Months

Community functions that enhance a community's general well-being and

expedite the return to normalcy.

universities

non-"essential" government buildings - municipal admin/tax, elected officials offices

court houses

Industrial (manufacturing, heavy equipment)

commercial (major employer; employer-owned)

hotels

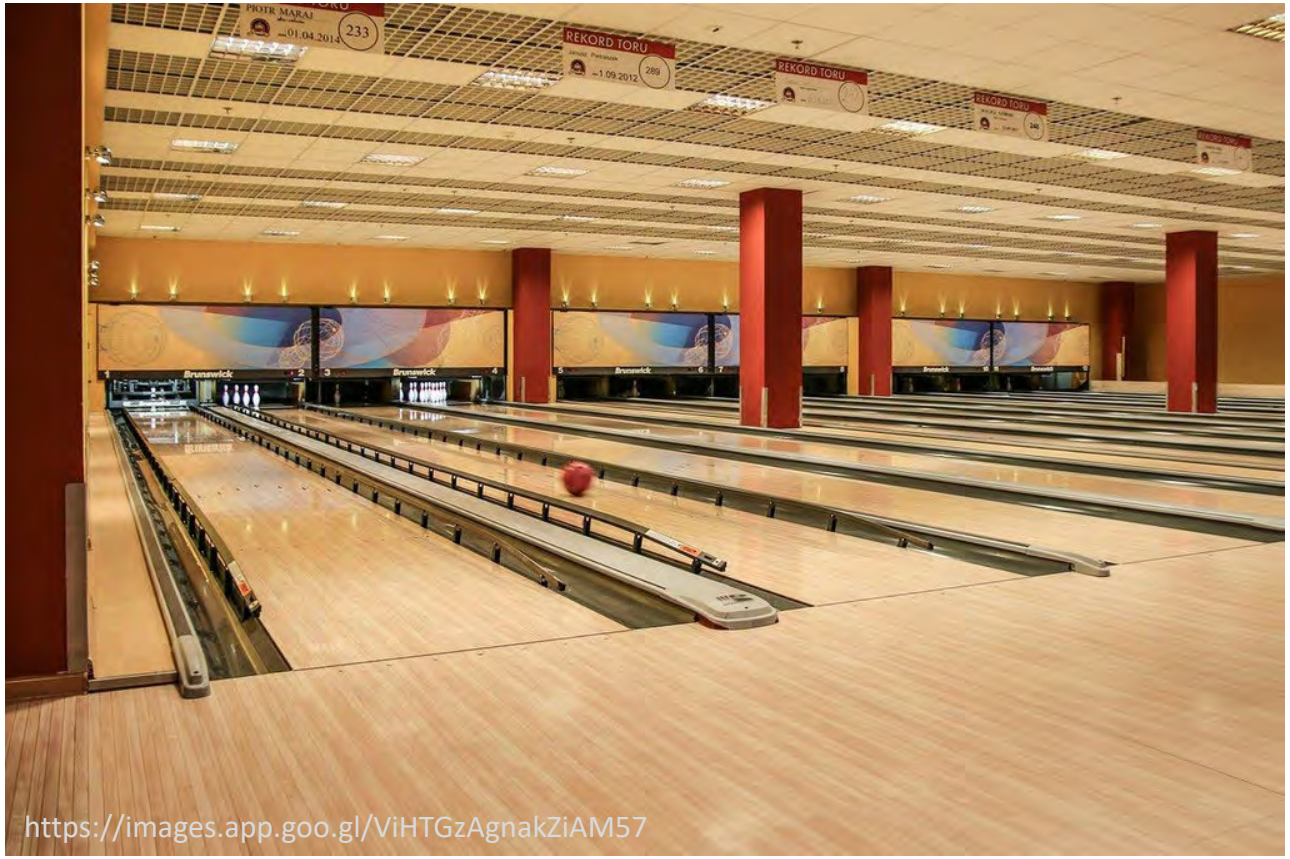
restaurants

community recreational facilities (eg, gymnasium, pool)

veterinary clinics - outpatient clinics for domestic animals

religious centers (churches, temples, mosque, excluding schools listed above)

12+ Months



https://images.app.goo.gl/ViHTGzAgnakZiAM57


https://images.app.goo.gl/yxNPeRRjJuKSA1xA8

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12+ Months

Community functions that enhance general well-being and amplify people's

quality of life. The recovery timeline of these functions may not be essential in overall recovery of the community.

office buildings

historic buildings

recreation center/gymnasium - private; not to provide emergency shelter or services

stadiums (outdoor)

arenas (indoor; not intended to be used for emergency shelters/services)

movie & performance theaters, concert halls

museums

country clubs

night clubs

What Can YOU Do?

RECOVERY BASED APPROACHES TO PRE-DISASTER MITIGATION

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Discussion

- What we walked through is not a theoretical exercise. This is recovery-based *pre*-disaster mitigation
- It is the foundation to current efforts to develop recovery-based building codes and planning…but we don't need to wait for lengthy code review and adoption process
- The concerns and places and things you identified can be addressed – by you, our community, MEWG – starting now
- As a community want to move forward to prepare & build capacity to address all the deficiencies we identified
- Who is not here that should be?

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Thank you
ANNA@ZYLIENT.COM