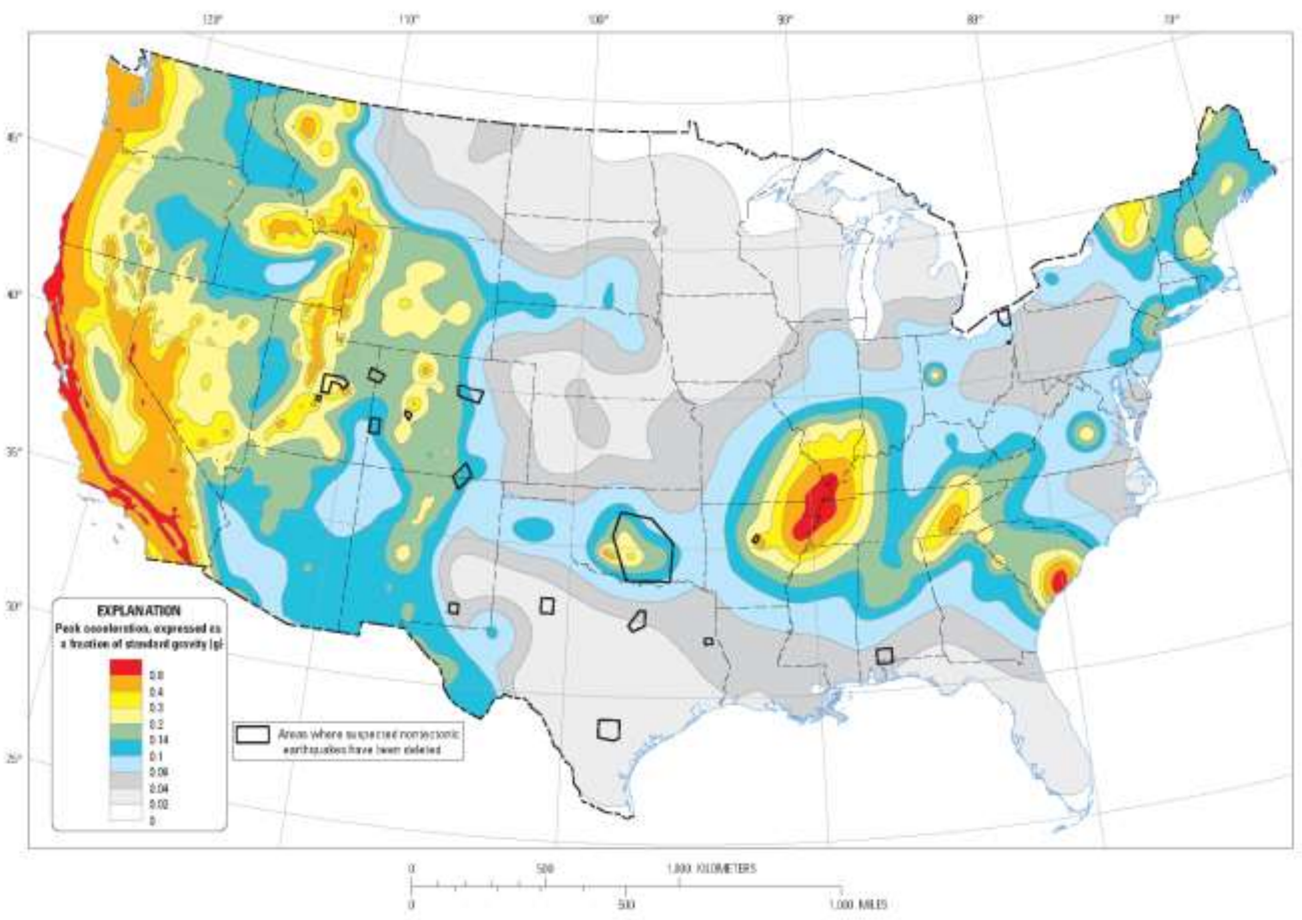
USGS Earthquake Geology Intermountain West (IMW)

Ryan Gold, USGS Intermountain West Regional Coordinator

Photo credit: Chris DuRoss

USGS National Seismic Hazard Model 2023



Two-percent probability of exceedance in 50 years map of peak ground acceleration

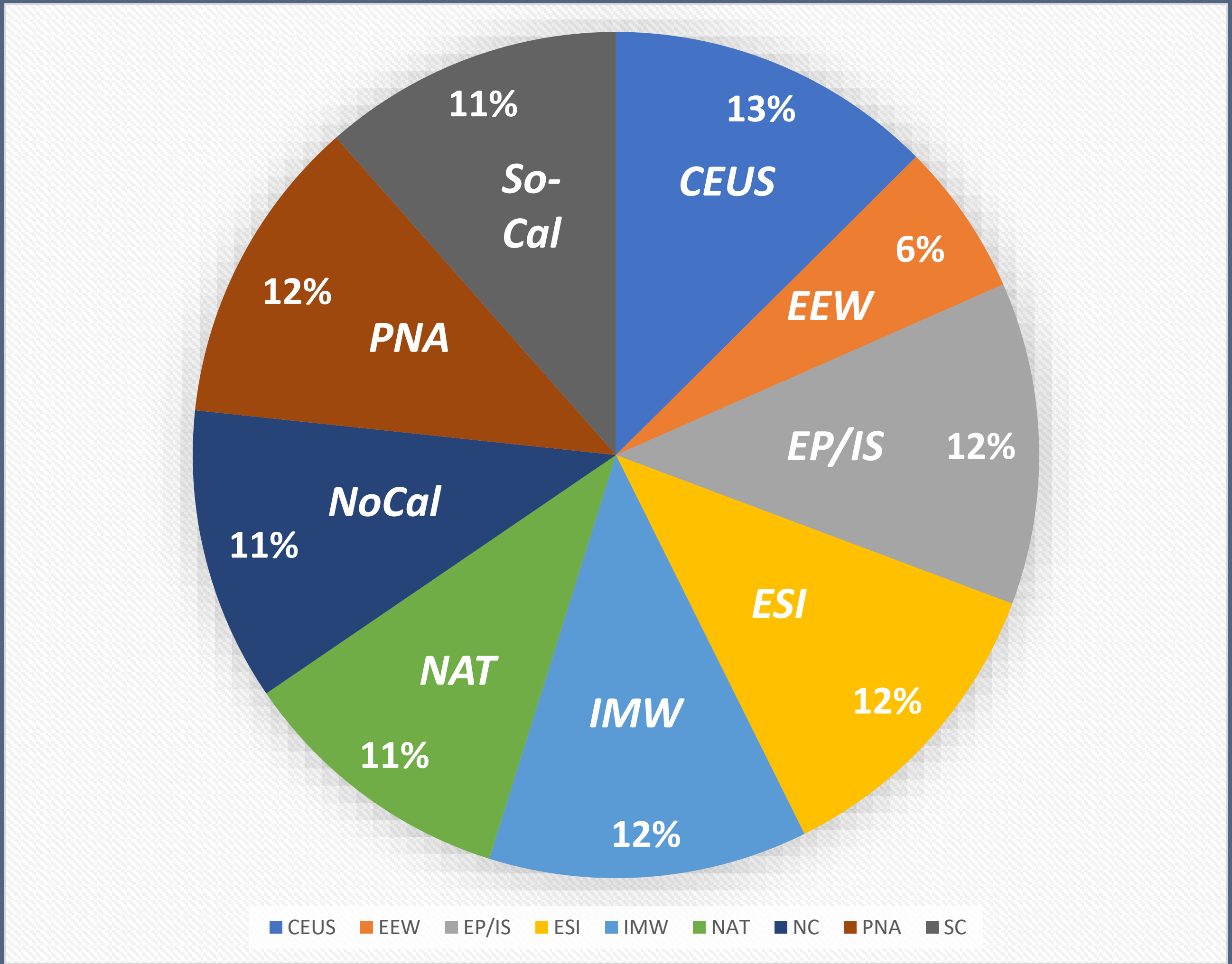
- Factored into building codes and impacts billions of dollars in construction
- Impacts insurance rates
- Guide for emergency planning
- 2023 update process underway. Current focus (2020) on source fault model. More details tomorrow.

USGS - Ongoing Research and Collaboration in IMW

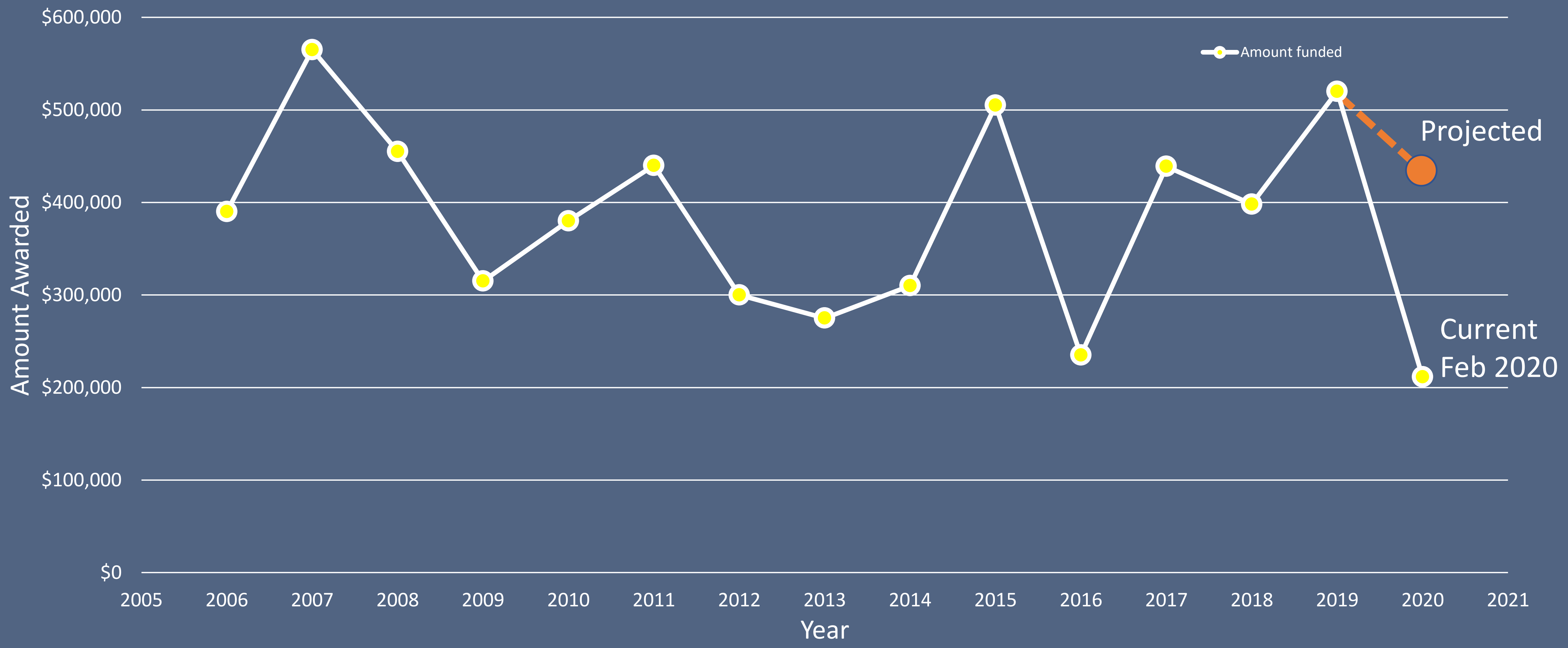
- *Wasatch Front* **(UGS, UVU)**
- *Teton Range* **(BoR, USFS, WGS, Univ. of ID, BGC)**
- *Las Vegas* **(NBMG, UNR, UNLV)**
- *NE California* **(PG&E, Univ. of Oregon)**
- *Walker Lane* **(NBMG, UNR)**
- *Borah Peak, Idaho* **(UVU, IGS, UGS)**
- *Ridgecrest* **(CGS, SoCal, UNR)**

USGS External Grants Program, FY2019 (last year)

- $4.3M competitive research grants funded
- 212 Proposals received, 66 funded (31% success rate)
- IMW funded 9 proposals ($519k)



Intermountain West External Grants funding



IMW External Grants 2020 (in progress)

- IMW received 17 proposals (down from 23 proposals in FY19).
- Total request $750k. Best case scenario: $433k will be funded.
- Average proposal in fund/fund if possible category: $43.3k (FY20), down from ~$57.7k in FY19.
- FY20 Federal budget passed (Dec 2019).

Funding by state

- NV: 1 grant funded; 3 in “hold” status
- UT: 0.5 grant funded
- ID: 1 grant in “hold” status
- AZ: 0.5 grant funded grant in “hold” status
- MT: 1 grant in “hold” status
- CO: 1 grant funded
- IMW general: 1 grant funded
- Meetings/Workshops: 1 grant funded

External Grants – guidance going forward (FY21)

- Look for program announcement in March 2020.
- Proposal dues in ~May 2020.
- Panel meets in August – please contact me (rgold@usgs.gov) if you'd be interested in serving and won't have conflict of interest (e.g., submitting a proposal this year or from an institution submitting proposals).
- USGS letters of commitment.
- Panels scrutinize history of publishing USGS-funded research.

STATE OF SEISMIC HAZARD ASSESSMENT, ARIZONA

BASIN AND RANGE PROVINCE EARTHQUAKE WORKING GROUP

February 5th, 2020

Jeri Y Ben-Horin

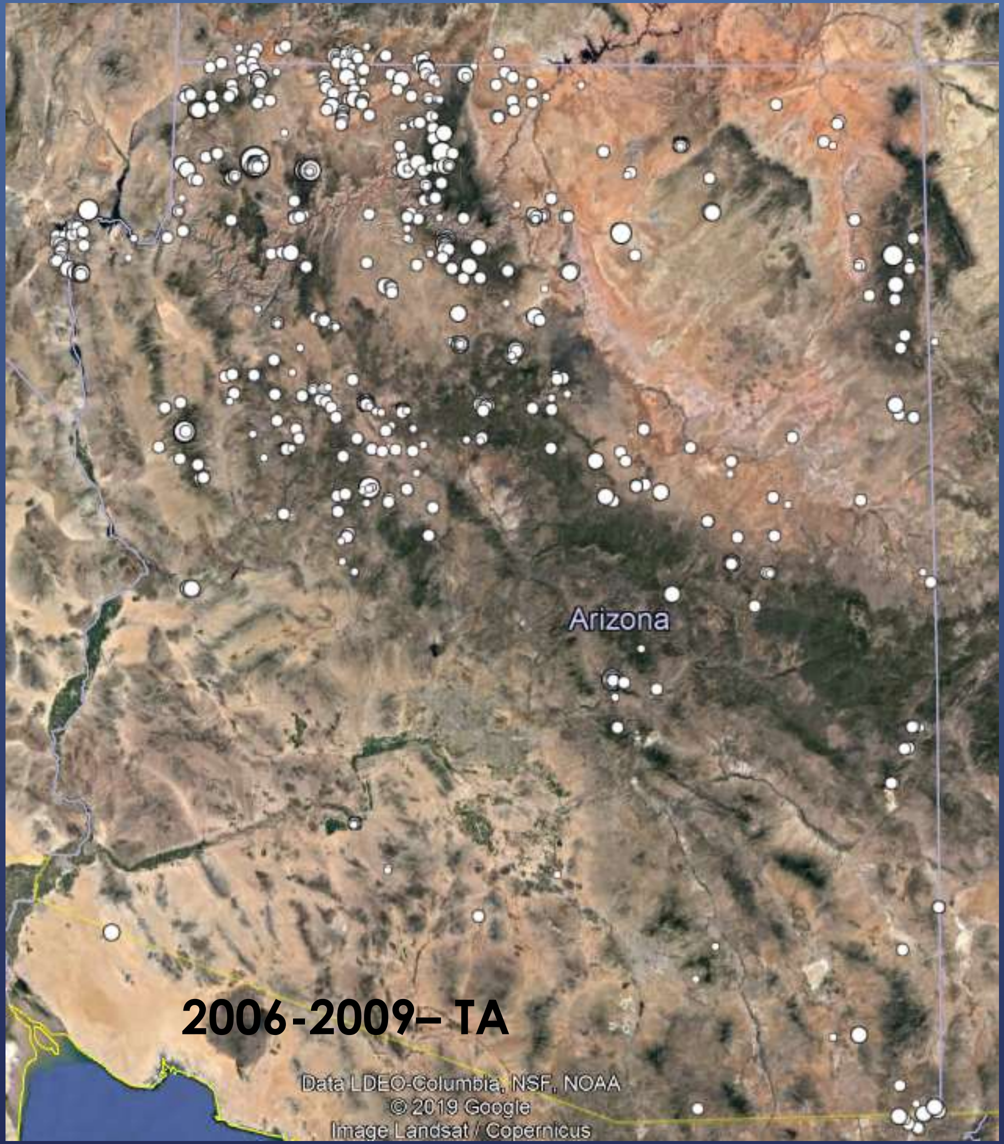
Arizona Geological Survey

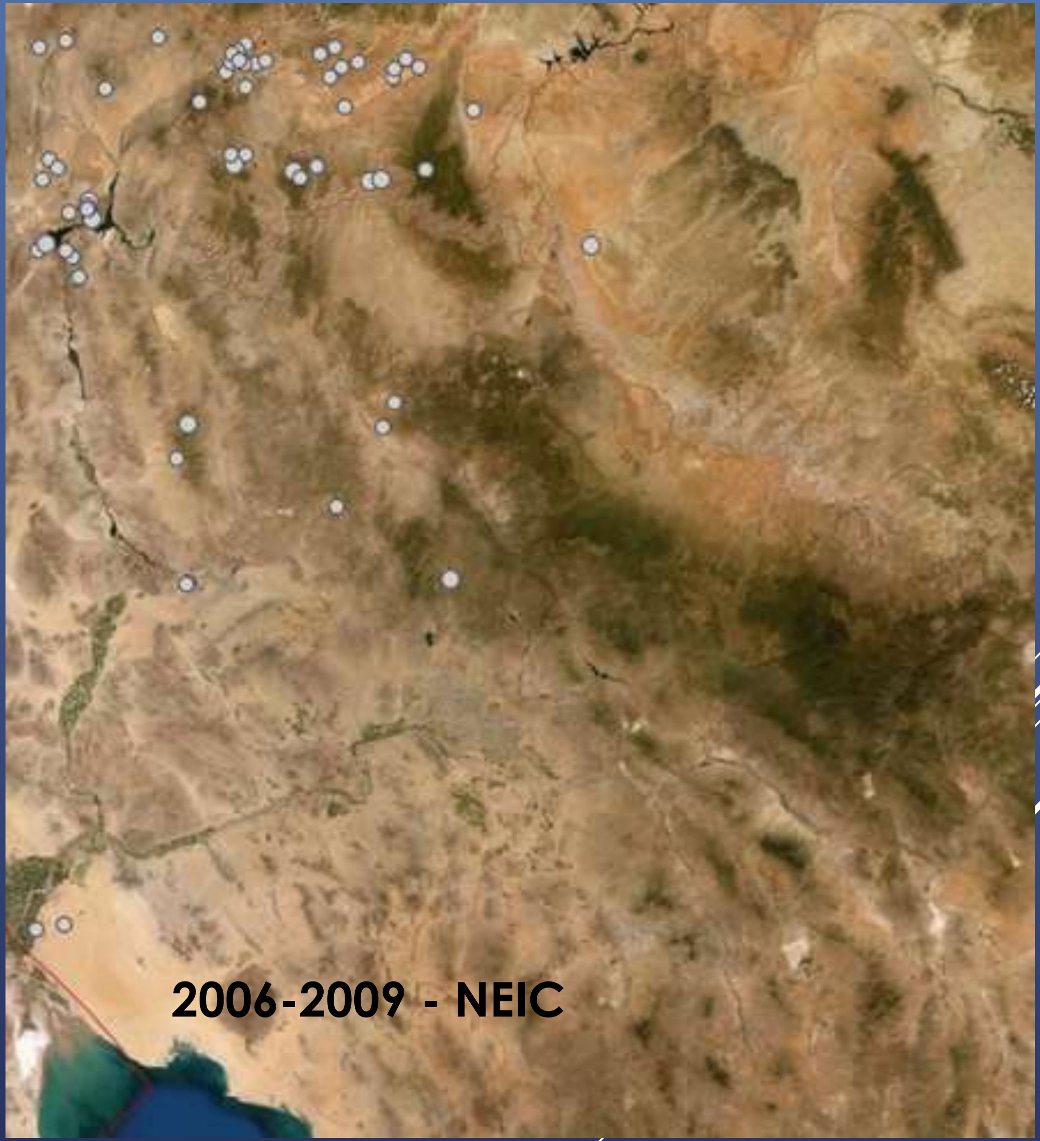
UA SCIENCE ARIZONA GEOLOGICAL SURVEY

Topics

- AZGS Broadband Seismic Network Operation–
  - Does AZ need monitoring?
  - EQ catalogue completeness, magnitude calculations and errors, location errors
  - Not a “Regional and Cooperating Network” - funding problematic
- Arizona’s active faults
- Quaternary faulting – ongoing and planned projects
  - Mead Slope fault –Quaternary mapping and paleoseismic site potential
  - Lake Mary fault – Quaternary mapping and paleoseismic site potential
  - Big Chino fault?- Planned: Update Q mapping, date landforms, paleoseismic sites?
- Outreach
  - AZ Shake Out
  - Arizona Council on Earthquake Safety - resurrected

Does AZ need monitoring?

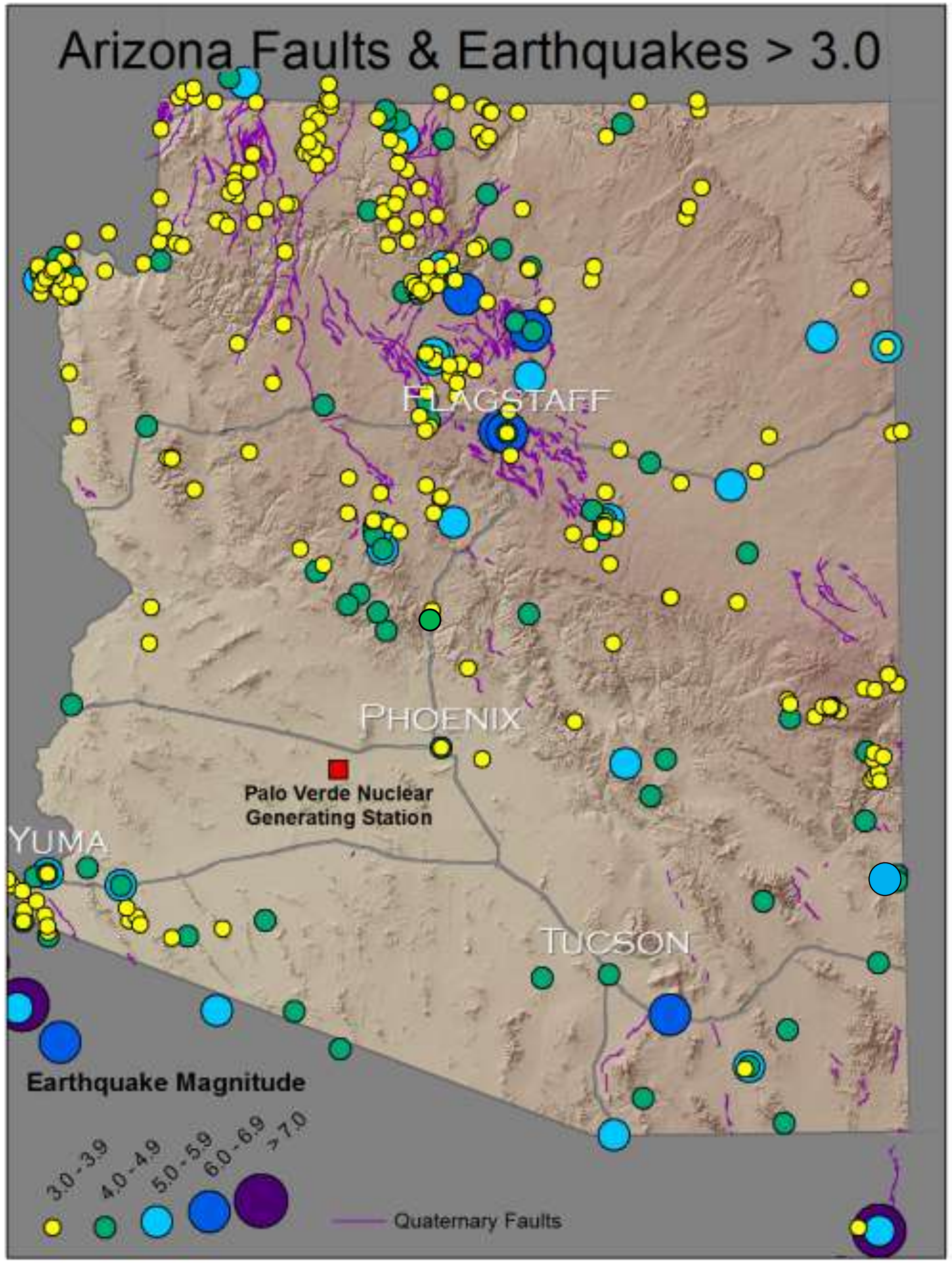




GOAL: IMPROVE AZ'S CATALOGUE

ARIZONA HAS EARTHQUAKES

- Flagstaff M6.0+s
- Seismicity rates higher in the northern half of the state - NASB
- M7.6 – Pitaycachi Earthquake
  - Long recurrence interval, large event
- M5.0+ every 8-10yrs on average
- Notable recent events: M4.0 Black Cyn City (2015), M4.7 north of Sedona (2014), M5.3 near Safford (2014), M5.2 Holbrook (2004)

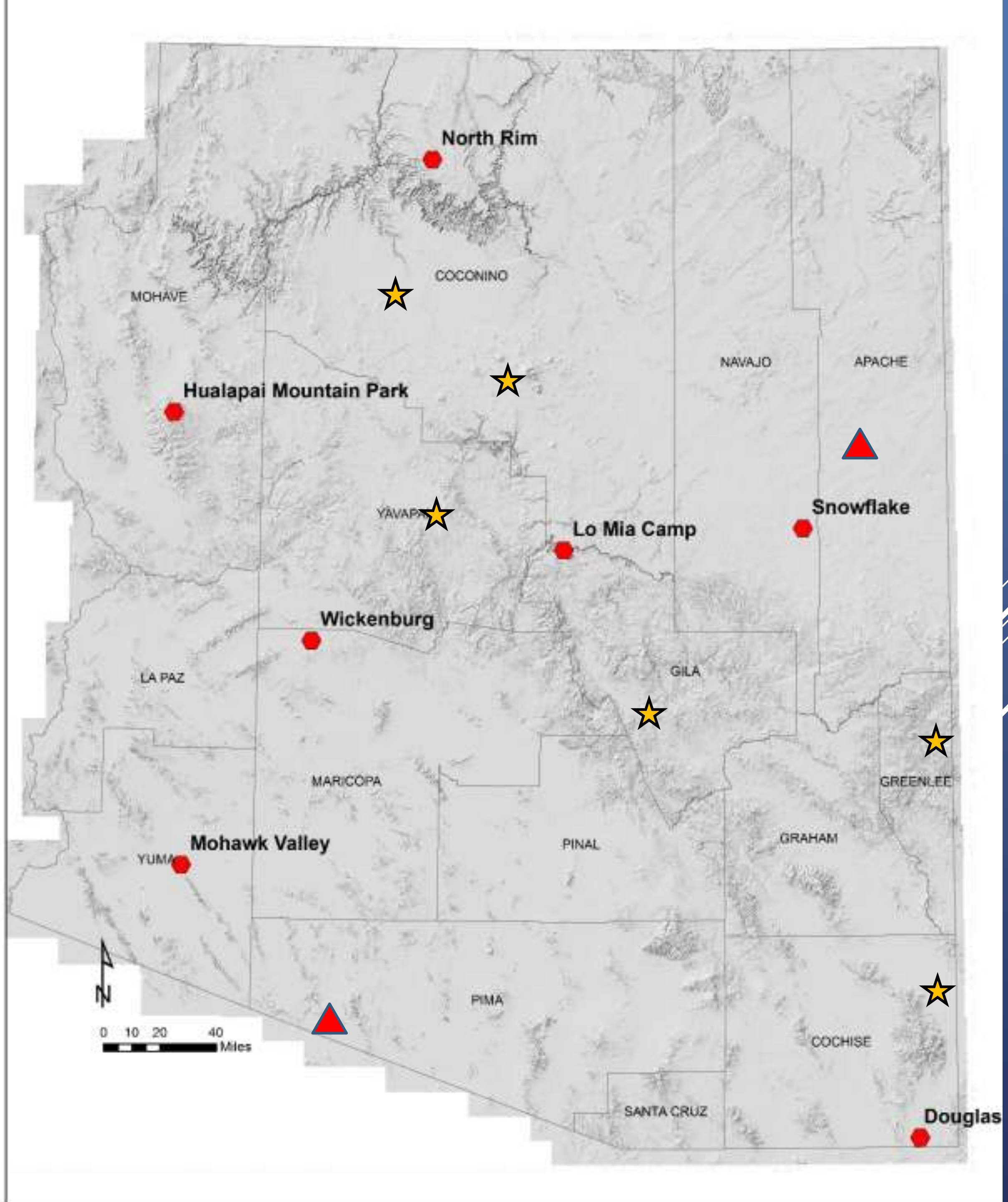


Arizona Broadband Seismic Network

15 Broadband Stations

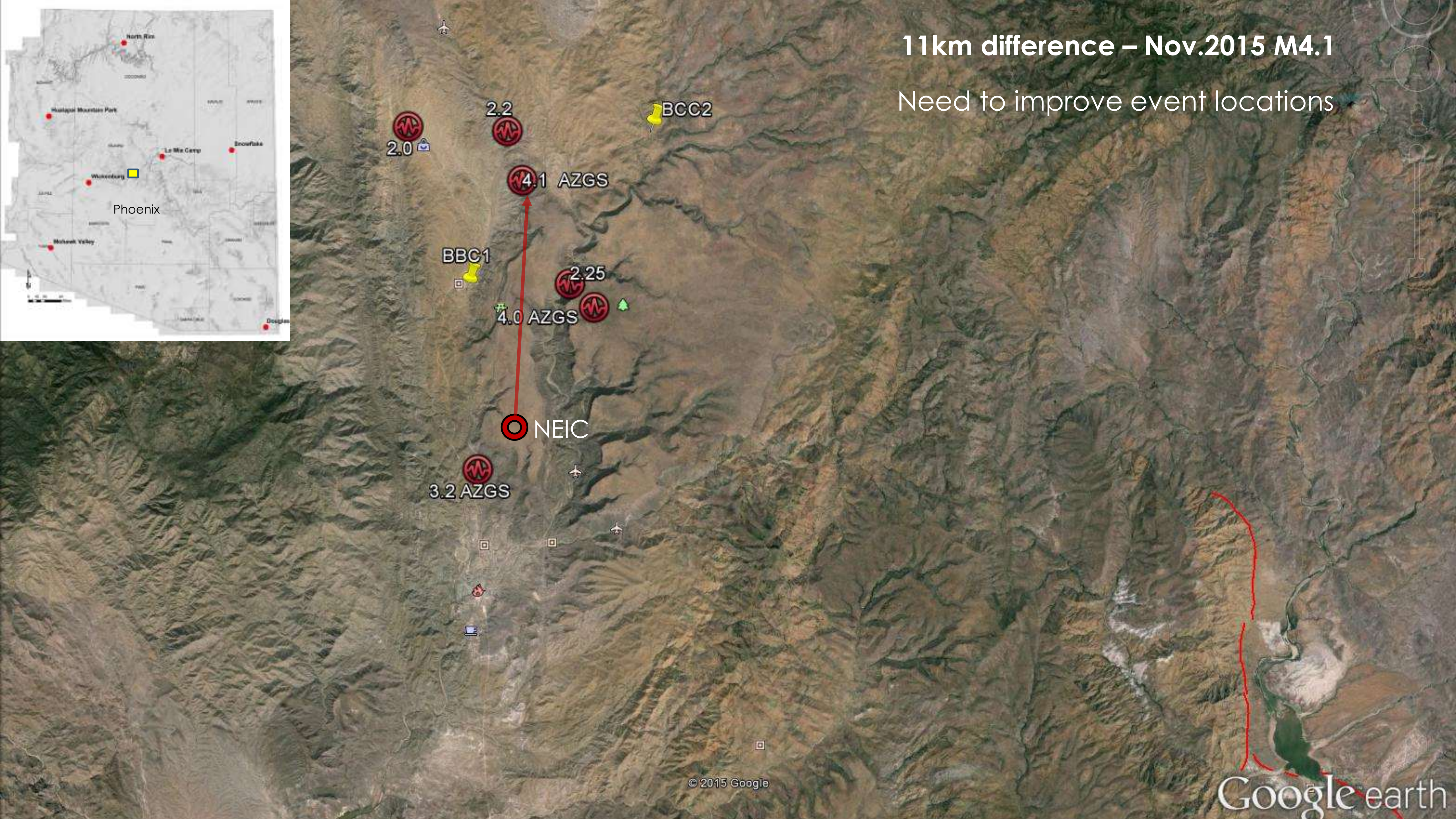
7 Original Legacy TA ⬟
6 New BB ★
2 Additional TA ▲

- Not a "Regional or Cooperating Network"
  - Funding and collaboration problematic
- ABSN provides statewide monitoring
- Real-time data available with IRIS-DMC
- Data archived – DMC
- Improved locations and improved catalogue completeness
- Still need to improve detection threshold
- Need to improve mag calculations



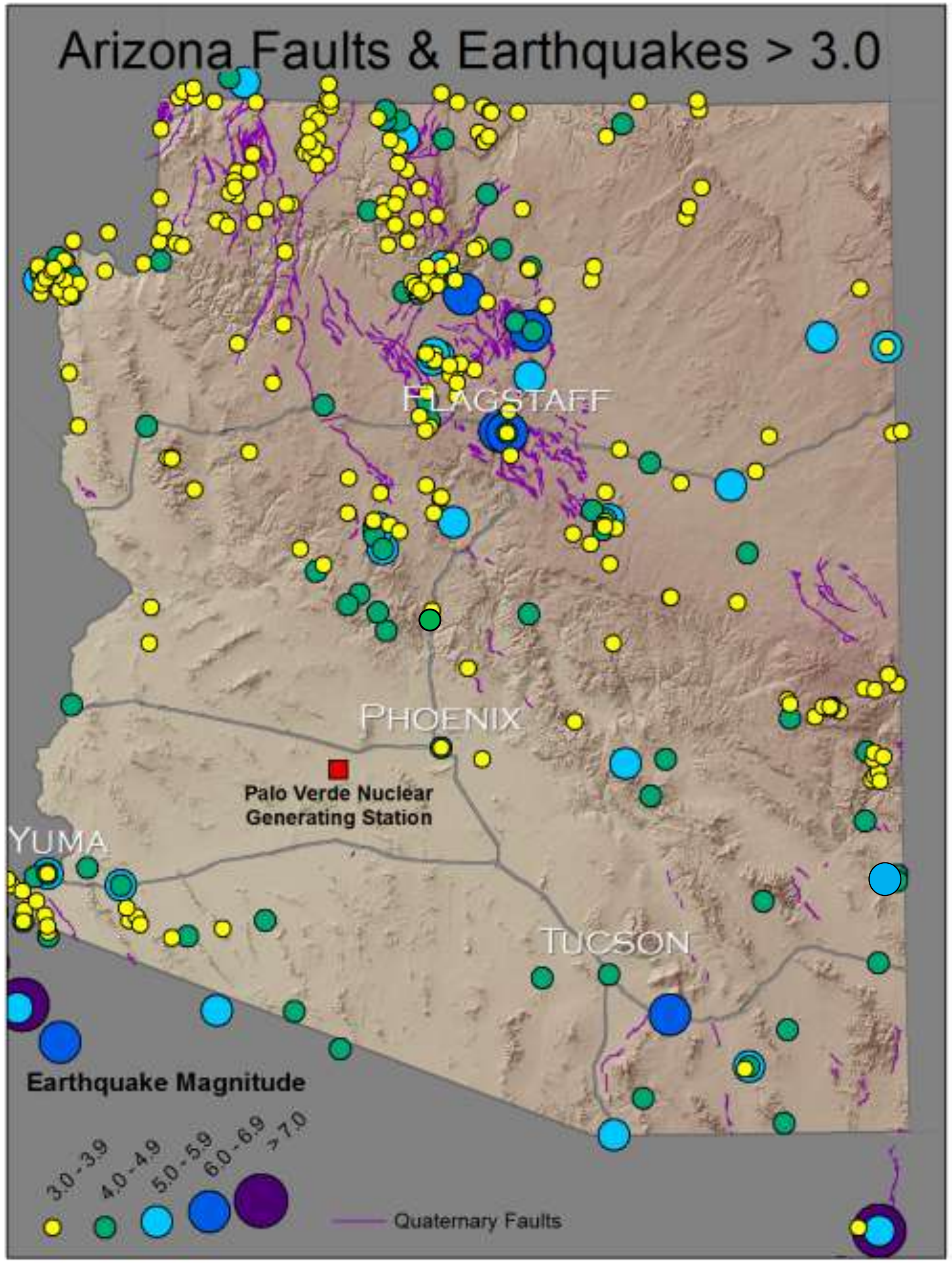
11km difference – Nov.2015 M4.1

Need to improve event locations



QUATERNARY FAULTS IN AZ

- Over 100 active faults since 2.6Ma
  - Mead Slope
  - Big Chino
  - Lake Mary
  - Hurricane
  - Sevier-Toroweap
  - Washington
  - Needles
  - Algodones
- Concentrated mostly along the CO Plateau margin
- Highest known slip rate is ~0.2mm/kyr
- ~15 active since 15ka
- ~12 faults have been excavated for analyses



Mead Slope fault, AZ

nehrp

USGS
science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

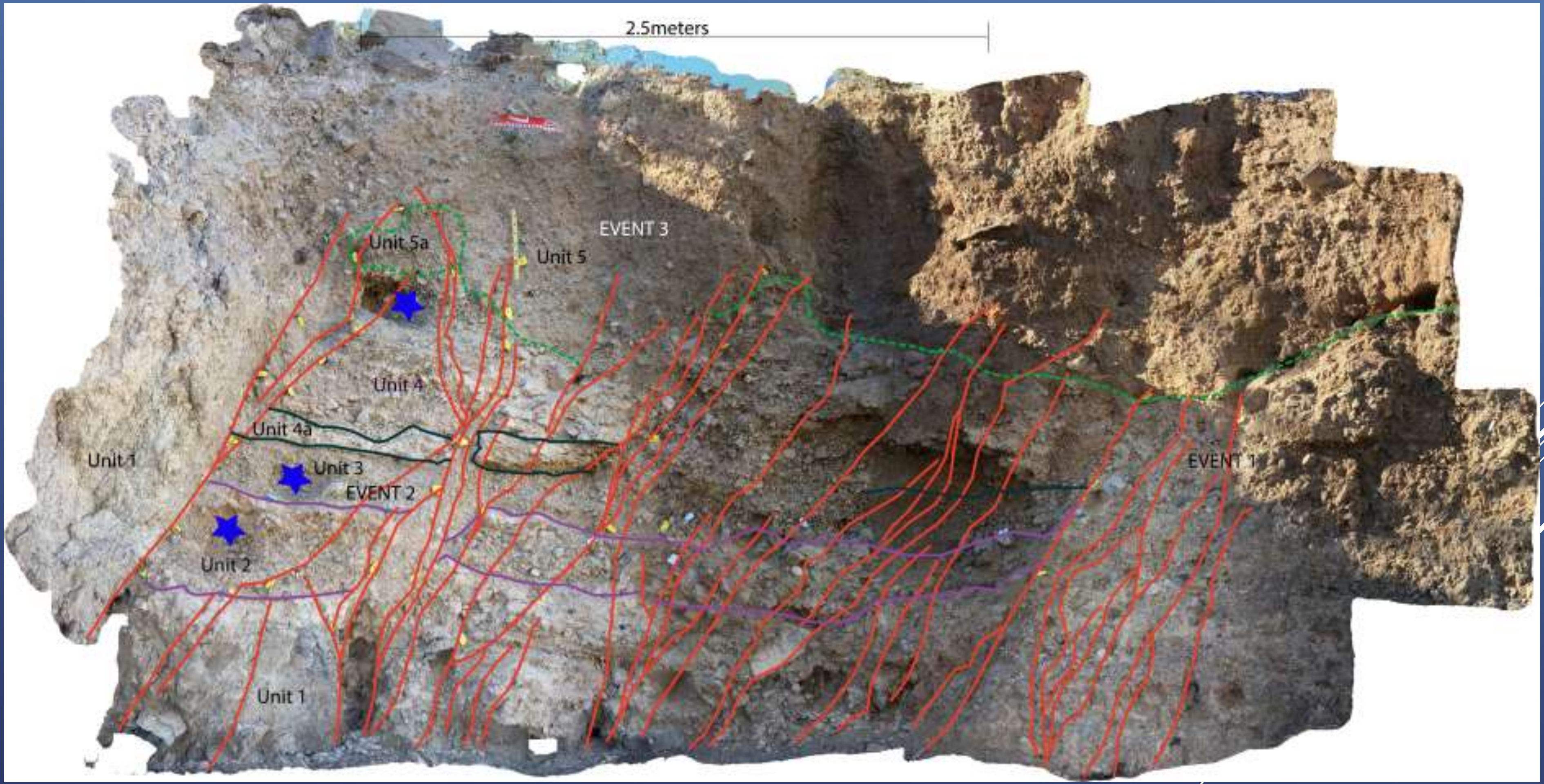
Geologic Mapping

- Offset measurements depend on:
  - Preservation of landform
  - Interaction with multiple strands
  - Inconsistency in fault motion over time
    - Southern end – fault shows down to the east sense
    - Northern end – down to the west

https://uagis.maps.arcgis.com/apps/webappviewer/index.html?id=3a52e869f32b41c2a0849b47d9c51645

PRELIMINARY PALEOSEISMIC RESULTS

- 2-3 Events
- Near uppermost event horizon - Unit 4 ~ 23k yrs old (OSL)
- Lowest discernable event horizon aboe Unit 2 ~61k yrs old (OSL)

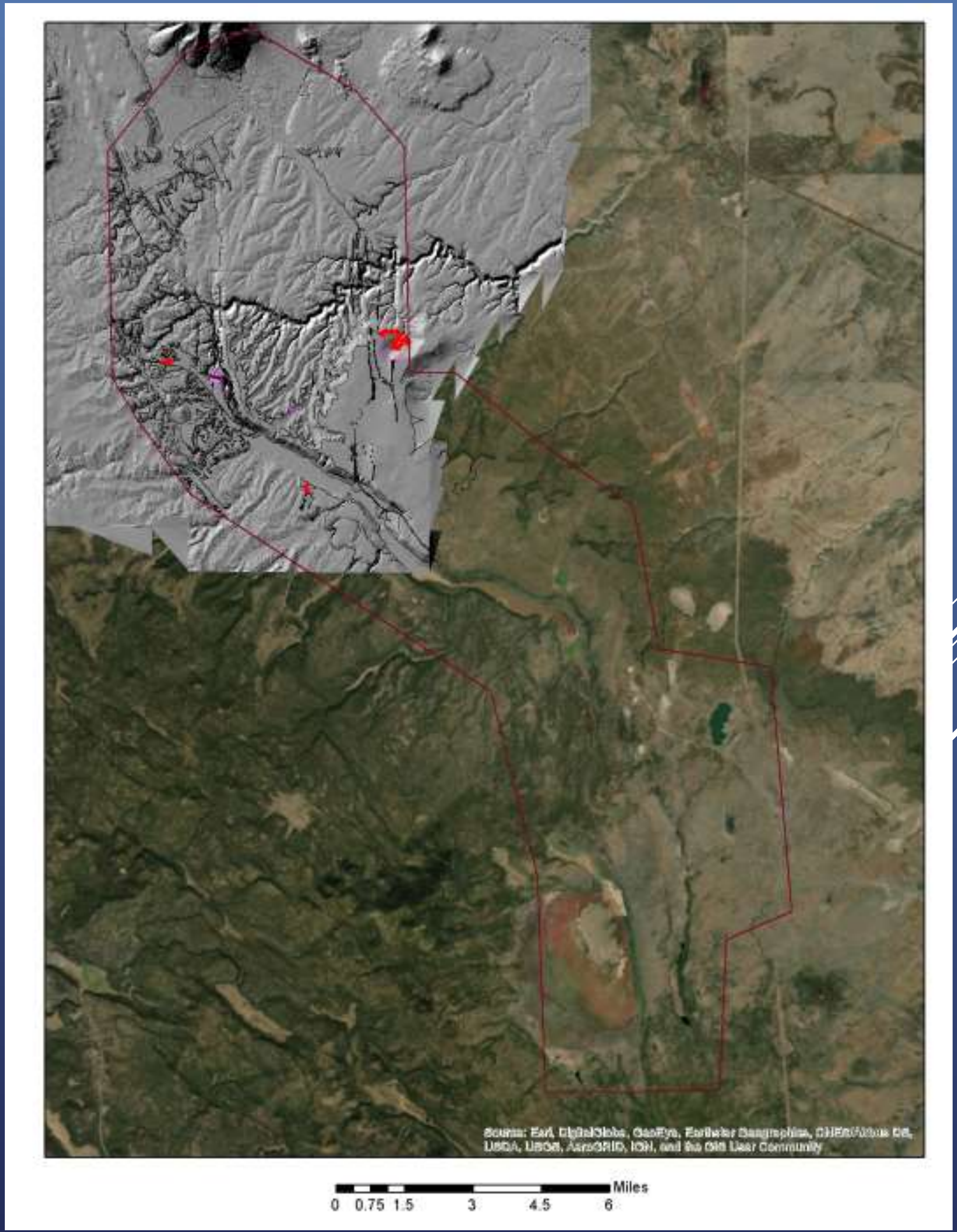


MSF CONCLUSIONS

- Drone aerial imagery and ground-control points were used to generate high-resolution DEMs and hillshades, limited only by computational capacity.
- The DEMs were essential in mapping and measuring offsets along the MSF.
- Slip Rates - were consistently 0.20mm/yr or less when measured on landforms that varied in age from Qo to Qi4 (~2ma to 12ka).
- ^3He cosmogenic dating may improve slip rate estimates (May 2020)
- The last one-two ground-rupturing earthquakes were recorded in young tributary deposits, approx. age < 23K yrs old (OSL dates).
- MSF – appears to be mostly a left-lateral fault system that has had 10s of meters of normal faulting since Qo time.
- The Mead Slope fault is an active fault that is part of the NE-trending Lake Mead Fault System.
  - Are other faults in the system active?
  - Can this fault potentially link with the Black Hills fault?

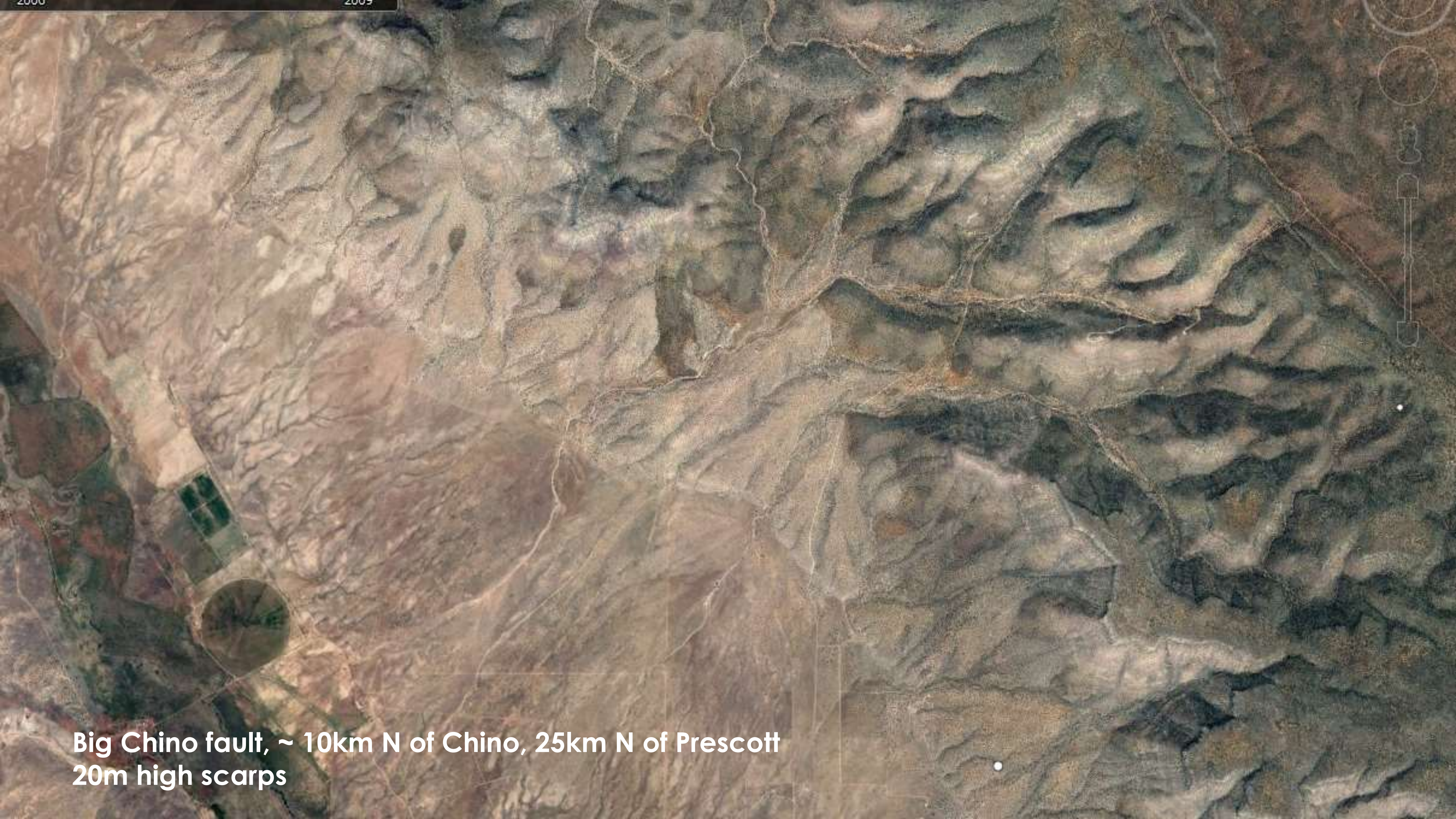
LAKE MARY FAULT ZONE

- 30-45km long set of normal faults
- Sharply defined scarp with at least 130m of vertical offset
- A surface rupture would cause widespread damage to the city of Flagstaff
- No previous studies, some incomplete bedrock mapping
- New mapping with an emphasis on offsets and potential paleoseismic sites
    - Will incorporate available LiDAR
    - Due to vegetation, drone imagery/DEM generation will be limited to wide-swath profiles



Big Chino Fault Zone

- 50km to 65km long
- Offsets of 25m on late Quaternary fans
- 7-8m offsets on younger landforms
- Youngest rupture ~ 10-15ka
- LiDAR now available


Big Chino fault, ~ 10km N of Chino, 25km N of Prescott
20m high scarps

OUTREACH

- AZ Shakes – Shake Out on 10-15-2019
  - 88,000 participants
- Arizona Seismic Safety Council
  - Resurrected - Mike Conway, AZGS
  - Goal: provide a platform for professional and community stakeholders to address earthquake science, hazards and risk that can impact the safety and resilience of AZ.


Thank you

California Geological Survey

California
Department of Conservation

California Geological Survey

Seismic Hazards Assessment and Zonation Program

Gordon Seitz, San Mateo, CA

CALIFORNIA

Ridgecrest earthquakes caused up to $5 billion in damage to China Lake naval base

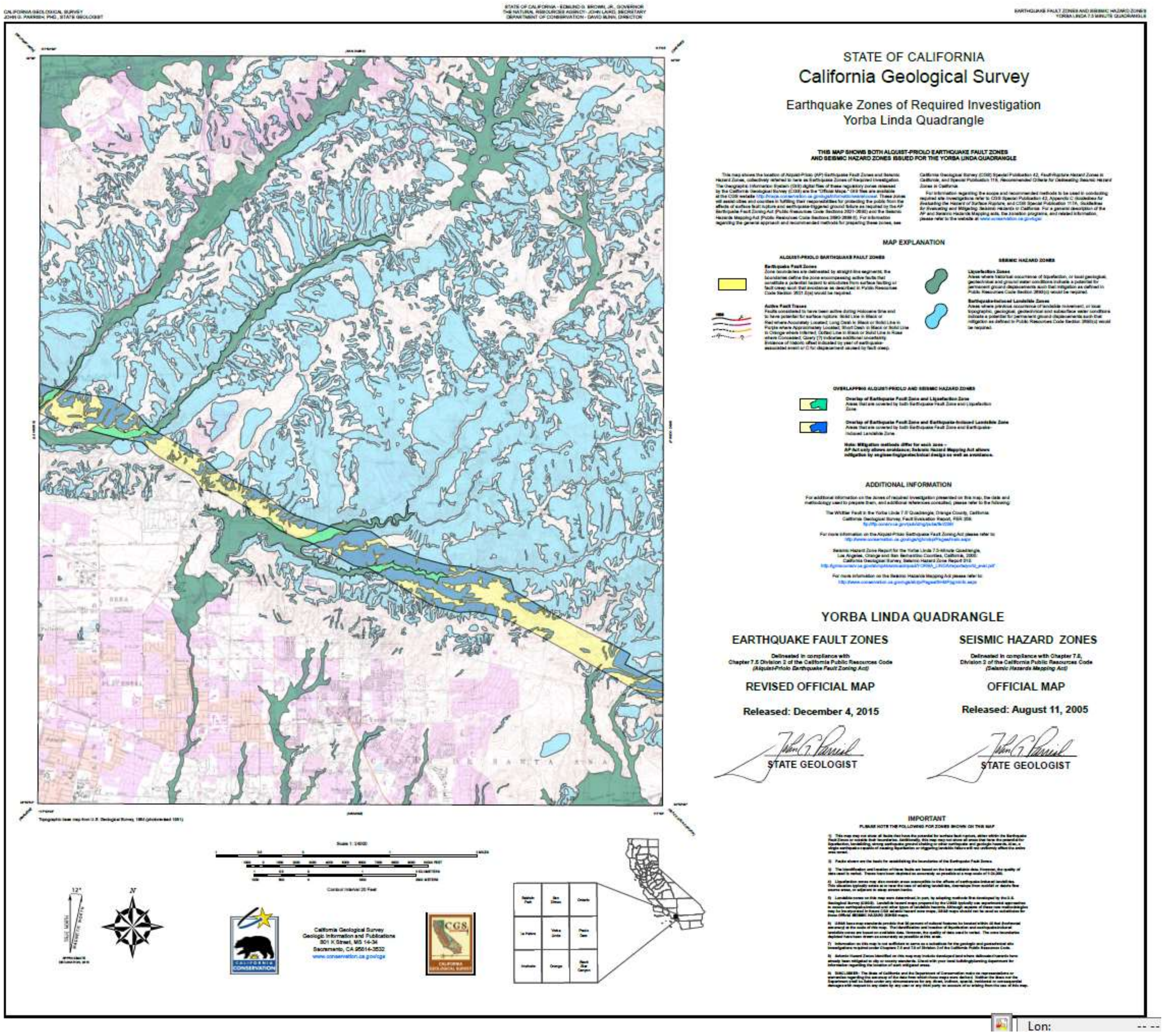
A sign posted July 7 outside the main gate of the China Lake naval station in Ridgecrest, Calif., shows the base is closed. (Mario Tama / Getty Images)

A-P Background: CGS Fault evaluations and zoning

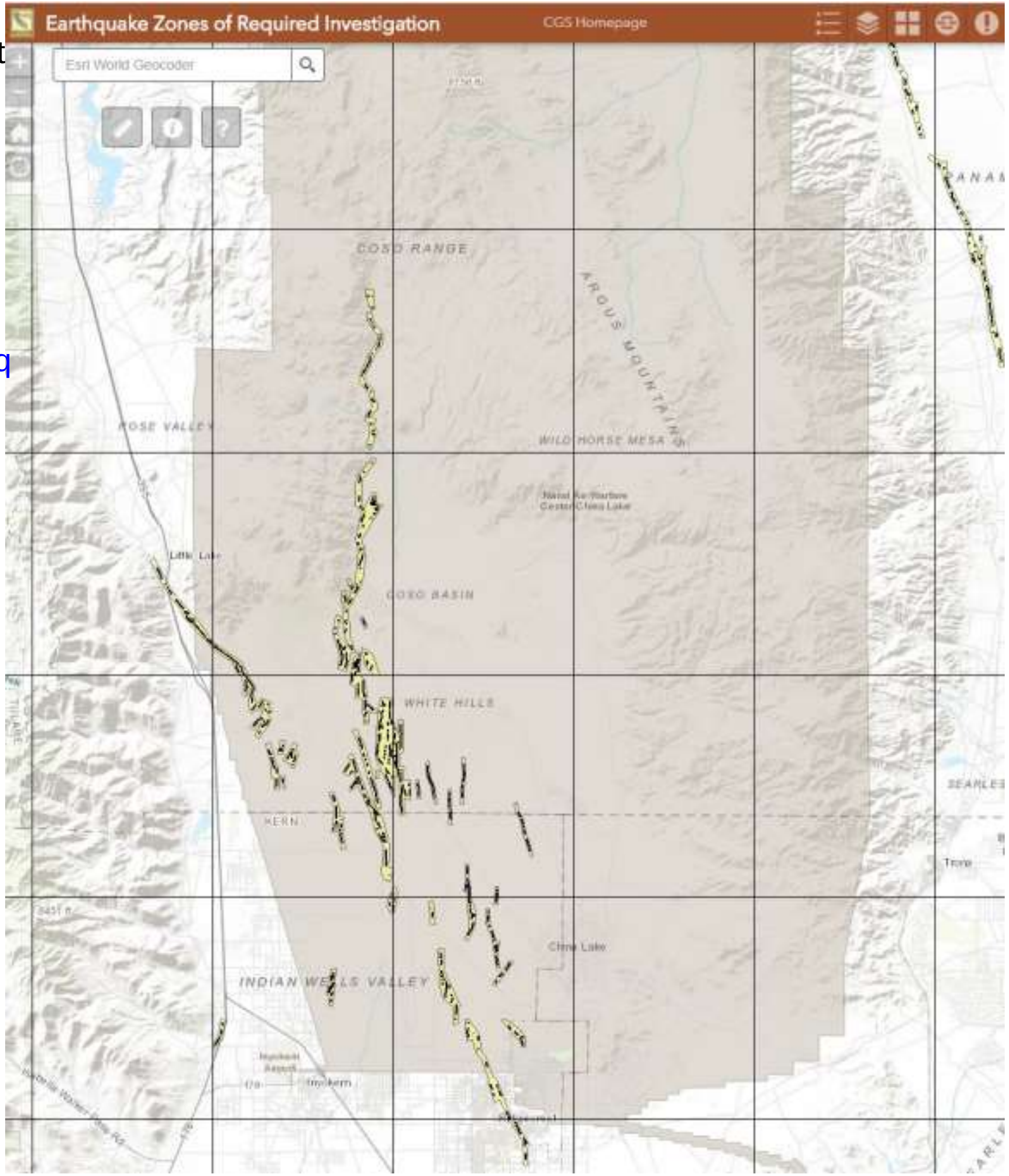
Earthquake Fault Zones are regulatory zones, delineated by the State Geologist (California Geological Survey), that encompass hazardous faults, which are defined as those faults that are *sufficiently active* and *well-defined*.

Sufficiently active	Fault that exhibits evidence of Holocene displacement (11,700 years).
Well-defined	Trace detectable by trained geologist at or just below ground surface.

Combined Fault, Liquefaction and Seismic Landslide Zone Map GeoPDF



Maps of Earthquake Fault Zones are now available in multiple formats. Most recently, these maps have been made available through a web application (https://maps.conservation.ca.gov/cgs/EQZApp/) that allows users to navigate to an individual parcel and determine whether or not it is affected by any of CGS's regulatory zones (fault rupture, soil liquefaction, or earthquake landslides). Institutional users, such as cities and counties, can access the zone maps on their systems through an interactive web map service: (https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS_Earthquake_Hazard_Zones)



https://www.conservation.ca.gov/cgs/Documents/SP_042.pdf

SPECIAL PUBLICATION 42

EARTHQUAKE FAULT ZONES

A GUIDE FOR GOVERNMENT AGENCIES, PROPERTY OWNERS / DEVELOPERS, AND GEOSCIENCE PRACTITIONERS FOR ASSESSING FAULT RUPTURE HAZARDS IN CALIFORNIA

Revised 2018

California Department of Conservation
California Geological Survey
801 K Street, MS 12-31
Sacramento, CA 95814

Photo: Cottage destroyed by surface fault rupture on the Kekerengu Fault during the Mw 7.8 2016 Kaikoura earthquake, New Zealand. Approximately 10 meters of right-lateral fault displacement occurred under this house, tearing it from its foundation. Photo credit: VML 190573, Julian Thomson, GNS Science / Earthquake Commission

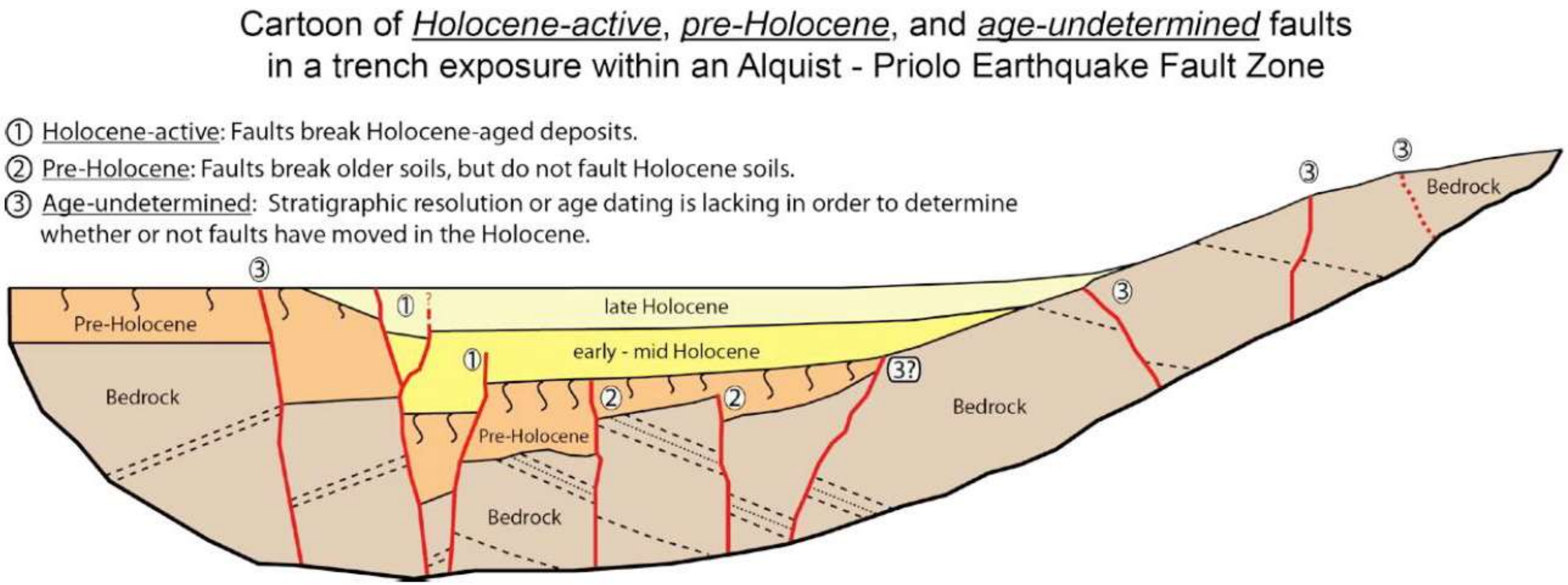


Figure 5-1. Fault classifications in a hypothetical trench log where *Holocene-active faults* break Holocene-age deposits and *pre-Holocene faults* break pre-Holocene age deposits, but not Holocene age deposits. The recency of movement for *age-undetermined faults* are unconstrained due to a lack of overlying deposits to determine the timing of the most recent fault displacement.

Table 5-1. Most Applicable Age Dating Methods for Fault Activity Investigations.

Method	Age Range / Uncertainty Range	Property Measured / Sample Materials	Application Criteria
Radiocarbon Dating	0 to 50,000 years 2 to 5%	^{14}C Organic matter	Most favored method due to its proven reliability to provide objective results. • multiple sample analyses allow an increase in confidence and accuracy • fast turn around • single dates can be misleading due to the difficulty in evaluating the context uncertainty
Luminescence	100 to 100,000 years Greater than 10%	Luminescence Quartz or Feldspar Crystals	Often suitable where sand-size material exists and when little C-14 dateable material can be found. Often requires research level effort to properly integrate all aspects of the method. Can provide reliable age estimate if done correctly. • strict sampling protocol • may complement ^{14}C well, as it can help assess context uncertainty
Cosmogenic nuclide	1,000 to 2,000,000 years Greater than 10%	^{10}Be, ^{26}Al, ^{36}Cl Quartz Feldspars Carbonates	Unique for its ability to date surfaces or burial events. Often requires research level effort to properly integrate all aspects of the method. Can provide reliable age estimate if done correctly. • strongly influenced by sampling protocol • accurate results are model dependent
Soil Profile Development Index (SDI)	500 to 500,000 Greater than 30%	Numerous Alteration of parent material	Requires quantitative dating of similar soil profiles in the area as calibration. Significant expertise is required for SDI age estimates.

Context Uncertainty

Context uncertainty generally represents the largest uncertainty in dating fault activity, and consists of the generally poorly known relationship of the chronologic measurement of an individual sample to the faulting event of interest. For example, a ^{14}C date derived from a detrital charcoal sample may have a considerable inherited age because it was either reworked from an older sedimentary unit or because it was derived from older wood that does not represent the deposit age, such as the core of a long-lived tree. For all quantitative dating methods, the context uncertainty can be thought of as the unknown age difference between the event of interest and the dated samples.

Laboratory Uncertainty

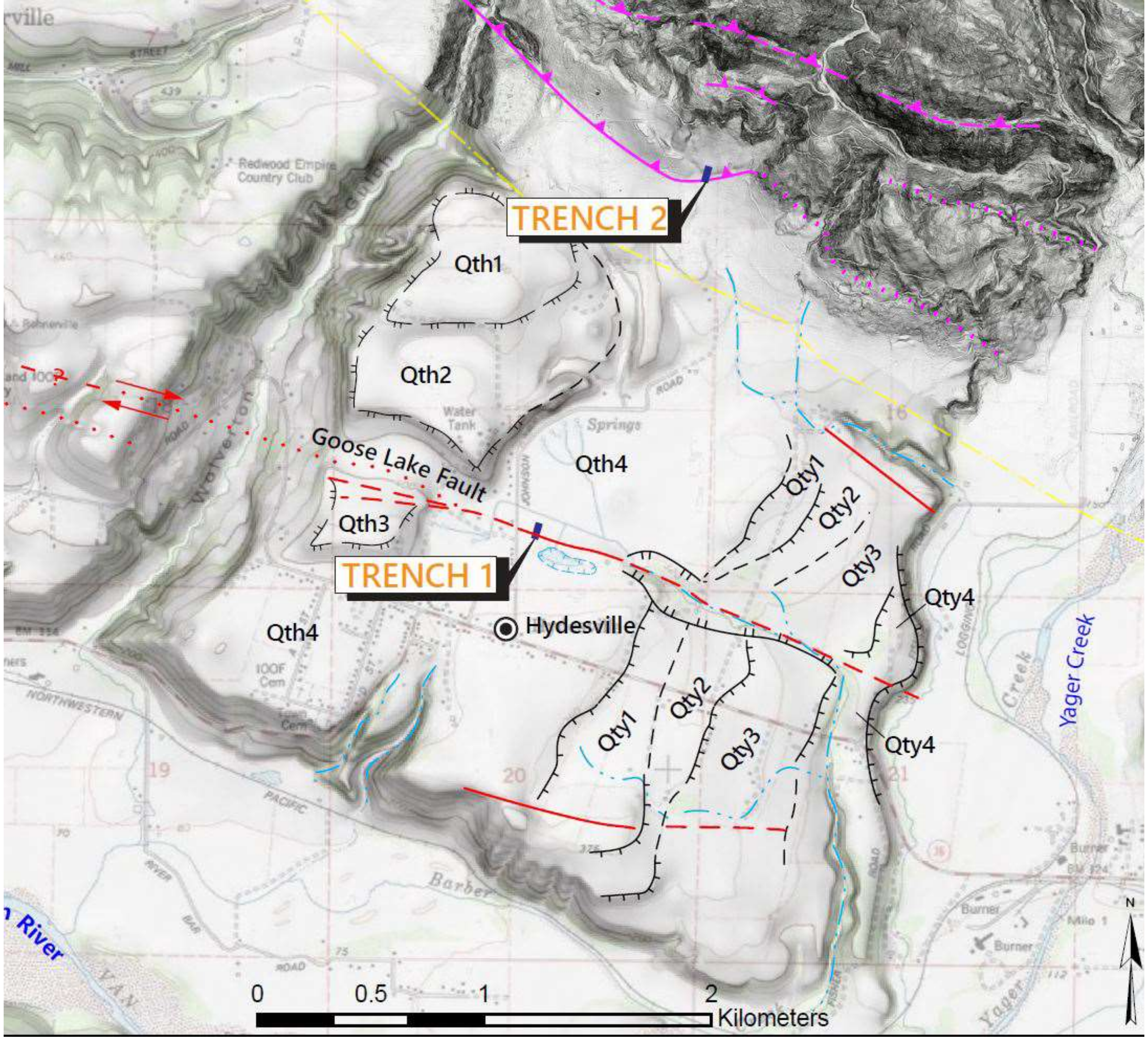
There are inherent laboratory uncertainties associated with each quantitative dating method that need to be considered in any chronological assessment. These uncertainties are difficult to reduce, although, dating of additional samples can improve accuracy and confidence.

Chronologic Modeling Uncertainty

All chronological data must be interpreted to assess the age of faulting. In general, this requires some extrapolation or interpolation, or bracketing of the event of interest. How the data are related to the event of interest is a "chronologic model." The type of model used will influence the chronological result. For example, when evaluating a scatter of different sample ages from one geologic unit, a decision must be made as to how to use the results. One may have sample ages from two different sample types, or different dating methods, or there may be stratigraphically inconsistent results. A careful consideration of each chronological constraint must go into the development of the chronologic model.

2020 ongoing Fault Evaluations by CGS

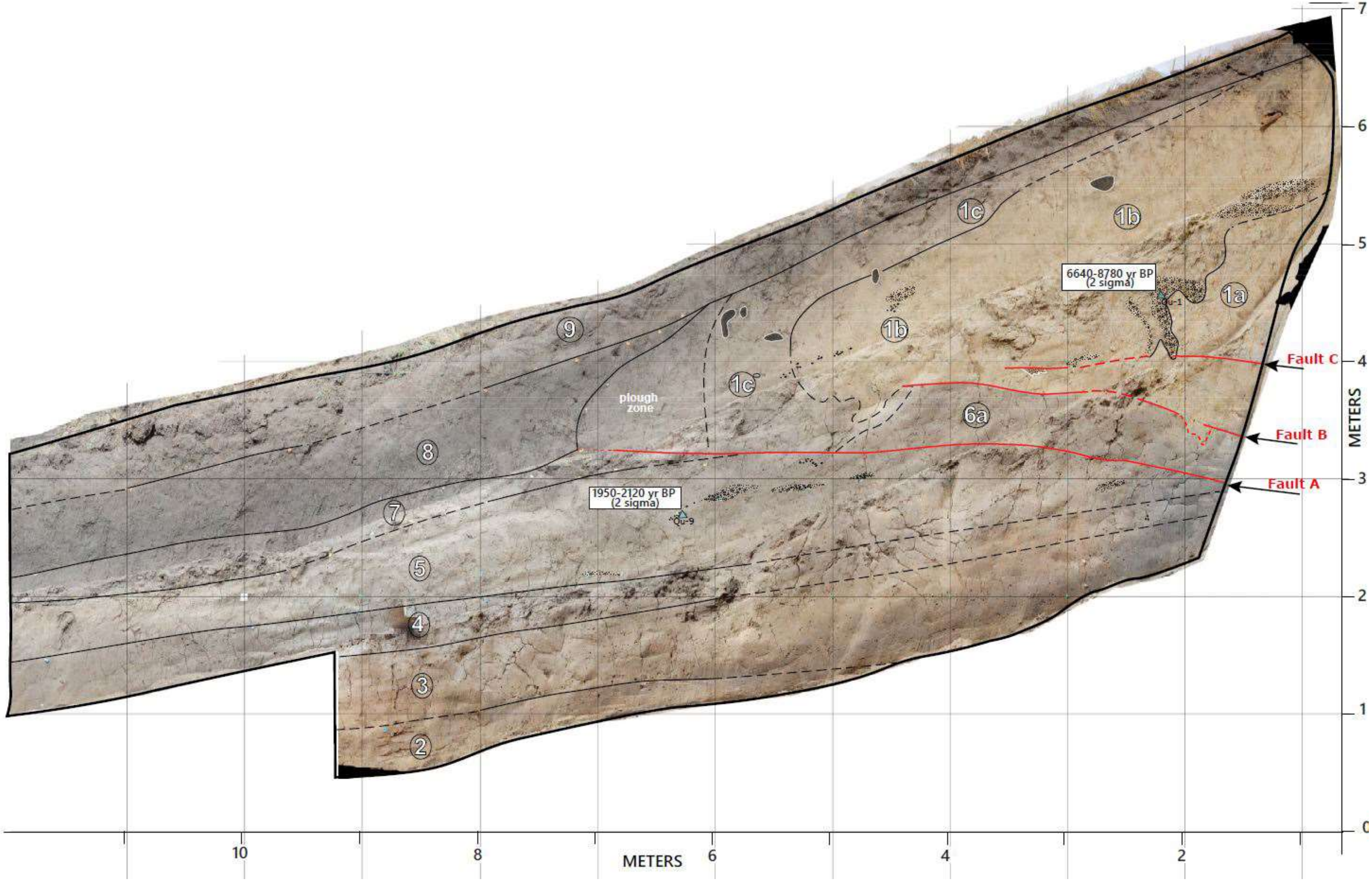
- San Andreas Fault, peninsular- 22 mm/yr
- Rogers Creek Fault- 10 mm/yr
- Hayward Fault- 10 mm/yr
- Rose Canyon Fault- 1.5 mm/yr
- San Cayentano- 2-9 mm/yr
- Ridgecrest Earthquake Ruptures: China Lake right lateral
  Salt Wells Valley left lateral



Little Salmon Fault Paleoseimic Investigation 2019

Ladinsky, CGS San Mateo

NEHRP/USGS funded



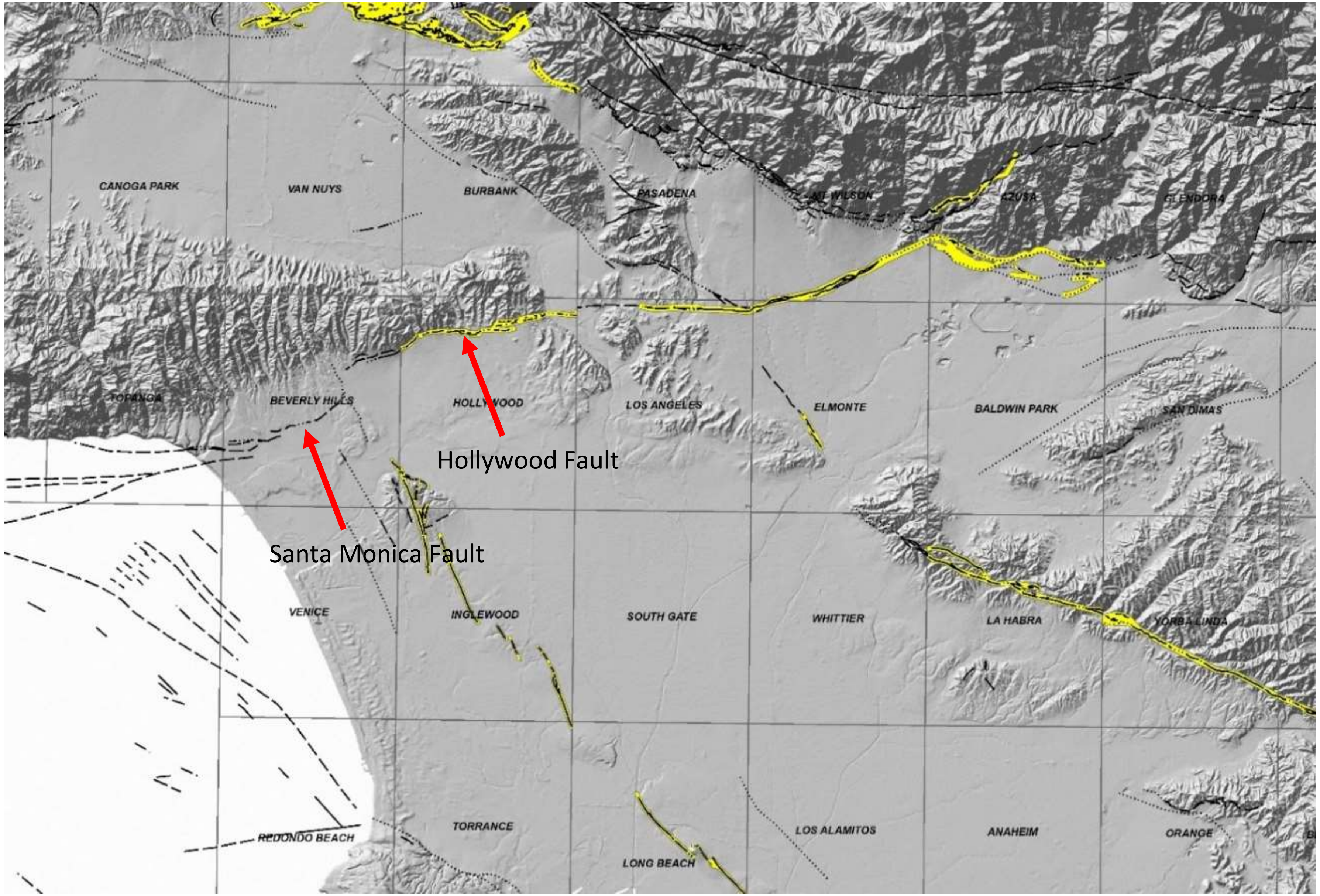
7
6
5
4
3
2
1
0
METERS
10
8
6
4
2
METERS
Fault C
Fault B
Fault A
6640-8780 yr BP (2 sigma)
Qu-1
1950-2120 yr BP (2 sigma)
Qu-9
plough zone
1a
1b
1c
6a
9
8
7
5
4
3
2

CGS-USGS Cooperative Seismic Studies

Guided Wave and Seismic Refraction and Reflection Study

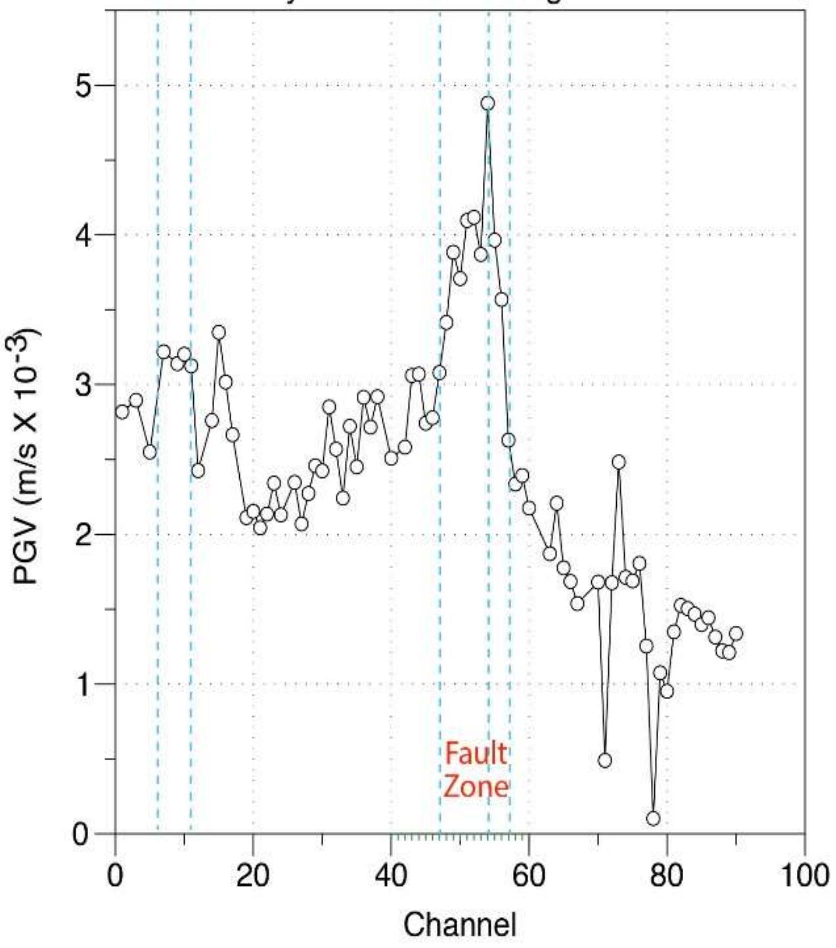
Hollywood and Santa Monica Faults

2018-2019



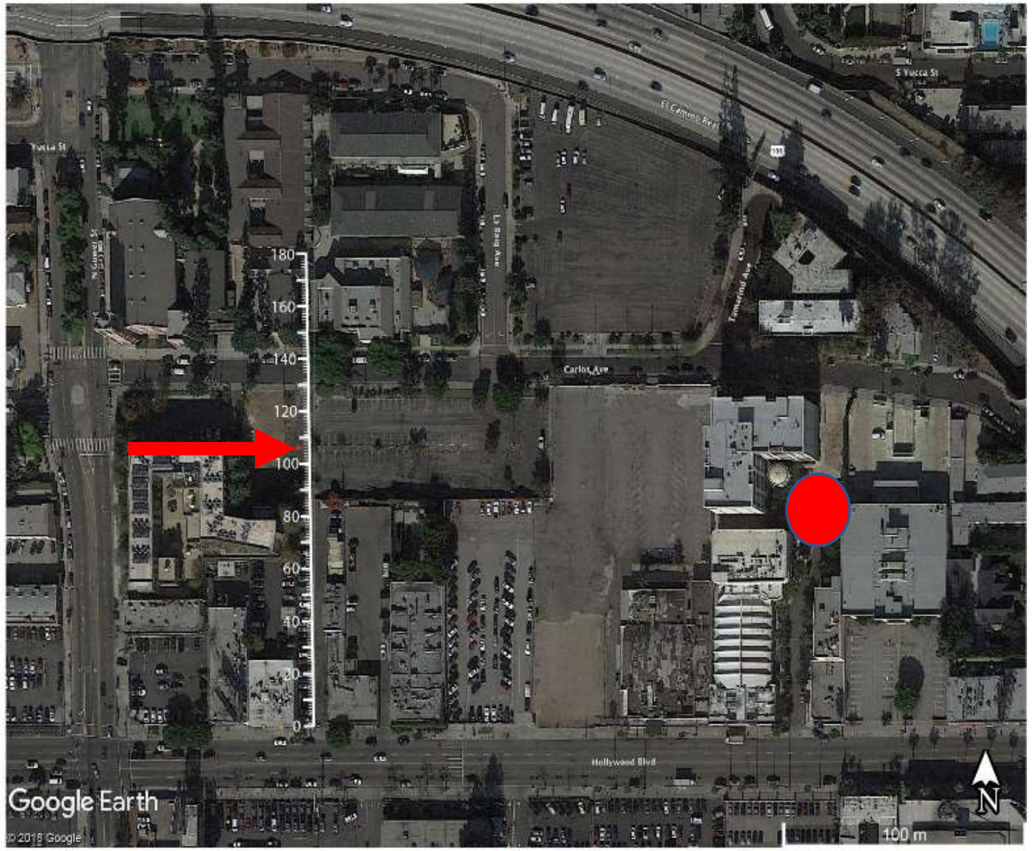
Hollywood Fault (Parking Lot) Guided Wave Investigation 2018

Hollywood Fault Parking Lot PGV



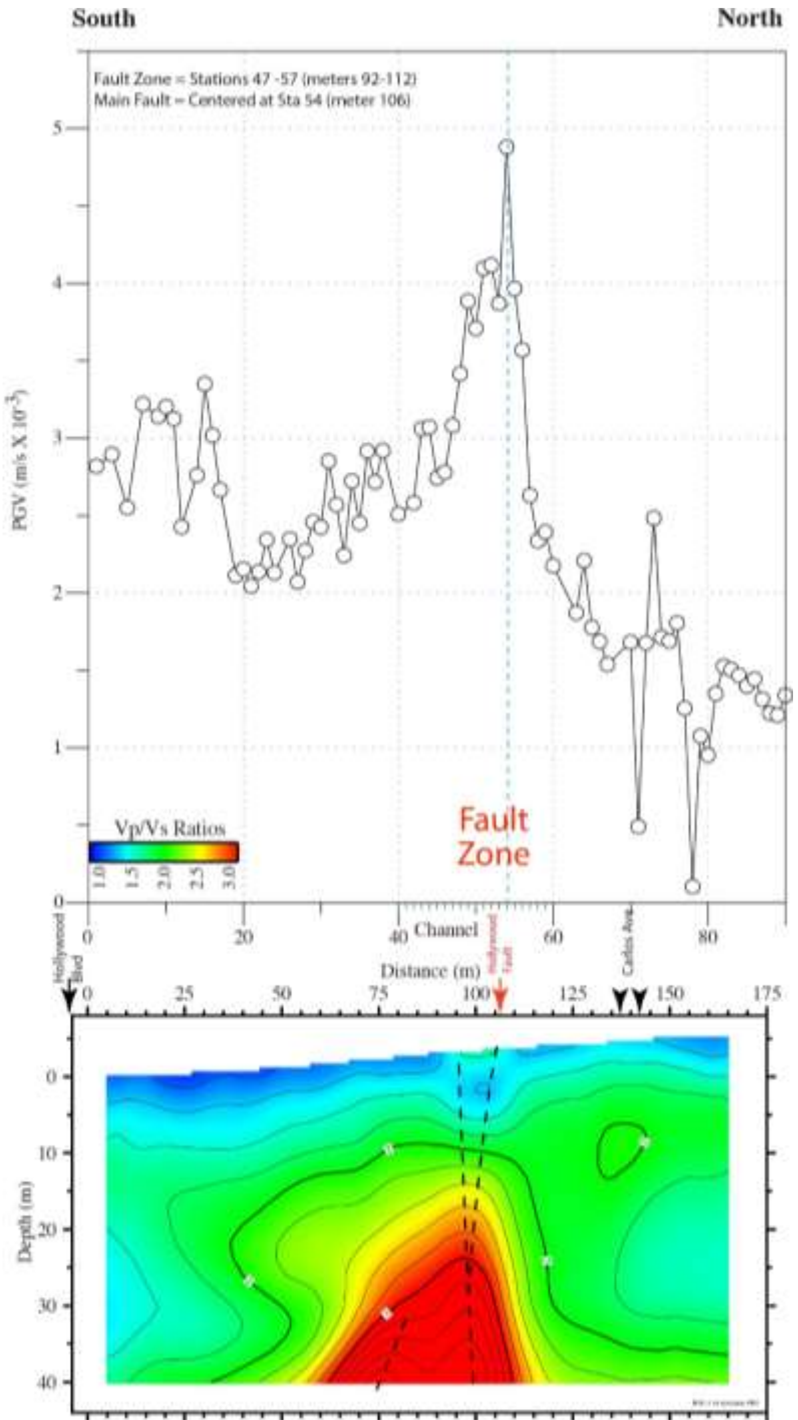
Fault Zone = Stations 47 -57 (meters 92-112)
Main Fault = Centered at Sta 54 (meter 106)

Hollywood Fault Parking Lot Photo

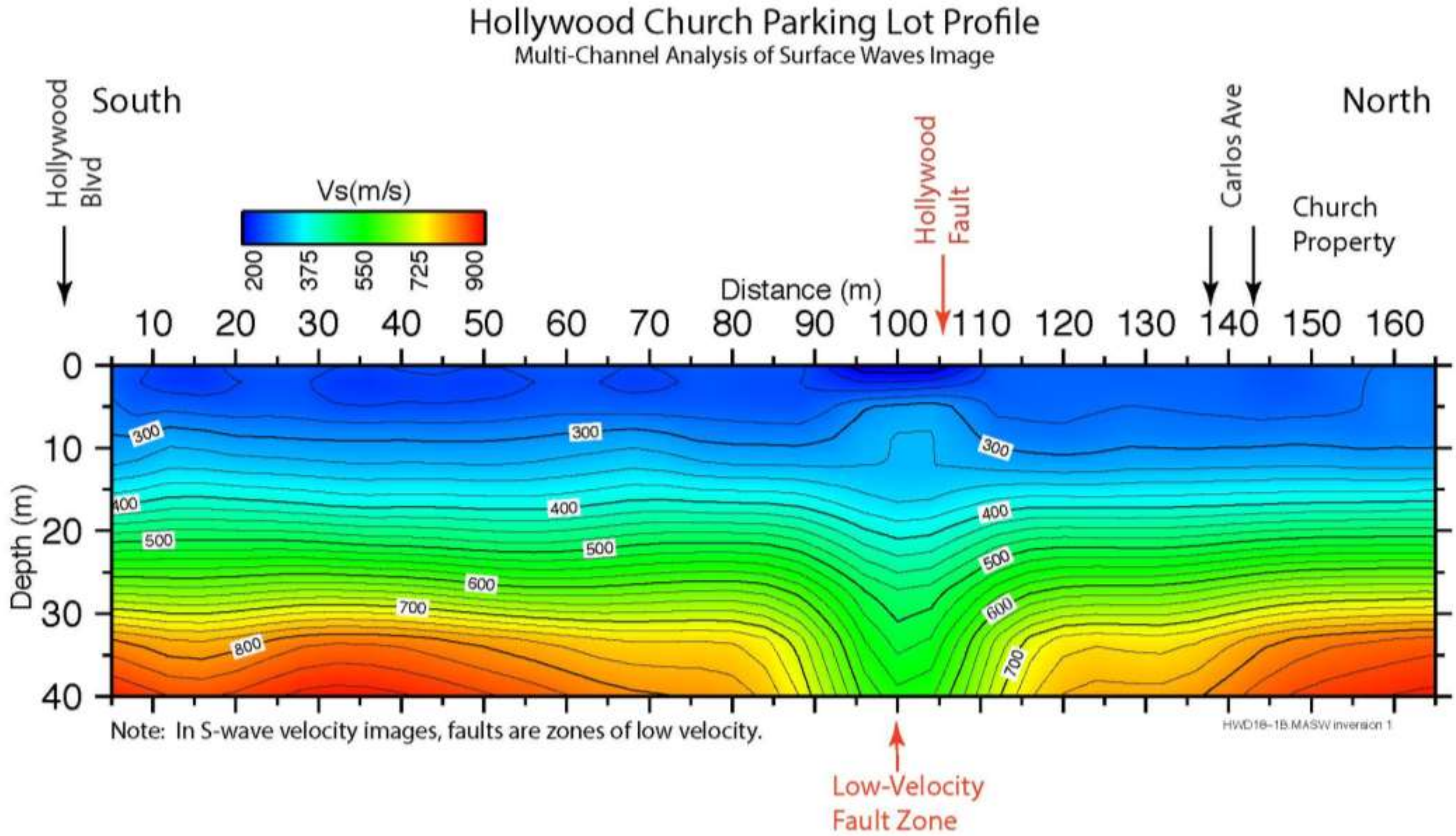


Guided wave travels at 181 m/s to main Fault Zone. It is unclear if the higher PGV values between stations 5 and 11 are guided waves, as they travel at 255 m/s. If guided waves travel an indirect path to stations 5-11, it is possible that there is a second fault zone. The high PGV values near station 15 are probably not from guided waves, as they travel at 288 m/s. I will have to do more testing for the arrivals between stations 5 and 15.

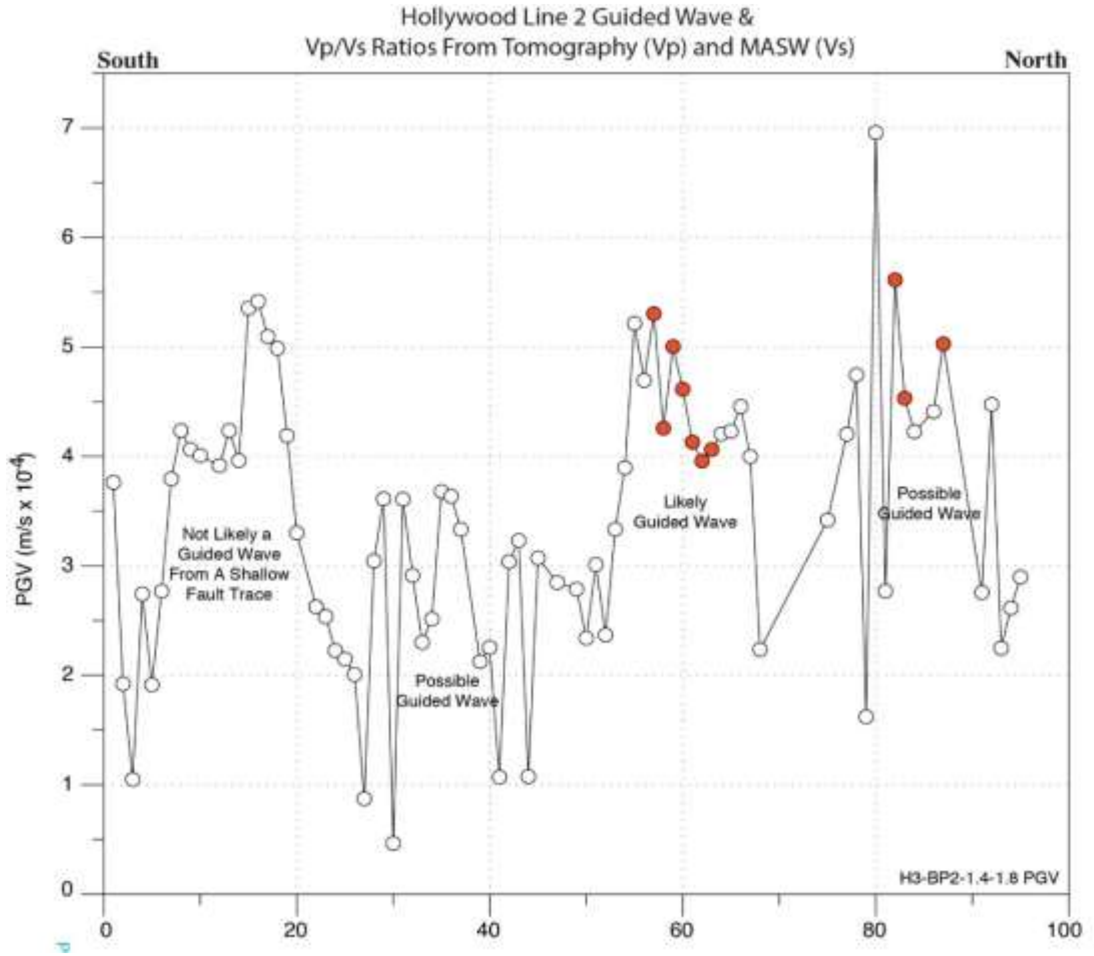
CGS
CALIFORNIA GEOLOGICAL SURVEY

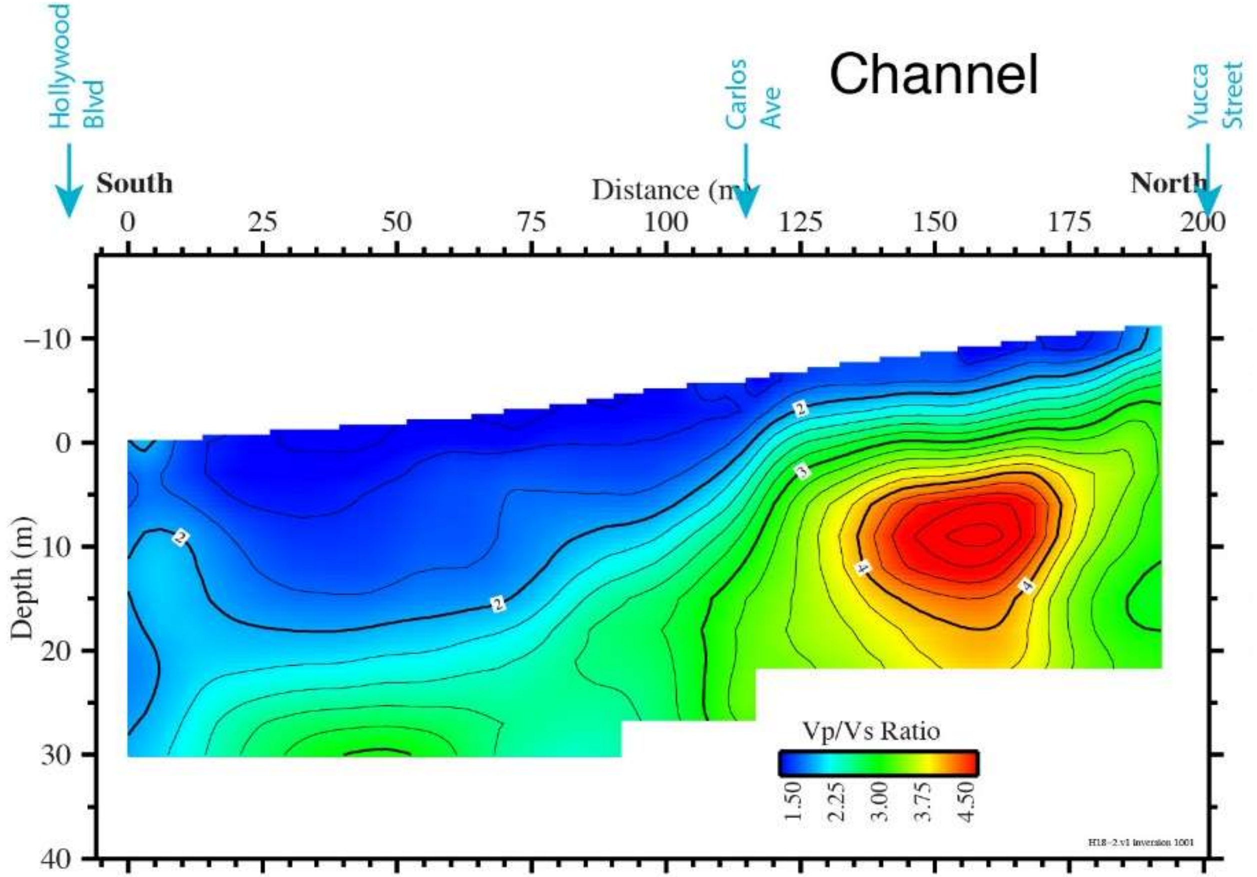


South
North
Fault Zone = Stations 47 -57 (meters 92-112)
Main Fault = Centered at Sta 54 (meter 106)
PGV (m/s X 10^-3)
Vp/Vs Ratios
1.0
1.5
2.0
2.5
3.0
Fault
Zone
Channel
Hollywood Blvd
Hollywood Fault
Carlos Ave.
Distance (m)
Depth (m)



Hollywood Church Parking Lot Profile
Multi-Channel Analysis of Surface Waves Image
South
North
Hollywood Blvd
Carlos Ave
Church Property
Hollywood Fault
Vs(m/s)
200 375 550 725 900
Distance (m)
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
Depth (m)
0 10 20 30 40
300
400
500
600
700
800
Note: In S-wave velocity images, faults are zones of low velocity.
HWD16-1B.MASW inversion 1
Low-Velocity Fault Zone


Hollywood Line 2 Guided Wave &
Vp/Vs Ratios From Tomography (Vp) and MASW (Vs)
South
North
PGV (m/s x 10⁴)
Not Likely a Guided Wave From A Shallow Fault Trace
Possible Guided Wave
Likely Guided Wave
Possible Guided Wave
H3-BP2-1.4-1.8 PGV
0
20
40
60
80
100


Hollywood Blvd
Carlos Ave
Channel
Yucca Street
South
Distance (m)
North
Depth (m)
Vp/Vs Ratio
1.50
2.25
3.00
3.75
4.50

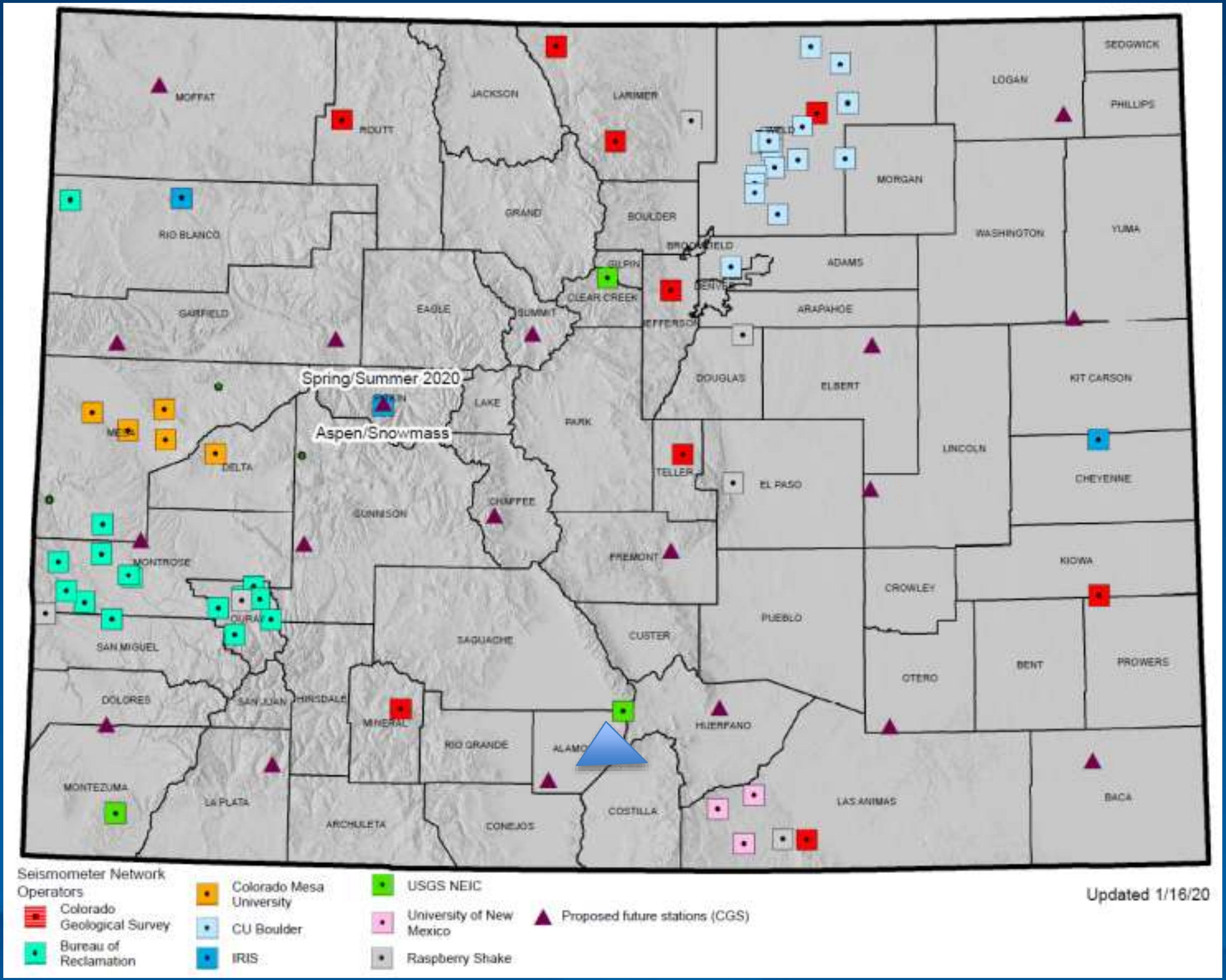
“The report will explain all of this”

Rufus Catchings, USGS.

Update and Issues Facing Earthquake Research in Colorado 2020

Jim McCalpin and Matt Morgan

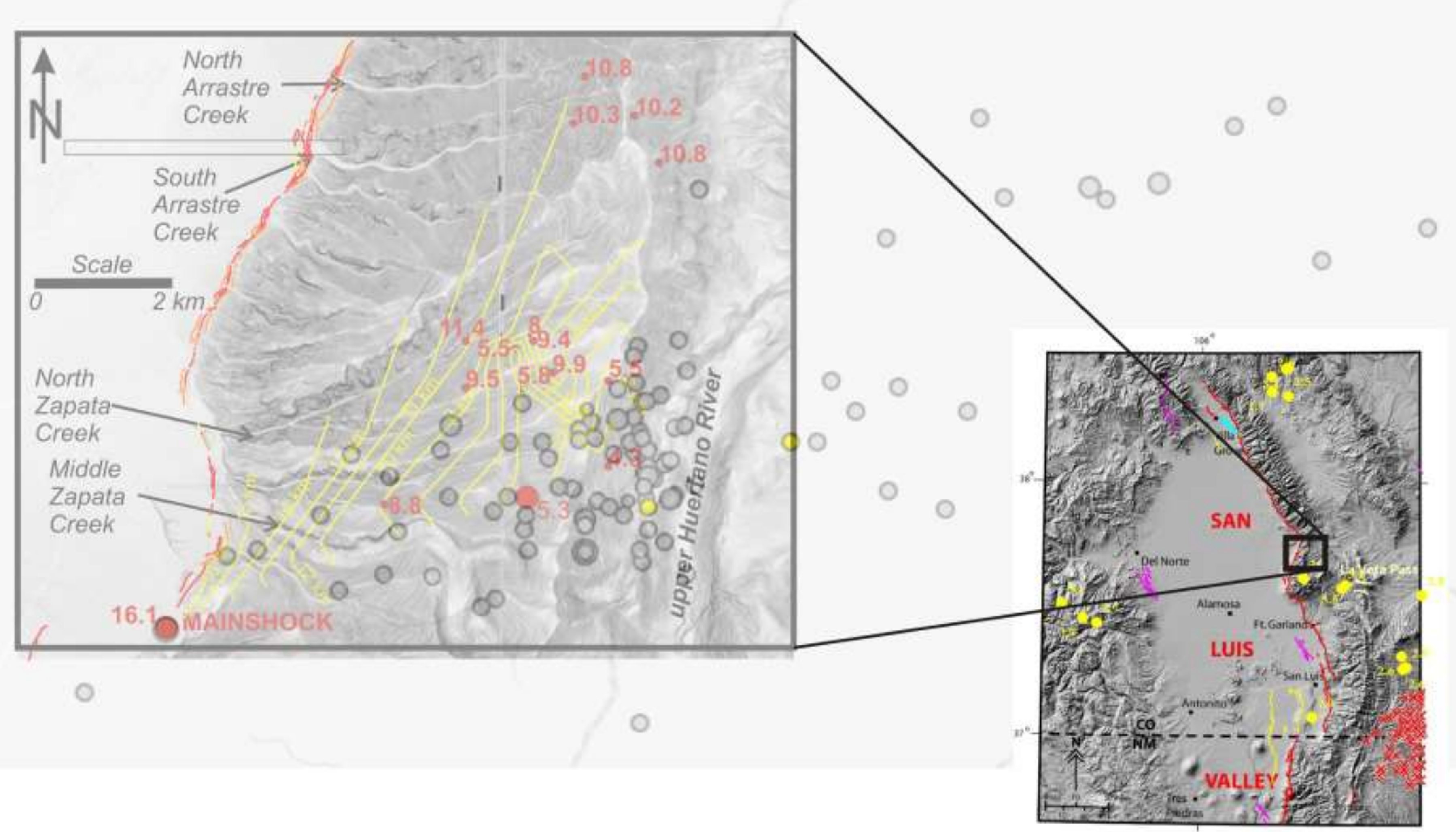
Seismometer Locations



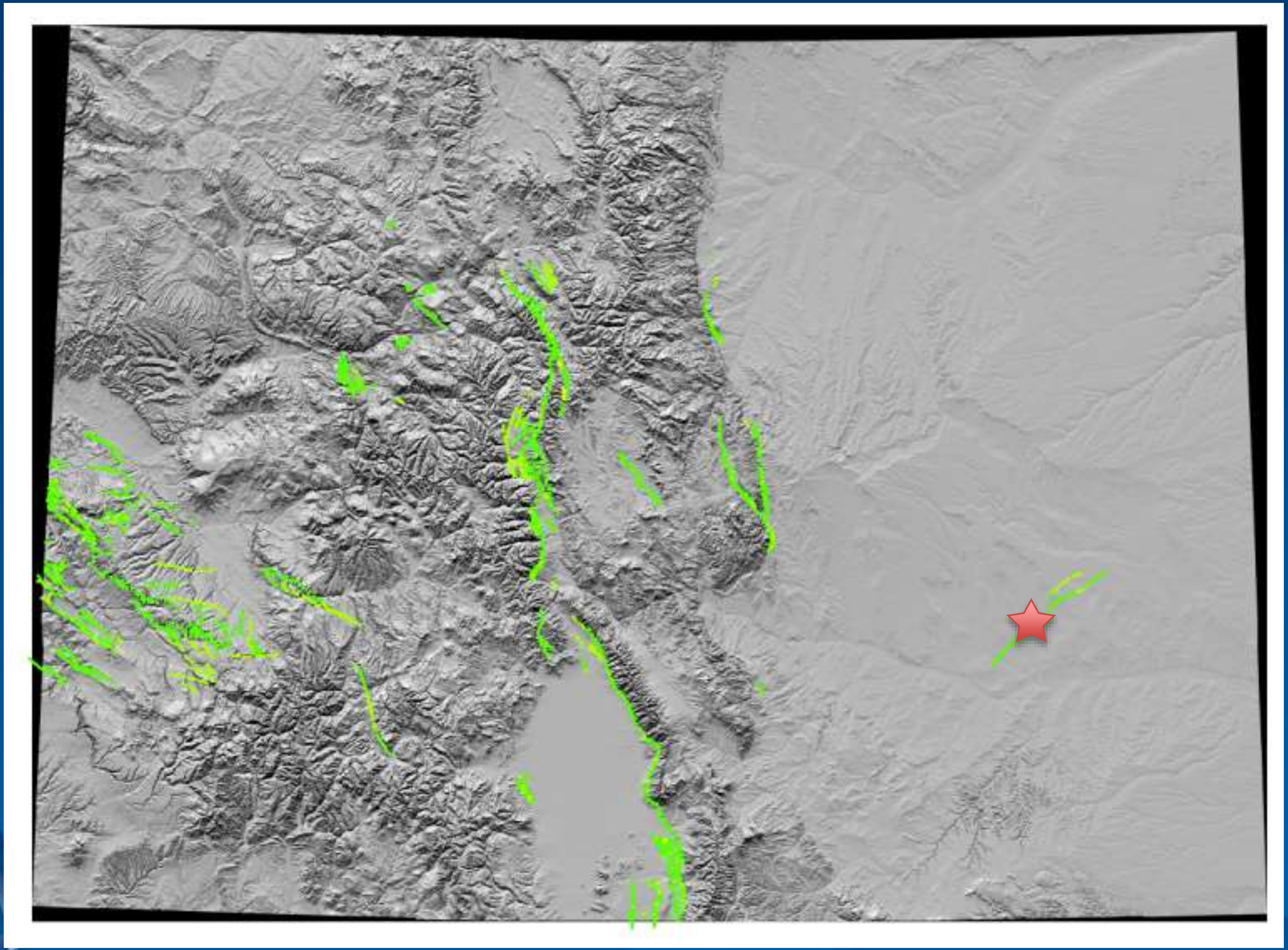
COLORADO SCHOOL OF MINES

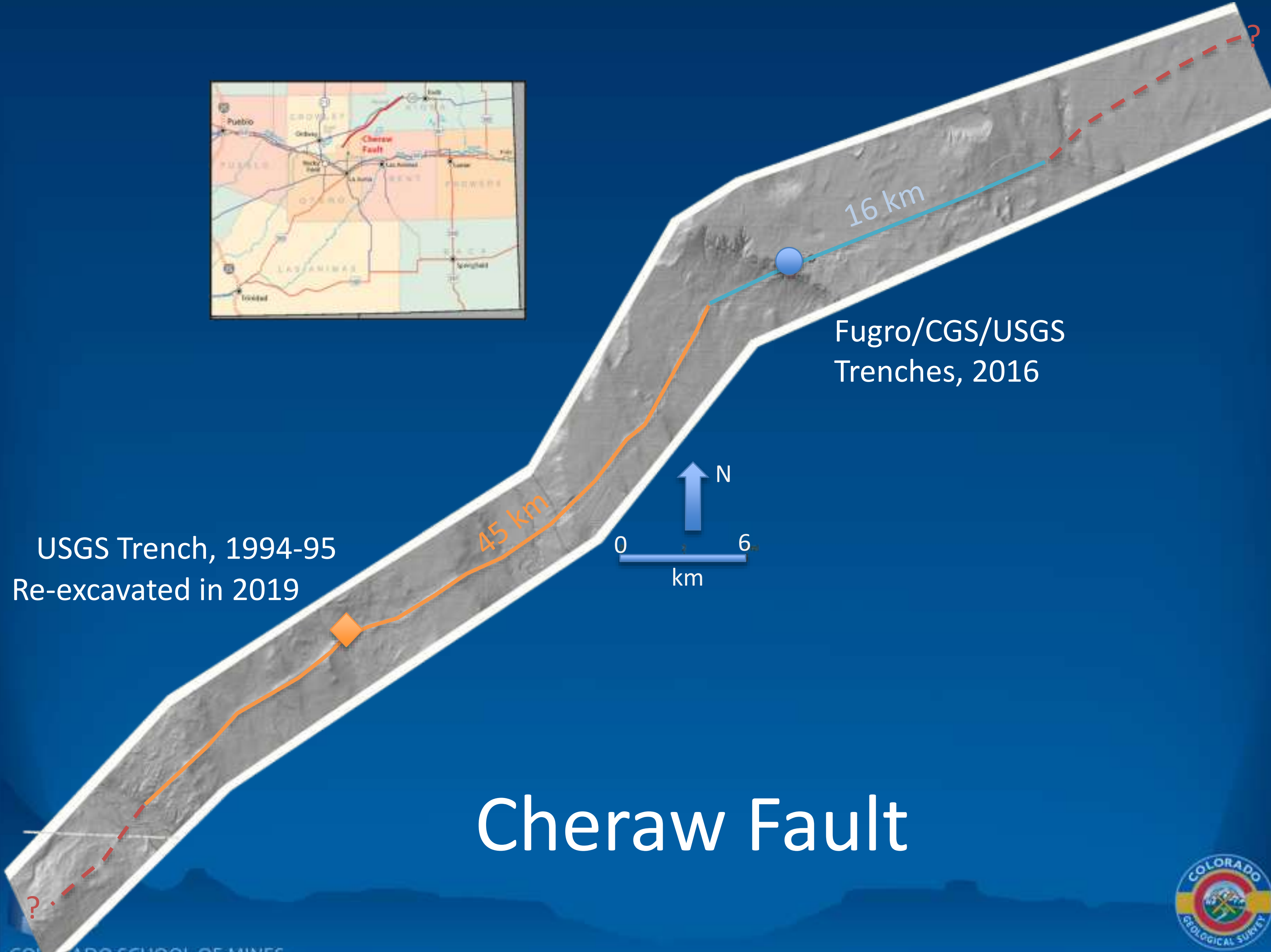
EQ Swarm on E Boundary of Rio Grande rift (2019-FEB-27 to 2020-JAN-21)

95 EQs M1.0-1.9; 7 EQs M2.0-2.9; 2 EQs M3.0-3.4
(#15, #23 in sequence)



Cheraw Fault Trenching
Phase II





Cheraw Fault

COLORADO SCHOOL OF MINES

Cheraw Fault Trenching

Cheraw Fault Findings 2016-2020

2016-18, NEW TRENCH on NE Section

- Fault ~80 km (vs 45 in 1994)
- Earliest Pleist "Nussbaum Alluvium" vertically offset >5 to 6 m, most likely ~9 m
- 'Nussbaum' here is 126 ka to >>160 ka (NOT earliest Pleist)
- Slip occurred after ~126 to 159 ka, min vert slip rate ~0.06 to 0.07 mm/yr

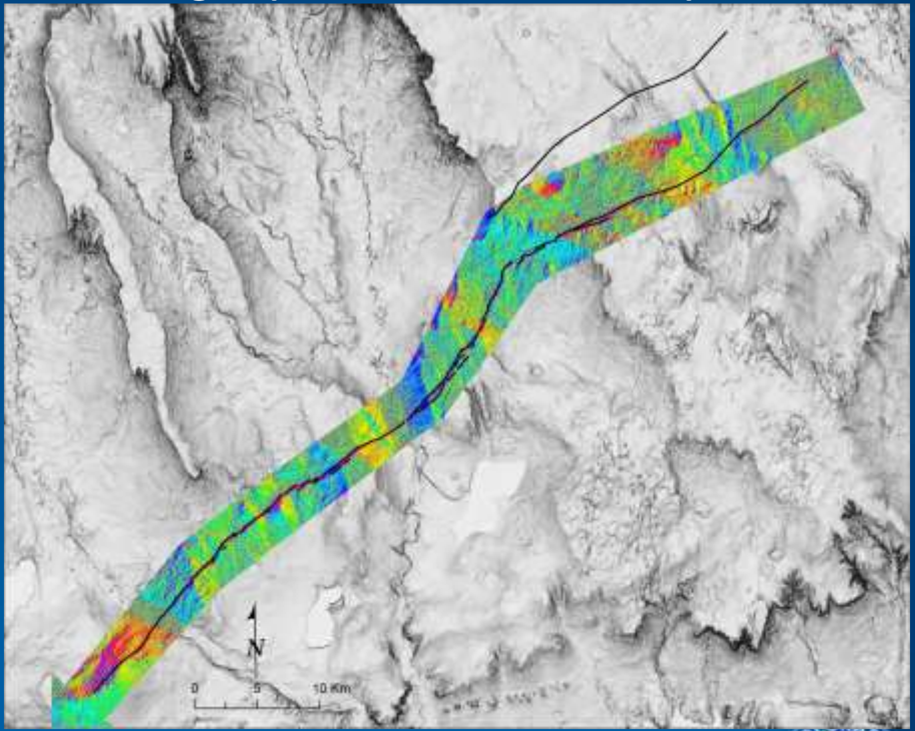
2019-20 (RETRENCH CRONE 1994)

Three surface faulting events since formation of a prominent buried soil on eolian silt.

- **E1: ~8-7 ka or <7 ka (not well constrained)**
- **E2: ~8.8 ka (well constrained)**
- **E3: ~10.8 ka (well constrained)**

- at least 2 additional events since ~12.5 ka.
- The uppermost fluvial deposits in the truncated Pleistocene channel are offset ~3.7 m, which matches topographic scarp height. Preliminary age models for this horizon suggest an age of ~12.5 ka, with a resultant slip rate of ~0.3 mm/yr.

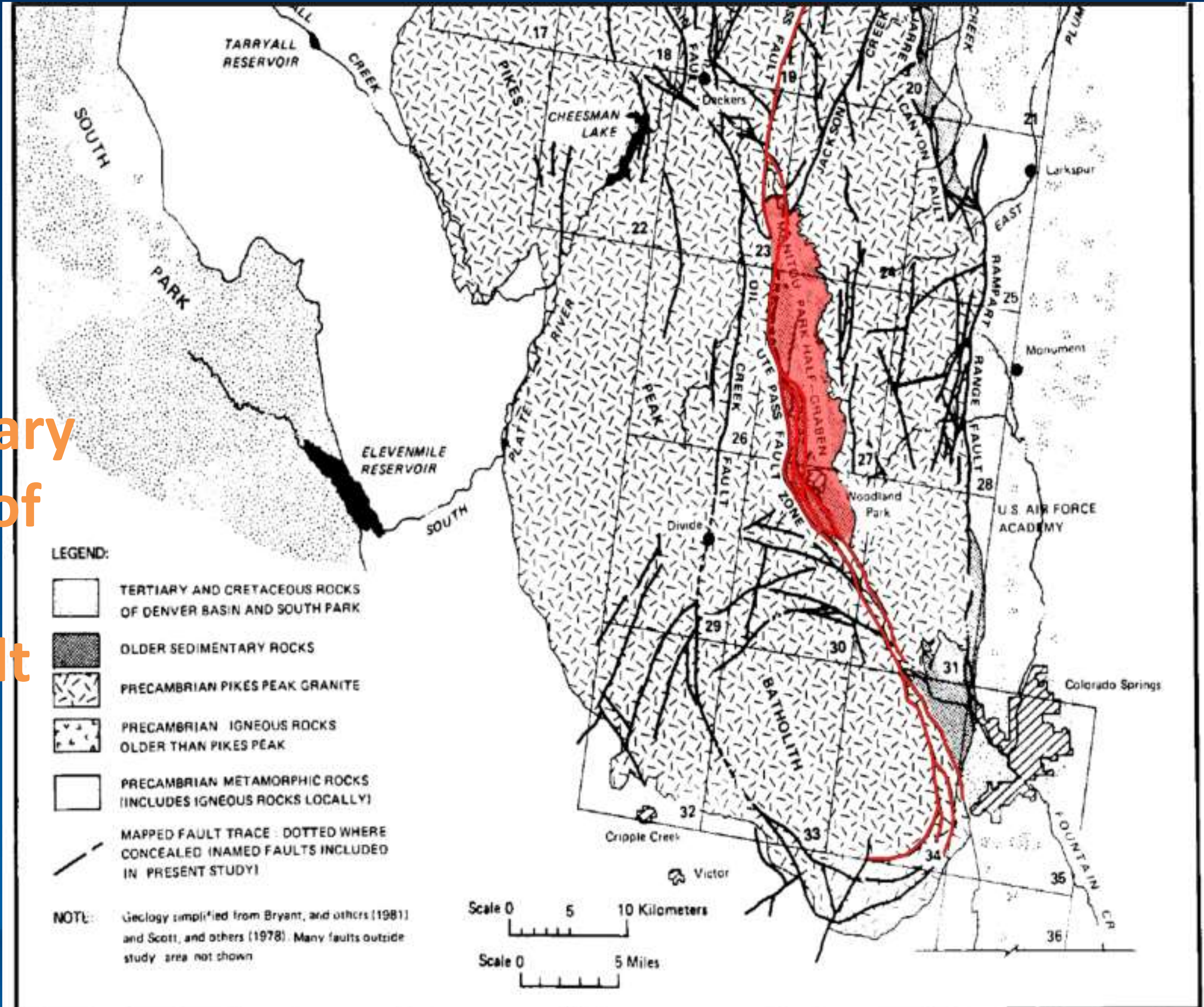
PROBLEM: SRL 45 km=M7.0=Davg 0.97m, Dmax 2.32m; SRL 80 km=M7.37=Davg 1.56m, Dmax 4.56. BUT in trenches Davg=0.75 m. Which equates to M6.5 (as Dmax) to M6.7 (as Davg). Those ruptures should have SRL of only 17.4-22km. Trench displ don't match fault length (LONG SKINNY FAULT)

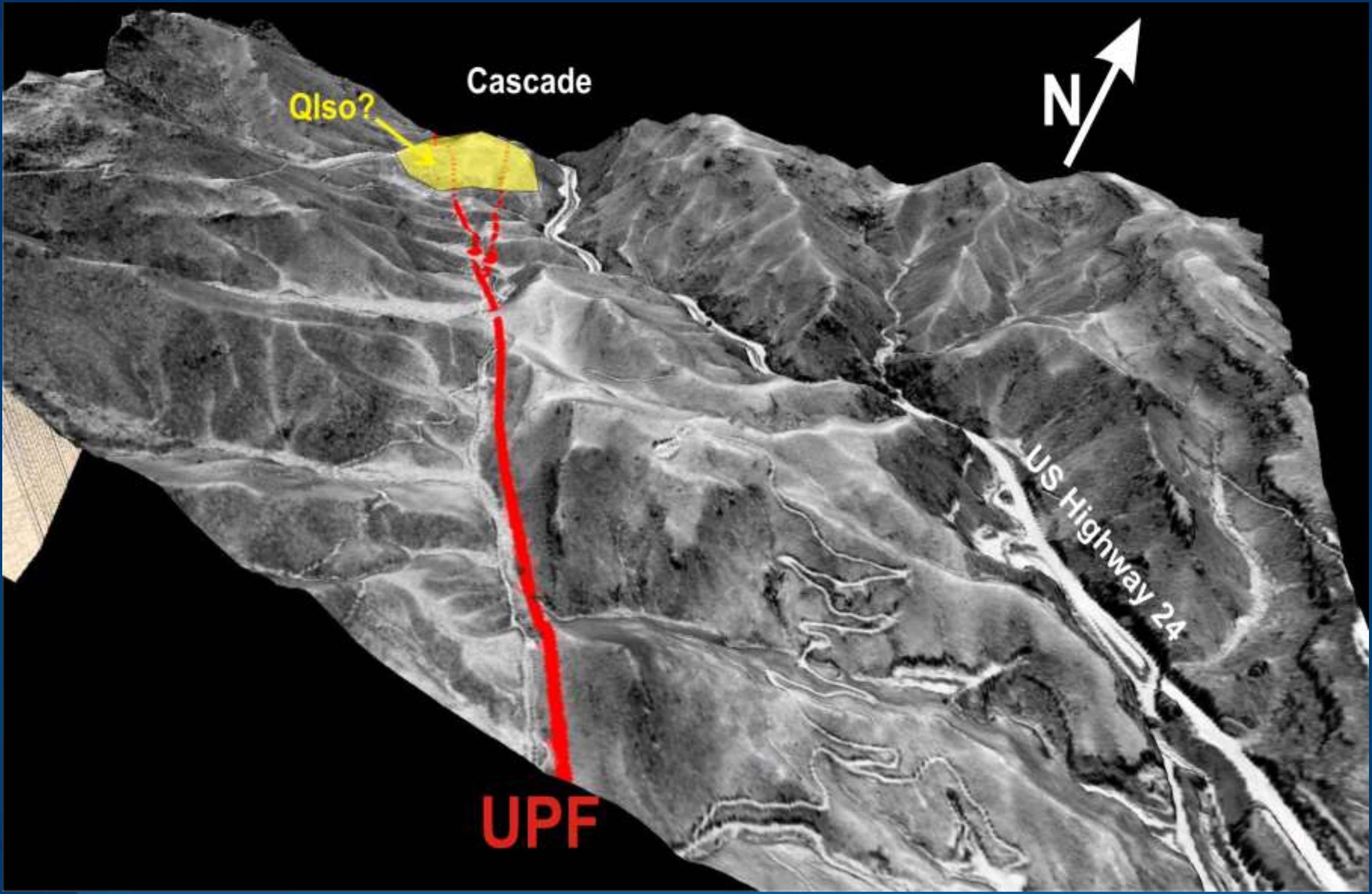


Mark Zellman, BGC Engineering; Lidar CGS

COLORADO SCHOOL OF MINES

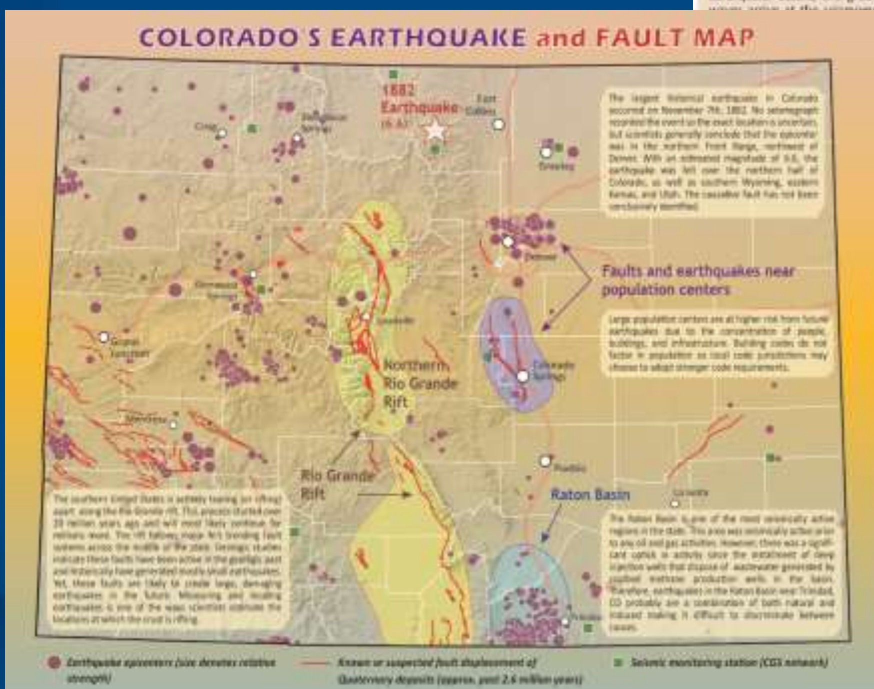
FY 2020 NEHRP: Late Quaternary Activity of the Ute Pass Fault





Oblique lidar slopeshade view of the UPF south of Cascade, looking NW up the valley of Fountain Creek.

Earthquake Brochure



Quaternary Fault Database Update

- USGS funded
- Last updated in 1998
- Update fault traces and trenches using 24k and 100k maps, LiDAR, consultant reports
- Traces submitted to USGS for review at end of January 2020

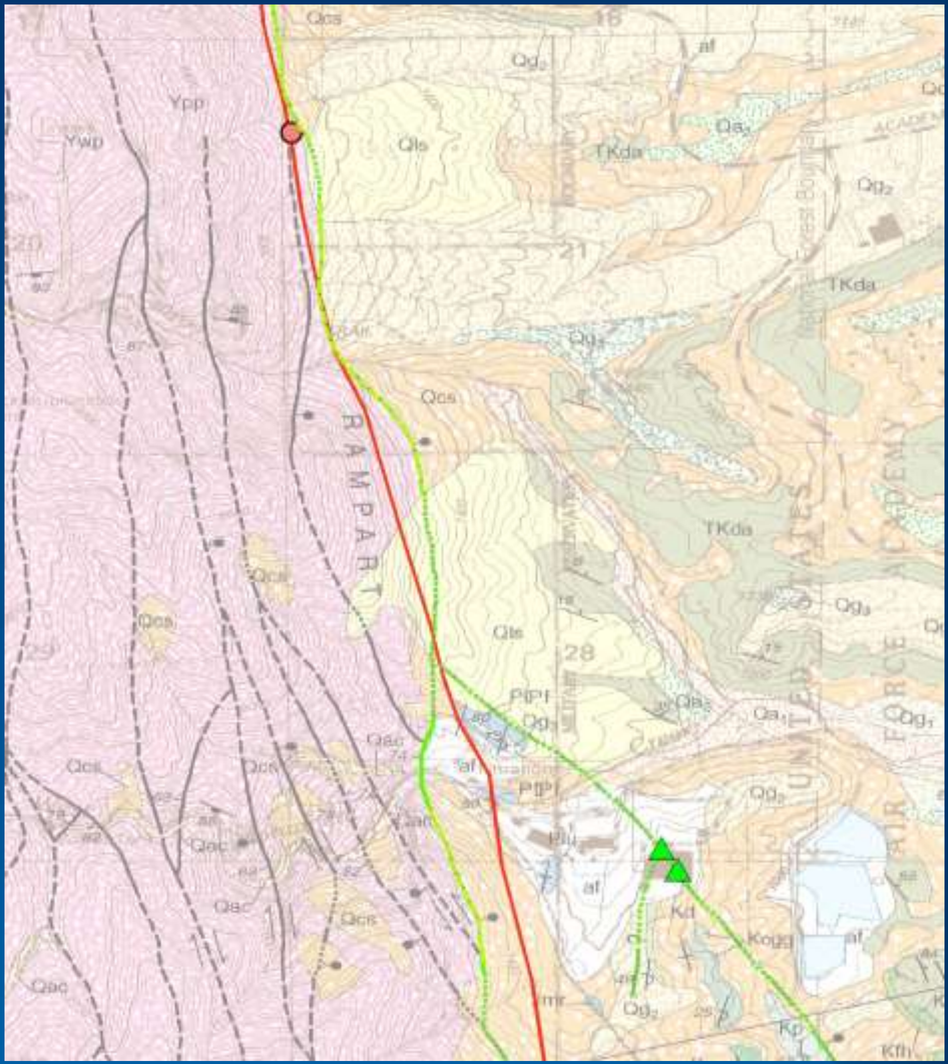
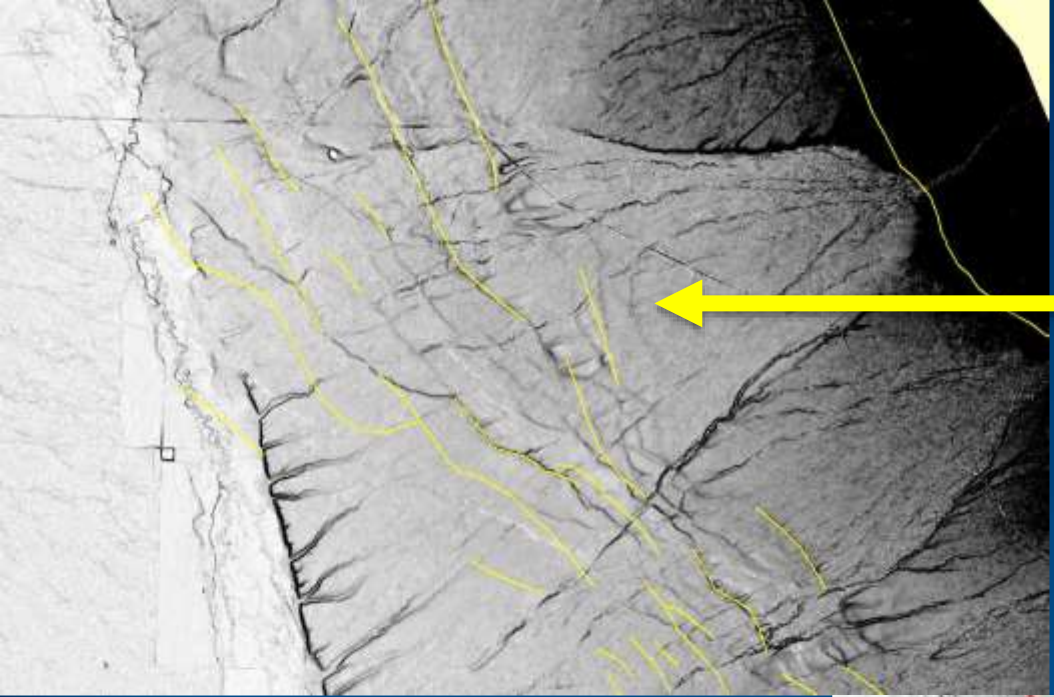
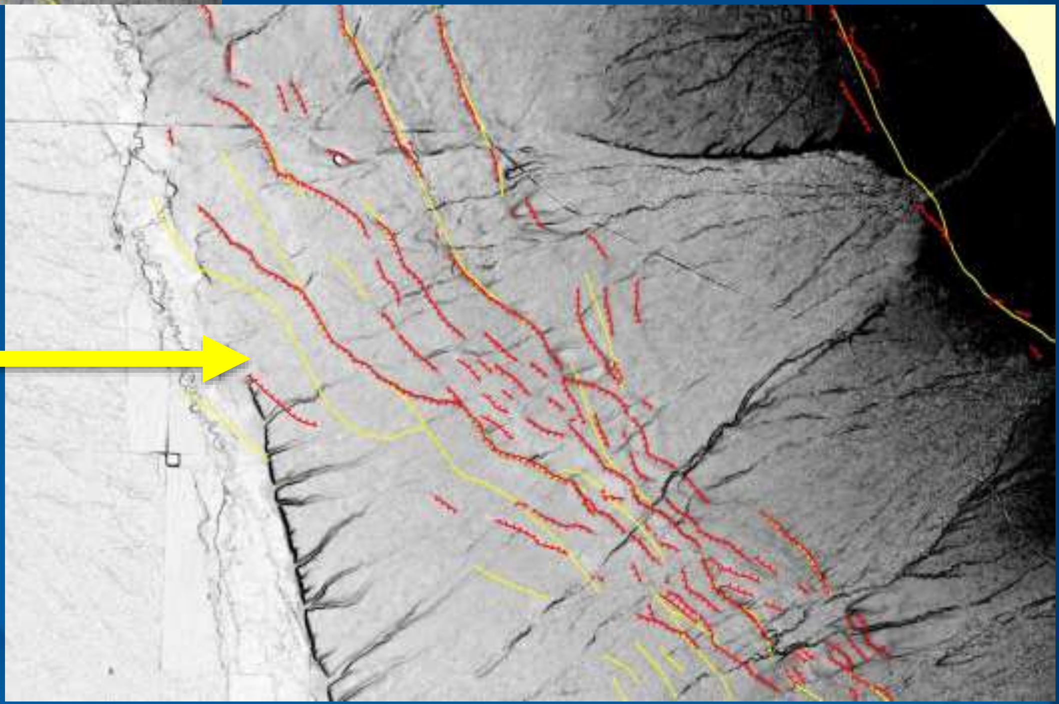


Image at right: 24k geologic map showing Rampart Range fault (green lines) compared to trace of fault from 250k map (red line). Green triangles are relocated trench locations; compare to prior location (red dot).

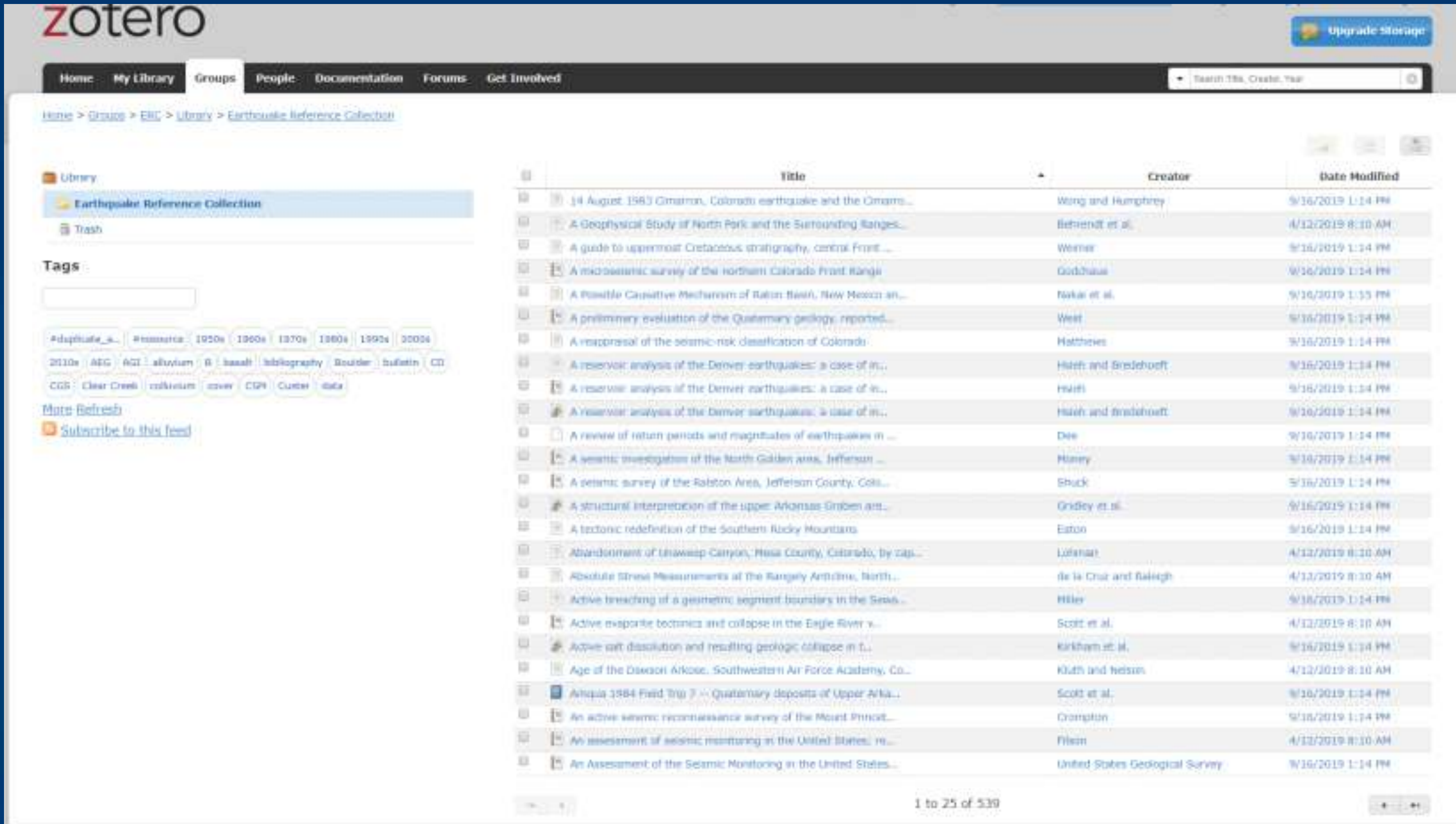


Fault traces of Villa Grove fault zone, San Luis Valley, CO from QF&FDB, on 1m bare-earth lidar DEM. Many scarps clearly visible on lidar DEM were overlooked. Scarp mapping based on stereo airphotos and (pre-GPS) field checking (1979-1980). Perhaps generalized for QF&FDB.

Scarps mapped from 1m bare-earth lidar DEM. HOWEVER, note yellow lines not overlain by red lines. These are fault traces inferred from vegetation lineaments caused by groundwater damming along faults. Insufficient relief to be mapped as scarps on lidar.



Earthquake Reference Collection (ERC)



- **Contains 540 papers, consultant reports, abstracts, maps, theses**
- **Search by Author, Title, Year**
- **Access through the CGS website**

Technical Issues

- Q-Faults are not fully characterized
  - Mapped in the 70s-90s, only a handful have reliable absolute ages, most ages assigned by soils and height in landscape
  - **COLORADO, 67 Class A faults/sections in QF&FDB; but only 9 in NSHM (13%)**
  - **UTAH: 176 Class A fault/sections in QF&FDB; but only 25 in NSHM (14%)**
  - **NEVADA: 624 Class A fault/sections in QF&FDB; and 125 in NSHM (20%)**
  - Paucity of trenches
  - Poorly constrained ages of Q deposits; need more GOOD ages!
- Faults of priority: Williams Fork, Frontal, **Ute Pass**, Rampart Range, Golden
- Lidar is making identification of faults a bit easier (~70% of Colorado is covered by Lidar)
- Cross-border coordination, could help on Lidar collection, geo mapping, proposals for funding

Non-Technical Issues

- Funding-Little internally; externally, money available for outreach but not science
- More pressing projects (Debris flows, landslides, hydrology, minerals)
- Lack of available technical staff; rely on experienced contractors

Conclusions

- A small amount (<20k) of funding goes a long way in Colorado
- Installing additional seismometers
- Lidar and geochron are first steps to make faster progress, start small > larger, detailed projects
- More work needed on Williams Fork, Frontal, Ute Pass, Rampart Range, Golden faults; Cheraw study on-going
- More public outreach, make our science understandable and research funding easier to justify
- Cross-border coordination very important

Idaho Earthquakes and Seismic Hazards Activity

2020 Basin and Range Province Earthquake Working Group

February 5, 2020

Zach Lifton

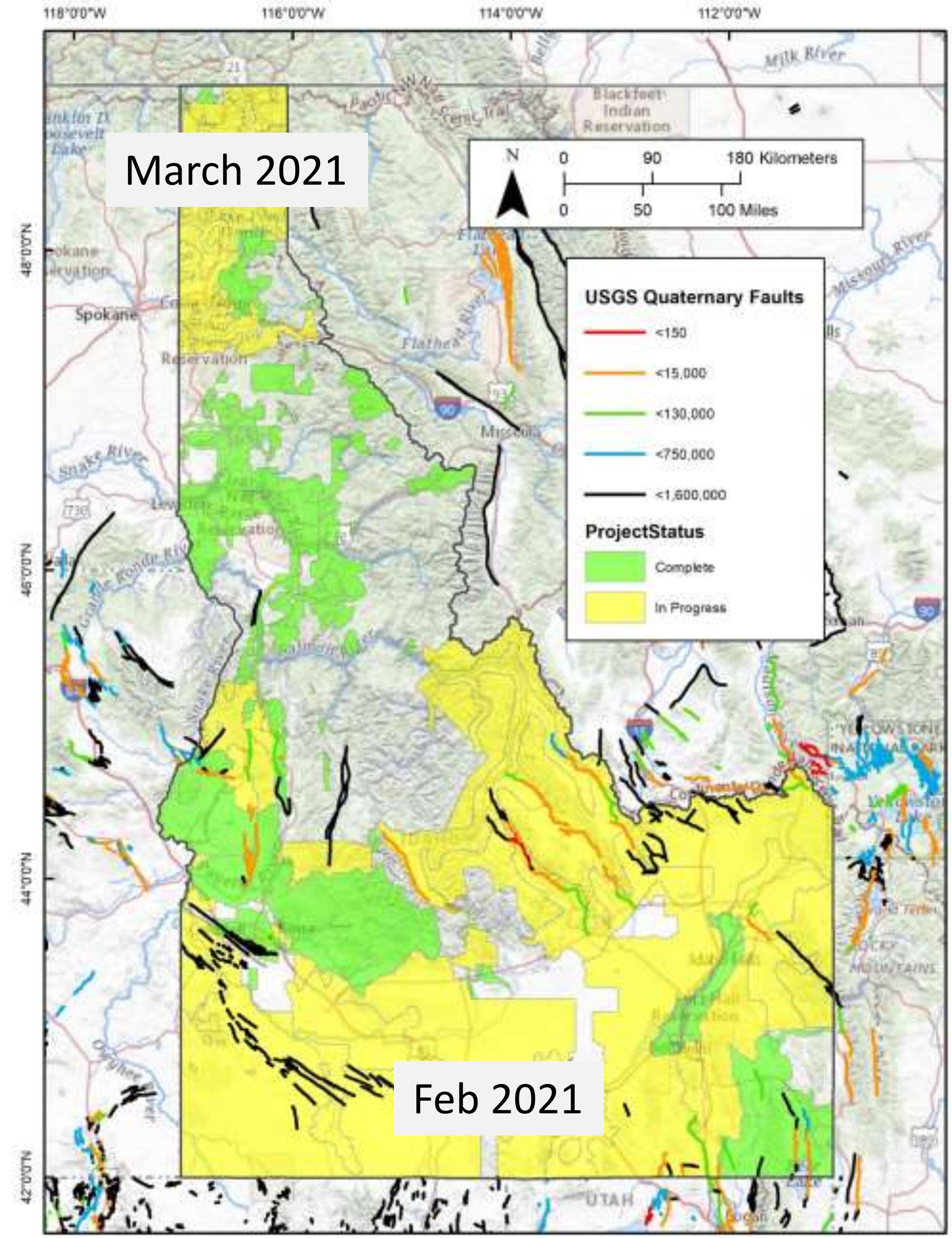
Idaho Geological Survey

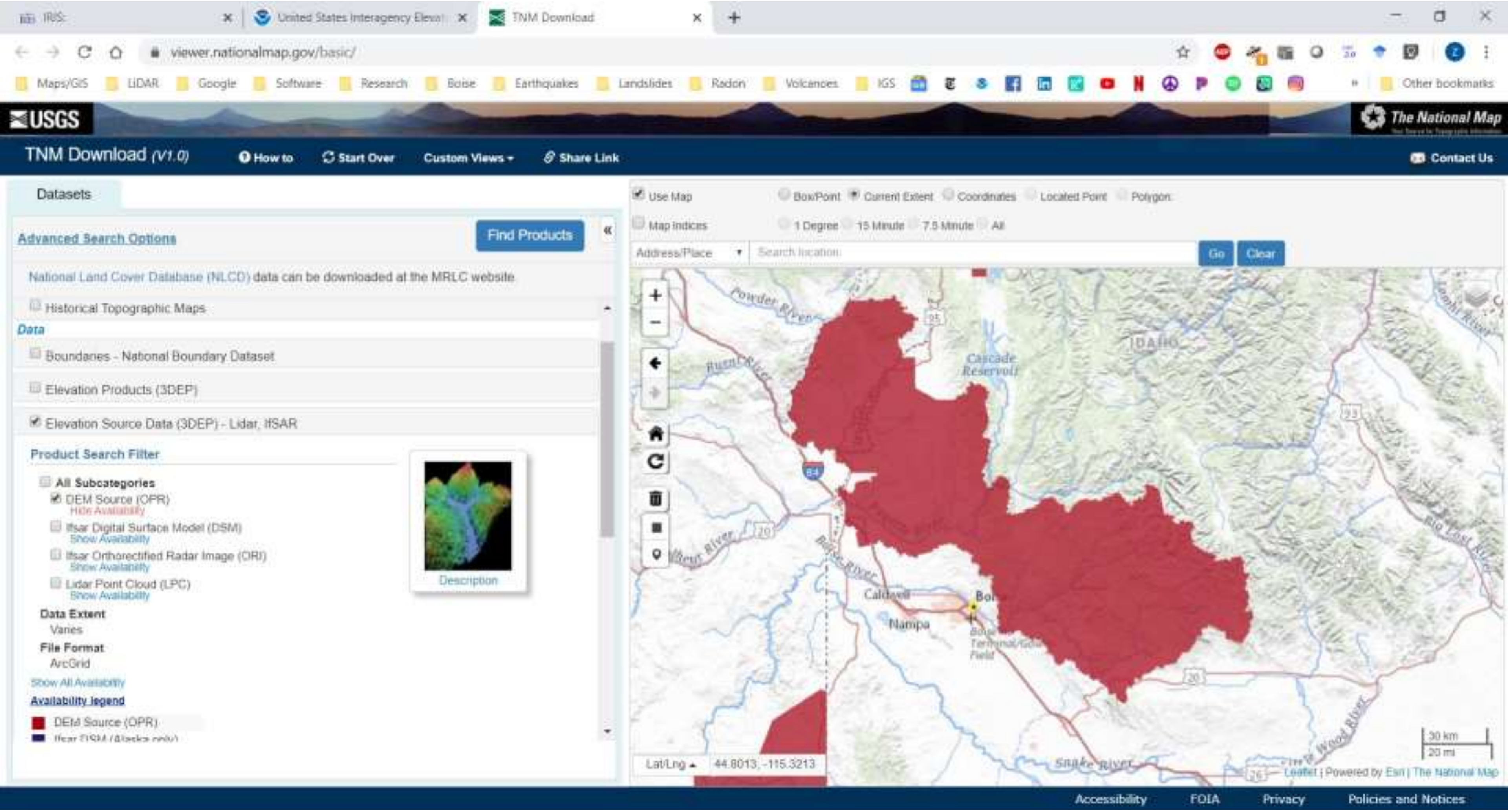
Outline

- Lidar update
- Clearinghouse exercise
- NEHRP SE Idaho/N Utah project
- New NEHRP proposal for Halfway Gulch fault
- USGS Lost River fault trenching
- USBR Deadwood fault investigation
- Seismic monitoring issues
- National Seismic Hazard Map 2023 update

LiDAR Data Availability

- Current coverage
- New datasets
- Forthcoming datasets



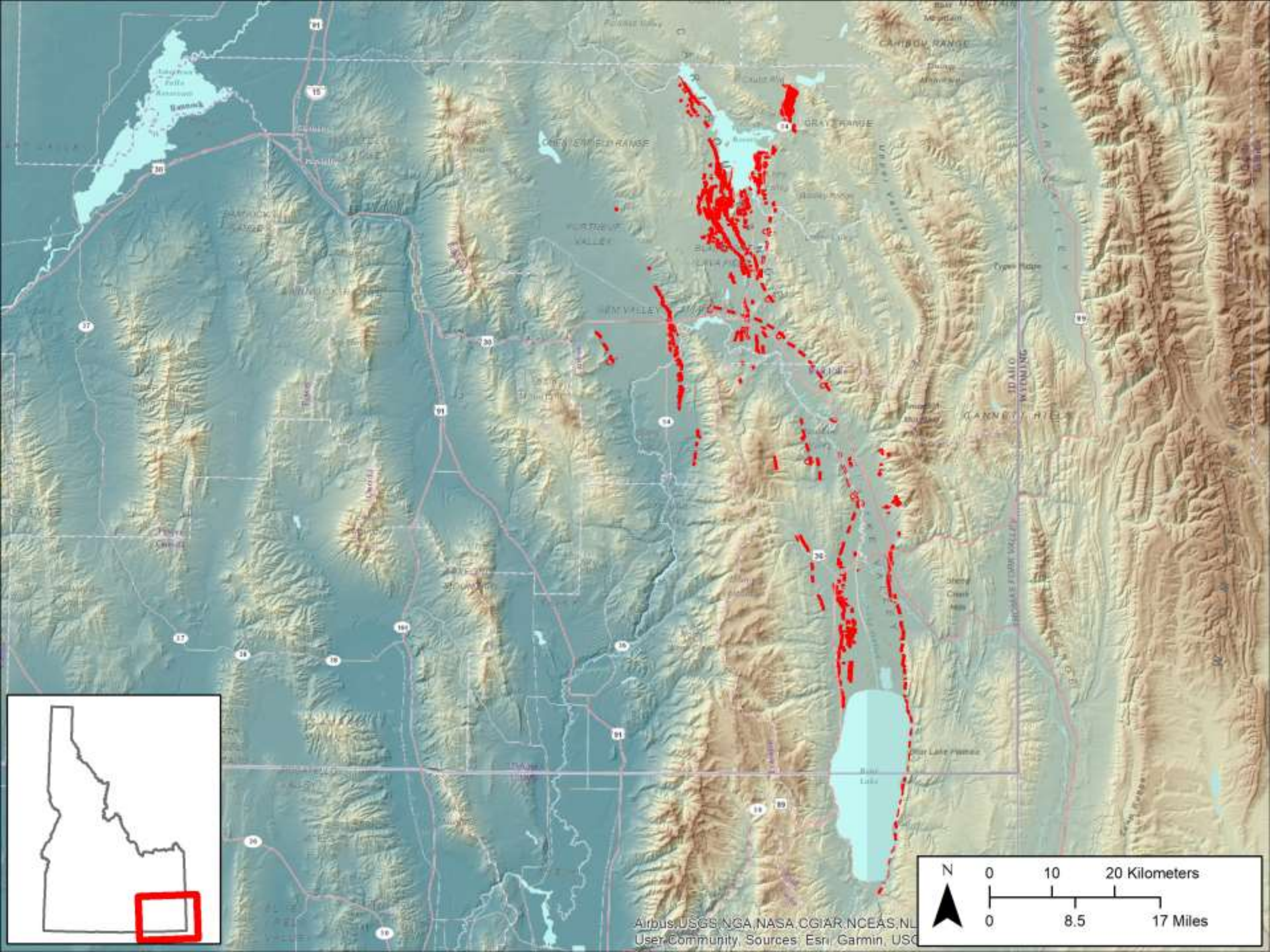

TNM Download
viewer.nationalmap.gov/basic/
USGS
The National Map
TNM Download (V1.0)
How to
Start Over
Custom Views
Share Link
Contact Us
Datasets
Advanced Search Options
Find Products
National Land Cover Database (NLCD) data can be downloaded at the MRLC website
Historical Topographic Maps
Data
Boundaries - National Boundary Dataset
Elevation Products (3DEP)
Elevation Source Data (3DEP) - Lidar, IfSAR
Product Search Filter
All Subcategories
DEM Source (OPR)
Ifsar Digital Surface Model (DSM)
Ifsar Orthorectified Radar Image (ORI)
Lidar Point Cloud (LPC)
Description
Data Extent
Varies
File Format
ArcGrid
Availability legend
DEM Source (OPR)
Use Map
Box/Point
Current Extent
Coordinates
Located Point
Polygon
Map Indices
1 Degree
15 Minute
7.5 Minute
All
Address/Place
Go
Clear
Cascade Reservoir
IDAHO
Boise River
Caldwell
Nampa
Snake River
Lat/Lng
44.8013, -115.3213
30 km
20 mi
Accessibility
FOIA
Privacy
Policies and Notices

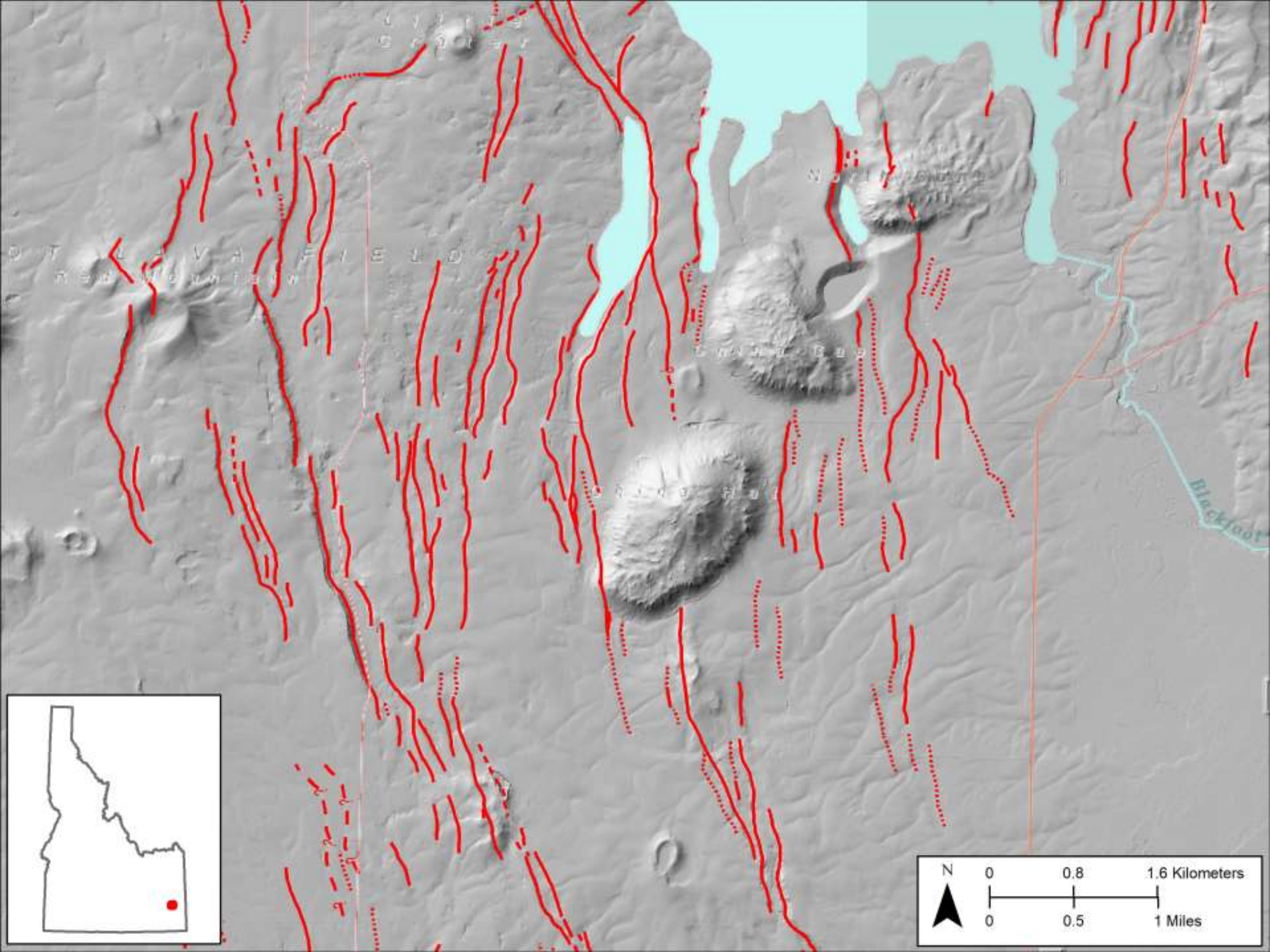
Earthquake Clearinghouse

- Operations plan for post-earthquake reconnaissance
- Developed by IOEM, EERI, and IGS
- Physical and virtual clearinghouse
- Statewide earthquake exercise
- WSSPC provided support to run a real-time exercise of the plan
- Great participation and input from agencies and neighboring states

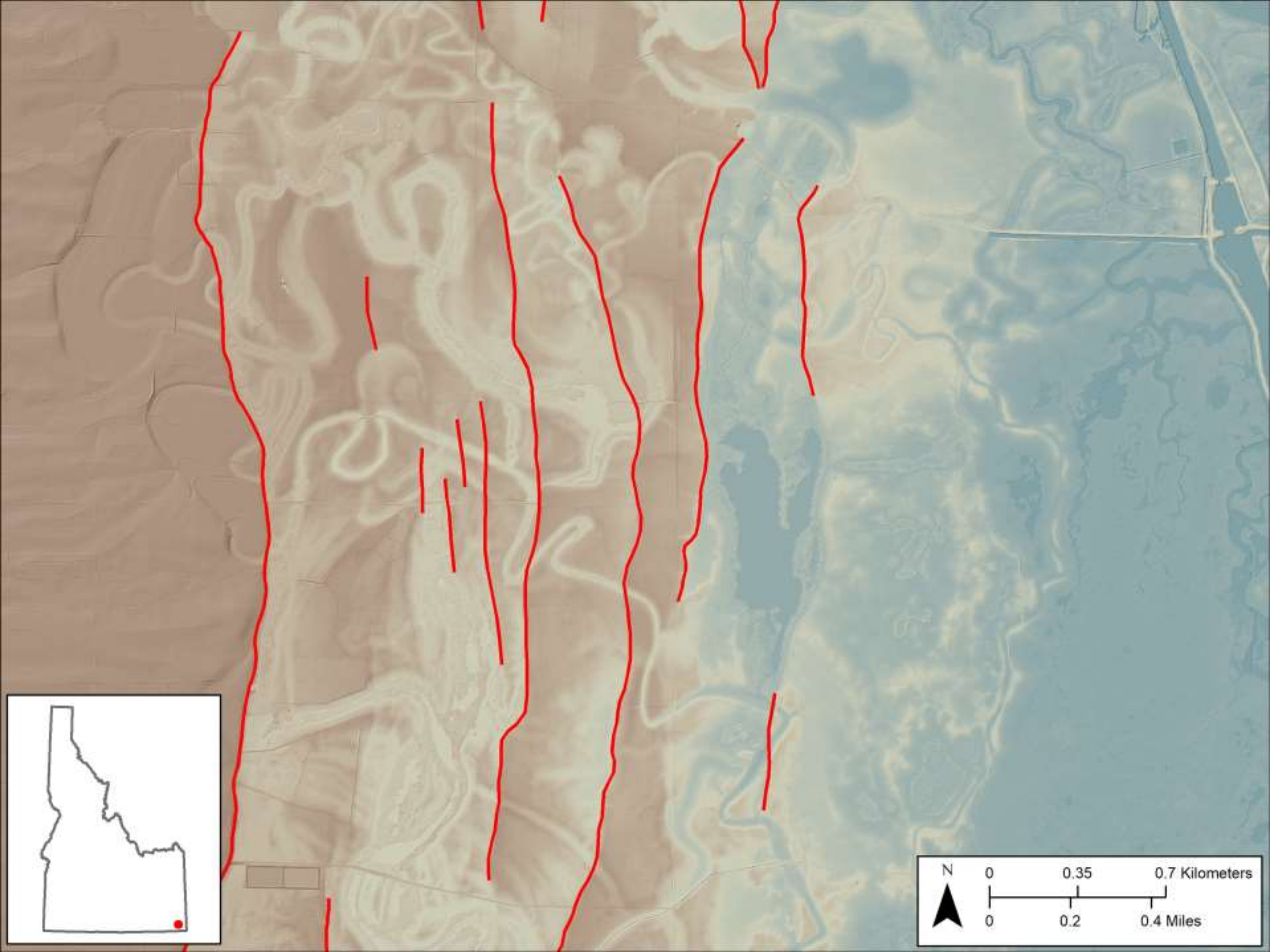
2019 NEHRP Project

- Collaborative with UGS
- Use new lidar to map surface fault traces
  - East Bear Lake fault (ID/UT)
  - West Bear Lake fault (ID/UT)
  - Oquirrh fault zone (UT)
  - South Oquirrh Mountain fault zone (UT)
  - Topliff Hill fault zone (UT)
- Identify sites for paleoseismic trenching


CARIBOU RANGE
GRAYS RANGE
PORTNEUF VALLEY
GANNETT HILLS
IDAHO
WYOMING
Tygee Ridge
Bear Lake Plateau
N
0
10
20 Kilometers
0
8.5
17 Miles
Airbus, USGS, NGA, NASA, CGIAR, NCEAS, NL
User Community, Sources: Esri, Garmin, USG

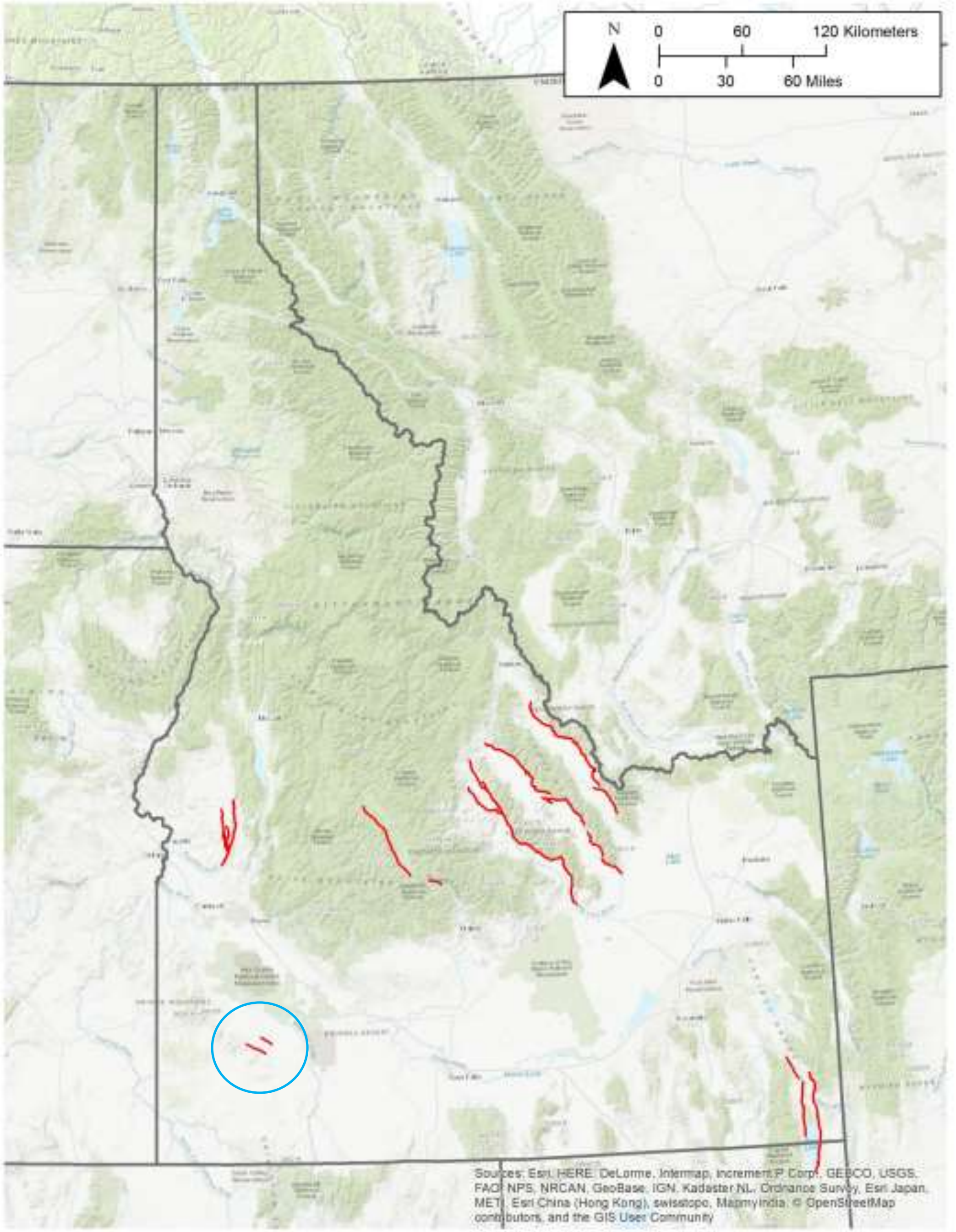


N
0
0.8
1.6 Kilometers
0
0.5
1 Miles

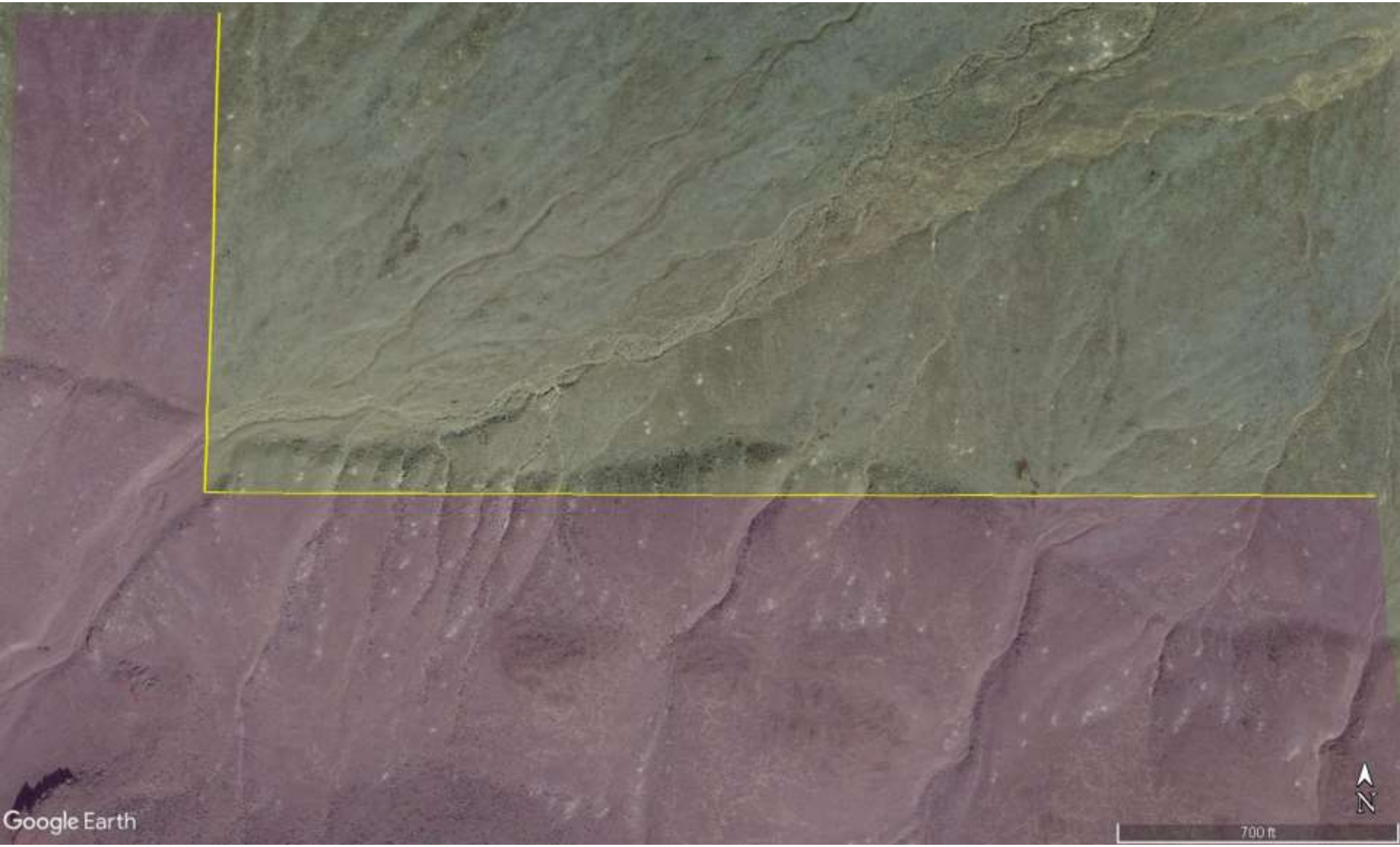

N
0
0.35
0.7 Kilometers
0
0.2
0.4 Miles

Developing new NEHRP proposal:

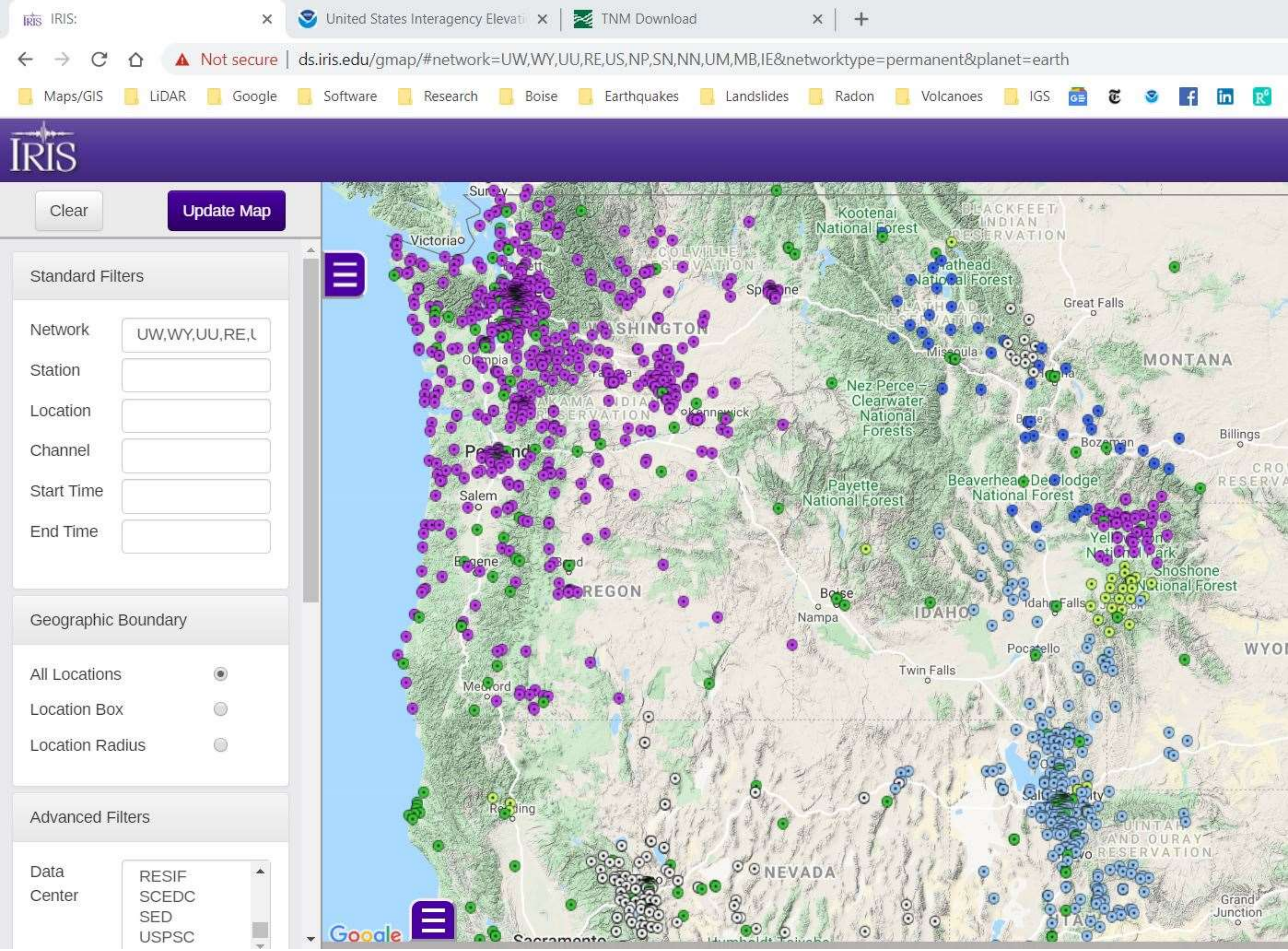
- Halfway Gulch fault
- Displaces bedrock and relatively young deposits
- Previous work by Beukelman (1997) on nearby strand suggests 5 events in last 26 ka
- Potential permitting challenges



Little Jacks Creek Wilderness
Google Earth
N
1 mi



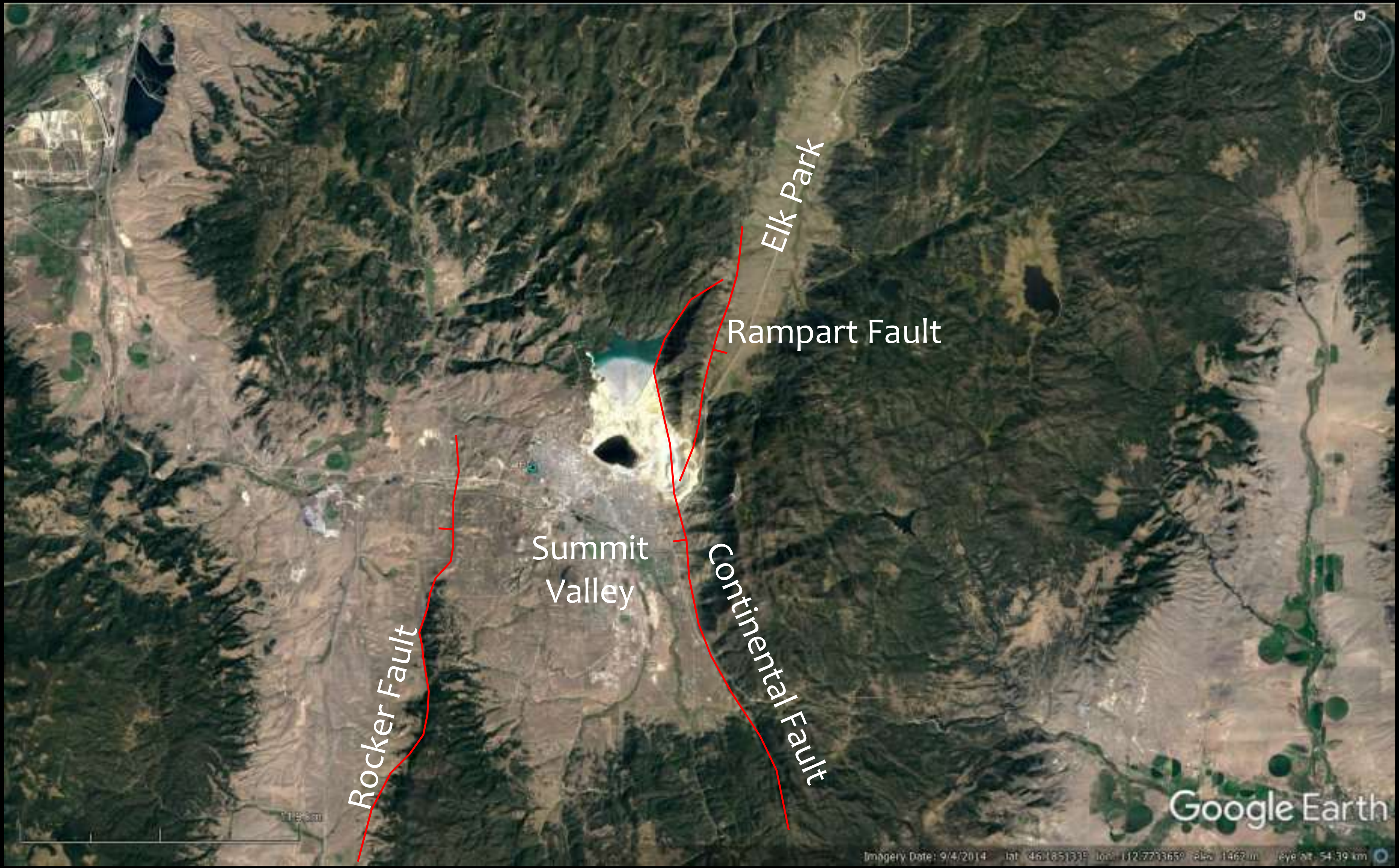
Google Earth
N
700 ft


IRIS:
United States Interagency Elevati
TNM Download
Not secure | ds.iris.edu/gmap/#network=UW,WY,UU,RE,US,NP,SN,NN,UM,MB,IE&networktype=permanent&planet=earth
Maps/GIS
LiDAR
Google
Software
Research
Boise
Earthquakes
Landslides
Radon
Volcanoes
IGS
IRIS
Clear
Update Map
Standard Filters
Network
UW,WY,UU,RE,U
Station
Location
Channel
Start Time
End Time
Geographic Boundary
All Locations
Location Box
Location Radius
Advanced Filters
Data Center
RESIF
SCEDC
SED
USPSC
Victoria
Kootenai National Forest
BLACKFEET INDIAN RESERVATION
COLVILLE RESERVATION
Flathead National Forest
Great Falls
WASHINGTON
Olympia
Missoula
MONTANA
Nez Perce - Clearwater National Forests
Kennewick
Billings
Salem
Payette National Forest
Beaverhead-Deerlodge National Forest
Eugene
Bend
OREGON
Boise
Nampa
IDAHO
Shoshone National Forest
Idaho Falls
Pocatello
Twin Falls
Medford
Redding
NEVADA
UINTAH AND OURAY RESERVATION
Grand Junction
Sacramento
Google

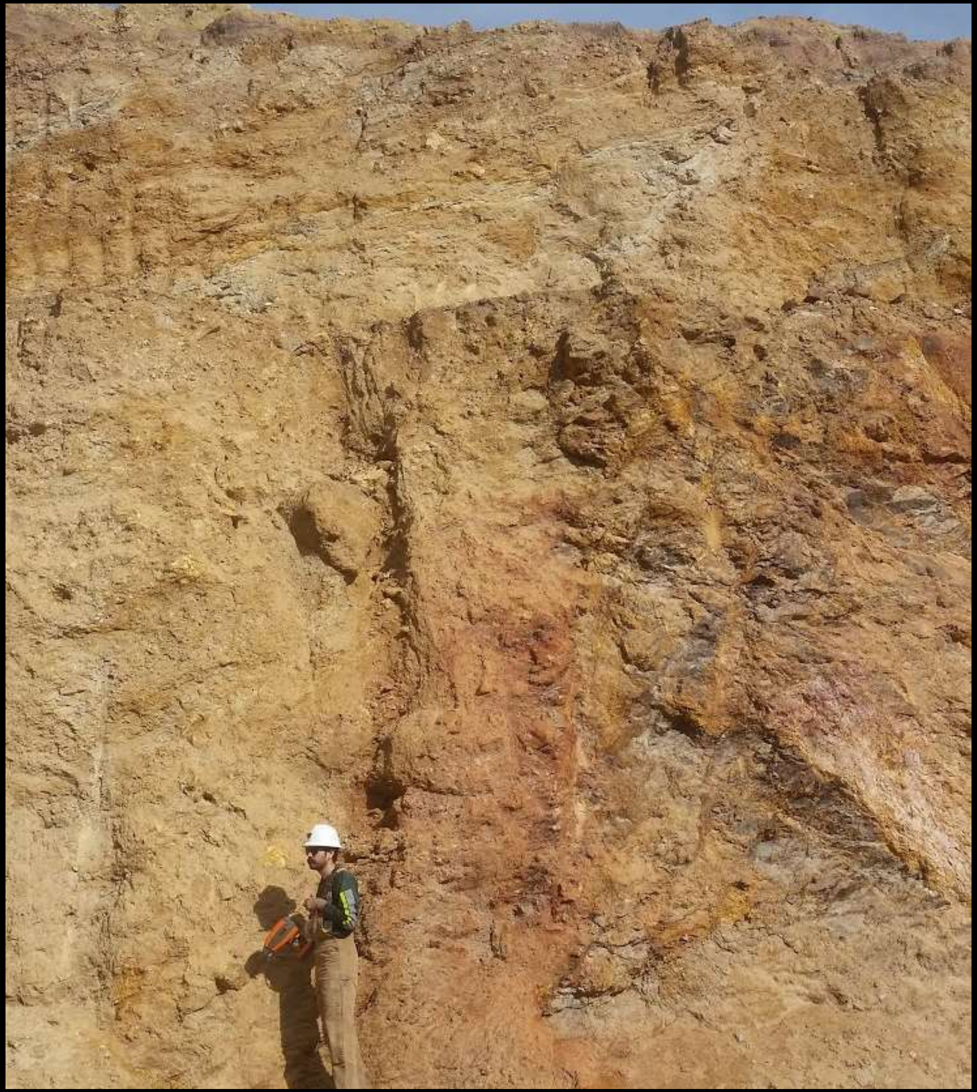
Montana Activities 2019

Mike Stickney
Montana Bureau of Mines and Geology

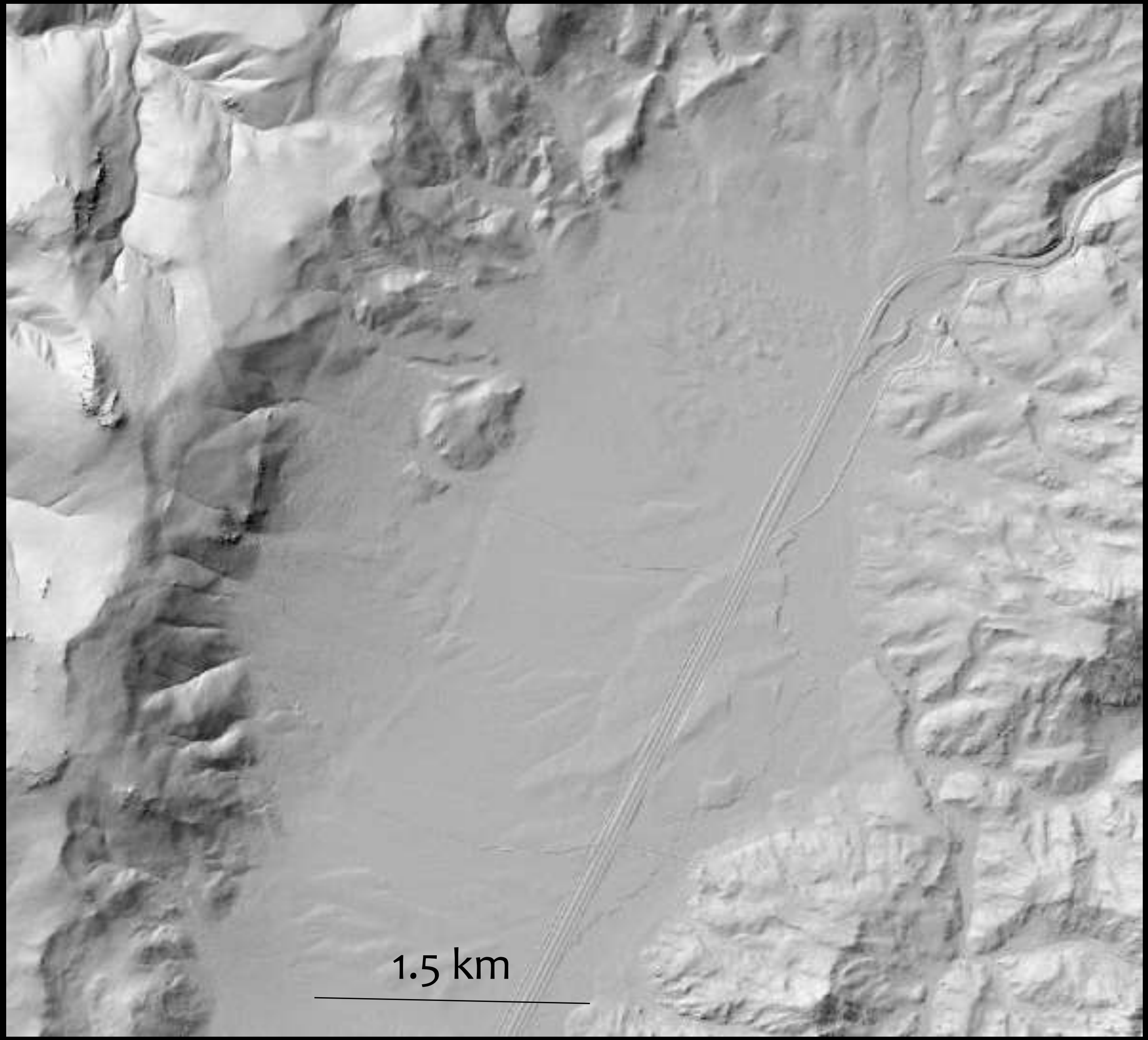
Faults near Butte

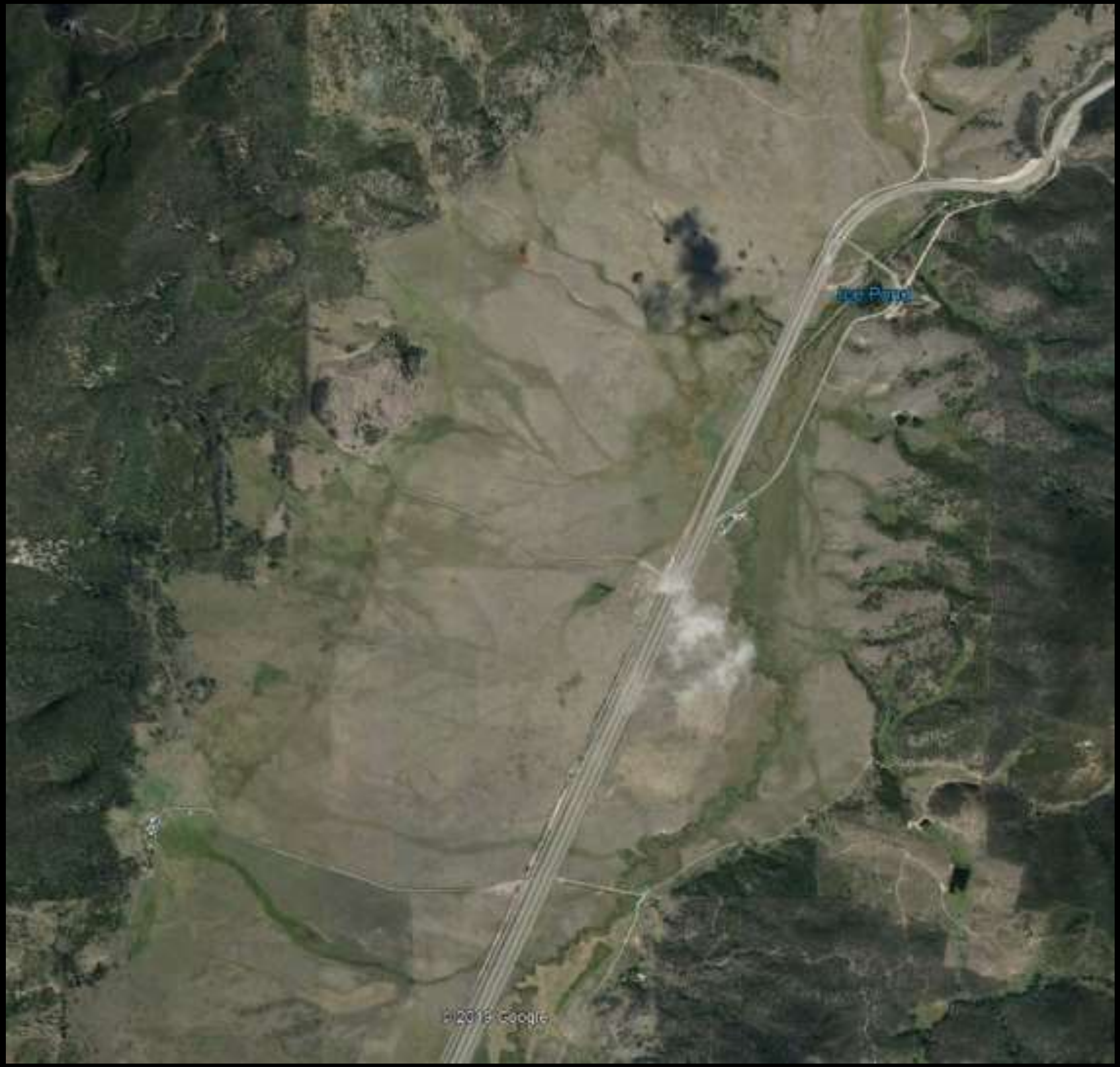


Rampart and Continental faults



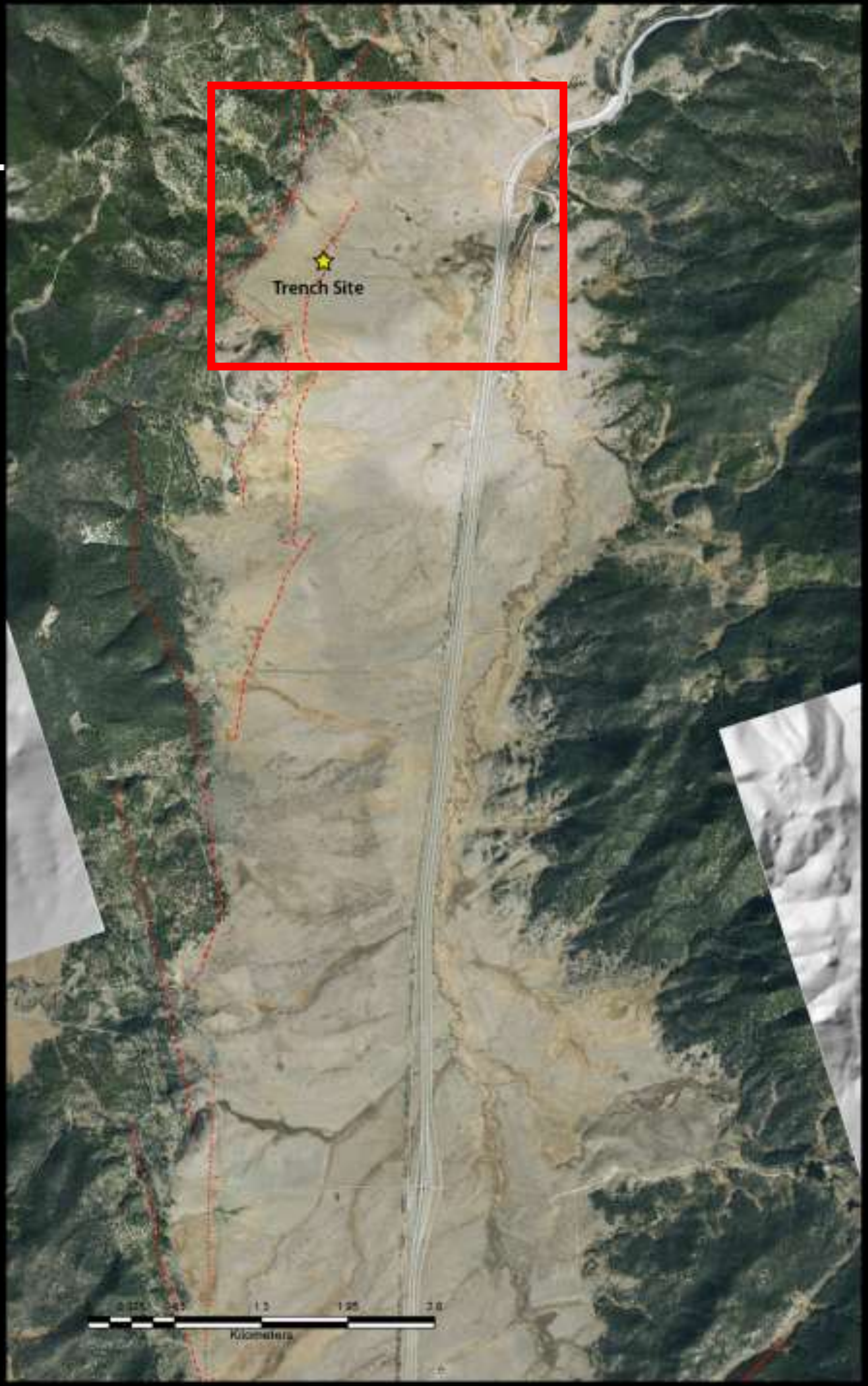
New LiDAR vs Old Google Earth





Geologic Setting

- Mapping in Butte North quadrangle revealed a potential fault scarp in the area
- Potential northern extent of Continental Fault
- Trench site at northern end of Elk Park



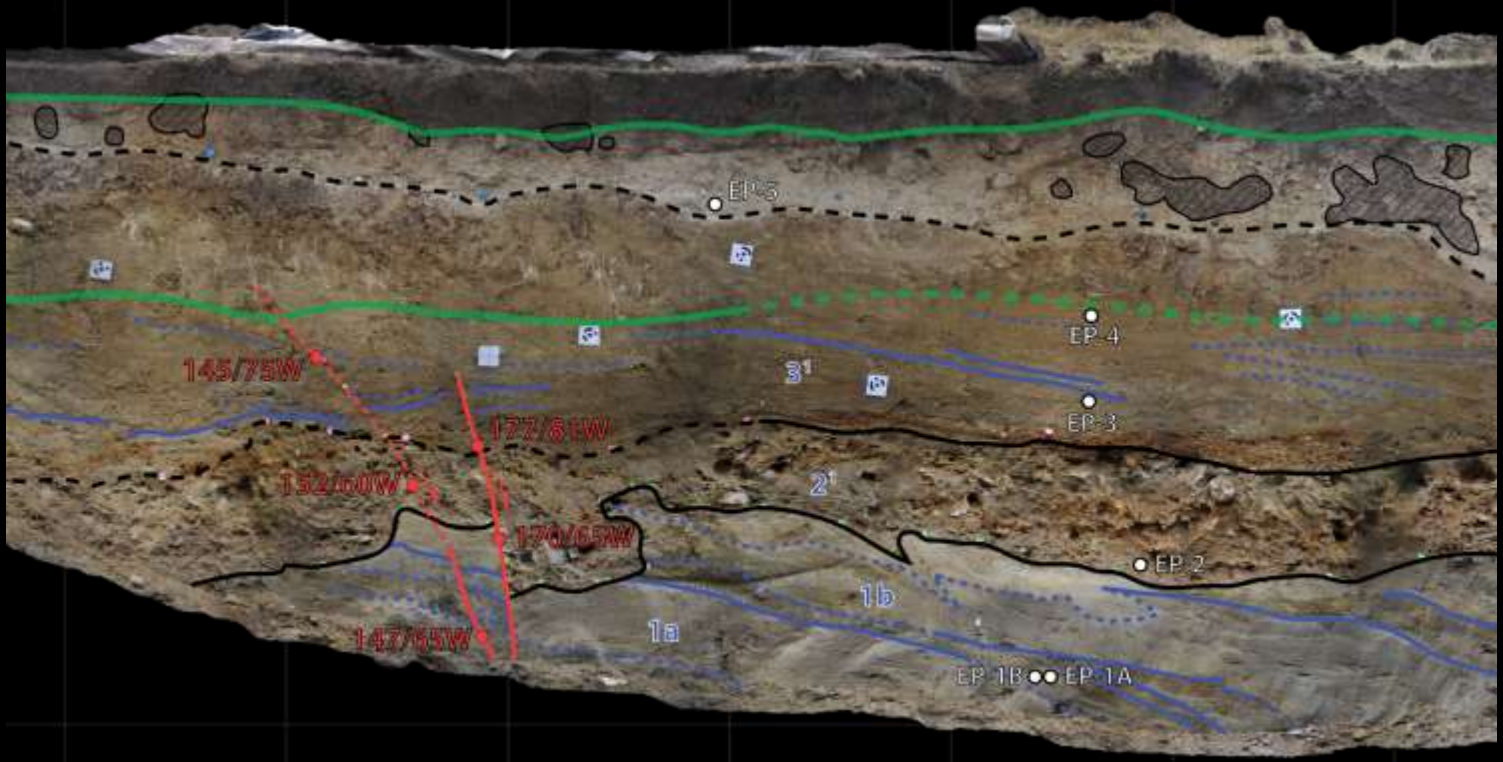
Geologic Setting

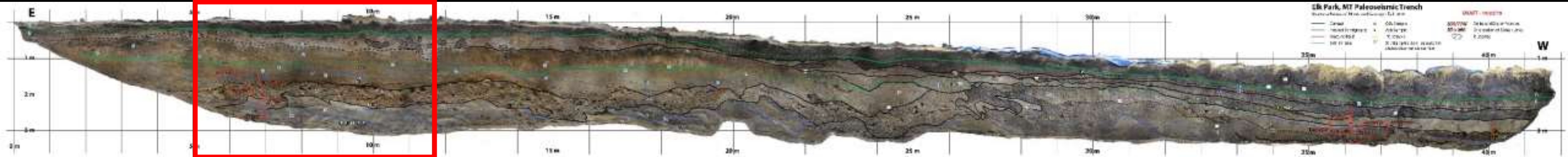
- Large area of lateral spread or landslide causing hummocky topography
- Seismically triggered?
- Whatever this unit is, it appears to be cut by a fault scarp

Sub-horizontal slickensides in clay unit

Results

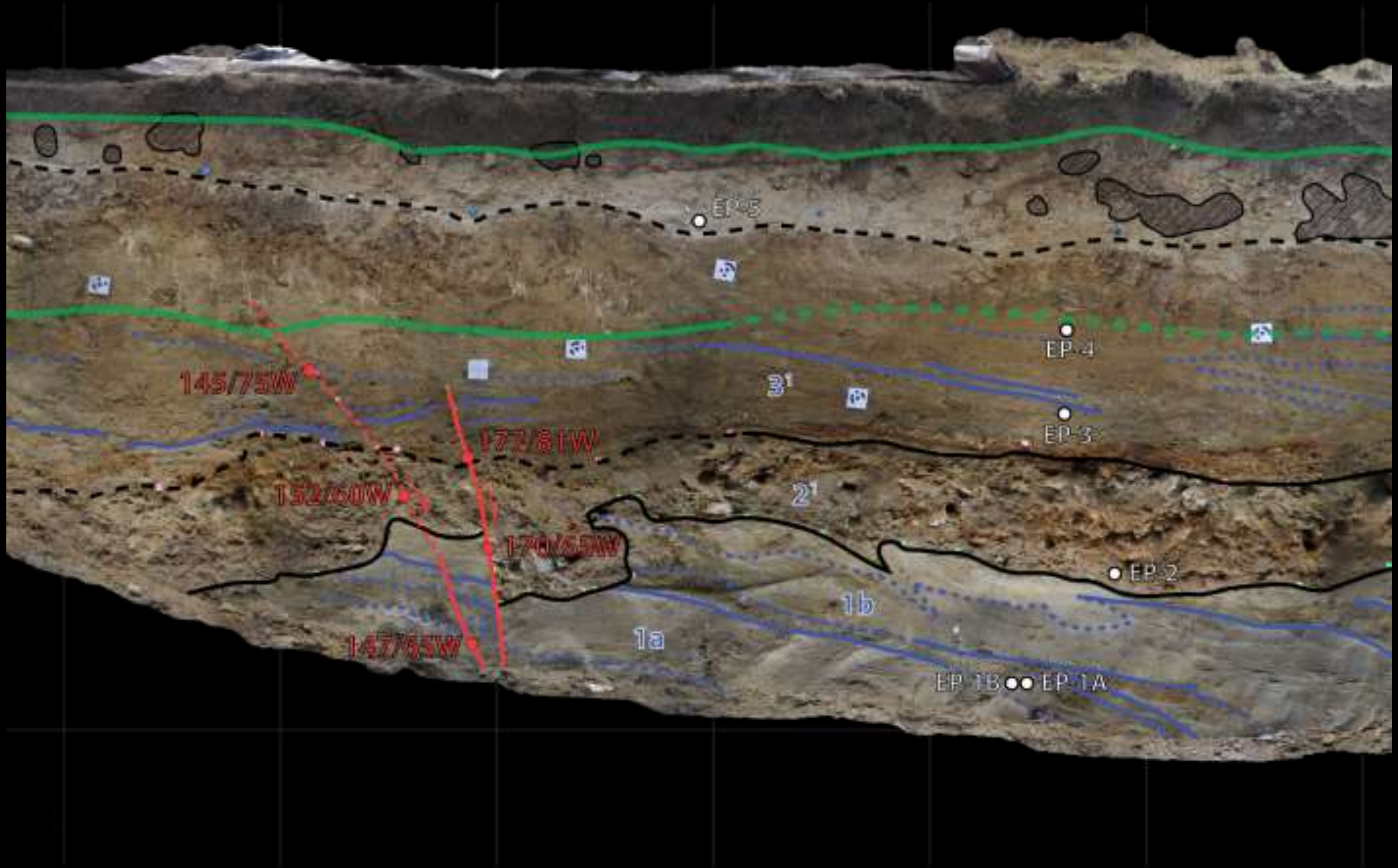
- Unit 1 – Highly deformed sands and clays with top to east sense of shear
- Offset by small fault
- Unit 2 – Gravels (potential debris flow)
- Offset by fault and generally folded

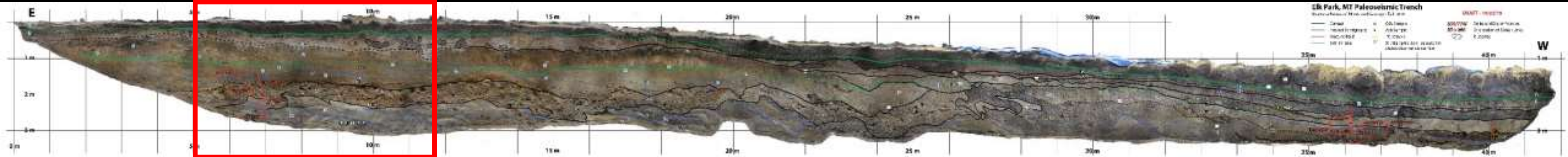




Results

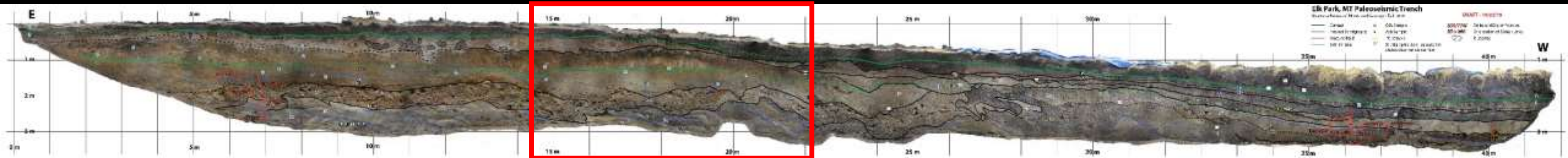
- Unit 3 – Sands to sandy clay
- Bottom half is offset and deformed
- Upper half is not deformed
- Unit 4 – Sands to clays
- Undeformed at west end





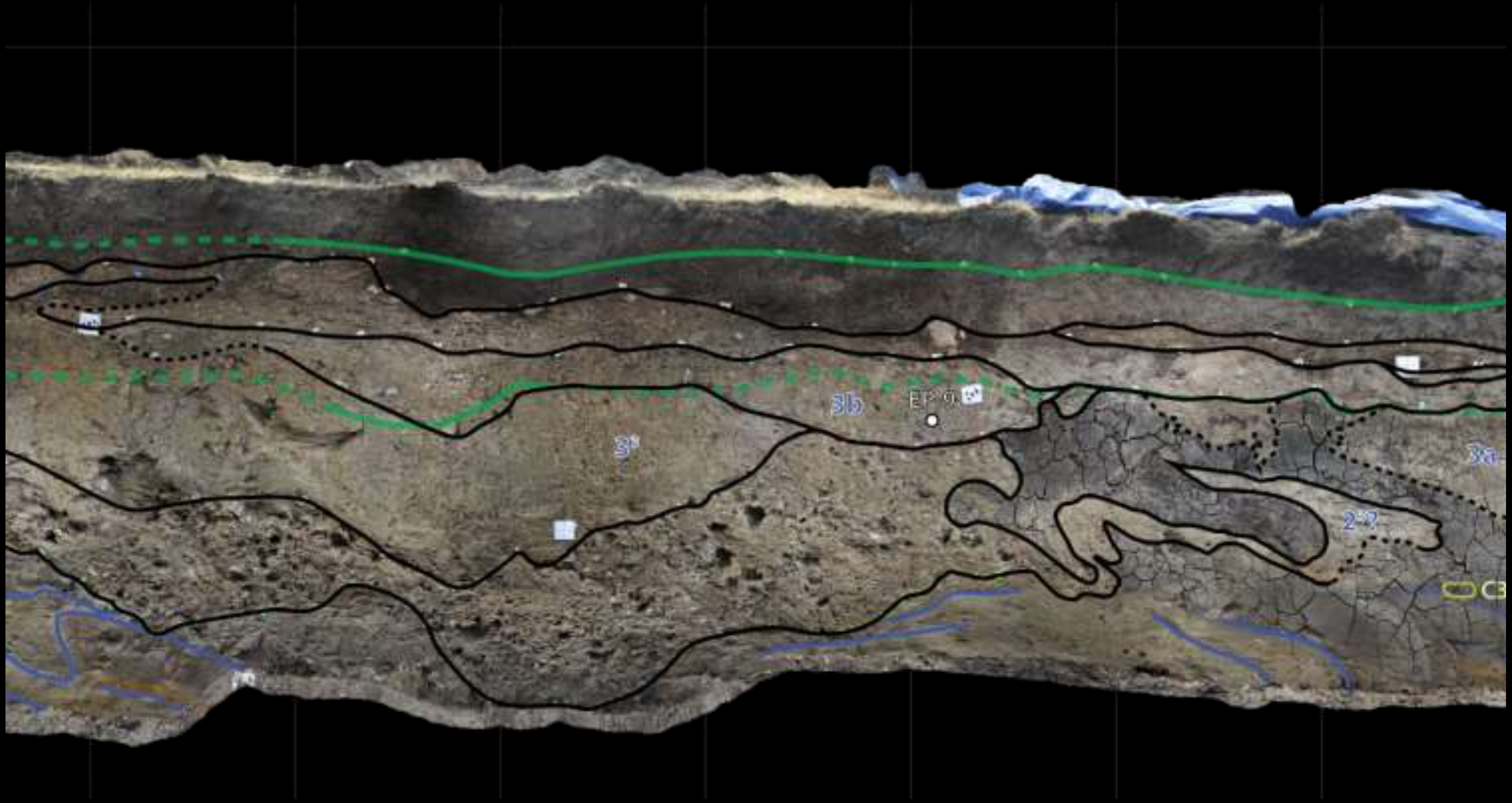
Results

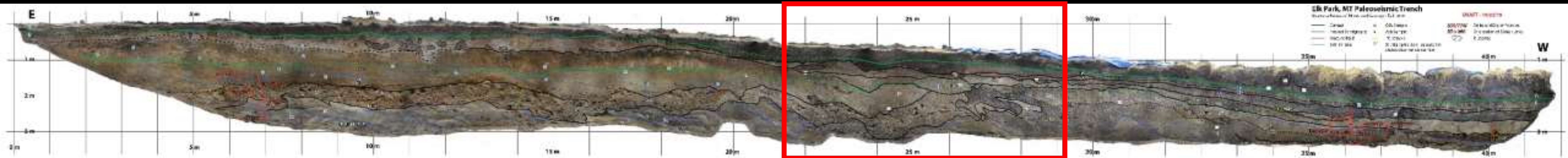
- Unit 1 is very deformed and incised by Unit 2, which is also deformed
- Unit 3 is tilted
- Unit 4 pinches out on potential paleo-fold scarp



Results

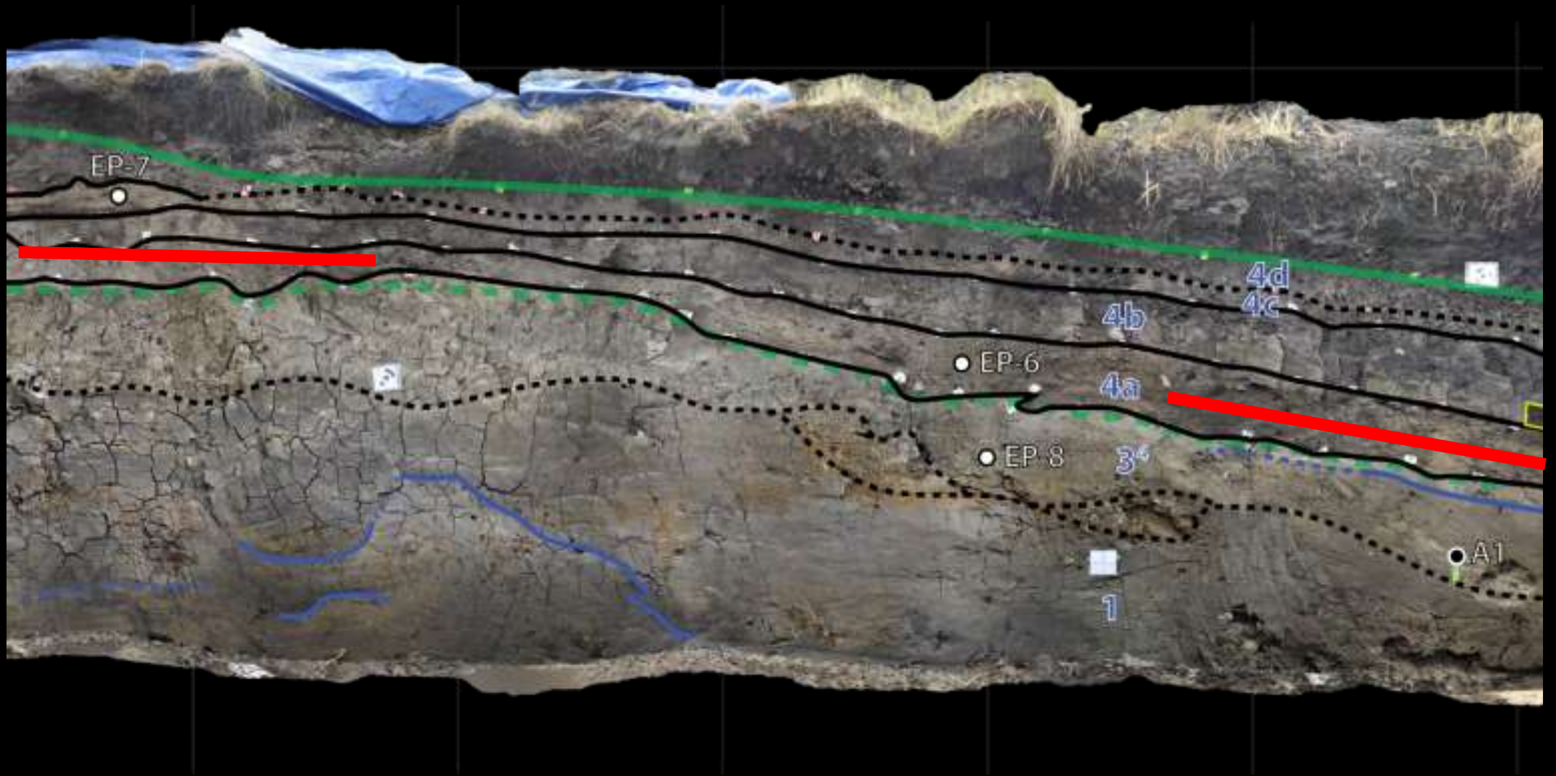
- Erosion of Unit 1 by Unit 2
- Potential piping of sandy material of Unit 2 at edge of channel
- Fluvial deposits overlying unit 3 (potential channel)

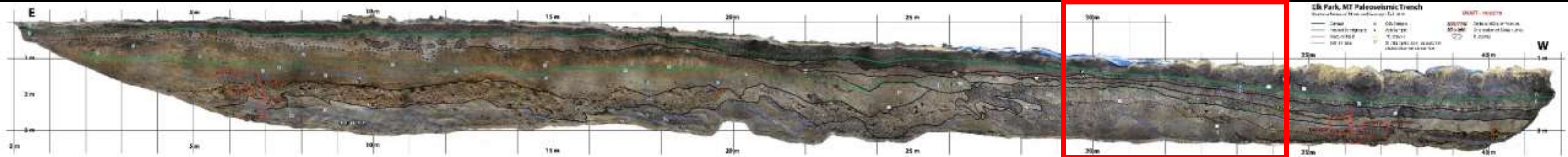




Results

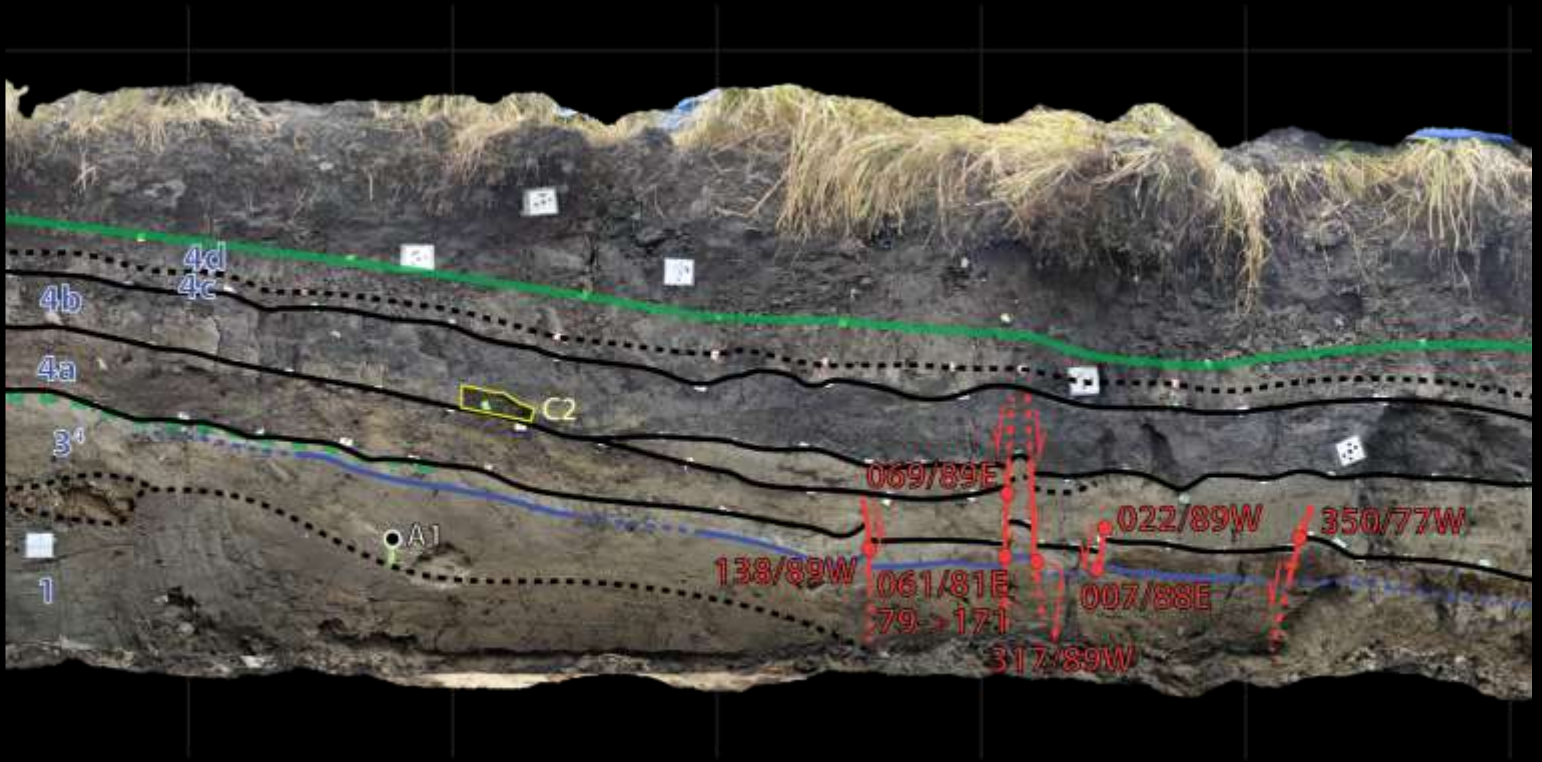
- Unit 4 fans and thickens to the west (right)
- Units 3 and 4 appear to be folded

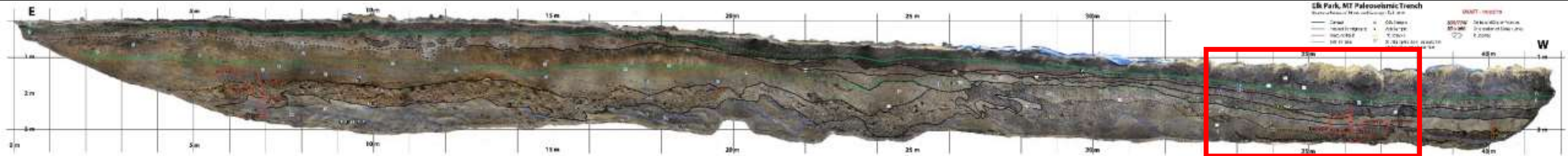




Results

- Units 1-4a are offset by small faults
- Overlying units are not





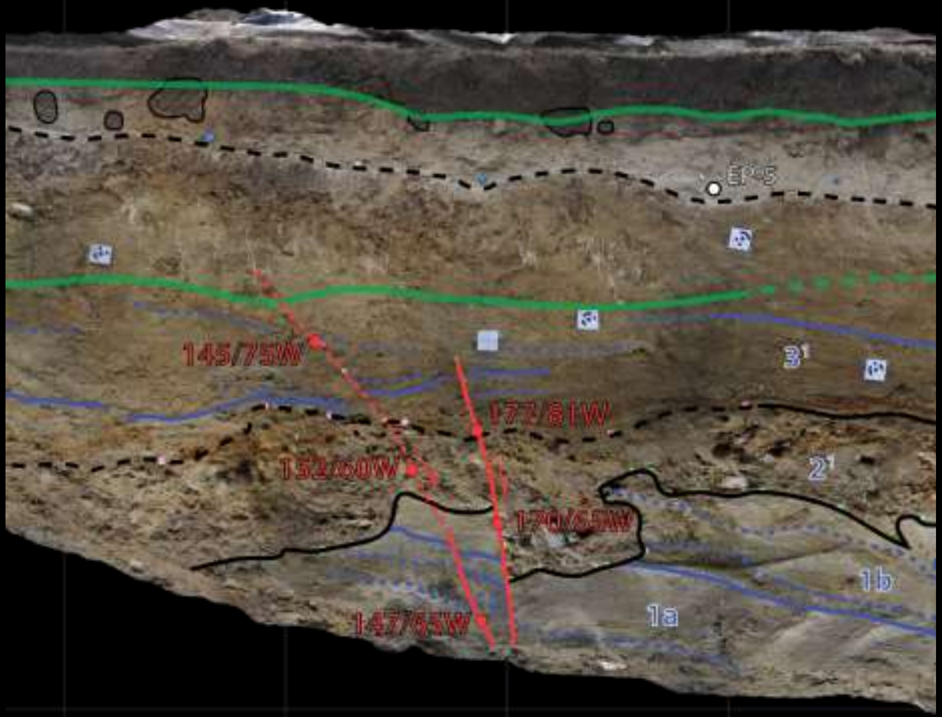
Summary and Interpretations

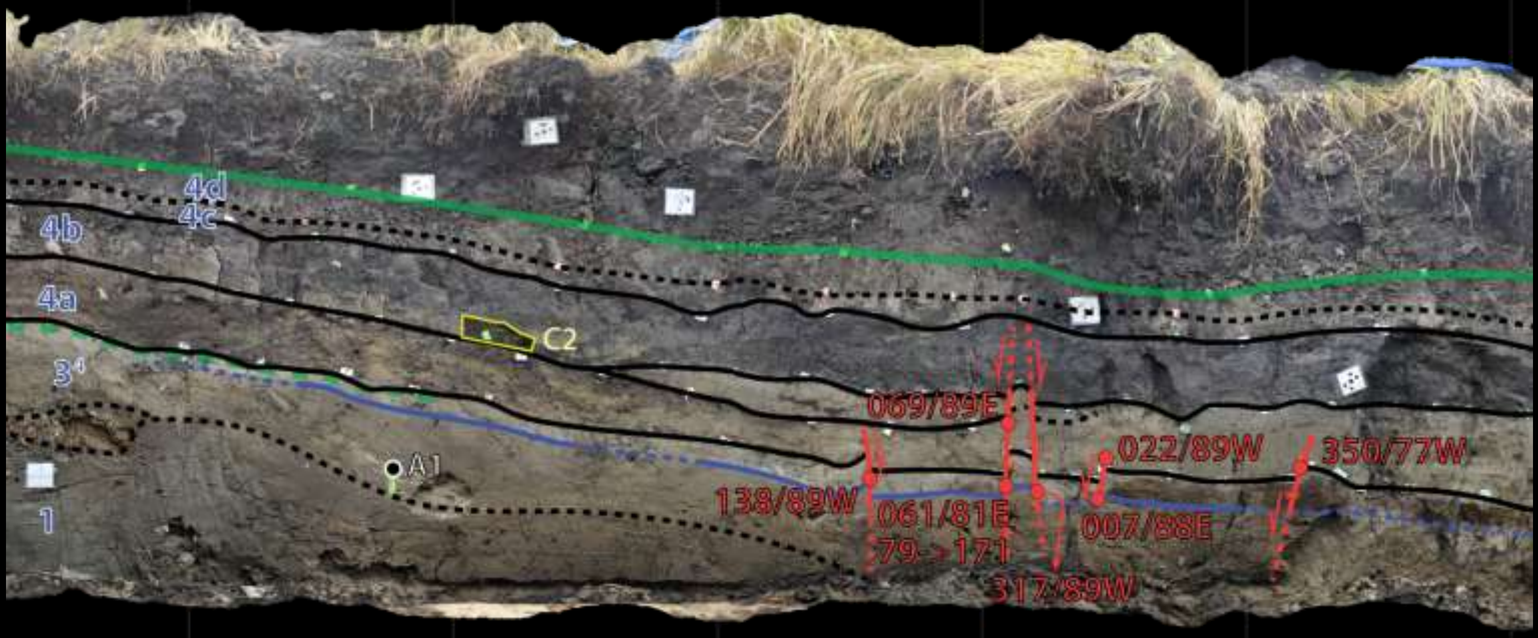
Chronology

- Deposition of Unit 1
  - Deformation of Unit 1 via landslide or lateral spread
- Deposition of Unit 2 and erosion of Unit 1
  - Continued deformation (slow or reactivated landslide?)
- Deposition of Unit 3
  - Faulting, folding at east end of trench
  - Migration of deposition to area of modern pond (west of trench)
- Deposition of Unit 4
  - Faulting, folding at west end of trench
- Deposition of modern sediment and formation of modern soil

Chronology

- At least two fracturing events (earthquakes):
  - During deposition of Unit 3
  - During deposition of Unit 4
  - Top ash (sample A1, unit 3) is Glacier Peak 11,200 CBP

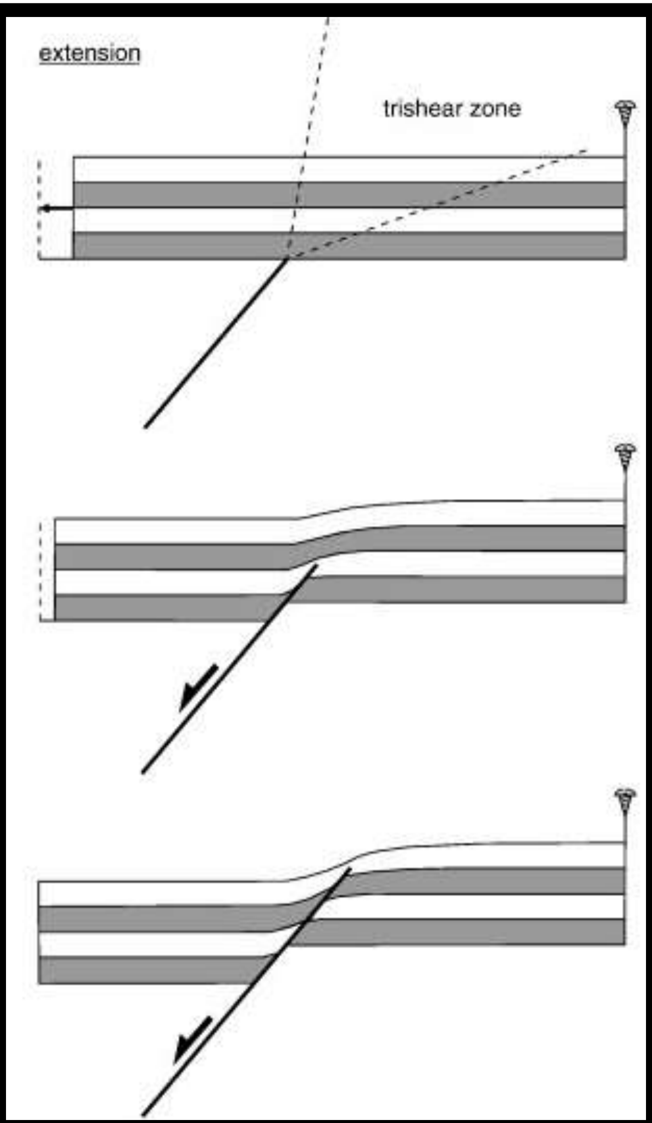




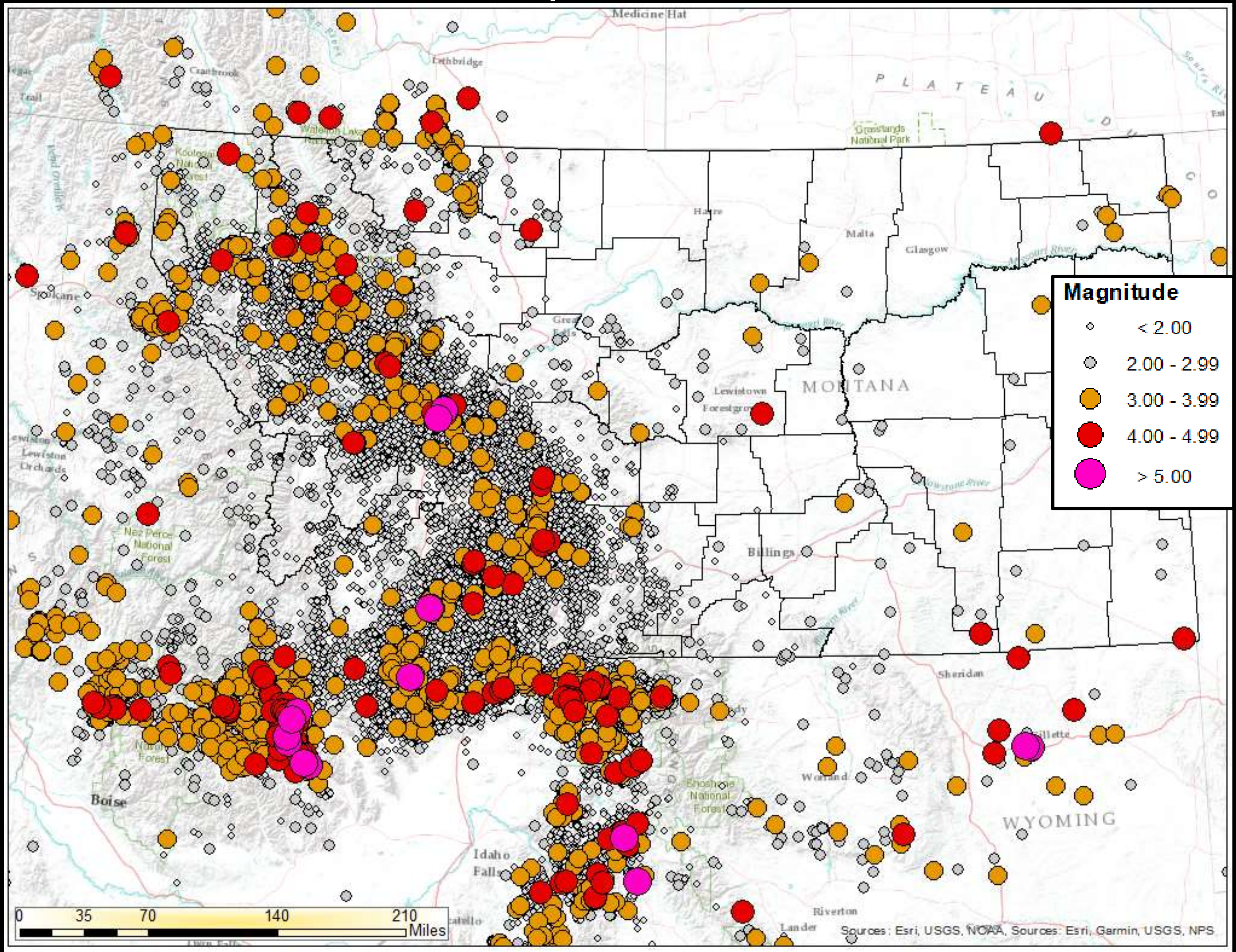
Summary and Interpretations

What's driving deformation?

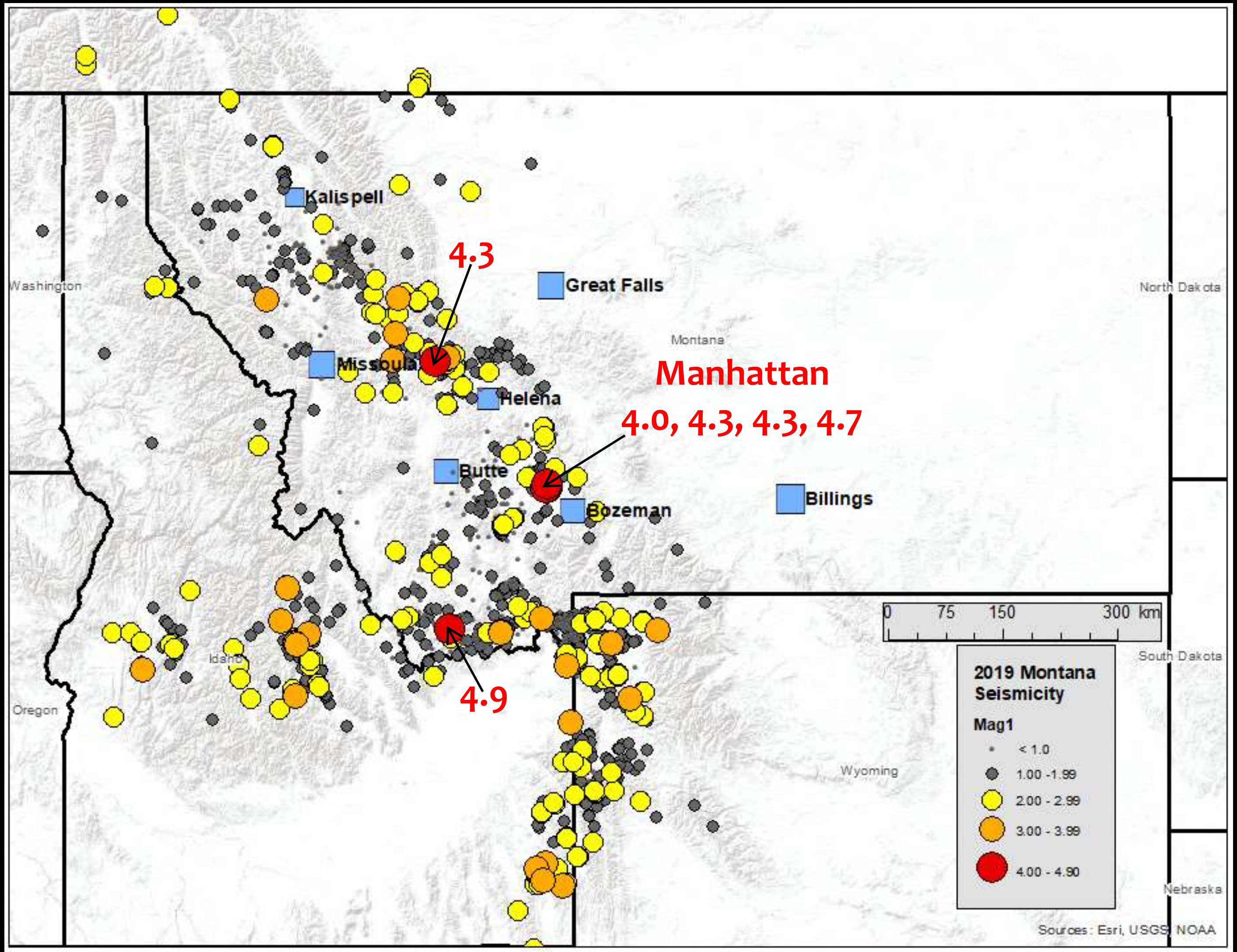
- No clear offset at the surface
- Probably a fault propagation fold
- Suggests fault is young and not well developed
- Continental fault breaking through to the north?



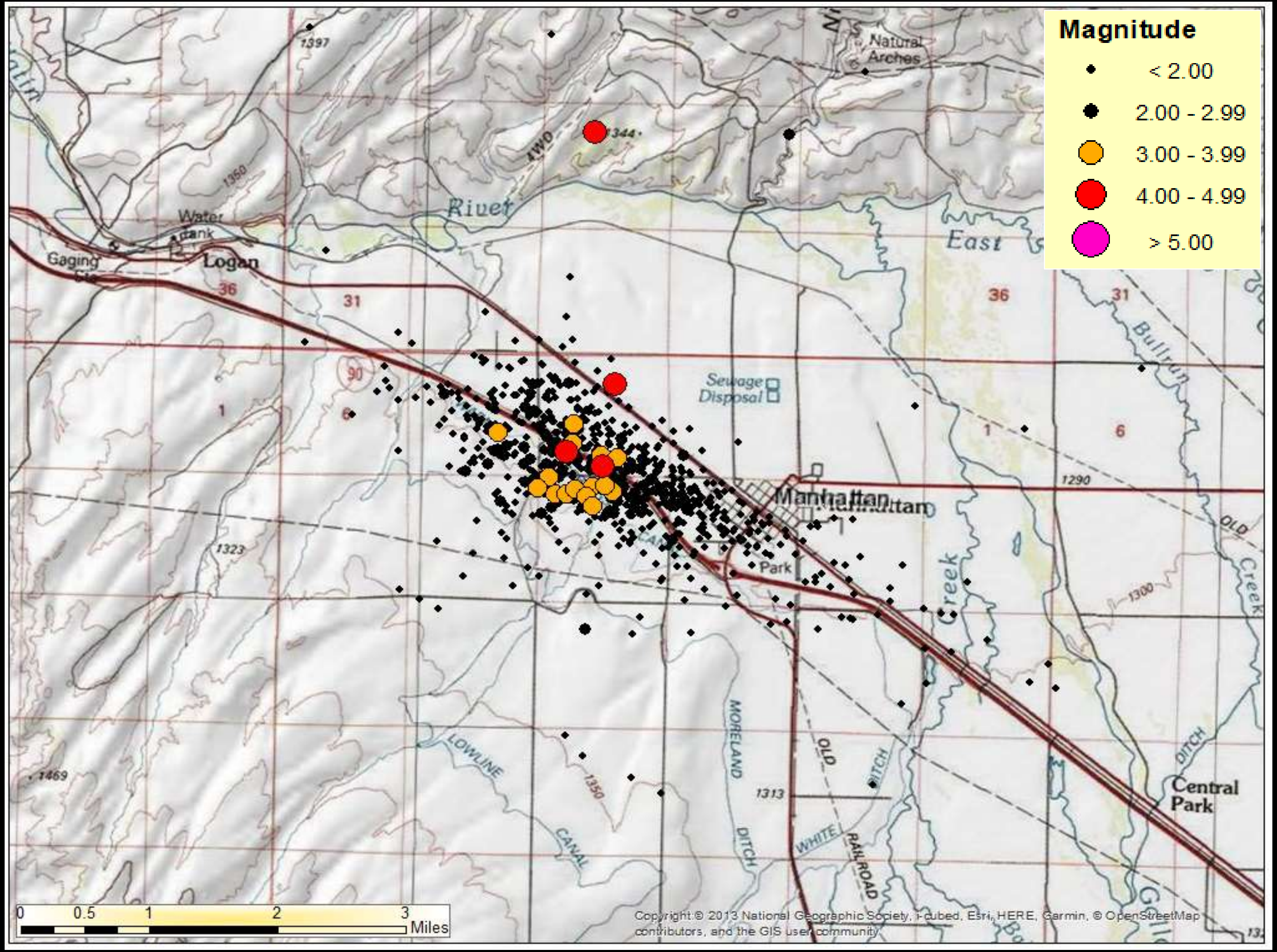
59,687 Earthquakes since 1982

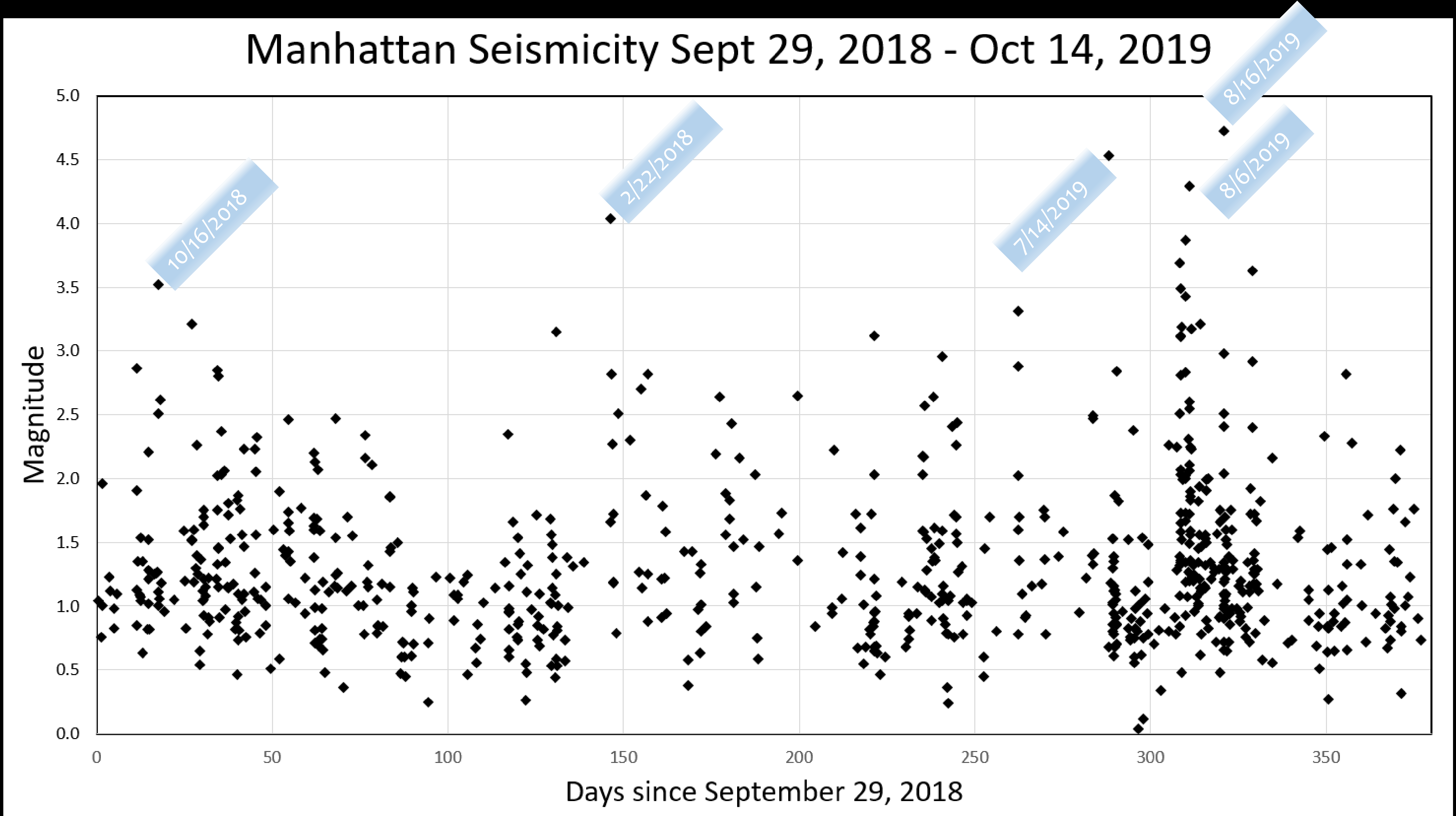


MBMG Located 3,208 Earthquakes in 2019



745 Earthquakes; Sep. 29, 2018 – Oct. 14, 2019





Manhattan Seismicity Sept 29, 2018 - Oct 14, 2019
Magnitude
Days since September 29, 2018
10/16/2018
2/22/2018
7/14/2019
8/16/2019
8/6/2019
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
50
100
150
200
250
300
350

M 4.2 - 4km NW of Manhattan, Montana

2019-08-16 00:02:37 (UTC) | 45.884°N 111.377°W | 8.3 km depth

Moment Tensor

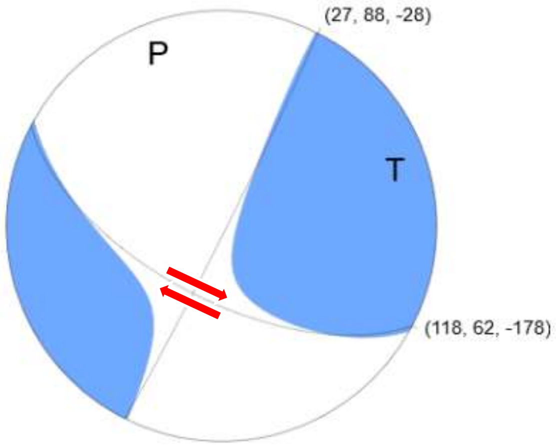
View all moment-tensor products (1 total)

Contributed by US [2] last updated 2019-09-20 20:52:09 (UTC)

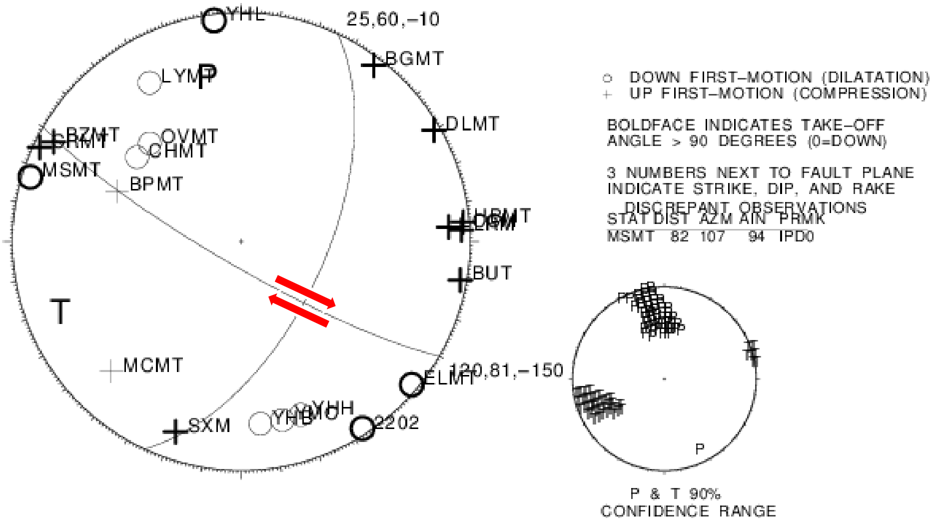
✓ The data below are the most preferred data available
✓ The data below have been reviewed by a scientist

Regional Moment Tensor (Mwr)

Moment	2.185e+15 N-m
Magnitude	4.16 Mwr
Depth	11.0 km
Percent DC	82%
Half Duration	-
Catalog	US

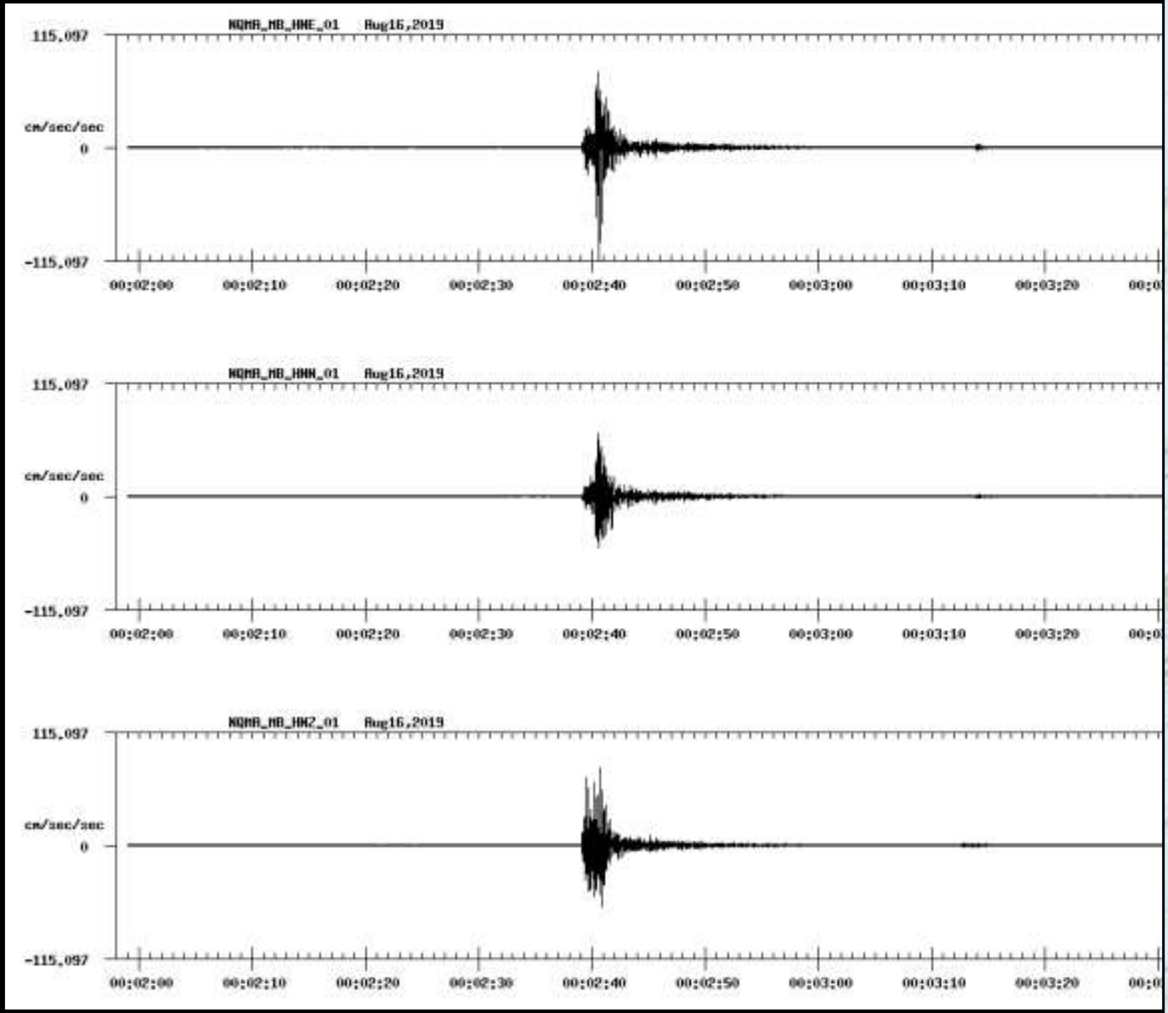


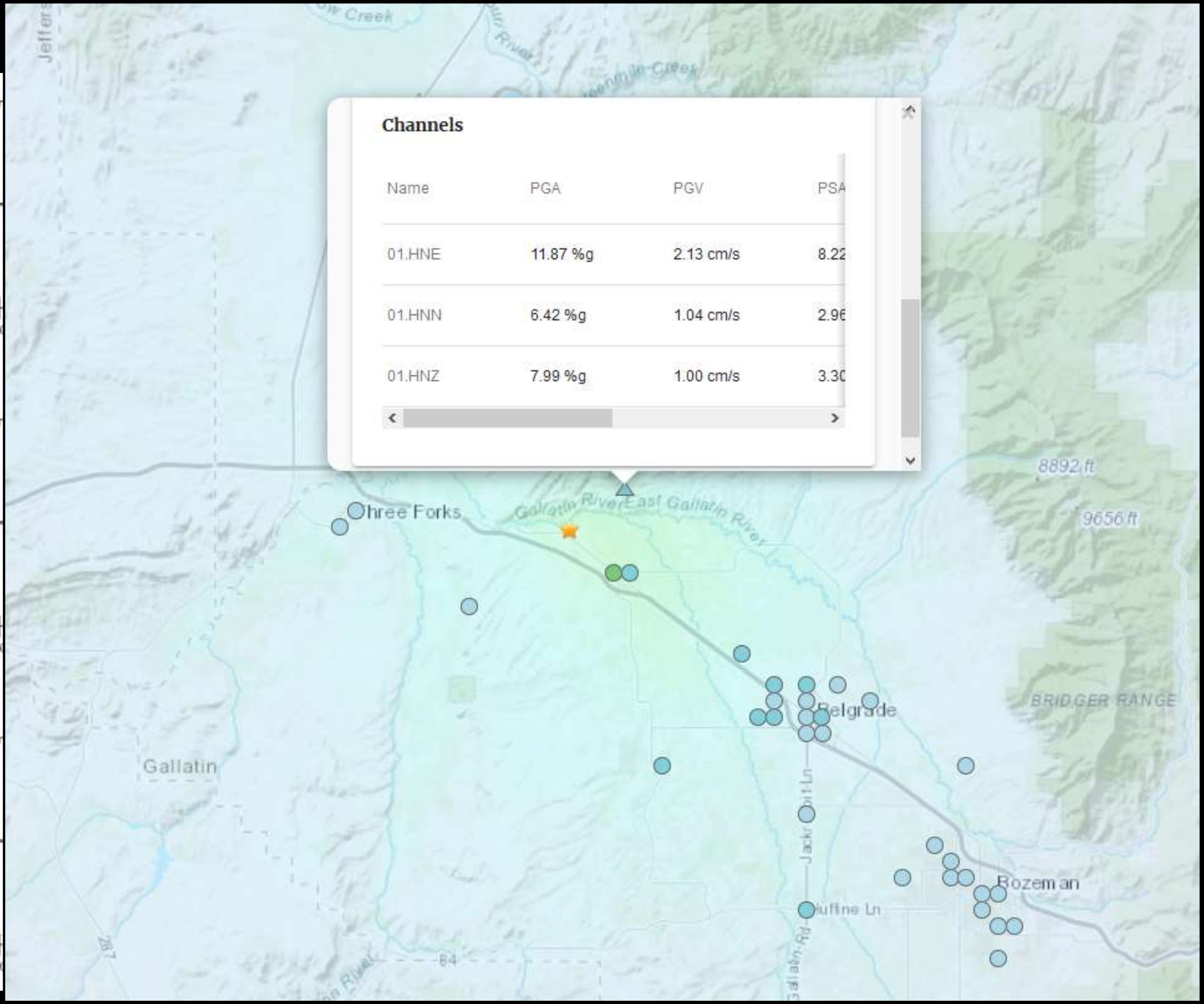

```
MB First Motion Mechanism
 P FIRST-MOTION FOCAL MECHANISM
 (double-couple source assumed)

 Event Date & Time          : 08/16/2019 00:02:38 GMT = Thu Aug 15 18:02:38 MDT 2019
 Location                   : 45.8617 N, 111.3577 W
                            : (45 deg. 51.70 min. N, 111.deg. 21.46 min. W)
 Depth                      :  9.3 km. deep (  5.8 miles)
 Magnitude                  : 4.7 ML
 # P First motions          :  21
 Strike uncertainty         :   5 deg.
 Dip    uncertainty         :  23 deg.
 Rake   uncertainty         :  10 deg.
```

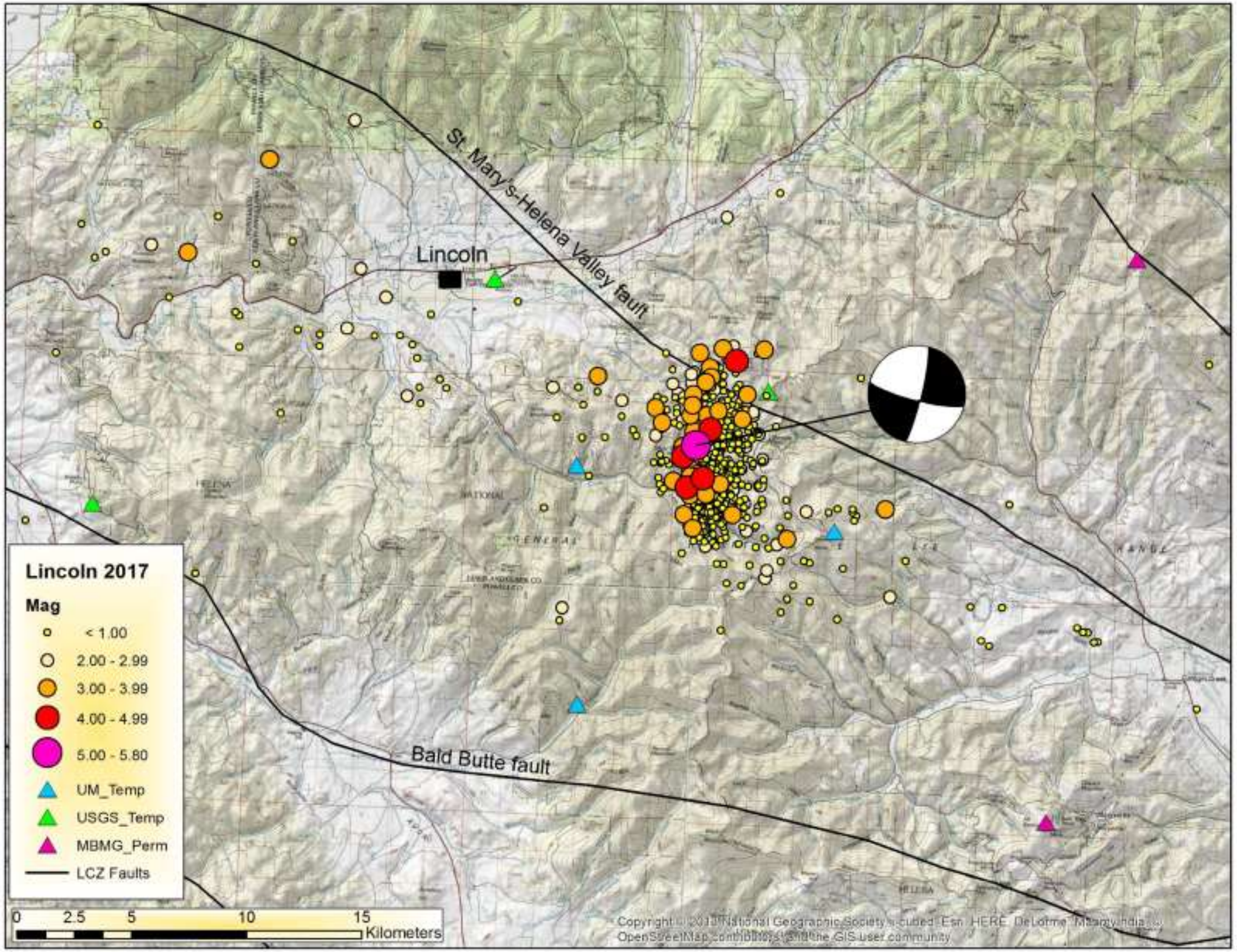


USGS ShakeMap

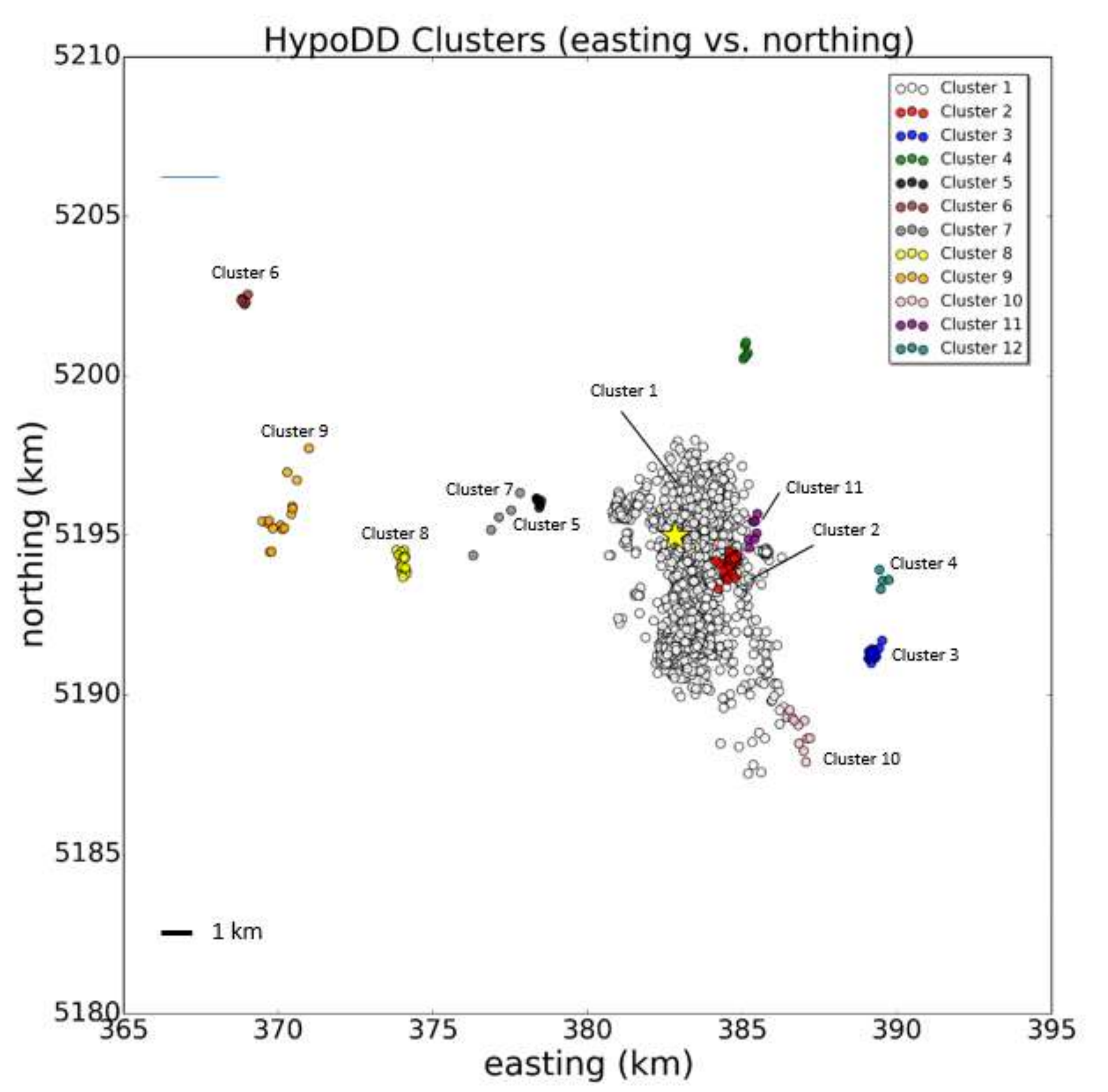
Gallatin River Ranch strong motion seismograph recorded 11.87% g in the east-west direction.



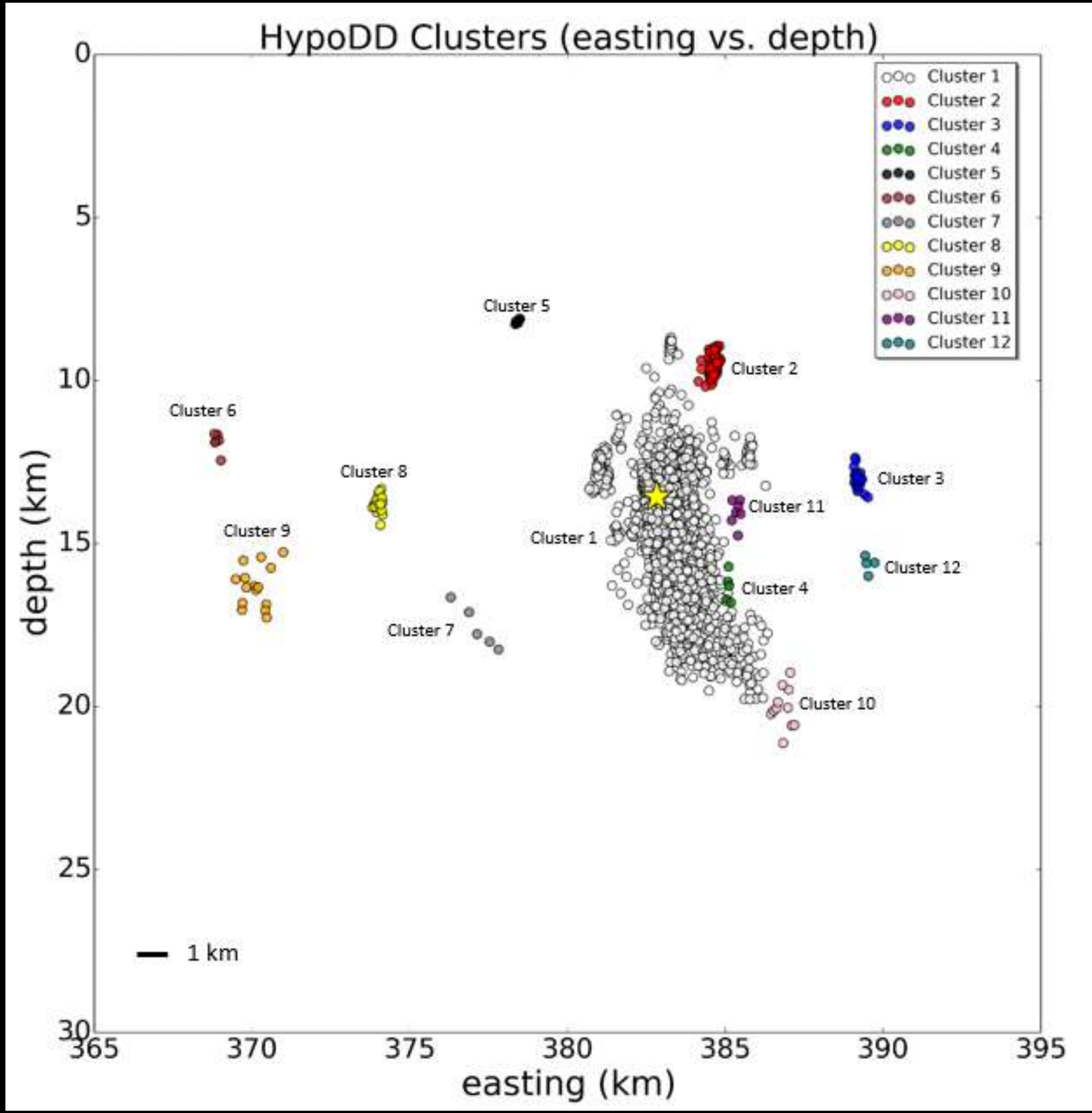




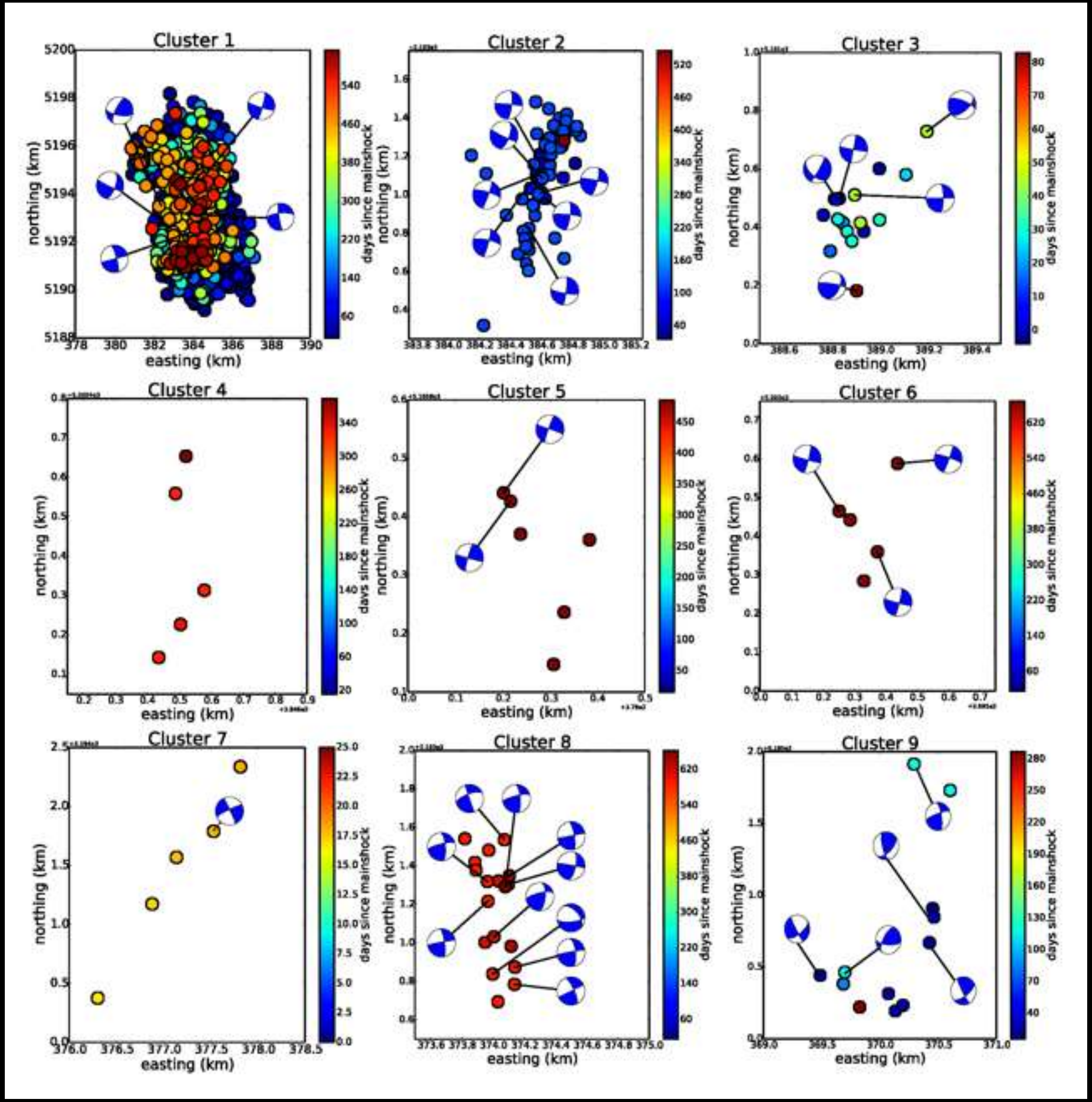
Lincoln
St. Mary's-Helena Valley fault
Bald Butte fault
Lincoln 2017
Mag
< 1.00
2.00 - 2.99
3.00 - 3.99
4.00 - 4.99
5.00 - 5.80
UM_Temp
USGS_Temp
MBMG_Perm
LCZ Faults
0
2.5
5
10
15
Kilometers



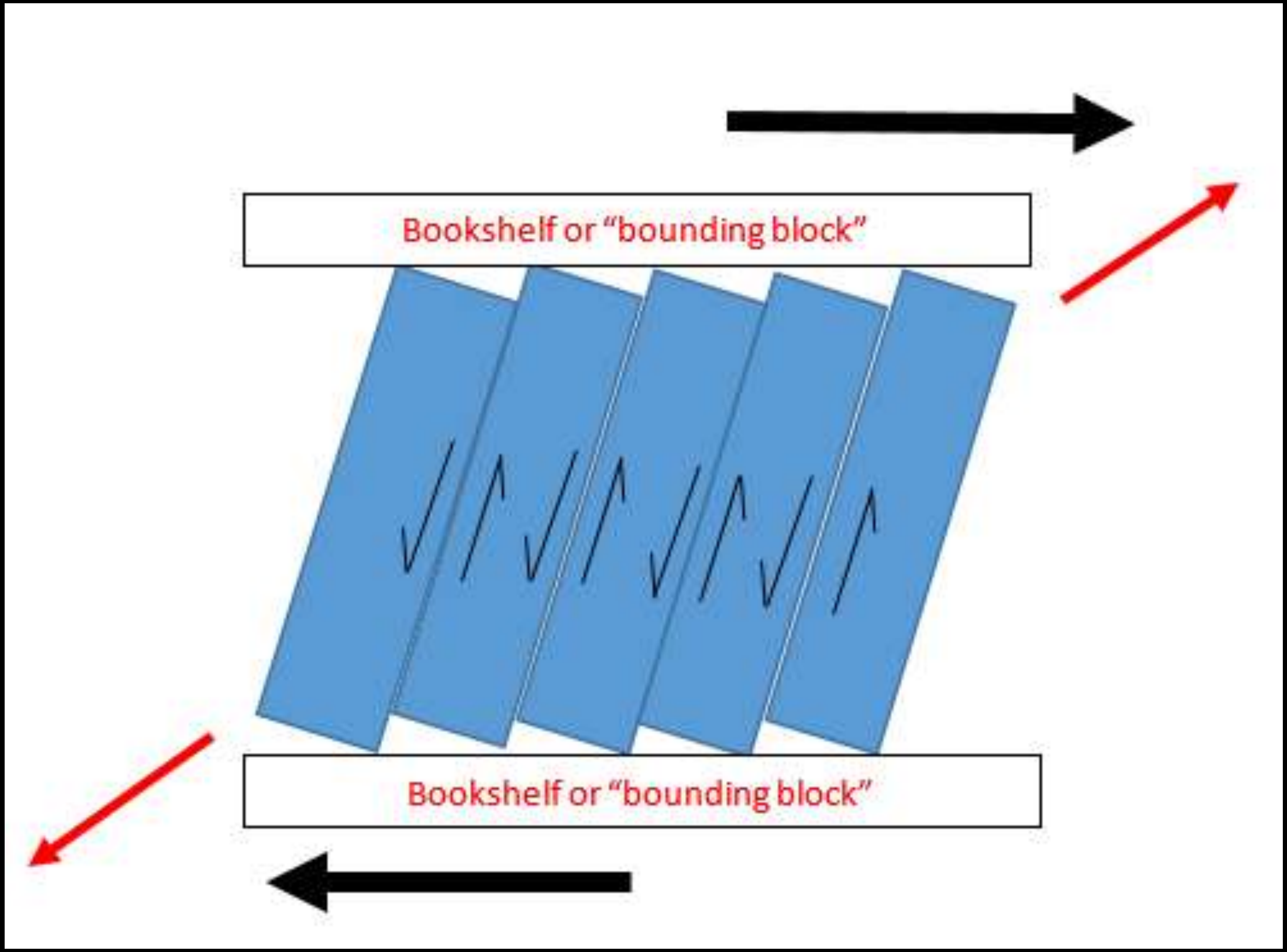
Smith 2020, Figure 13



Smith 2020, Figure 14



Smith 2020, Figure 19



Smith 2020, Figure 27

Questions?

BUREAU OF GEOLOGY AND MINERAL RESOURCES

Paleoseismic and Seismic Studies in New Mexico

Daniel J. Koning and Mairi Litherland

Unclassified LA-UR-20-21039

OUTLINE

New Mexico Earthquake Research in 2019

Paleoseismic

- Master thesis on Quaternary fault slip rates in southern Rio Grande rift
- Pajarito fault – multi-team effort spearheaded by Lettis Consultants International, Inc.

Modern seismicity

- WIPP site and Permian basin
- Areas that need attention

OUTLINE

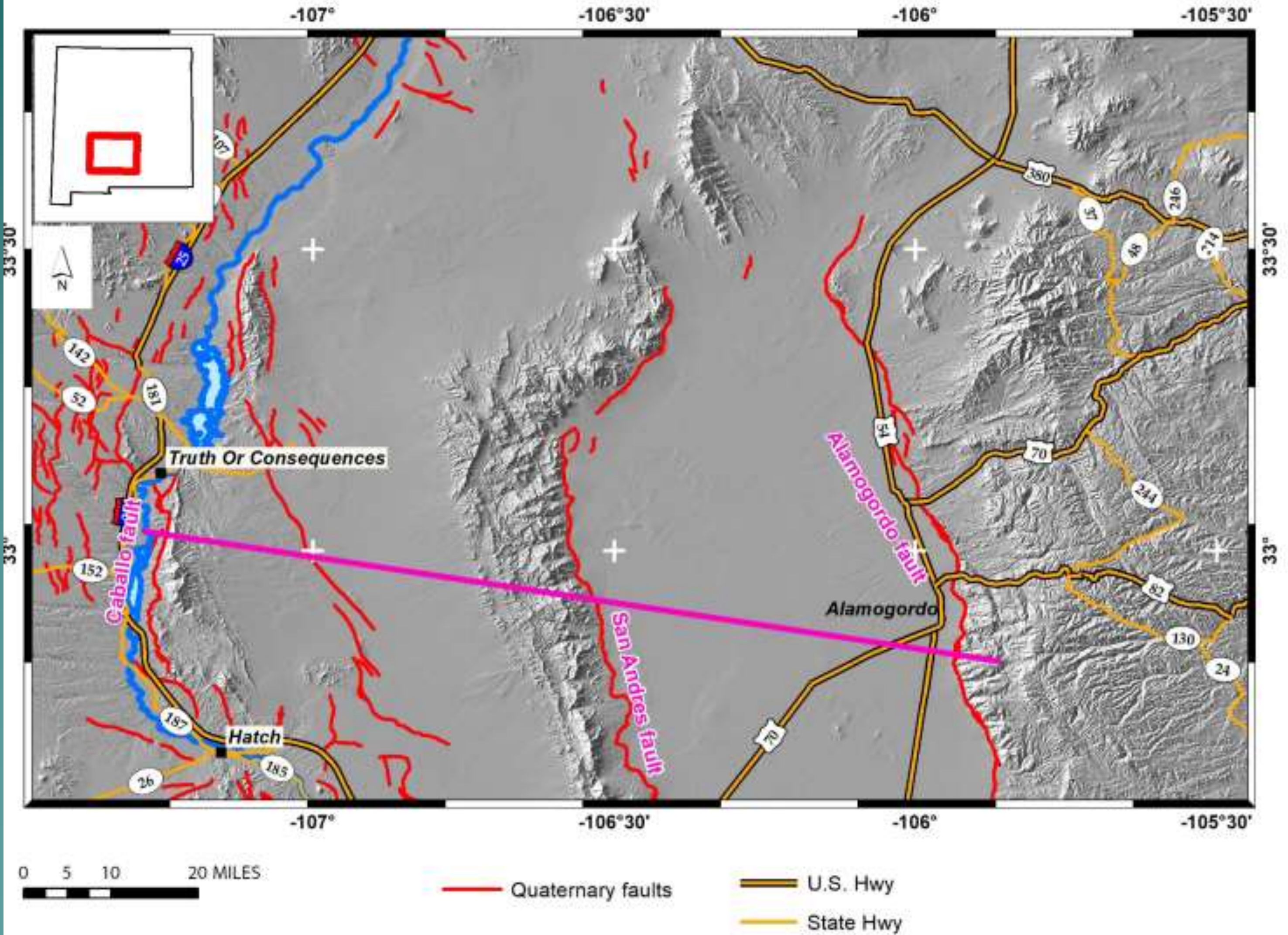
New Mexico Earthquake Research in 2020

LiDAR acquisition

Post-earthquake technical clearinghouse

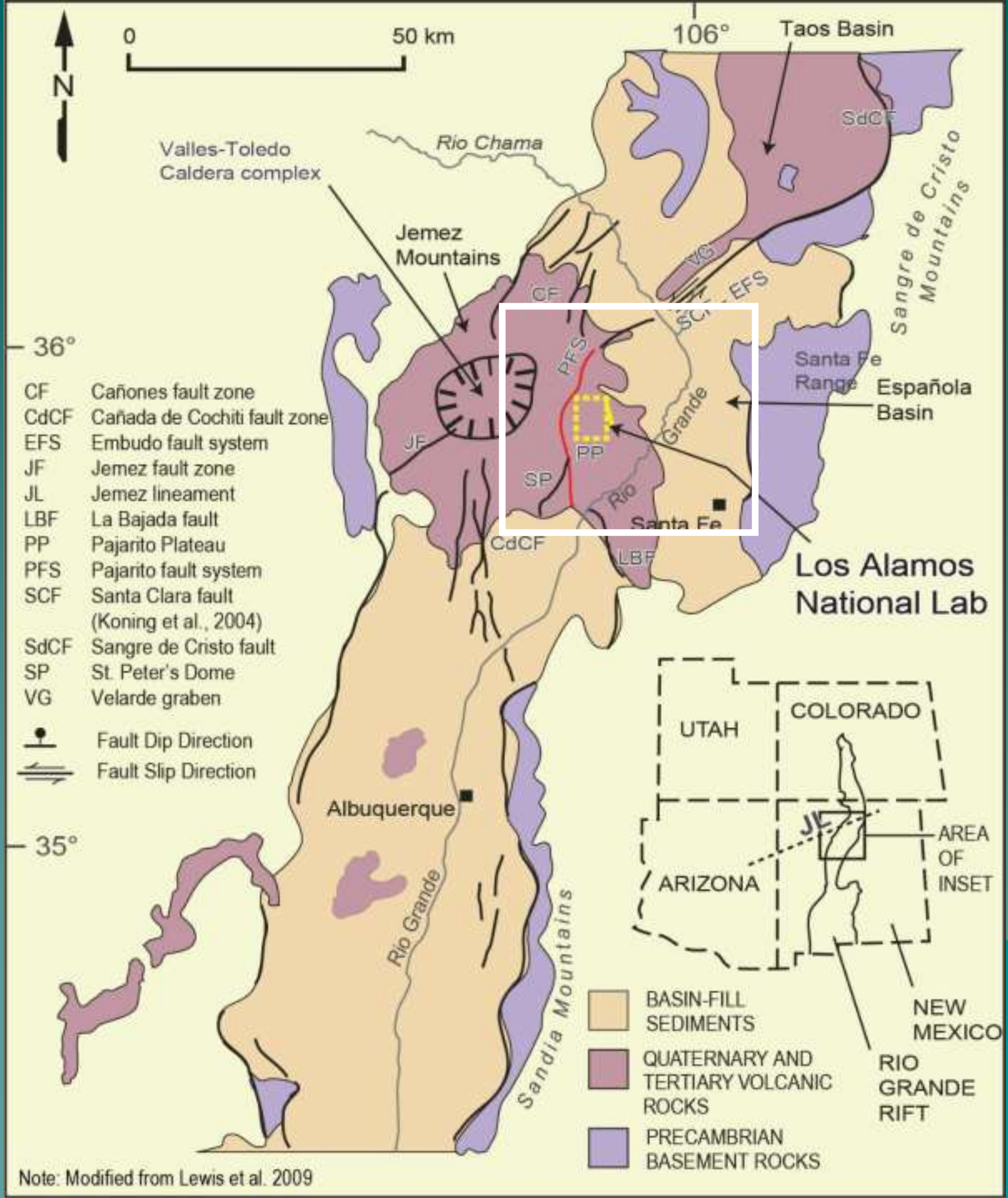
Master thesis work by Ron Sholdt (NMSU)

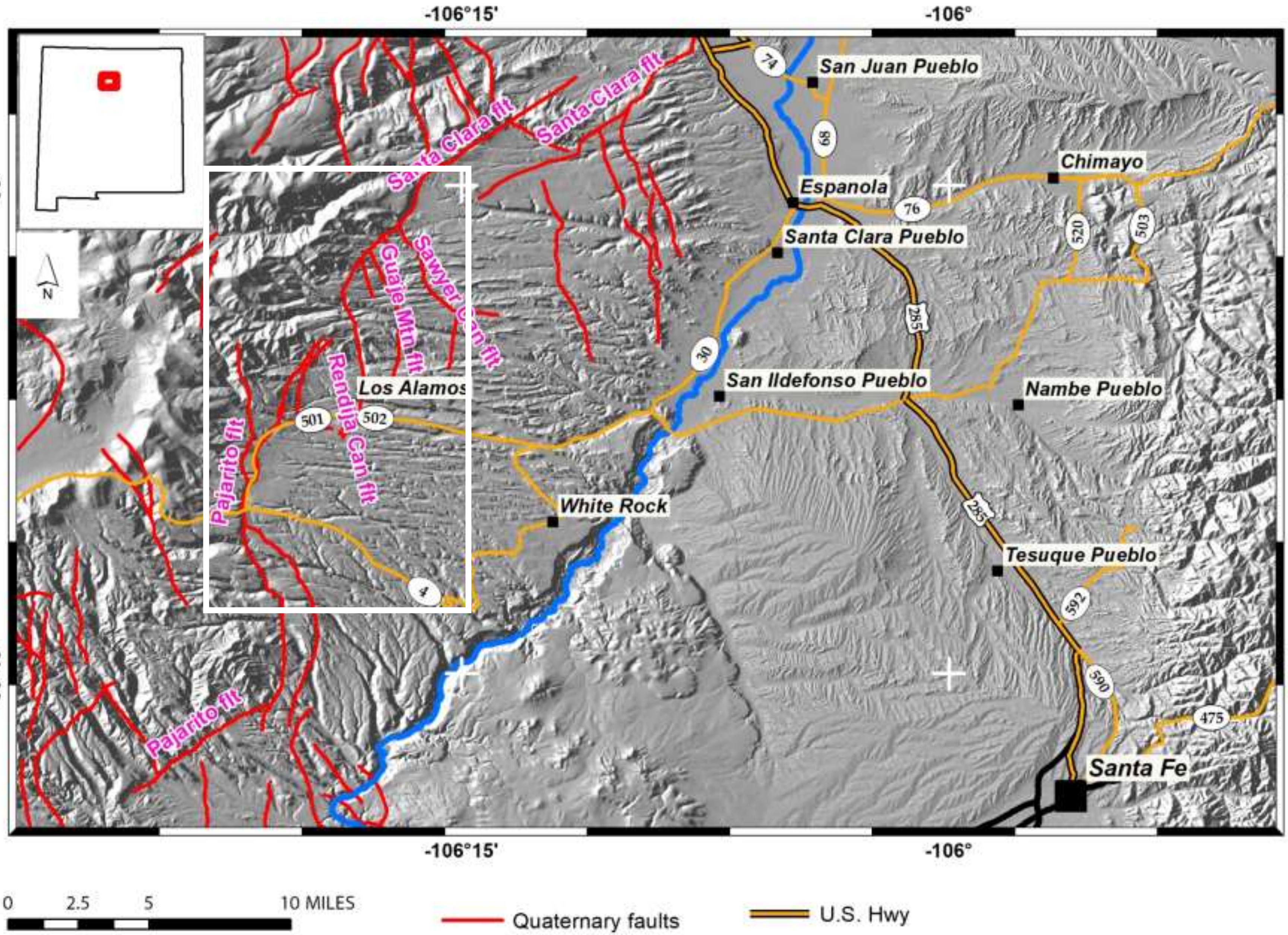
- Use detailed mapping of faulted geomorphic surfaces to obtain a mid-late Quaternary slip rate for three major faults: Caballo, San Andres, and Alamogordo. Compare with long-term (25 Ma) slip rate determined from balanced cross-section across the southern rift.



Pajarito fault

- Master fault system for the Española basin
- Links with Embudo fault system via step-overs and ramp structures
- Southern end extends into northern Santo Domingo Basin





-106°15'
-106°
36°
35°45'
San Juan Pueblo
Santa Clara flt
Santa Clara flt
Chimayo
Espanola
Santa Clara Pueblo
Sawyer Can flt
Guaje Mtn flt
Rendija Can flt
Los Alamos
San Ildefonso Pueblo
Nambe Pueblo
Pajarito flt
White Rock
Tesuque Pueblo
Pajarito flt
Santa Fe
N
74
68
76
520
503
285
30
501
502
4
592
590
475
0
2.5
5
10 MILES
Quaternary faults
U.S. Hwy
State Hwy

On-going research effort on Pajarito fault

Paleoseismic study funded by Los Alamos National Labs and spearheaded by Rob Givler of Lettis Consultants International, Inc.

Geologic mapping along northern Pajarito fault: Dan Koning and Shari Kelley

Team of expert paleoseismologists:

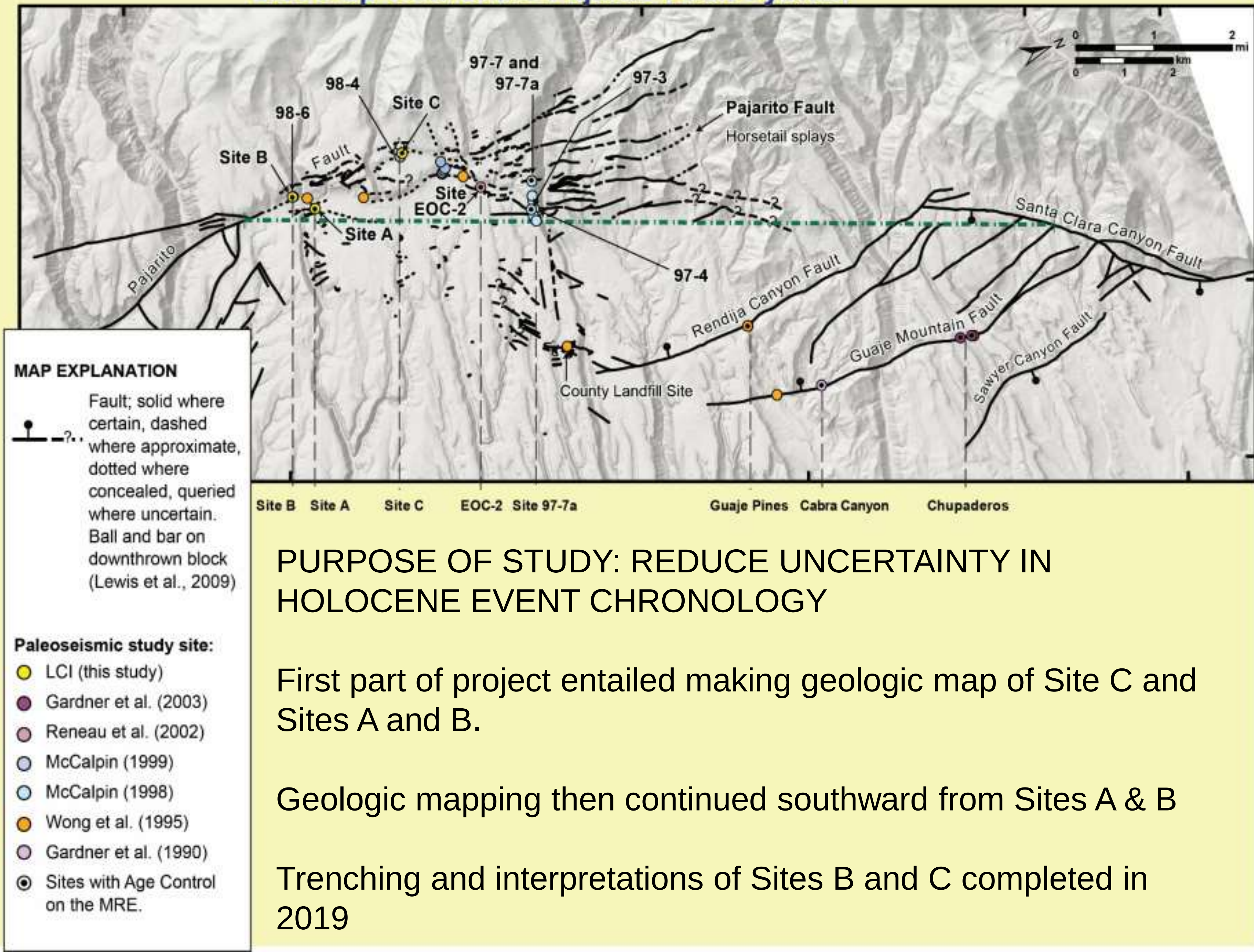
Rob Givler	John Baldwin
William Lettis	Tom Rockwell
Susan Olig	Michael Machette

Collaboration with LANL geologists:

Emily Shulz-Fellenz	Erika Sanson
Brandon Crawford	

Soil PDI in trenches done by Eric McDonald

Close-up view of the Pajarito Fault System



PURPOSE OF STUDY: REDUCE UNCERTAINTY IN HOLOCENE EVENT CHRONOLOGY

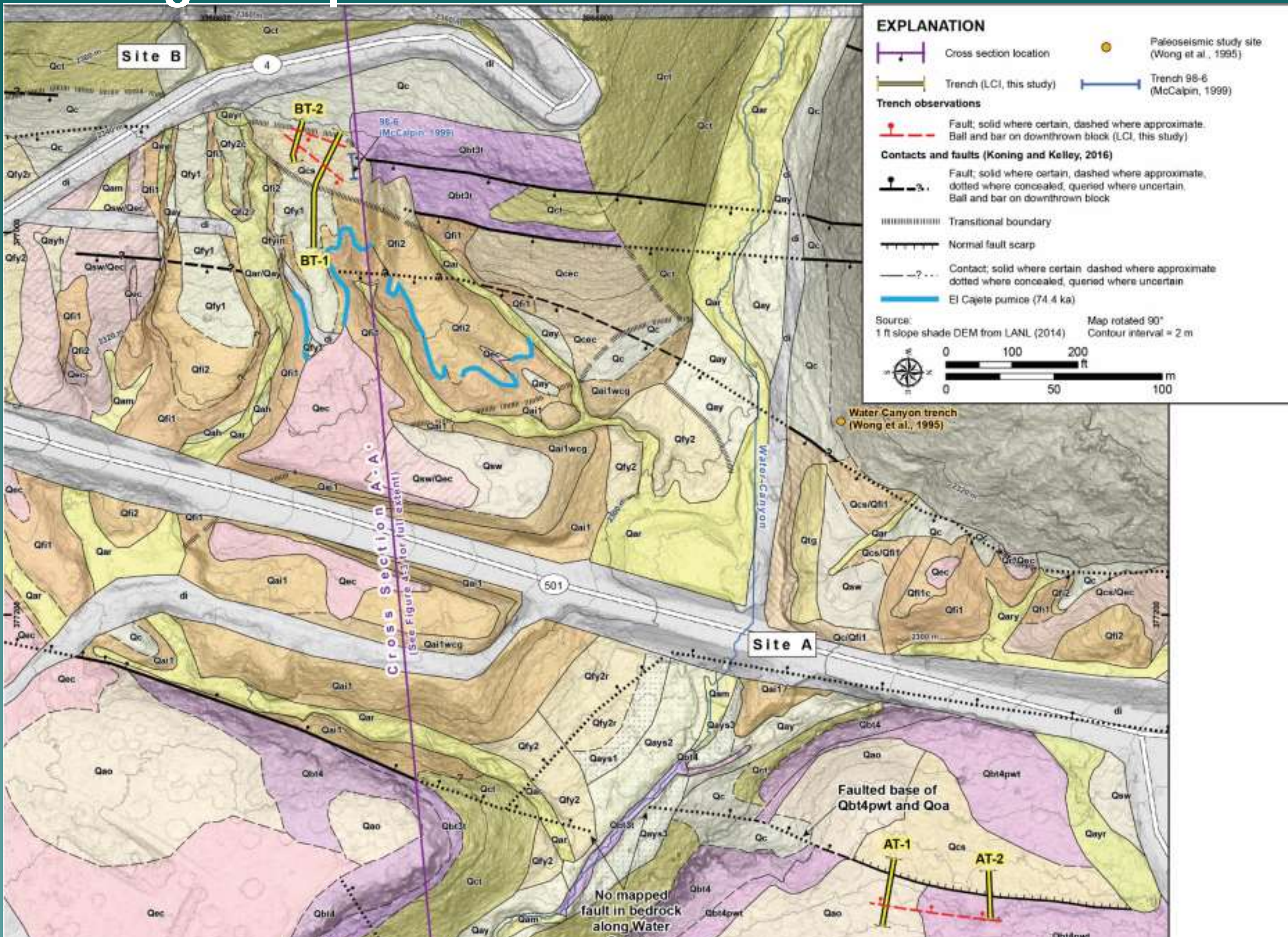
First part of project entailed making geologic map of Site C and Sites A and B.

Geologic mapping then continued southward from Sites A & B

Trenching and interpretations of Sites B and C completed in 2019

BUREAU OF GEOLOGY AND MINERAL RESOURCES

Geologic map of Sites A & B



Future efforts on Pajarito fault

- More trenches to south
- To south, however, 45% of long-term throw accommodated by monoclinal folding.

Modern seismicity (courtesy of Mairi Litherland)

- Most of NM Bureau of Geology’s efforts focused on monitoring seismicity near a low-level radioactive waste repository called WIPP, located in southeast N.M.

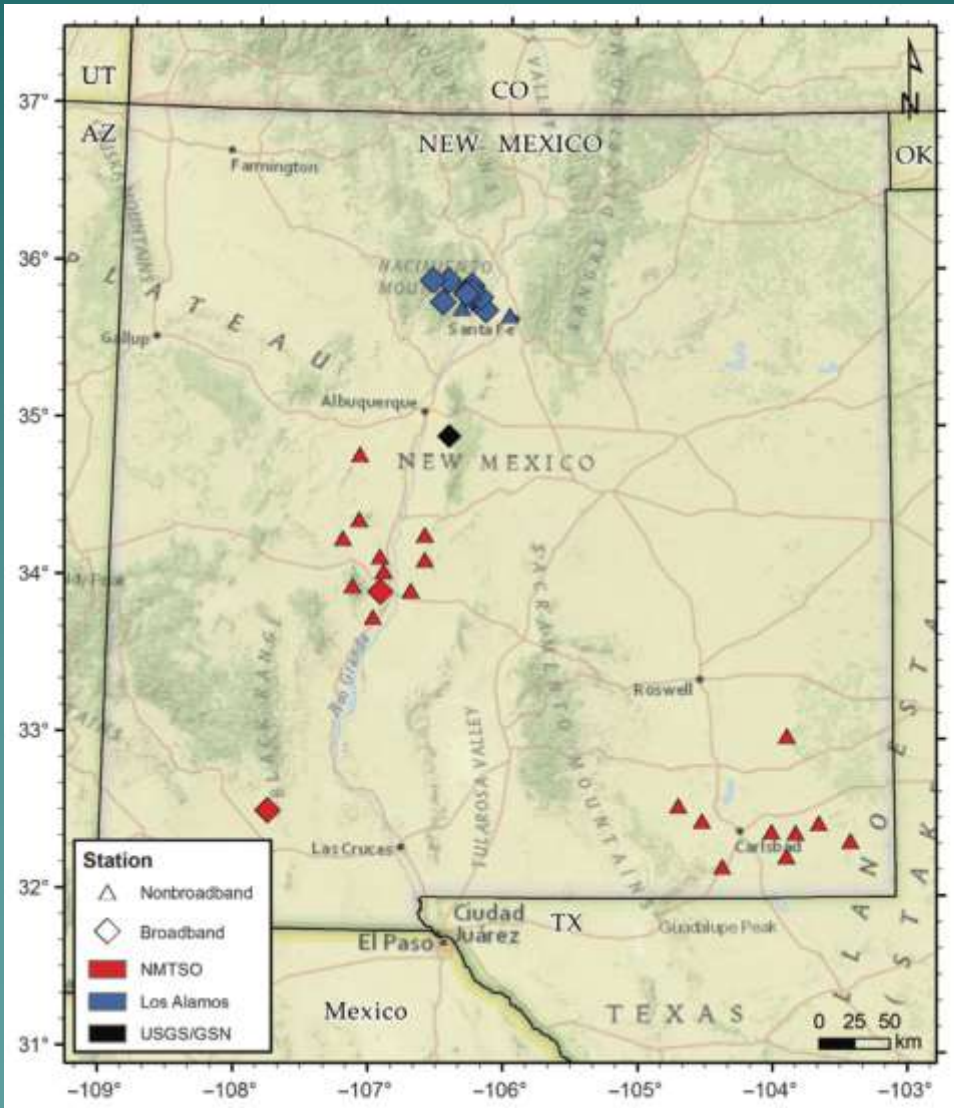
- Coincidently, this area coincides with elevated seismicity (up to ~M3) in the Permian basin, near and south of Texas border.

- Two new seismic stations were donated by Cimarex. USGS also has put in 2 temporary seismic stations.

- We are working with Oil Conservation Division to further improve monitoring capability by: (1) adding new stations, and (2) reporting events in real time.

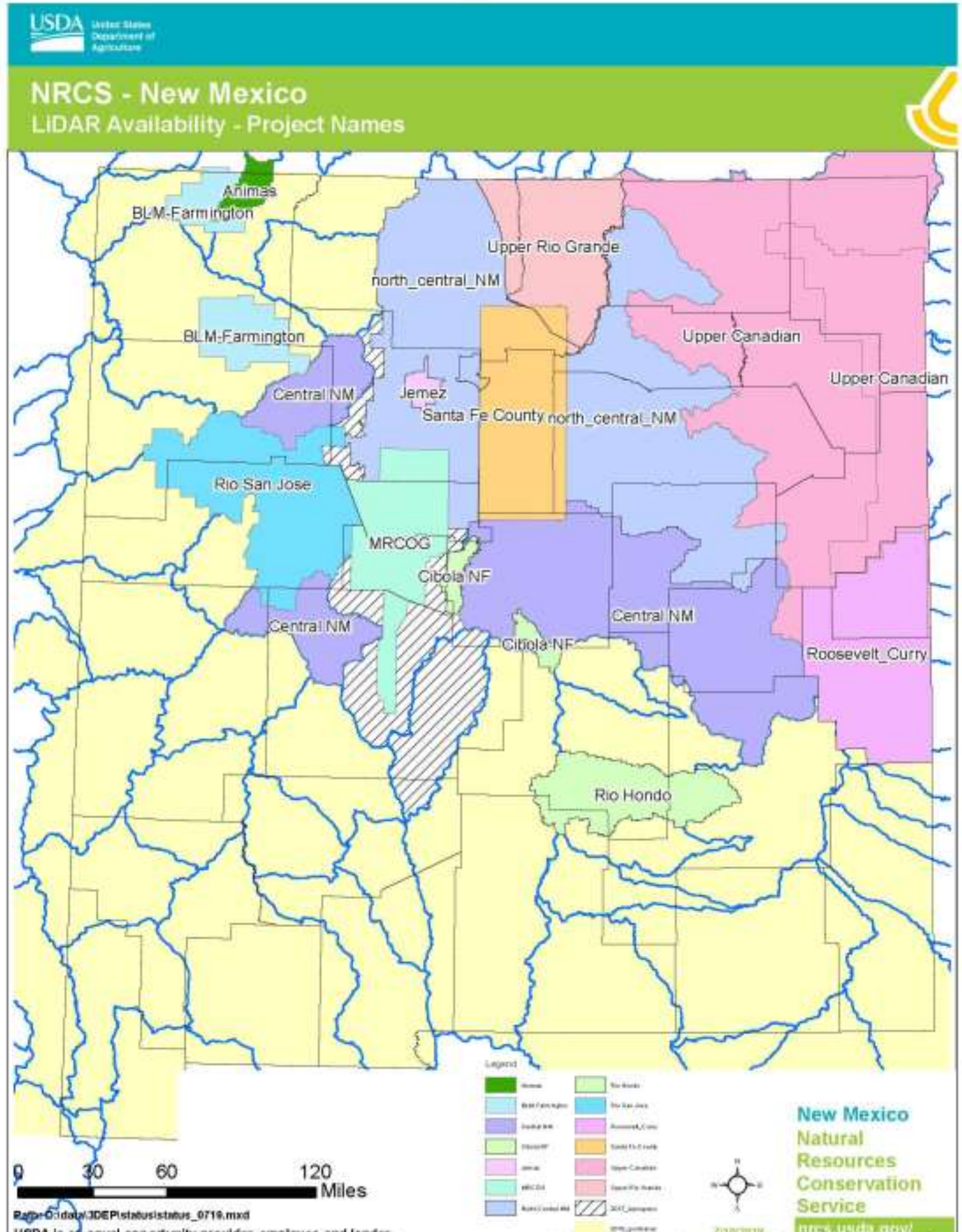
Modern seismicity (courtesy of Mairi Litherland)

- PROBLEM: Seismic stations near the Socorro magma body (60 miles south of Albuquerque) are getting old and failing. No money to replace or upgrade them.
- PROBLEM: There are large areas in state with no seismic coverage at all, including the San Juan basin (NW part of state) where there are low levels of oil and gas production.



LiDAR acquisition

- Statewide coverage should be available this year.
- Much thanks to the LiDAR subcommittee of the state's Geospatial Advisory Committee (Mike Timmons of NMBGMR represented geologic interests)
- Group has been in dialogue with USDA, FEMA, NRCS & others—when money was available, the group lobbied for project areas that achieved maximum benefit to interested parties.
- State coverage achieved in piecemeal fashion.

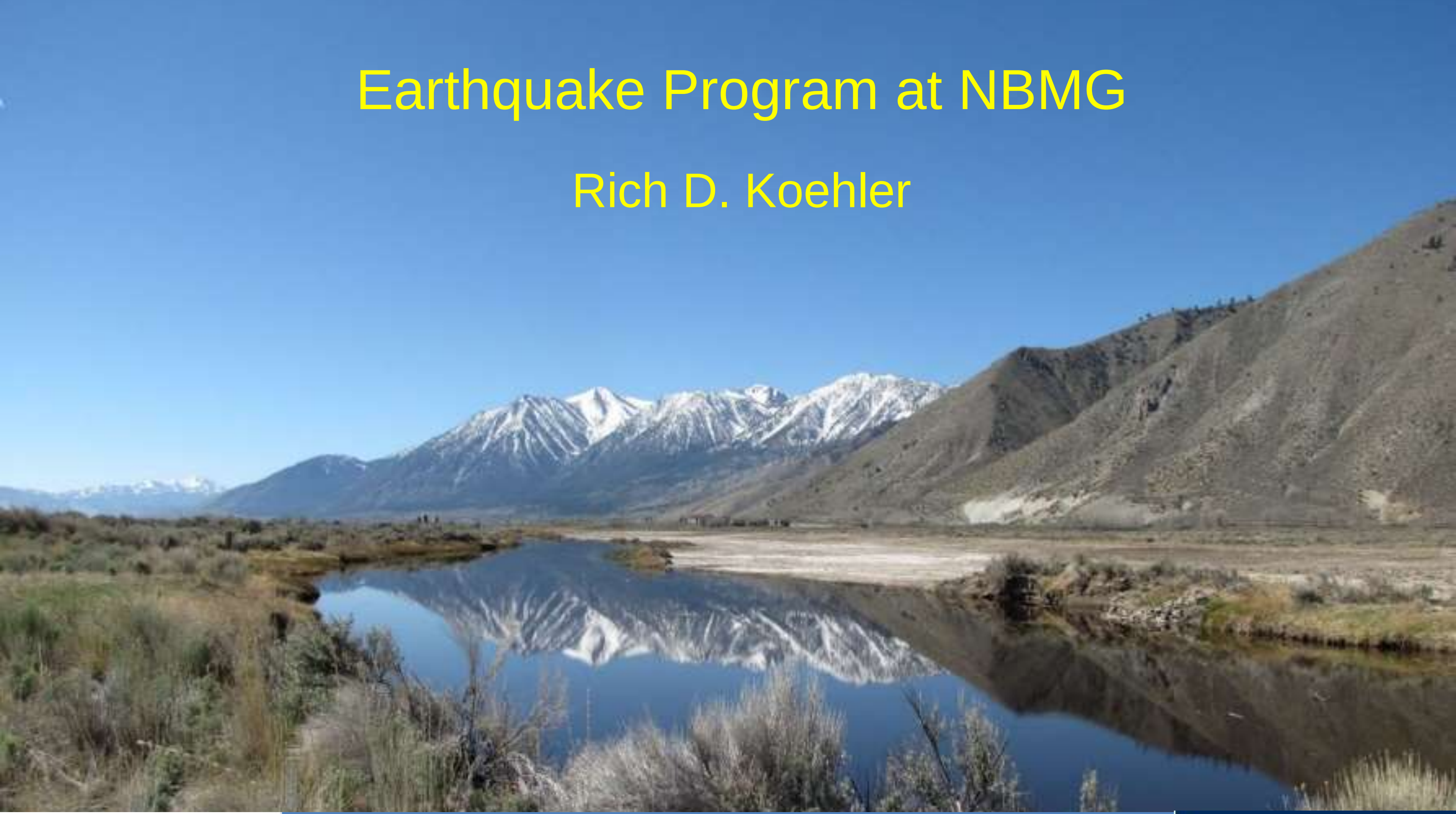


Post-earthquake clearinghouse

- NM Bureau of Geology may apply for FEMA funding to set one up a physical and virtual clearinghouse.
- Depends on staff availability.
- Would use Idaho's plan as a template.

Earthquake Program at NBMG

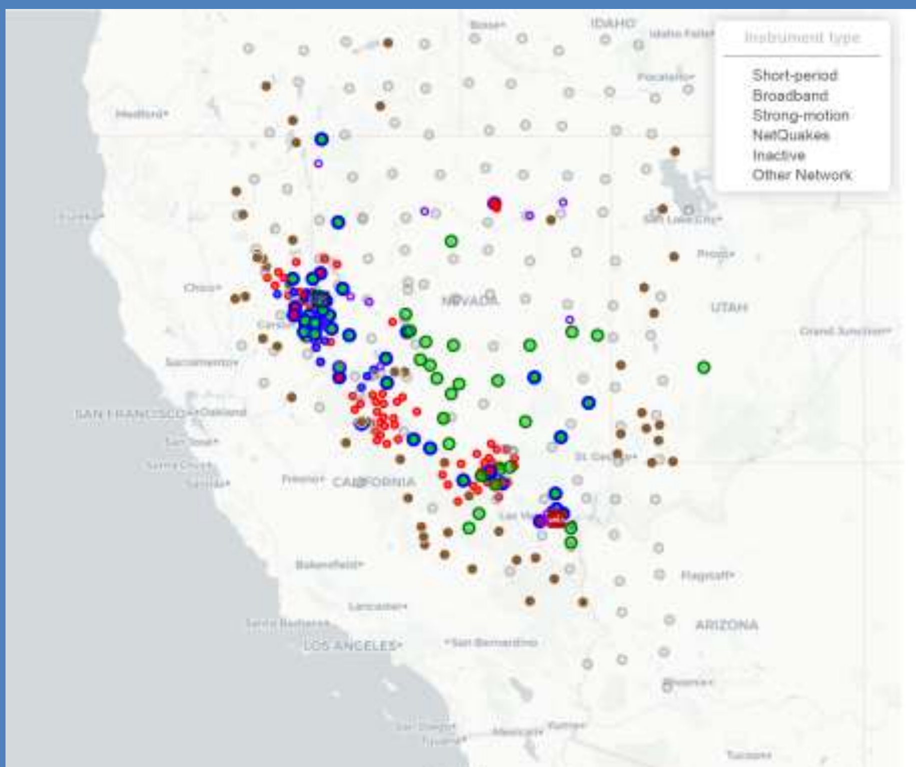
Rich D. Koehler

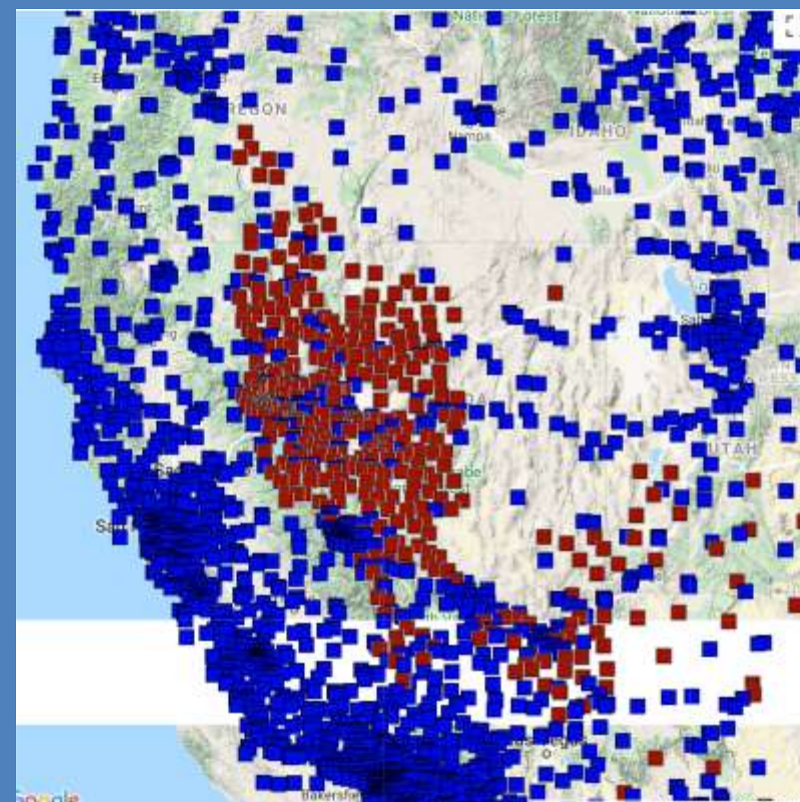


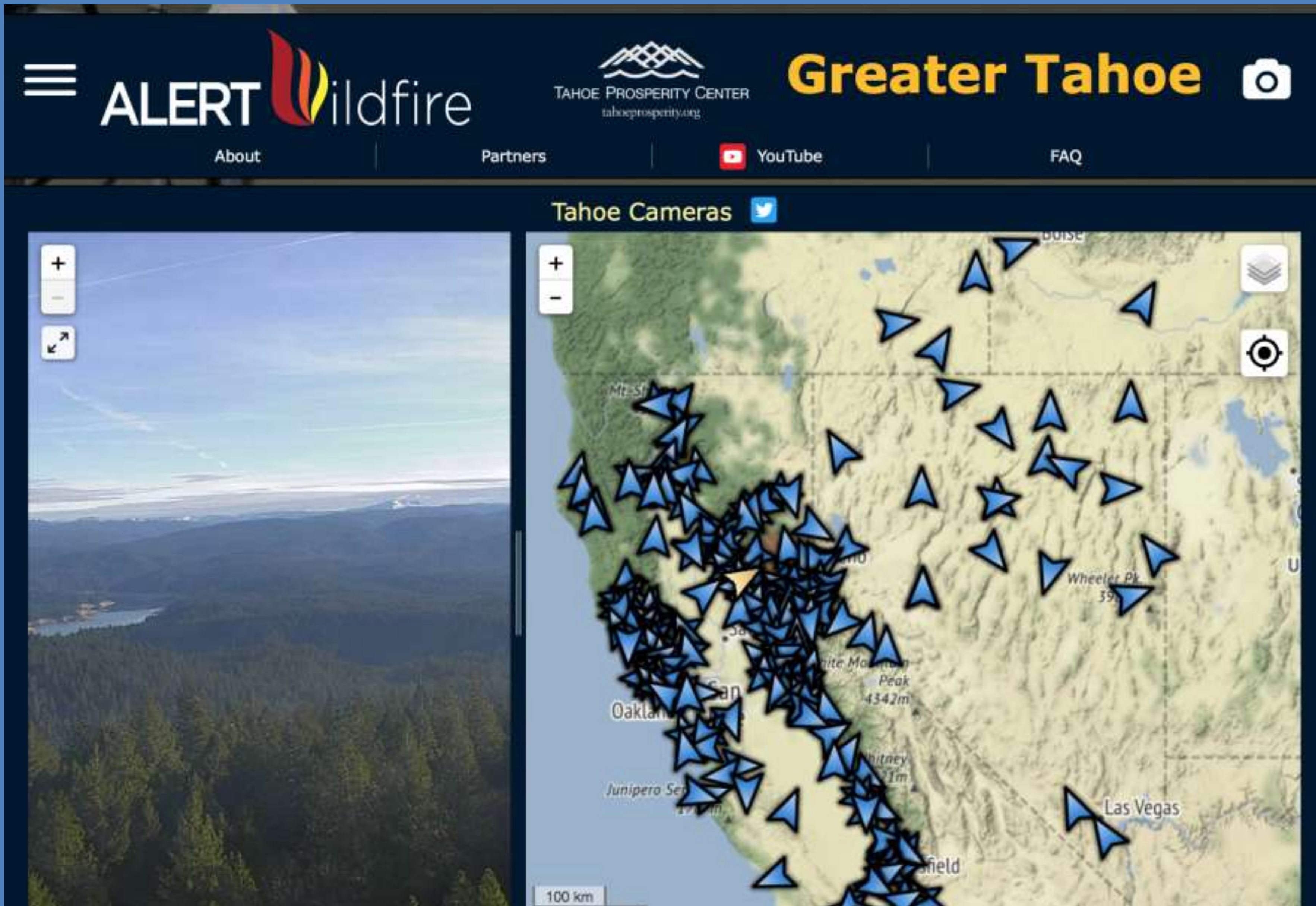
2020 Basin and Range Province
Earthquake Working Group Meeting
Nevada Bureau of Mines and Geology
February 5, 2020

Nevada Geodetic Laboratory

The Nevada Seismological Laboratory






ALERT Wildfire
Tahoe Prosperity Center
tahoeprosperity.org
Greater Tahoe
About
Partners
YouTube
FAQ
Tahoe Cameras
Wheeler Pk
Peak
4342m
Oakla
Junipero Se
Las Vegas
field
100 km

Earthquake hazards projects 2019-20

- Nevada’s Quaternary fault database
- Development of Nevada specific post-earthquake technical clearinghouse and operations plan – Earthquake Direct State Assistance Program DHS&EM
- Paleoseismic studies along active faults
- NBMG StateMAP projects
- Las Vegas Valley fault study
- Ridgecrest Reconnaissance

NEHRP Final Technical Reports

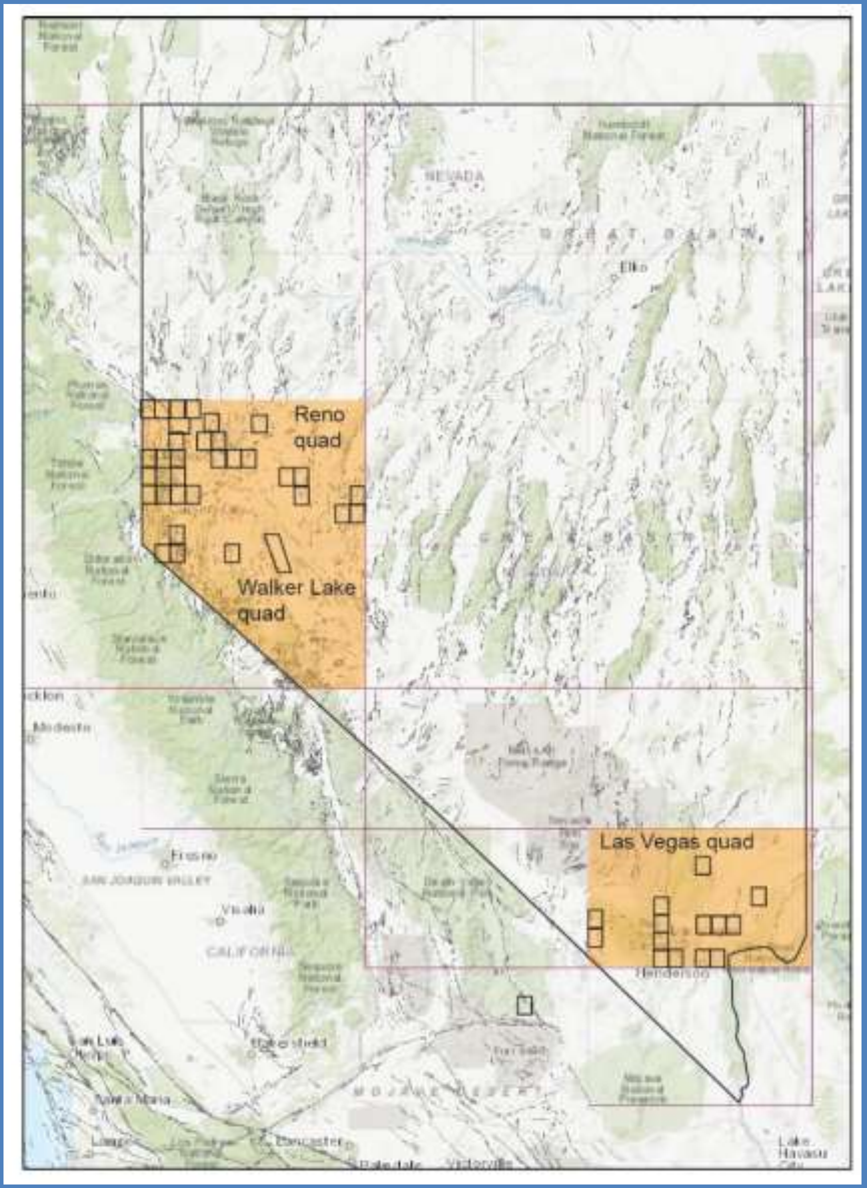
Koehler, R.D., De Masi, C., and Dee, S., 2019, New lidar mapping and paleoseismic characterization of the Petersen Mountain fault zone, north of Reno, NV, Final Technical Report, U.S. Geological Survey (Award #G18AP00007).

Koehler, R.D., and Chupik, C., 2019, Development of earthquake chronology, recurrence and slip rate data for the northern Warm Springs Valley Fault – Using trenching and high-resolution UAV photography, Washoe County, Nevada, Final Technical Report, U.S. Geological Survey (Award #G18AP00020).

Koehler, R.D., and Anderson, J.G., 2019, Working Group on Nevada Seismic Hazards, Final Technical Report, U.S. Geological Survey (Award #G17AC00406).

Dee, S., dePolo, C., and Koehler, R.D., 2019, Paleoseismic investigation of the Eglington fault, Clark County, NV. Final Technical Report, U.S. Geological Survey National Earthquake Hazards Reduction Program (Award #G18AP00013).

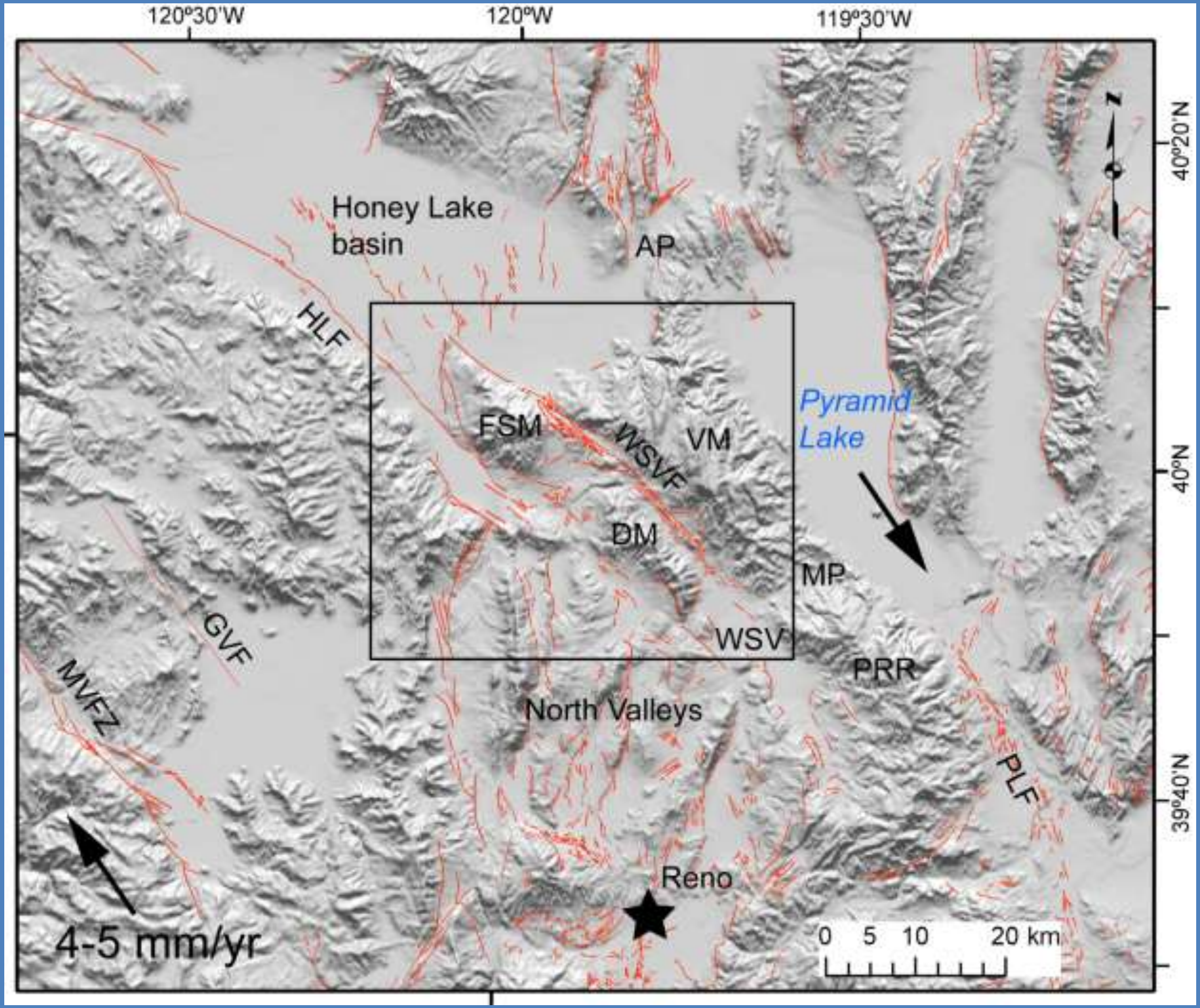
Nevada's Quaternary fault database

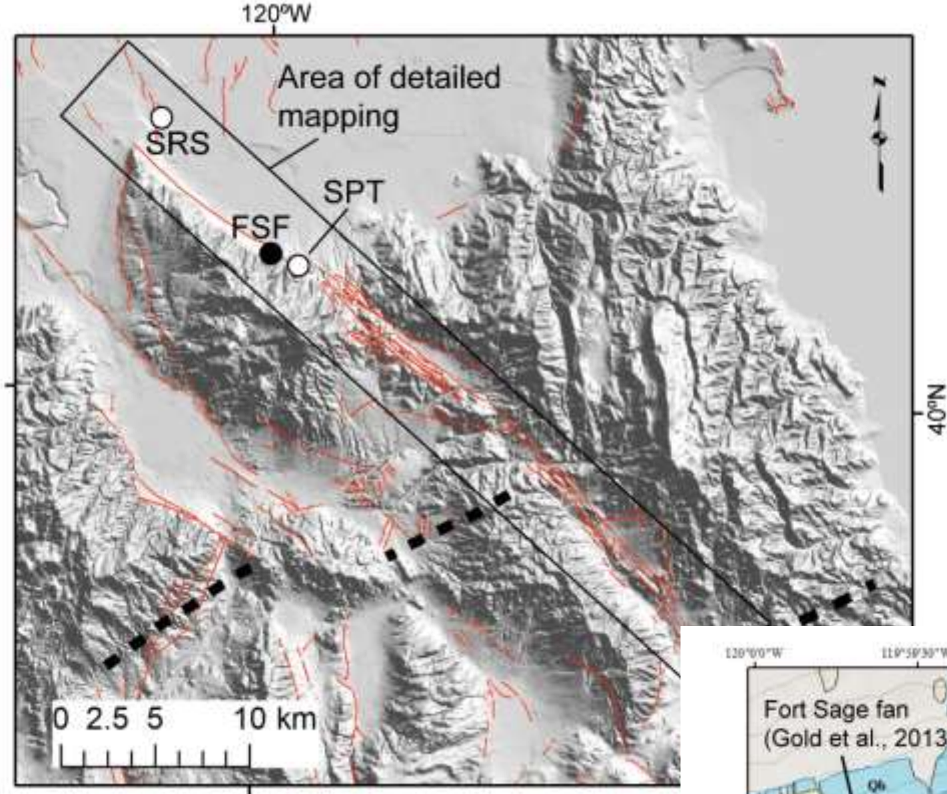


Completed NEHRP projects 2019

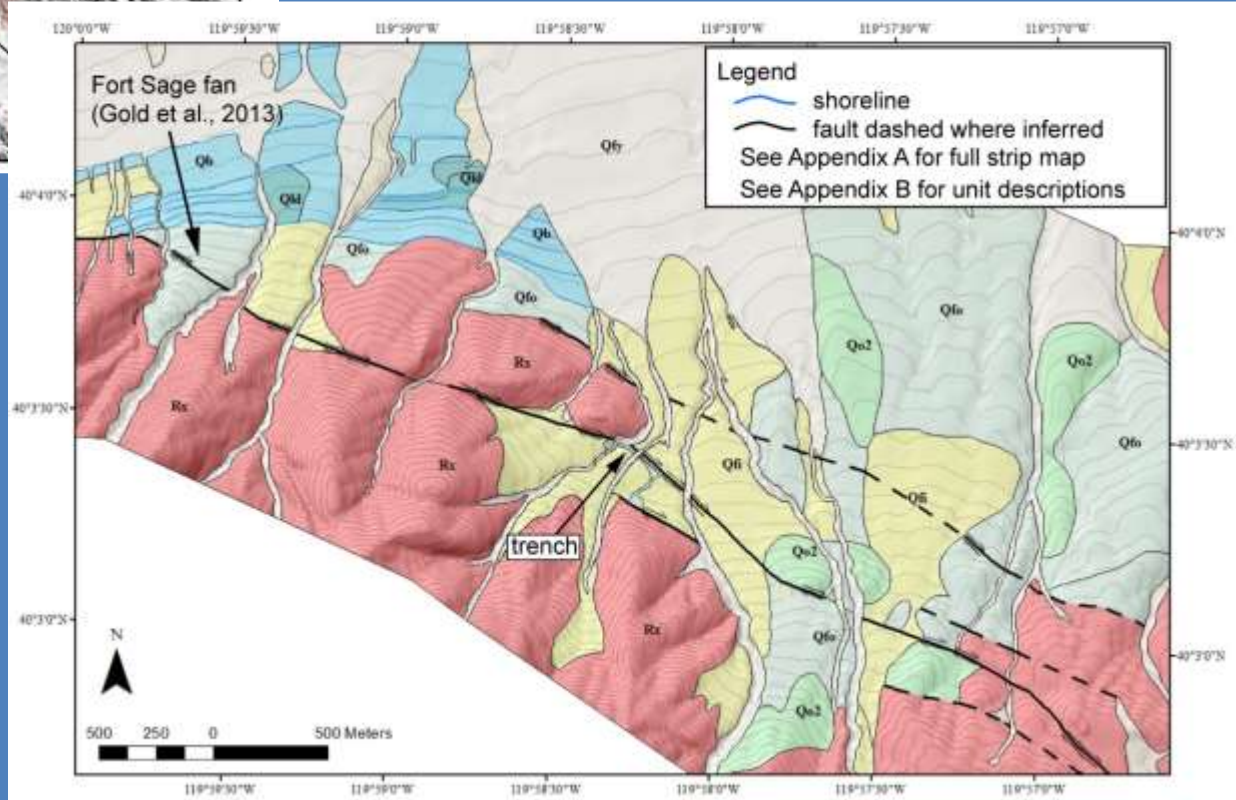
Warm Springs Valley fault

Petersen Mountain fault





Warm Springs Valley fault



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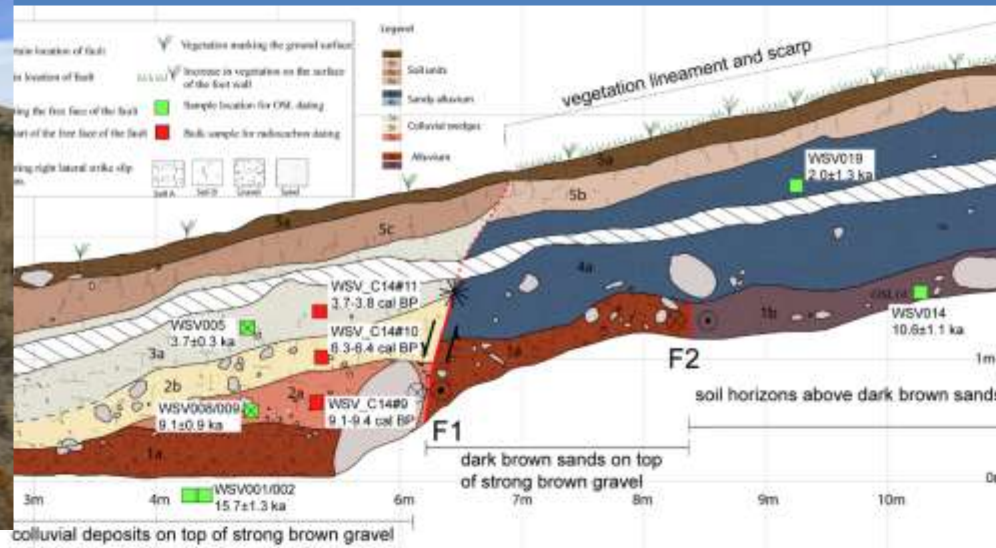
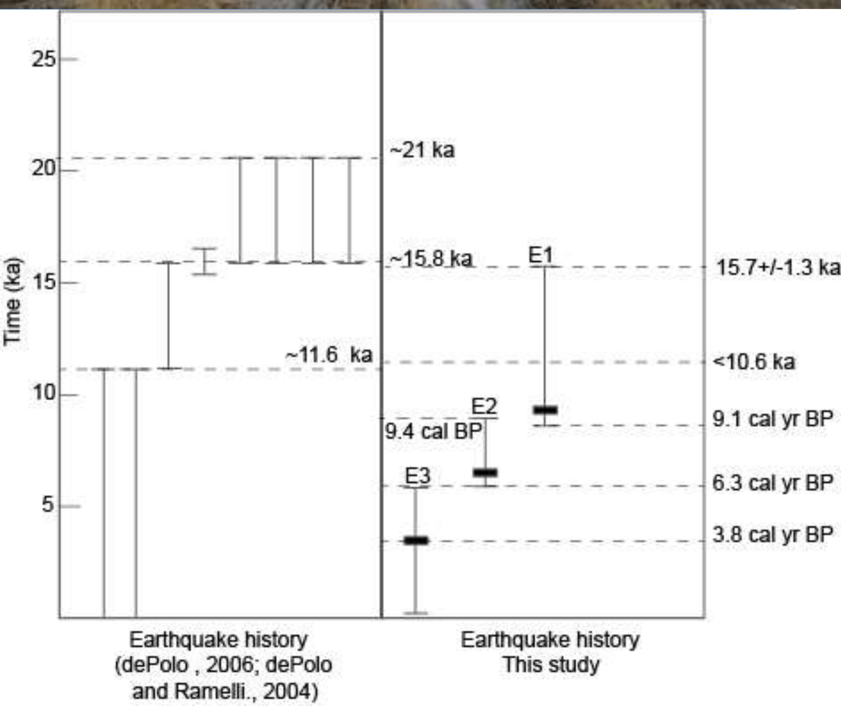
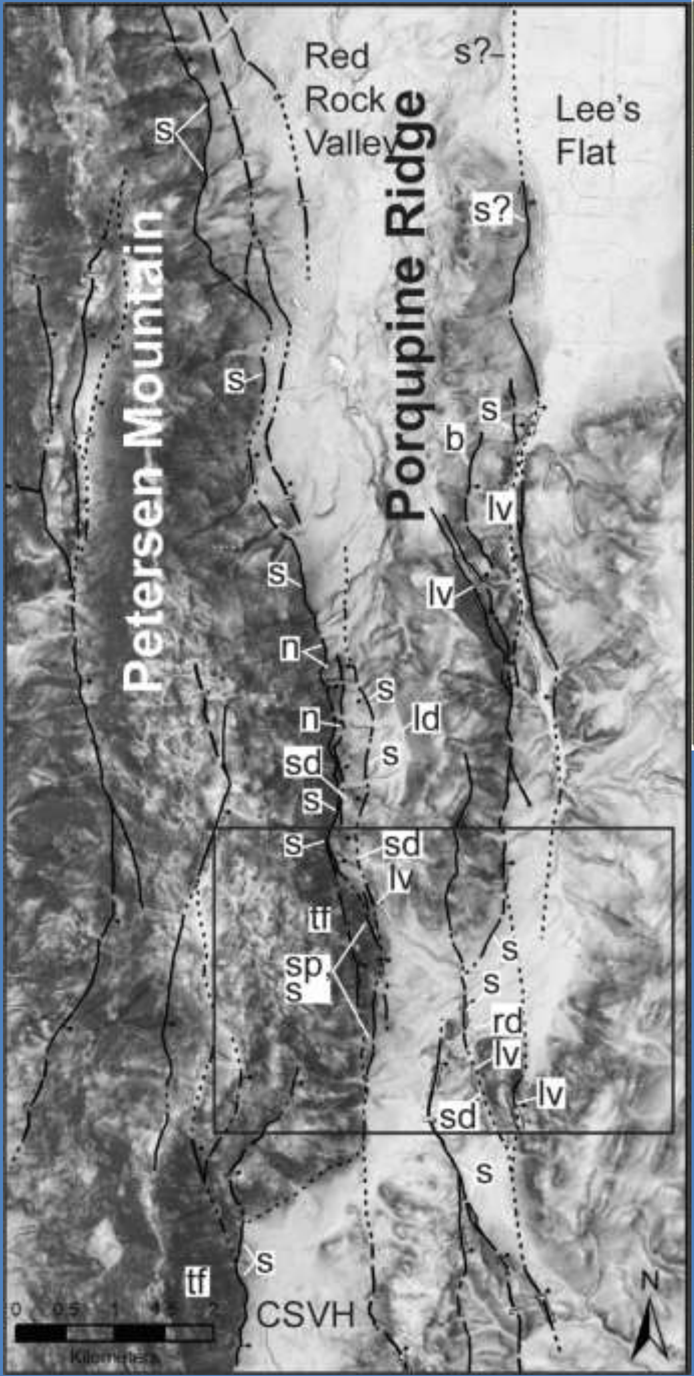
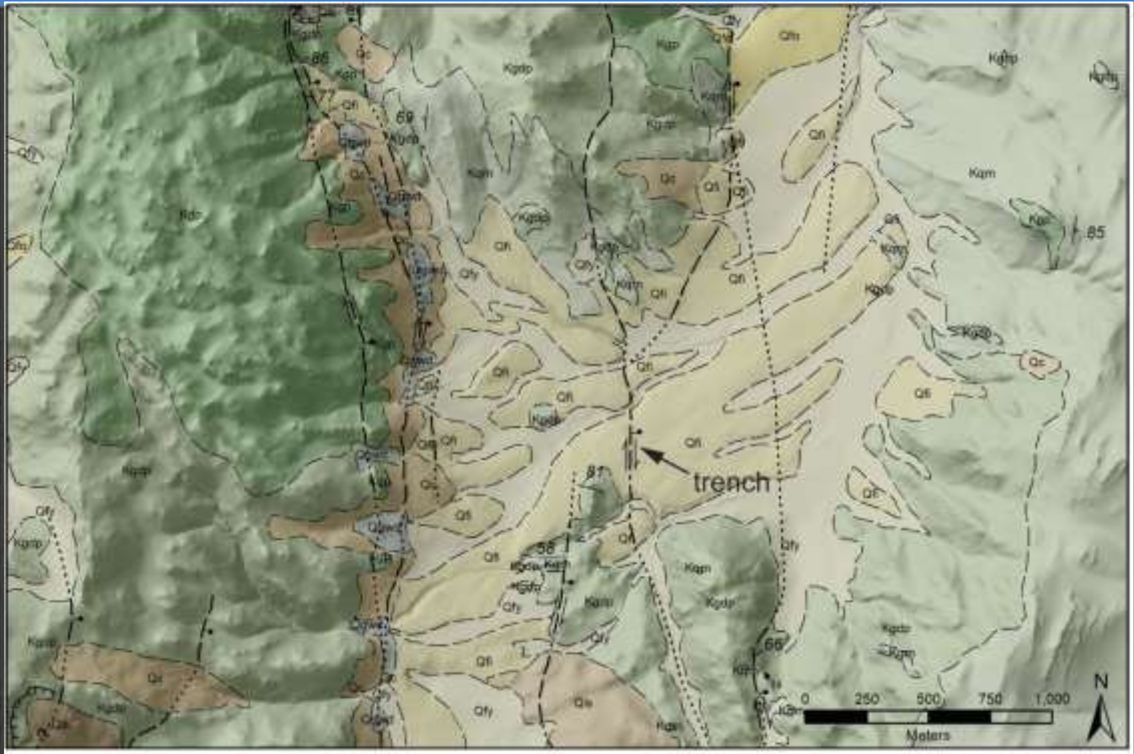
University of Nevada, Reno

Warm Springs Valley fault



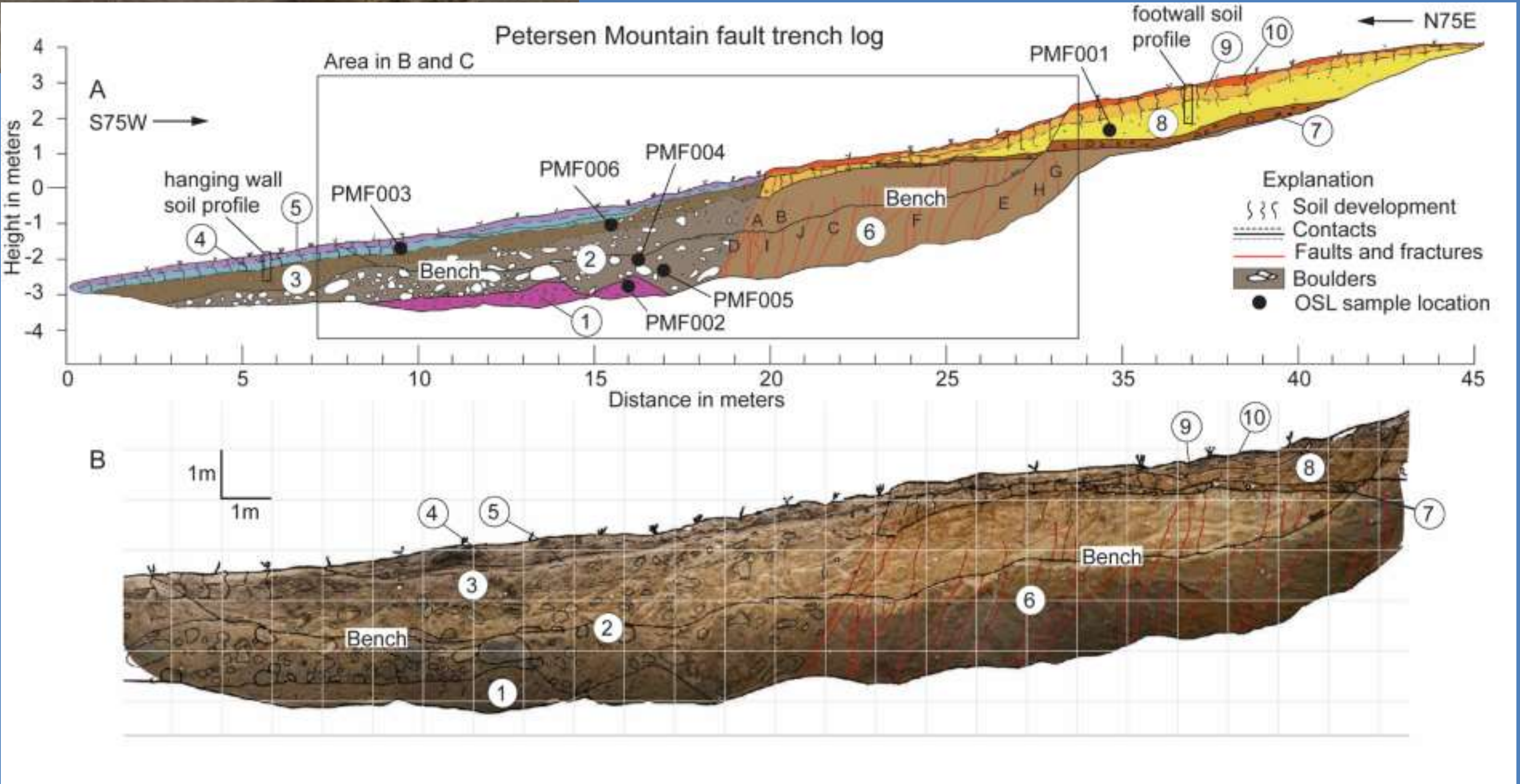


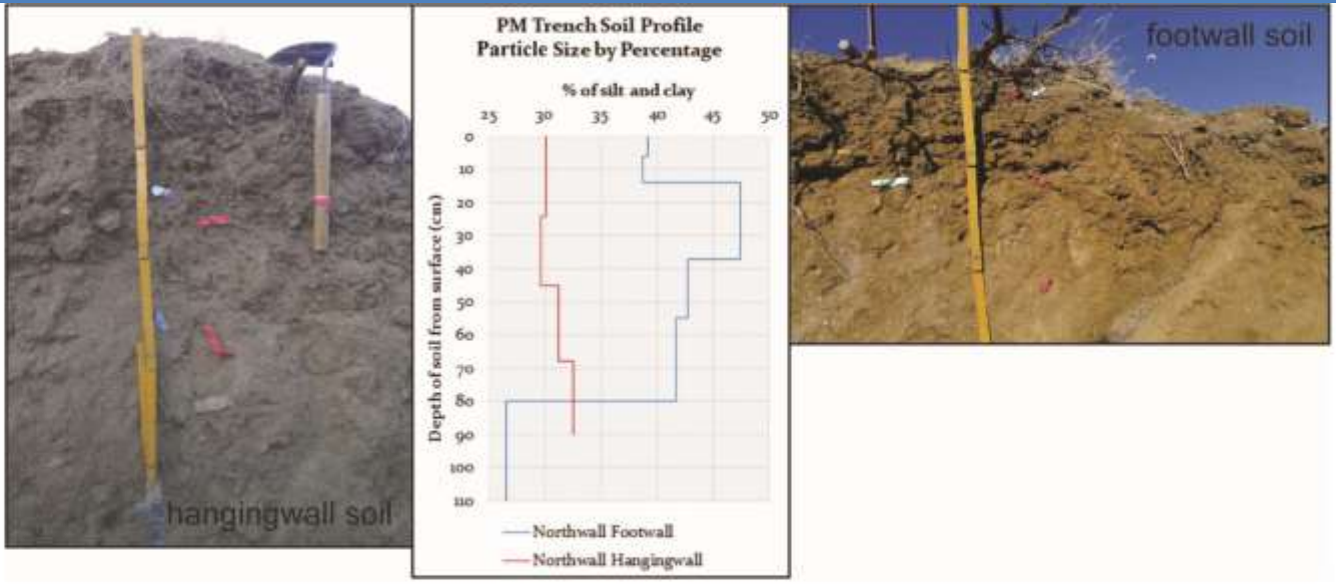


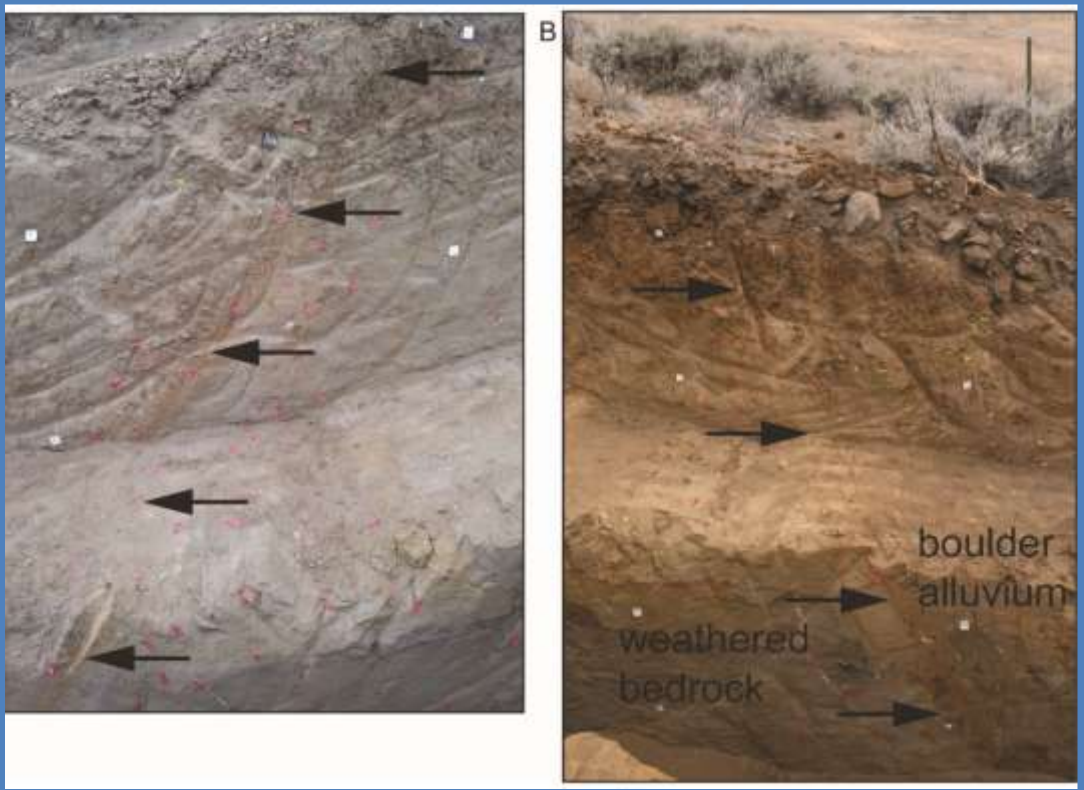


Petersen Mountain fault

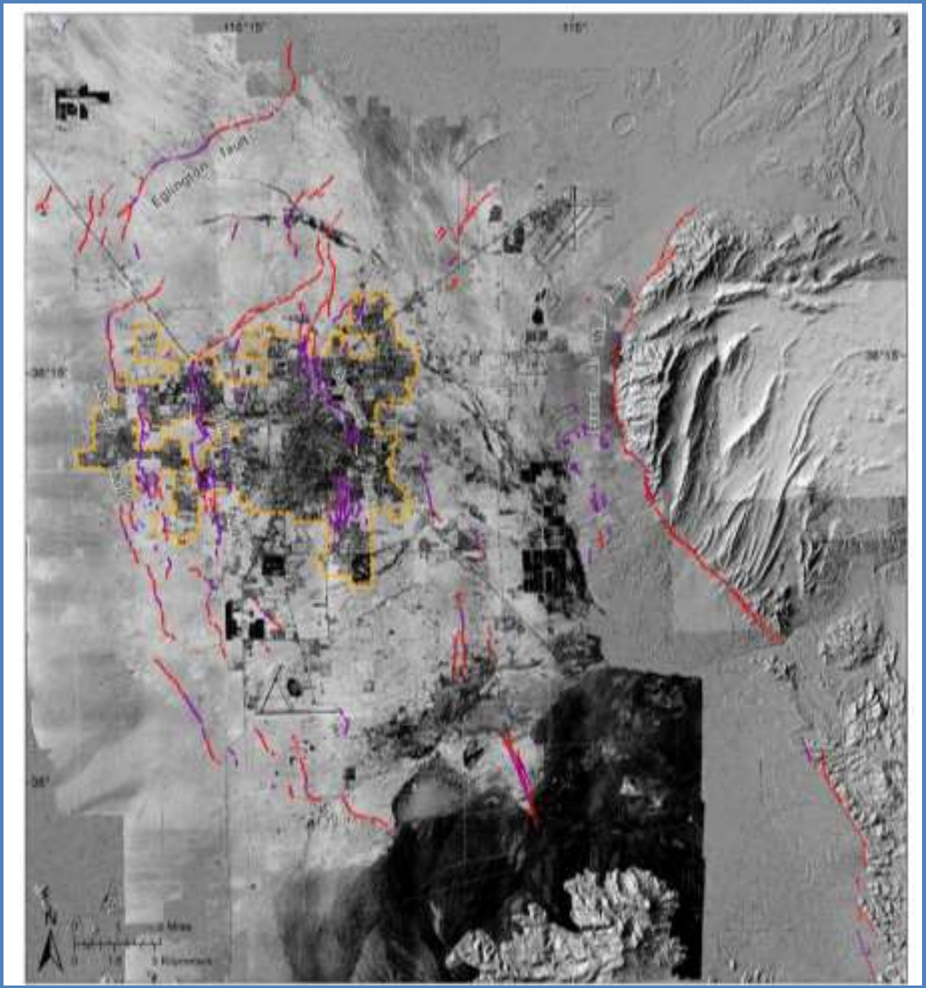
Petersen Mountain fault




hangingwall soil
PM Trench Soil Profile
Particle Size by Percentage
% of silt and clay
25 30 35 40 45 50
0 10 20 30 40 50 60 70 80 90 100 110
Depth of soil from surface (cm)
Northwall Footwall
Northwall Hangingwall
footwall soil


B
boulder alluvium
weathered bedrock

Las Vegas Valley Fault Study

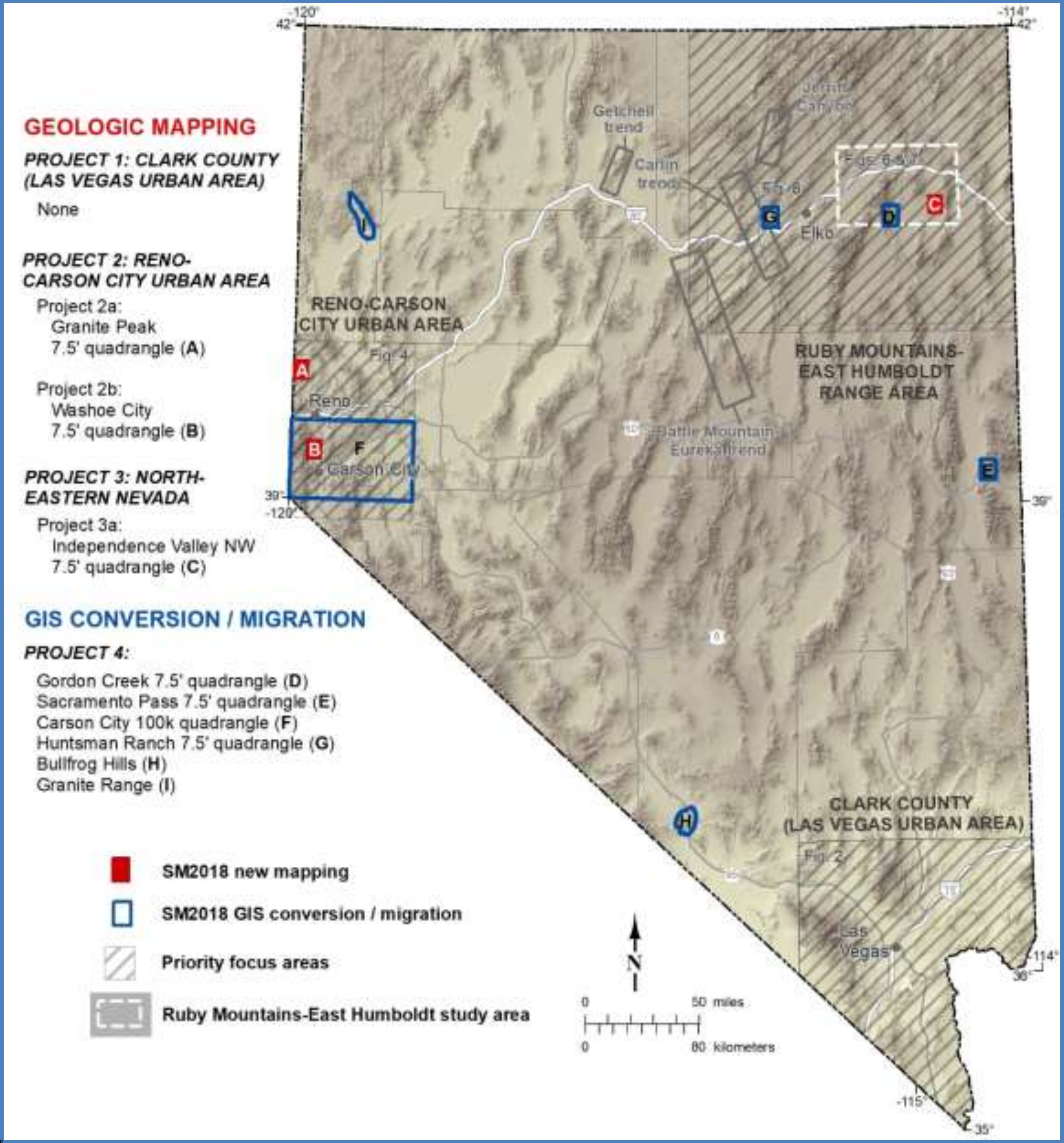


Updated Las Vegas Valley fault mapping

Lee Liberty (NEHRP support) to conduct seismic reflection survey of faults
Seth and Lee in Vegas
selecting survey locations this Friday (2/7).

- 5-year study (2016-2021) to characterize the seismic hazards of the Las Vegas Valley, Clark County Building Department
- Evaluation of differential compaction potential across LV scarps
  Status: Wanda Taylor / Shaimaa Abd El Haleem PhD in progress
- Las Vegas fault system scarp profiling using 1965 SFM topography
  Status: 100+ scarp profiles complete
- Lidar mapping, slip rate and fault recurrence of the Frenchman Mountain fault
  Status: complete pending final OSL dates
- Paleoseismic trenching of the Eglington warp
  Status: trenching complete, FTR submitted, pending OSL dates
- New Quaternary geologic map compilation of the LV Basin
  Status: in progress, complete mid-2020

2018 STATEMAP Deliverables



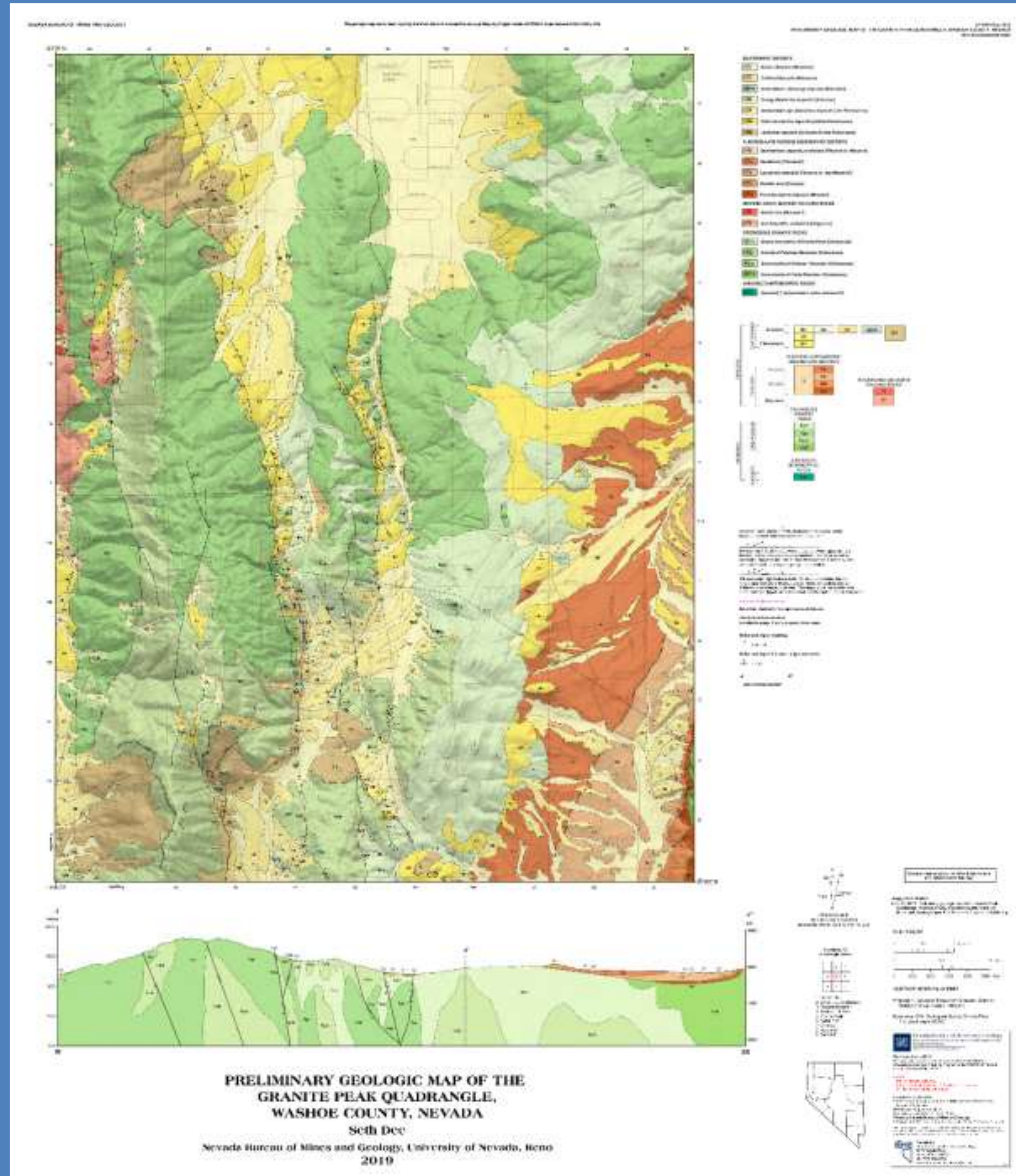
2018 STATEMAP–Funded July 2nd, 2018 ($164,518)

Submitted to USGS October, 2019

Nevada Bureau of Mines and Geology
University of Nevada, Reno

Geologic Mapping Program StateMAP

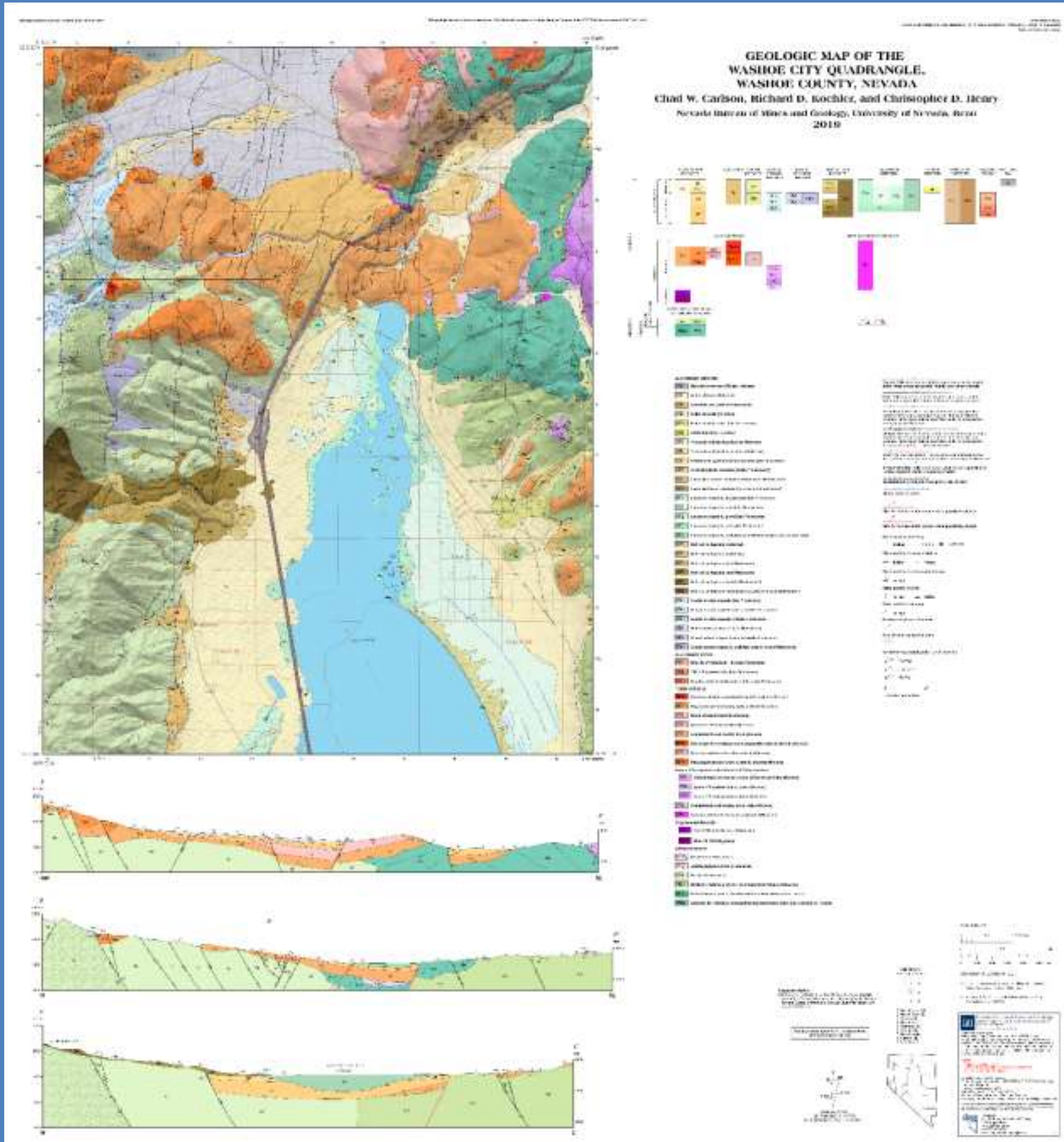
Granite Peak quadrangle



Nevada Bureau of Mines and Geology
University of Nevada, Reno

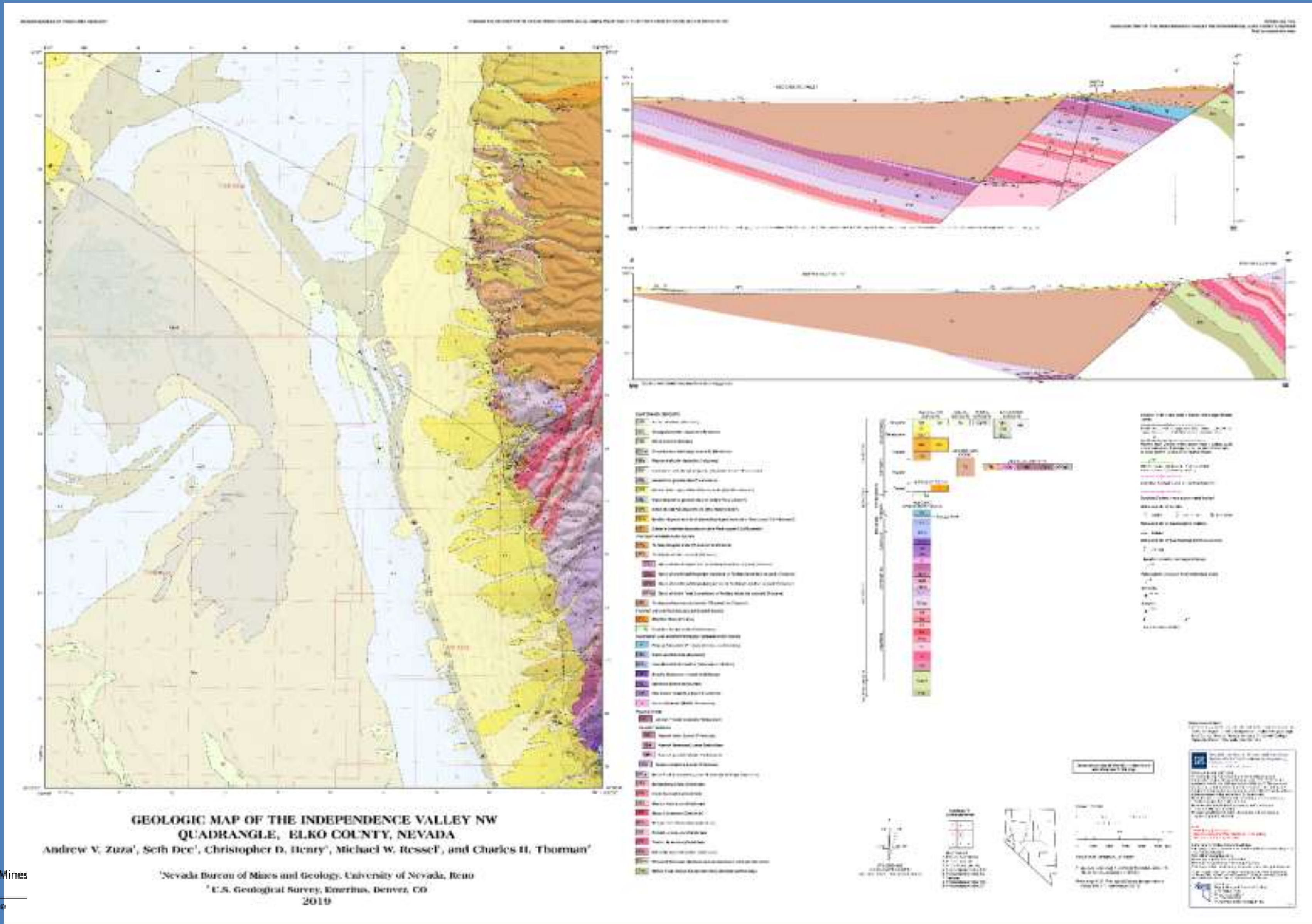
Geologic Mapping Program StateMAP

Washoe City quadrangle



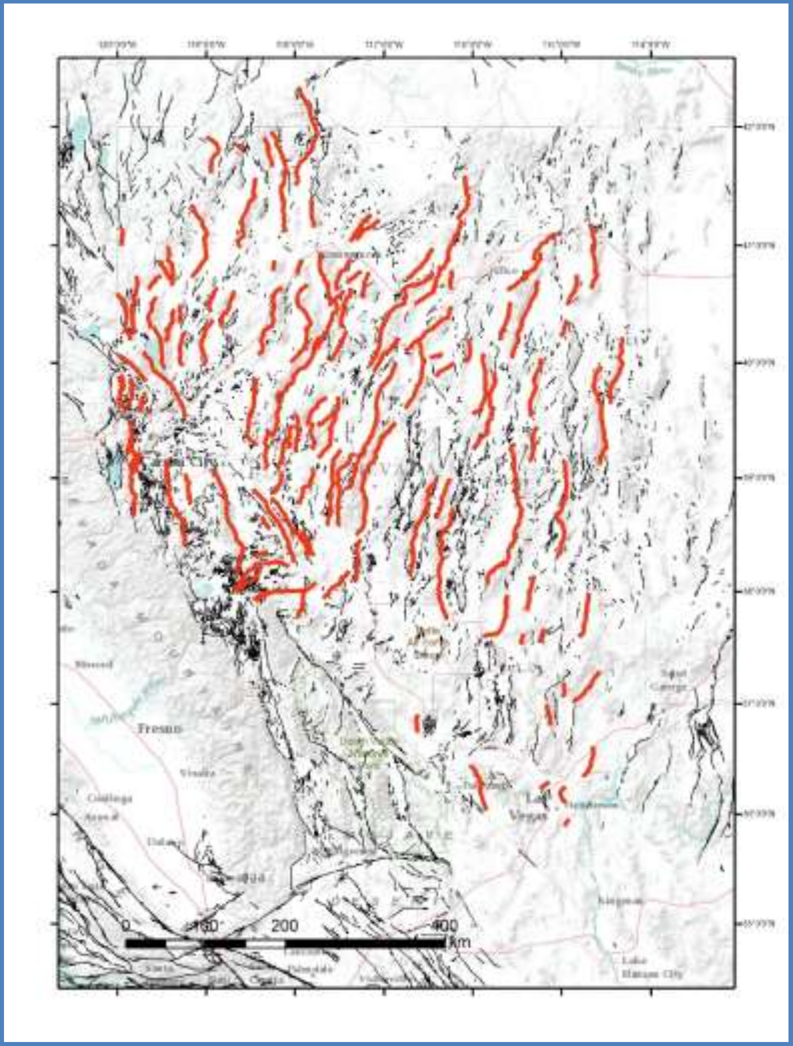
Geologic Mapping Program
StateMAP

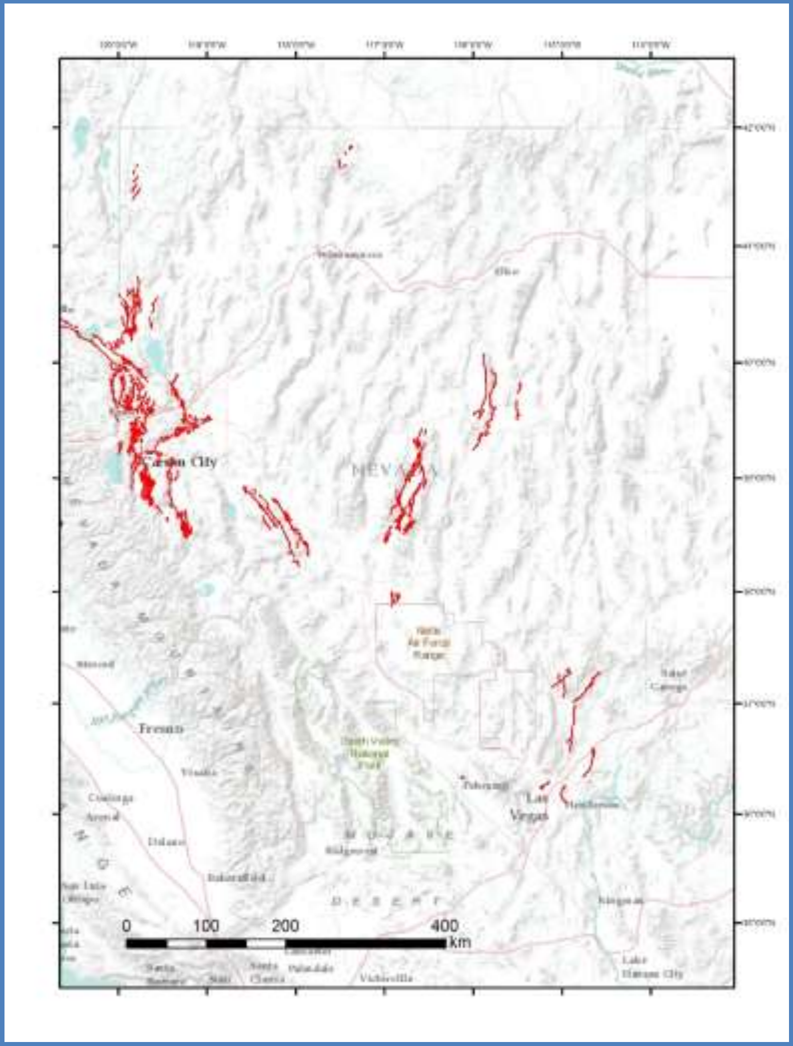
Independence Valley NW quadrangle



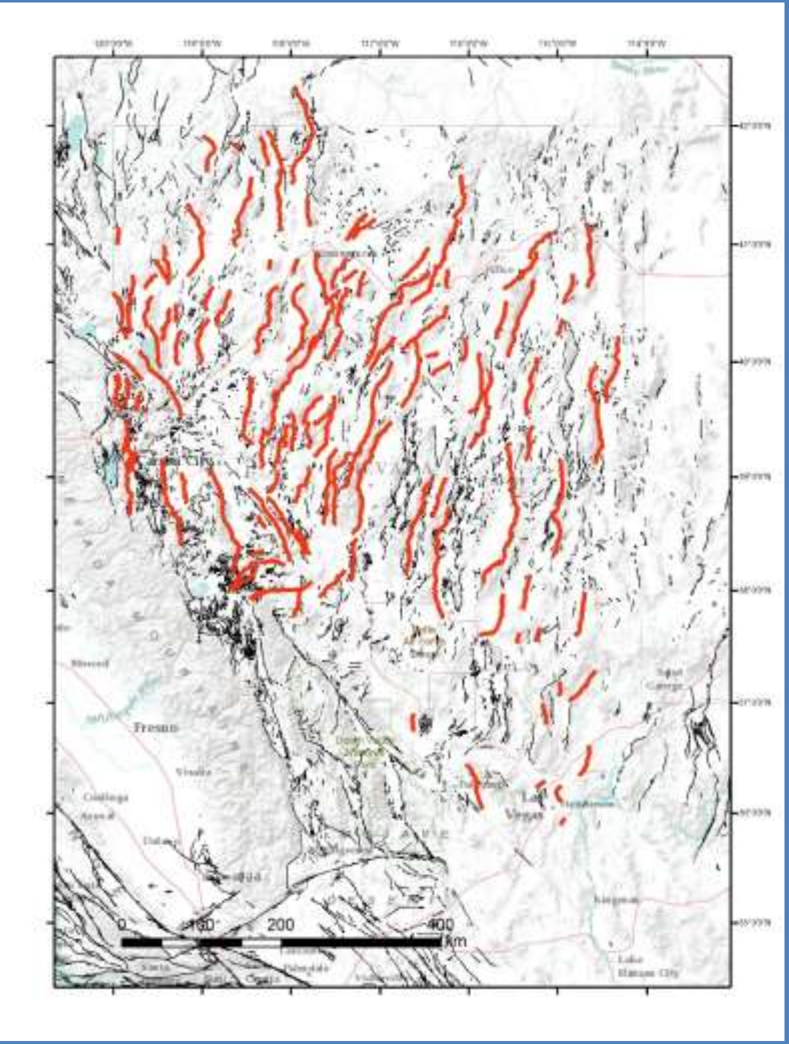
Nevada Bureau of Mines and Geology
University of Nevada, Reno

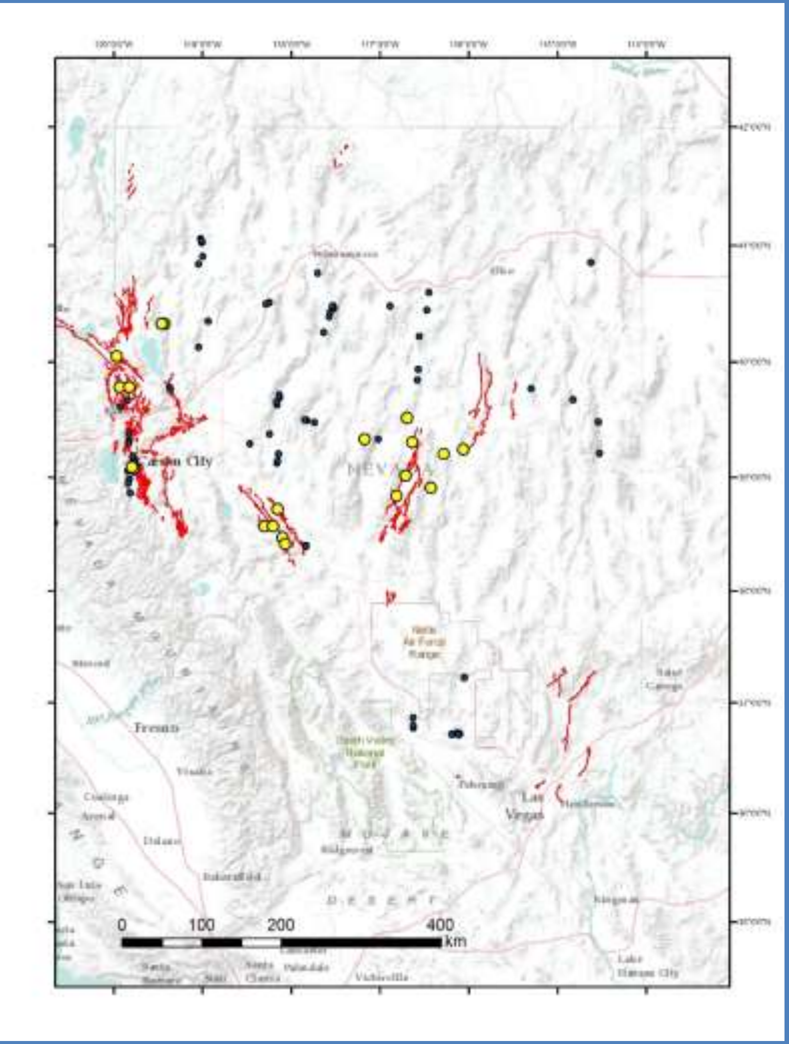
Communication with USGS on NSHM updates



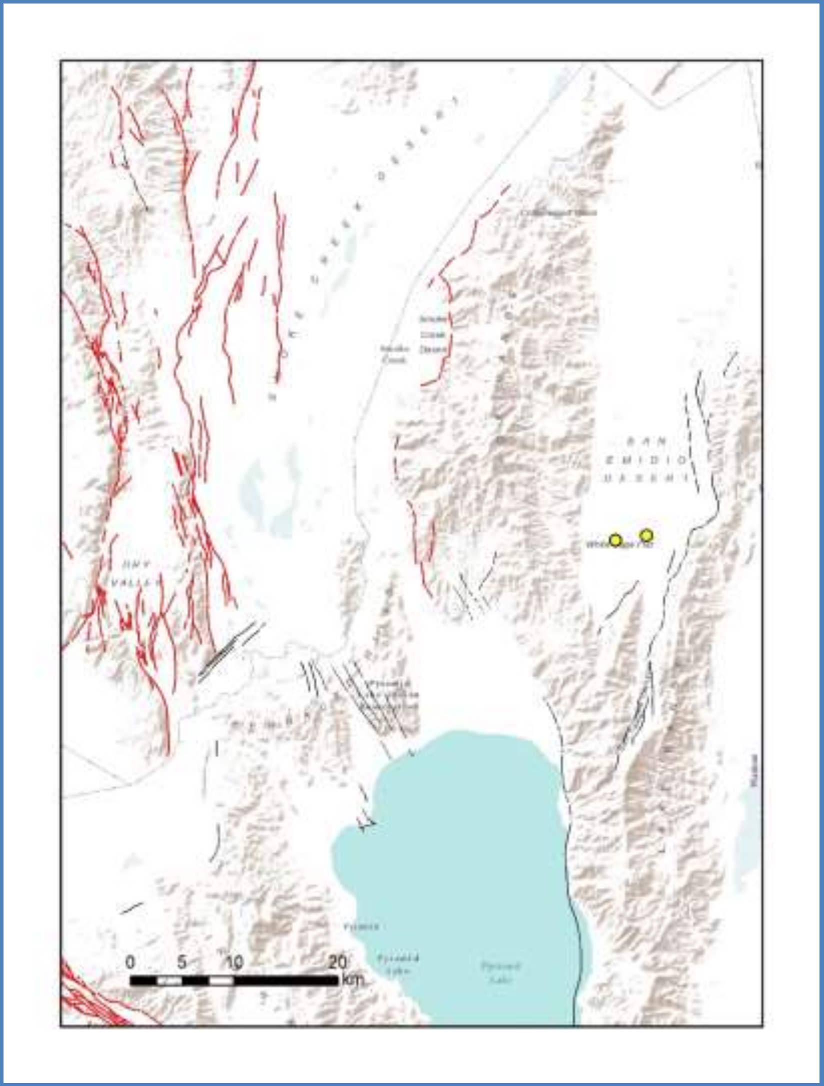


Communication with USGS on NSHM updates

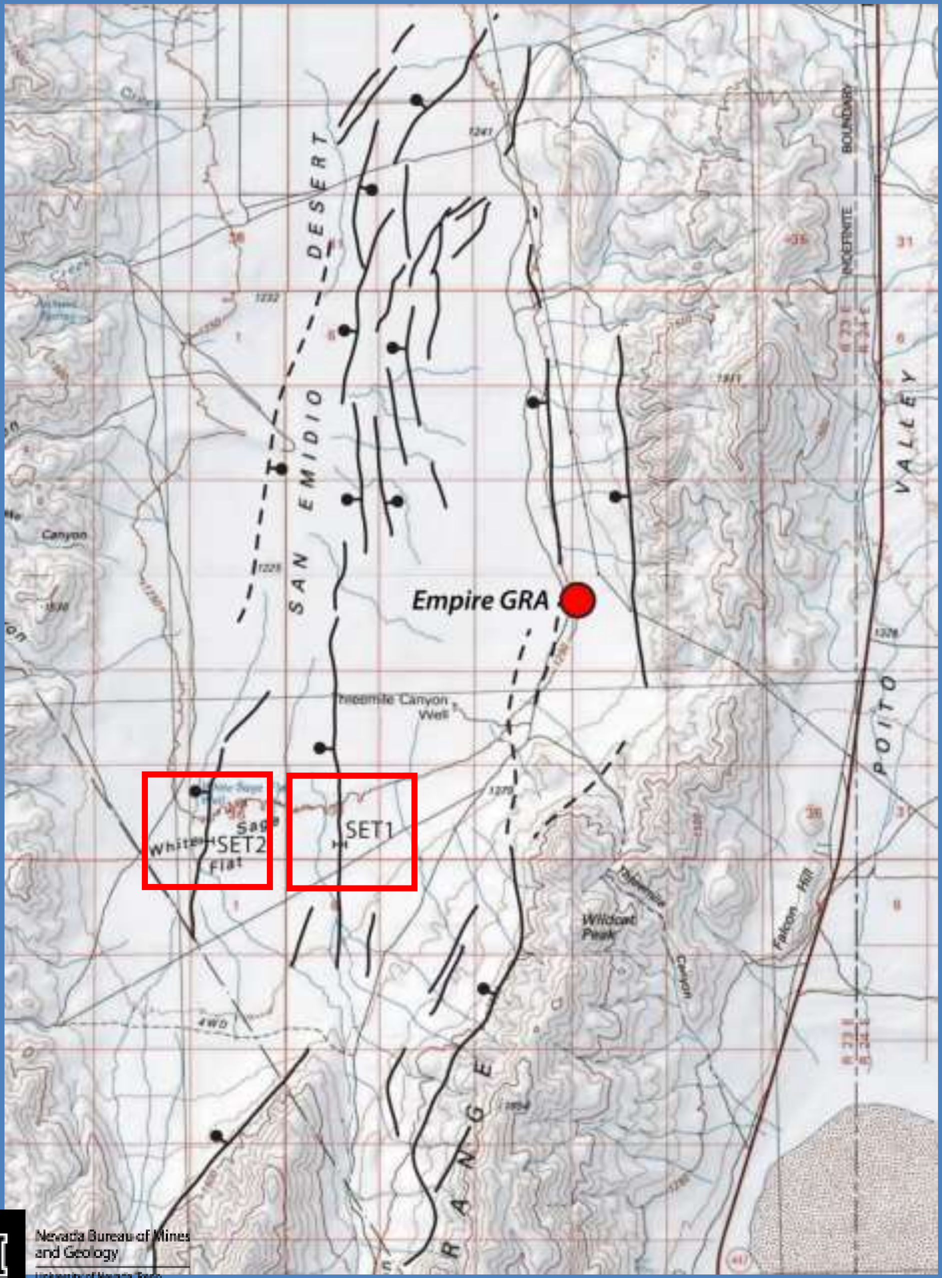


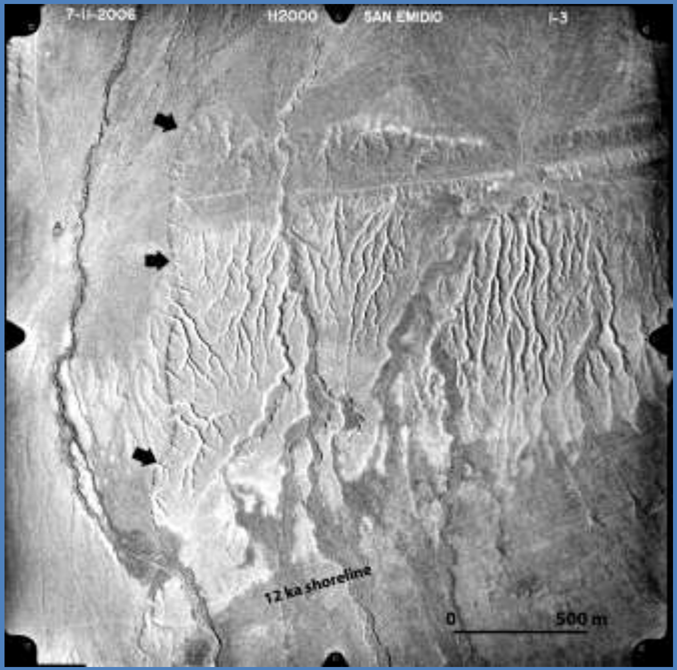


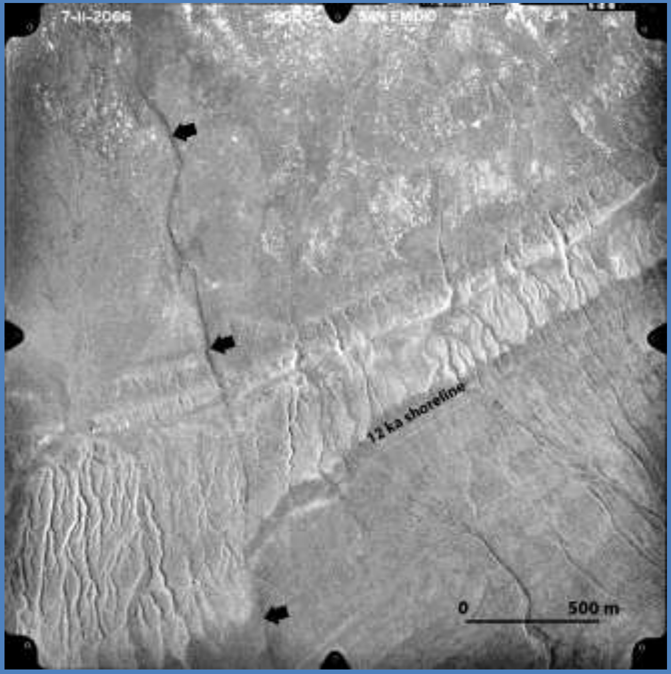
Other studies



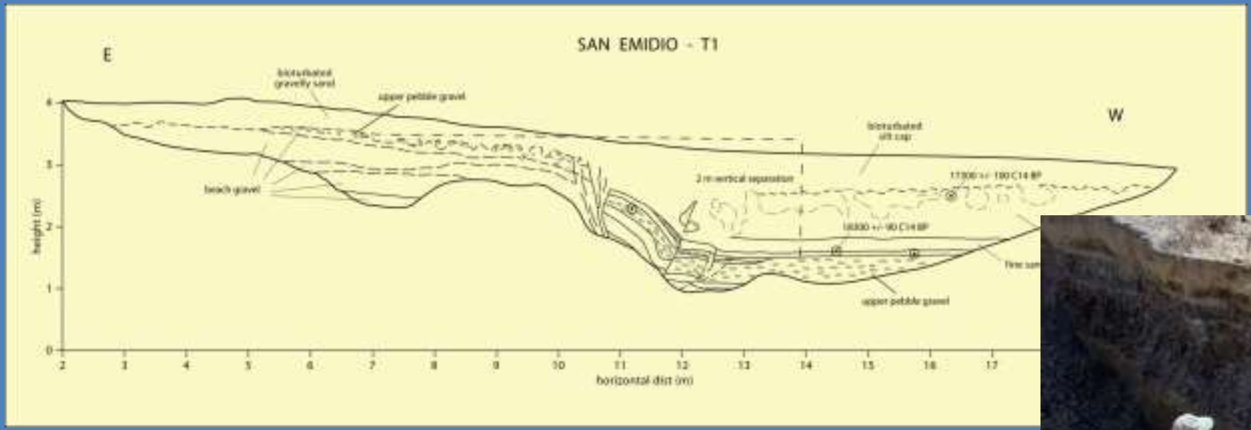
San Emidio fault zone



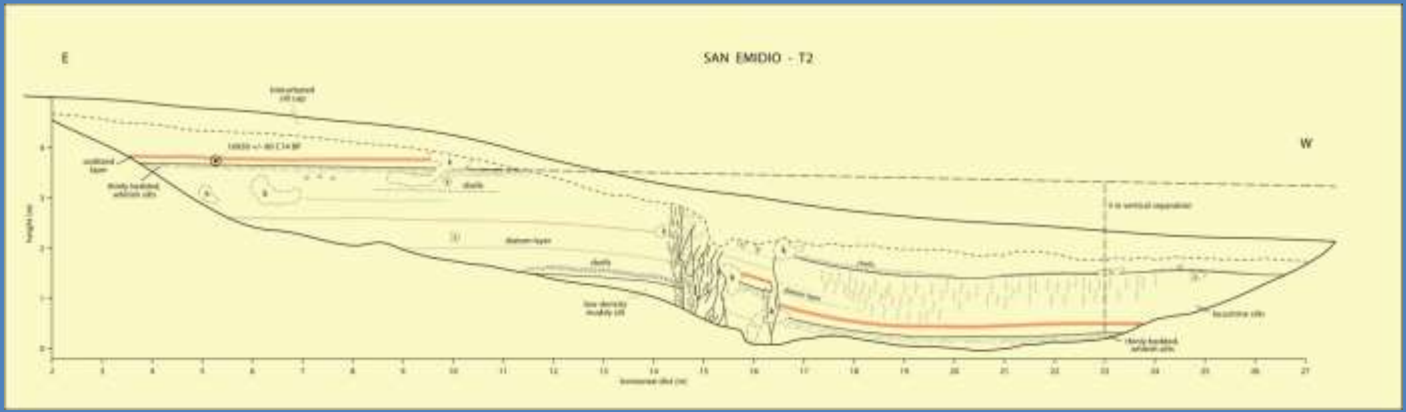




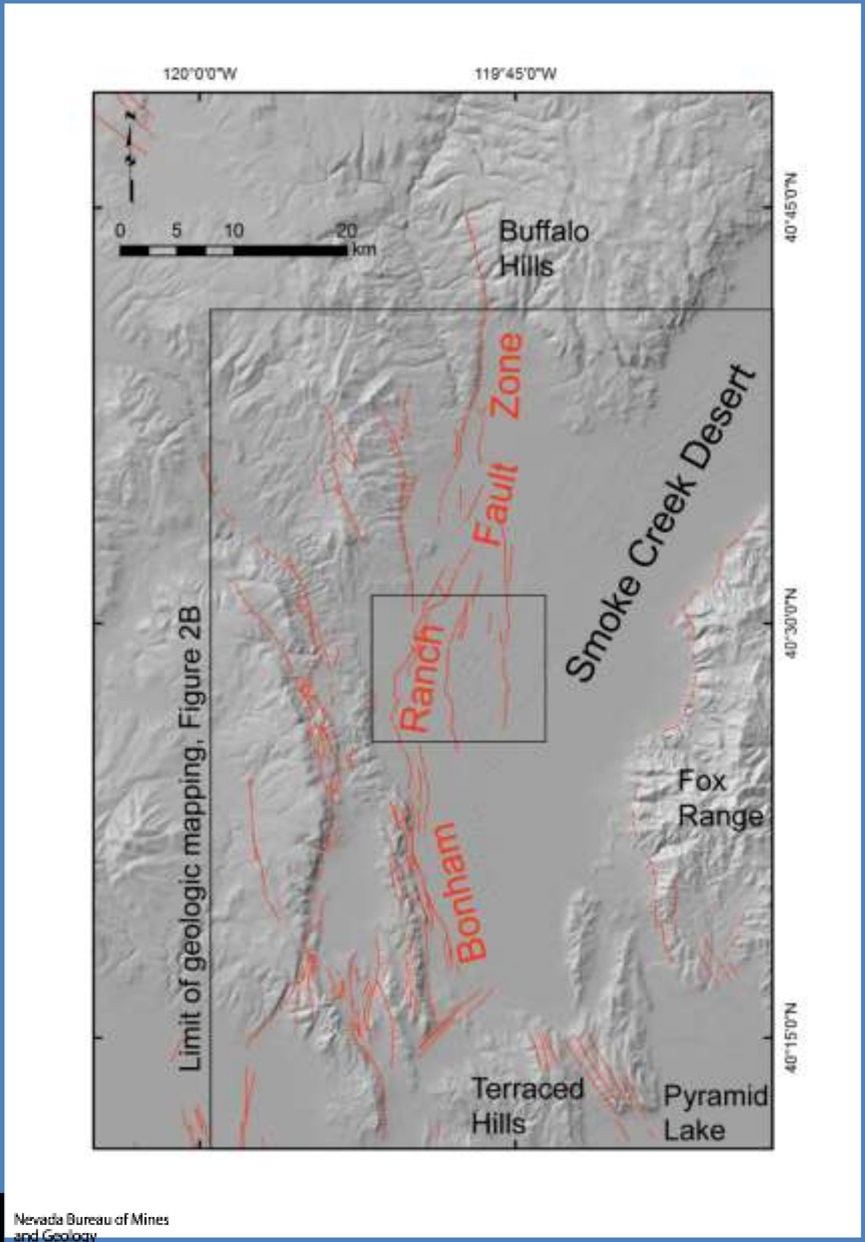
San Emidio fault zone

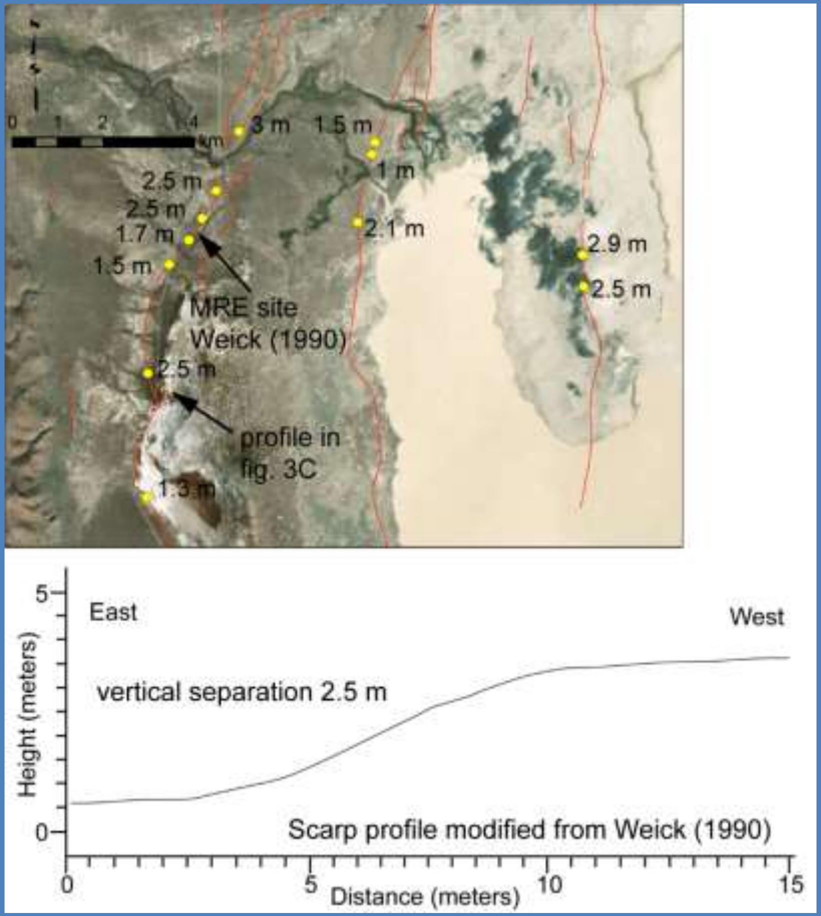


Trenches and C14 dates indicate
Post late Pleistocene faulting

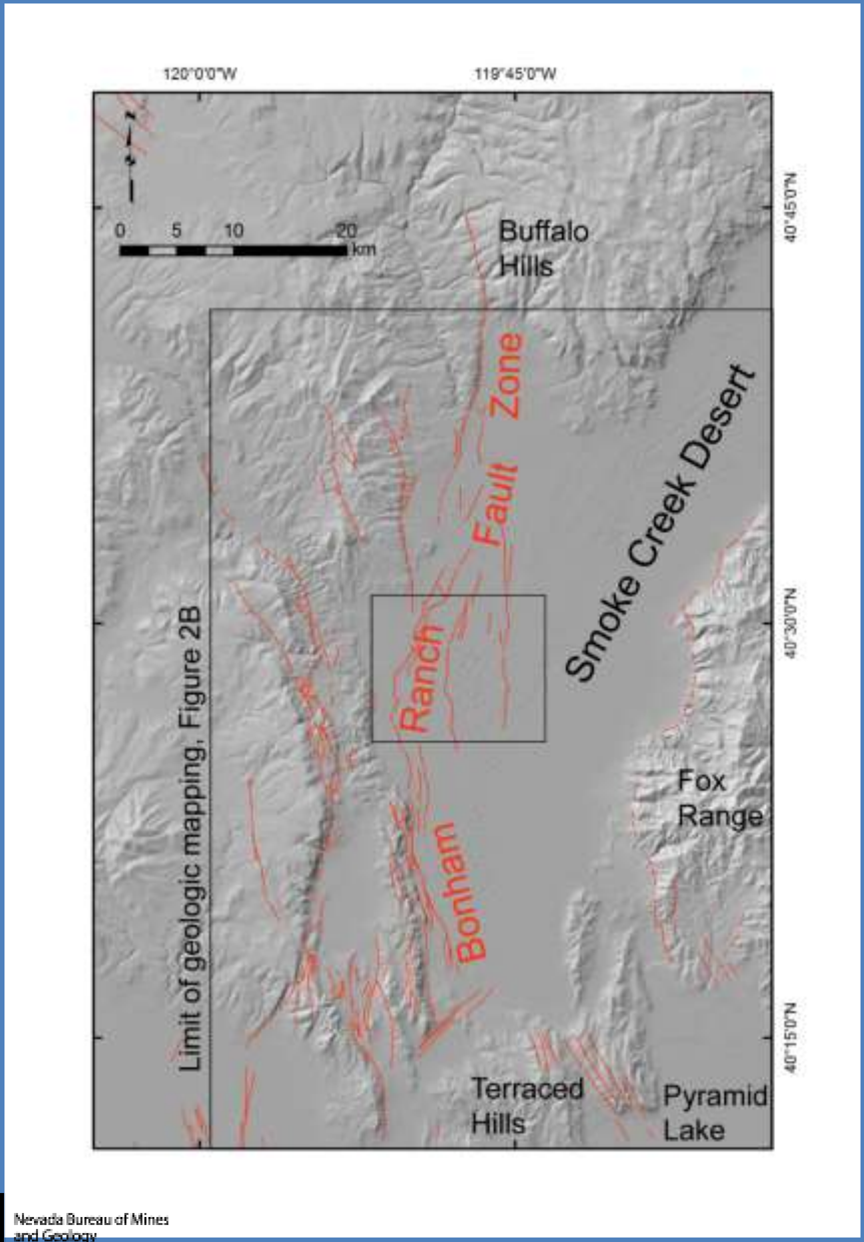


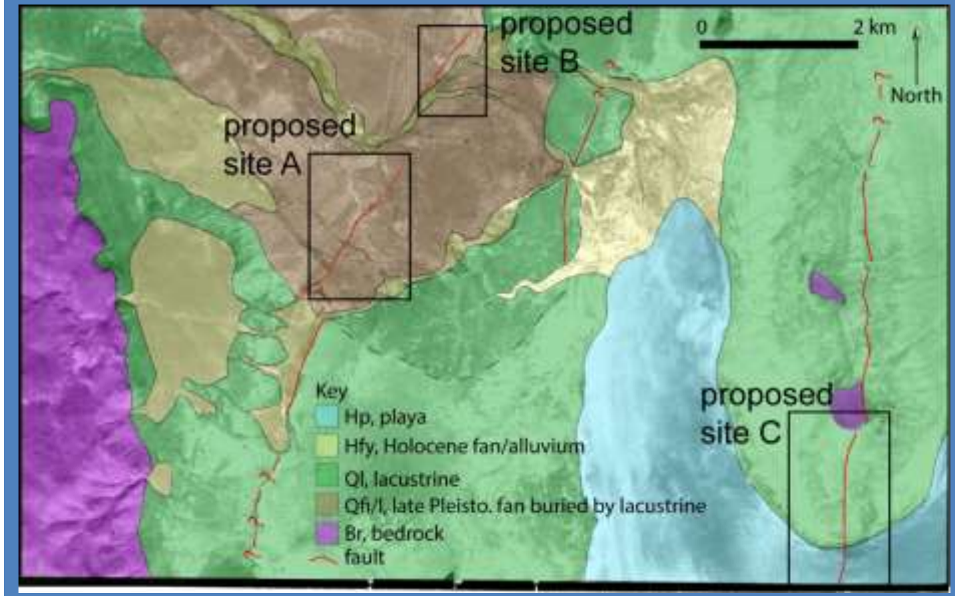
Bonham Ranch fault zone





Bonham Ranch fault zone





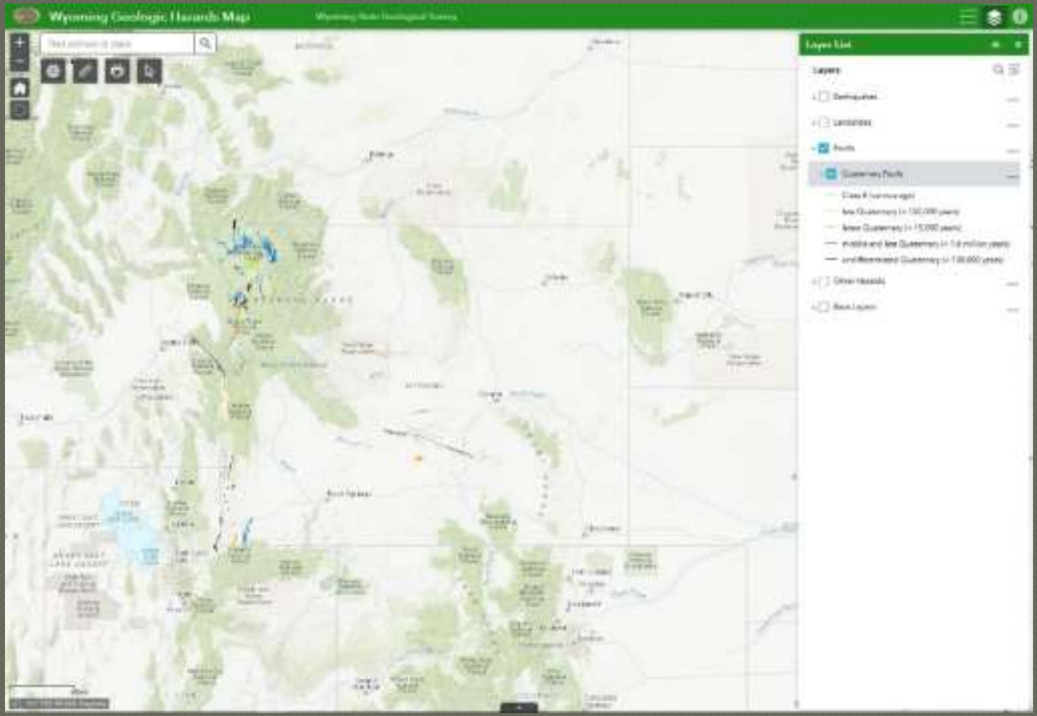

Thanks!
Nevada Bureau of Mines and Geology

Issues Facing Wyoming

Seth Wittke
Wyoming Geological Survey
BRPEWG - 2020

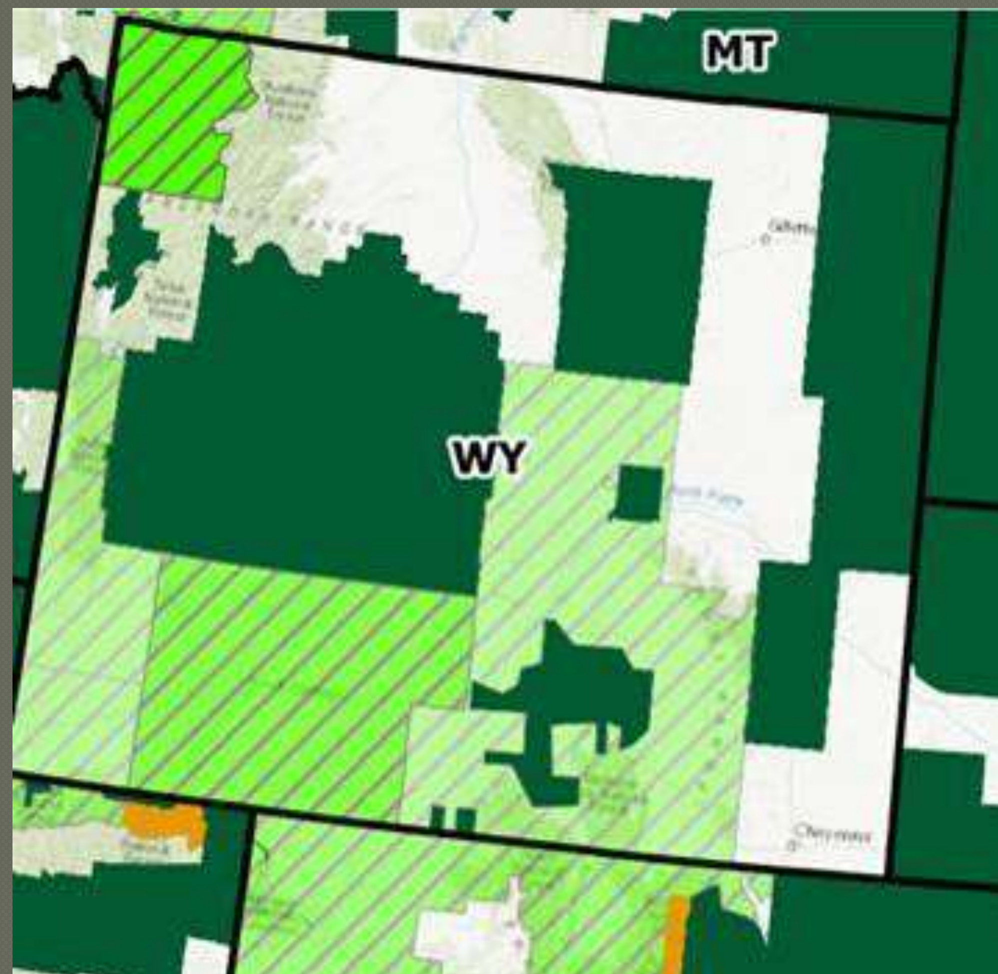
Quaternary-aged Fault Database

- WSGS does not currently have it's own fault database
  - We have enough new data to start developing one
- WSGS Geological Hazards Map
  - Multiple hazards
  - Currently using USGS fault data



LiDAR

- Until 2019 coverage was sparse
  - FEMA funded 6 counties (Drk Green)
  - 2020 will add 6 more (striped)
- Will cover 95% of faults
- Changes everything



Access

- For the most part access is good
  - A few locations have proven difficult

Public Knowledge/Perception

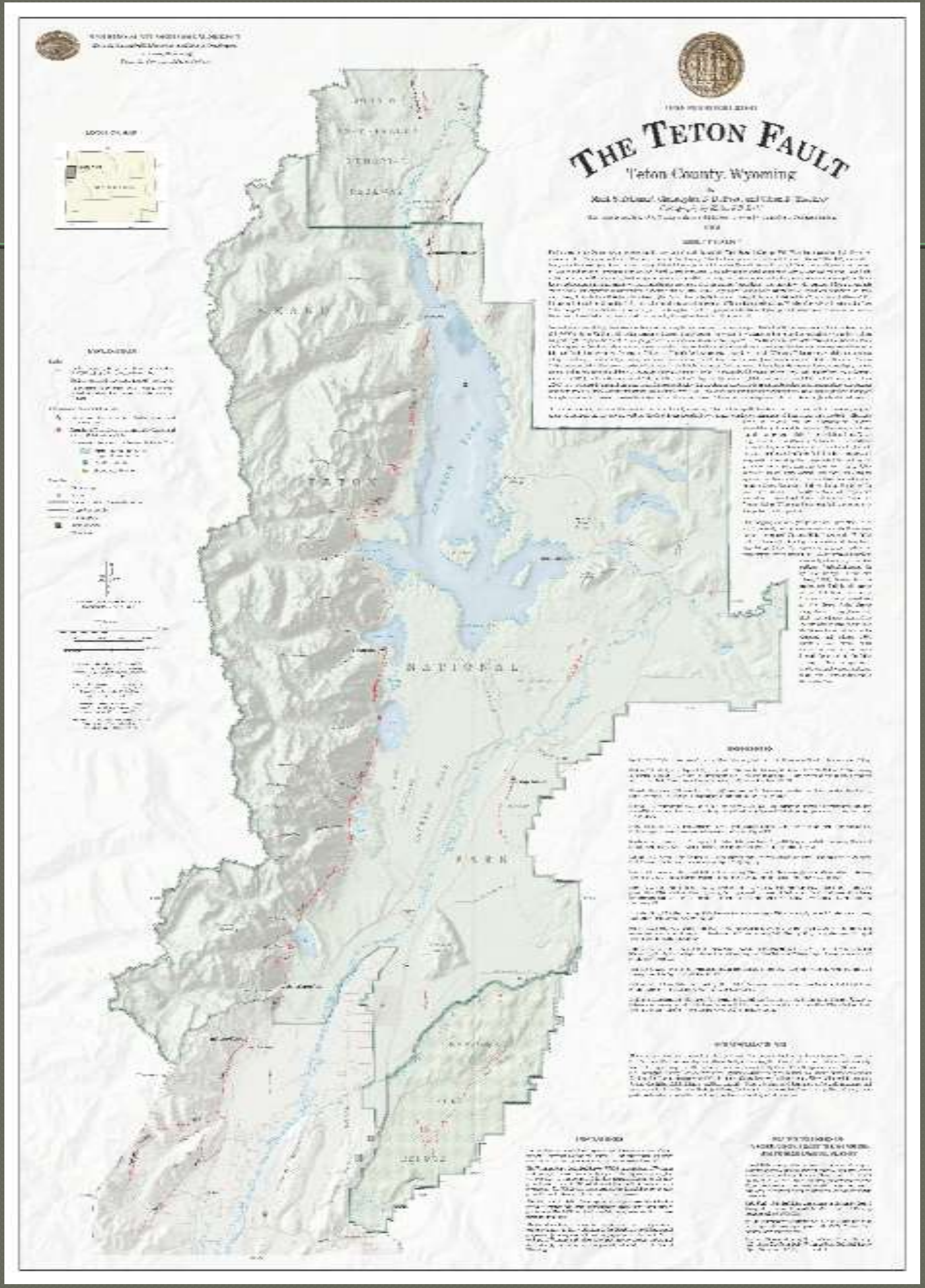
- Driven by a number of factors
  - Low population
    - Creates numerous difficulties
  - Lack of historic events
    - Makes this a low priority
  - Combined, it has proven difficult to get local/state buy-in or interest

Random Thoughts

- Consistency across state lines
  - Data and data format
    - GeMS?
  - Methods
  - Mapping
  - Good working relationships
- Also being consistent with non-state entities
- Effective communication with the public
  - How do we make the information understandable?

Update

- Teton Fault Map!



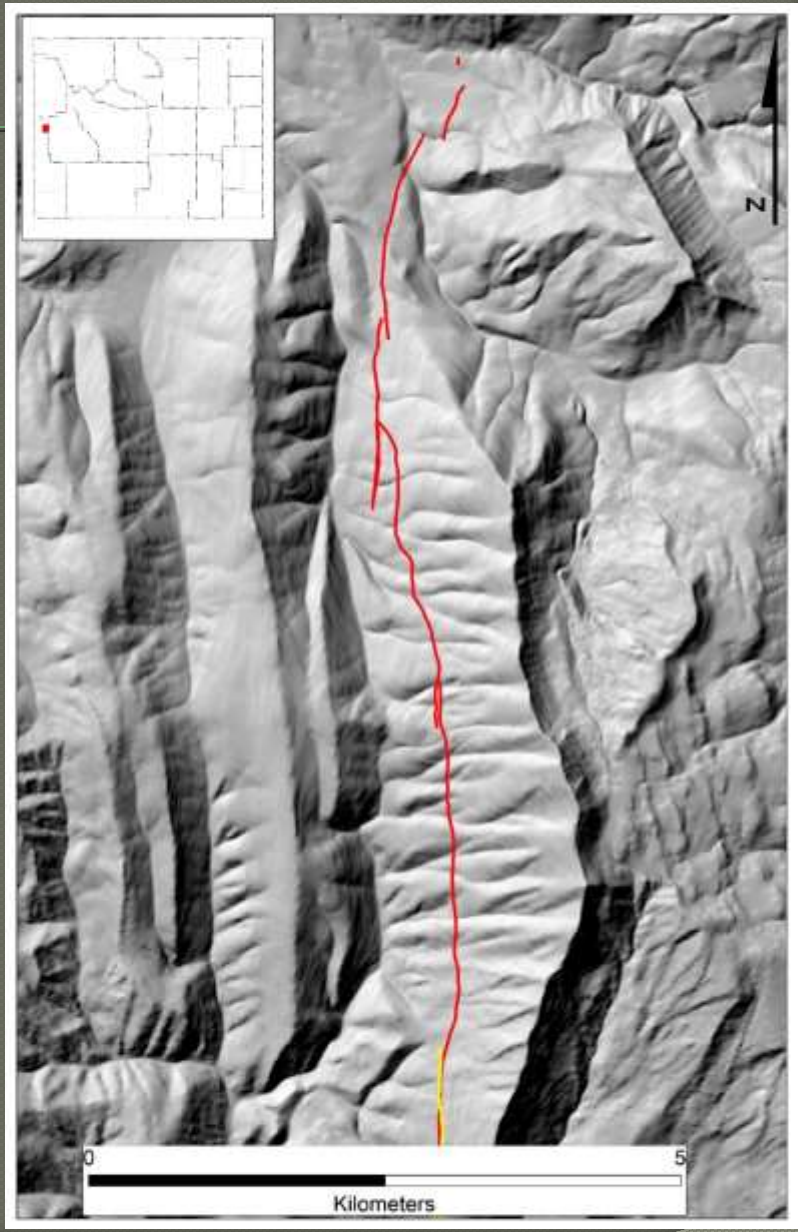
Ski Lake

- Summer 2019
  - Phillips Valley fault
  - Two trenches
  - Glacial till/moraine

- Continued work of numerous groups

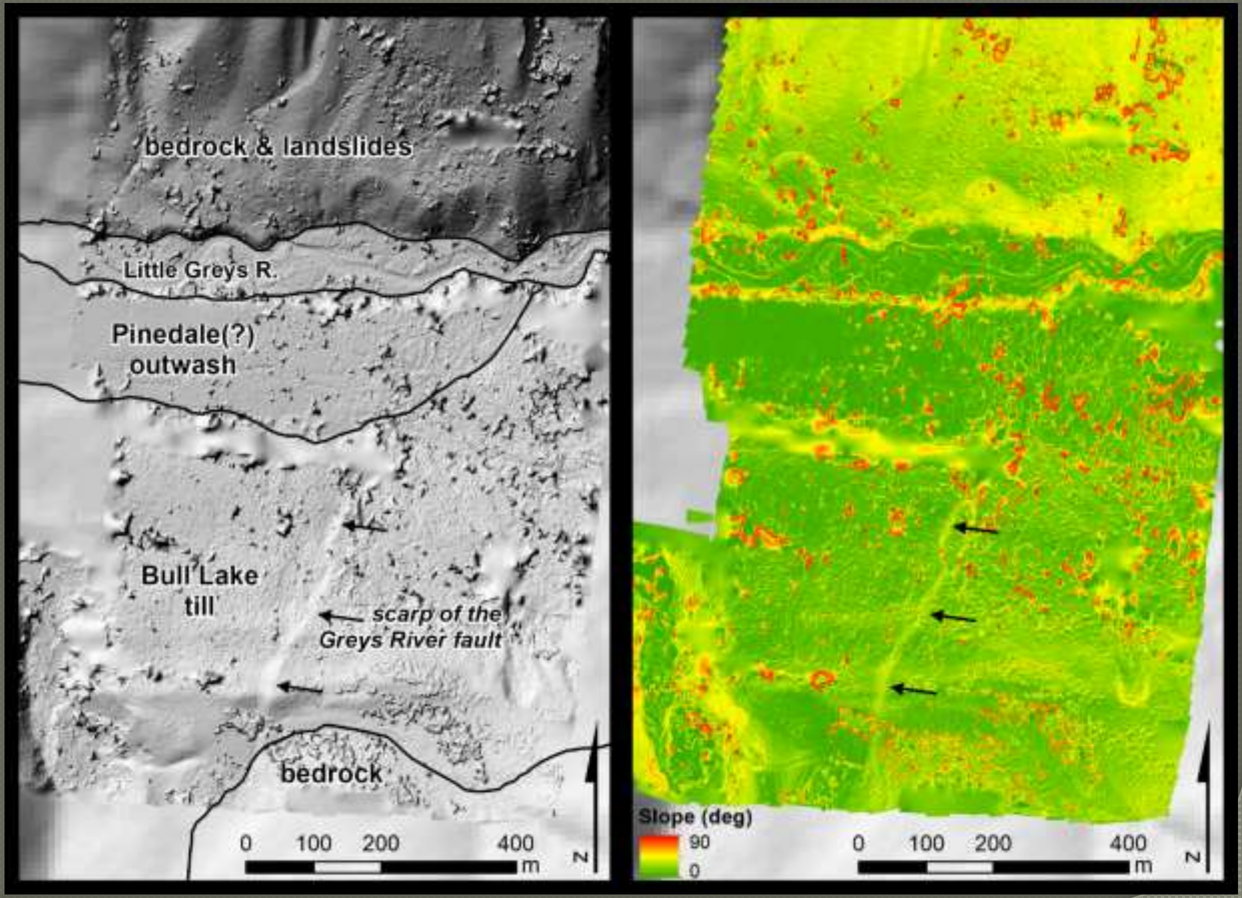
Greys River fault

- Unmapped northern extent recognized in 2016
  - Fault trace previously ended at a map boundary
  - Have extended the trace ~10km to the Little Greys River



Greys River fault

- UAV campaign to help constrain the fault trace
  - Worked with WyGISC
  - Mixed results in steep heavily forested areas
  - Still provided valuable data



Summary

- Issues in Wyoming
  - Lack of in-house (or updated) q-faults database
  - LiDAR coverage
  - Land access
  - Buy-in
- New work
  - Teton fault map
  - Greys River
  - LiDAR acquisition

Thank You

Questions?

BASIN AND RANGE PROVINCE EARTHQUAKE WORKING GROUP
Utah Update

Emily Kleber, Greg McDonald, Adam Hiscock, Steve Bowman

Wednesday, February 5, 2020

Utah Geological Survey
Geologic Hazards Program

UGS Hazards Program

- 1 Program manager – Steve Bowman
- 6 geologists – Jessica Castleton, Ben Erickson, Rich Giraud, Adam Hiscock, Emily Kleber, Tyler Knudsen
- 1 Joint position Geologic Mapping Program – Geologic Hazards Program – Adam Mckean
- 1 GIS manager – Gordon Douglass
- 2 student intern positions –nd Brigham Whitney (UVU) and Liz Williams (Weber State)
- Additional project support by Bill Lund (Emeritus) and Mike Hylland (UGS Deputy Director)

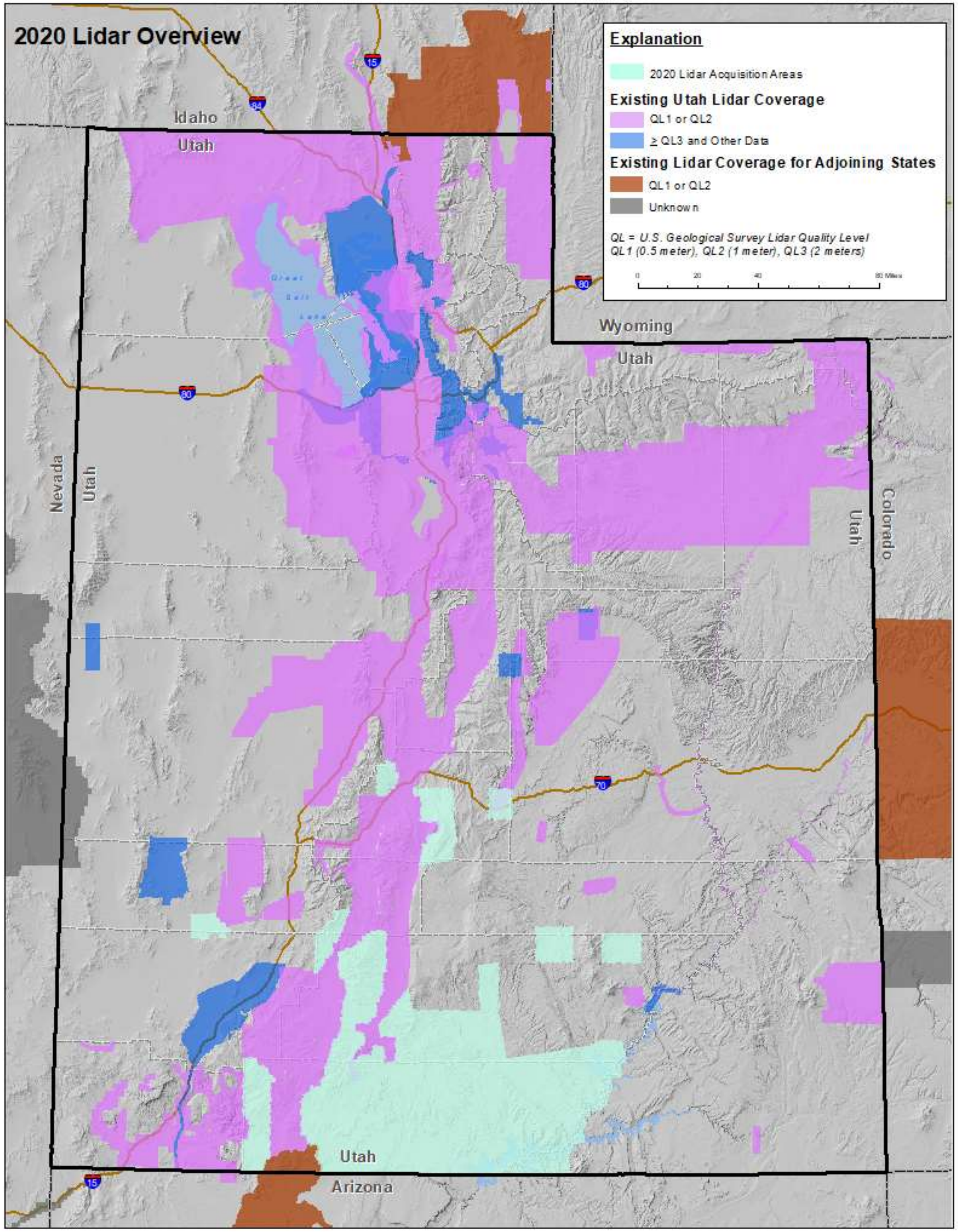
Ongoing NEHRP Collaborative Proposals and Work

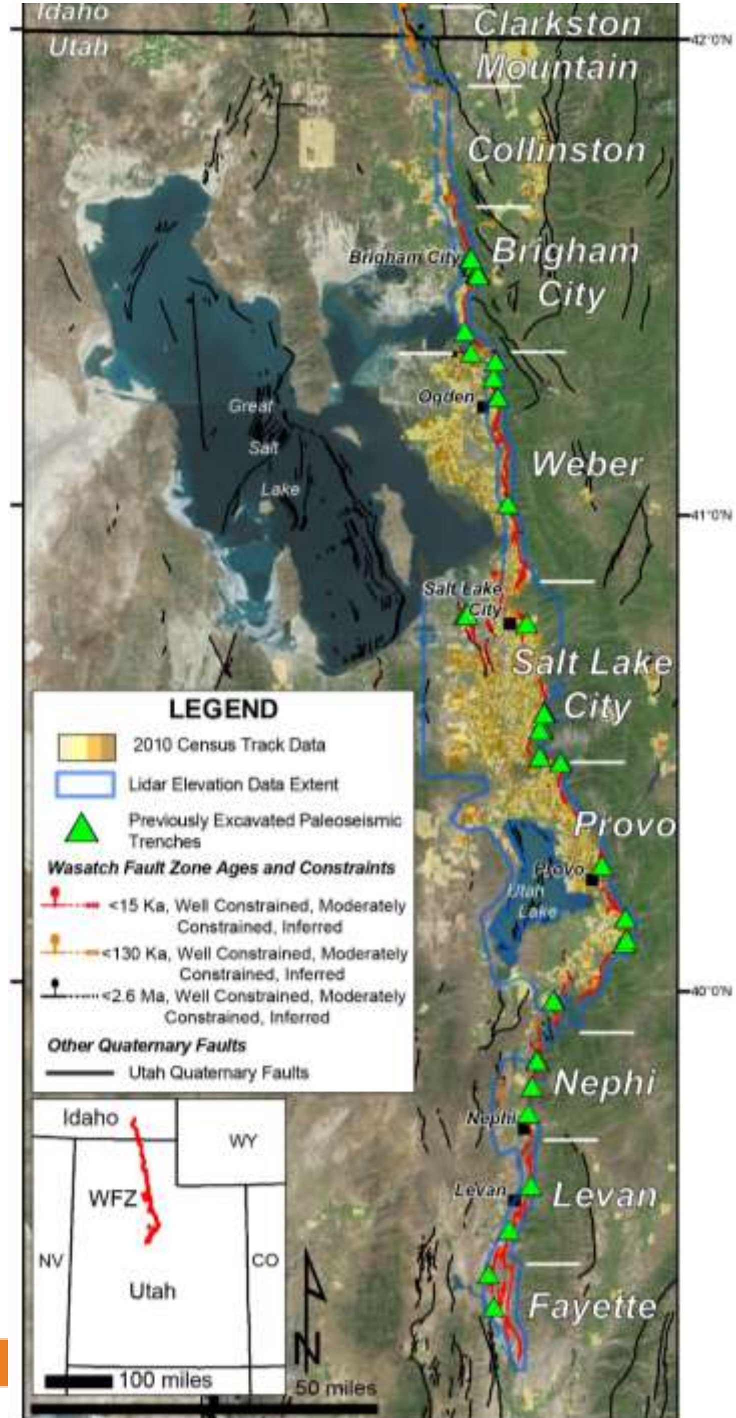
- **Cache Valley Fault Mapping – East Cache and West Cache Fault Zones (FTR due June 2019)**
  - Collaborating with Susanne Janecke and Bob Oakes of Utah State University
- **Collaborative proposal with the Idaho Geological Survey mapping the Bear Lake Faults, Oquirrh faults and Topliff hills faults (FTR due September 2019)**
  - Collaborating with Mike Bunds and Nate Toke of Utah Valley University
- **Collaborative proposal with Arizona Geological Survey – Washington, Hurricane, Sevier, and Toroweap faults (FTR Due March 2021)**
- **Basin and Range Province Earthquake Working Group Meeting and updates to the Utah Quaternary fault database (FTR due March 2021)**

Lidar

- **Multi-agency partnerships are key to lidar acquisition success in Utah.**
- Data is extensively reviewed in house.

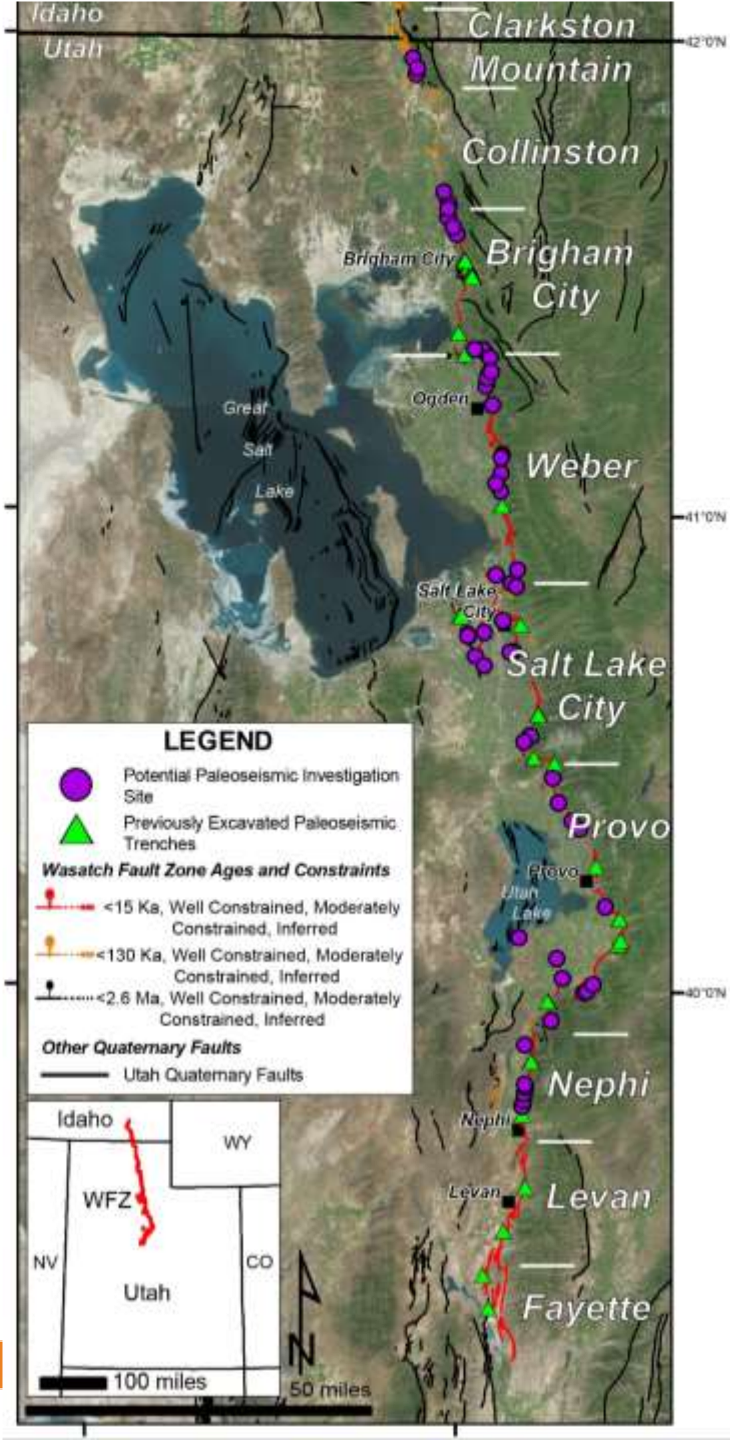
UTAH AGRC



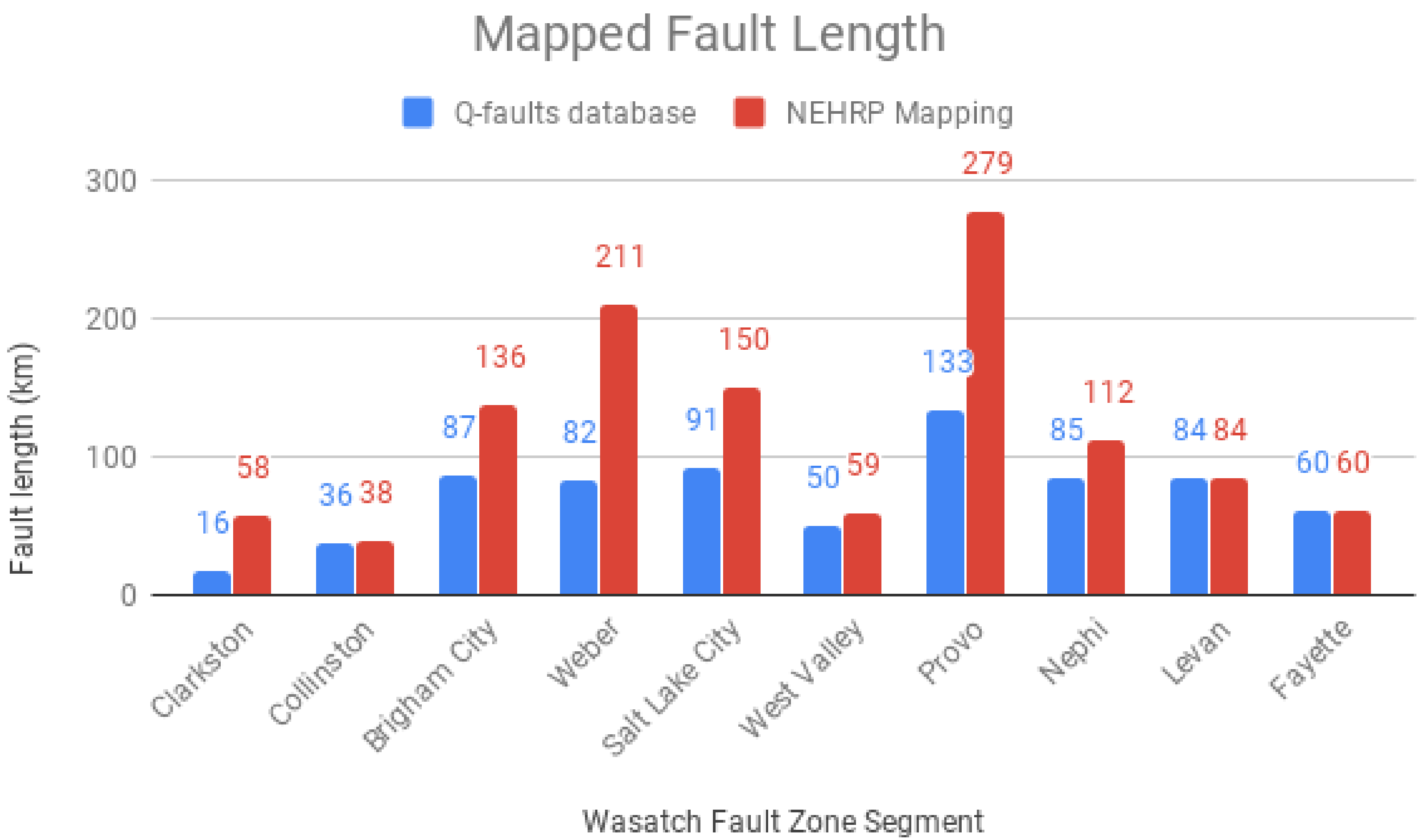


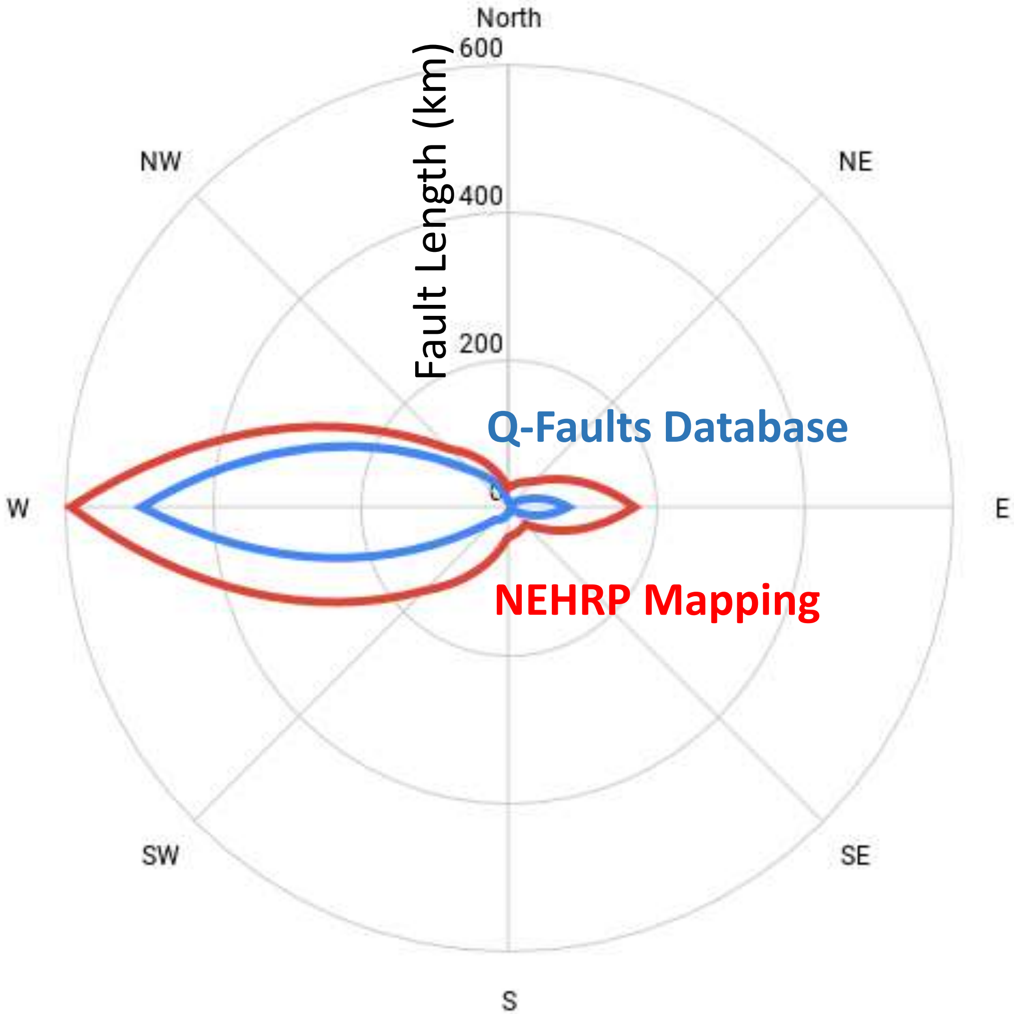
Idaho
Utah
Clarkston Mountain
Collinston
Brigham City
Brigham City
Ogden
Weber
Great Salt Lake
Salt Lake City
Salt Lake City
Provo
Provo
Utah Lake
Nephi
Nephi
Levan
Levan
Fayette
42°0'N
41°0'N
40°0'N
LEGEND
2010 Census Track Data
Lidar Elevation Data Extent
Previously Excavated Paleoseismic Trenches
Wasatch Fault Zone Ages and Constraints
<15 Ka, Well Constrained, Moderately Constrained, Inferred
<130 Ka, Well Constrained, Moderately Constrained, Inferred
<2.6 Ma, Well Constrained, Moderately Constrained, Inferred
Other Quaternary Faults
Utah Quaternary Faults
Idaho
WY
WFZ
NV
Utah
CO
100 miles
N
50 miles

Wasatch fault

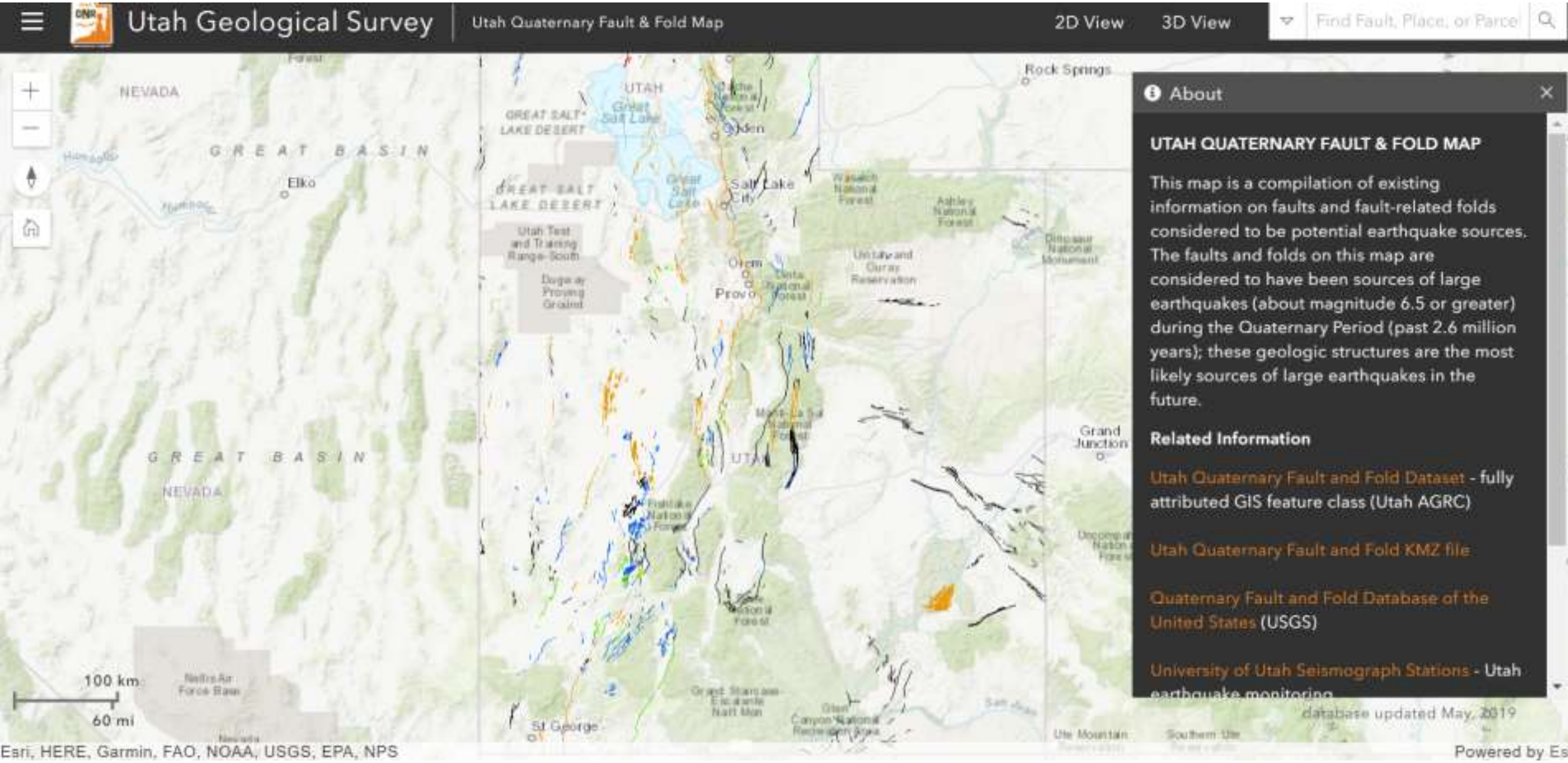


Results of Fault Mapping

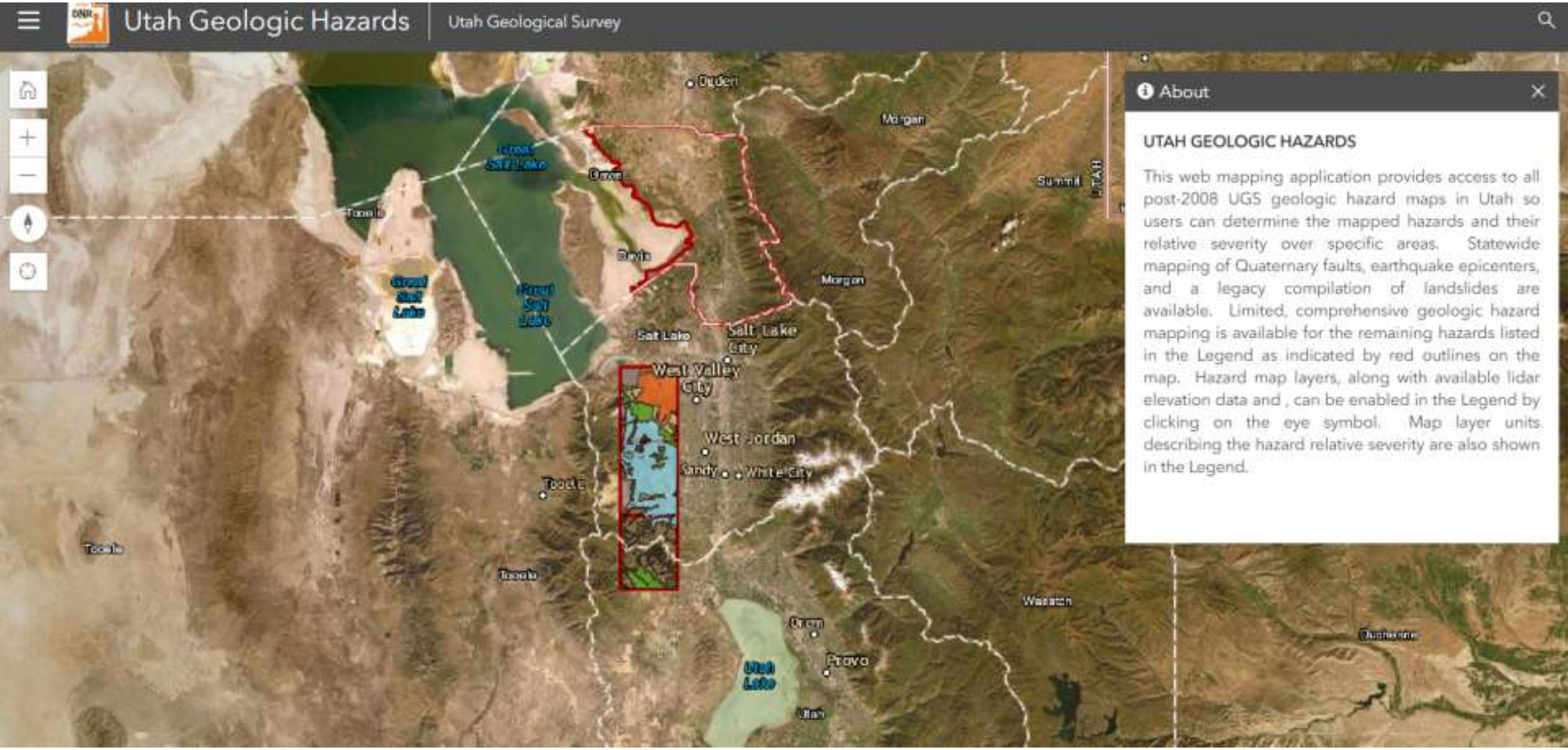




Dip Direction	Q-faults database (km)	NEHRP Mapping (km)
North	9	25
NE	7	48
E	82	171
SE	6	35
S	10	40
SW	24	162
W	496	592
NW	68	112

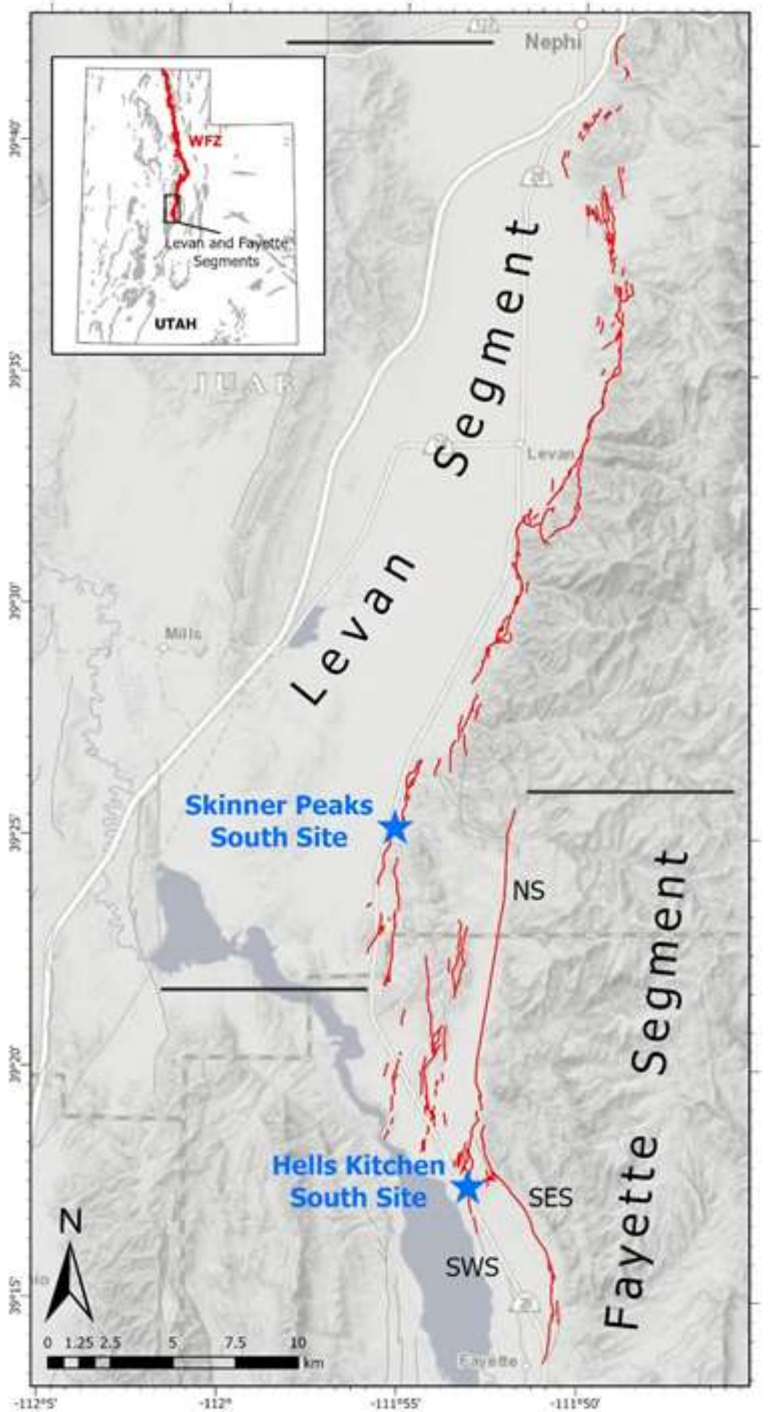

Utah Geological Survey
Utah Quaternary Fault & Fold Map
2D View
3D View
Find Fault, Place, or Parcel
About
UTAH QUATERNARY FAULT & FOLD MAP
This map is a compilation of existing information on faults and fault-related folds considered to be potential earthquake sources. The faults and folds on this map are considered to have been sources of large earthquakes (about magnitude 6.5 or greater) during the Quaternary Period (past 2.6 million years); these geologic structures are the most likely sources of large earthquakes in the future.
Related Information
Utah Quaternary Fault and Fold Dataset - fully attributed GIS feature class (Utah AGRC)
Utah Quaternary Fault and Fold KMZ file
Quaternary Fault and Fold Database of the United States (USGS)
University of Utah Seismograph Stations - Utah earthquake monitoring
database updated May, 2019
NEVADA
GREAT BASIN
Elko
GREAT SALT LAKE DESERT
UTAH
Great Salt Lake
Ogden
Salt Lake City
Orem
Provo
Rock Springs
Grand Junction
St George
100 km
60 mi
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS
Powered by Esri

Future home of Q-faults



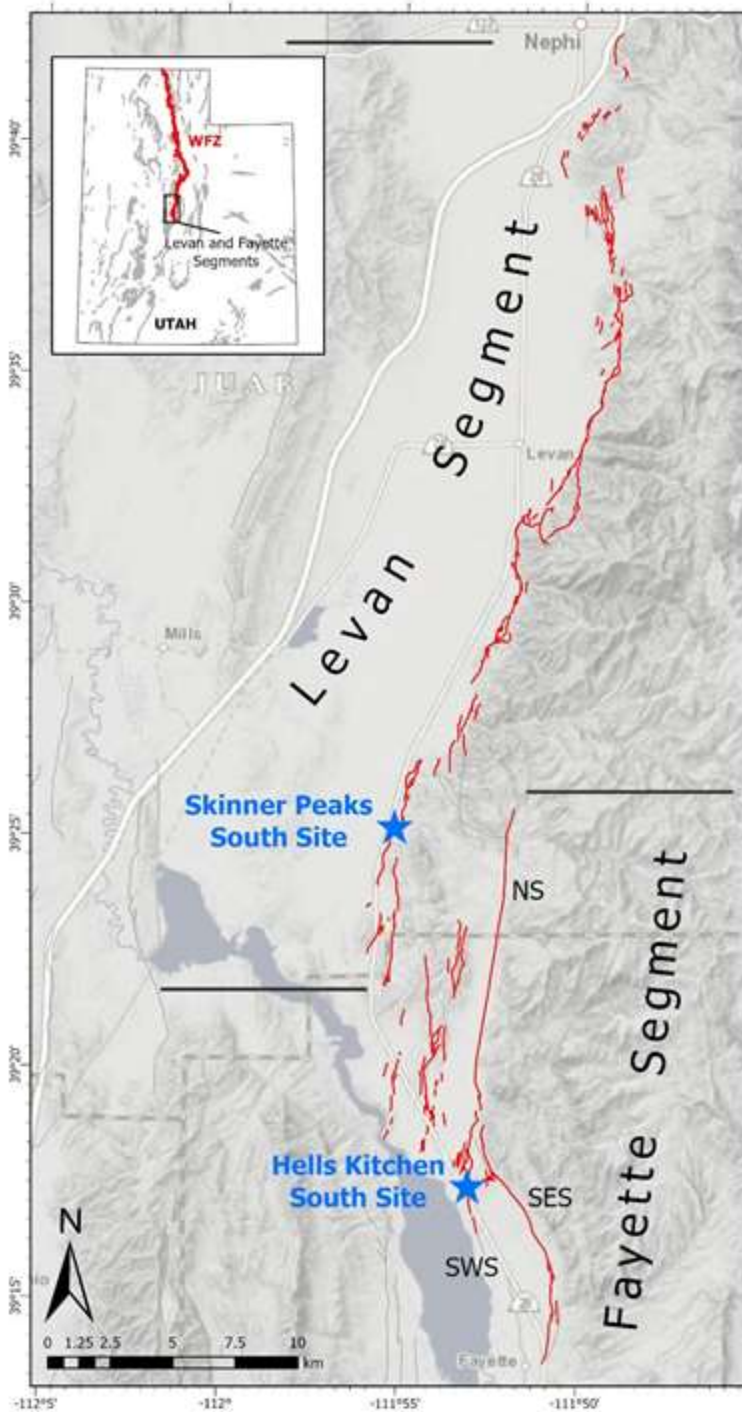
Levan/Fayette Trenching

- Skinner Peaks South
  - 12 RC, 7 OSL
  - MRE 1.6 ± 0.1 ka; PE >14.7 ± 2.5 ka
  - Recurrence 4.6 to 7.3 ky
  - Slip Rate 0.17-0.33 mm/yr



Levan/Fayette Trenching

- Skinner Peaks South
  - 12 RC, 7 OSL
  - MRE 1.6 ± 0.1 ka; PE >14.7 ± 2.5 ka
  - Recurrence 4.6 to 7.3 ky
  - Slip Rate 0.17-0.33 mm/yr
- Hells Kitchen South
  - 5 RC, 5 OSL
  - MRE 5.4 ± 0.1 ka; PE 11.2 ± 1.4 ka
  - Recurrence 4.6 to 7.3 ky
  - Slip Rate 0.17-0.33 mm/yr

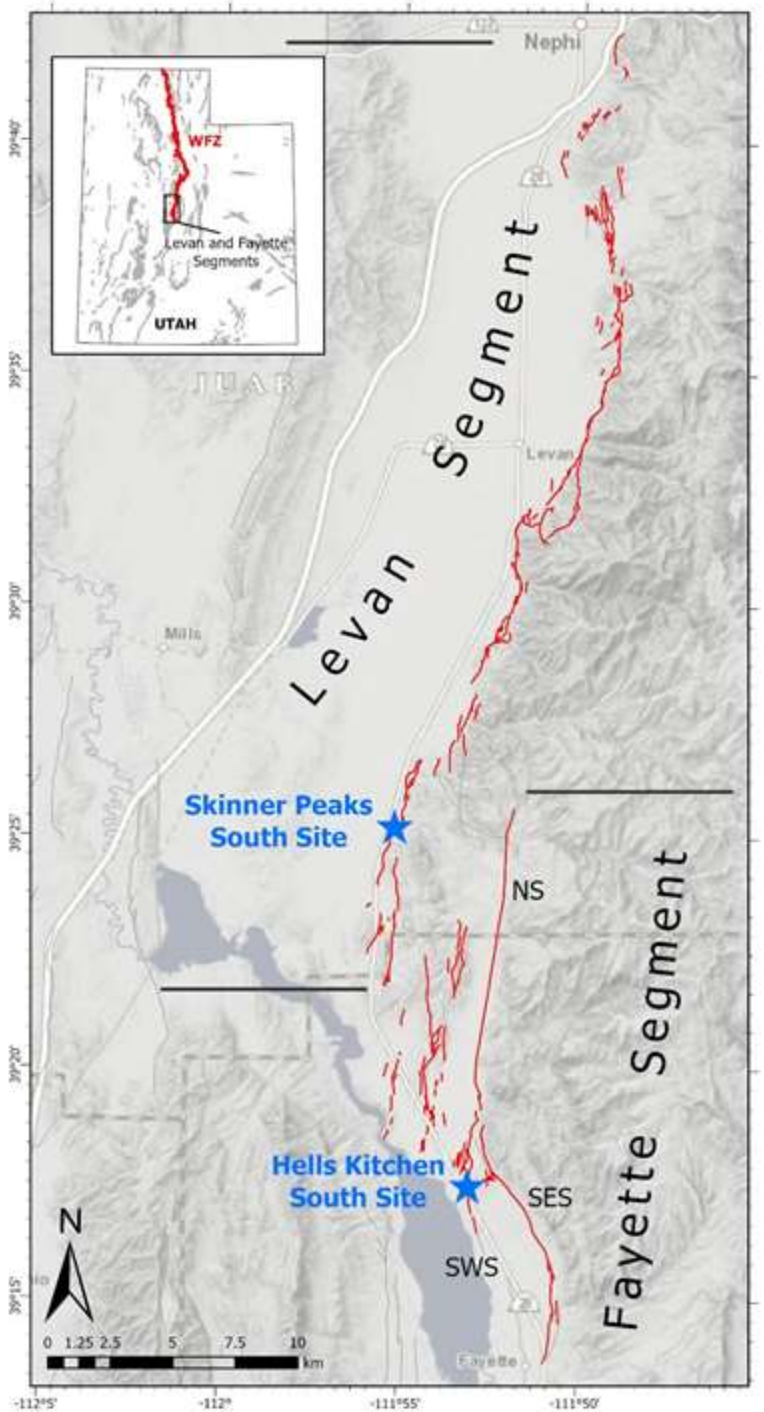


Levan/Fayette Trenching

- Skinner Peaks South
  - 12 RC, 7 OSL
  - MRE 1.6 ± 0.1 ka; PE >16.3 ± 2.4 ka
  - Recurrence 14.7 ± 2.5 ky
  - Slip Rate 0.20-0.28 mm/yr

- Hells Kitchen South
  - 5 RC, 5 OSL
  - MRE 5.4 ± 0.1 ka; PE 11.2 ± 1.4 ka
  - Recurrence 4.6 to 7.3 ky
  - Slip Rate 0.17-0.33 mm/yr

Preparation in progress of publication for the Paleoseismology of Utah Series

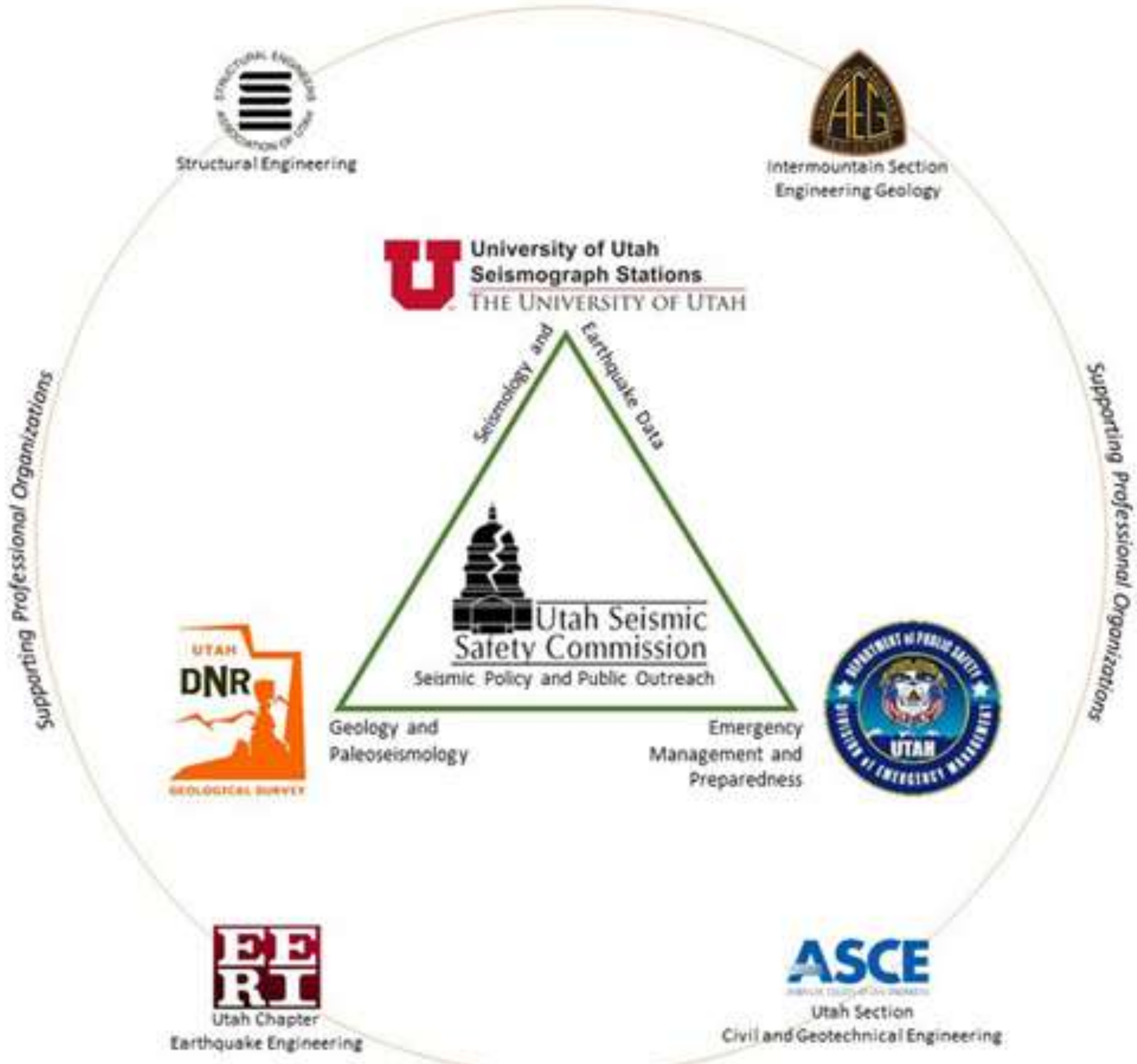


Other trenching updates

- Airport East trenching (2011) in preparation for a UGS Paleoseismology of Utah Series.
- Future NEHRP proposals
  - Cache Valley Faults
  - Northern Wasatch Fault
  - Perishable paleoseismic sites

Utah Earthquake Program

an integrated Utah state agency and professional organization partnership to reduce earthquake risk



2019 Shakeout Exercise

Upcoming Events for UGS Earthquake Hazards

- May 4 – 5, 2020 – Rocky Mountain GSA
- June 2020 – FEMA Exercise for the Exercise
- February 1-5, 2021 – Basin and Range Earthquake Summit (BRES) / Basin and Range Province Seismic Hazards Summit IV (BRPSHSIV)
- June 2021 – FEMA Wasatch Exercise
- June 22 – July 1, 2022 – National Earthquake Conference in SLC

Basin and Range Earthquake Summit (BRES) / Basin and Range Province Seismic Hazard Summit IV (BRPSHSIV)

- Save the Date! February 1-5, 2021
- CUSEC Clearinghouse workshop
- Earthquake Geology of the Basin and Range
- Seismology of the Basin and Range
- Emergency Management
- Short course(s?)
  - OxCal modeling and paleoseismology methods
  - Applications of High Resolution Topographic data – OpenTopography?

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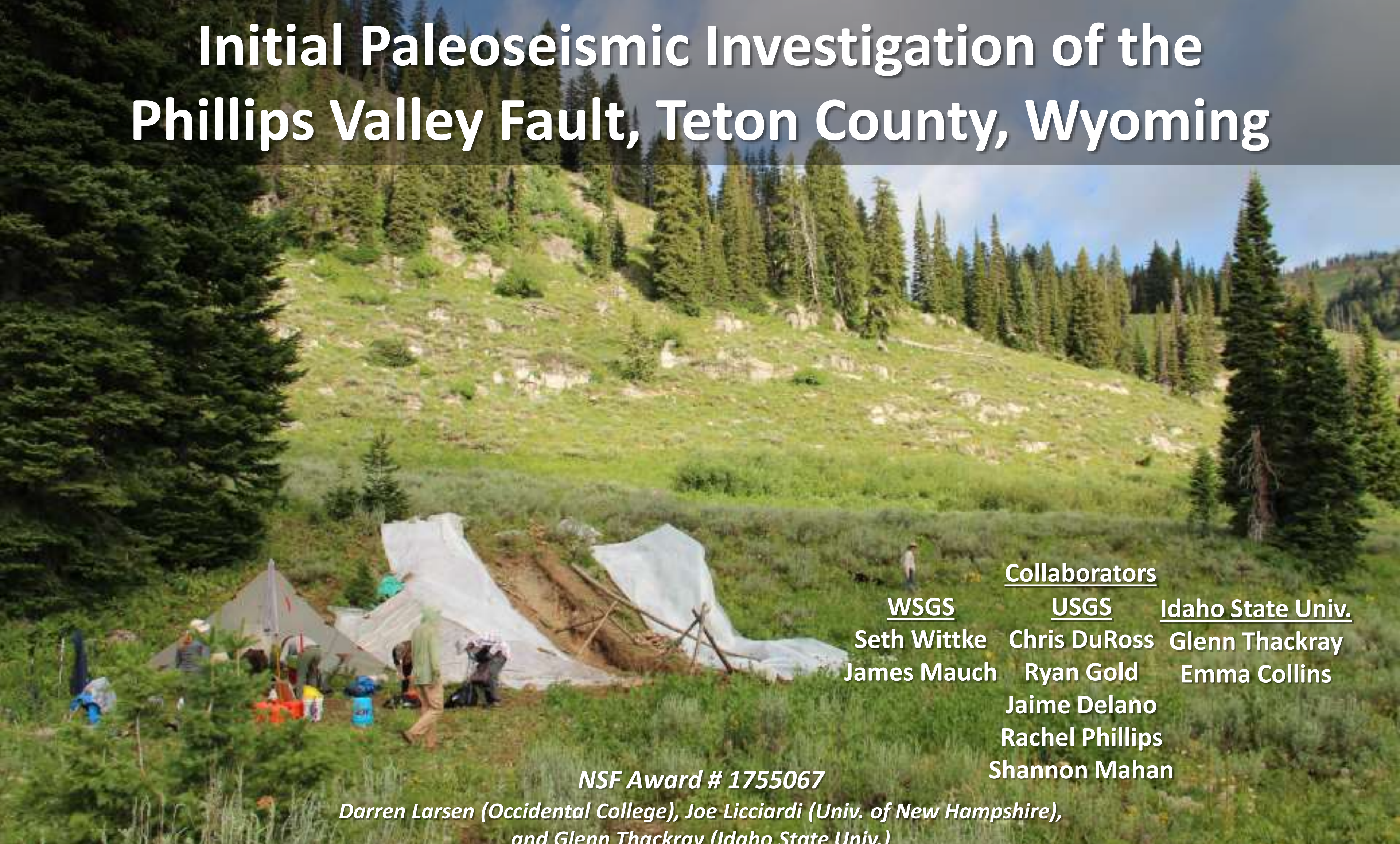


Initial Paleoseismic Investigation of the Phillips Valley Fault, Teton County, Wyoming

Collaborators

WSGS
Seth Wittke
James Mauch

USGS
Chris DuRoss
Ryan Gold
Jaime Delano
Rachel Phillips
Shannon Mahan

Idaho State Univ.
Glenn Thackray
Emma Collins

NSF Award # 1755067
Darren Larsen (Occidental College), Joe Licciardi (Univ. of New Hampshire), and Glenn Thackray (Idaho State Univ.)

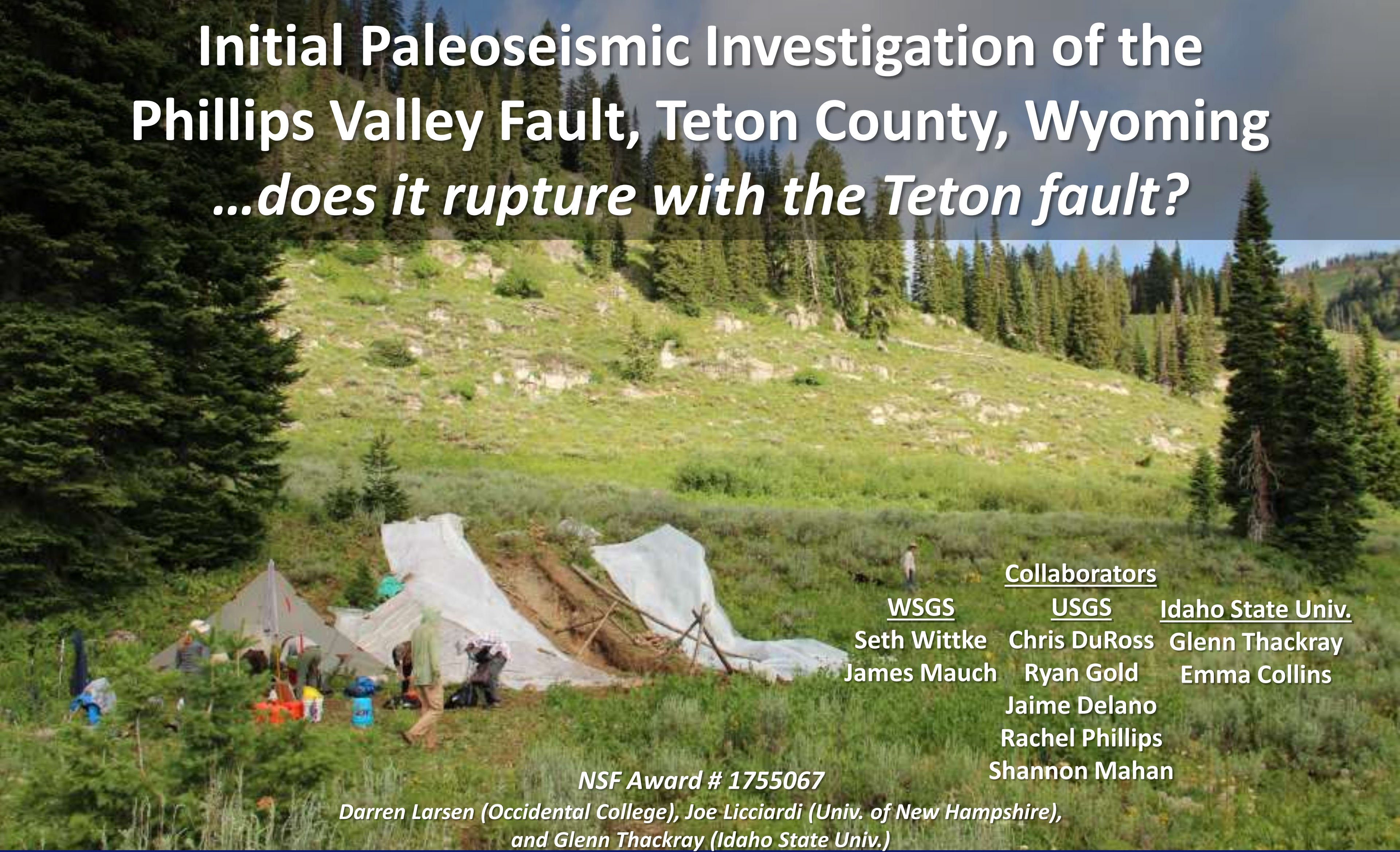
Mark Zellman
BGC Engineering

BGC

Basin and Range Province Earthquake Working Group Meeting
Salt Lake City, Utah ✪ February 5, 2020

Initial Paleoseismic Investigation of the Phillips Valley Fault, Teton County, Wyoming

…does it rupture with the Teton fault?



Collaborators

WSGS	USGS	Idaho State Univ.
Seth Wittke	Chris DuRoss	Glenn Thackray
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	Rachel Phillips	
	Shannon Mahan	

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Mark Zellman

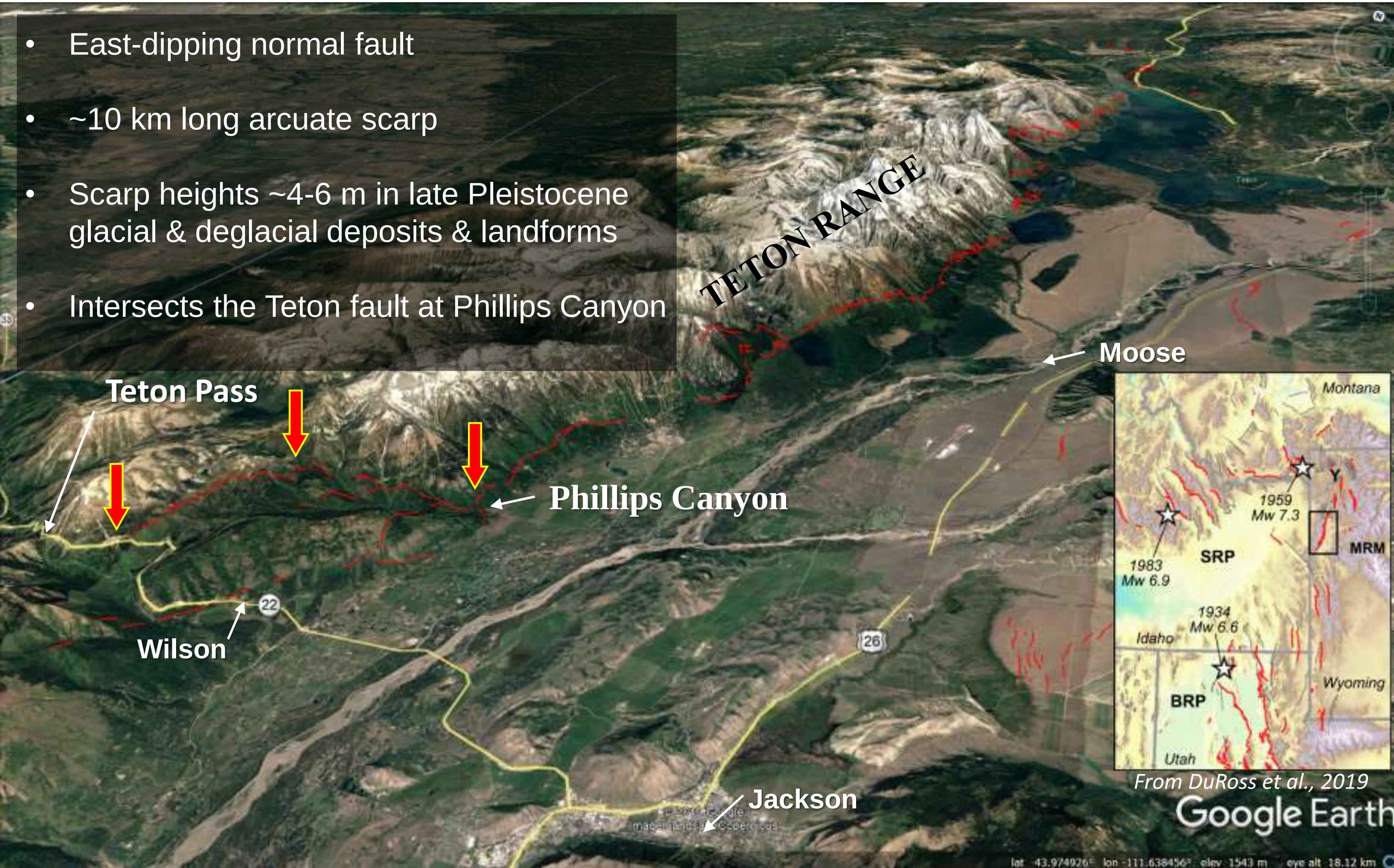
BGC Engineering

Basin and Range Province Earthquake Working Group Meeting

Salt Lake City, Utah ✪ February 5, 2020

The Phillips Valley Fault

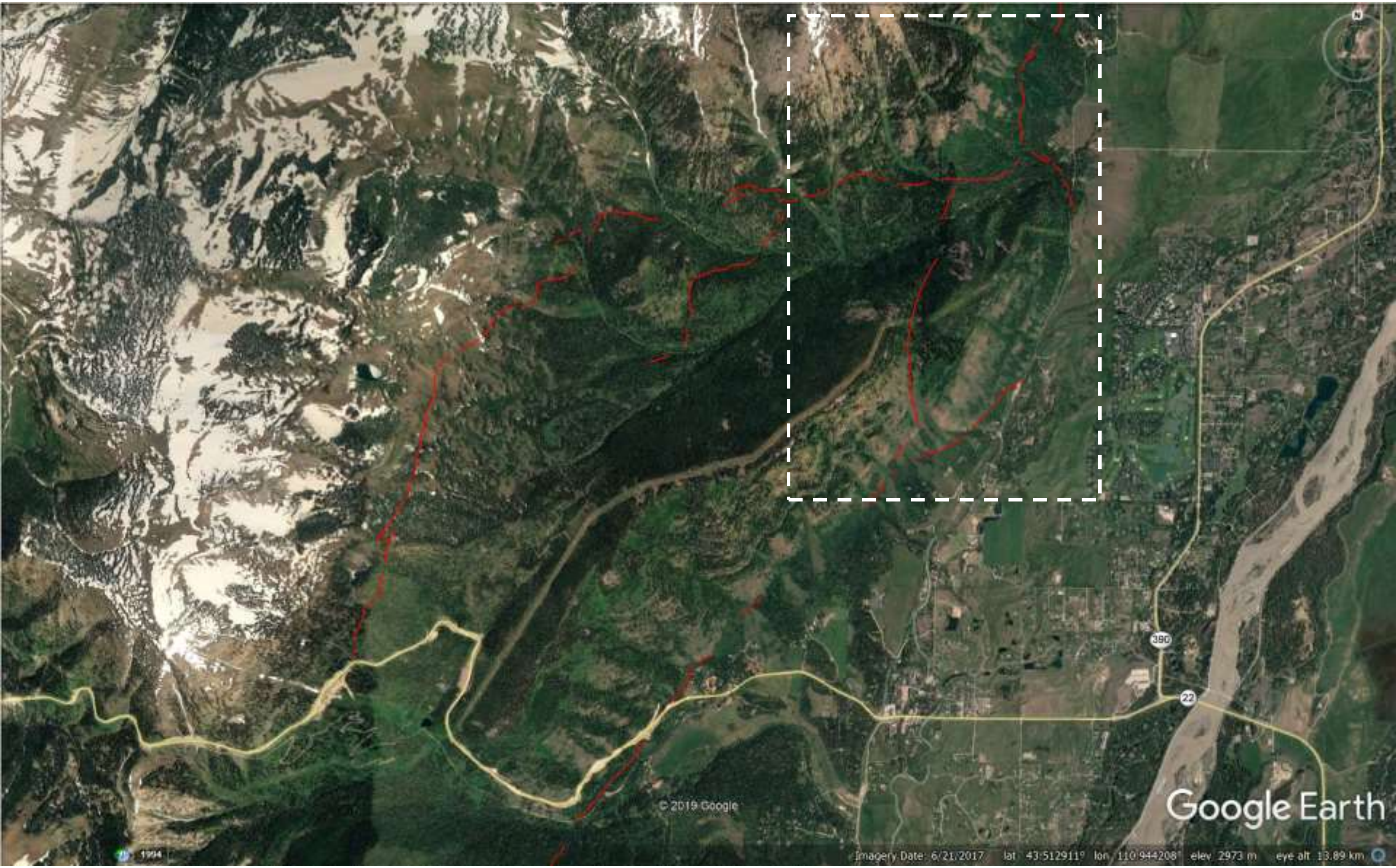
- East-dipping normal fault
- ~10 km long arcuate scarp
- Scarp heights ~4-6 m in late Pleistocene glacial & deglacial deposits & landforms
- Intersects the Teton fault at Phillips Canyon



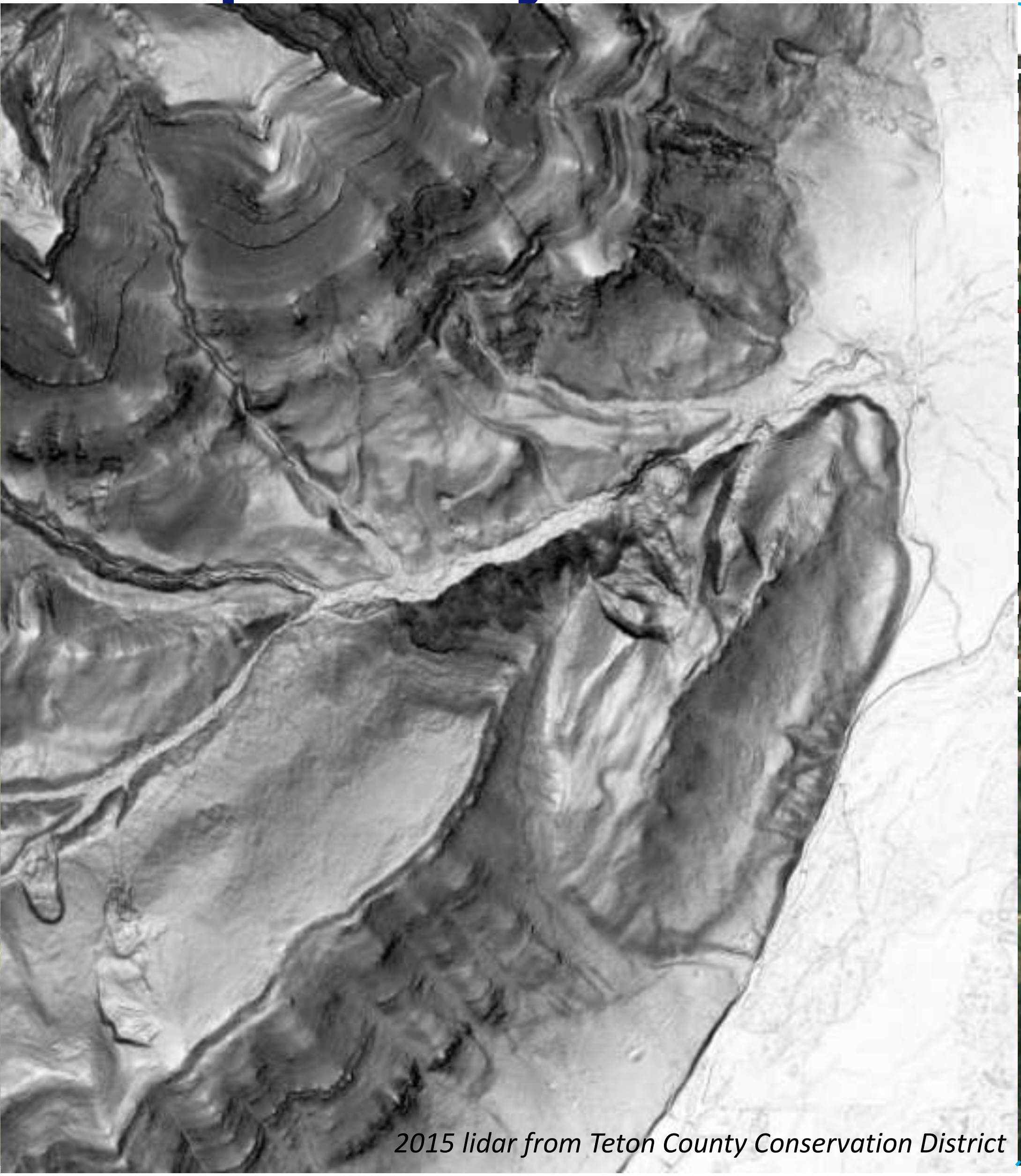
From DuRoss et al., 2019

Phillips Valley Fault and Southern Teton Fault

Phillips Valley Fault and Southern Teton Fault

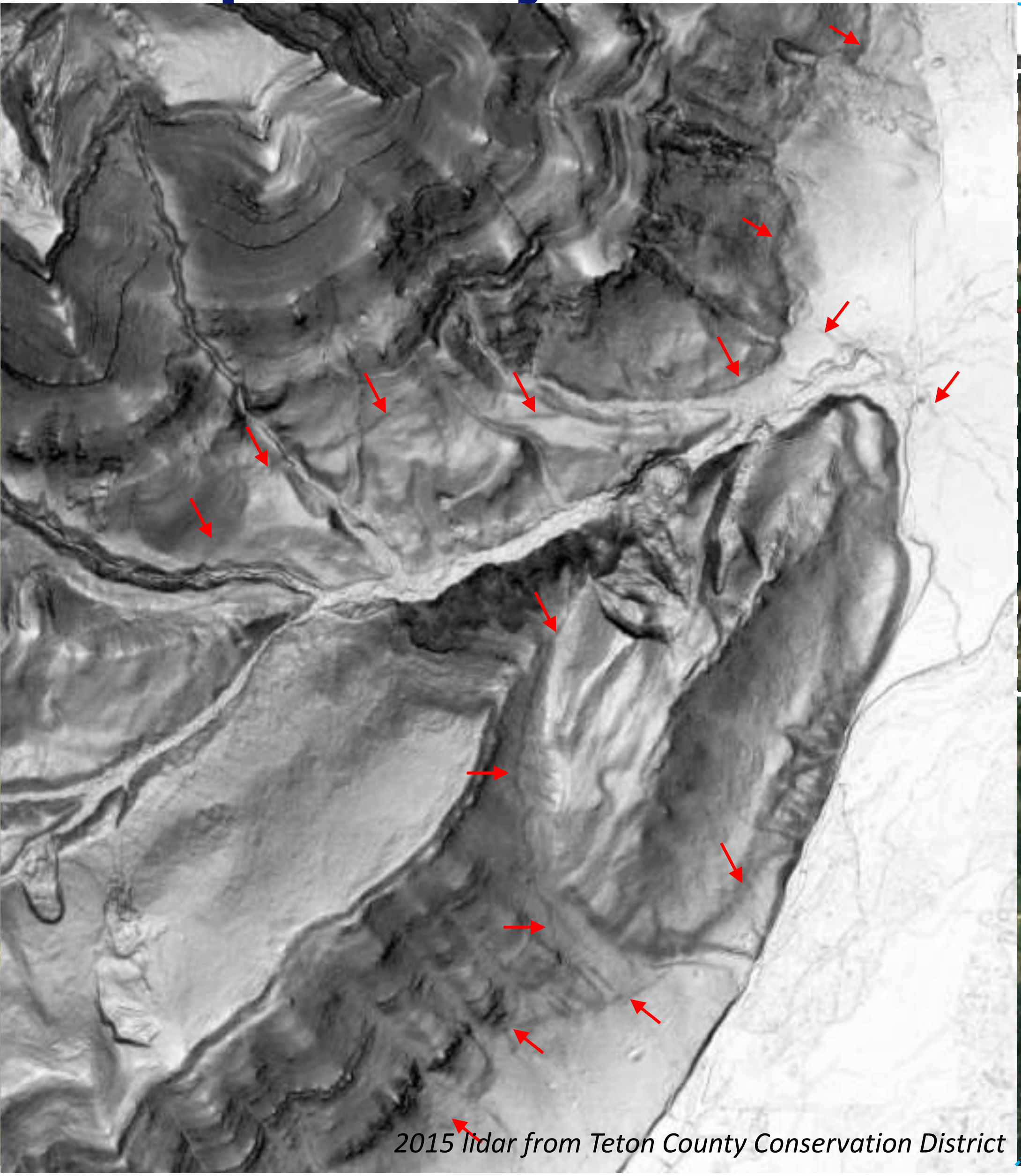


Phillips Valley Fault and Southern Teton Fault

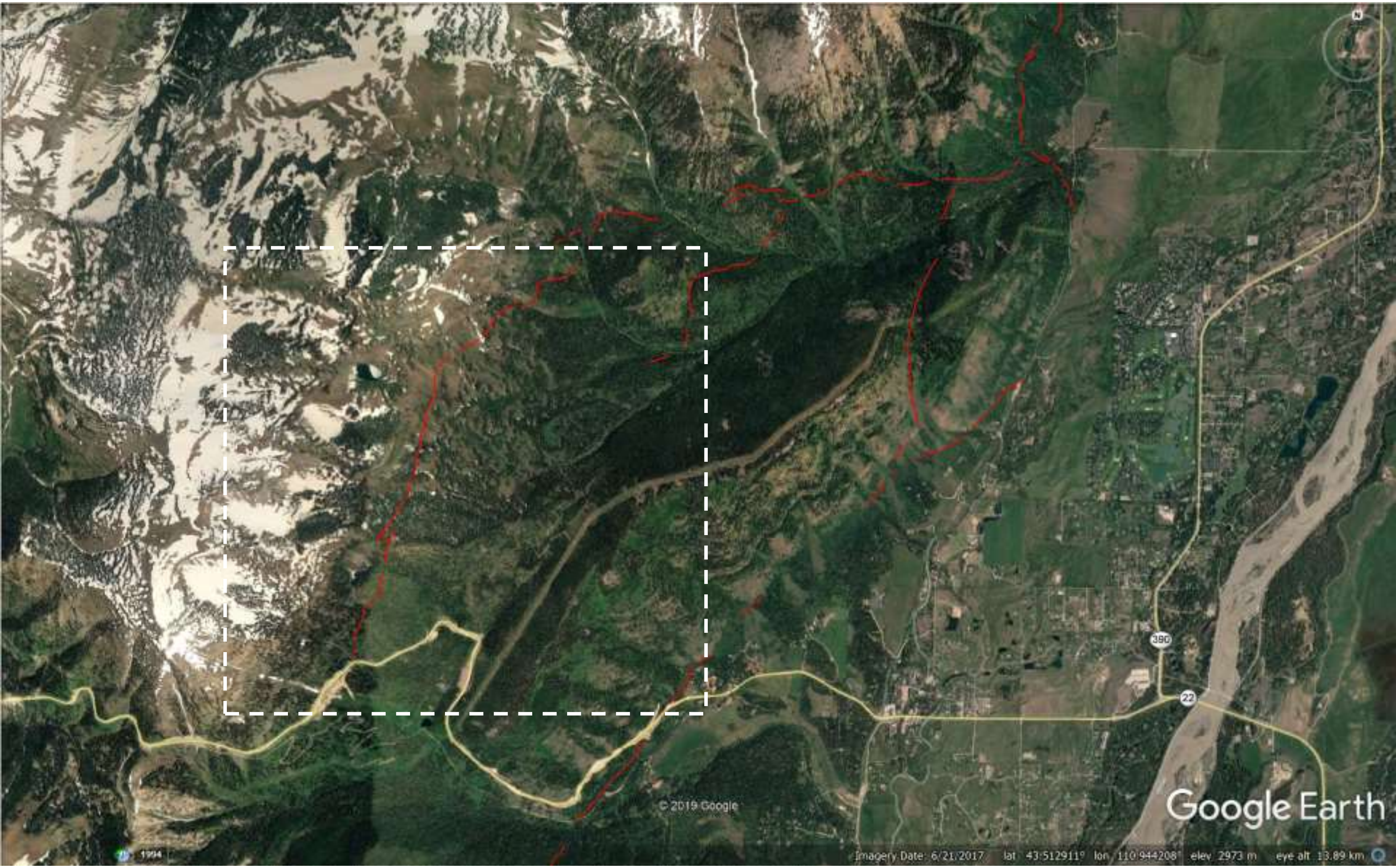


2015 lidar from Teton County Conservation District

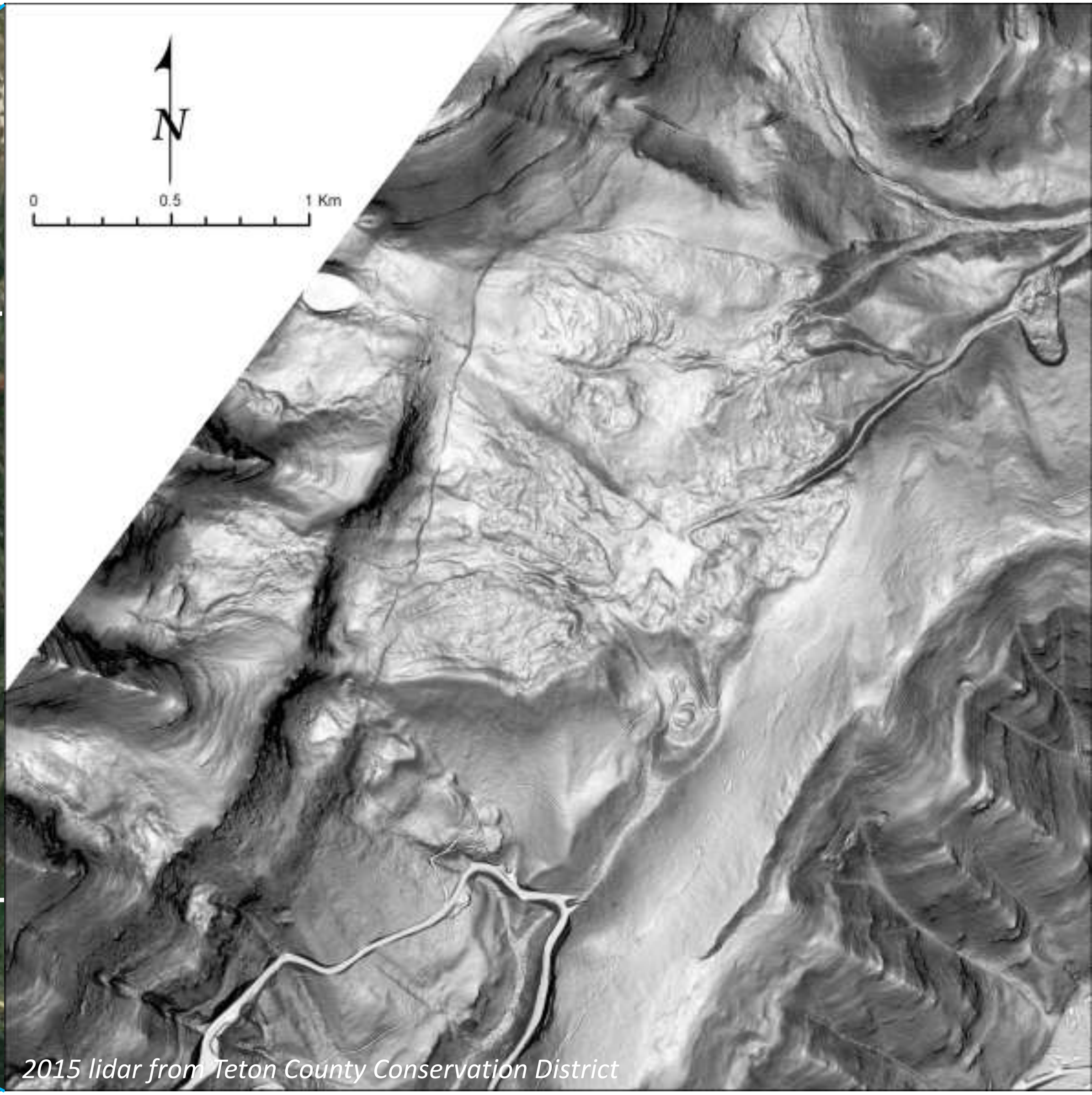
Phillips Valley Fault and Southern Teton Fault



Phillips Valley Fault – Ski Lake Area

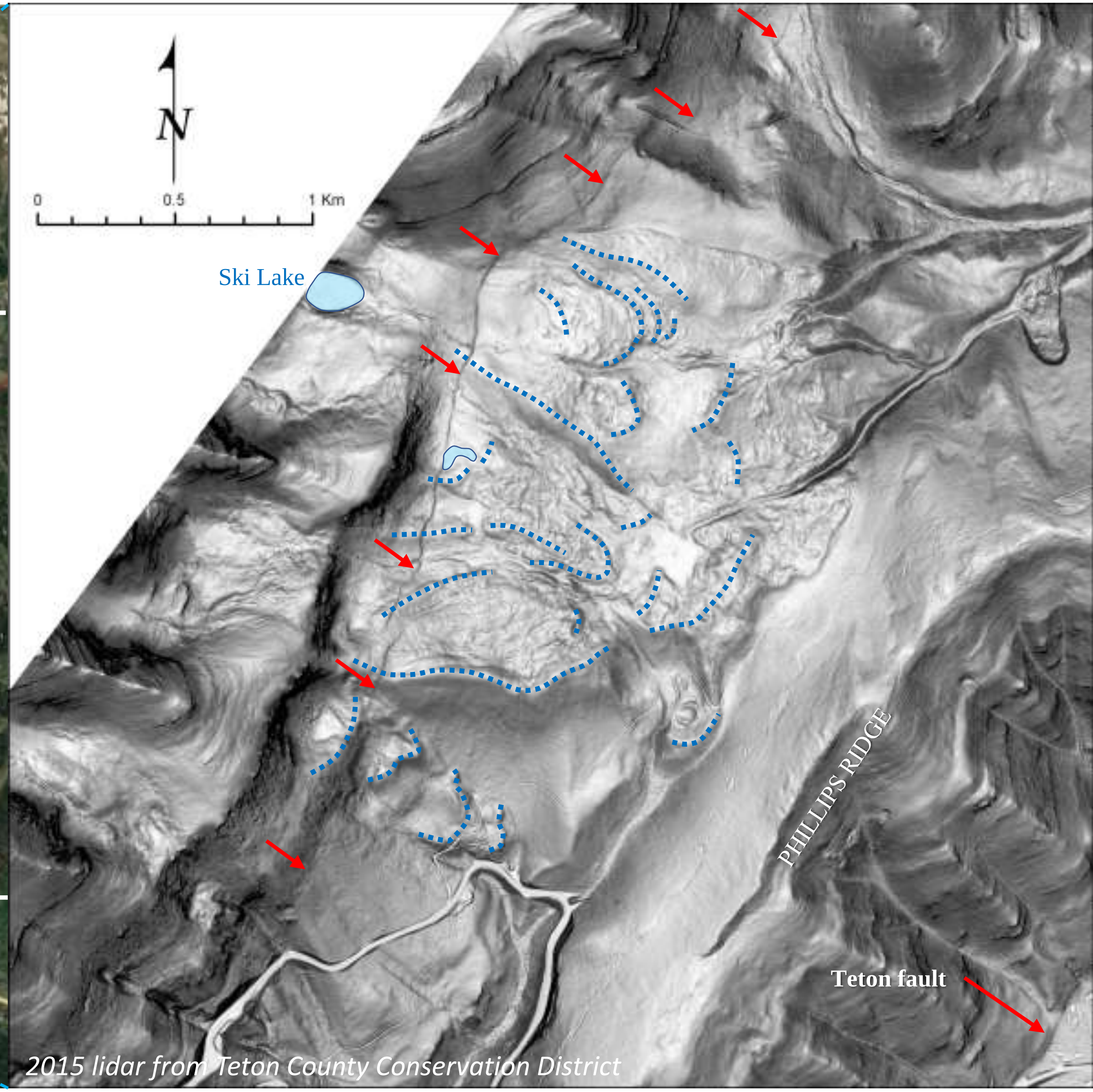


Phillips Valley Fault – Ski Lake Area



BGC ENGINEERING INC.

Phillips Valley Fault – Ski Lake Area



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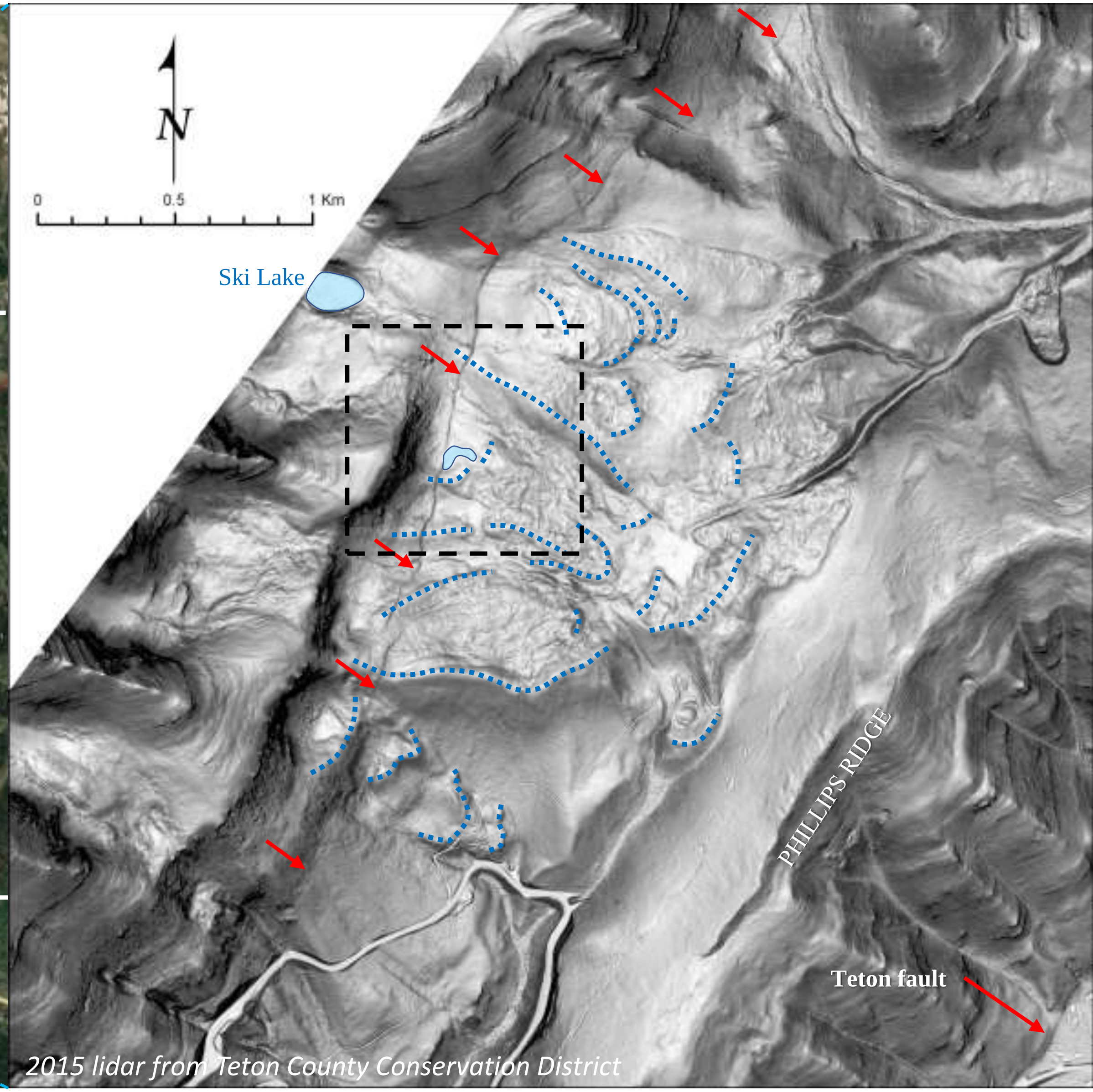
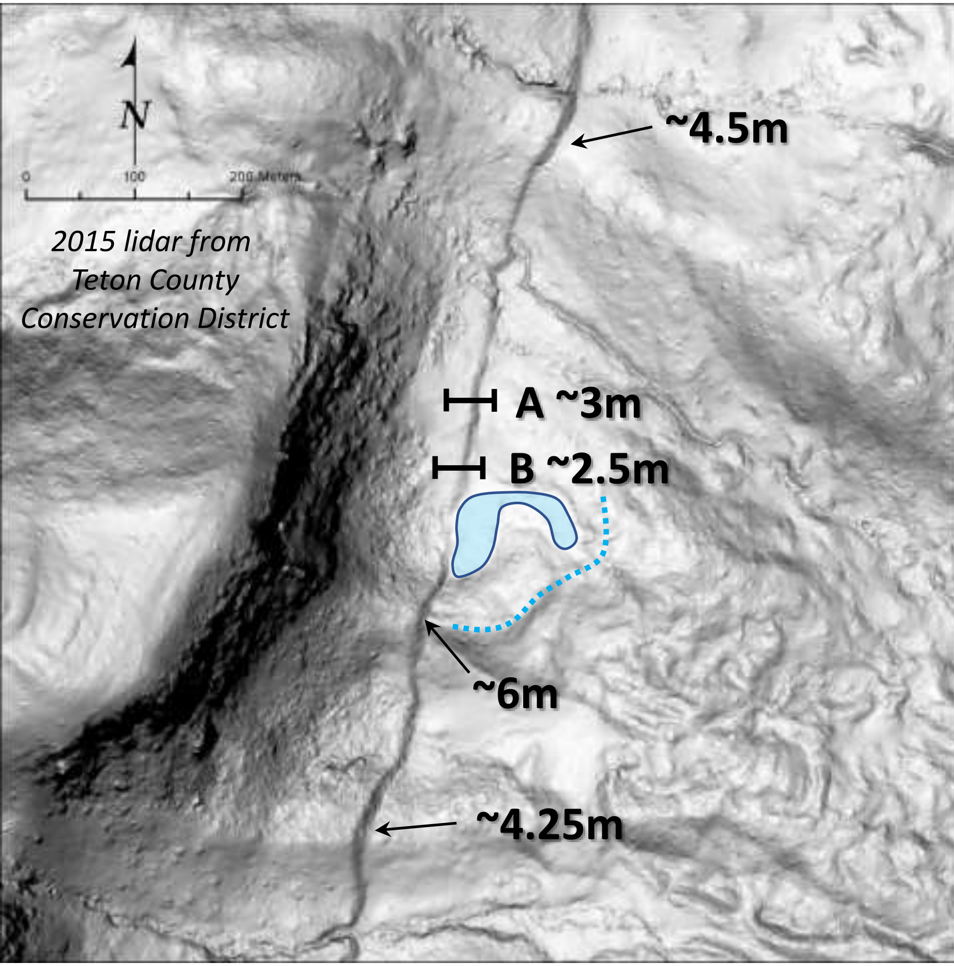


BGC ENGINEERING INC.

Ski Lake Paleoseismic Study Site



Ski Lake Trench Site

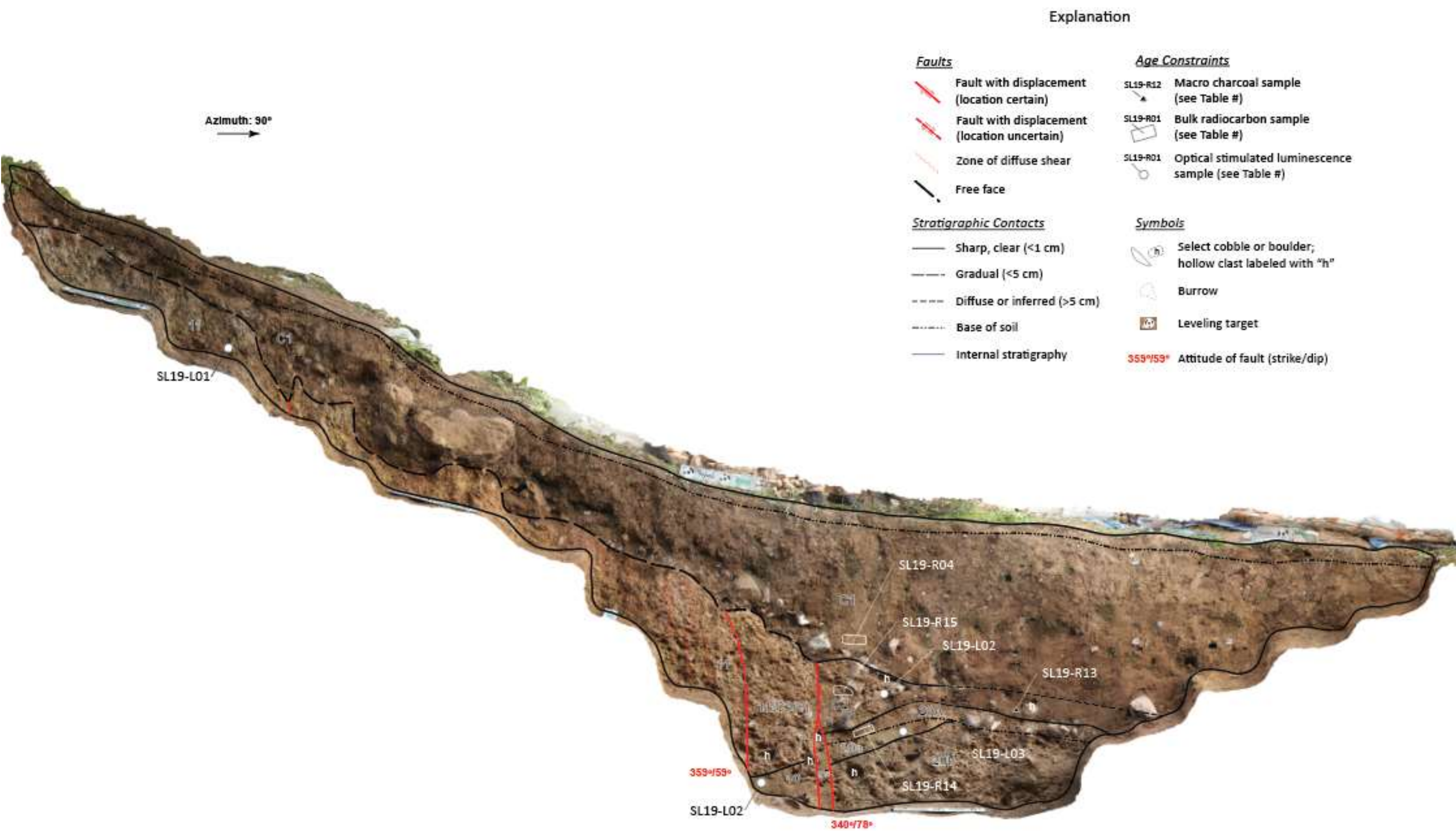
Ski Lake Trench Site

Ski Lake Trench Site

Ski Lake Trench Site

Trench A

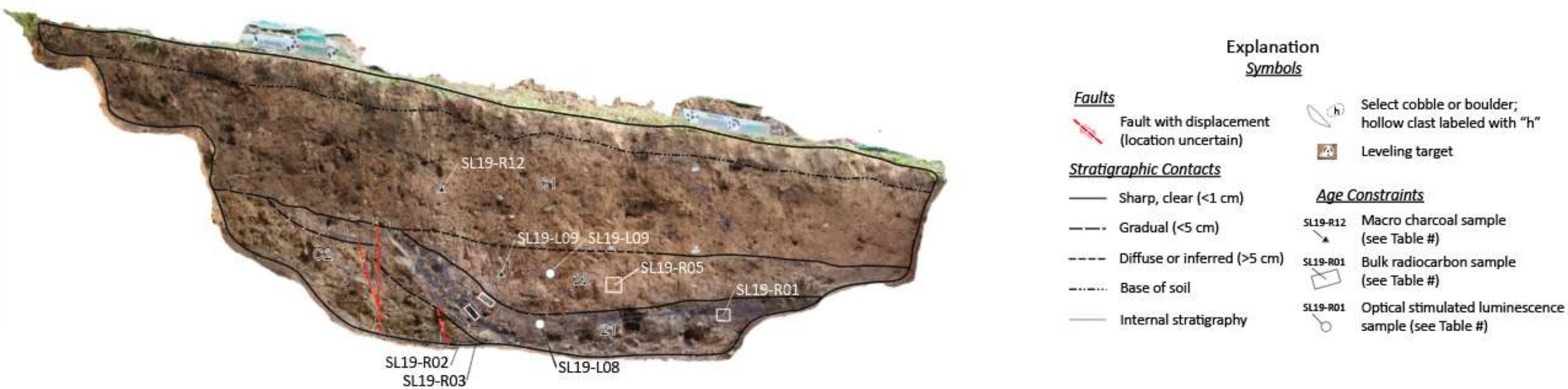
Trench A


Explanation
Faults
Fault with displacement (location certain)
Fault with displacement (location uncertain)
Zone of diffuse shear
Free face
Stratigraphic Contacts
Sharp, clear (<1 cm)
Gradual (<5 cm)
Diffuse or inferred (>5 cm)
Base of soil
Internal stratigraphy
Age Constraints
SL19-R12
Macro charcoal sample (see Table #)
SL19-R01
Bulk radiocarbon sample (see Table #)
SL19-R01
Optical stimulated luminescence sample (see Table #)
Symbols
Select cobble or boulder; hollow clast labeled with "h"
Burrow
Leveling target
359°/59°
Attitude of fault (strike/dip)
Azimuth: 90°
SL19-L01
SL19-R04
SL19-R15
SL19-L02
SL19-R13
SL19-L03
SL19-R14
359°/59°
SL19-L02
340°/78°

Trench B

Trench B

Trench B



SL19-R12
SL19-L09
SL19-L09
SL19-R05
SL19-R01
SL19-R02
SL19-R03
SL19-L08
Explanation
Symbols
Faults
Fault with displacement (location uncertain)
Stratigraphic Contacts
Sharp, clear (<1 cm)
Gradual (<5 cm)
Diffuse or inferred (>5 cm)
Base of soil
Internal stratigraphy
Select cobble or boulder; hollow clast labeled with "h"
Leveling target
Age Constraints
SL19-R12
Macro charcoal sample (see Table #)
SL19-R01
Bulk radiocarbon sample (see Table #)
SL19-R01
Optical stimulated luminescence sample (see Table #)

Filling in the Gaps

Steamboat Mtn - 2017

New Fault Mapping
Zellman et al., 2019a

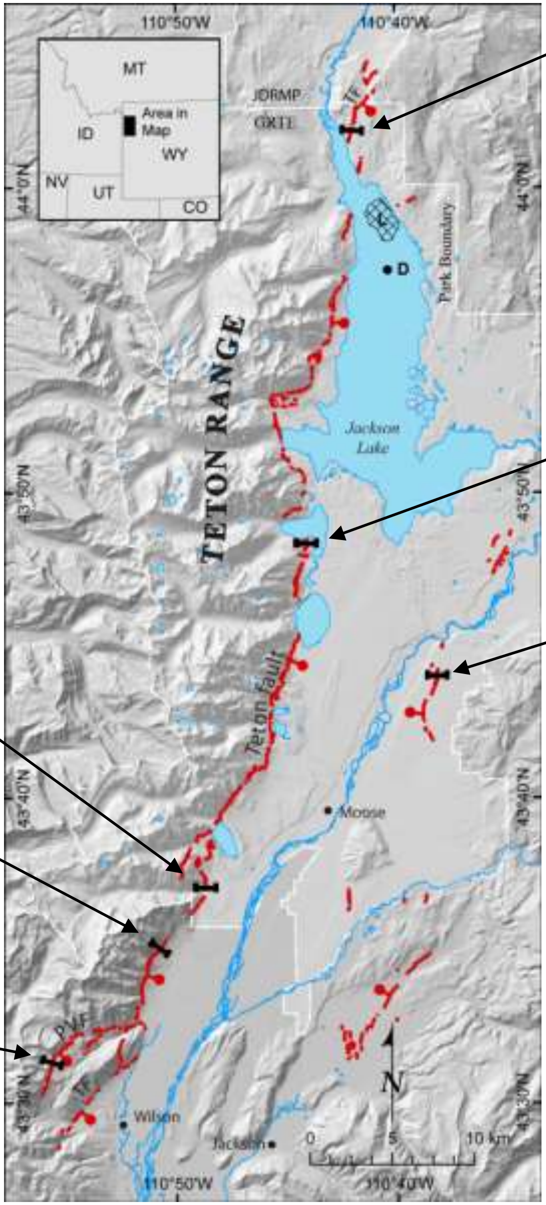
Leigh Lake - 2016
Zellman et al., 2019b

Antelope Flats - 2018

Buffalo Bowl - 2017
DuRoss et al., 2019

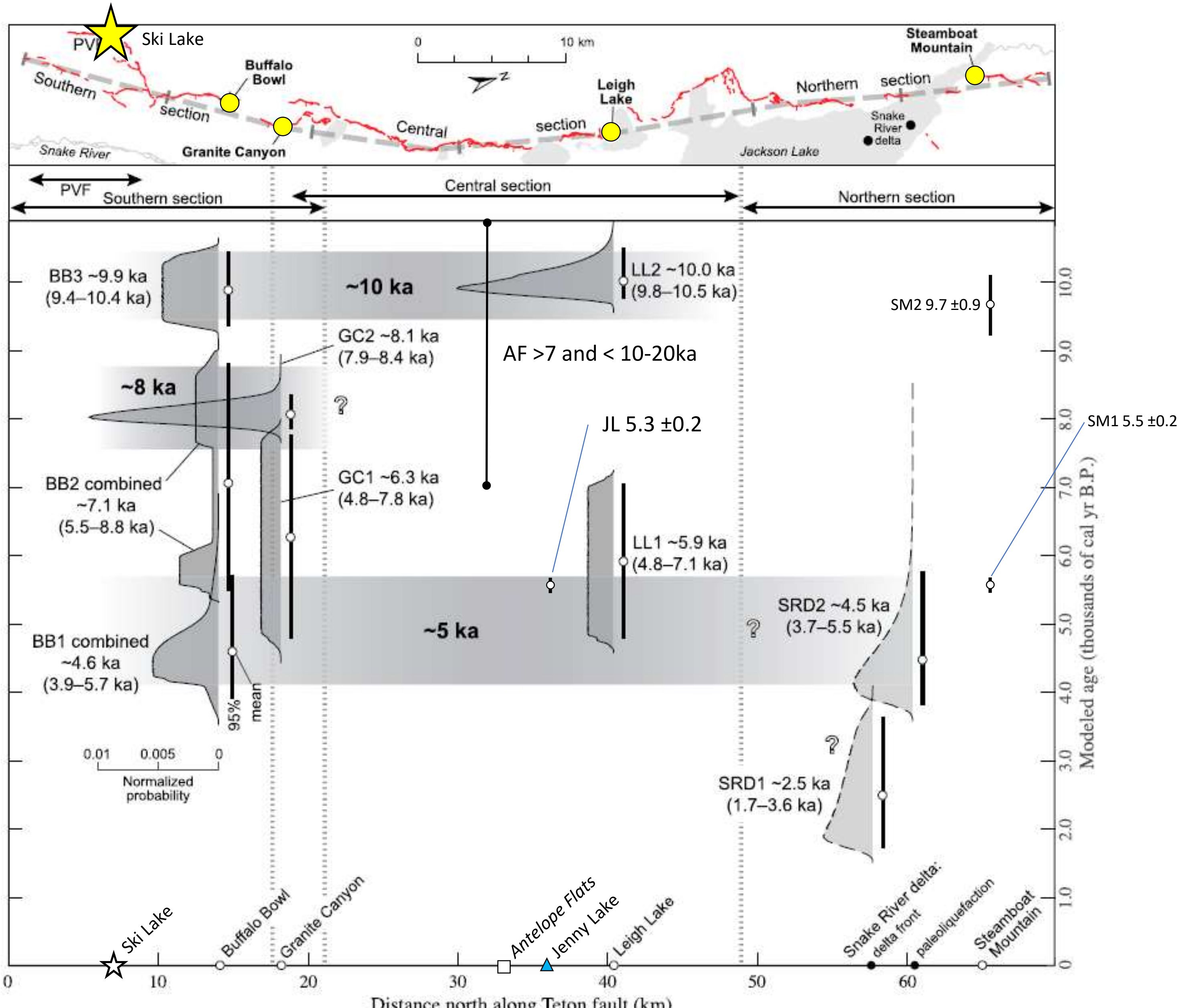
Granite Canyon - 1989
Byrd, 1995

Ski Lake - 2019



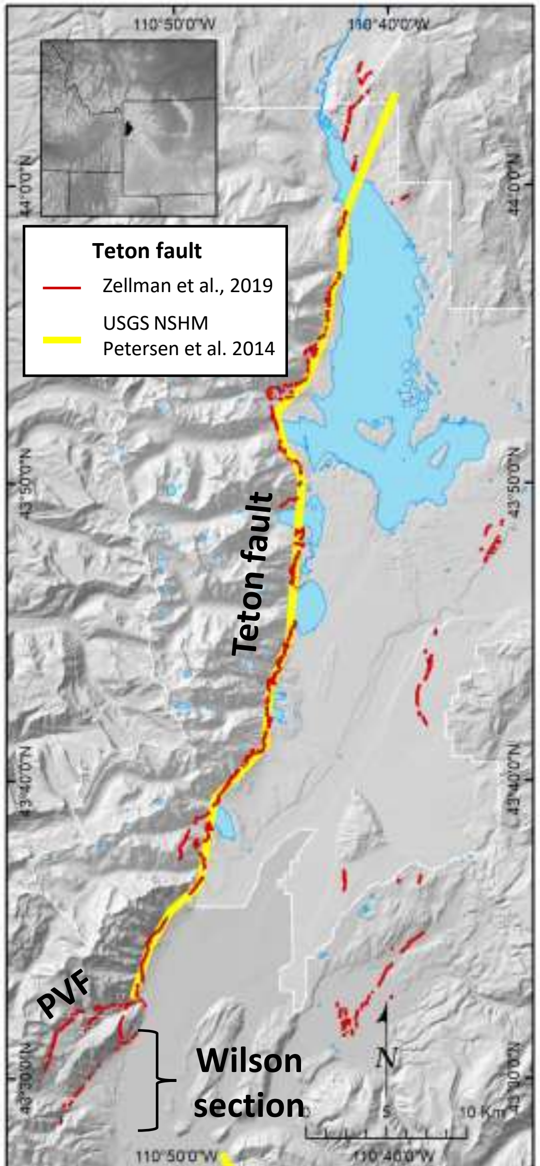
Faults from Zellman et al., 2019

Teton Fault Paleoseismic Data



Modified from DuRoss et al., 2019

Parting Thoughts and Comments



- Radiocarbon (n=11) and OSL (n=20) samples have been submitted for lab analysis.
- PVF event timing is not yet available.
- USGS NSHM Teton fault source recommendations:
  - The Teton fault should be extended ~10km to include the Wilson section
  - The PVF should be included as an extension of the Teton fault *or* an independent source depending on further analysis.


Thank You
Questions?

References

Byrd, J.O.D., 1995, Neotectonics of the Teton fault, Wyoming [Ph.D. thesis]: Salt Lake City, Utah, University of Utah, 214 p.

DuRoss, C. B., R. D. Gold, R. W. Briggs, J. E. Delano, D. A. Ostenaa, M. Zellman, N. Cholewinski, S. Wittke, and S. A. Mahan (2019). Holocene earthquake history and slip rate of the southern Teton fault, Wyoming, USA, Geol. Soc. Am. Bull. doi: 10.1130/B35363.1.

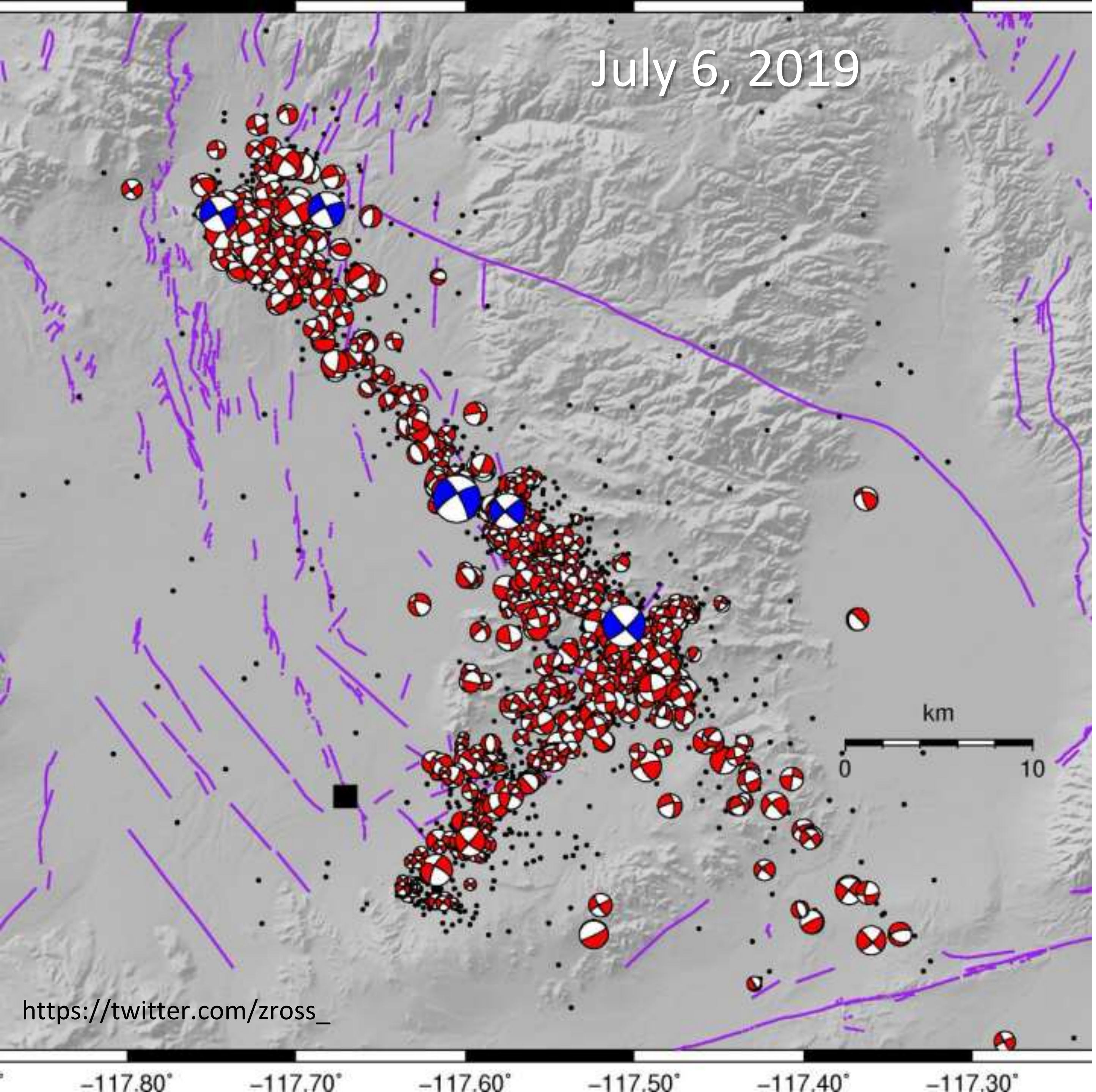
Zellman, M., DuRoss, C.B., and Thackray, G.D., 2019a, The Teton fault, Teton County, Wyoming: Wyoming Geological Survey Open-File Report 2019-01, scale 1:75,000, http://sales.wsgs.wyo.gov/the-teton-fault-2019/.

Zellman, M., DuRoss, C.B., Thackray, G.R., Personius, S.F., Reitman, N.G., Mahan, S.A., and Brossy, C., 2019b, Holocene rupture history of the central Teton fault at Leigh Lake; Grand Teton National Park, Wyoming: Bulletin of the Seismological Society of America, https://doi.org/10.1785/0120190129.

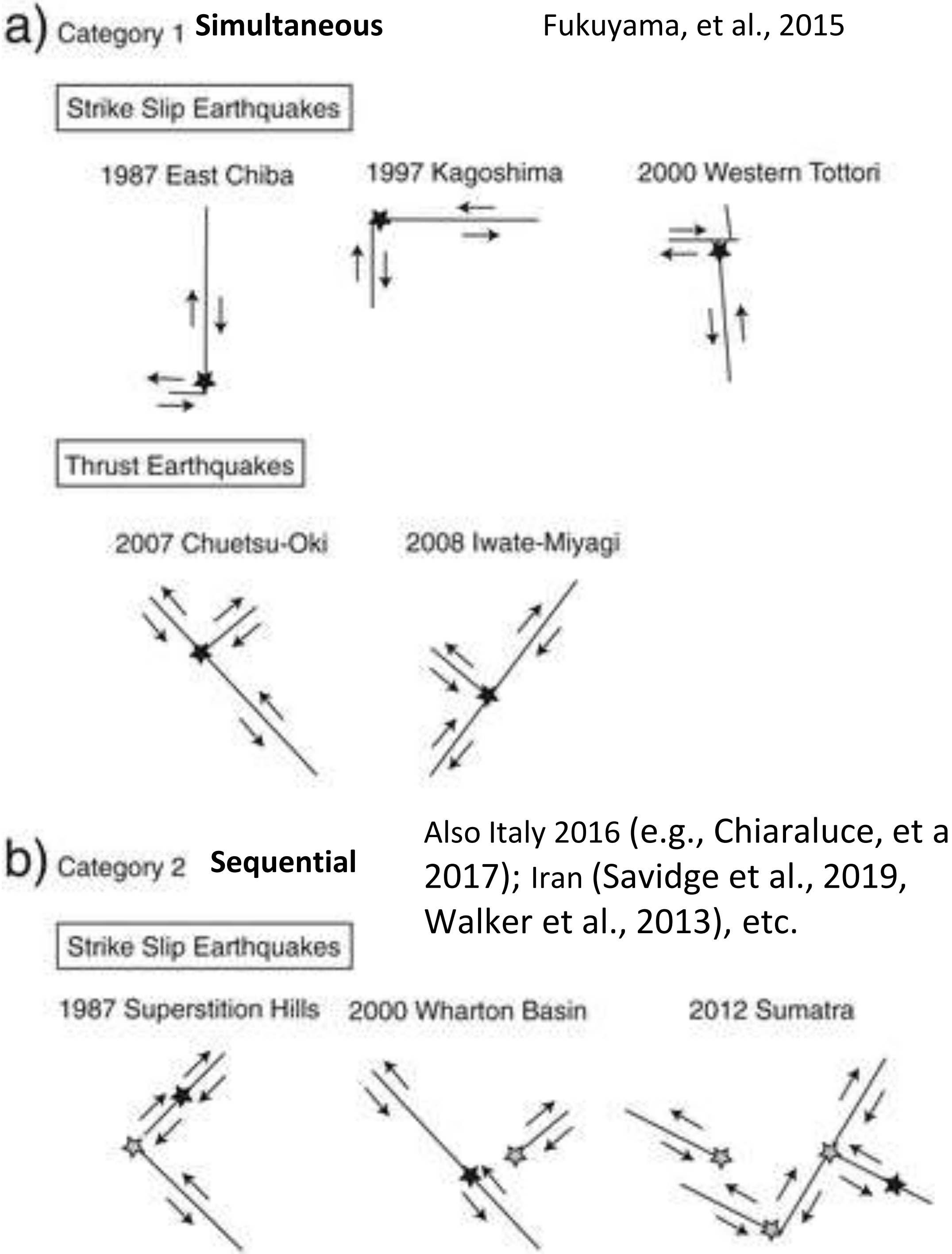
CALIFORNIA

Ridgecrest earthquakes caused up to $5 billion in damage to China Lake naval base

A sign posted July 7 outside the main gate of the China Lake naval station in Ridgecrest, Calif., shows the base is closed. (Mario Tama / Getty Images)



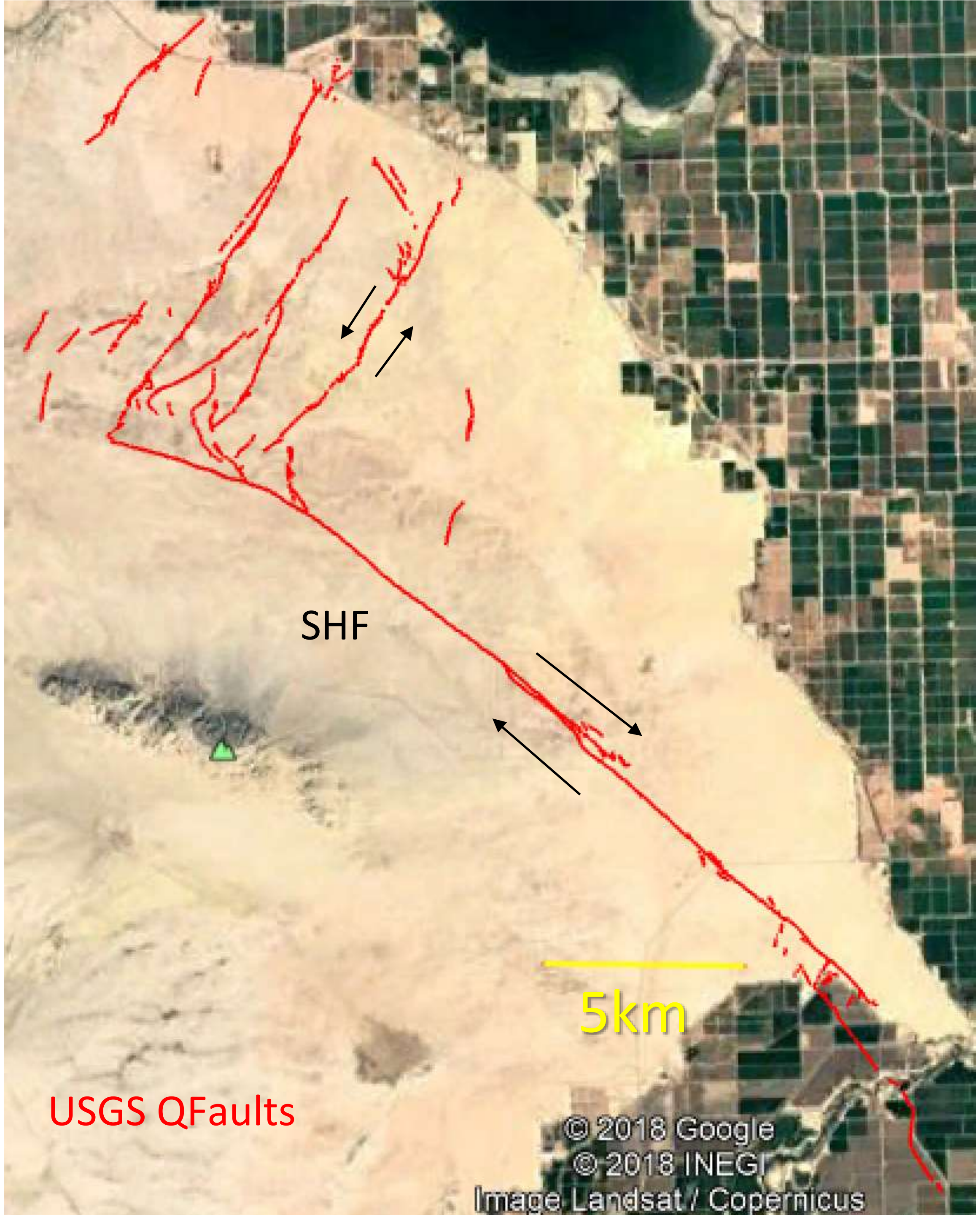
Fukuyama, et al., 2015



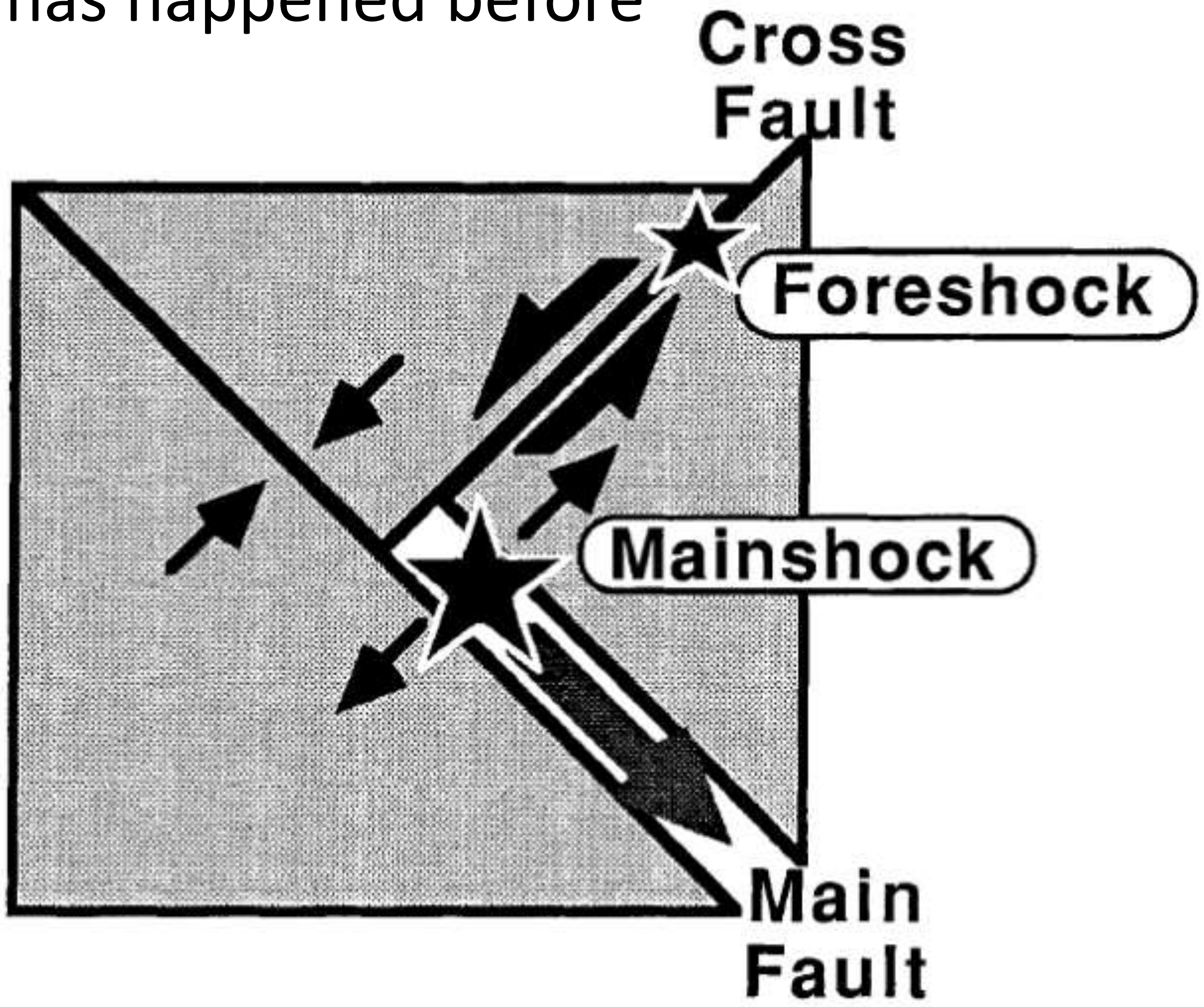
Simultaneous

Sequential

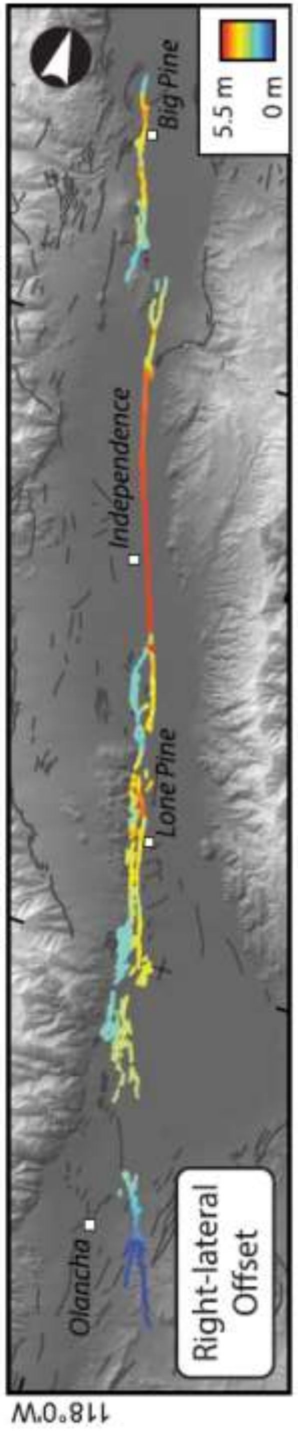
Also Italy 2016 (e.g., Chiaraluce, et al., 2017); Iran (Savidge et al., 2019, Walker et al., 2013), etc.

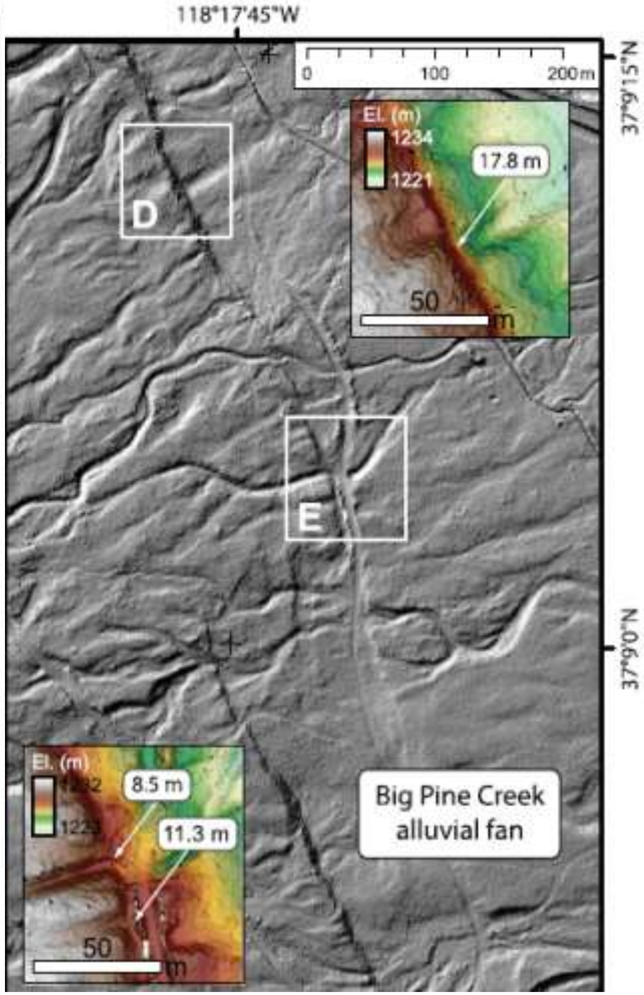


This has happened before

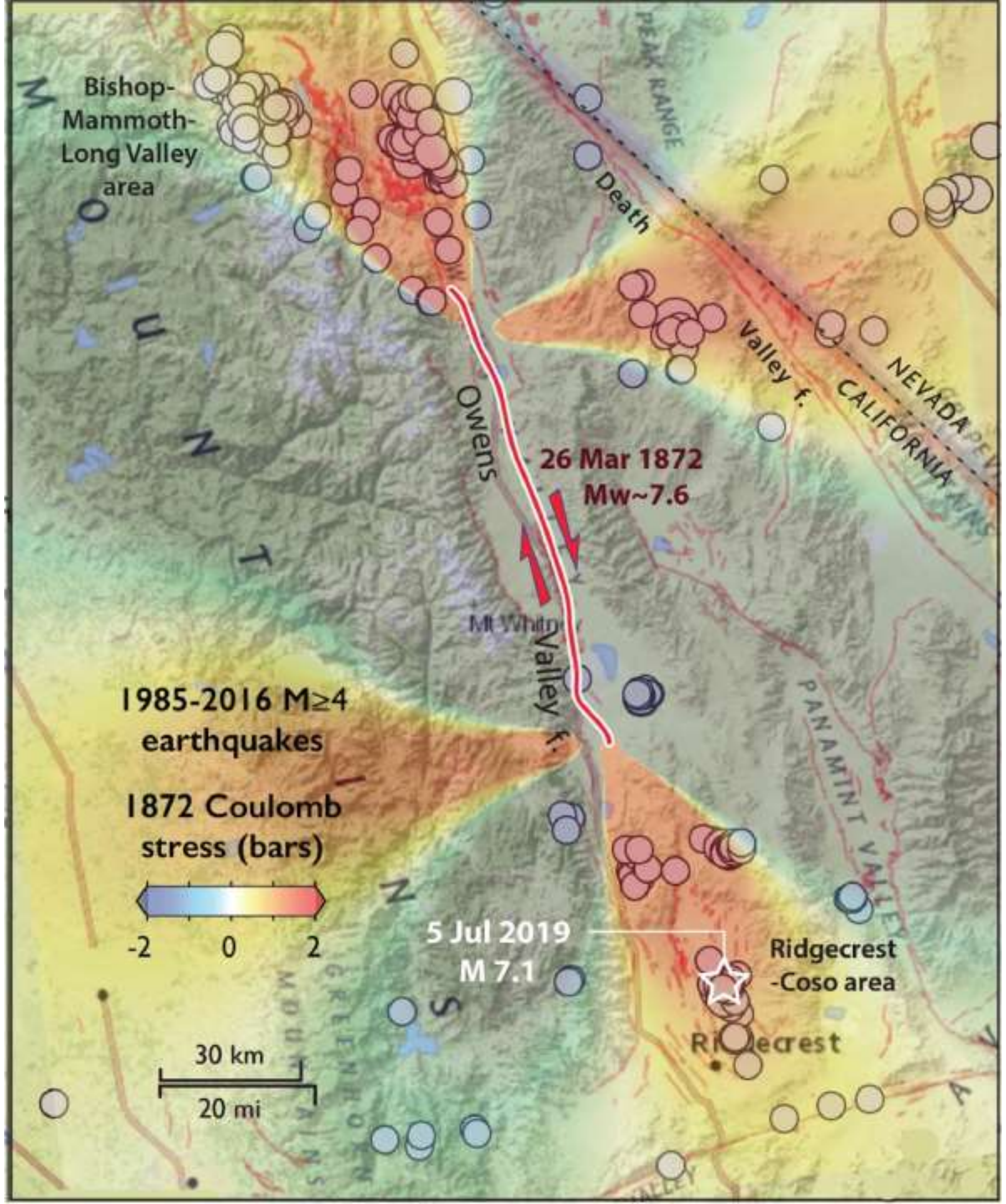


1987: "About half a day after the Ms = 6.2 [Elmore Ranch left-lateral] event, an Ms = 6.6 [Superstition Hills right-lateral] earthquake nucleated near the intersection of the cross-faults with the SHF, and rupture propagated southeast along the SHF."
–Hudnut, et al., 1989





Haddon, E. K., C. B. Amos, O. Zielke, A. S. Jayko, and R. Burgmann (2016), Surface slip during large Owens Valley earthquakes, Geochem. Geophys. Geosyst., 17, 2239–2269, doi: 10.1002/2015GC006033



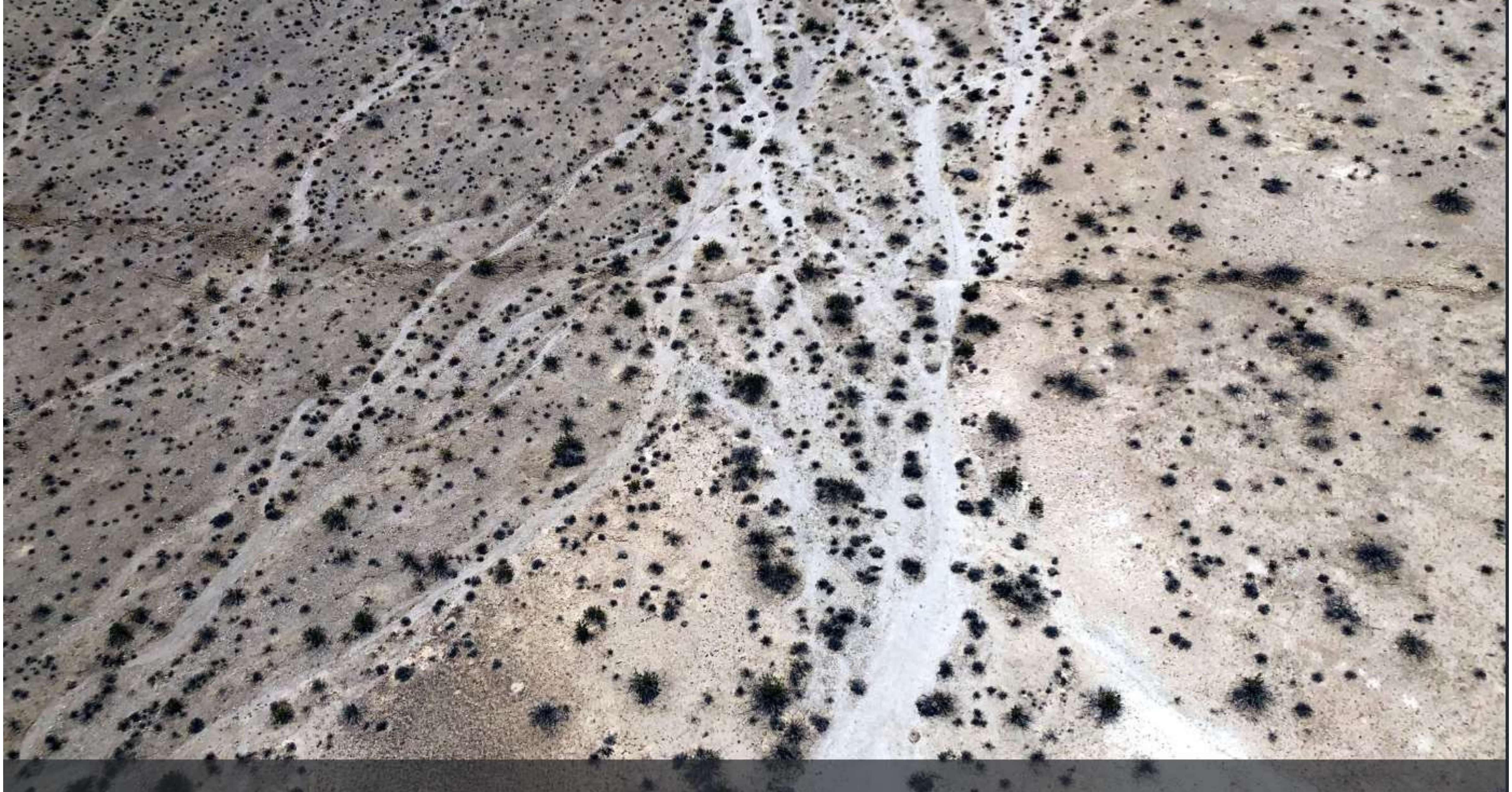
2019 events are in a position of increased Coulomb Failure Stress from historic events and regional shearing

http://temblor.net/earthquake-insights/m-7-1-socal-earthquake-triggers-aftershocks-up-to-100-mi-away-whats-next-9055/

https://twitter.com/mrbrianolson

https://www.thedrive.com/the-war-zone/25281/what-its-like-to-work-inside-the-navys-secretive-china-lake-weapons-development-center

https://twitter.com/mrbrianolson



Brian Olson @mrbrianolson · 16h
Excellent views of the NW-trending fault rupture from my seat in a US Navy Night Hawk helicopter 🚁 Measured up to 6′ of right-lateral offset on the China Lake NWAS base.

https://twitter.com/neotectonic

UAS photo

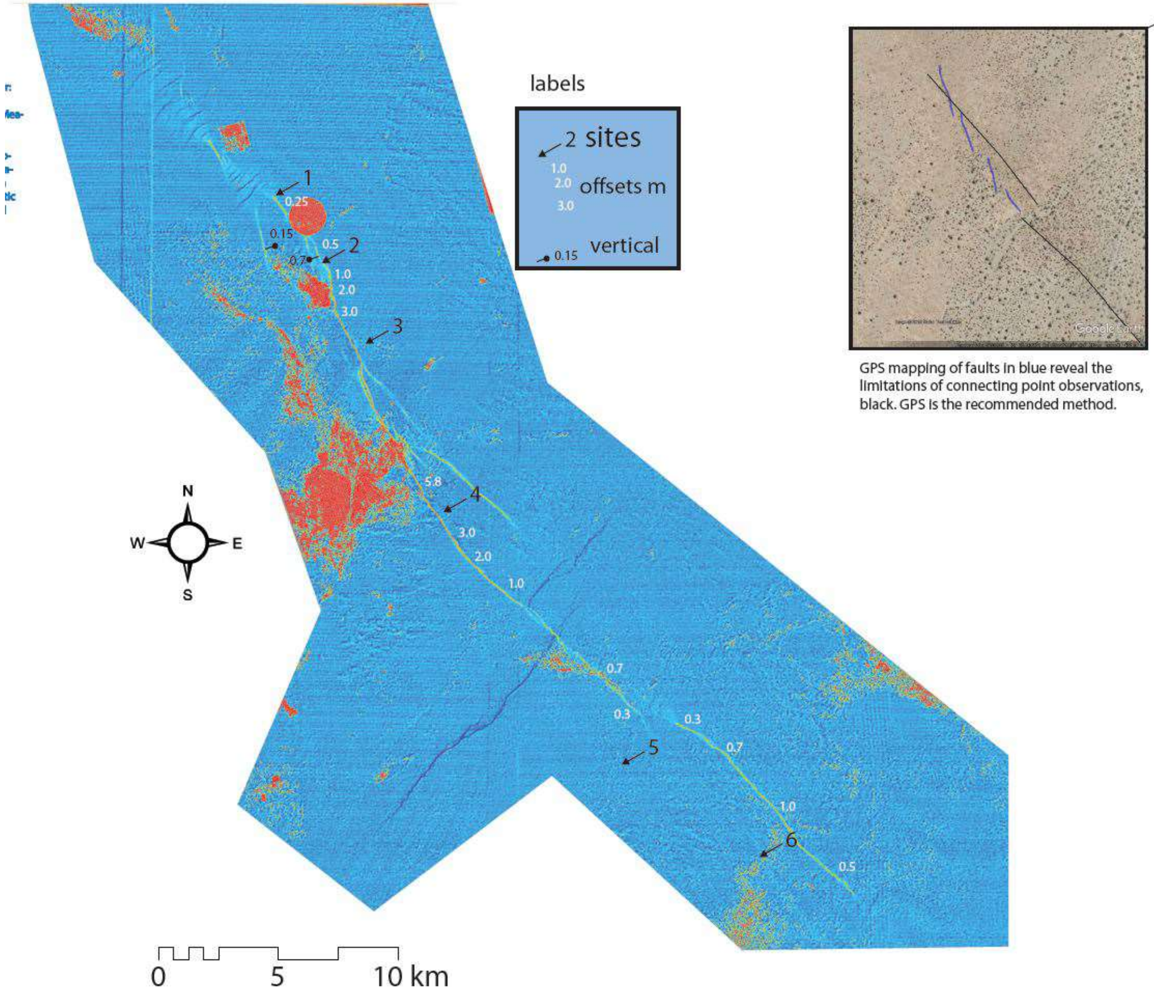
Strain Map: MILLINER 2019

Observations:

- Rupture Zone is narrow: generally, less than 5 m
- Cracking Zone can be very wide 100s of m
  - Pervasive cracking fabric, with regular spaced cracks
  - Displacements on individual cracks often not measurable
  - cracking pattern often indicates sense of lateral displacement

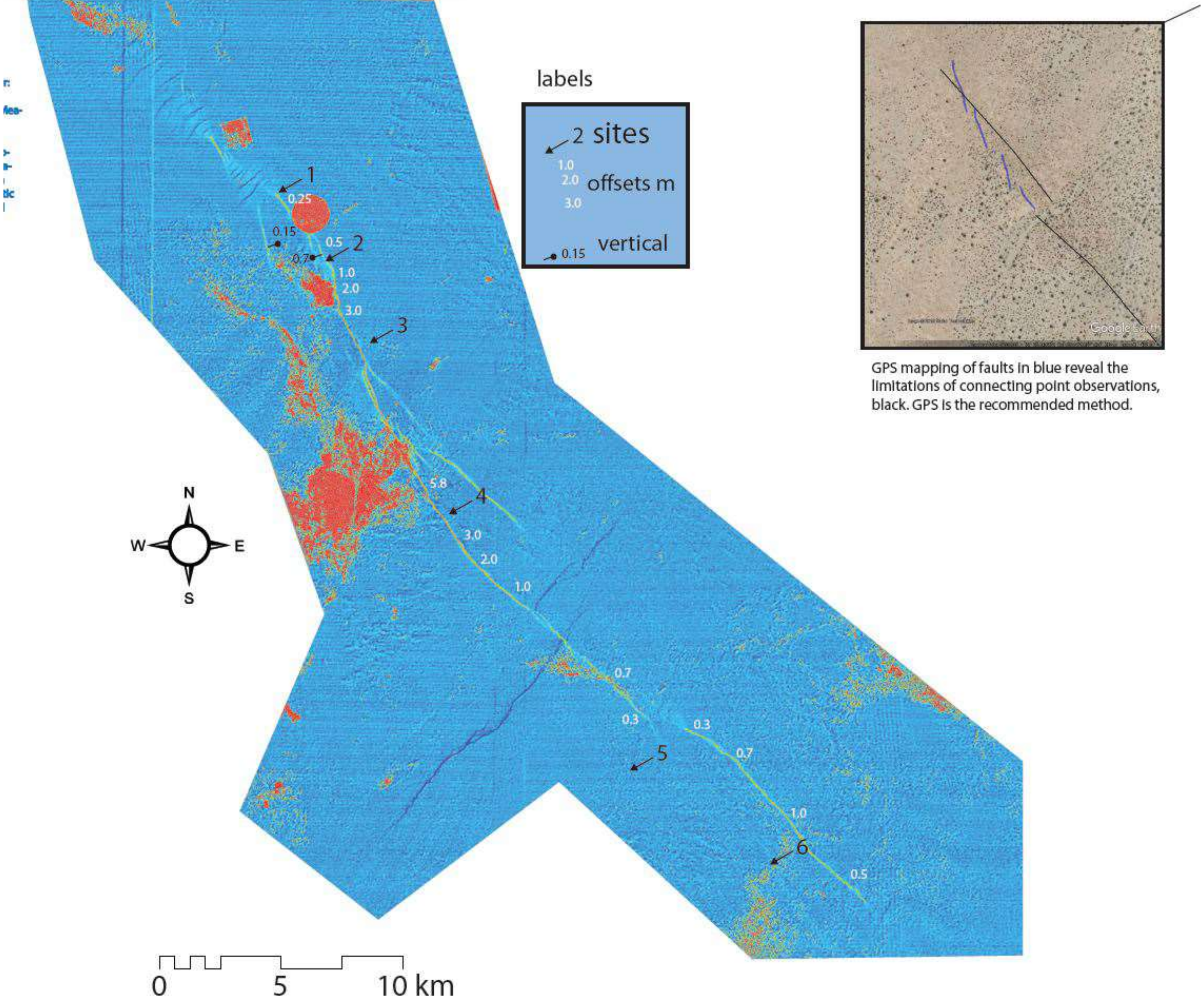
Controlling Factors:

- Fault orientation
  - Extensional areas show extensive zones of cracking
  - Cracking is asymmetrical often limited to the hanging wall or down-dropped block
- Surficial Geology
  - We used Vs30 seismic velocity estimates (Allen and Wald, 1998) as a proxy for surficial geology
  - Lower velocity surficial sediments are correlated with wider cracking zones



GPS mapping of faults in blue reveal the limitations of connecting point observations, black. GPS is the recommended method.

This strain map shows the curl of the 2D horizontal vector field, which is a convenient way of depicting the intensity and orientation of surface motion as it is invariant of the chosen orientation. Warm, yellow to red colors denote right-lateral motion, while cold blue colors show left-lateral. The displacement maps are determined from sub-pixel correlation of pre and post SPOT-6 images (1.5 m resolution) that are acquired on 09/15/2018 and 07/24/2019. The strain maps contain horizontal stripes which are satellite image artifacts related to problems of the sensor. Faults less than ~20 cm of displacement cannot be resolved by the pixel tracking technique due to noise in the optical images.



GPS mapping of faults in blue reveal the limitations of connecting point observations, black. GPS is the recommended method.

Site 1 with R. Gold, C. DuRoss, B. Philibosian

Character: left stepping en echelon breaks 50-100m in length

Strike	Slip	Rupture Zone Width	Cracking Zone Width	Qal Vs30*
322	0.3m right lateral-normal	50m	500m West of RZ	300-360m/s

Site 2 with M. DeFrisco, B. Hadden, R. Gold, C. DuRoss, B. Philibosian

Character: left stepping en echelon breaks 100-200m in length

Strike	Slip	Rupture Zone Width	Cracking Zone Width	Qal, Qeol Vs30*
332	1.0m right lateral-normal	40m	600m West of RZ	360-490m/s

Site 3 with J. Thompson Jobe

Character: left stepping en echelon breaks 100-300m in length with 25 m wide fault graben

Strike	Slip	Rupture Zone Width	Cracking Zone Width	Qyal Vs30*
332	1.2m right lateral-normal	40m	400m West of RZ	360-490m/s

Site 4 with S. Bennett, B. Philibosian, K.Scharer, temp > 115°

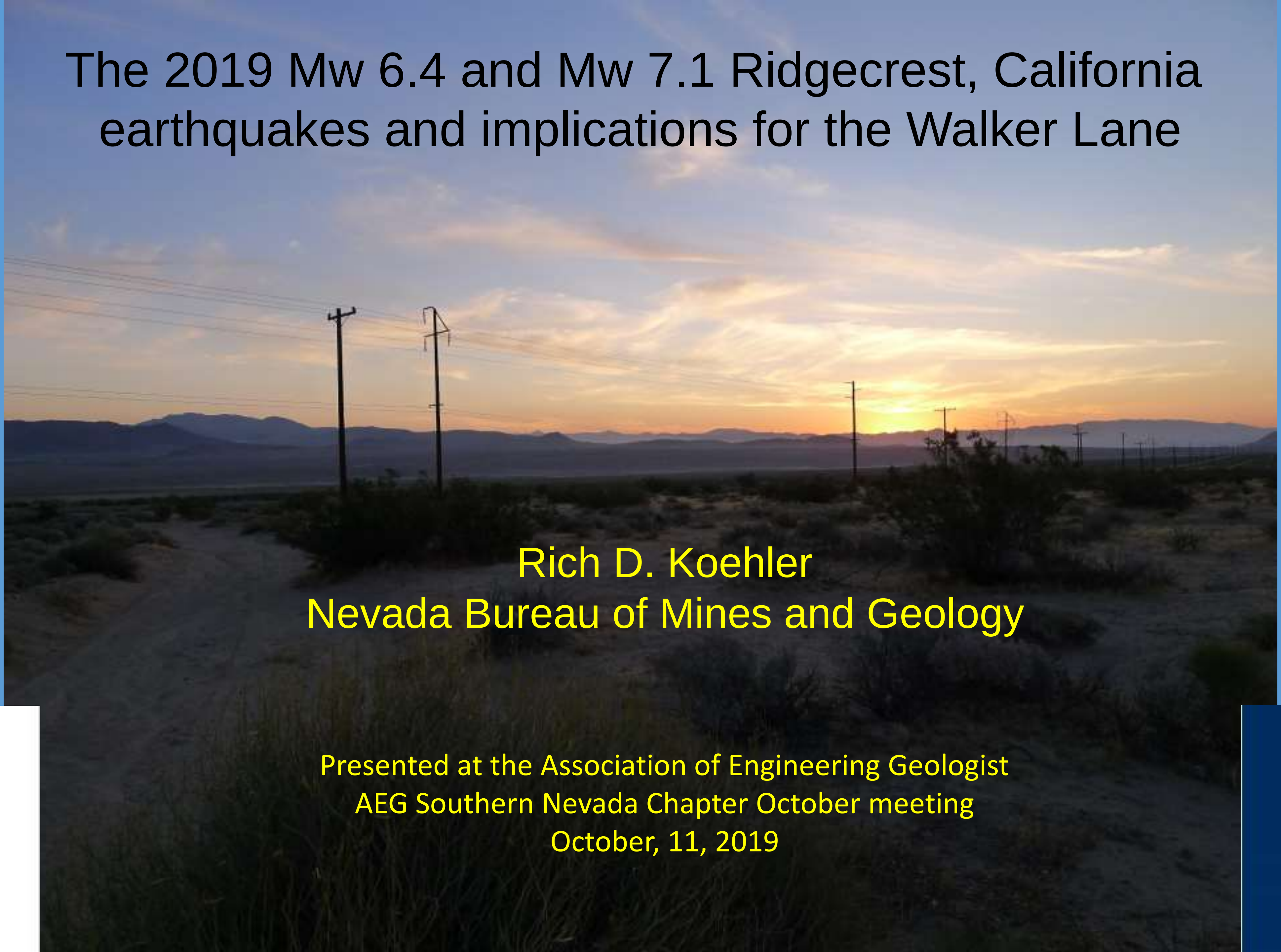
Character: continuous rupture, mostly single trace with +70% of total slip

Strike	Slip	Rupture Zone Width	Cracking Zone Width	rock Vs30*
318	3-4m	5m	20m	>760m/s

- Fault orientation
  - Extensional areas show extensive zones of cracking
  - Cracking is asymmetrical often limited to the hanging wall or down-dropped block

- Surficial Geology
  - We used Vs30 seismic velocity estimates (Allen and Wald, 1998) as a proxy for surficial geology
  - Lower velocity surficial sediments are correlated with wider cracking zones

- Optical strain maps can provide a rapid view of the rupture, without the issues of decorrelations associated with Insar in high strain areas
- Remote sensing methods provide unprecedented overall view of the deformation that is very difficult to get from field mapping
- Remote sensing methods require ground truthing to identify thresholds of how strain is accomodated
- Field observations provide information of how the surface deformation was accommodated; cracking, cracking patterns, or folding
- Multi-method approach improves surface rupture characterizaton
- Improved understanding of surface ruptures helps anticipate future ruptures and hence can lead to better mitigation and zoning efforts



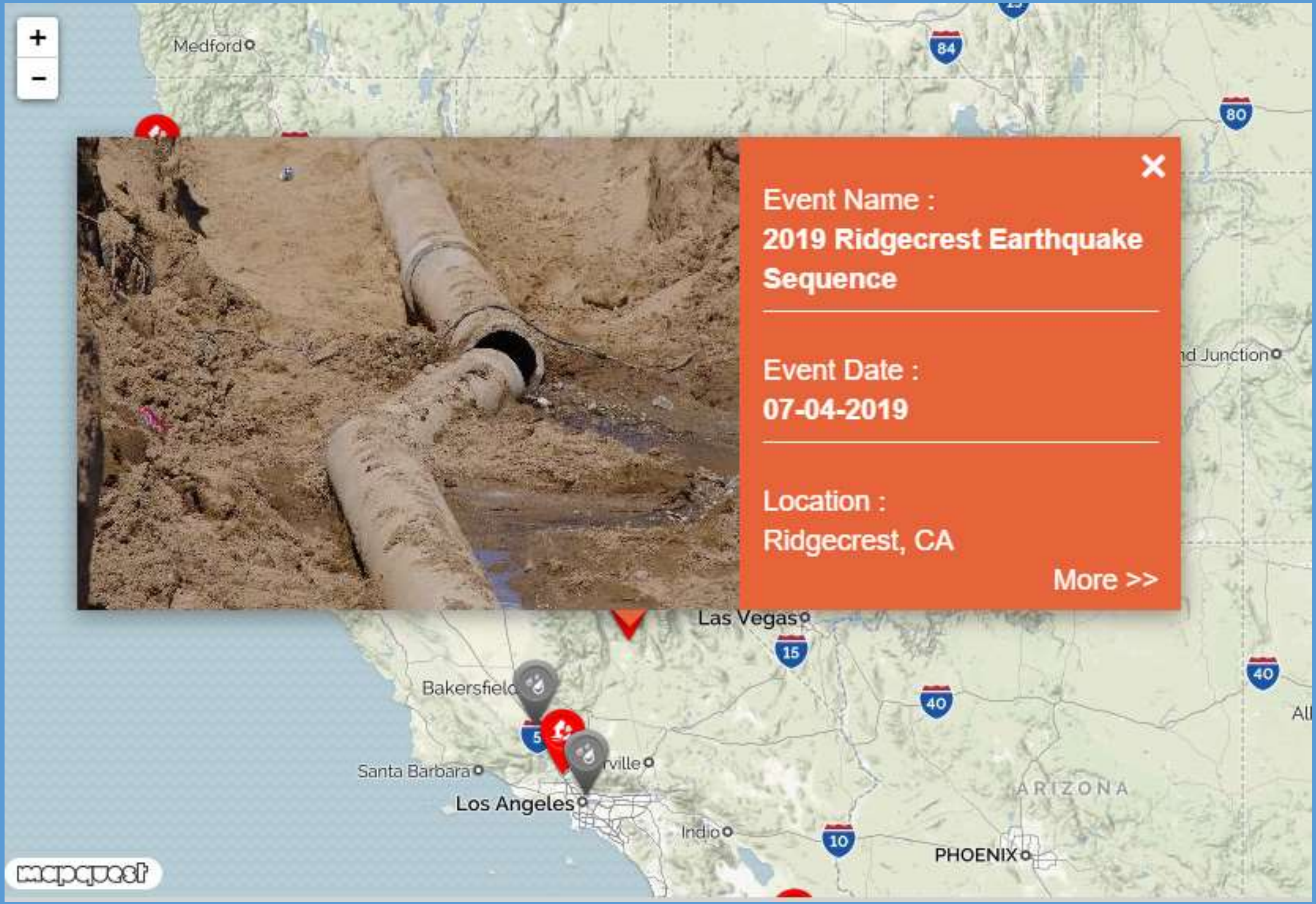
The 2019 Mw 6.4 and Mw 7.1 Ridgecrest, California earthquakes and implications for the Walker Lane

Rich D. Koehler
Nevada Bureau of Mines and Geology

Presented at the Association of Engineering Geologist
AEG Southern Nevada Chapter October meeting
October, 11, 2019

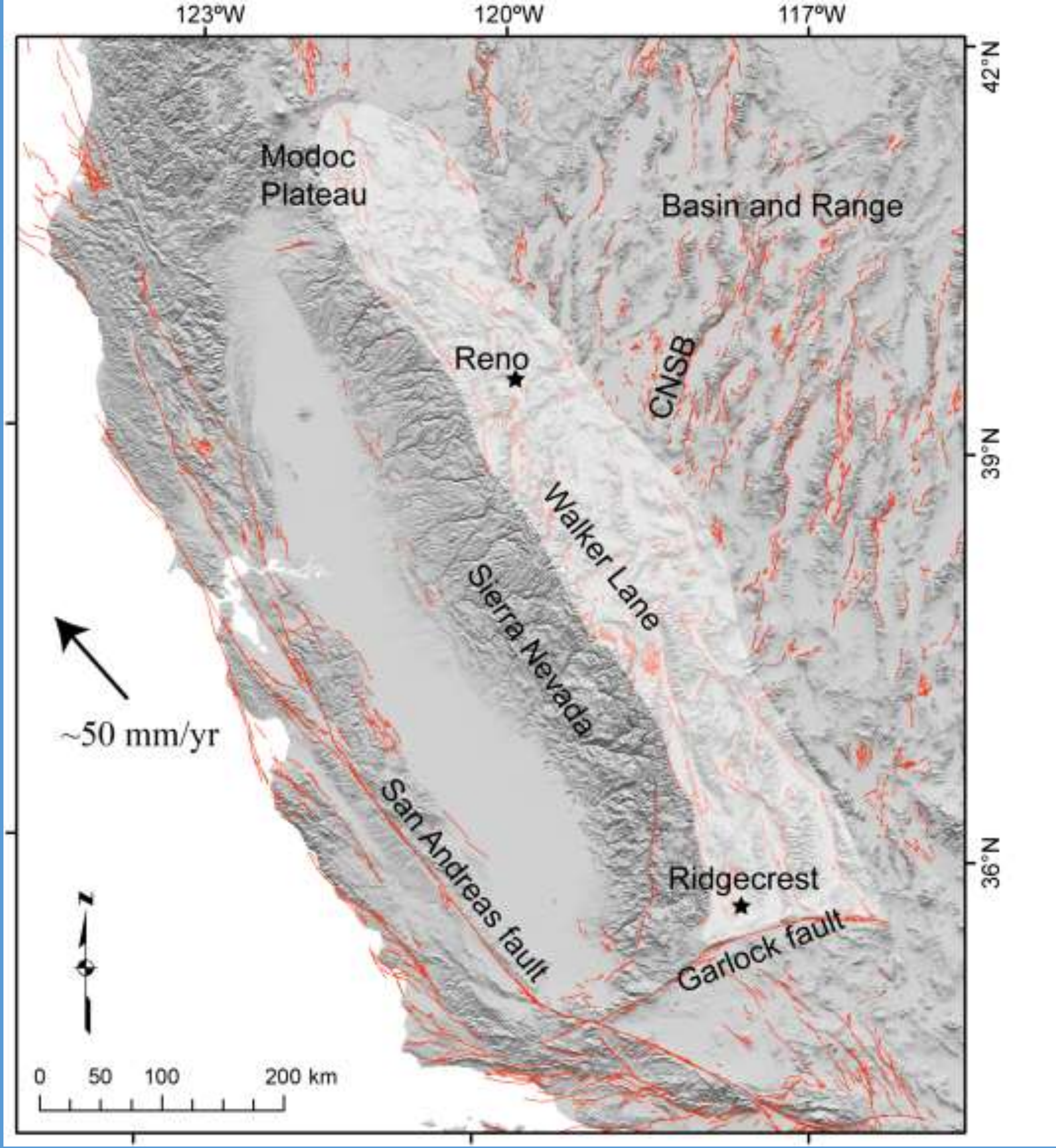
Collaborators
UNR
Arizona State University
CSU Fullerton
PG&E
Geotechnical Extreme Events Reconnaissance
California Geological Survey
U.S. Geological Survey

Preliminary Report on Engineering and Geological Effects of the July 2019 Ridgecrest Earthquake Sequence

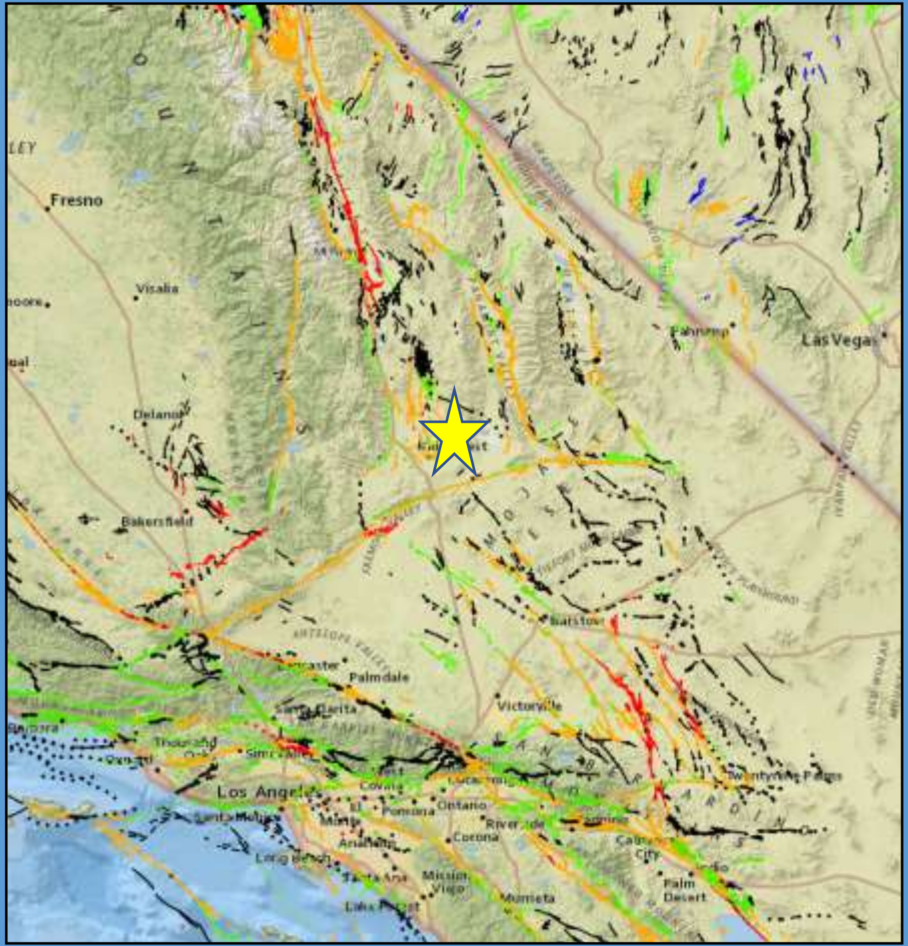


http://www.geerassociation.org/

Tectonic setting



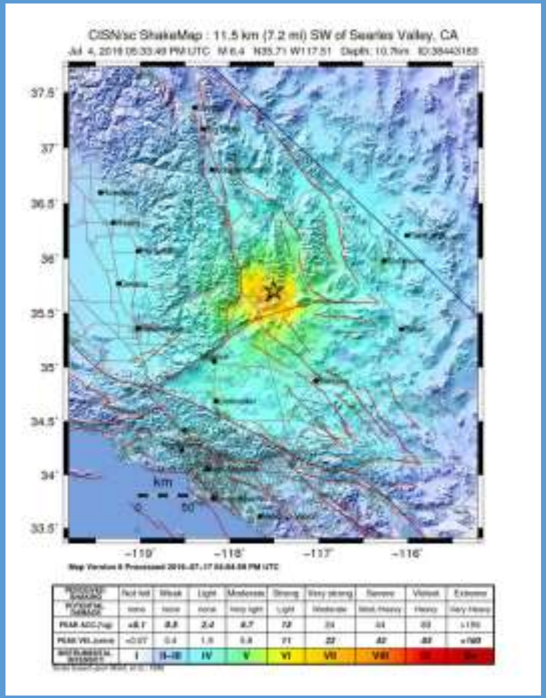
- Southern Walker Lane/Eastern CA shear zone accomodates 20-25% of the plate motion.
- Individual fault slip rates <5 mm/yr on major faults.



The 2019 Mw 6.4 and Mw 7.1 Ridgecrest, California earthquakes

M6.4 event

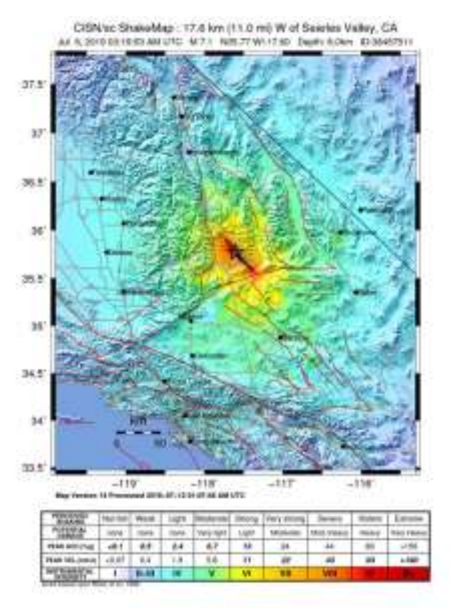
- July 4, 2019
- NE oriented left-lateral strike-slip fault.
- Hypocentral depth of ~11 km
- Rupture length or ~15 km.
- Unilaterally ruptured to the southwest.
- Max lateral displacements >1 m.



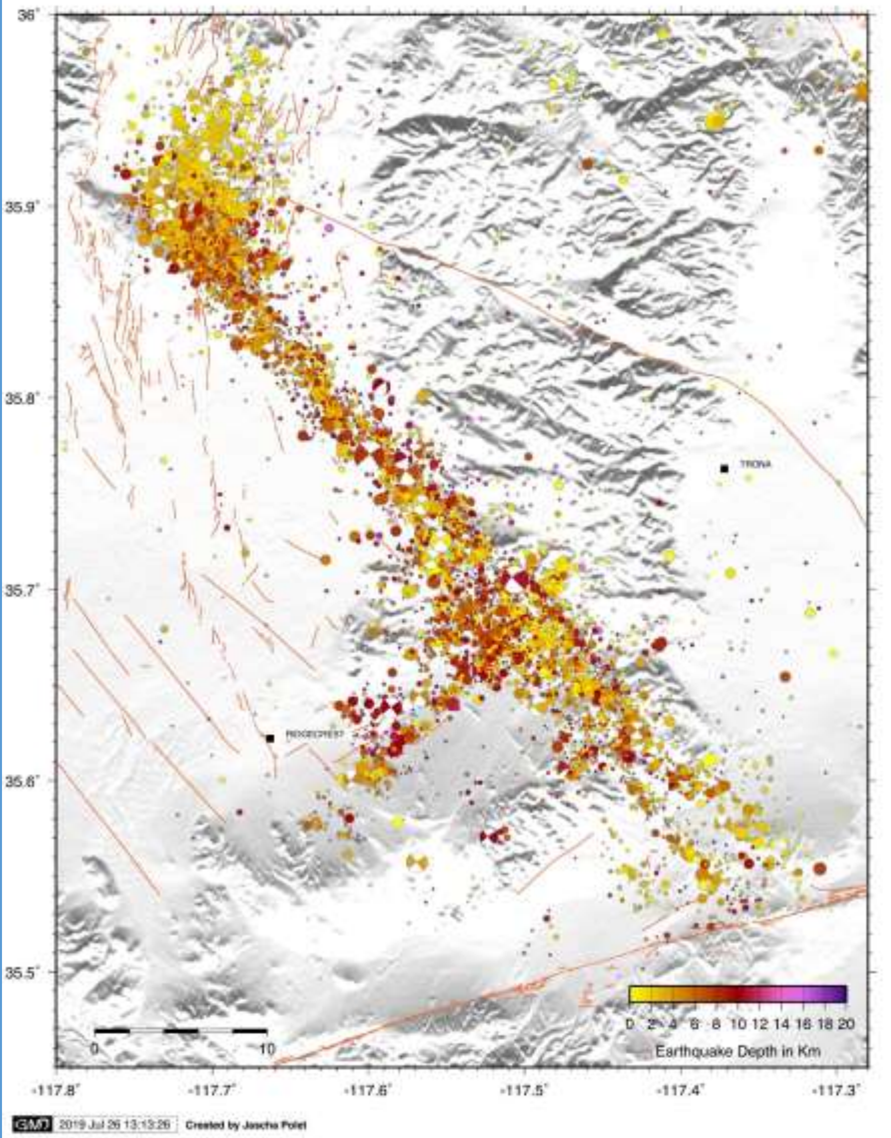
The 2019 Mw 6.4 and Mw 7.1 Ridgecrest, California earthquakes

M7.1 event

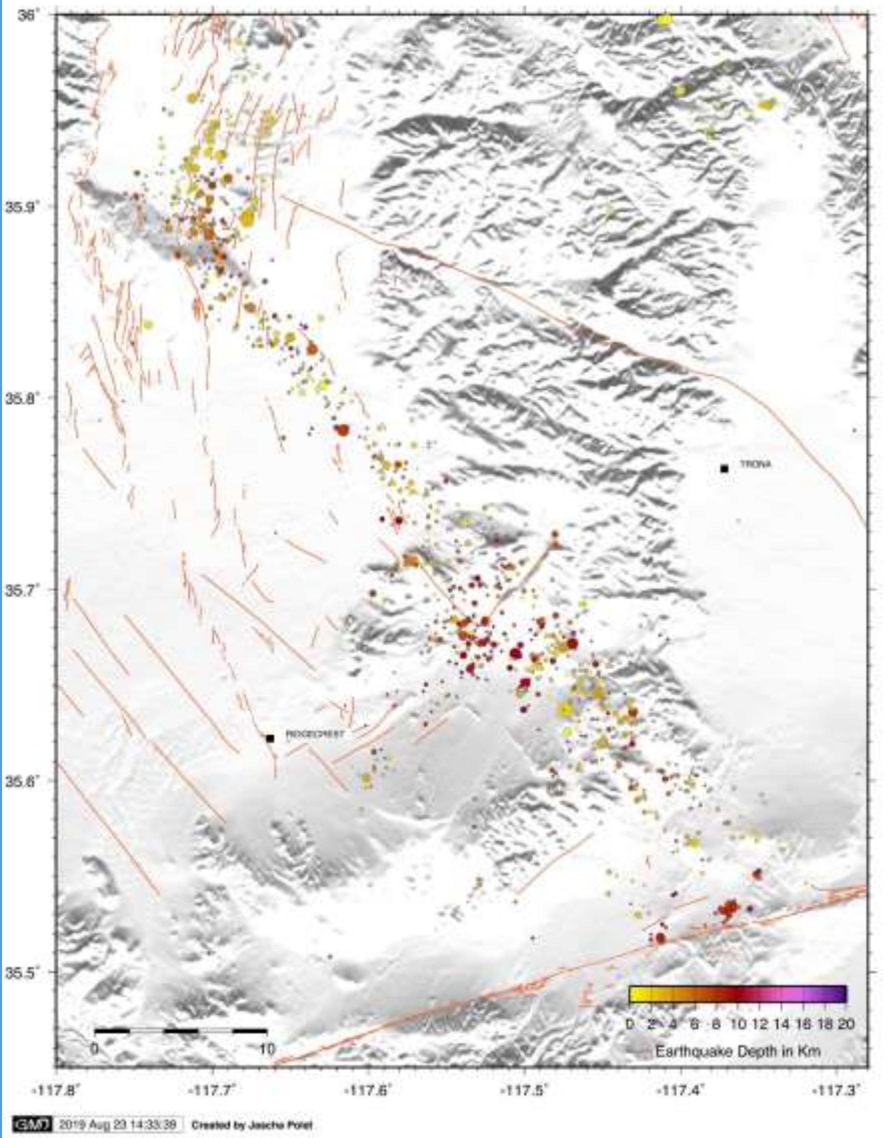
- July 5, 2019, 8:19 PM
- NW oriented right-lateral strike-slip fault.
- Hypocentral depth of ~8 km
- Rupture length of >50 km km.
- Bilaterally ruptured to the NW and SE.
- Max lateral displacements >4.5 m.
- Rupture distributed over 2.5 km



Seismicity before 07/26



Seismicity 07/24-08/23

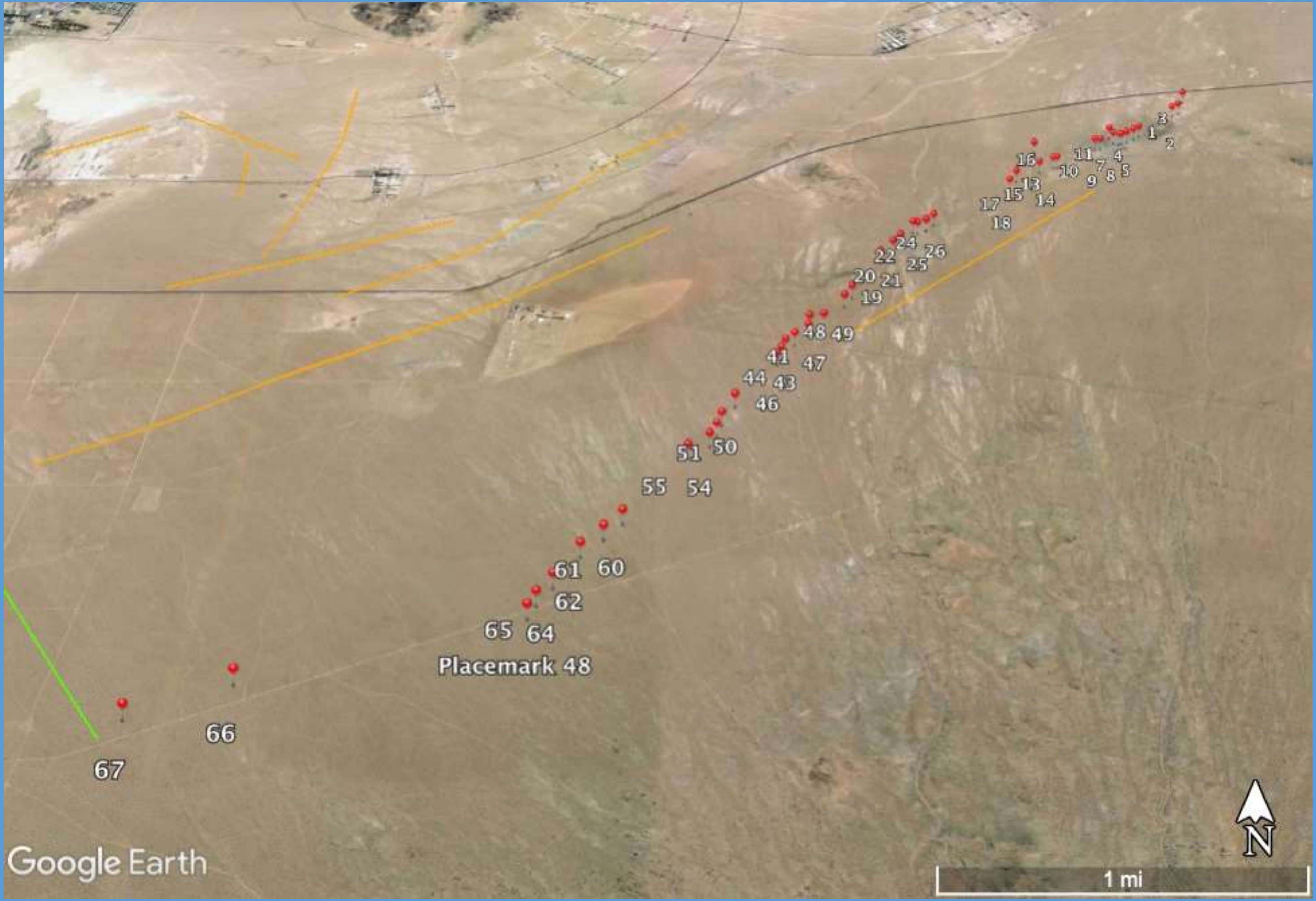


Jascha Polet, CalPoly

Why do rapid reconnaissance?

M6.4 around 5 AM,
July 5th

No sleep,
M5+ aftershock



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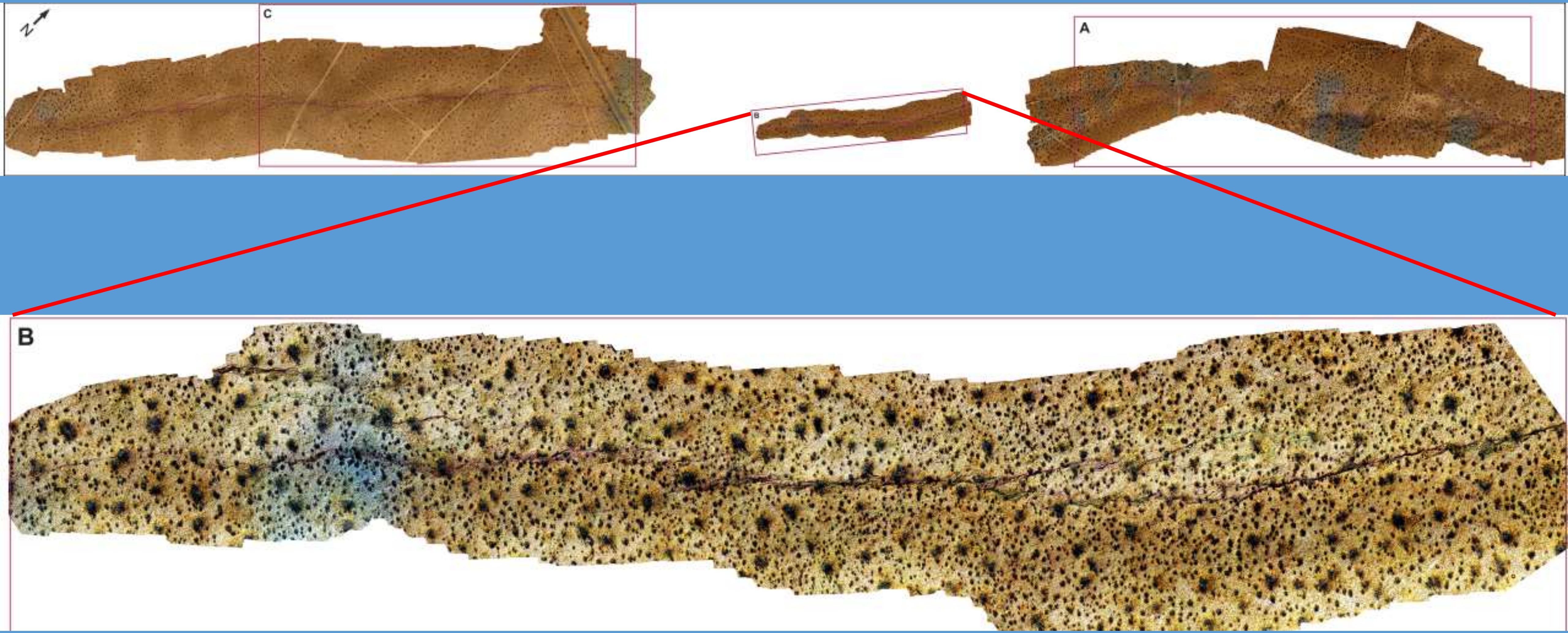
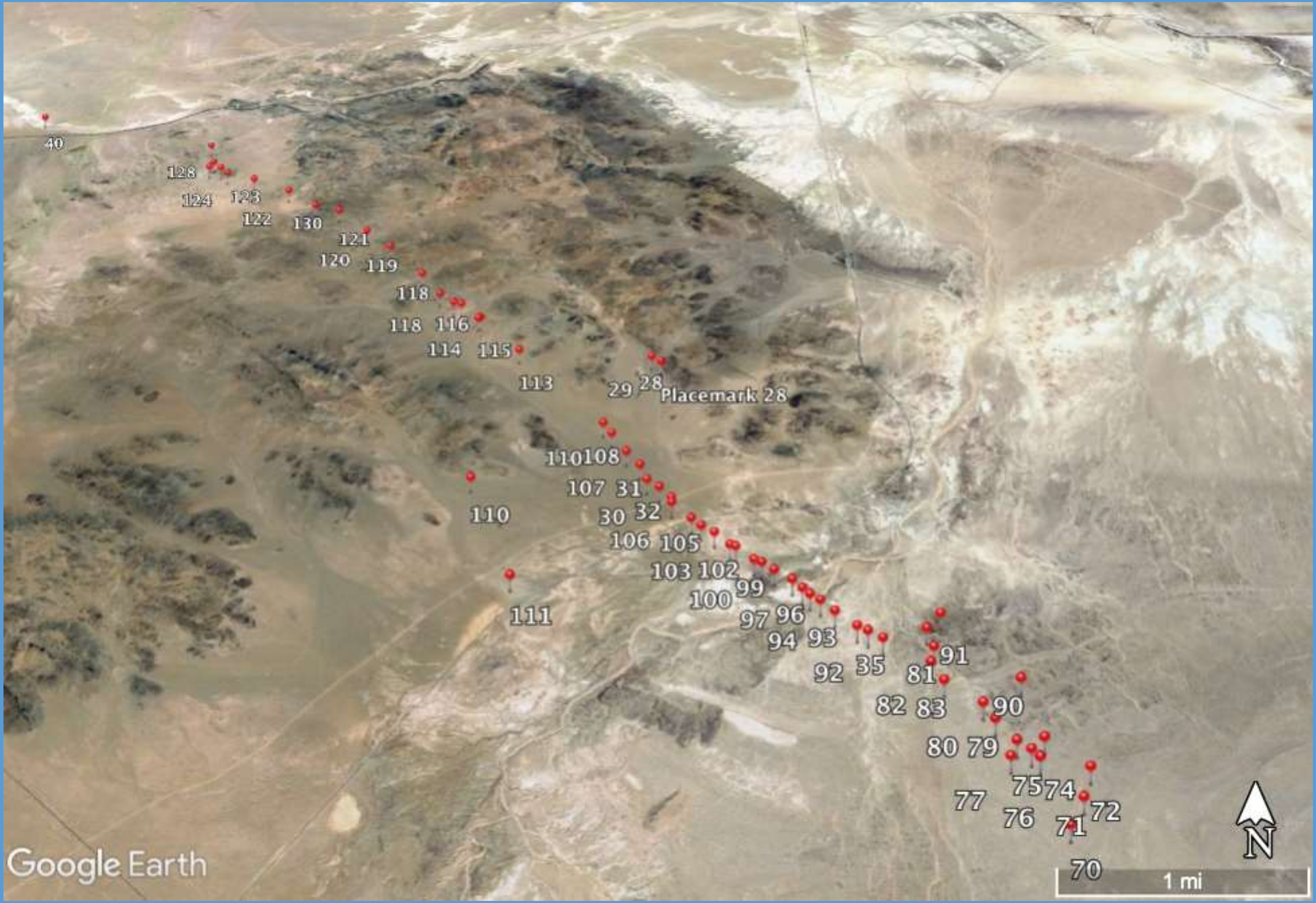
Mw6.4 surface rupture



M7.1 Earthquake

Highway 178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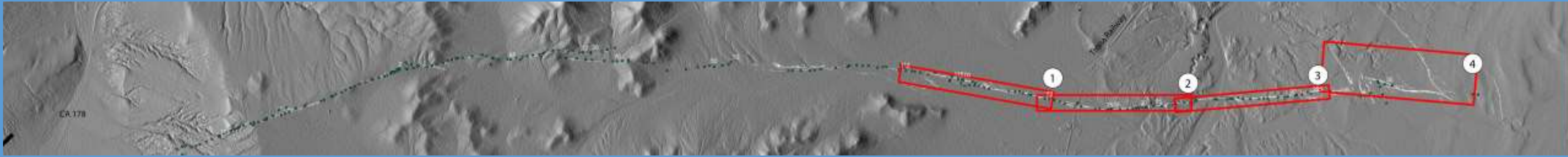
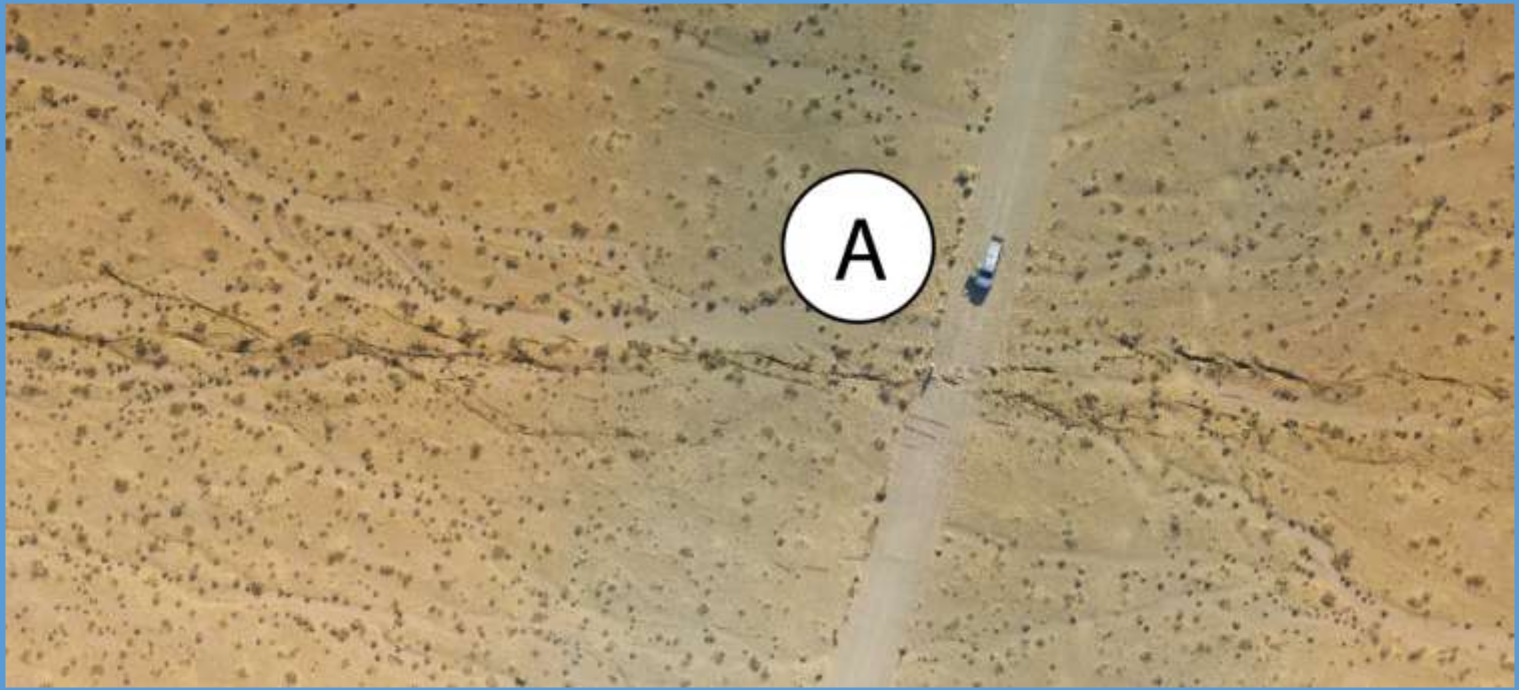
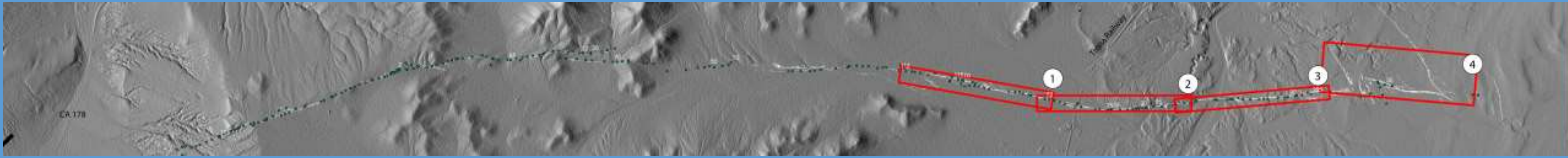
Mw7.1 surface rupture

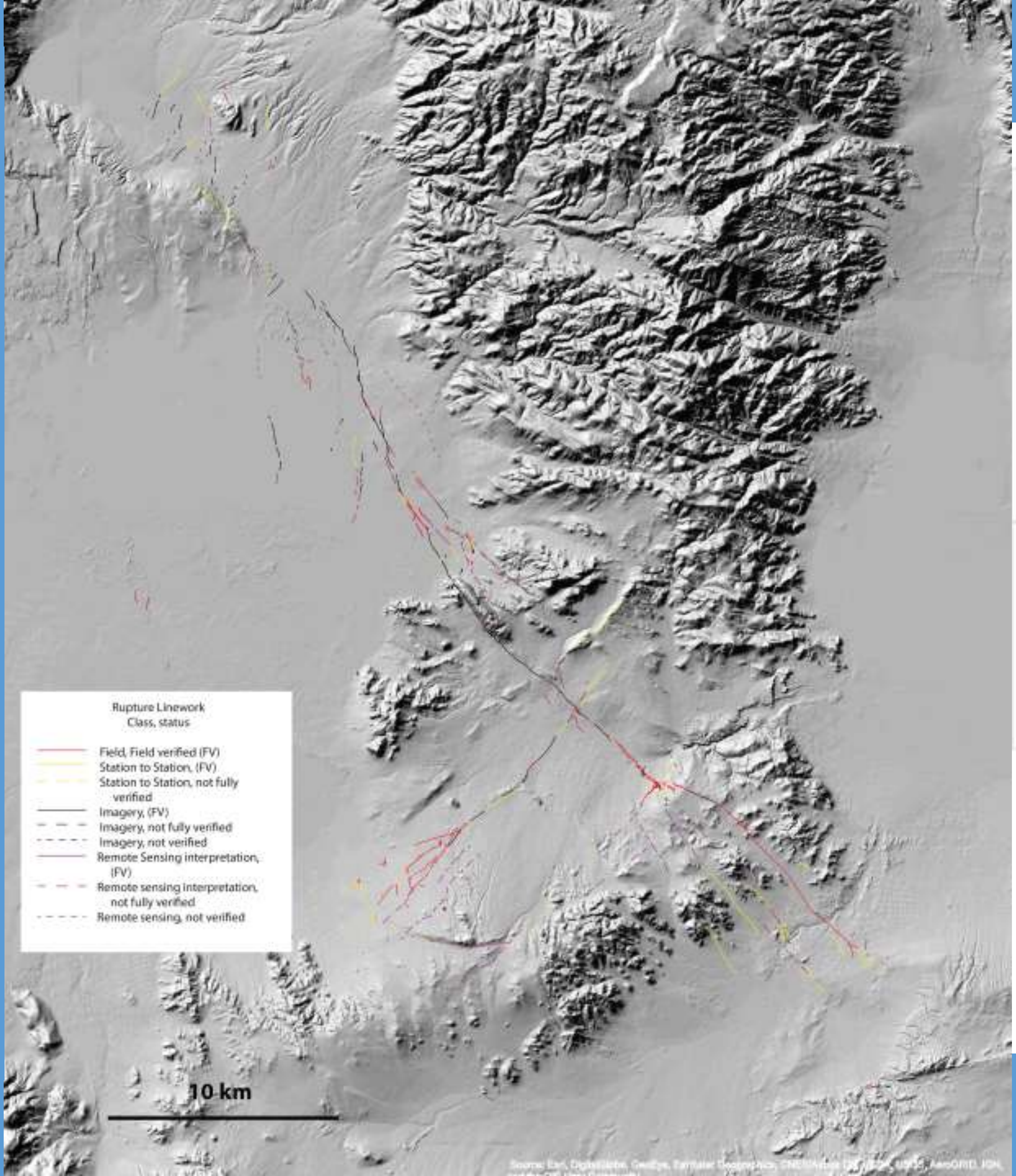
High resolution drone imagery and orthophotographs

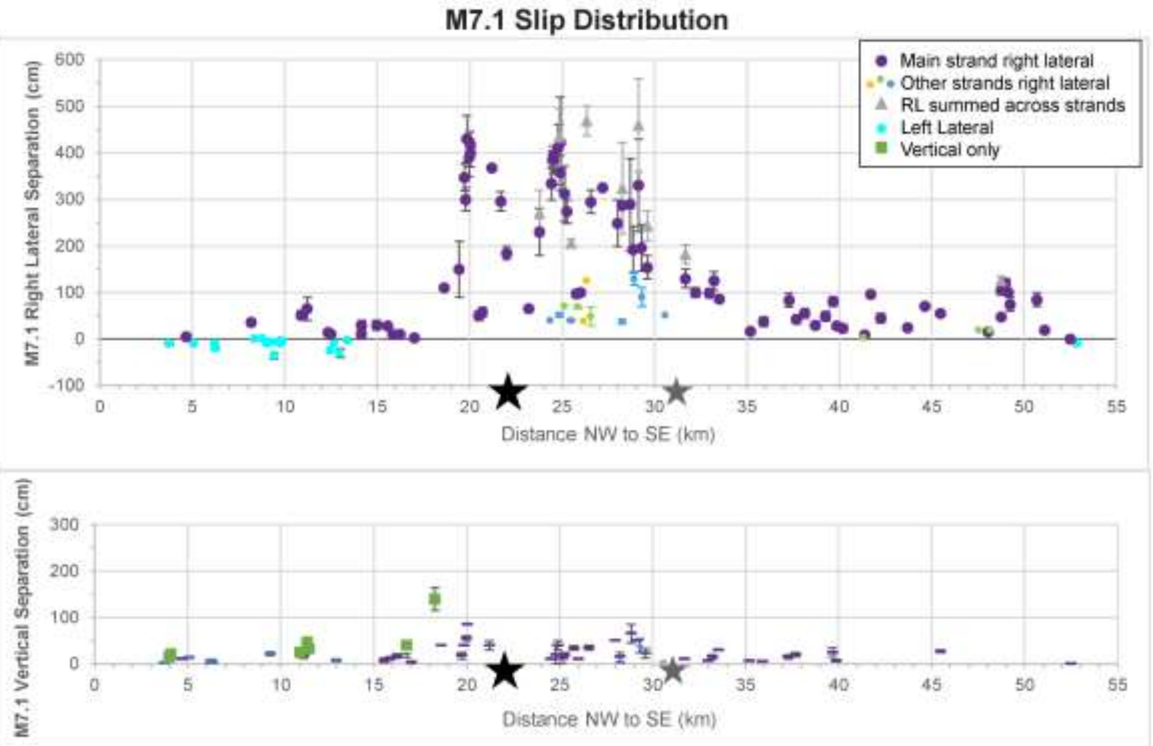


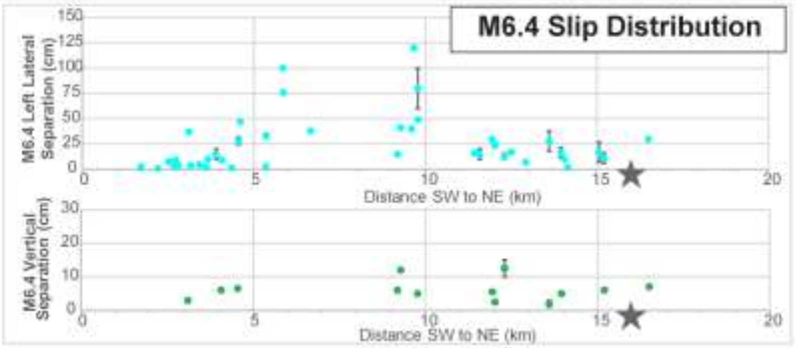


Mw7.1 surface rupture







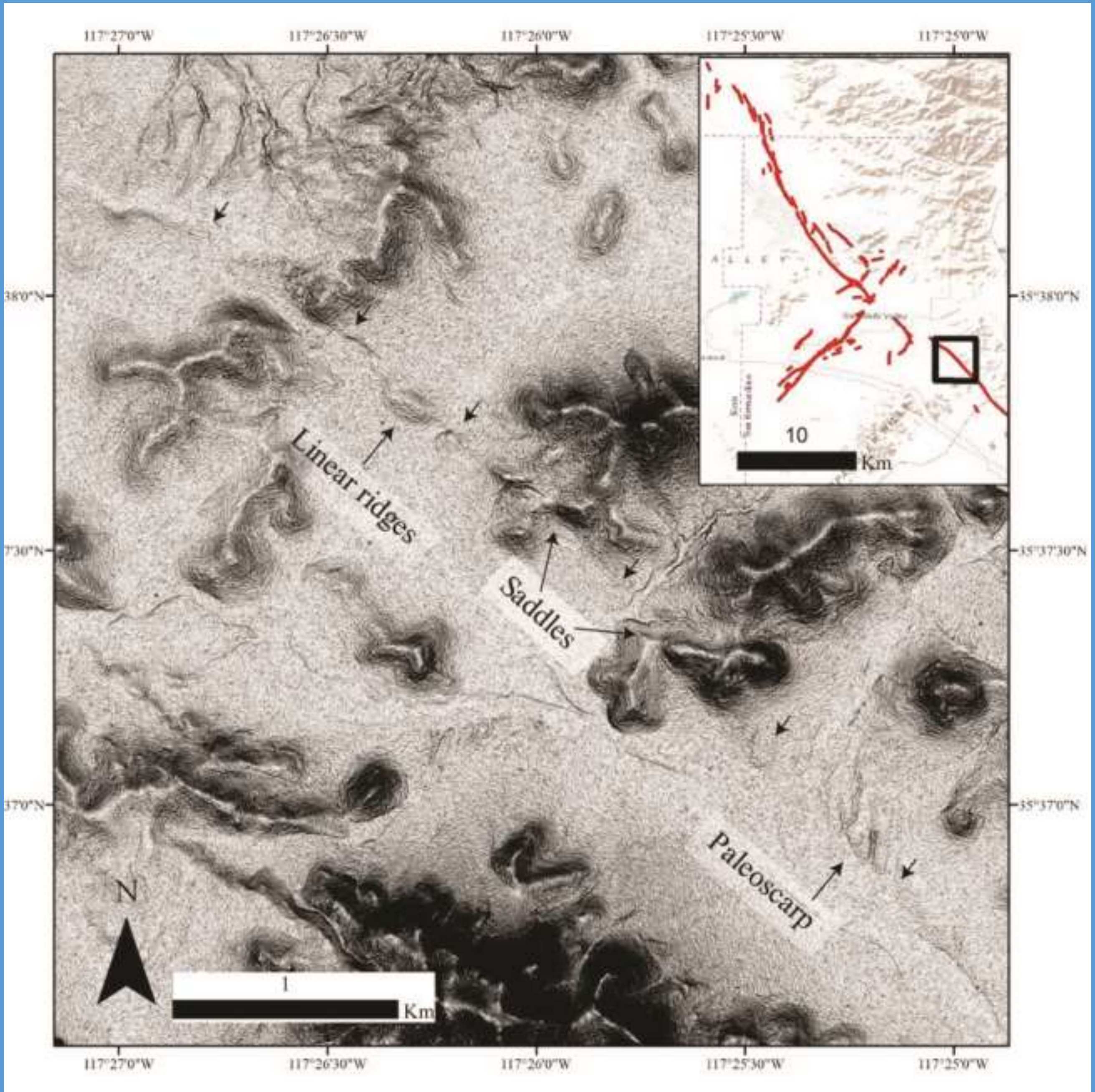


Cite: Kendrick et al., SCEC Annual Meeting 2019, https://www.scec.org/publication/9779

PROVISIONAL: Slip data compiled 09/05/19 by Tim Dawson, Ryan Gold, and Kate Scharer, from the Ridgecrest Rupture Mapping Group provisional map dated 08/23/18.

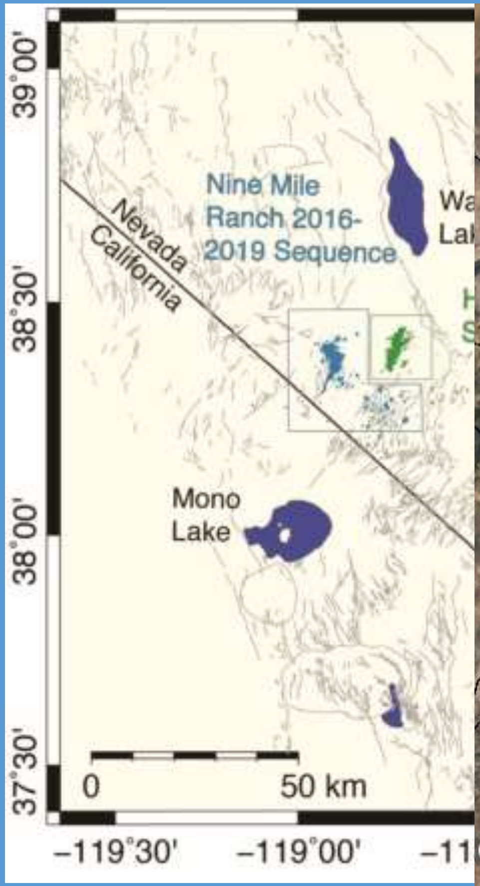
Base DEM from 2 m DSM (Willis et al., Opentopography.org, https://doi.org/10.5069/G998854C)

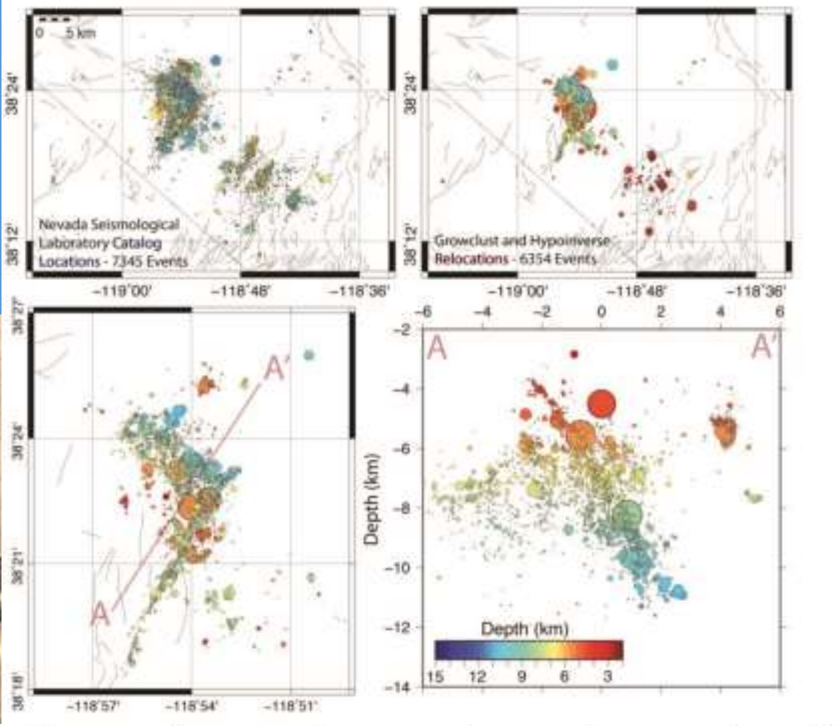
Quaternary faults from CGS Fault Activity Map.

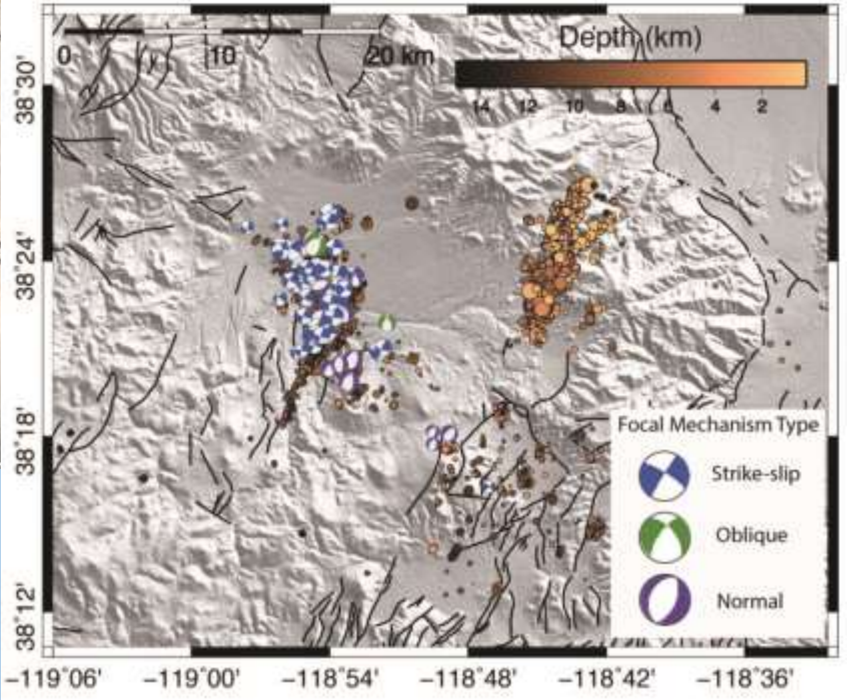

117°27'0"W
117°26'30"W
117°26'0"W
117°25'30"W
117°25'0"W
35°38'0"N
35°37'30"N
35°37'0"N
Linear ridges
Saddles
Paleoscarp
N
1
Km
10
Km

Nine Mile Ranch Earthquake sequence Dec. 28, 2016

3 Mw 5.4-5.6 events

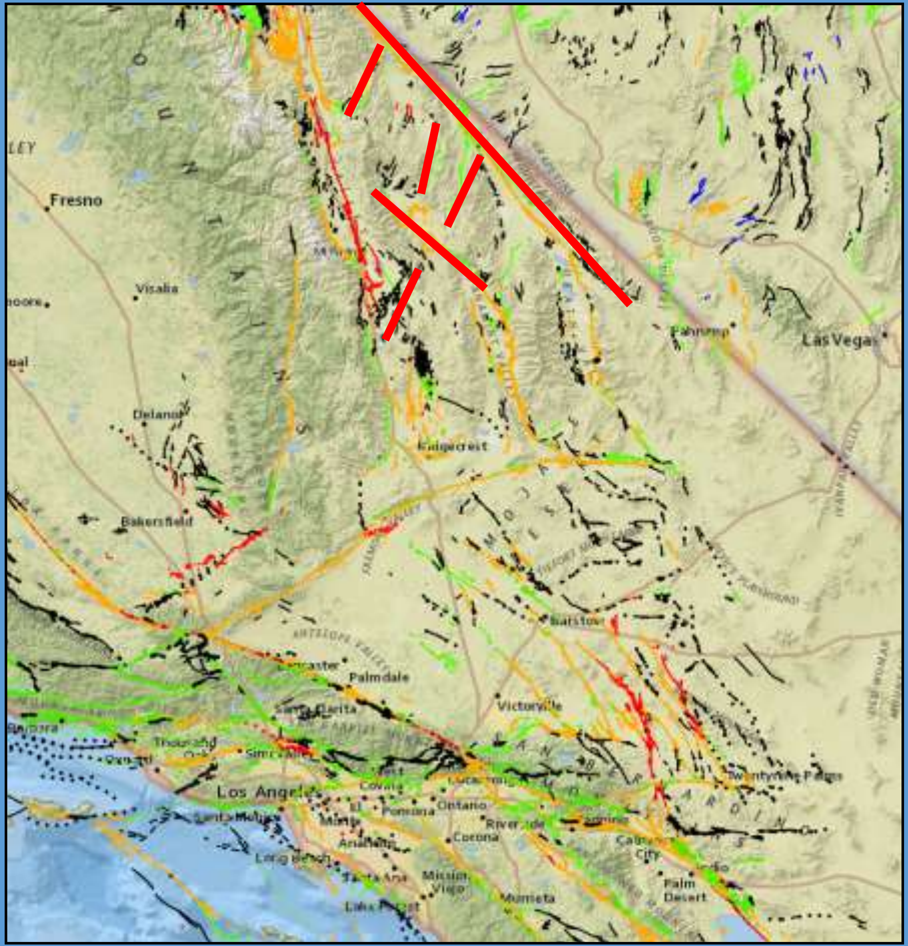




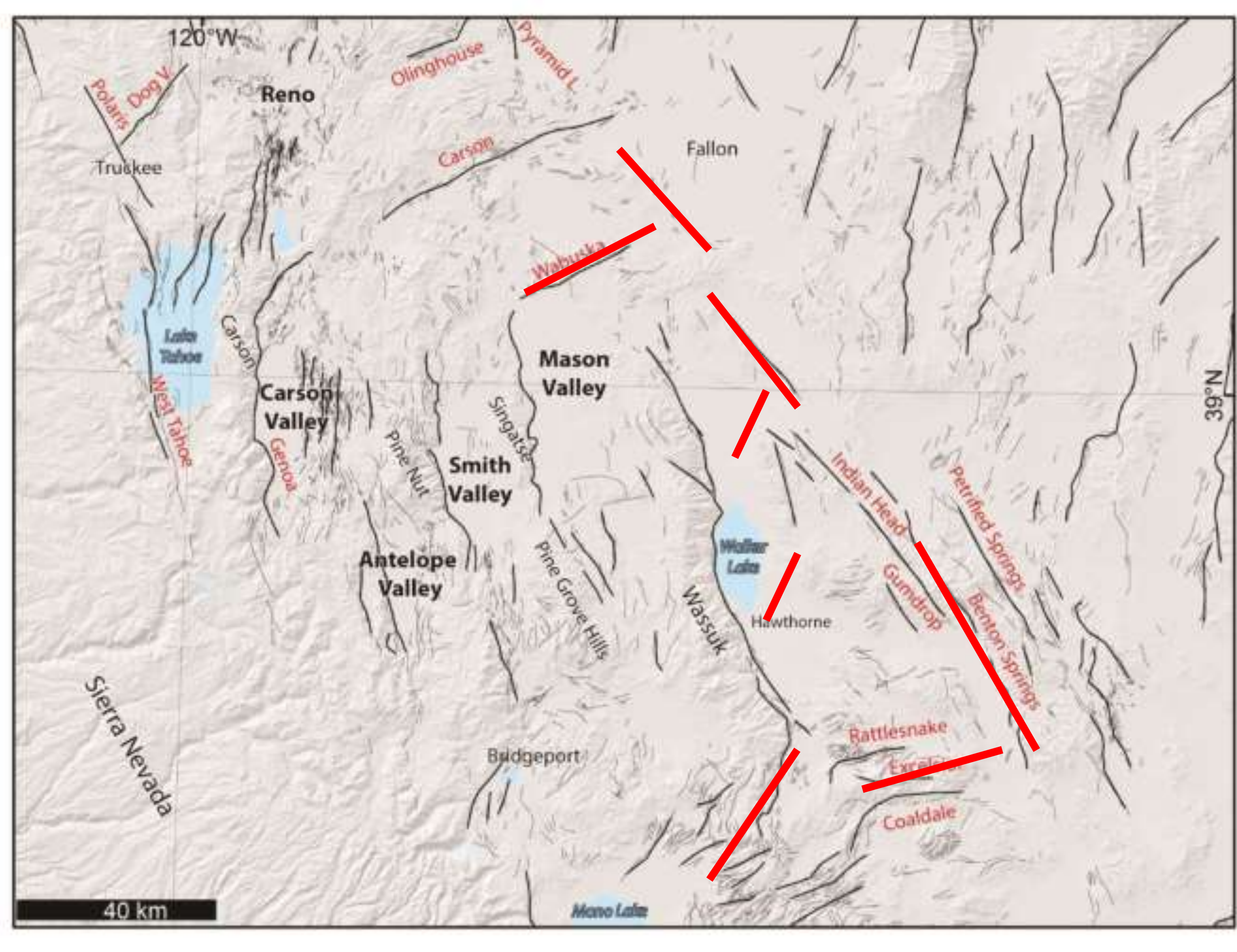


Hatch, 2019

Implications for the Walker Lane

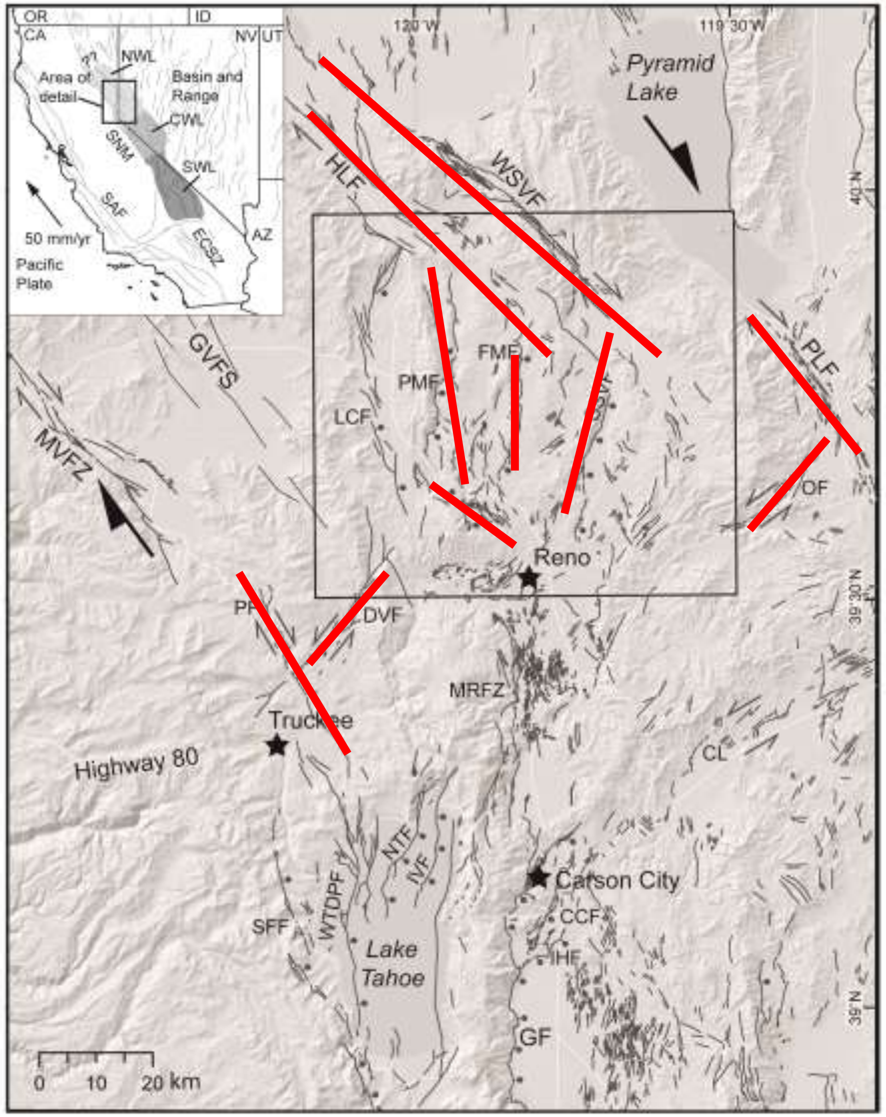


Southern Walker Lane



Central Walker Lane

Northern Walker Lane

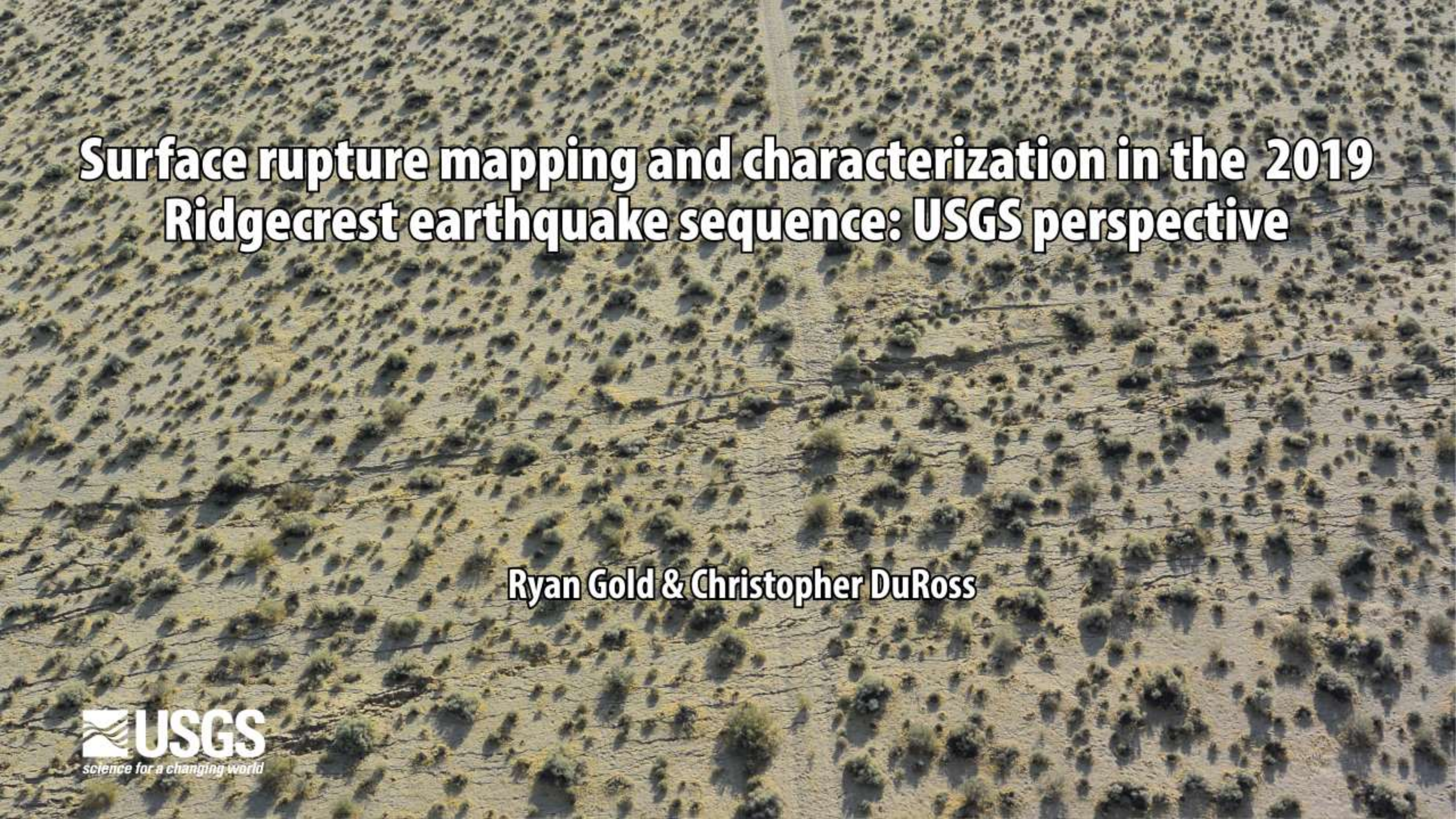



Thanks!





HONDA

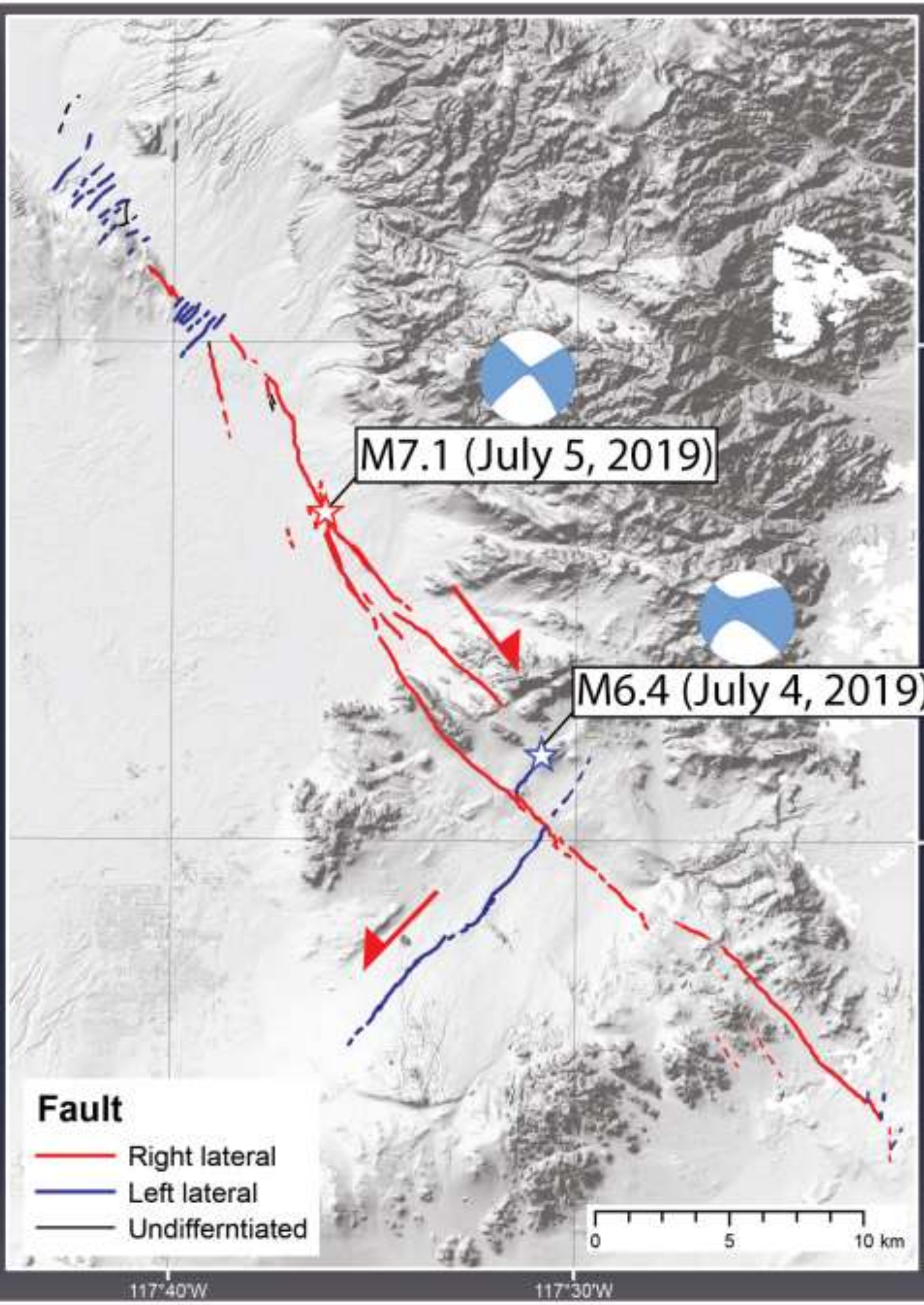


Surface rupture mapping and characterization in the 2019 Ridgecrest earthquake sequence: USGS perspective

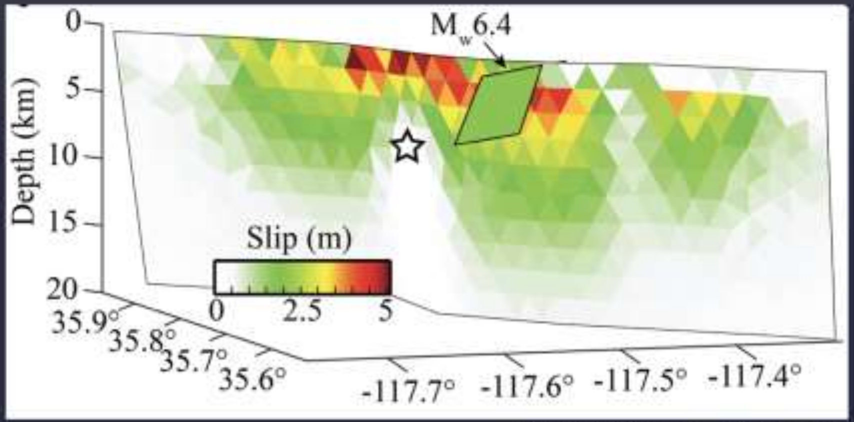
Ryan Gold & Christopher DuRoss

USGS
science for a changing world

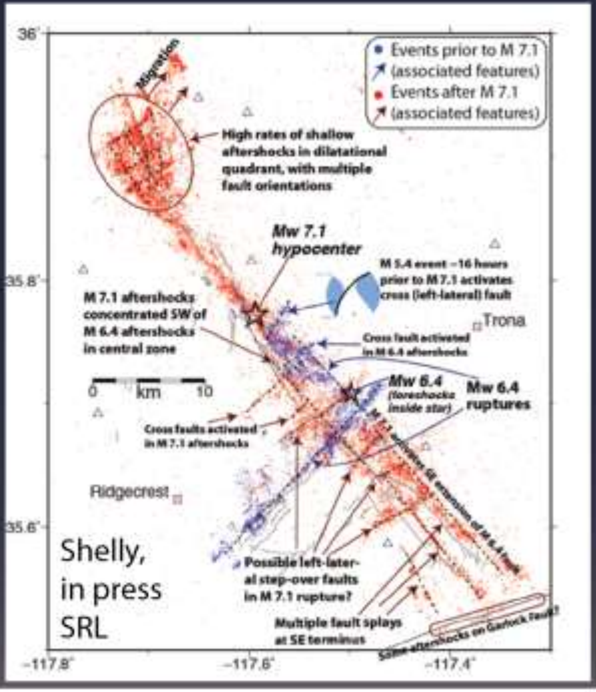
2019 Ridgecrest EQ Sequence



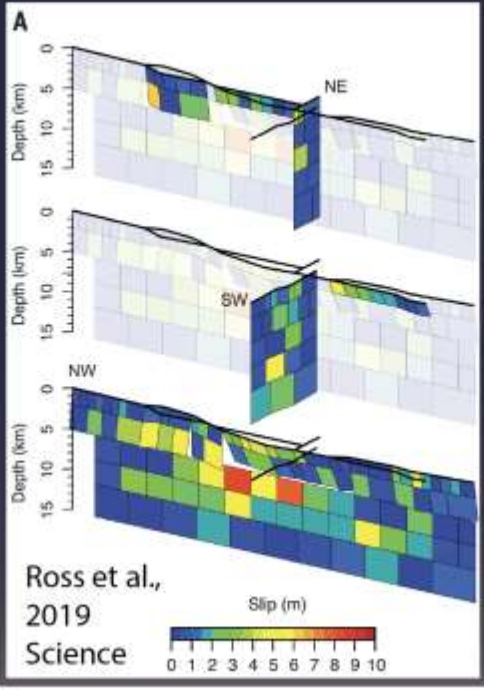
Mapping from pixel tracking results



Barnhart et al., 2019, GRL



Shelly, in press SRL



Ross et al., 2019 Science

Field Based Measurements

Data:
•9500 observations submitted to CGS/USGS. See credits on last slide.
•Post review, M7.1 = 576 measurements and M6.4, 96 measurements identified for slip distribution analysis.

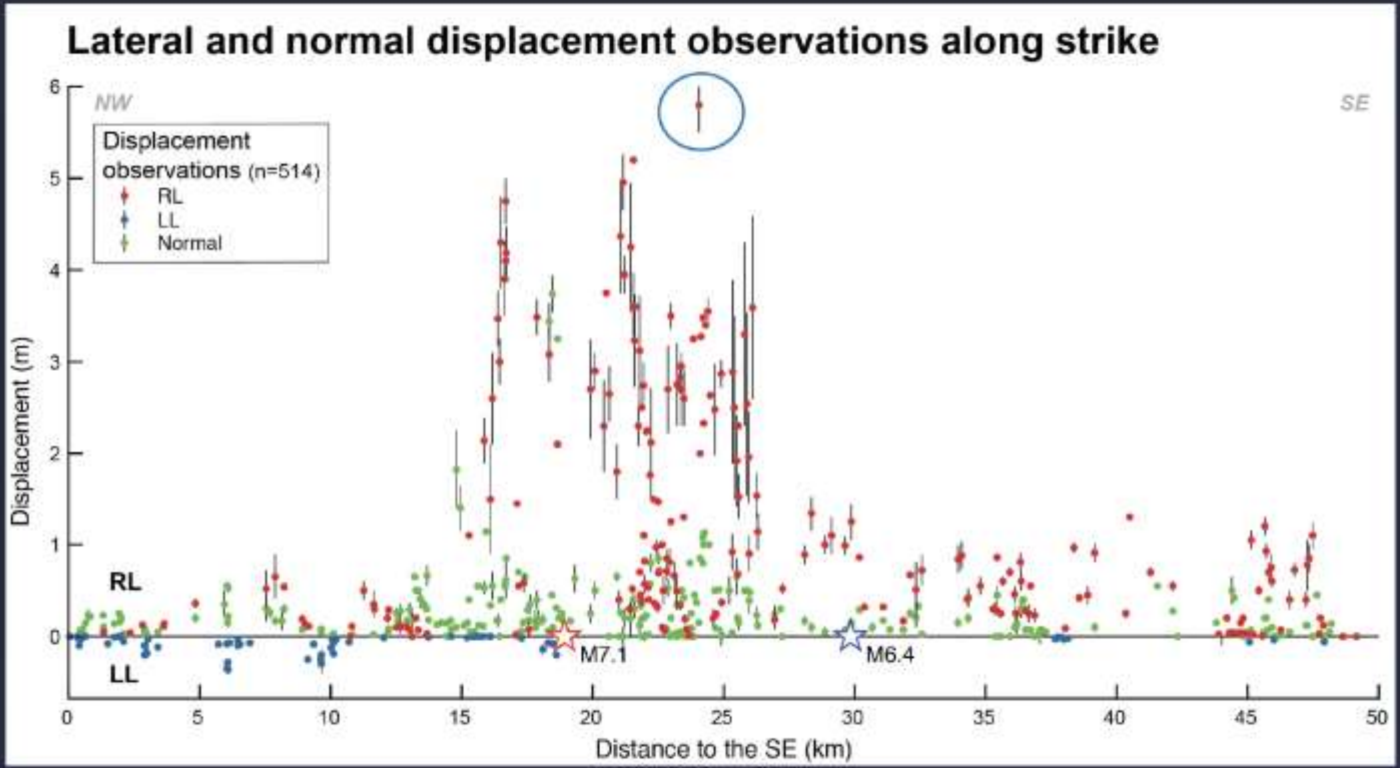
Measurements:
•Lateral & vertical displacement (cm), w/uncertainty
Fault zone width (m)
•Scarp facing direction

USGS scientist (DuRoss) measures vertical separation

(Ponti et al., in review, SRL; DuRoss et al., in review, BSSA)

Field Based Measurements - Problems

- Digital vs fieldnotebook
- Too many fields in ArcCollector
- Variable measurement style
- Measurement units,
- Measurement methods (indiv vs sum)
- Team size (smaller = better)
- Signal vs. noise (slip observations vs crack measurement, field track lines, general rupture obs, helicopter pts, etc)
- Transcription errors, limited documentation
- no reported uncertainties



Earthquake response - structure

USGS

-Event response coordinator (Hough)
-Geologic coordinators (Gold & Kendrick)
-NEHRP coordinator (Scharer)
-Seismic deployment (Cochran)
-Geodesy deployment (Brooks)
-Landslides & liquefaction (Jibson)
-Media (Davis)
-Talking points & situation reports (Page)
-Aftershock forecasting (Michael)

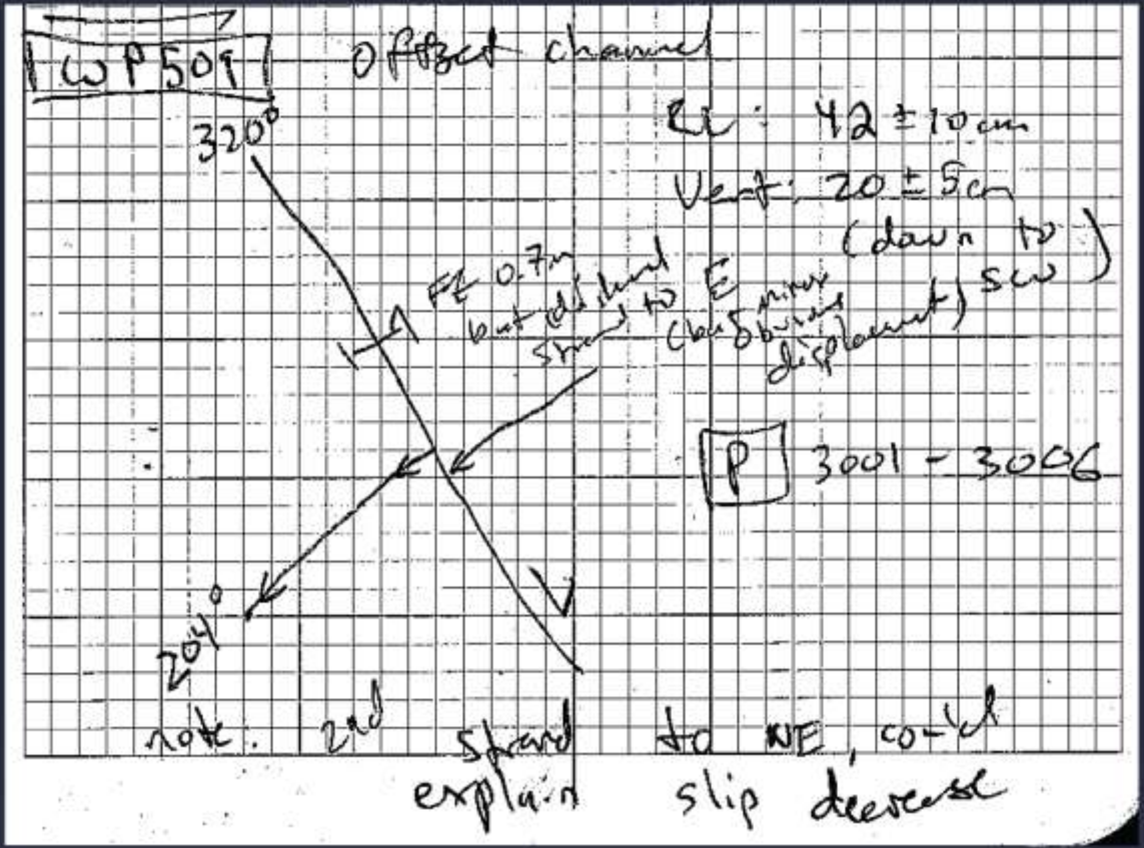
CGS

-Geologic coordinators (Dawson & Hernandez)
-and certainly more activities

Partnership was/is strong!

Data Collection (digital and/vs analog)

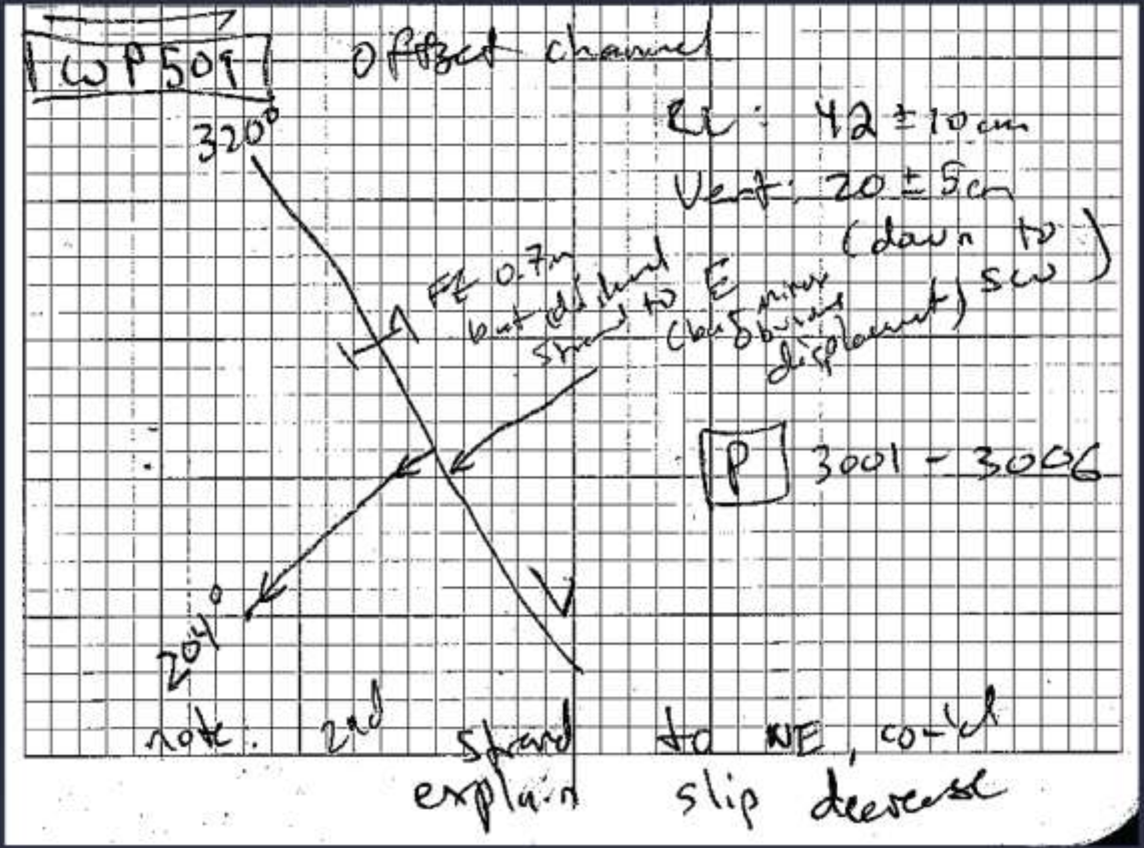
Field Notebook



7/12/19, Field Notes

Data Collection (digital and/vs analog)

Field Notebook



7/12/19, Field Notes

Challenges

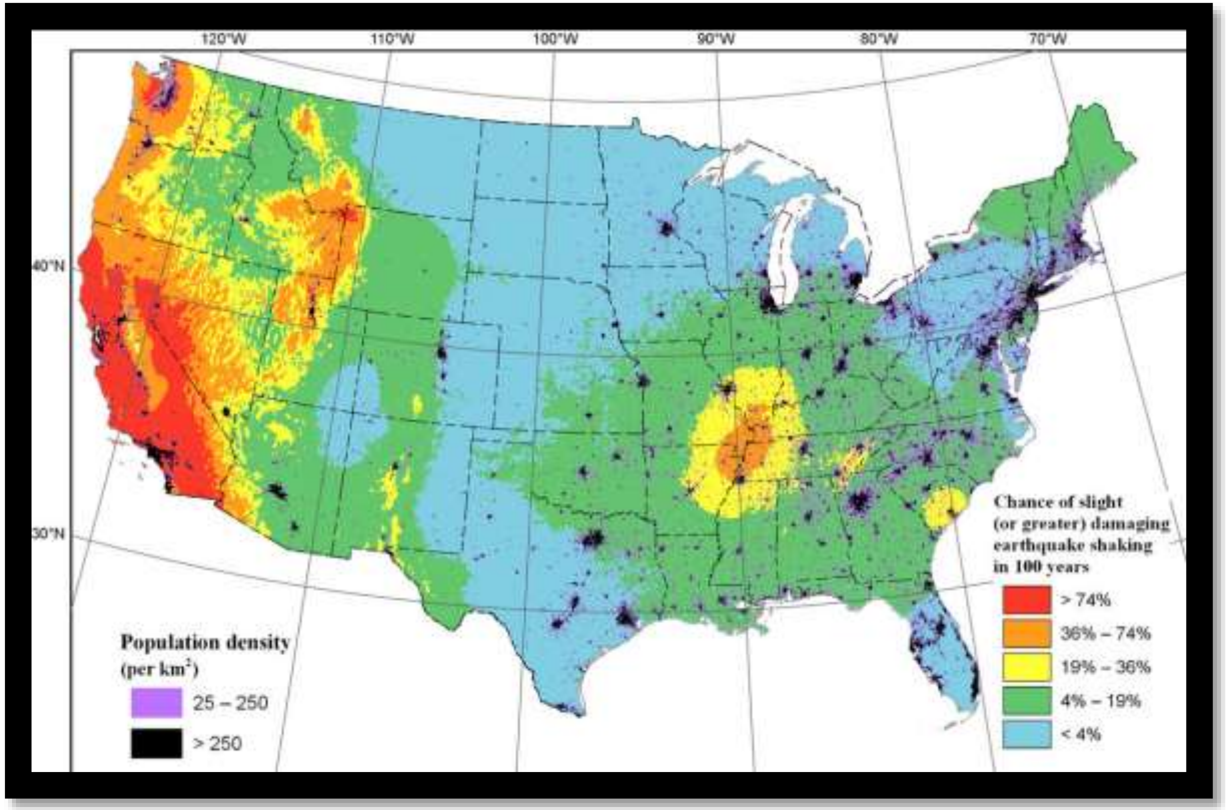
- Coordination/Communication
- Site acccess (NAWS)
- Many needs, limited resources
- Situational awareness
- Data collection standards
- Progress Reports (management)
- Long (18+ hr) days
- Many participants
- Data Access/Ownership

Updates to Basin and Range geology input data for 2023 USGS National Seismic Hazard Model

Alex Hatem, Ryan Gold, Rich Briggs, Ned Field, Peter Powers, Camille Collett
USGS-Golden, CO

Motivation

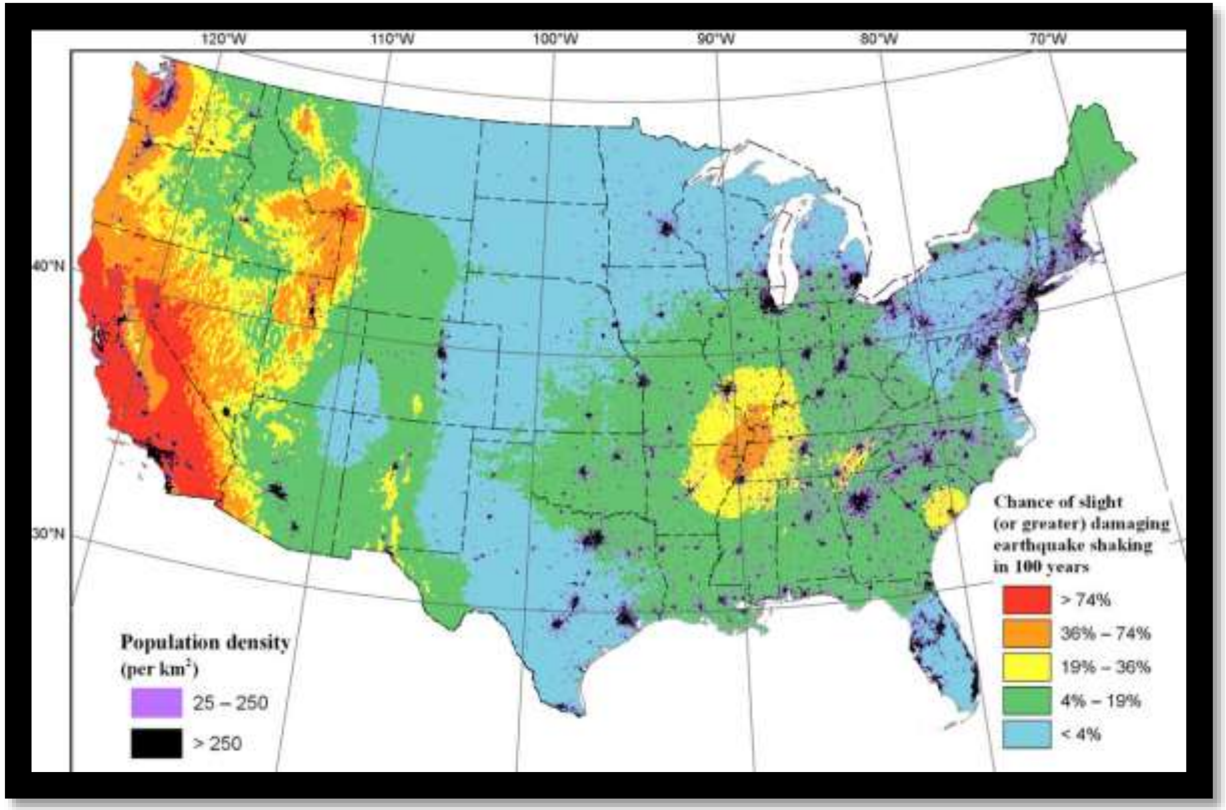
- USGS plans to release an update to U.S. National Seismic Hazard Model (NSHM) in 2023
- Geologic inputs have not been updated for NSHM since 2014, despite a map release in 2018
- Poorly organized geologic data for inputs to deformation model



Petersen et al., 2019

Goals

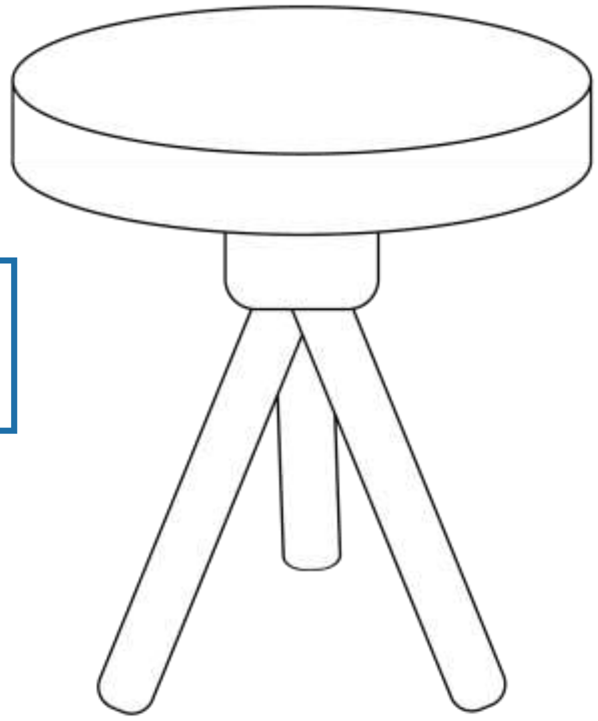
- Provide NSHM group with most up-to-date knowledge of earthquake geology across the U.S.
- Organize geologic data into a useable, shareable format
- Create a database of what is known along active faults nationwide

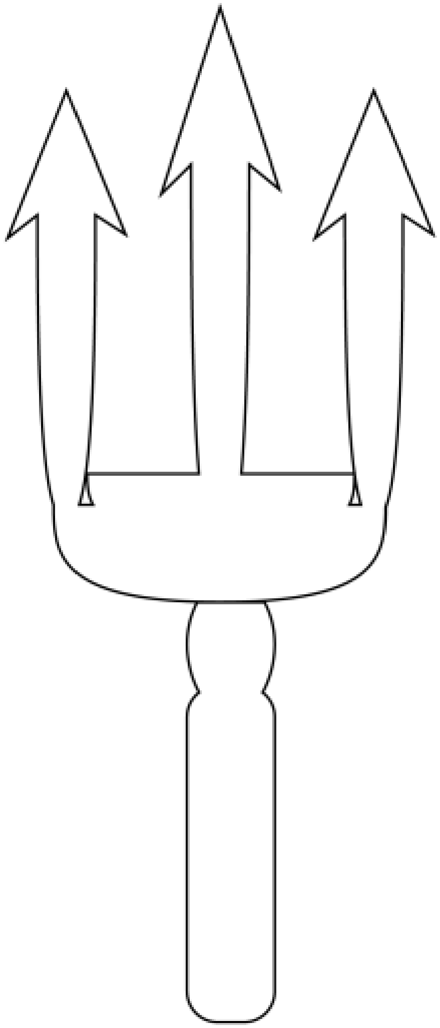


Petersen et al., 2019

Our objectives

1. Bring the rest of the country up to California (UCERF3) standard
2. Add recent studies to dataset
3. Densify fault network & reassess fault geometries





UCERF3 & WGUEP 2016 headers

Fault Section										
UCERF3 Fault Section	ID #	Style	Dip	Rake	Recency of Activity	USGS Slip Rate Category (mm/yr)	UCERF2 Section Slip Rate (mm/yr)	UCERF3 Slip Rate Bounds (mm/yr)	UCERF3 Best Estimate Rate (mm/yr)	UCERF3 assigned rate comments

Quality rating (QR1: offset feature, QR2: dating, QR3: overall)							
QR1	QR2	QR3	Reported Component (offset)	Preferred Offset (m)	Maximum offset (m)	Minimum Offset (m)	Offset Feature

Site-specific Data								
Site Name	Longitude	Latitude	Local Strike	UCERF3 Geologic Site Slip Rate (fault parallel, mm/yr)	Reported Geologic Rate (mm/yr)	Reported Component (slip rate)	Maximum Slip Rate (mm/yr)	Minimum Slip Rate (mm/yr)

Preferred Start Age (ka)	Maximum Start Age (ka)	Minimum Start Age (ka)	Preferred End Age	Maximum End Age	Minimum End Age	Dating Method	Slip rate time frame category (ka)

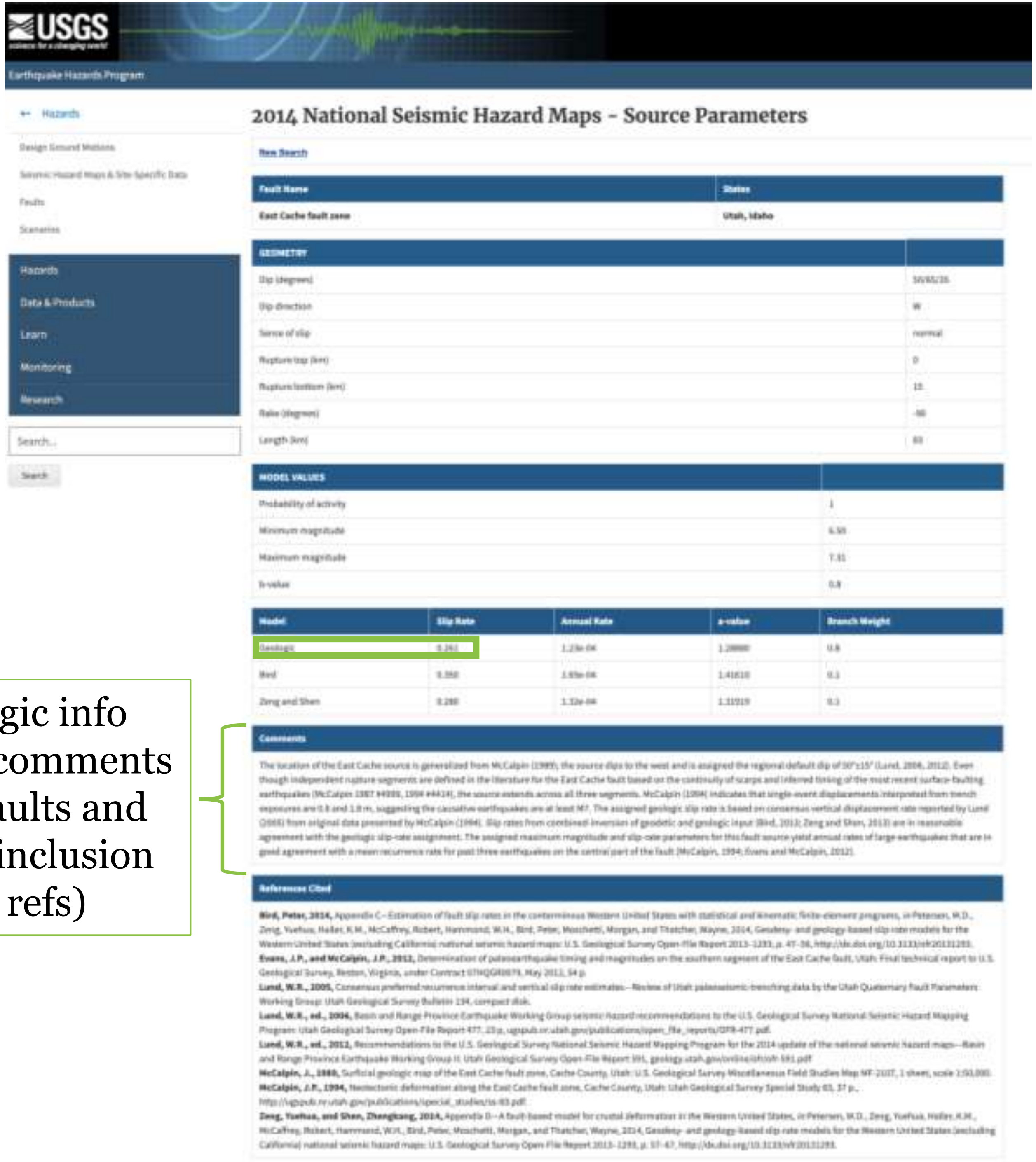
Table 4.6-1. Estimated surface-faulting earthquakes < 18 ka for the WGUEP Wasatch Front region.

WASATCH FAULT ZONE								
Segment Name	Most Recent Deformation	Quantity/ Quality Paleoseismic Data[2]	WGUEP Slip Rate (mm/yr)	WGUEP Recurrence Interval (kyr)	Displacement (m)	Documented Paleoearthquakes < 18 ka	Estimated Number Earthquakes (N) < 18 ka min/pref/max	Comments

NSHM 2014

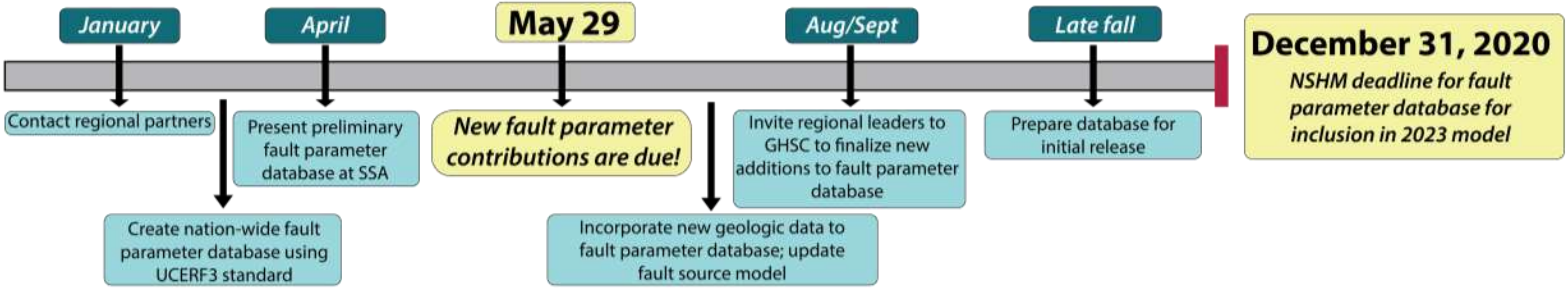
<u>Example:</u> East Cache fault zone

No metadata fields for NSHM "hazfaults" included in source parameter page



Some geologic info embedded in comments (not for all faults and inconsistent inclusion of data & refs)

Our timeline



- Time is tight, but we will do what we can
- This will hopefully become a regularly updated database, so what is not included this time will be considered in future iterations

What data do we need to achieve these goals?

- Geologic slip rates
- Paleoearthquake data
- Slip per event estimates
- Fault geometries

....and metadata!

How can you contribute/get involved?

- Microsoft form is accessible online for all agencies
- Flexibility in how to get your data to me
  - form is not the only vehicle!

General fault info

"Paleo-Sites" data contributions

Please use this form to send data to Alex Hatem, who is leading the compilation and review these submissions for use in the National Seismic Hazard Map geologic source parameters. By filling out this form, you understand that data will be used at the discretion of database compilers and final modeling decisions, and agree to communicate with Alex Hatem (Mendenhall post-doc in Golden USGS office/GHSC) if questions with your data arise. You can reach Alex by email at ahatem@usgs.gov or by phone at 303-273-8474.

THE DEADLINE TO CONTRIBUTE NEW DATA USING THIS FORM IS MAY 29, 2020.

BE SURE TO CLICK SUBMIT AT THE END OF LAST PAGE FOR ALEX TO RECEIVE YOUR RESPONSES!

1

Your name *

Enter your answer

2

Fault name, including segment if applicable *

i.e., Garlock (central)

Enter your answer

3

Is this fault already included as an EQ source in Hazfaults?

View a rendering of Hazfaults here: https://arcg.is/1mnCW4
Generate Hazfaults KML file here:
https://earthquake.usgs.gov/arcgis/rest/services/haz/hazfaults2014/MapServer/generateKml

- Yes
- No
- Not sure

4

If not, is this fault in the Qfaults database?

View a rendering of Qfaults here: https://arcg.is/1mnCW4
Download Qfaults KMZ file here: https://earthquake.usgs.gov/hazards/qfaults/

- Yes
- No
- Not sure
- This fault is a hazfault

5

Does this fault require updated geometry in the fault source database compared to the Hazfaults 2018 source data?

If so, please make such changes within the workflow outlined by Peter Powers (pmpowers@usgs.gov).

- Yes
- No
- Not sure

6

Site name, if applicable

Enter your answer

7

Site latitude and longitude (decimal degrees preferred), if applicable

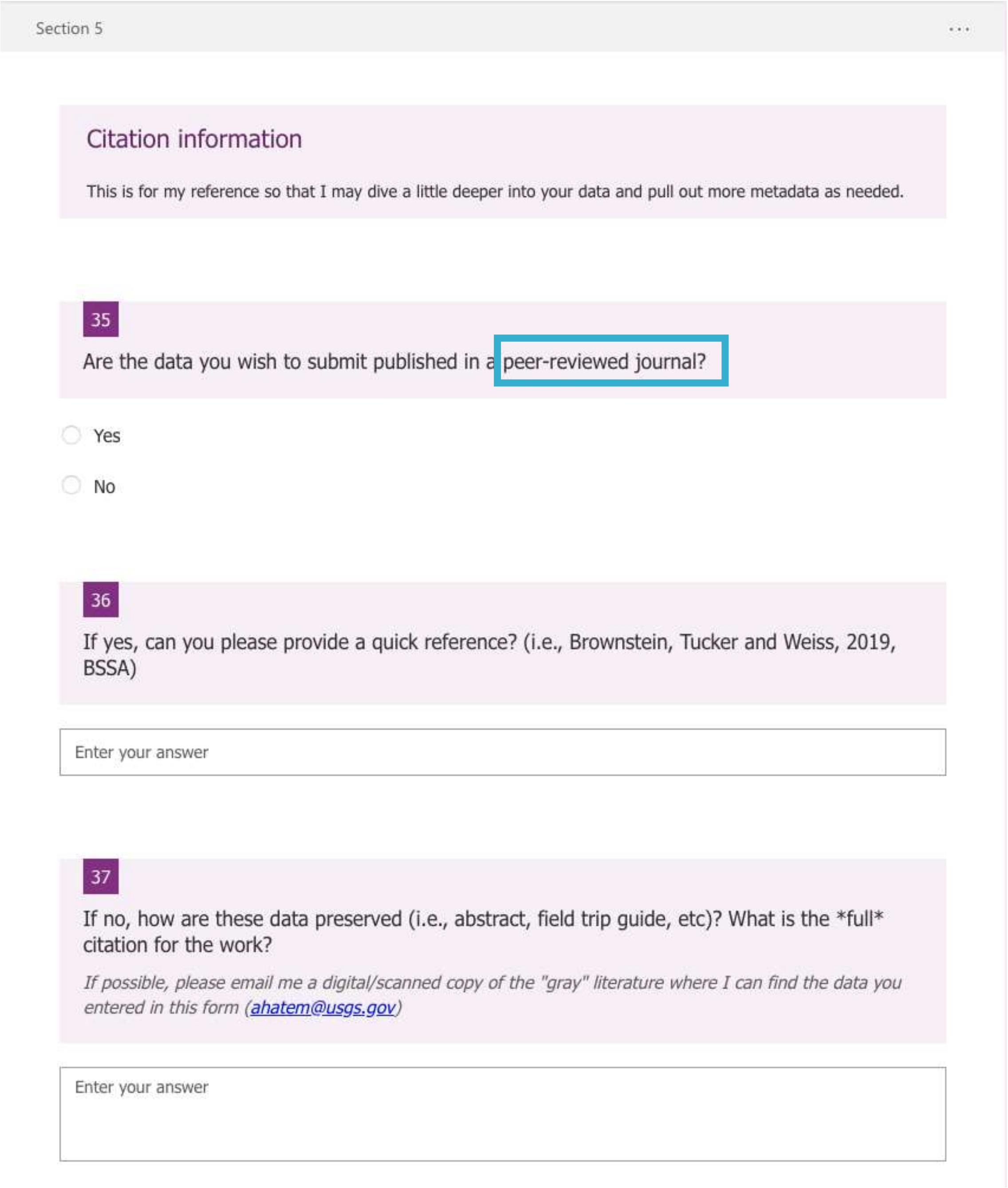
Enter your answer

Geologic data fields within form

- Slip rates
  - Time interval, dating method, uncertainty in measurements, how many EQ intervals included in each rate, ratings, etc…
- Paleoearthquakes
  - Oxcal input files, number of events, depositional hiatuses, ratings, etc…
- Slip per event
  - Show your work!

Citation information

- Willing to accept anything for internal review, but unpublished/unreviewed work may not be included in the final database
- Our preference is peer-reviewed *products*
- Because USGS is a public entity, all data should be available to the public



Section 5 ...

Citation information

This is for my reference so that I may dive a little deeper into your data and pull out more metadata as needed.

35

Are the data you wish to submit published in a peer-reviewed journal?

Yes

No

36

If yes, can you please provide a quick reference? (i.e., Brownstein, Tucker and Weiss, 2019, BSSA)

Enter your answer

37

If no, how are these data preserved (i.e., abstract, field trip guide, etc)? What is the *full* citation for the work?

If possible, please email me a digital/scanned copy of the "gray" literature where I can find the data you entered in this form (ahatem@usgs.gov)

Enter your answer

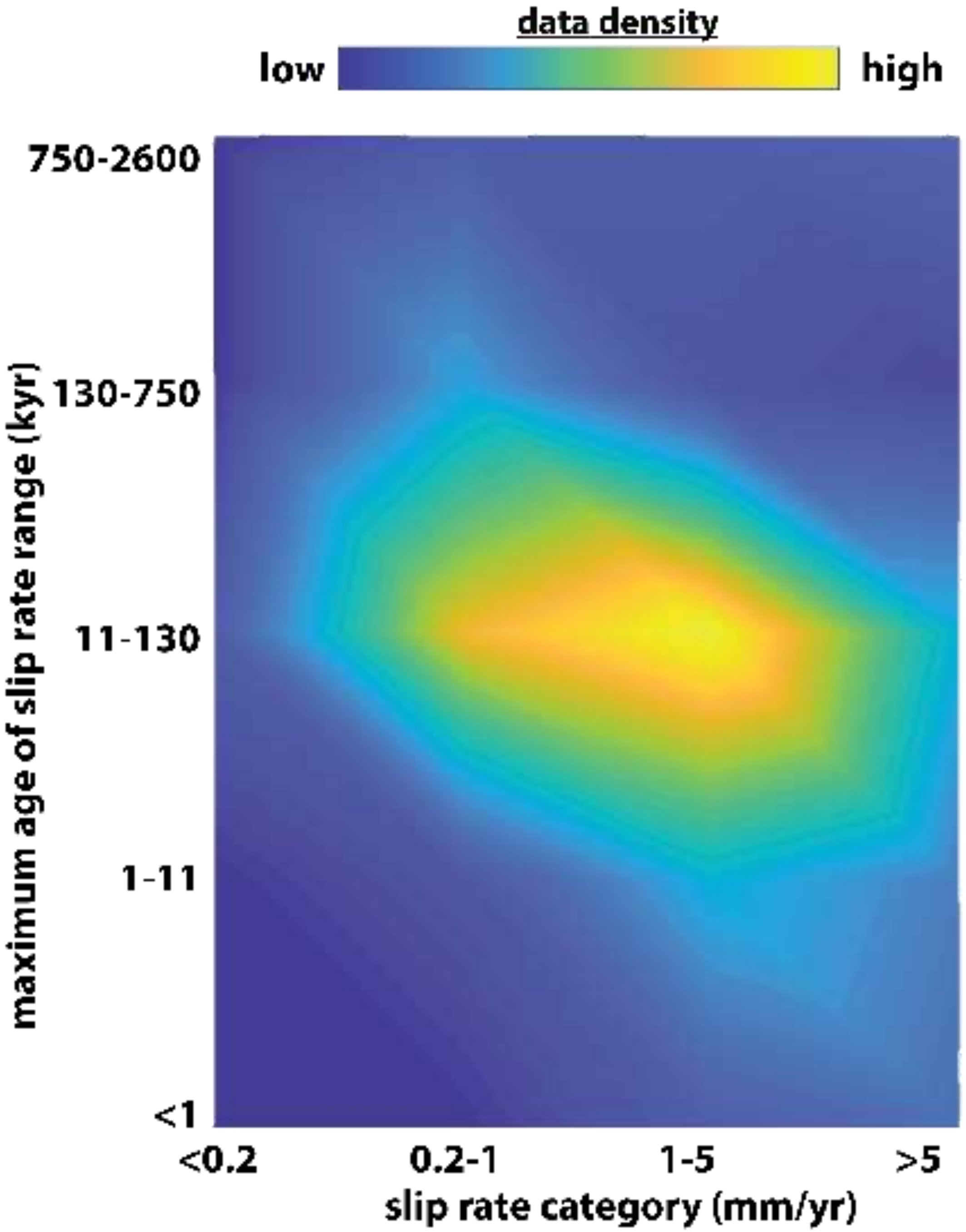
Overall interpretation

- Attempt to capture the nuance in geologic data that may not be well-expressed otherwise in the form questions/publication on this site

Importance of database science

- Apparent sampling bias of slip rates in California as sampled by Dawson and Weldon, 2013 for UCERF3
    - *Does this bias matter for hazard calculations?*
    - *How does hazard change when using similarly aged*

  → Conduct sensitivity analyses



Importance of site-specific data

- Capture changes in geologic behavior along faults measured as points on a line

→Example for why this matters:

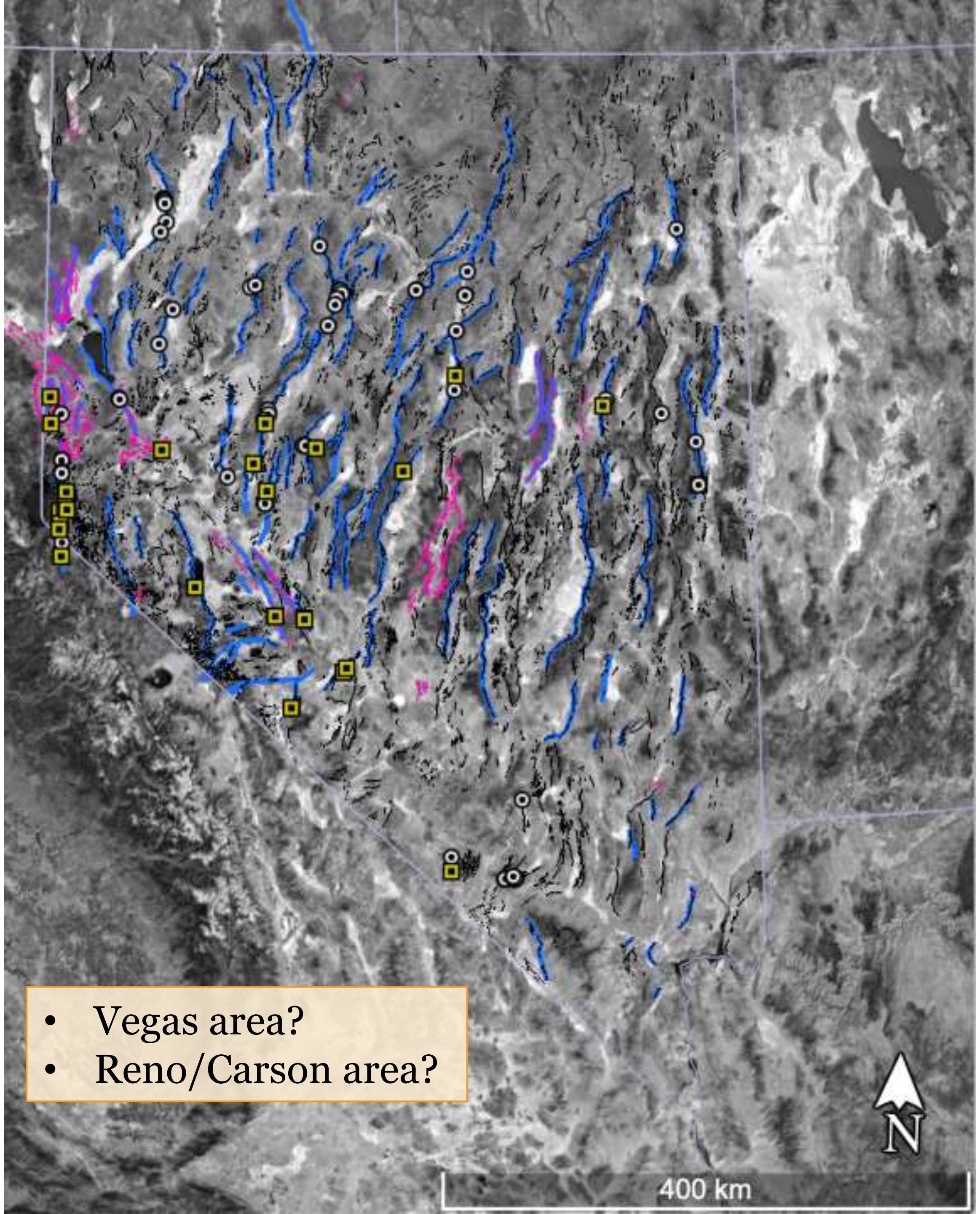
Potential to highlight non-geometric segmentation

(could be expressed as slip rate gradients along strike)

Example of how we are starting…

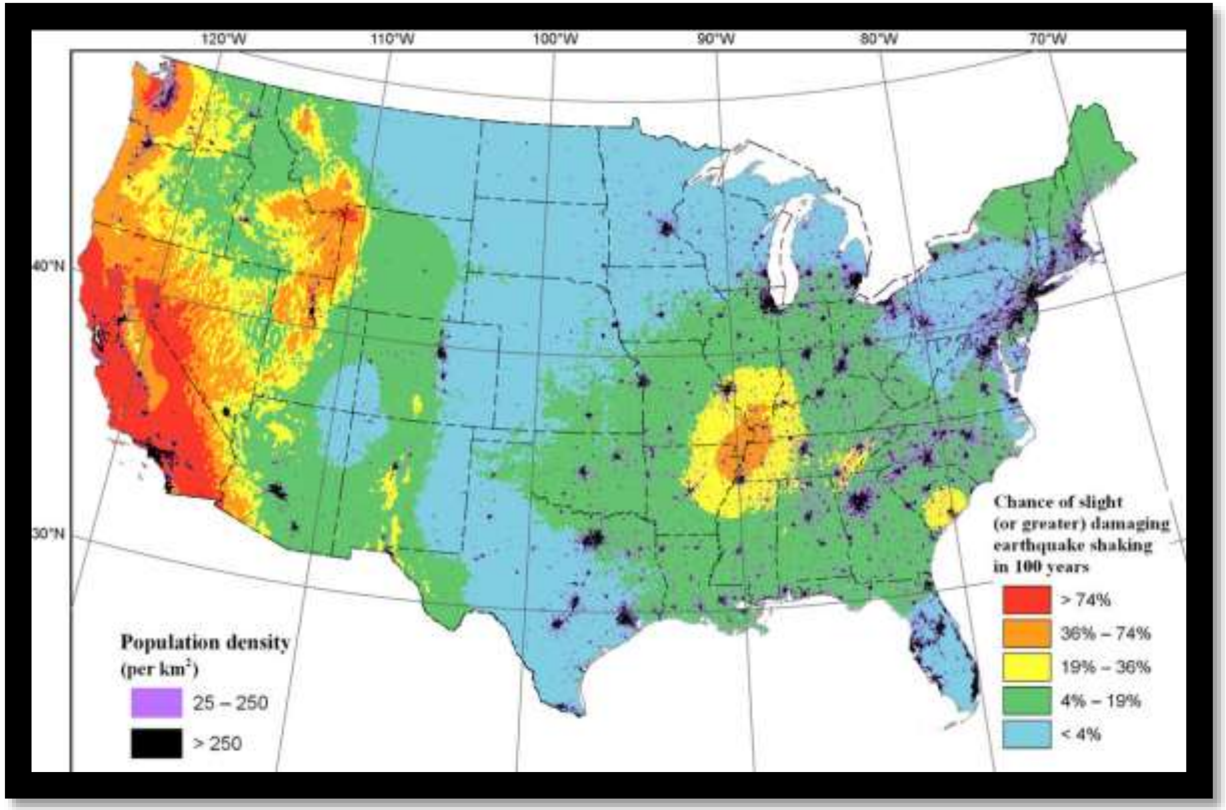
State of Nevada

<u>Blue lines:</u>
NSHM modelled faults
<u>Black lines:</u>
USGS QFaults
<u>White circles:</u>
"site_investigations"/QFFD refs
<u>Yellow squares:</u>
USGS ID'ed sites to be reviewed
<u>Pink lines:</u>
Faults of concern as listed in previous Nevada Working Group reports



Contributions are welcome from now until May 29, 2020!

Alex Hatem
ahatem@usgs.gov
303-273-8474

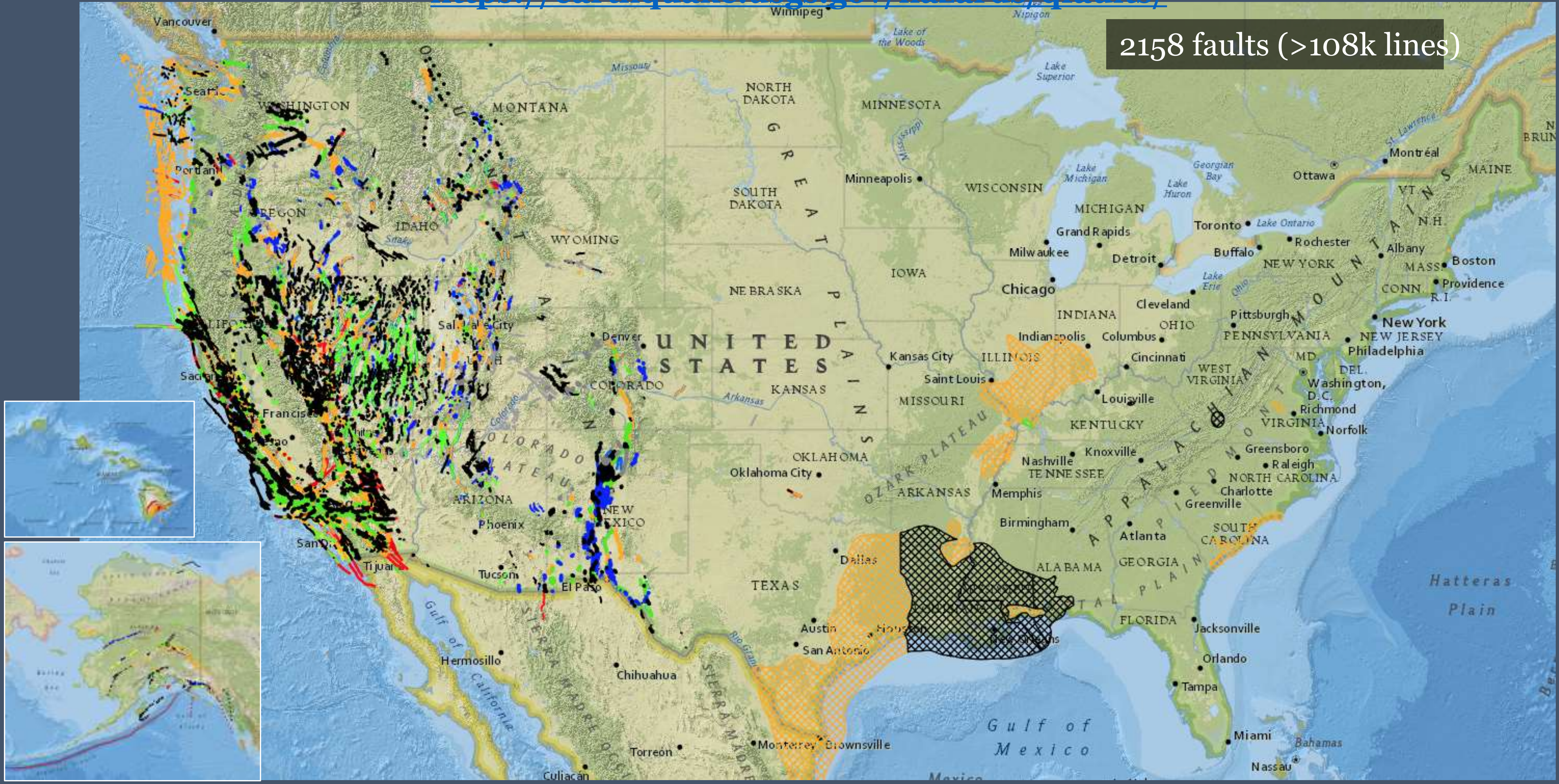


Ryan with specific IMW examples of high priority updates

Quaternary fault and fold database "Qfaults"

https://earthquake.usgs.gov/hazards/qfaults/

2158 faults (>108k lines)

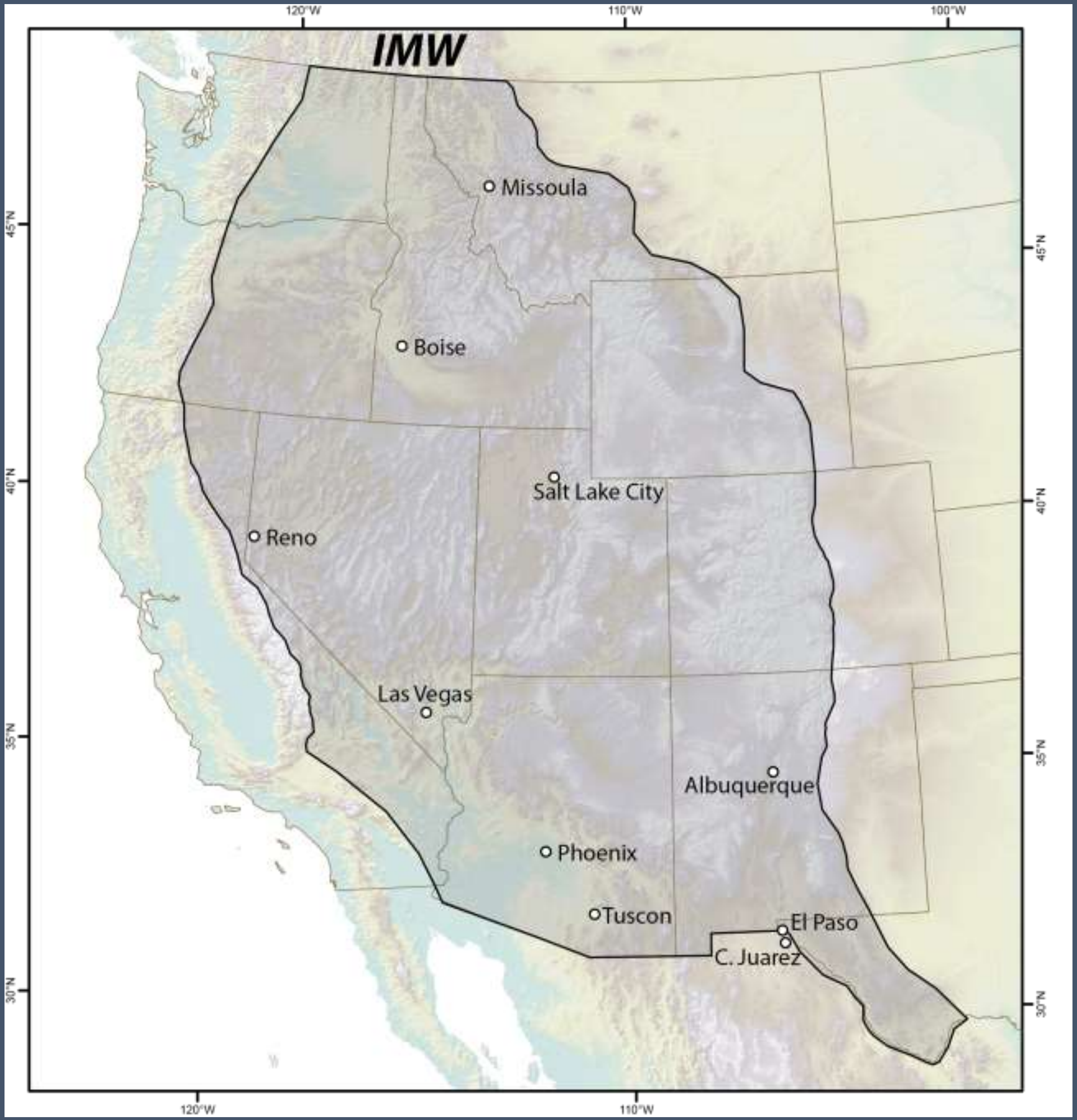


2014 NSHM source faults "Hazfaults"

https://earthquake.usgs.gov/cfusion/hazfaults_2014_search/query_main.cfm

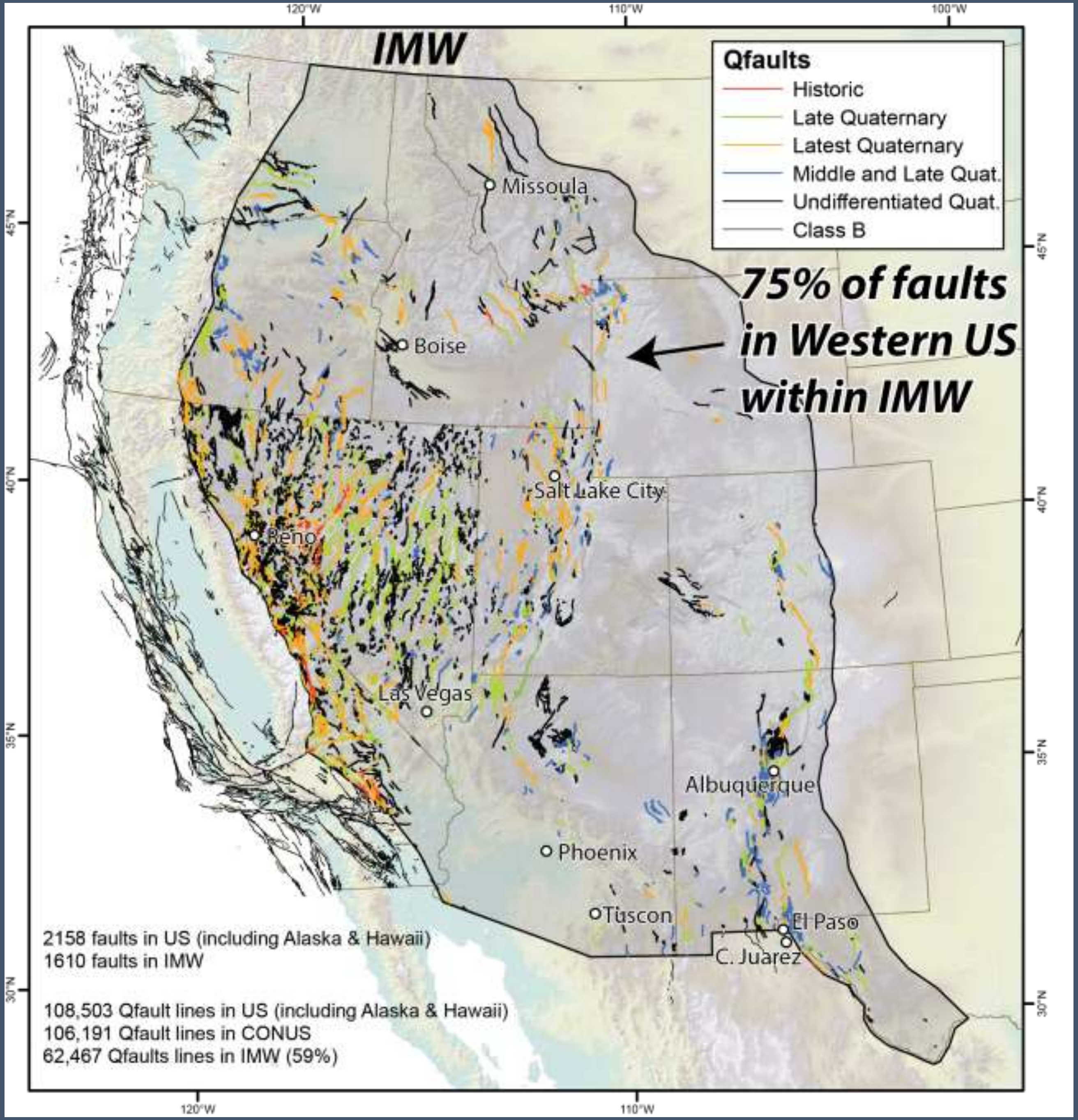
CONUS: 645 source faults
-last updated 2014 NSHM
(Petersen et al., 2014, USGS OFR)

2007 Alaska Hazard Model
-8 faults



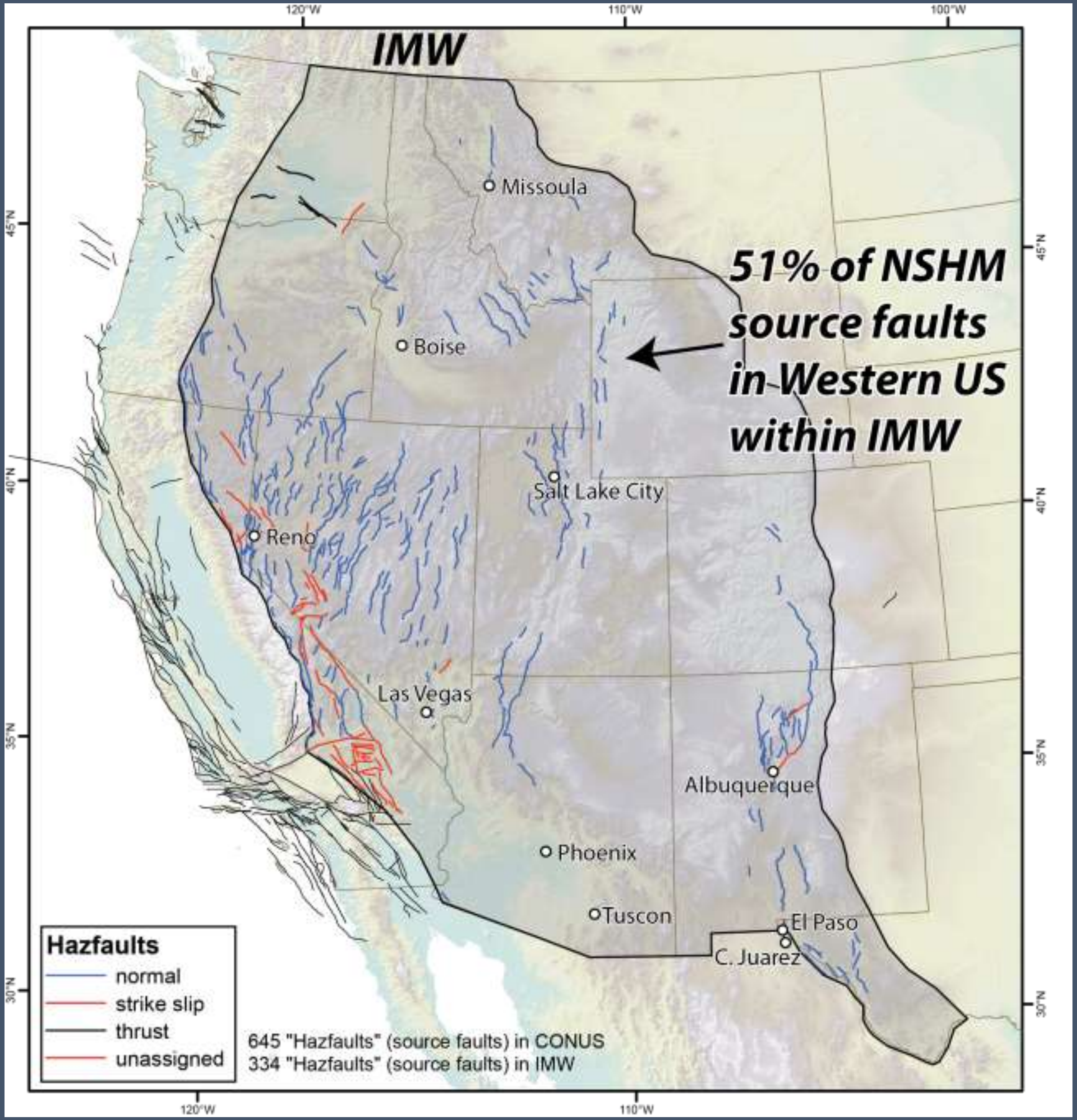
IMW Region

- spans 12 states
- Overlap with other USGS regions: PacNW/Cascadia, N. California, and S. California
- Most populous metro areas
  - 4.9M Phoenix, AZ
  - 2.7M El Paso-Juarez, AZ/Mexico
  - 2.2M Las Vegas, NV
  - 1.2M Salt Lake City, UT
  - 1.0M Tuscon, AZ
  - 0.9M Albuquerque, NM
  - 0.7M Boise, ID
  - 0.4M Reno, NV
  - 0.1M Missoula, MT



IMW Region - Qfaults

- 1610 faults in IMW (2158 total for United States)
- 62k Qfault lines in IMW (>108k total for United States)



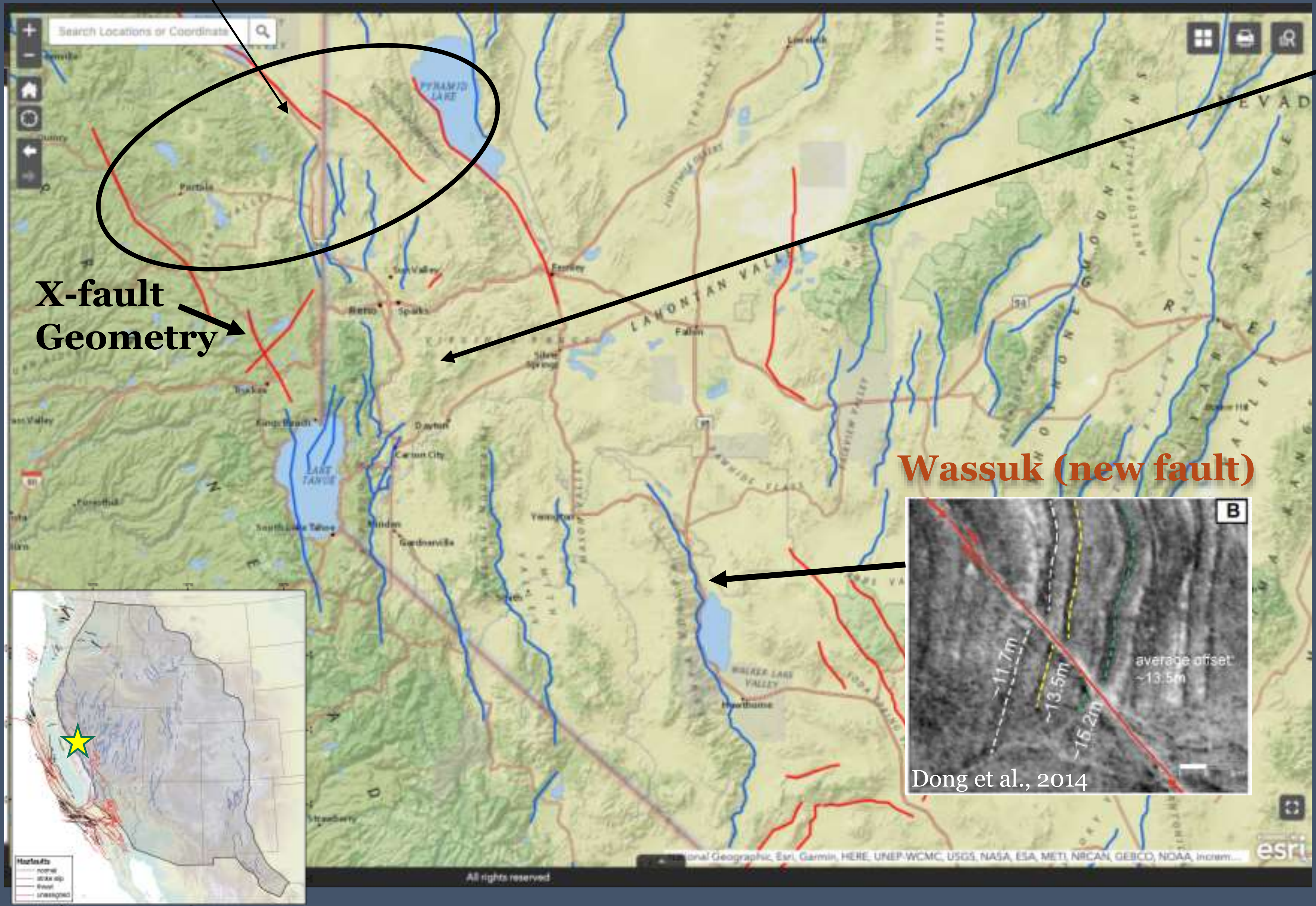
Seismic source faults (NSHM 2014)

- 334 faults in IMW (645 total for United States)…many missing sources compared to Qfaults

Reno/Carson City/Tahoe (<1M pop.)

New Slip rates

X-fault Geometry



Priorities

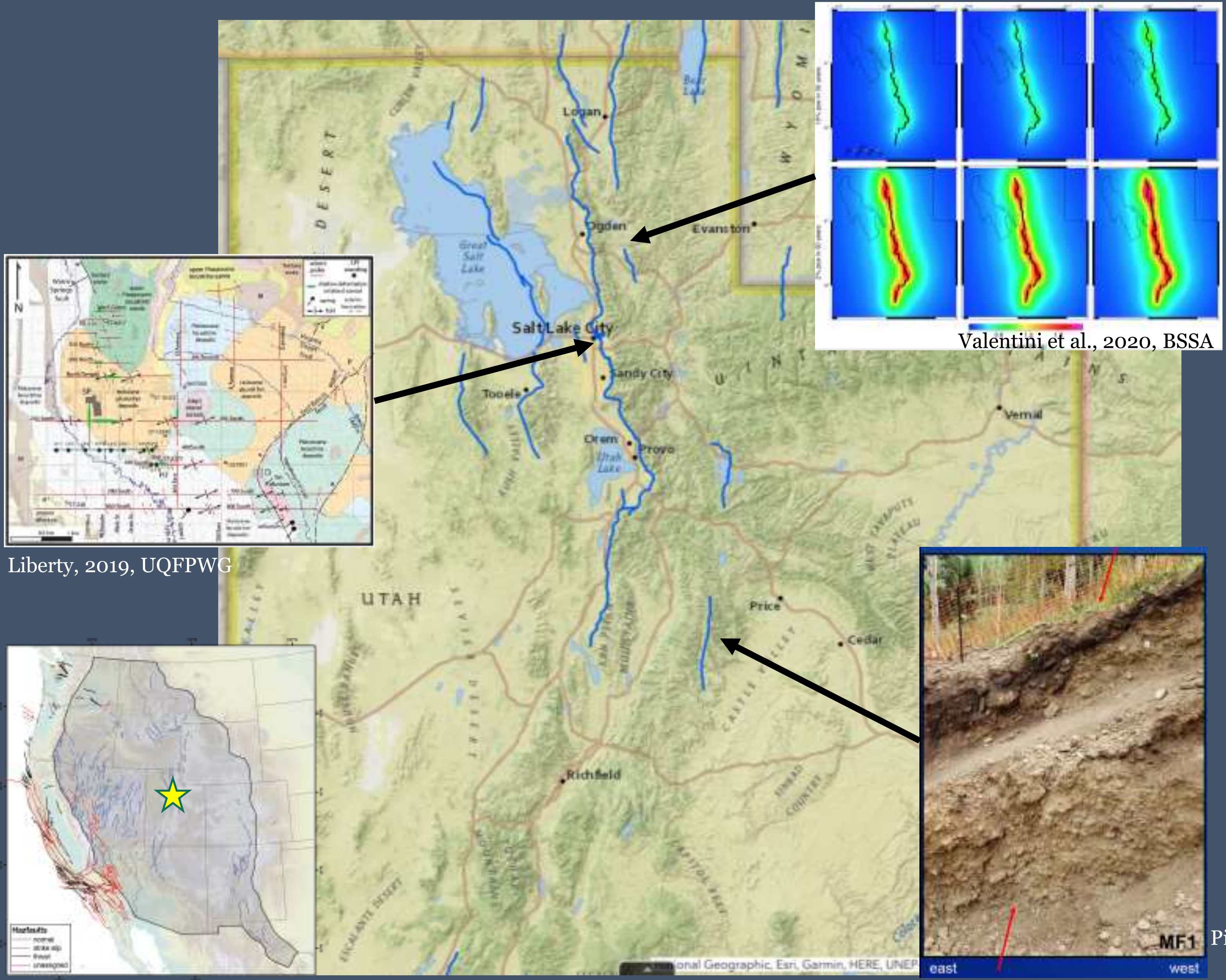
1. Revisit distributed dextral shear (C-Zone? More faults?)
2. Address Dog Valley/Polaris X-fault geometry
3. Add additional faults (Olinghouse, Wassuk strike-slip, Grizzly Valley, etc.)
4. Update slip-rates based on recent studies (N. Valley faults, Honey Lake fault, Mohawk Valley fault, etc.)

Las Vegas, NV (2.2M pop.) + W. Arizona

Priorities

1. Eglington fault – revise slip rate lower based on recent studies
2. Eglington fault - Consider logic-tree approach to deal with seismogenic potential of this fault
3. Consider adding additional Las Vegas Valley faults
4. Mead Slope fault – Add?

Salt Lake City, UT (2.2M pop.)



Valentini et al., 2020, BSSA

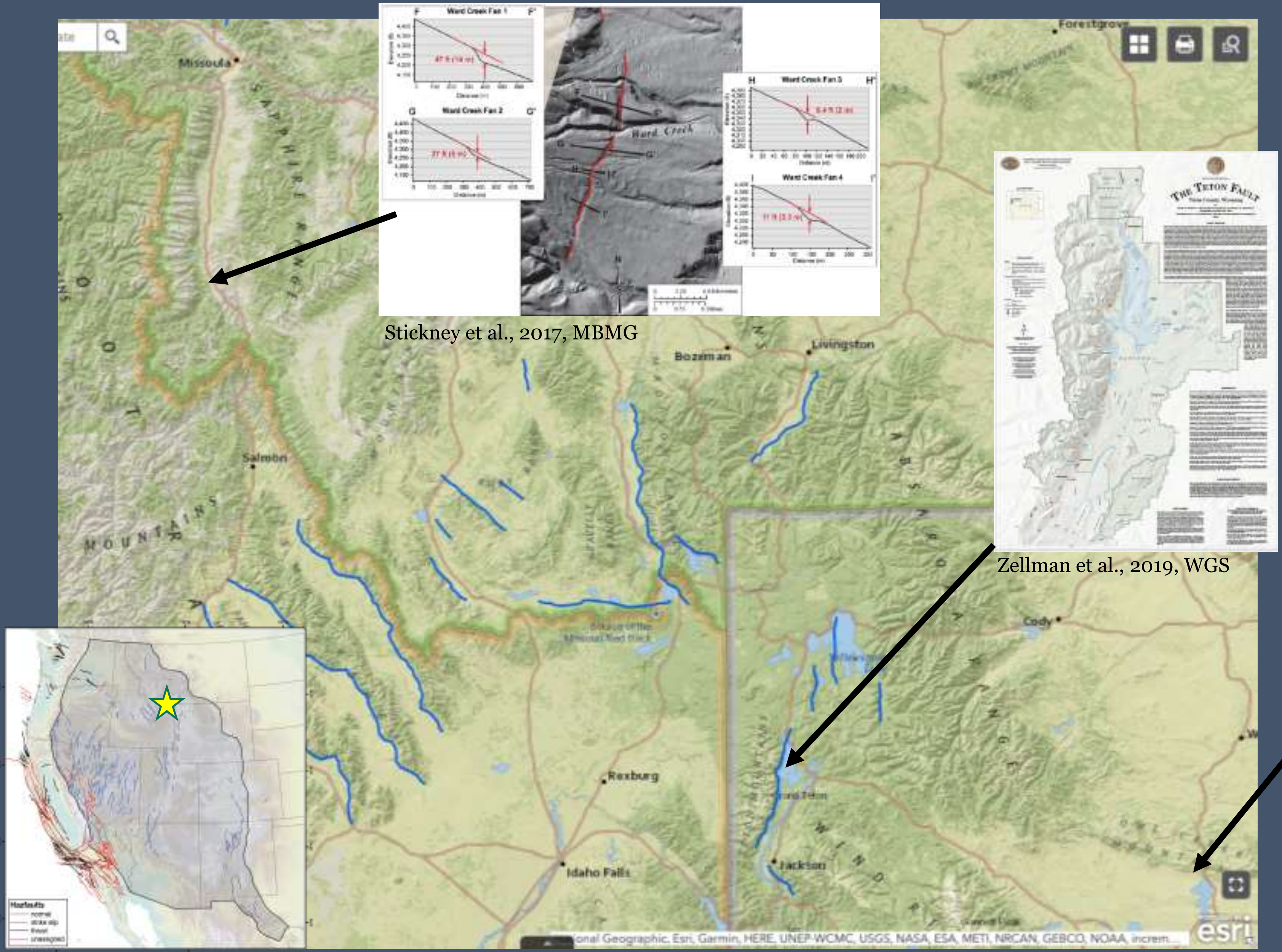
Liberty, 2019, UQFPWG

Piety et al., 2019, UQFPWG

Priorities

1. Wasatch fault – update geometry based on (a) lidar mapping from Utah Geological Survey and (b) seismic-reflection imaging in downtown area
2. Integrate UCERF3-style modeling
3. Consider Joe's Valley fault
4. WGUEP 2016 Report
5. Faults in SW Utah (add as sources?)

Missoula, MT / Jackson, WY



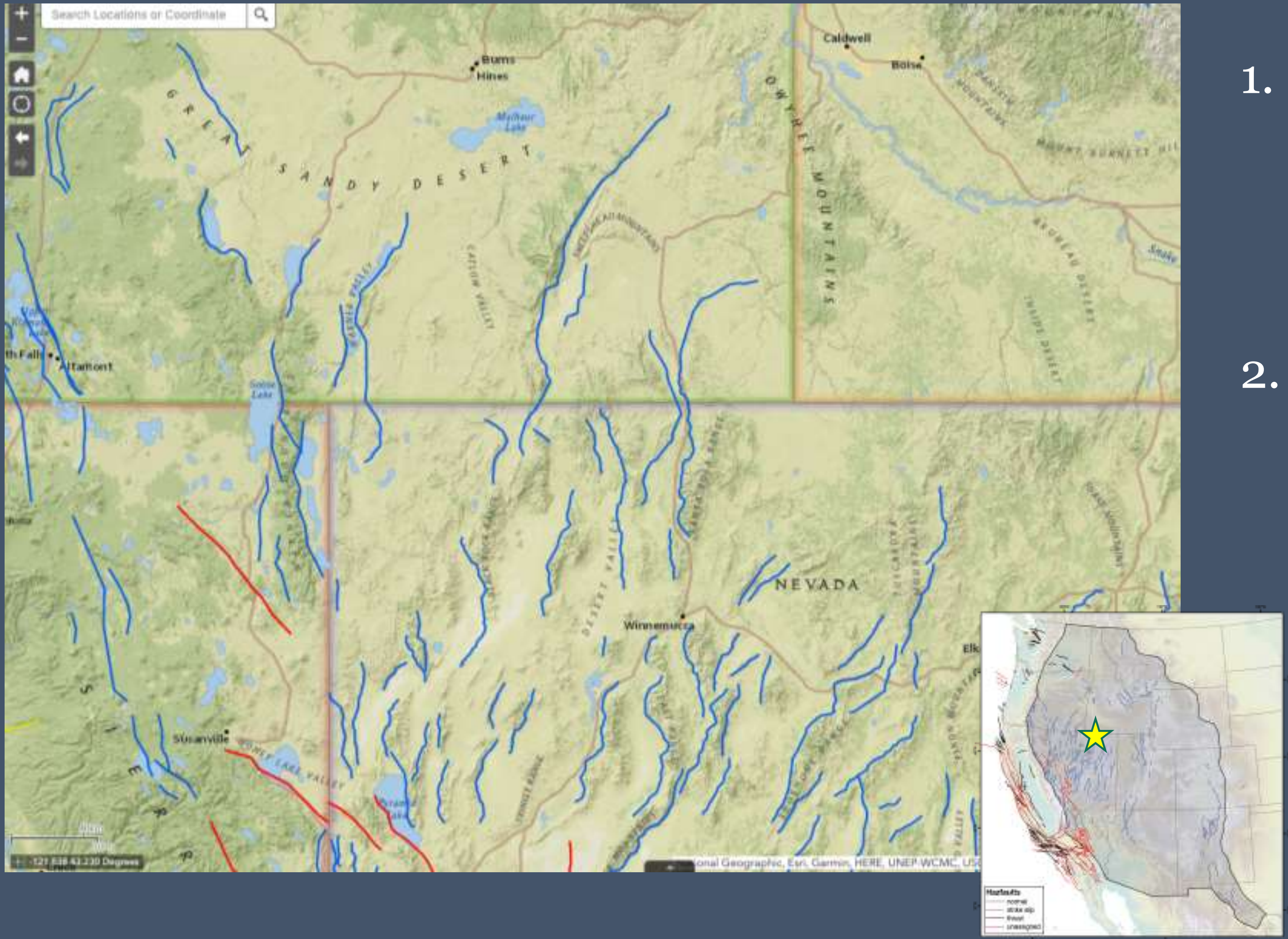
Stickney et al., 2017, MBMG

Zellman et al., 2019, WGS

Priorities

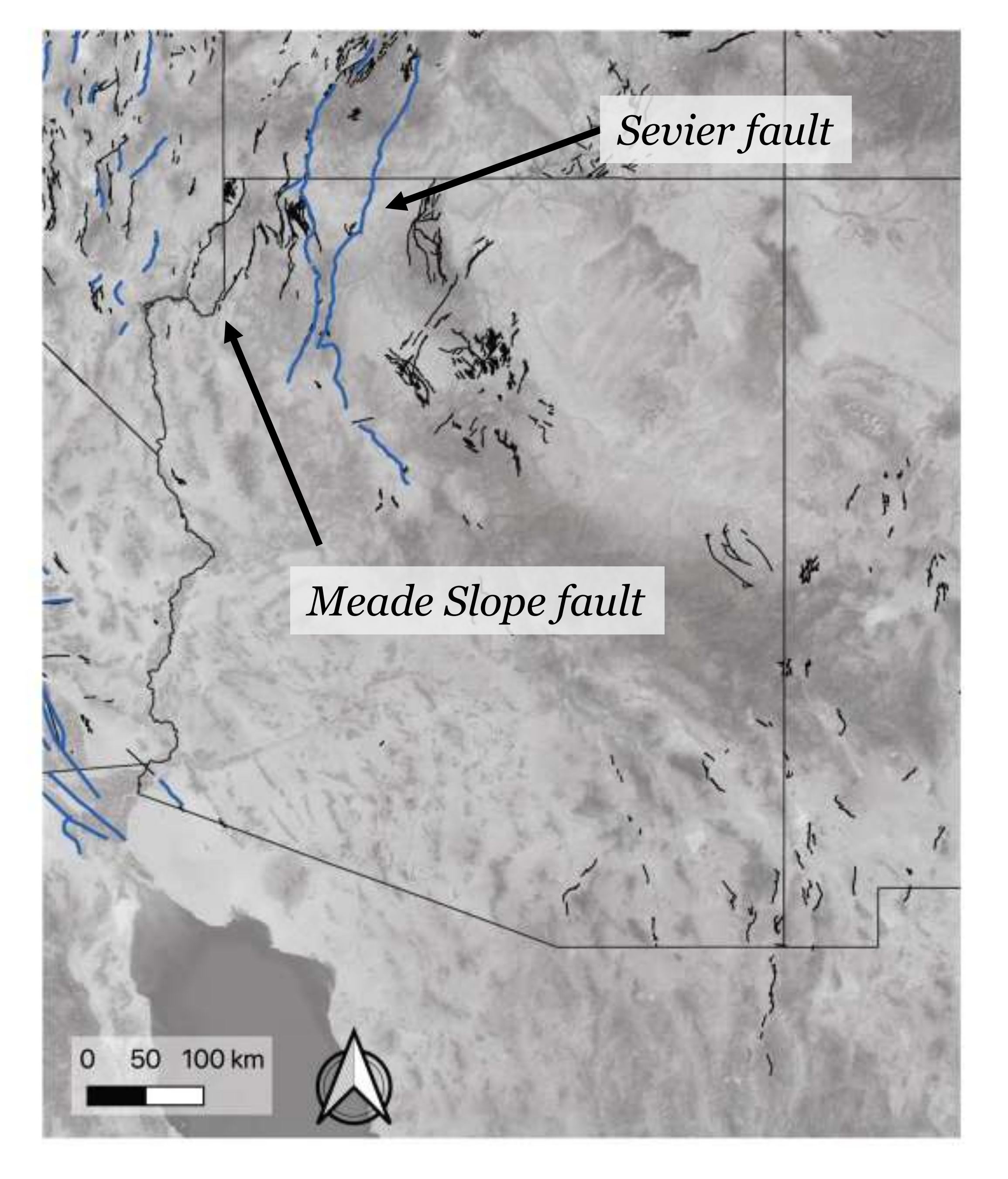
1. Bitterroot fault – Add as source (100 km long normal fault, 0.1-0.3 mm/yr vertical slip rate)
2. Teton fault – Update (extend) southern extent. Update slip-rate based on recent work
3. Stagner Creek and S. Granite Mtn. fault (WY) – (Re)evaluate whether should be included as source

NE California & N. Nevada



Priorities

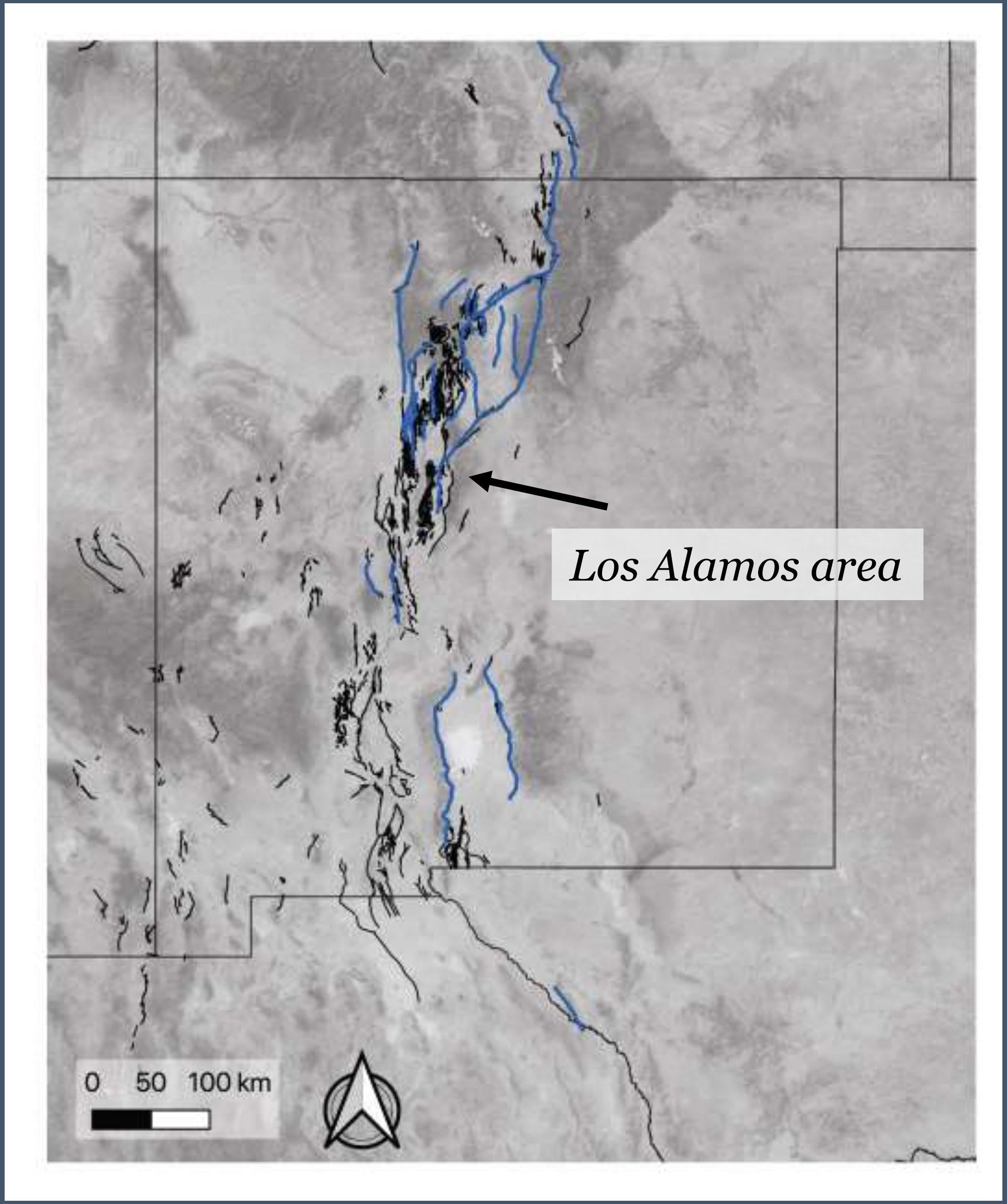
1. N. Nevada – Add additional Quaternary undifferentiated faults as sources with nominal slip-rate?
2. NE California – Add additional sources?



Arizona

Priorities

1. Incorporate new data from Sevier fault as available
2. Add Meade Slope fault to NSHM sources and incorporate paleoseismology/slip rates as available



New Mexico

Priorities

1. Faults surrounding Los Alamos Lab

Potential discussion topics

- How can we make this work easiest for you?
- Feedback on approach/database construction
- High priority faults/studies to focus on
- How to treat uncertainty in geologic inputs?
- How to assign geologic slip rates where they don't (yet) exist?

    →i.e., fault polygons/broad zones of "distributed" deformation