PROBABILISTIC SURFACE FAULT DISPLACEMENT HAZARD ANALYSIS (PFDHA) DATA FOR STRIKE SLIP FAULTS

PEER SURFACE FAULT DISPLACEMENT HAZARD WORKSHOP

U.C. Berkeley

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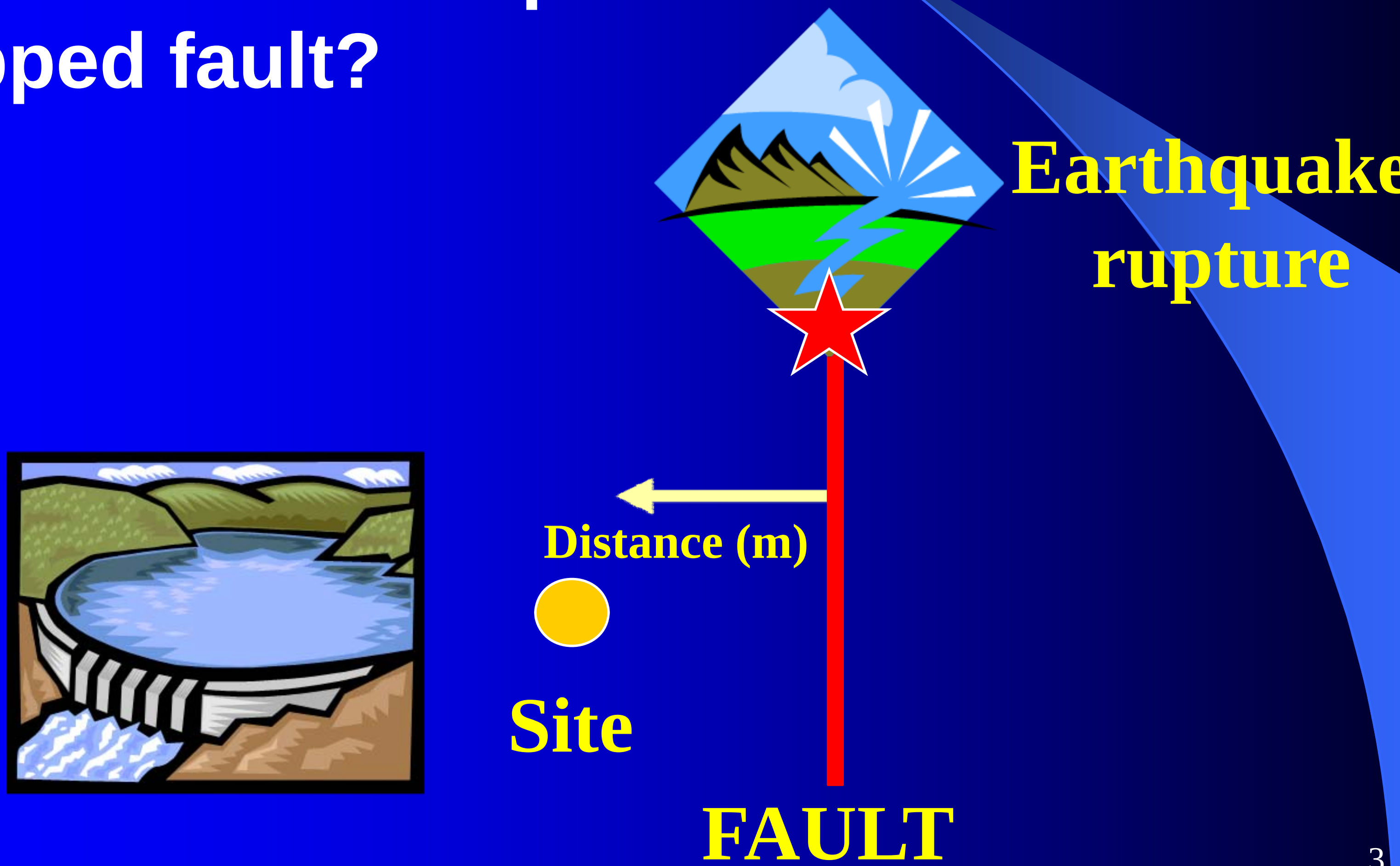
California Geological Survey

Background

PEER Lifelines sponsored project to develop improved design-oriented conditional probability models needed for estimating fault rupture hazard within either a deterministic or probabilistic framework, and implementing them both in spreadsheet form and as trial fault rupture hazard maps.

Problem to solve:

What is the probability of displacement at the site if the rupture occurs on a mapped fault?



This Study

Adapted approach described by Coppersmith and Youngs (1999) and Youngs and others (2003) for normal faults and modified it for strike-slip faults.

Principal vs Distributed Faulting

Coppersmith and Youngs (1999):

- ***Principal faulting*** **is slip along the main plane (or planes) of crustal weakness responsible for the release of seismic energy during the earthquake**

- ***Distributed faulting*** **is defined as displacement that occurs on other faults, shears, or fractures in the vicinity of the principal rupture in response to the principal faulting (triggered slip near and far-field)**

Data Needs – Principal Faulting

- **Distribution of earthquakes (location & magnitude)**

  - Location and magnitude from ground motion hazard studies (NSHM)

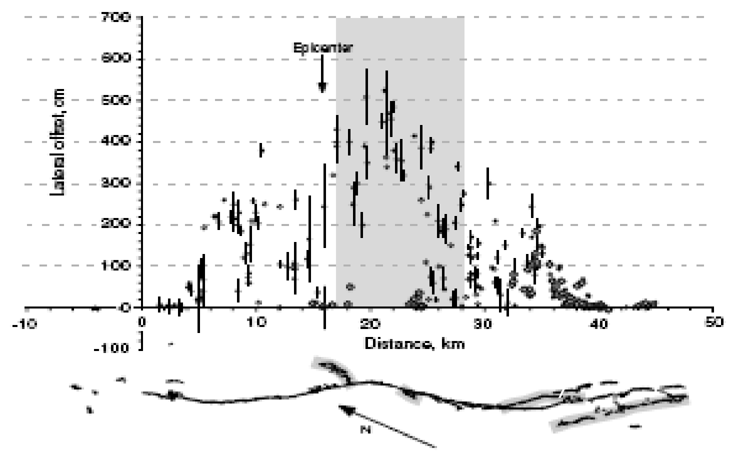
  - Probability that faulting reaches the surface (Wells and Coppersmith, 1994)

Data Needs – Principal Faulting

- **Distribution of displacement along fault trace (slip distributions)**

  -This study (Used in Petersen and others, 2004; *in prep*

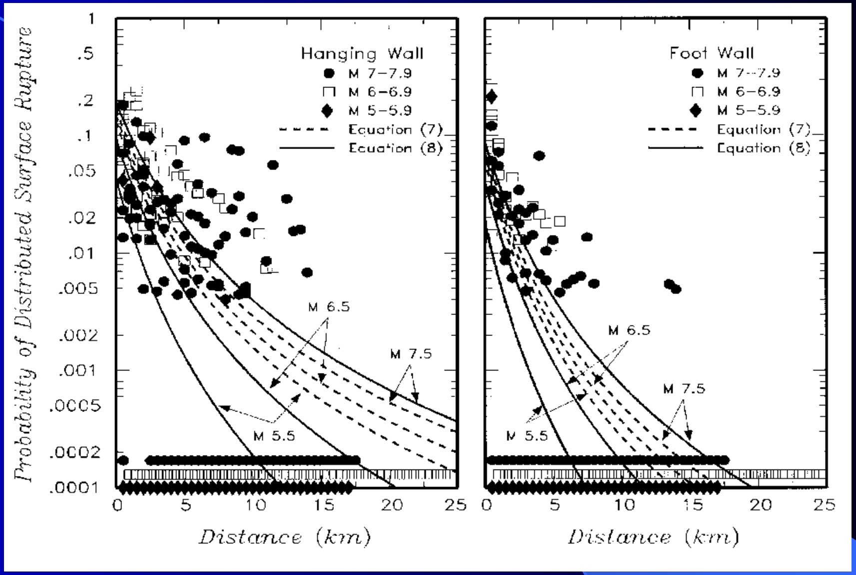
  - More comprehensive analysis by Wesnousky (2008)



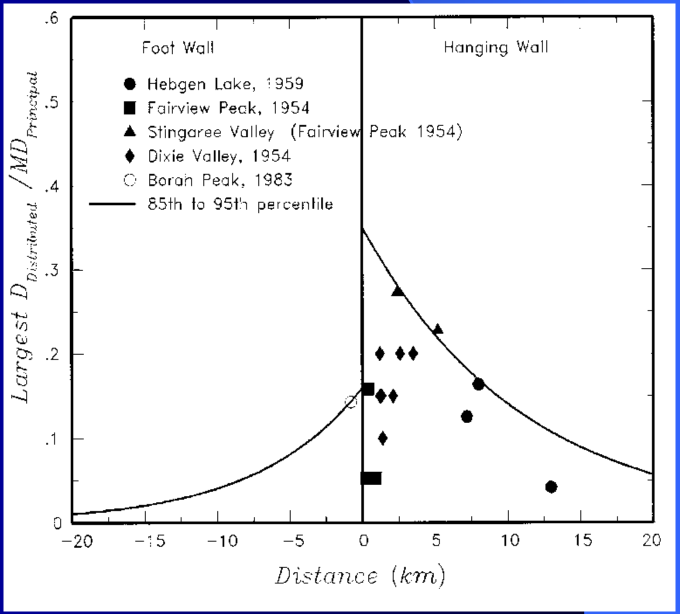
Hector Mine EQ (Treiman et al. 2002)

Data Needs – Distributed Faulting

- Distribution of secondary faulting

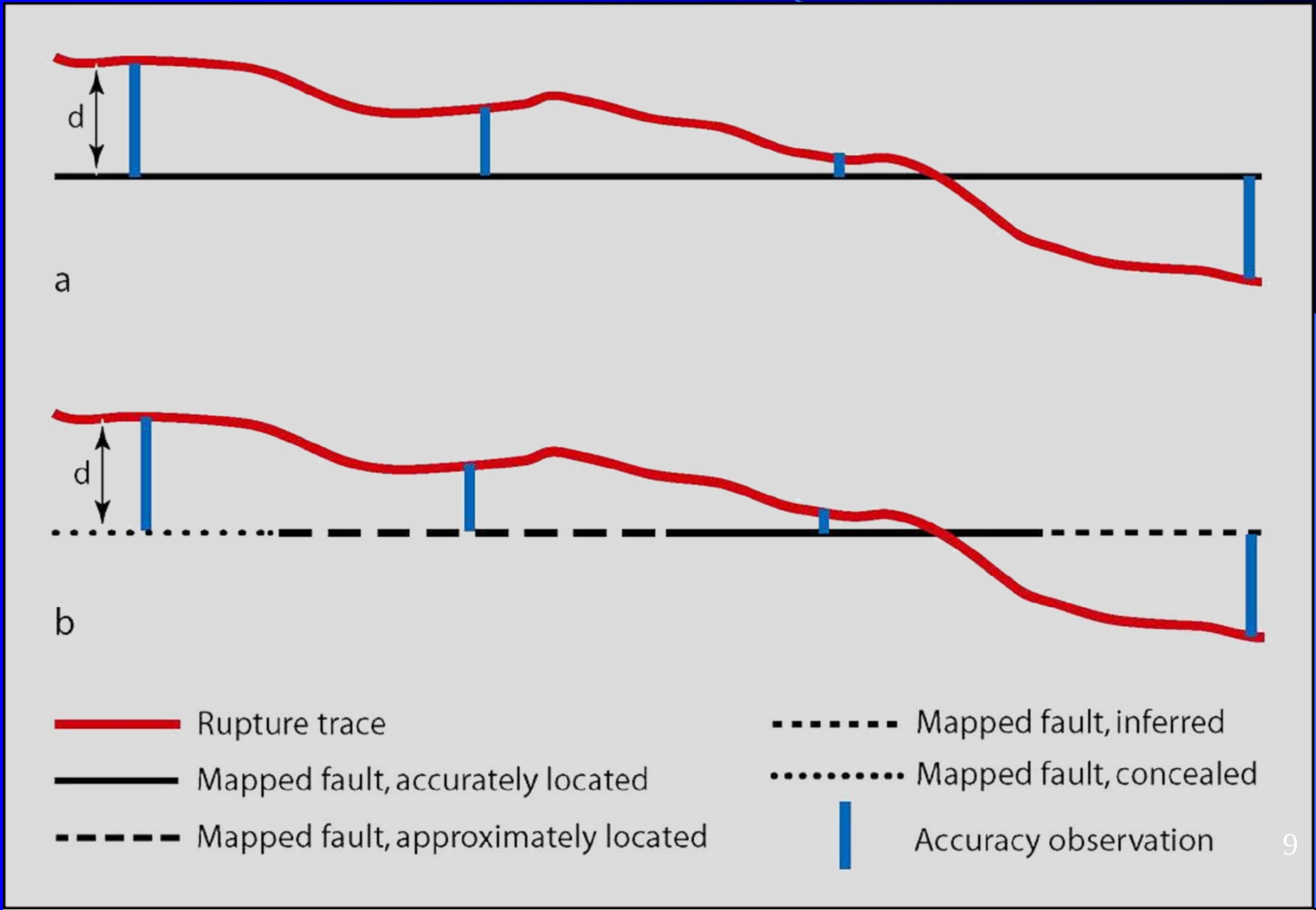


- Magnitude of displacement on secondary faults



Coppersmith and Youngs, 1999

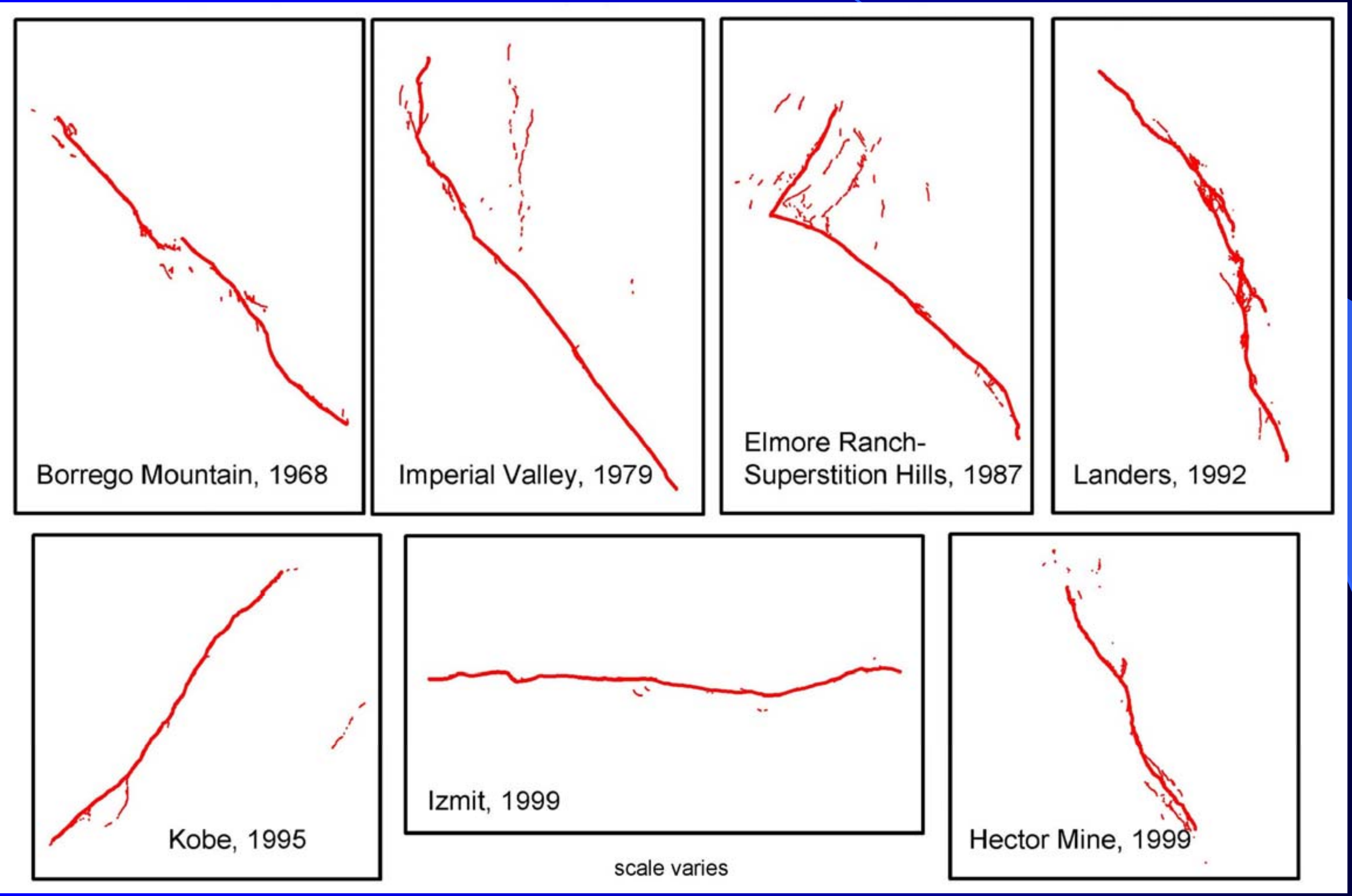
Data Needs – Uncertainty in location of mapped fault traces



Earthquakes in Analysis

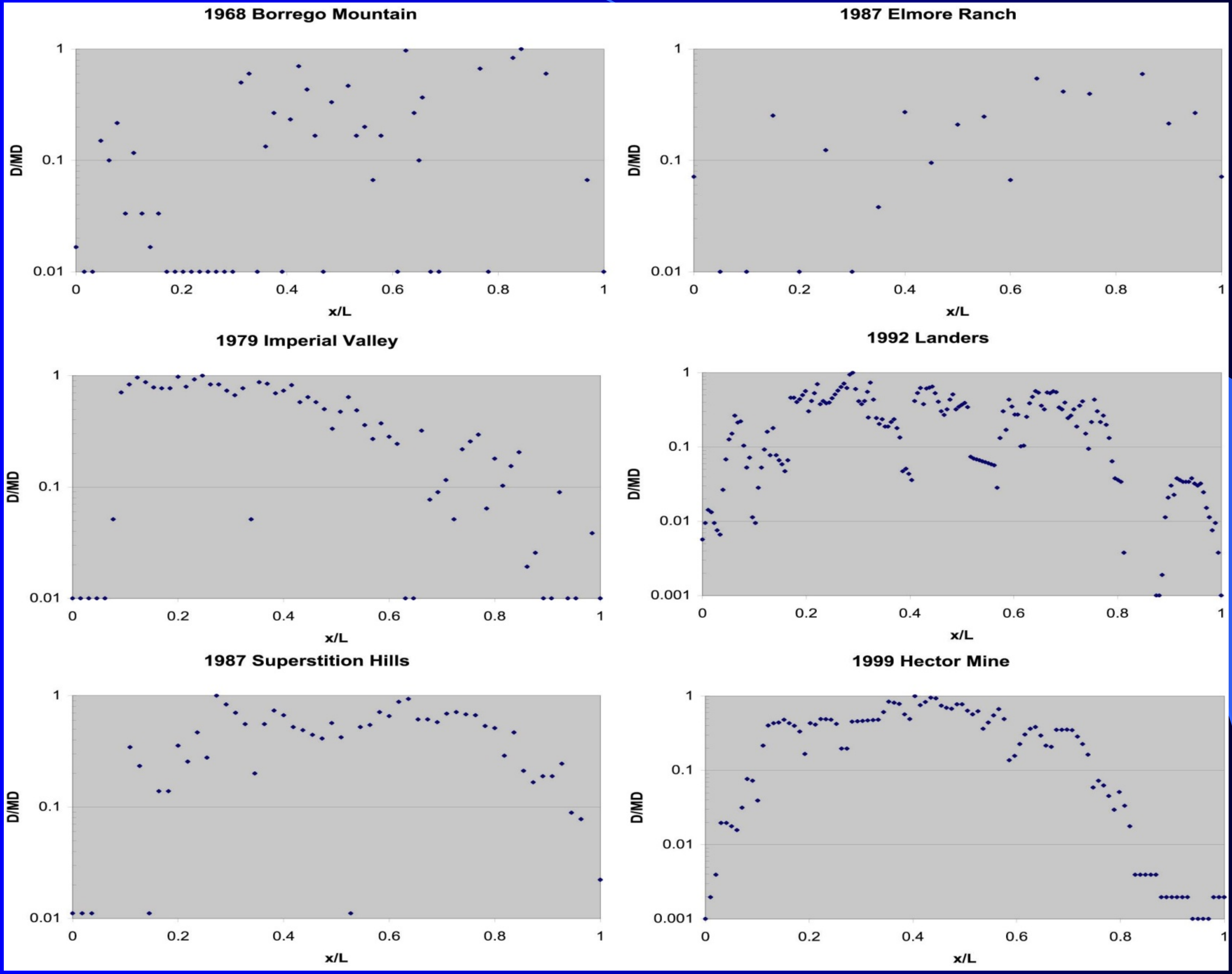
- Selected based on high-quality, large scale (>1:50,000) mapping
  - 1968 Borrego Mountain
  - 1979 Imperial Valley
  - 1987 Superstition Hill/Elmore Ranch
  - 1995 Kobe (Japan)
  - 1999 Izmit and Duzce (Turkey)
  - 1999 Hector Mine

Examples of strike-slip earthquakes in analysis



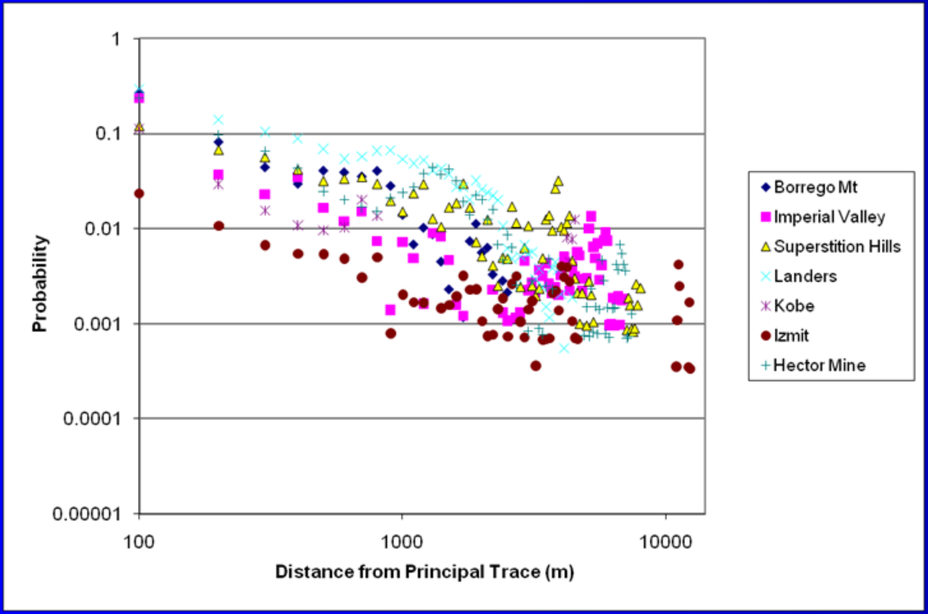
Scale varies

Principal faulting displacement

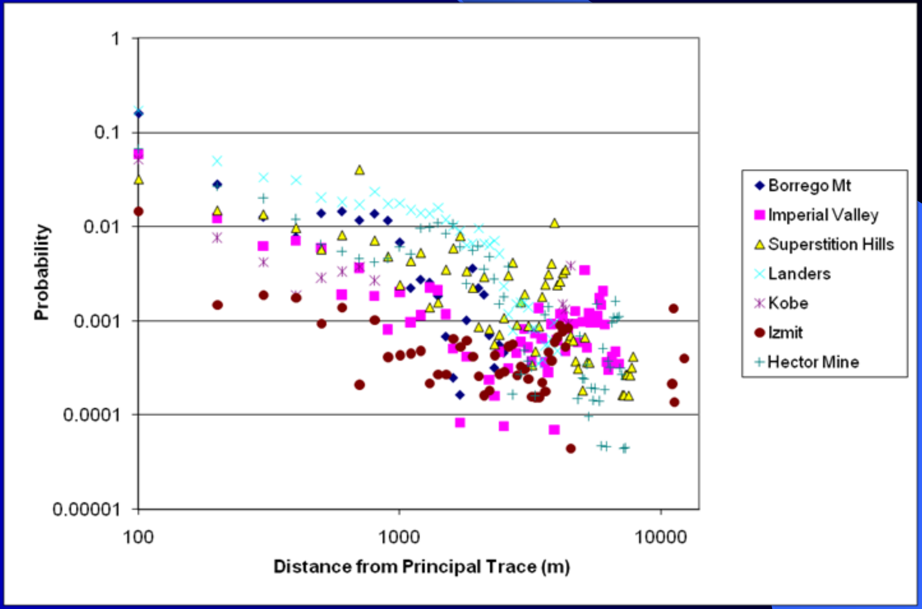


Distribution of Secondary Faulting

- Examined in GIS for various footprint sizes

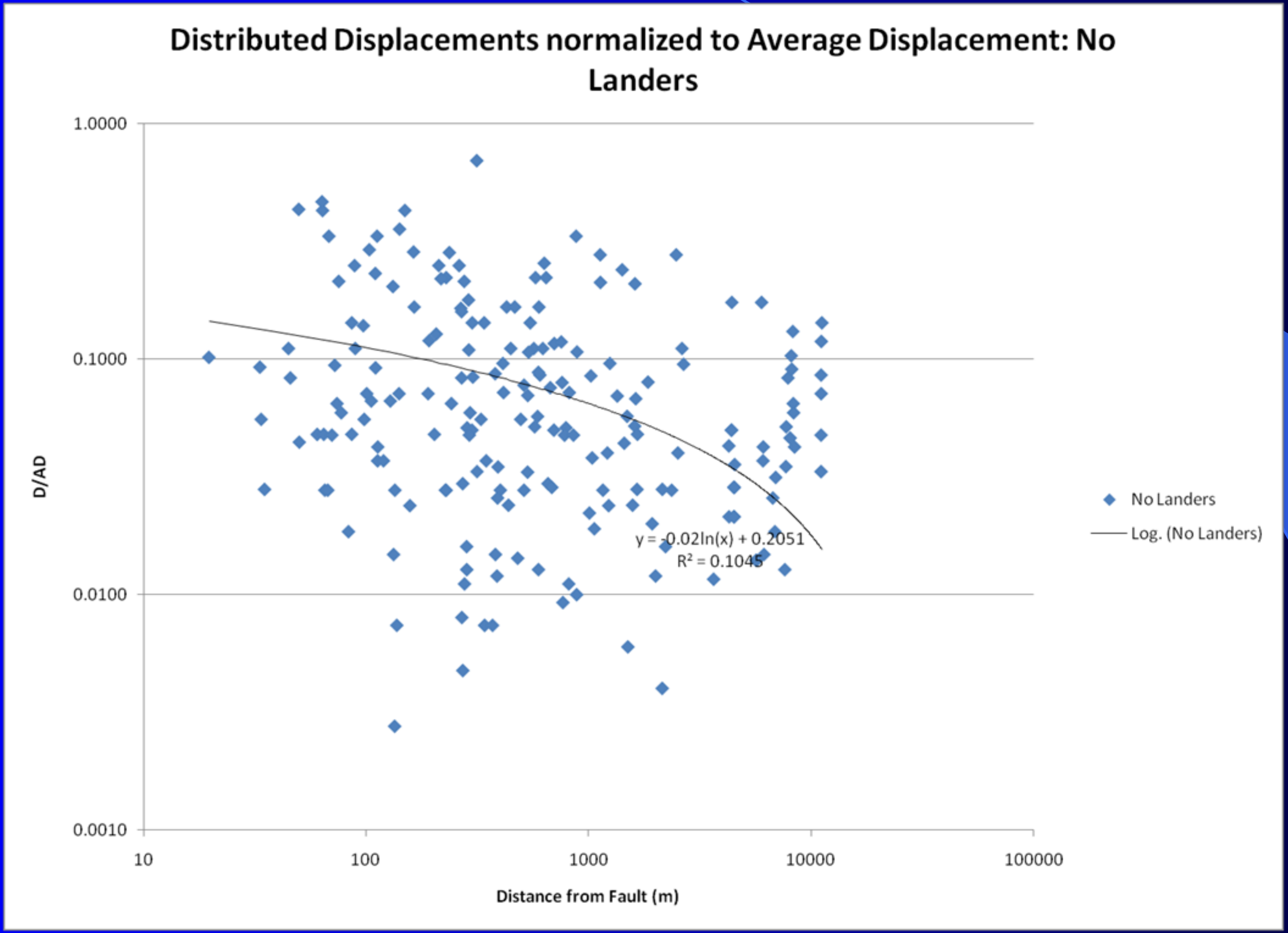


100x100 m cell



25x25 m cell

Secondary Faulting Displacements



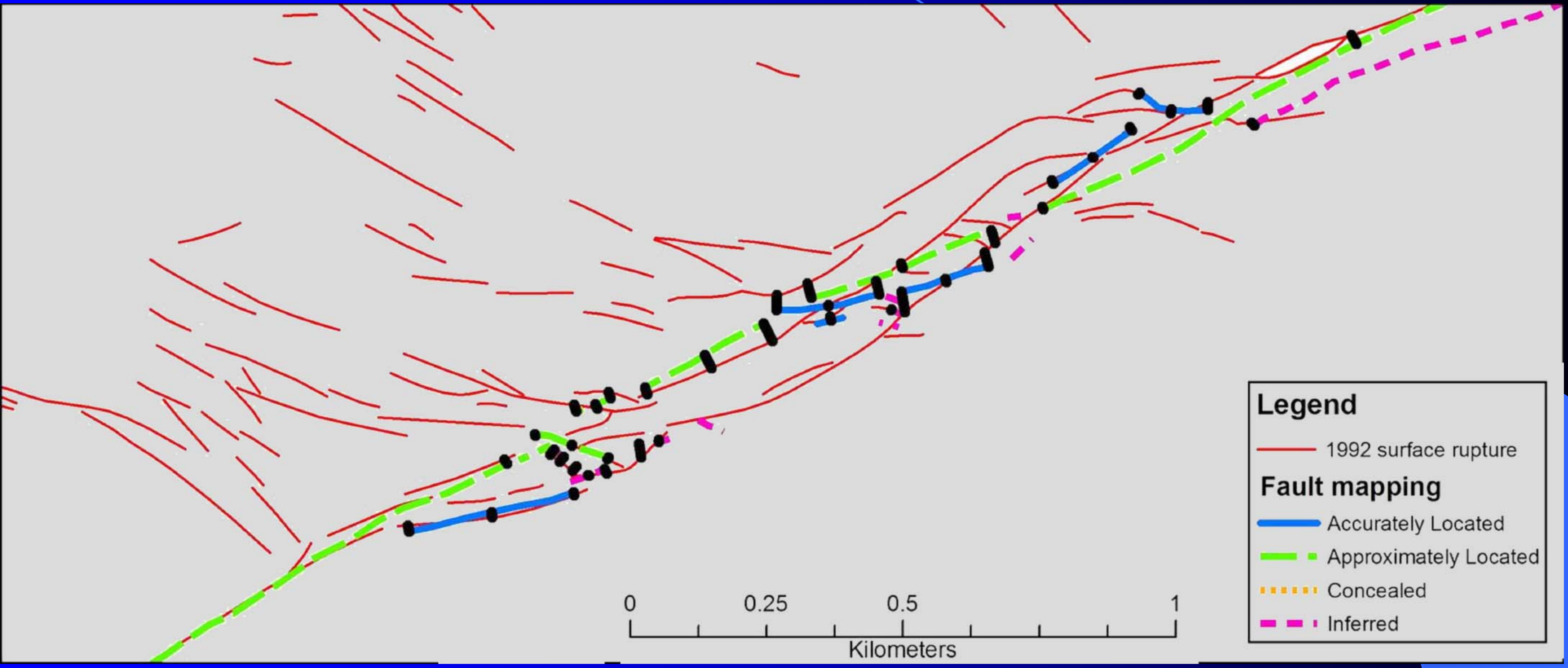
Uncertainty in location of mapped fault traces

This study: Examined deviation of mapped fault trace from rupture trace

- Used Alquist-Priolo (mostly) maps and compared them against earthquake rupture maps in same areas (e.g. Landers, Hector Mine)

- Categorized by location uncertainty of mapped trace

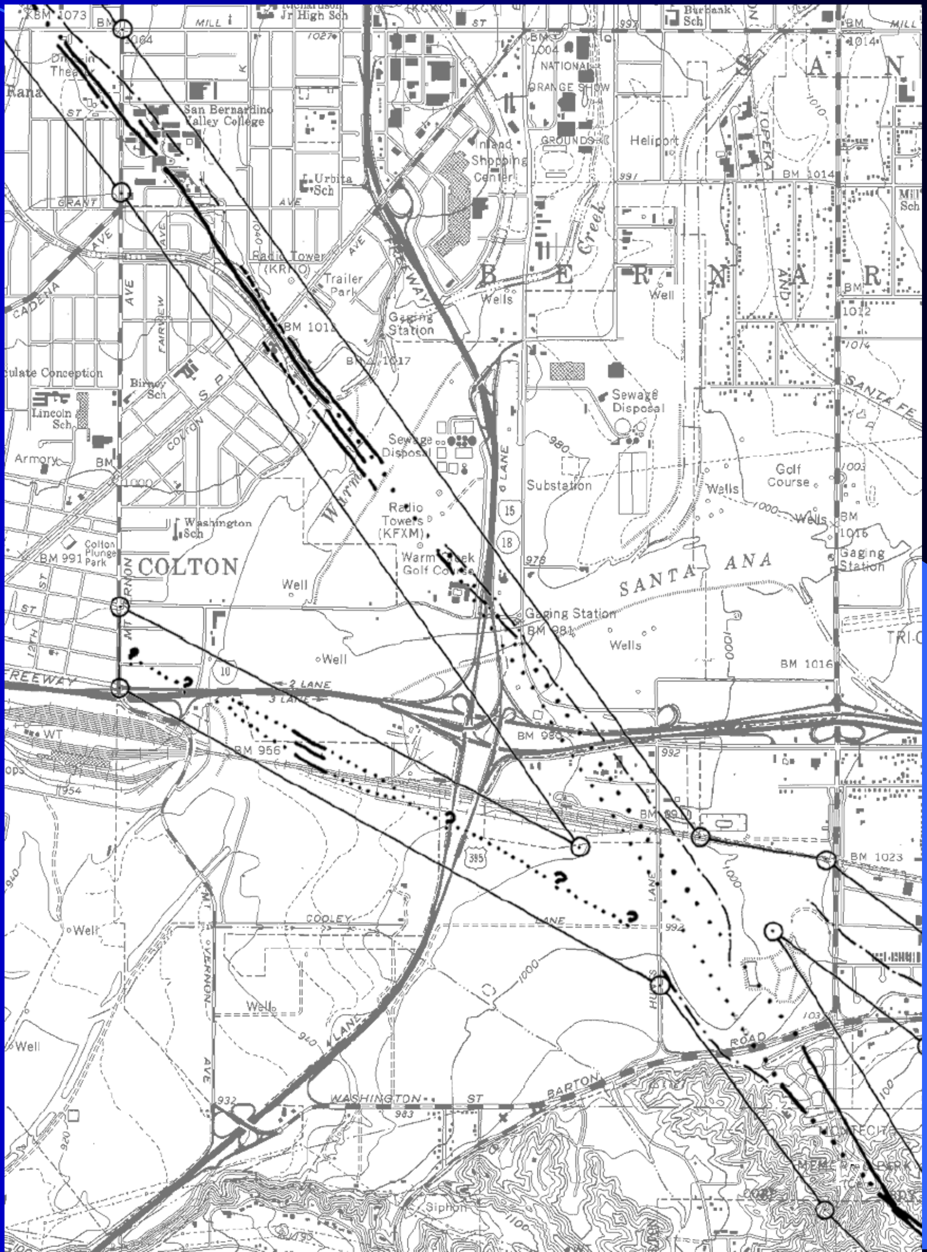
Uncertainty in location of mapped fault traces



Comparison of surface fault rupture in Landers earthquake, 1992 with pre-earthquake fault mapping from Alquist-Priolo Earthquake Fault Zones Map

Approach

ALQUIST-PRIOLO EARTHQUAKE FAULT ZONES MAPS ARE A TYPICAL SOURCE FOR PRE-EARTHQUAKE FAULT MAPPING



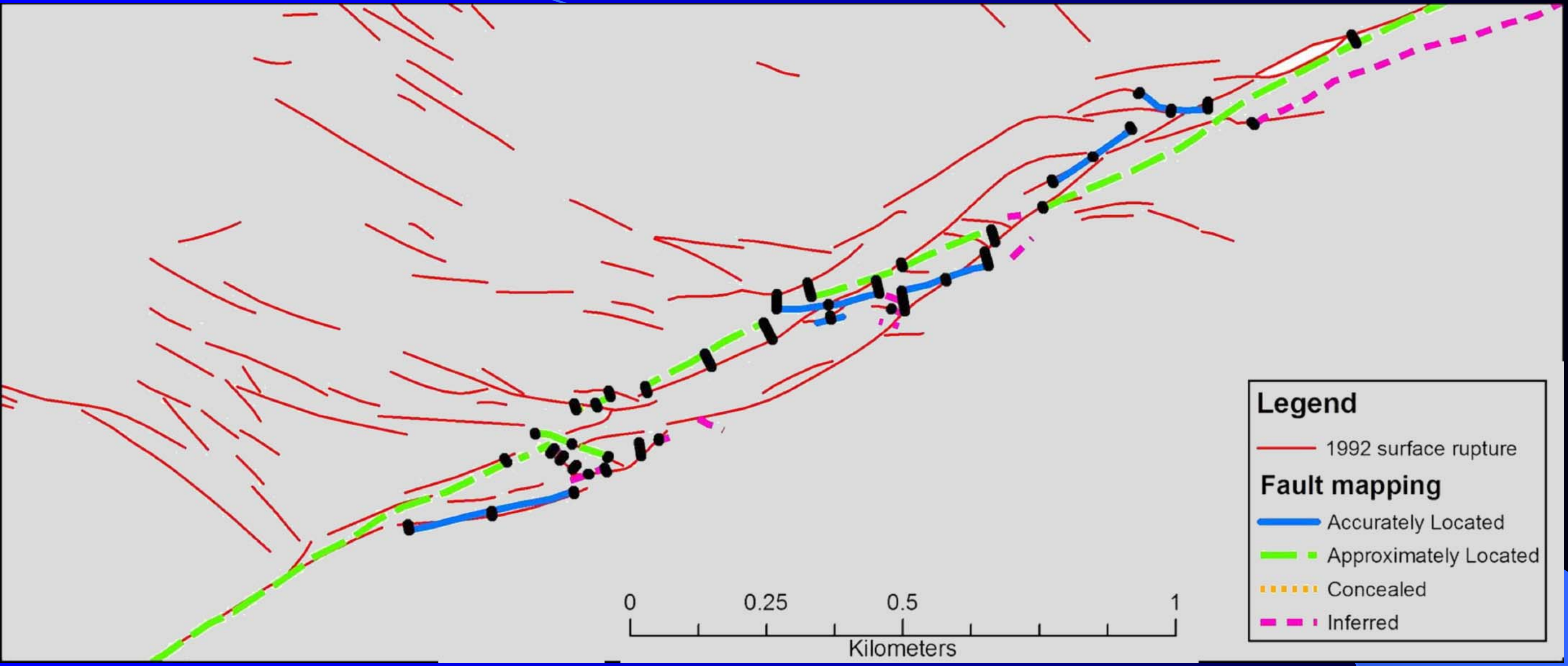
FAULT TRACE CATEGORIES

ACCURATELY LOCATED

APPROXIMATELY LOCATED

INFERRED

CONCEALED

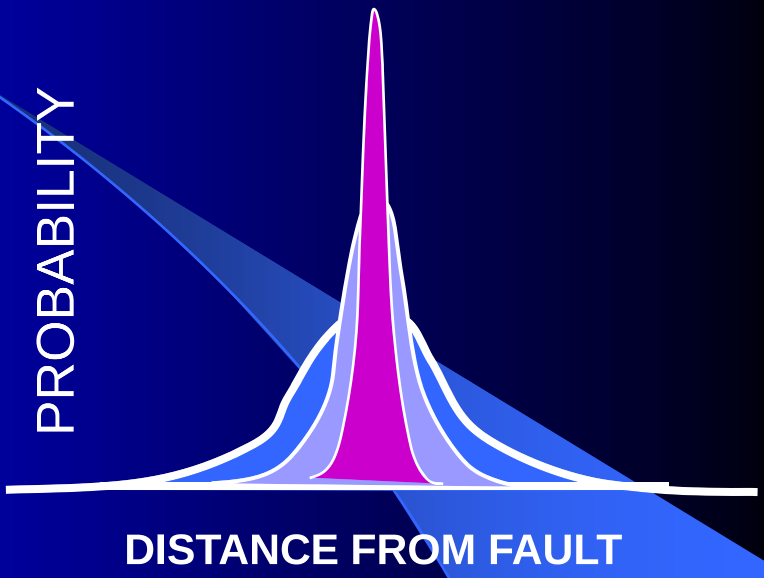


Comparison of surface fault rupture in Landers earthquake, 1992 with pre-earthquake fault mapping from Alquist-Priolo Earthquake Fault Zones Map

INPUT FOR PDF

DATA EXTRACTED FROM GIS

Distance along fault	Category	Distance from mapped trace
0	inferred	75
100	inferred	45
200	approximate	30
300	approximate	20
400	well-located	0
500	well-located	-5
600	well-located	-7
700	approximate	-10
800	approximate	-45
900	inferred	-90
1000	inferred	-90

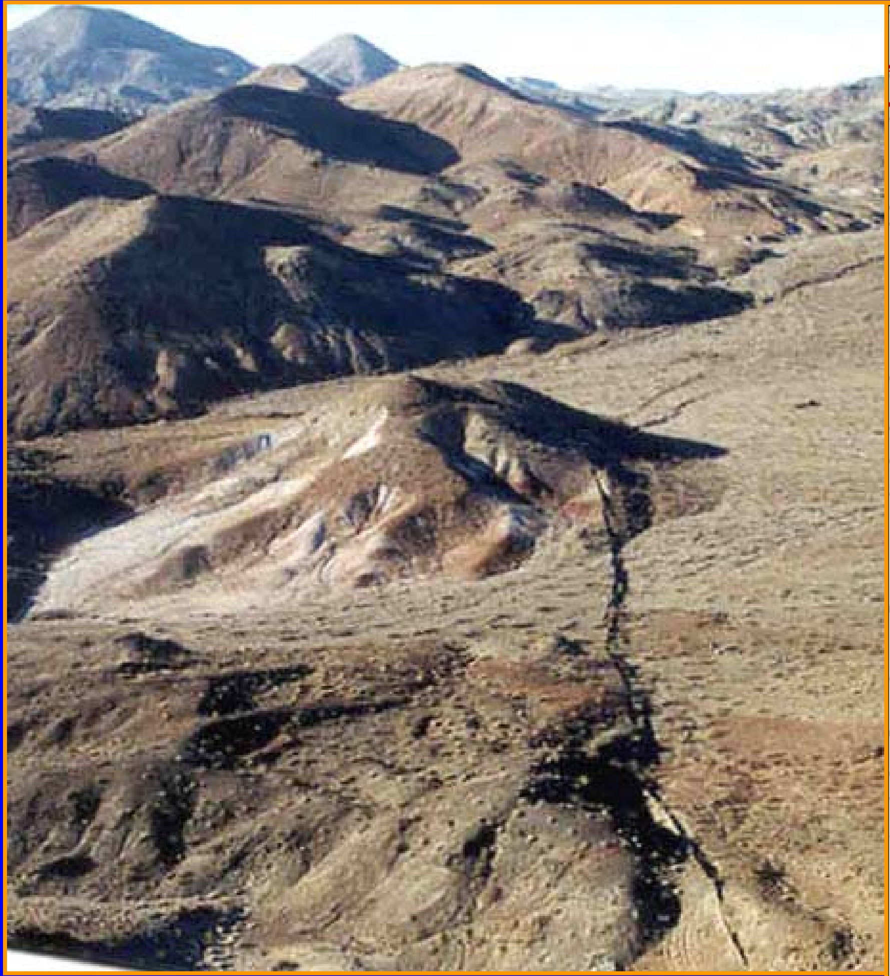


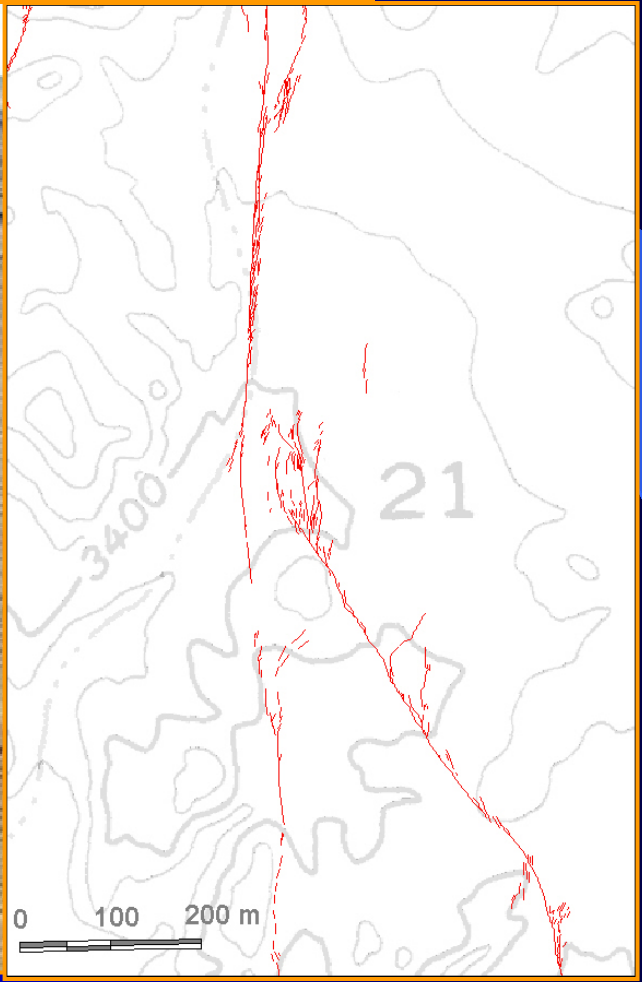
ADDITIONAL ANALYSIS

Test whether or not other variables influence mapping accuracy

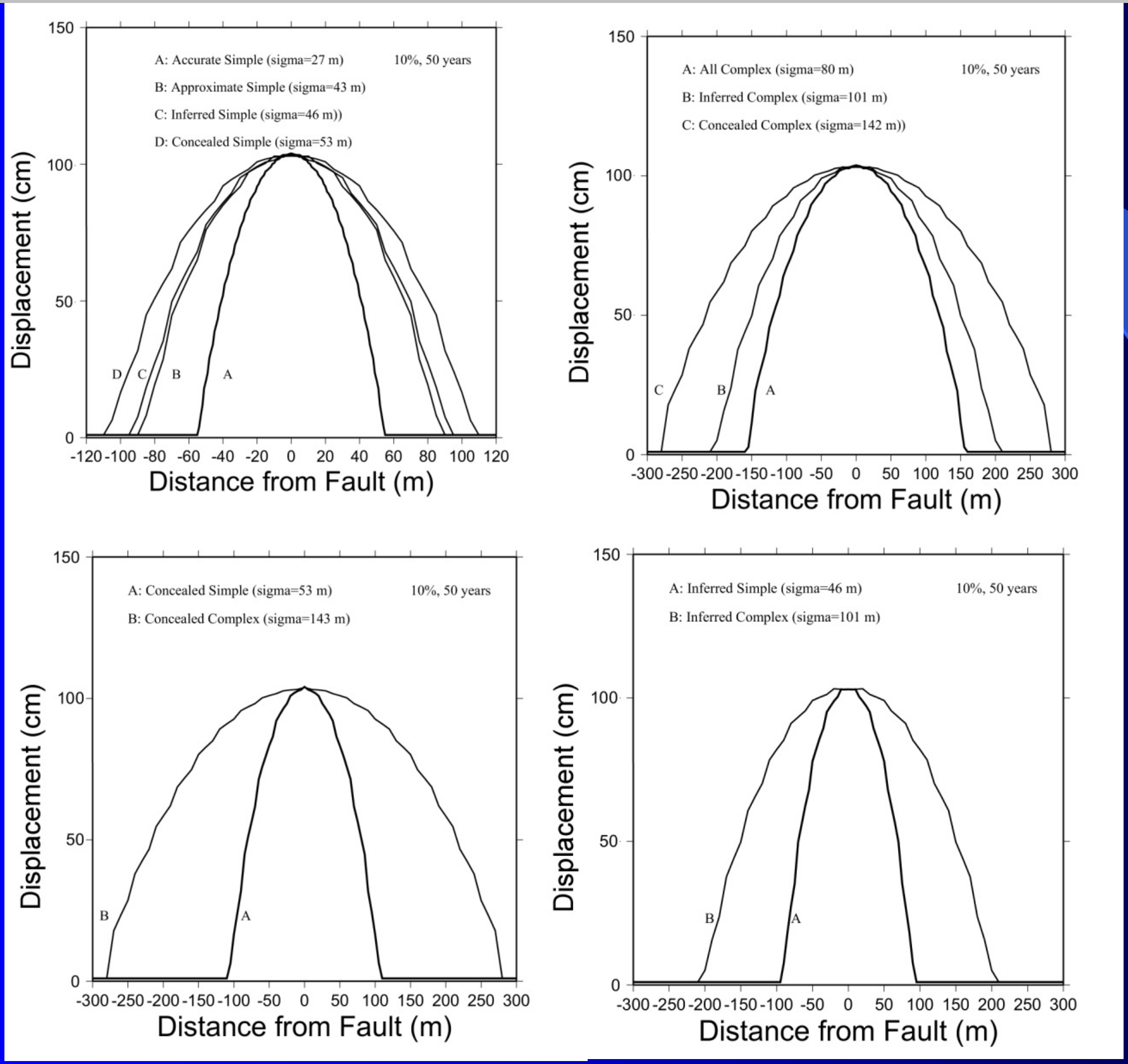
FAULT COMPLEXITY

1. Bends
2. Branches
3. Stepovers





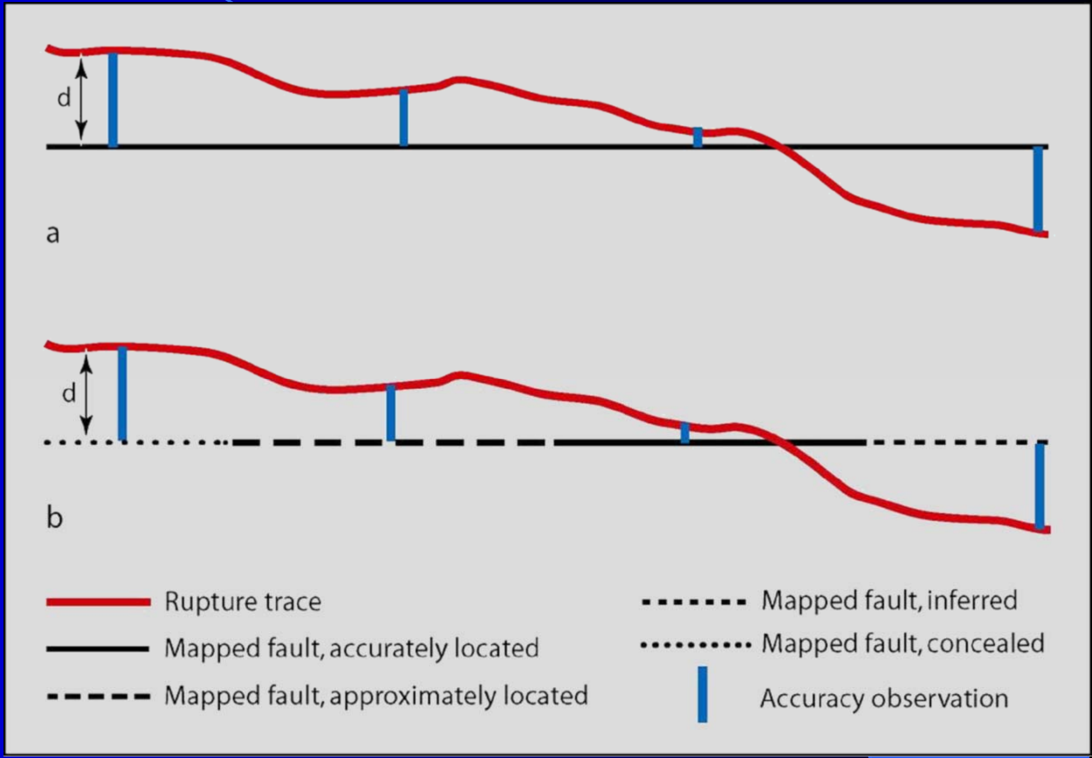
	All (mean)	SD	Accurate (mean)	SD	Approximate (mean)	SD	Concealed (mean)	SD	Inferred (mean)	SD
Undifferentiated	30.69	43.06	18.35	19.95	25.65	34.98	37.62	51.00	44.68	56.77
Simple	-	-	18.35	19.95	25.65	34.98	36.56	52.36	31.68	39.19
Complex	-	-	-	-	-	-	82.64	62.46	89.75	83.45



What are the variables that control rupture trace location?

• Uncertainty due to mapping accuracy, map scale, quality of mapping (Epistemic): Can be addressed with more detailed studies

• Uncertainty due to variability of rupture location from earthquake to earthquake (Aleatory).: Not yet addressed. What is the variability in rupture location from earthquake to earthquake?



To be continued…
(see Mark’s talk tomorrow)