Overview and Problem

Paleoseismic investigations provide point estimates of earthquake timing and location. Seismic hazard assessments require more information, such as total rupture length and location. By matching displacements across multiple sites, we can hypothesize the existence and location of multiple rupture segments. These displacement estimates can be combined to more fully understand the source of an earthquake, which can be used to constrain models of the fault system and its history.

Displacement estimates from the source to the site usually span from one site to the next. We present the simplest such mapping here. The displacement generally corresponds to a longer surface rupture length (SRL). Point dating of ruptures can provide only a general idea of when a rupture event occurred. However, if ruptures are closely spaced in time, we can correlate ruptures between sites to provide rupture length and location evidence. Seismic hazard applications require more information, such as total rupture length and location among neighboring paleoseismic sites.

Graphical Assessment of Time and Spatial Correlation

1. Event time estimates, step chronology; high uncertainty and low confidence.
2. Grouping of events, step chronology; high uncertainty but lower confidence.
3. Confidence tests, step chronology; time confidence is low. Spatial confidence cannot be determined.
4. Consider time estimates, time and spatial confidence.

Graphical Assessment of Time and Spatial Correlation

Spatial and time evidence are independent, but can be combined at least qualitatively. A vertical axis position for any given site, obtained displacement, and site date estimate for any given site, obtained displacement, and site date estimate, the horizontal position may be estimated. However, see box below. For new or unstable sites, one may use spatial correlation probabilities of (vertical axis, latitude, north) to infer an age. When sites can be linked with spatial correlation, timing information is crucial at any given site. In some cases, the site can be assumed to be the same, and the point in time can be assumed to be the same. When the age is not known, it is probably assumed to be the same. However, care must be taken because of the fault, and thus constrains rupture length. Distant evidence strongly supported by spatial evidence (box 2) may reject more. Missing events may be assumed to be nearby from spatial evidence.

Correlation By Dating Evidence Alone

Key points:
- Temporal matches and evidence may itself be a constraint on the time.
- Accelerated dating provides a chronological order.

Overlapping Gaussian:

- Gaussian at one site = Gaussian at another site

Overlap Probability

- Gaussian at one site = Gaussian at another site

Weighted Range Overlap

- Gaussian at one site = Gaussian at another site

Overlap Gaussian: If two

Rupture Length and Magnitude Given Observed Displacement - A Bayesian Inverse

One uses plots above for precise magnitude and rupture length, given point estimates of slip, P(M|L) and P(SR|L) respectively. P(SR|L) shows how far one may expect seismic rupture to extend and what weight probability. For example, e.g., the 0.95 level is about 80 km, meaning that an event is sure to have ruptured either at Pilgrim Canyon or Pallet Creek, and possibly both. If rupture over 115 km is expected at 50% and 200 km at 8%. P(SR|L) provides a quantitative basis for event correlation among neighboring paleoseismic sites.

Unconditional Correlation

Probability of correlation given rupture length

- Smaller bins => smaller correlation.
- Two dice, identical pdf’s, have 6 of 36 “same-bin” overlap.

Conditional Correlation

- Does not assume correlation.
- Weighs as solid one => can skew dates.

Temporal and Spatial Correlation

Overlapping Gaussian - II

- Gaussian at one site = Gaussian at another site

Graphical Assessment of Time and Spatial Correlation

Spaced and well-constrained events

Events plotted as 95% ranges (bars)

(2) Poor and well-constrained events

(1) Assumes correlation; Temporal overlap is weak evidence by itself.

Background on the Bayesian Inversion of Slip Distributions

Probability of a rupture of a given length spanning to an adjacent site.

- Initiates distances are labeled in the figure. The site with observed rupture is assumed to be randomly placed.