Fault Geometry Decisions and The Alquist-Priolo Act:

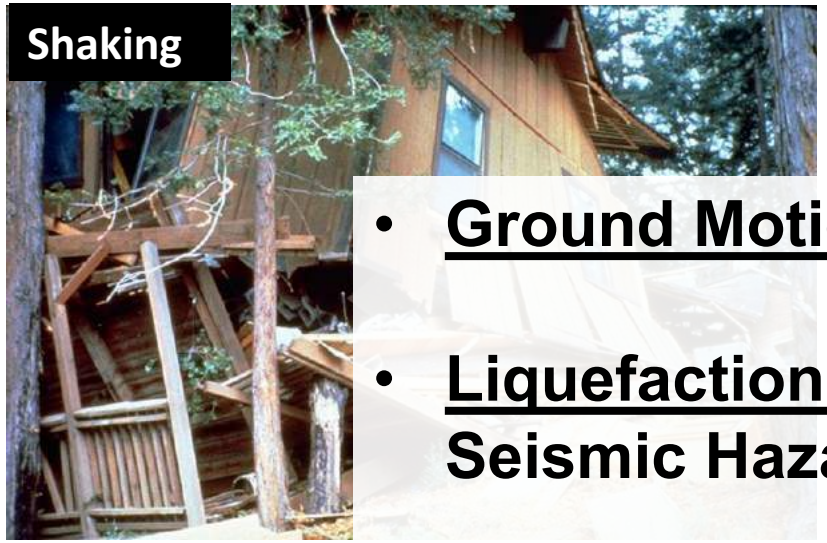
How A-P Fault Evaluations Inform Fault Geometry

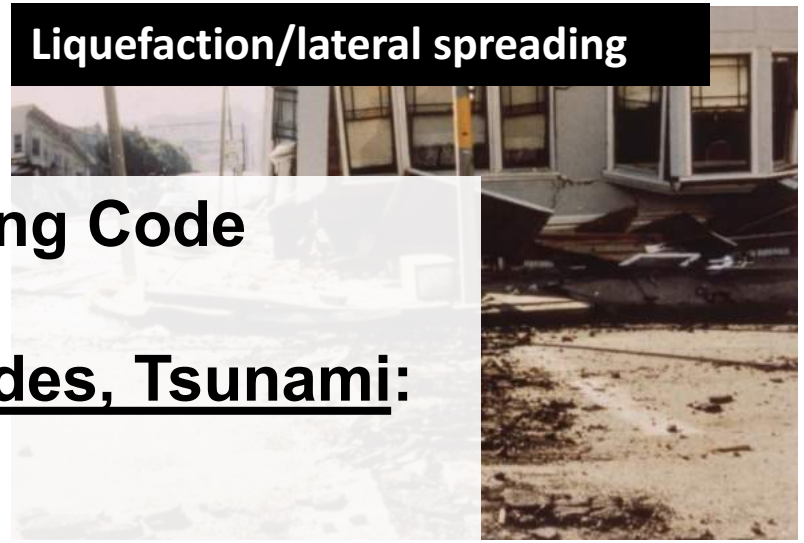
(and how dynamic rupture modelers might help inform fault displacement hazard analysis)

Tim Dawson
Senior Engineering Geologist
California Geological Survey

San Jose Fault on the Cal Poly Pomona Campus

Earthquake-related effects regulated by California





- **Ground Motion/Shaking: California Building Code**
- **Liquefaction, Earthquake-induced landslides, Tsunami: Seismic Hazards Mapping Act**
- **Surface Fault Rupture: Alquist - Priolo Earthquake Fault Zoning Act**

1971 Mw 6.6 San Fernando earthquake fault rupture

Lessons: 1.) Damage localized near fault zones

2.) Fault location could have been identified had studies been conducted prior to the earthquake. (Yerkes, 1973)

Statutes and Regulations Related to the A-P Act

Statute:

The Alquist-Priolo Earthquake Fault Zoning Act
California Public Resources Code, Division 2, Chapter 7.5

Signed into law: 12/22/1972, amended 11 times (most recently 1997)

Regulations:

"Policies and Criteria of the State Mining and Geology Board"
California Code of Regulations, Title 14, Division 2

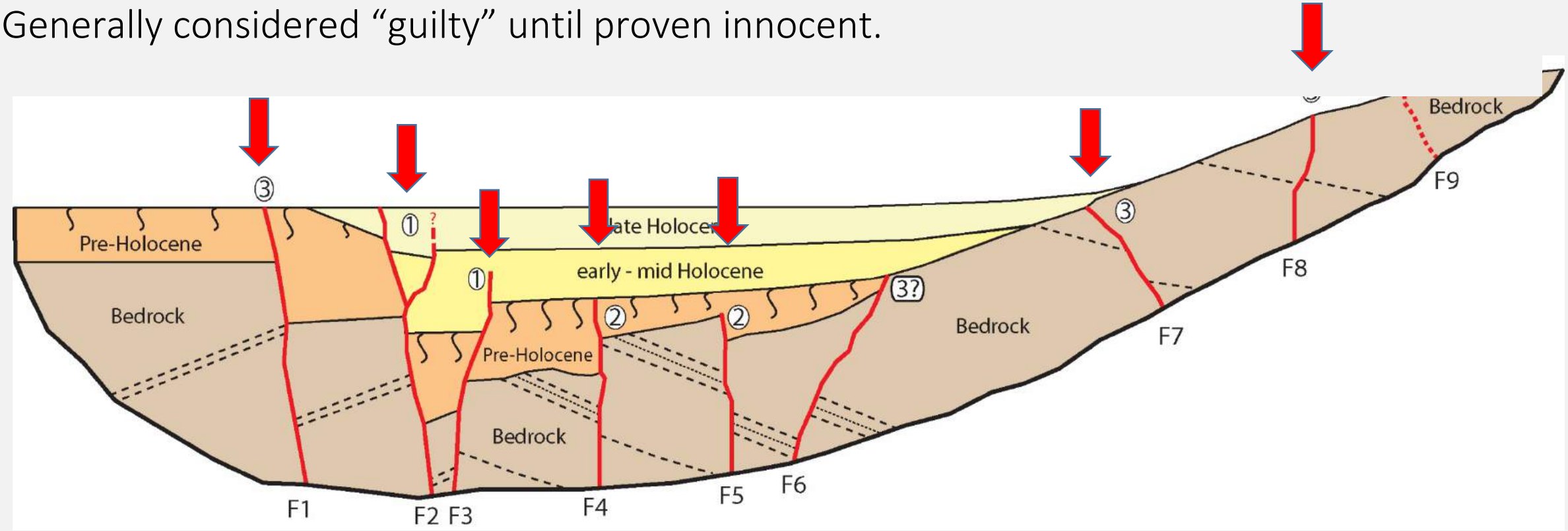
The intent of the A-P Act is to prohibit building structures for human occupancy across the trace of an active fault, thus avoiding the hazard of surface fault rupture.

What constitutes an Active Fault?

1.) **Holocene-active faults**: Cut Holocene-age deposits; regulated by the A-P Act

2.) **Pre-Holocene faults**: Faults do not cut Holocene deposits; not regulated by the A-P Act

3.) **Age-undetermined**: Stratigraphic or age constraints do not provide recency of activity. Generally considered "guilty" until proven innocent.

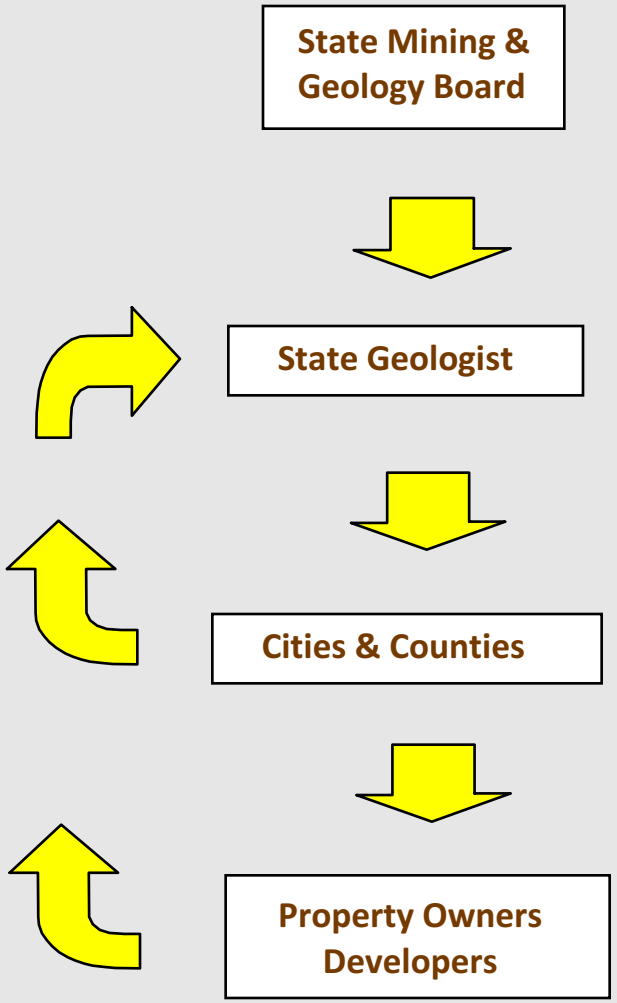


So how does the A-P Act Relate to Fault Models?

It mostly doesn't! But:

- The A-P Act gives the State Geologist (CGS) authority to establish regulatory zones around active faults
- The State Geologist is also required to *"…continually review new geologic maps and seismic data…."* that bears on regulatory A-P Earthquake Fault Zones in the State
- These evaluations lead to other authoritative, derivative products such as the Fault Activity Map of California and contributions to the USGS Quaternary Fault and Fold Database (QFFD) – first order data for faults most likely to produce large earthquakes in CA
- These products inform and are used along with other products (e.g. Community Fault Model) for seismic hazard assessments such as UCERF

A-P Act: Roles and Responsibilities



- Establishes Policies and Criteria
- Receives Review Comments
- Provides Technical Advice

- Evaluates Faults
- Designates Earthquake Fault Zones
- Approves Waivers
- Provides Advisory Services

- Updates General Plans
- Requires Site Investigations
- Reviews and Approves Projects
- Applies for Waivers

- Determines if Hazard Present
- Avoids Hazard
- Discloses during property transactions

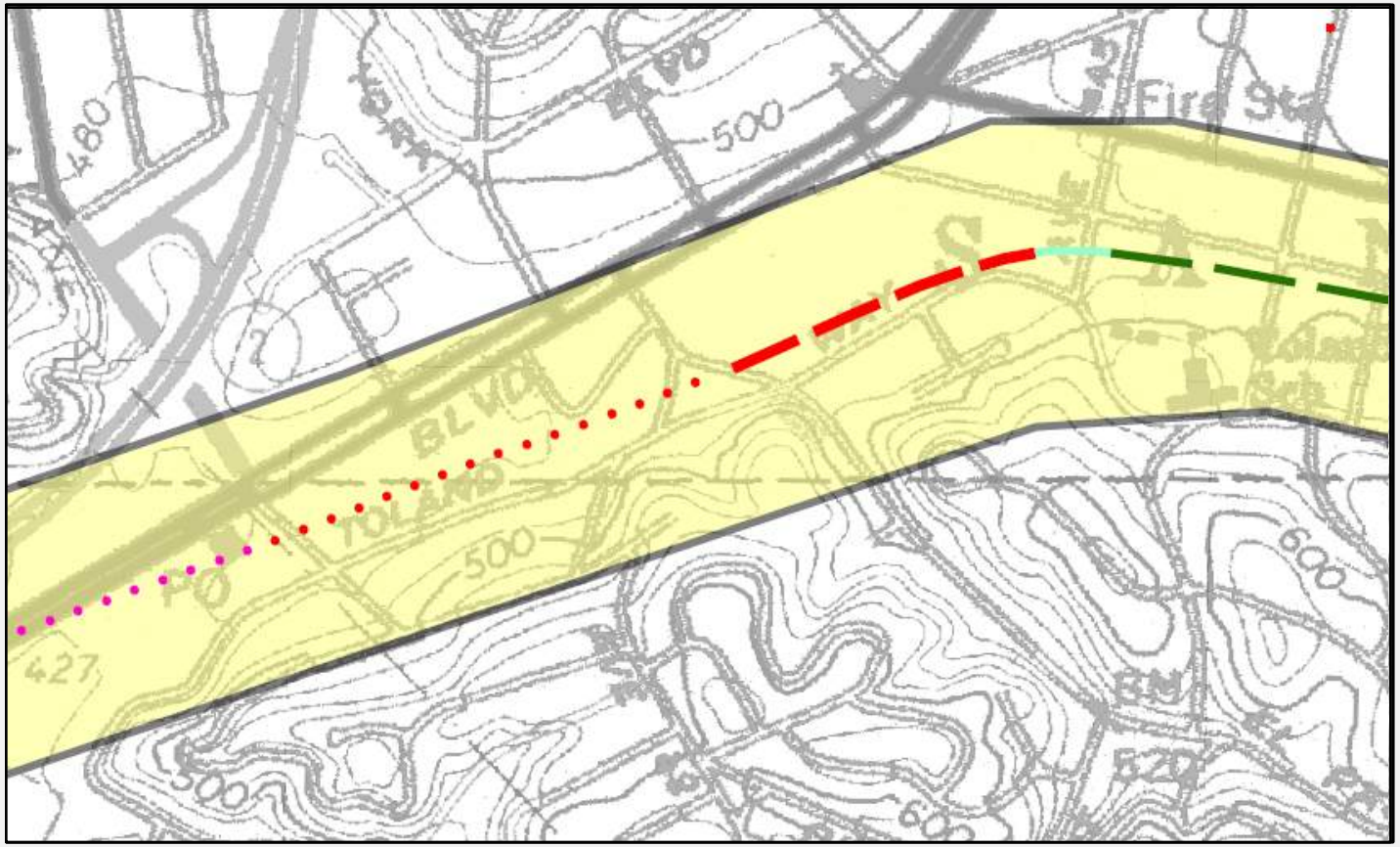
Data-generating activities

Establishing Earthquake Fault Zones: CGS Fault Evaluations

AP Act directs State Geologist to establish Earthquake Fault Zones [CPR § 2622.(a)] encompassing … *faults…the State Geologist determines to be sufficiently active and well-defined.*

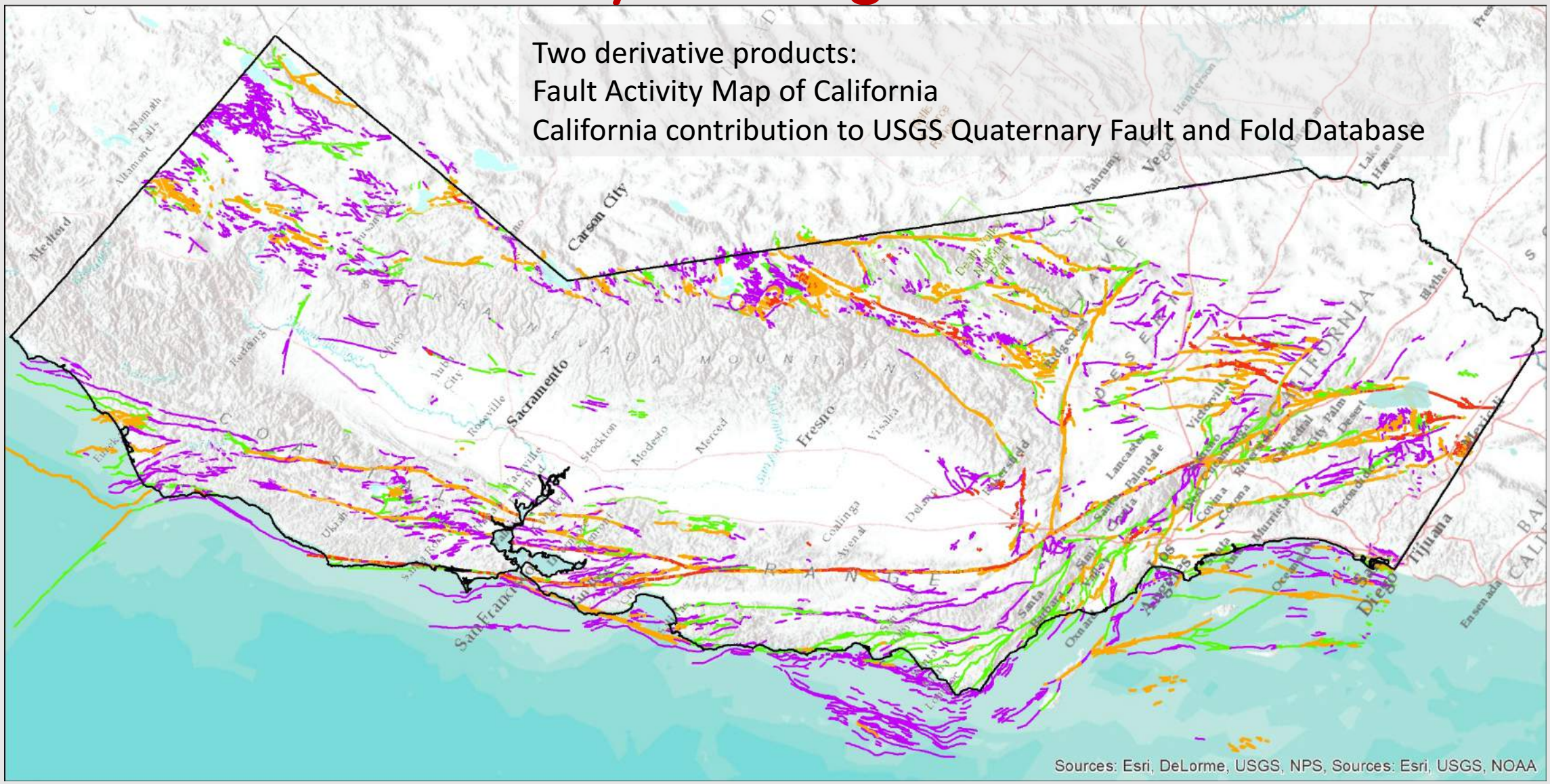
Fault Evaluations conducted using:

- Published literature and geologic mapping
- Original geomorphic mapping from aerial imagery, lidar, field reconnaissance
- Site-specific fault and geotechnical investigations
- Other available sub-surface data including groundwater observations and geophysics

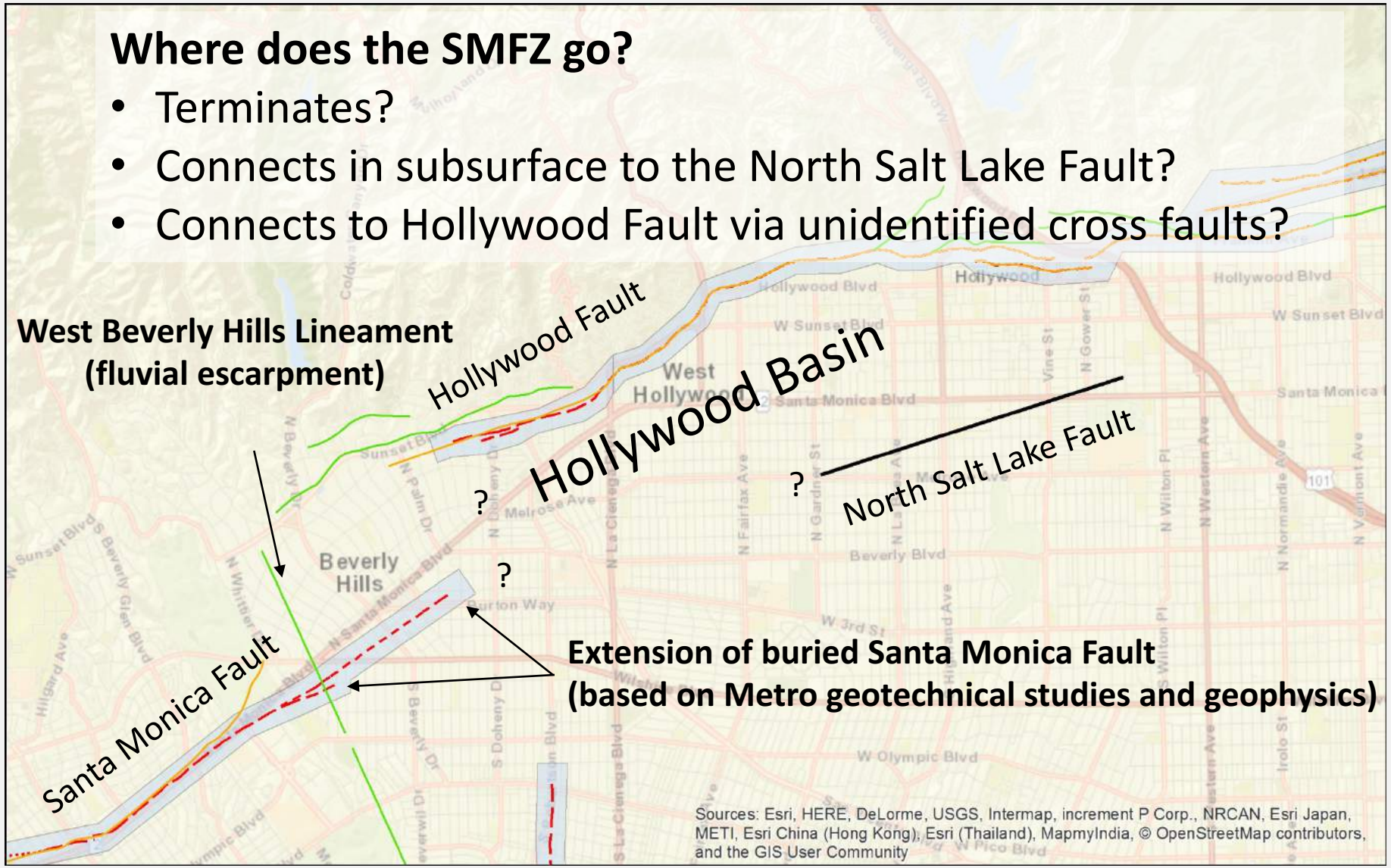


Data synthesized to provide scale-appropriate fault trace(s) that EFZs (~1000 feet wide) surround

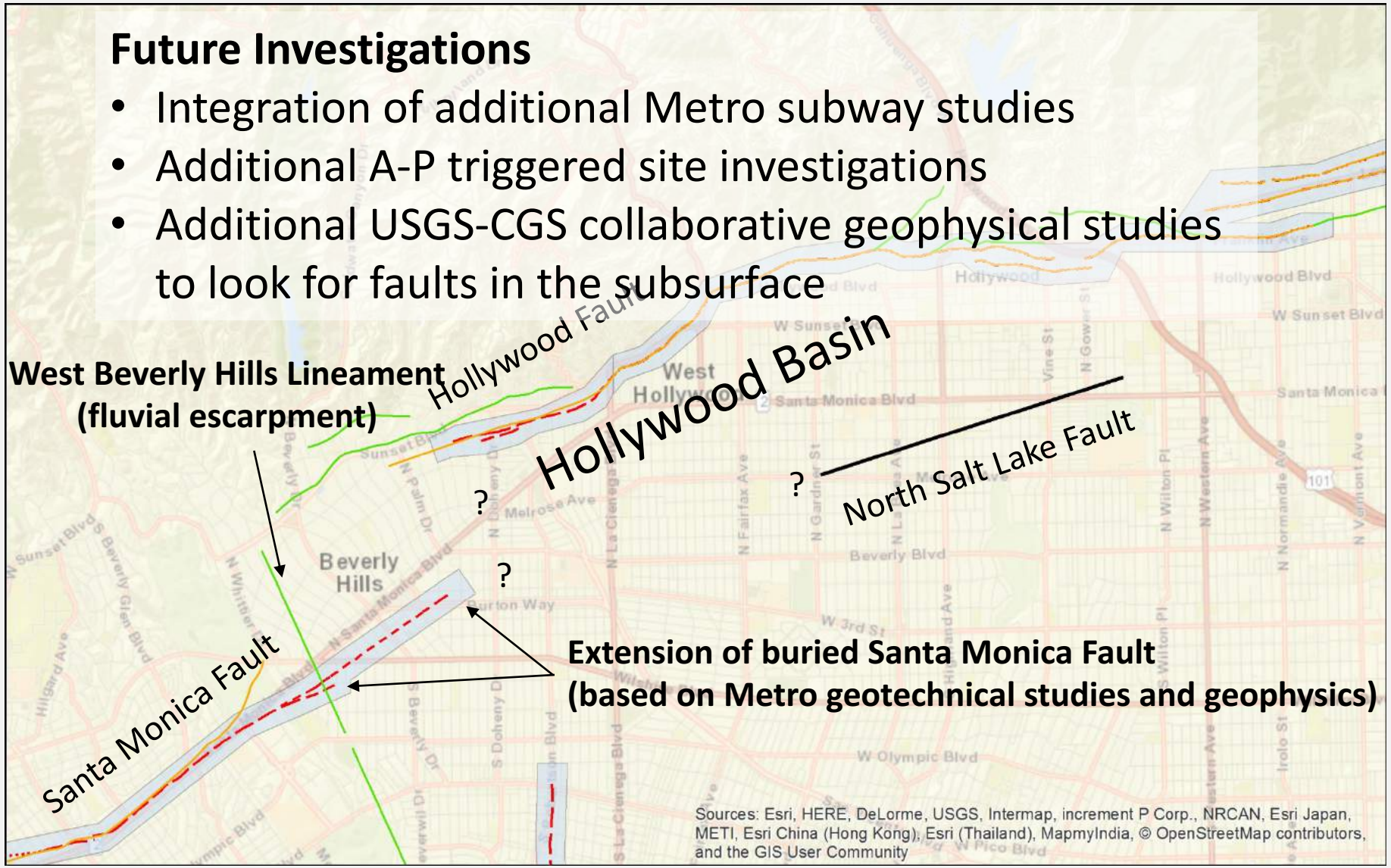
Quaternary Faulting in California



A-P studies as a driver of new research



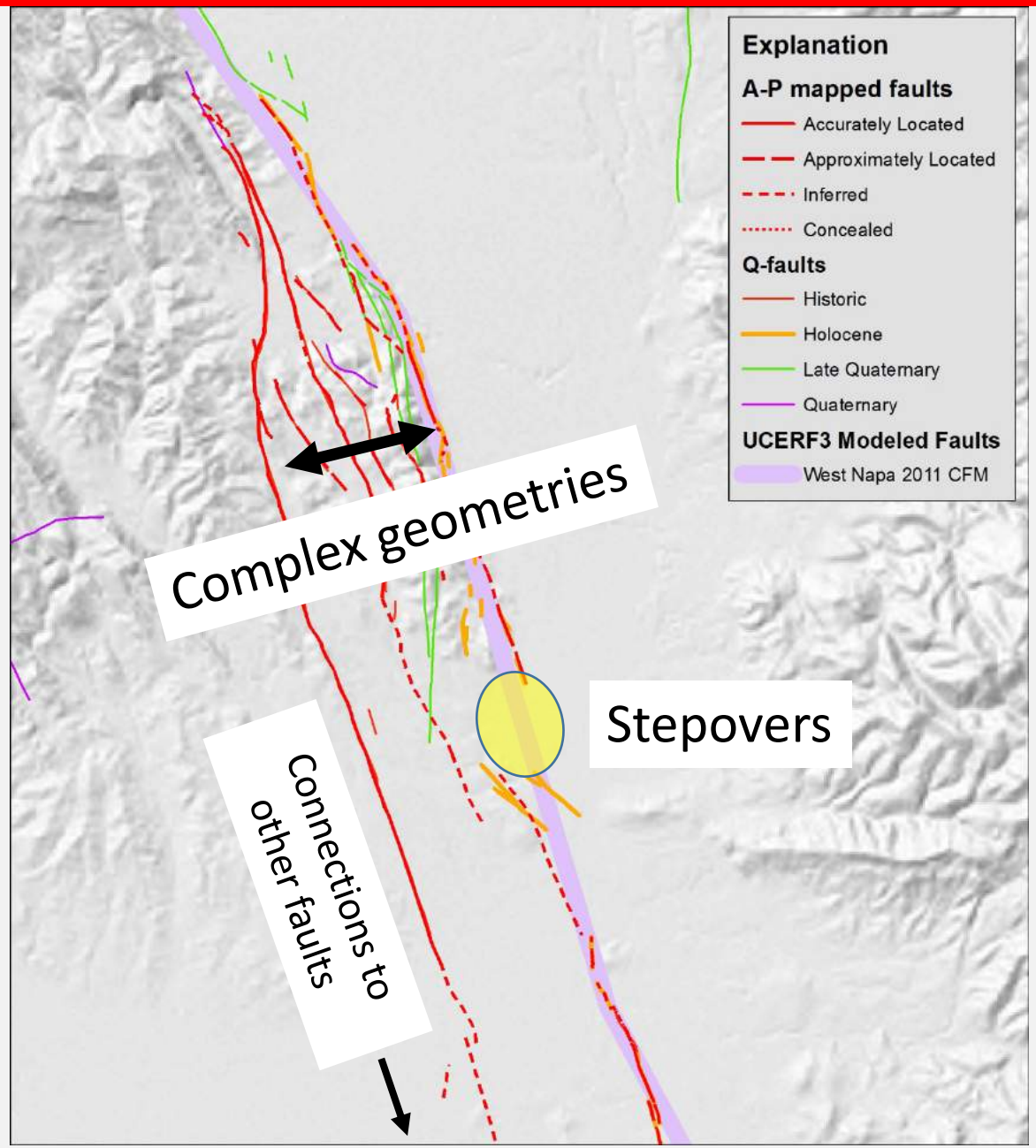
A-P studies as a driver of new research



Simplified fault models and A-P mapped faults

Detailed mapping may inform models on what might be important

- UCERF3 Modeled Faults Highly Simplified
- A-P Mapped Faults mapped at much more detail and locational precision (Published at 1:24k scale, but mapped at ~1:5,000 or greater)
- 2D mapping may show features important to model in 3D for rupture modeling



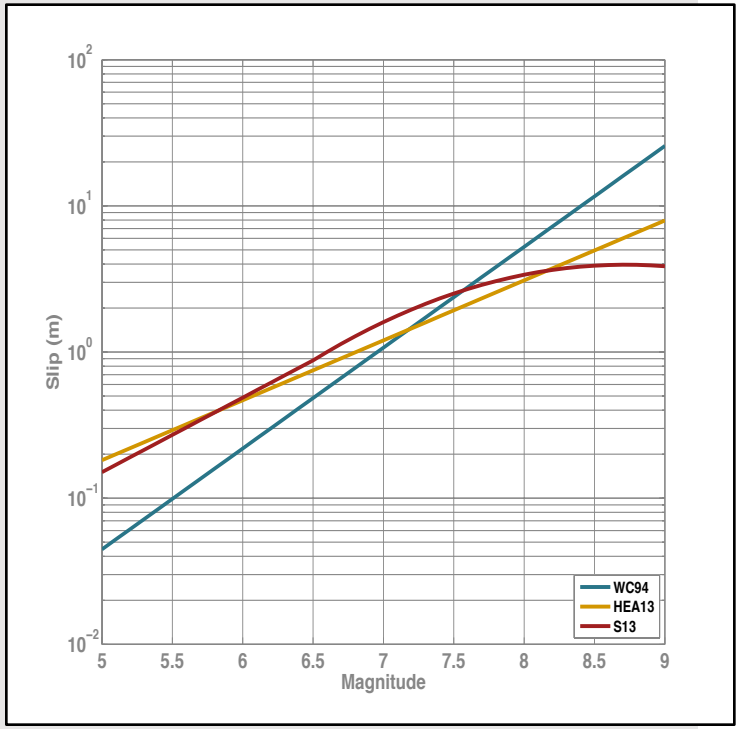
Take-ways from this presentation

- The A-P Act deals exclusively with the hazard of surface fault rupture.
- Fault Evaluations conducted by CGS provide vetted, derivative products that are used in Earthquake Fault Zone maps, State and National fault databases, and UCERF fault/seismic source models
- Studies triggered by the A-P Act helps drive data collection leading to a better understanding of the surface and near-surface geometry of active faults.
- Detailed surface mapping probably matters to you if your models are sensitive to the details of fault geometry.

Part II: How dynamic rupture modelers might help inform Fault Displacement Hazard Analysis (FDHA)

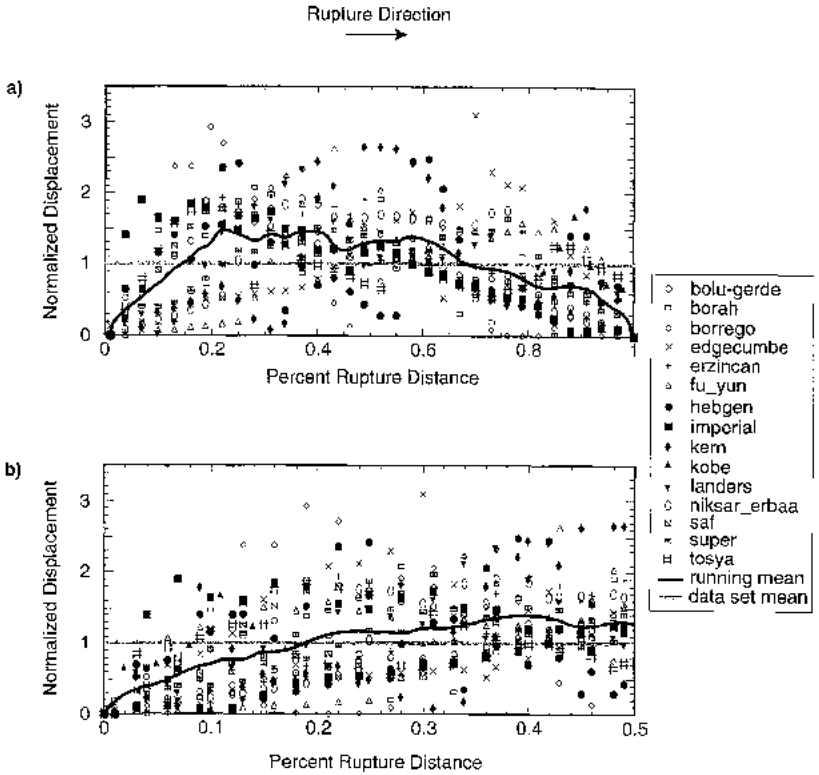
Issue: Current probabilistic FDHA models are empirical global models (Ergodic)

- Most Disp(M) models are based on global data
  - Standard Deviation is large
    - 0.35 (log10) for Ave Disp
    - 0.6 CV for along strike
    - Total CV about 1.0
- Variability of slip at a point is much smaller
  - CV = 0.4 – 0.55 (Hecker et al, 2013)



Slide modified from N. Abrahamson

Aleatory Variability of of Slip Along the Rupture

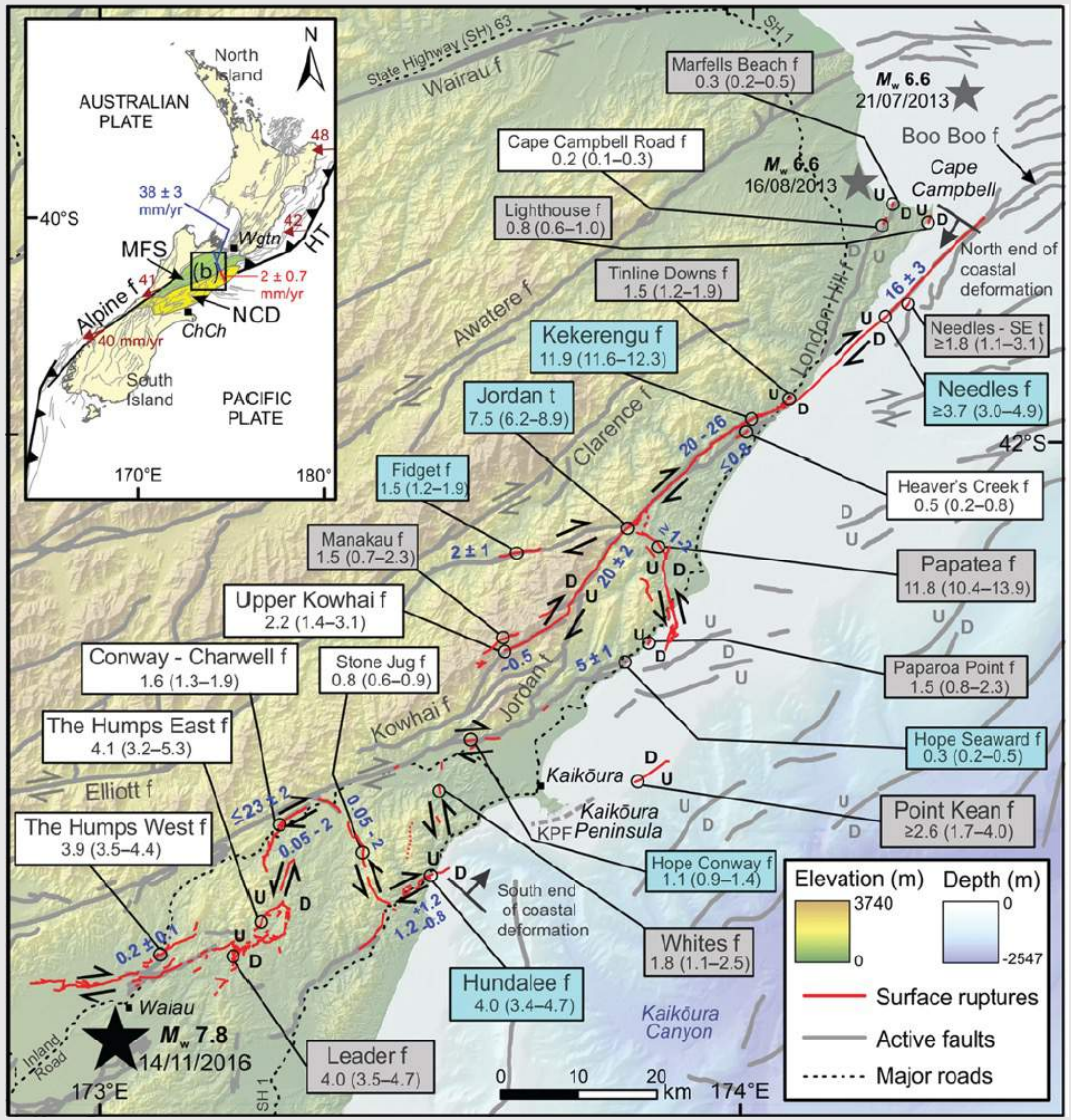


Fault Displacement Hazard Analysis

Are Empirical-Based Approaches Still Useful for FDHA?

Can Dynamic Rupture Simulations Provide Useful Constraints on:

- Distribution of ruptures (Given a known system of faults)?
- Magnitudes of displacements, especially in areas of structural complexities and multiple faults?
- Physical constraints on displacements – especially at long return periods



Litchfield et al., 2018

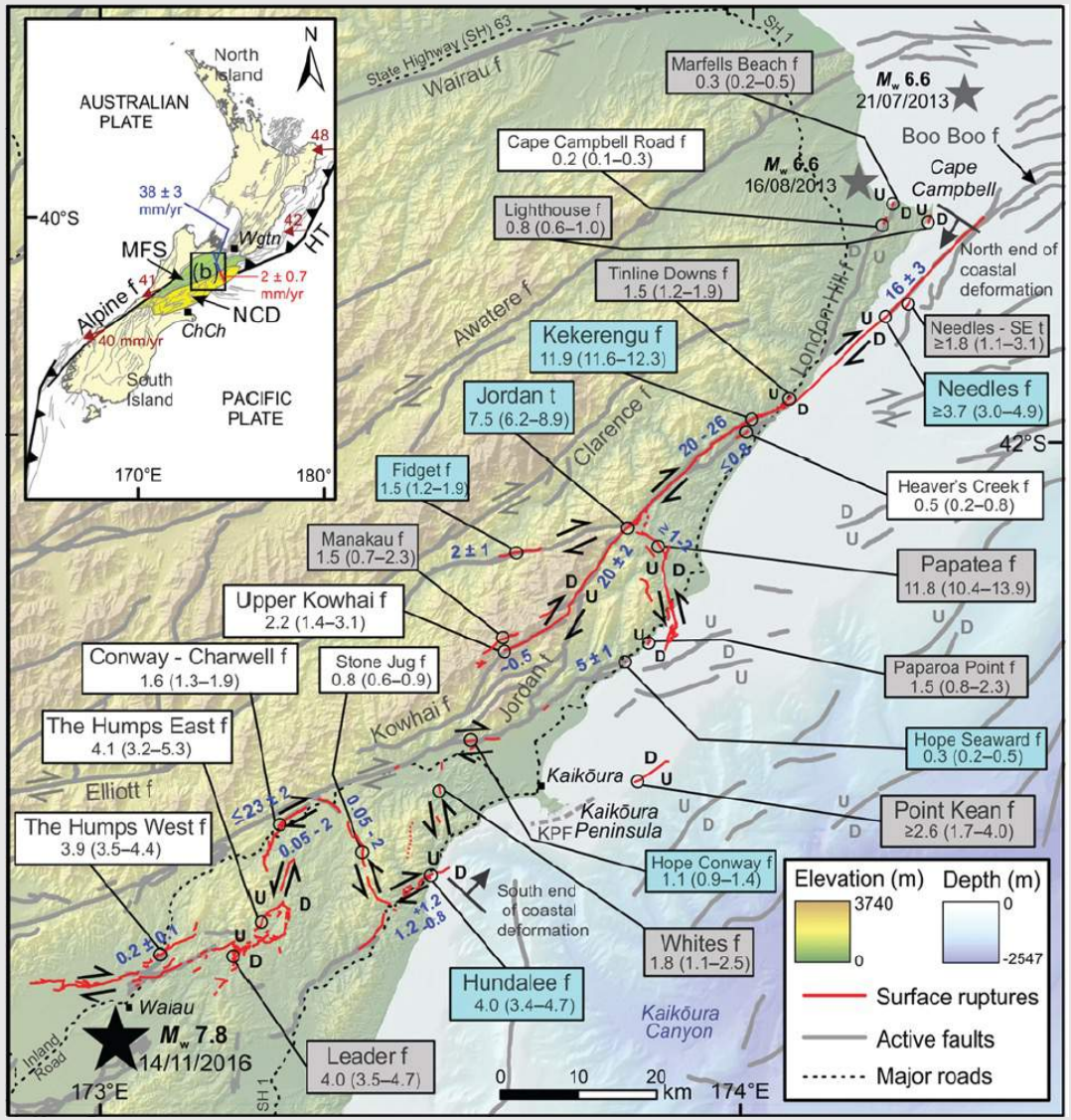
Potential Research Topics on Physical Constraints (From Norm Abrahamson)

- Issue: Extrapolation of limited empirical data
  - Get into problems when extrapolating models without constraints
- Candidate physical models
  - Dynamic rupture models
    - Distribution of stress, modulus of crust, and Friction law
    - self propagating ruptures
- Secondary ruptures
  - Use distribution of weak zones in the crust
  - Compute the surface rupture for large set of secondary ruptures scenarios
  - Develop constraints on the scaling based on the large suite of simulations
  - Apply constraints to empirical models
- Site effects
  - Including site conditions in dynamic rupture models or using geotechnical modeling of site effects

Fault Displacement Hazard Analysis

Current Activities:

- Updating, expanding observational databases using high-resolution datasets that capture on- and off-fault strain – Preliminary database for mid-2019
- Models for site effects using geologic/geotechnical data
- Plan is to engage dynamic modeling community to develop models of surface fault rupture distribution and displacements
- Planned SCEC FDHA Workshop for 2019



Litchfield et al., 2018

Questions?

Contact info:
Tim Dawson
timothy.dawson@conservation.ca.gov