Supporting data, references, and notes for paleo-earthquakes in the Los Angeles region

Data Repository for "Long-range and long-term fault interactions in southern California"

by

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Paleoseismologic data from Los Angeles-region faults **--** The Los Angeles, California, metropolitan region lies at a major structural transition (Wright, 1991; Dolan et al., 1995). To the south, plate-boundary deformation is accommodated along several major northwest-trending right-lateral strike-slip faults, including (from east to west) the Whittier fault, the Newport-Inglewood fault, and the Palos Verdes fault. To the north of the city, motion is accommodated by a combination of east-west-trending reverse (e. g., Sierra Madre and Puente Hills Thrust faults) and left-lateral strike-slip and oblique reverse strike-slip faults (e. g., Raymond-Hollywood-Santa Monica fault system). Collectively, this complex network of faults accommodates north-south shortening of the region. Geodetic data indicate a north-south shortening rate of ~4.5 mm/yr (Walls et al., 1998; Argus et al., 1999; 2005; Bawden et al., 2001).

Previous analyses of earthquake occurrence on Los Angeles-region faults (Fig. DR-1) have generated an exceptional paleoseismologic record that we use to analyze temporal patterns of strain release (Crook et al., 1987; Patterson and Rockwell, 1993; Fumal et al., 1995; Dolan et al., 1996; 1997; 2000a; 2000b; 2003; McNeilan et al., 1996; Grant et al., 1997; Rubin et al., 1998; Weaver and Dolan, 2000; Lindvall et al., 2001; Tucker and Dolan, 2001). The compilation of paleoseismologic data shown in Figs. DR-2 and DR-3 comprises 21 earthquakes that have occurred on nine different faults during the past ~12,000 years. This paleoseismologic catalog is by no means complete, as several faults exhibit significant data gaps (e. g., Whittier fault pre-3.5 ka, Palos Verdes fault post-4.5 ka), and no paleoseismologic data are currently available for several faults (e.g., Verdugo fault, Compton blind thrust fault). Nevertheless, the available data offer intriguing insights into the collective behavior of this complex network of faults on the millennial time scale.

In Figs. DR-2 and DR-3, we present alternative representations of moment release through time for the Los Angeles-region fault network. In Fig. DR-2, the area under each curve represents a simple Gaussian probability distribution function for each of these paleo-earthquakes, using the methodology of Rockwell et al. (2000). The Gaussian distribution function used in Fig. DR-2 will emphasize the center of the allowable age range for each event. In contrast, in Fig. DR-3, the same data are shown with a simple, rectangular “boxcar” distribution, such that all ages within the allowable age range for each earthquake are equally likely. In both figures, the area under each curve or rectangle represents our best estimate of the total seismic moment of each paleoseismologically defined earthquake. As detailed below, we have used a variety of methods to estimate preferred seismic moments for each of these paleo-earthquakes. The width of the seismic moment curve for each paleo-earthquake on the horizontal axis of the figures represents the possible age range of that event as defined by the paleoseismological studies described below. We use the full potential age ranges suggested by the authors of each study in the compilation shown in Figs.s DR-2 and DR-3. Below we define the age and seismic moment parameters for each of the paleo-earthquakes used in the construction of Figs. DR-2 and DR-3. In Fig. DR-4, we also show the alternative,“boxcar” probability distribution function for the comparison of seismic moment release in the Los Angeles-region and ECSZ fault networks shown in the main text of the paper as Fig. 2.

<u>*Sierra Madre fault*</u> -- A combination of paleoseismologic excavations, geomorphologic analysis of scarp degradation, and historical data provides an apparently complete record of large paleoearthquakes on the Sierra Madre fault for Holocene-latest Pleistocene time (Crook et al., 1987; Rubin et al., 1998; Tucker and Dolan, 2001; T. Fumal, Pers. Comm.., 2005; J. Dolan, Unpubl. Data). The most recent earthquake on the Sierra Madre fault was the 1971 Mw 6.7 San Fernando-Sylmar earthquake. The seismic moment that we use for this event (17*10^25 dyne-cm) is from Heaton (1982).

The penultimate event on the Sierra Madre fault is based on geomorphologic (Crook et al., 1987) and paleoseismologic data (Fumal et al., 1995). Detrital charcoal collected from paleoseismologic trenches along the 1971 rupture trace indicate that the penultimate surface rupture occurred within the past 500 years (Fumal et al., 1995; T. Fumal, pers. Comm.. 2005). Crook et al. (1987) noted the presence of geomorphologically youthful (but undated), pre-1971 scarps along the trace of Sierra Madre fault along the trace of the 1971 rupture and extending eastward for about 10 km from the eastern termination of the 1971 rupture. Based on these observations, we assume that the penultimate event was slightly larger (Mw 6.75) than the 1971 earthquake. The historical record of events of this size that occurred this close to the early Spanish settlements of the region probably extends back at least 200 years. The absence of any such events in this area during the past 200 years, coupled with the maximum age provided by the detrital charcoal ages, leads us to assume an age range of 200-500 years for this event.

The third-youngest earthquake we use for the Sierra Madre fault is based on the paleoseismological observations of Rubin et al. (1998) and Tucker and Dolan (2001), as well as on the geomorphological observations of Crook et al. (1987). Crook et al. (1987) noted that scarps along the Sierra Madre fault trace eastward of a point about 10 km east of the east end of the 1971 surface trace are much more degraded than to the west along the trace of 1971 and penultimate surface ruptures, indicative of a much longer elapsed time since the most recent surface rupture on the central and eastern Sierra Madre fault. Based on the degree of scarp degradation, Crook et al. (1987) estimated that the most recent surface rupture on the central and eastern Sierra Madre fault may have occurred during the early Holocene or latest Pleistocene time. This geomorphological inference has been borne out by subsequent paleoseismologic investigations by Rubin et al. (1998) and Tucker and Dolan (2001). Specifically, Rubin et al. (1998) excavated a trench across the central part of Sierra Madre fault. The trench data demonstrate that two surface ruptures have occurred on the fault during the past ~ 20 ka. Cumulative slip during these two events was ≥10.5 m. Slip during the most recent event was ≥~4 m. Tucker and Dolan (2001) excavated a trench on the eastern part of the Sierra Madre fault. Detrital charcoal ages from an unfaulted alluvial unit overlying the fault tip indicate that that it has been at least ~8,000 years since the most recent surface rupture on this part of the fault. Moreover, boreholes excavated directly below the trench exposure demonstrate that the fault accommodated at least 14 m of slip between 24 ka and 8 ka (Tucker and Dolan, 2001). An additional trench excavated one kilometer to the west revealed a buried soil horizon that was displaced by at least 5 to 6 m during the most recent Sierra Madre fault surface rupture (J. Dolan, unpubl. data). Detrital charcoal recovered from this faulted soil yielded a calibrated age range of BC 13,529-11,903 (95.4% confidence limits), indicating that the most recent surface rupture on this part of the fault occurred after 15.5 ka. . Based on the large displacements observed in the paleoseismological trenches, we assume a moment magnitude of M_w 7.5 for the third-youngest surface rupture on the Sierra Madre fault, consistent with an average displacement of 5 m (Wells and Coppersmith, 1994).

Newport-Inglewood fault -- We used data from Grant et al. (1997) for the Newport-Inglewood fault earthquakes included in figures DR-2 and DR-31. Grant et al. (1997) used CPT (cone penetrometer test) boreholes to determine the ages of five probable Holocene surface ruptures on the Newport-Inglewood fault at a small extensional step-over located in Huntington Beach. Although their paleoseismologic data span the entire Holocene, Grant et al. (1997) note that sediment accumulation patterns at their site were more conducive to preserving evidence for surface rupture during early to middle Holocene time.

The ages of these events are constrained by radiocarbon dates from the well-stratified section at the study site. For the oldest event, Grant et al. (1997) report that the surface rupture occurred after deposition of an 11.7±0.7 ka sample, and before deposition of a 10.5+0.4/-0.2 ka sample. We therefore use an age of 11.3±1.0 ka for this event in figure S1. For the fourth event back, Grant et al. (1997) report that the earthquake occurred "during or just before" deposition of 10.5+0.4/-0.2 ka sample. We therefore use an age of 10.7±0.4 ka for this event. The third event back occurred between 5.5±0.2 ka and 7.8+0.1/-0.2 ka; we use an age of 6.6±1.3 ka. The penultimate surface rupture occurred "shortly" after deposition of 4.3±0.4 ka bed (Grant et al., 1997). We use an age of 4.0±0.7 ka. The age of the most recent surface rupture is not well constrained. Grant et al. (1997) report that it "could post-date 4.3 ±0.4 ka by several millennia". We therefore use a broad age range of 2.0±1.5 ka to incorporate this level of uncertainly.

Displacements are not known for these earthquakes, although they were all probably larger than the 1933 M_w 6.4 Long Beach earthquake, which was not observed in the Grant et al. (1997) CPT borehole study. In the absence of slip-per-event information, we used the fault slip rate and the ages of past earthquakes to estimate seismic moment for past Newport-Inglewood fault earthquakes. The Newport-Inglewood fault is thought to have a relatively slow slip rate of 1.5±0.5 mm/yr (Frankel et al., 2002; [Grant et al., 1997 suggest a minimum slip rate of 0.35-0.55 mm/year]). The occurrence of five surface ruptures during the past ~11,700 years thus suggests approximately ~5 to17.5 m of Holocene displacement, assuming that displacement has been relatively constant during the Holocene. Dividing this value by five earthquakes suggests average displacements of ~1-3.5 m per event. The regressions of Wells and Coppersmith (1994) indicate that these average displacement values correspond to earthquakes of M_w ~6.9-7.15. We assume a low-intermediate value of M_w 7.0 for the Newport-Inglewood surface ruptures used in figures DR-2 and DR-3.

<u>*Palos Verdes fault*</u> -- MacNeilan et al. (1996) used a series of boreholes and a three-dimensional grid of closely spaced, high-resolution seismic reflection profiles to determine the ages and vertical separations of two probable mid- early Holocene surface ruptures on the Palos Verdes fault. They used the vertical separation of key sedimentary horizons to suggest that one interpretation of their data is that earthquakes producing

about one meter of dip-slip may have occurred shortly after ~ 10 to 9.5 ka and at about 7.6 ka. Although the occurrence of these two earthquakes is somewhat more speculative than some of the other earthquakes discussed here, we include them, as MacNeilan et al.'s (1996) interpretation seems to be a reasonable explanation of their vertical separation data. In figures DR-2 and DR-3, we use ages of 7.6±0.4 ka and 9.7±0.3 ka for these two inferred earthquakes. No large earthquakes apparently occurred between 4.5 ka and ~ 7.6 ka. Although no strata ≤4.5 ka are preserved at their study site, MacNeilan et al. (1996) speculate that one interpretation of the dip-slip history of the fault is that another earthquake may have occurred during the latest Holocene (0.5-2 ka). Although the occurrence of such an earthquake would strengthen the ~1.5 – 2.0 ka cluster shown in figures DR-2 and DR-3, we have not included this possible event because of its speculative nature. Nevertheless, the occurrence of at least two, and possibly three earthquakes on the Palos Verdes fault during the past 10 ka suggests a relatively long recurrence interval for the fault on the order of several thousand years. The right-lateral strike-slip rate for the fault is well documented at ~ 3.0±0.5 mm/yr (Ward and Valensise, 1994; Stephenson et al., 1995; MacNeilan et al.,1996). This moderately rapid slip rate, combined with the relatively long recurrence interval for surface ruptures, suggests the occurrence of large-displacement, large-magnitude events consistent with estimates of Mw ~7.2 earthquakes resulting from rupture of the entire Palos Verdes fault (e. g., Dolan et al., 1995; MacNeilan et al., 1996). In the construction of figures DR-2 and DR-3, we used M_w 7.2 for the ~7.6 and the ~9.7 ka surface ruptures.

Santa Monica-Hollywood-Raymond fault system -- Geomorphological mapping and structural studies indicate that the Santa Monica fault, the Hollywood fault, and the Raymond fault are part of a 120-km-long system of oblique reverse-left-lateral fault system that we refer to collectively as the Santa Monica-Hollywood-Raymond fault system (Dolan et al., 1995; 1997; 2000a; Weaver and Dolan, 2000).

It has been at least 1100 years since the most recent surface rupture on the Santa Monica section of the fault system, with a likely maximum age for this event of ~2,000-3,000 years (Dolan et al., 2000a). Similarly, Dolan et al. (1997) showed that it has been at least

1200 years since the most recent surface rupture on the Hollywood section of the fault system. Based on radiocarbon dates and soil analyses collected from their boreholes, Lindvall et al. (2001) suggest that the most recent event on the Hollywood fault occurred during latest Holocene time. Weaver and Dolan (2000) showed that the most recent surface rupture on the easternmost, Raymond section of the fault system occurred ≥~1,000 years ago. Crook et al. (1987) demonstrated, at a different site, that the most recent surface rupture on the Raymond part of the fault system occurred about 2,000 years ago (see also discussion of Crook et al. [1987] age data in Weaver and Dolan [2000]). Based on the general similarity in the age of the most recent event measured at all of these sites, we infer that the most recent earthquake ruptured the entire Raymond-Hollywood-Santa Monica fault system. It is also possible, however, that the system ruptured in a series of closely spaced, latest Holocene earthquakes between ~1-3 ka. In figures DR-2 and DR-3, we use an age of 1.7±0.7 ka for the most recent surface rupture on the Santa Monica-Hollywood-Raymond fault system.

Radiocarbon ages from above and below a well-defined paleo-surface rupture indicate that the penultimate surface rupture on the Hollywood fault occurred ~8.2±1.3 ka (Dolan et al., 2000b). The vertical component of displacement during this event was 1.2 m, mountain-side-up. Inasmuch as this sense of vertical separation is opposite to the long-term, oblique-reverse dip-slip component of motion on this predominantly left-lateral strike-slip fault, the total surface displacement during this earthquake must have been the result of strike-slip offset of irregular topography. This suggests that the total displacement was relatively large, probably on the order of several meters. We therefore conservatively assume a magnitude of 7.0 for this paleo-earthquake.

An apparently older event is recognized on the Raymond fault part of the system (Crook et al., 1987). The age of this event is constrained by radiocarbon dates on bulk-soil samples and detrital charcoal fragments to be between 7 ka and 13 ka. We therefore use an age of 10±3 ka. Although this age range overlaps with the age of the penultimate event on the Hollywood fault part of the system, we do not correlate these two earthquakes in figure DR-2 because of the broad nature of the age of the Raymond fault event. We assume a magnitude of the penultimate Raymond fault surface rupture of M_w 6.7, which is probably a minimum.

Puente Hills Thrust fault -- Dolan et al. (2003) used a combination of high-resolution seismic reflection data and continuously cored boreholes drilled directly along the reflection profile to determine the ages of the four most recent earthquakes on the central (Santa Fe Springs) segment of the Puente Hills blind thrust fault. Their study site, which is located on an active floodplain of a major river, is characterized by markedly continuous deposition, with no evidence of any major hiatuses during the past 12,000 years. Dolan et al. (2003) measured the heights of buried fold scarps that developed during past earthquakes. Together with the known, 27° dip of the fault (Shaw and Shearer, 1999; Shaw et al., 2002), they used the measured, vertical component of displacement in these earthquakes to estimate minimum thrust displacements. These estimates are minima because Dolan et al. (2003) assumed that: (1) no deep thrust slip was consumed as folding outside of the 450-m-wide kink band they studied; and (2) that no erosion of the up-thrust side of the paleo-fold scarps occurred before they were buried. Their minimum slip estimates for the past four earthquakes are 2.1 m, 2.0 m, 5.2 m, and 4.0 m, from youngest to oldest. Because of these large minimum displacements, these earthquakes probably involved rupture of the entire PHT. Dolan et al. (2003) used the regressions of Wells and Coppersmith (1994) to estimate seismic moments for these events. From oldest to youngest, these estimates are: M_w 7.2, M_w 7.2, M_w 7.5, and M_w 7.4. More than 35 radiocarbon ages on detrital charcoal and bulk-soil samples indicate that these four events occurred at 1.6±1.4 ka, 4.65±1.65, 7.4±0.8, 9.85±1.0 ka (Dolan et al., 2003; Leon et al., 2007). The minimum age for the most recent event is also constrained by the fact that such a large earthquake has not occurred during the ~200-year-long historic period in Los Angeles.

Whittier fault -- The ages and magnitudes of the two most recent Whittier fault surface ruptures are based on paleoseismological age data from Patterson and Rockwell (1993) and displacement data from three-dimensional excavations of small channels offset by the fault (Gath et al., 1992; WGCEP, 1995). Detrital charcoal recovered from above and below the event horizons of the two most recent surface ruptures indicates that the most recent event occurred at 1.8±0.4 ka and the penultimate event occurred at 3.35±0.5 ka (Patterson and Rockwell, 1993; T. Rockwell, Pers. Comm., 2006; E. Gath, Pers. Comm., 2006).The penultimate surface rupture is one of the temporally best-constrained paleo-earthquakes used in the compilation, accounting for its “spiky” appearance in the cumulative seismic moment curve shown in figures DR-2 and DR-3. Unfortunately, no paleoseismologic data are available for the Whittier fault prior to ~3.5 ka.

The most recent event generated 1.9 m of right-lateral displacement on one of two main fault strands. If this displacement represented average slip in the most recent surface rupture, the regressions of Wells and Coppersmith (1994) suggest a moment magnitude of M_w 7.15. We used the corresponding seismic M_o of 60*10^25 dyne-cm in the construction of figure DR-2. We assumed the same magnitude for the penultimate surface rupture. We note that the M_w 7.15 we use is consistent with estimates of rupture of the entire Whittier fault (e. g., M_w 7.1; Dolan et al., 1995).

Cucamonga fault -- The Cucamonga fault, which forms the easternmost 20 km of the Sierra Madre-Cucamonga fault system, is well expressed on Day Canyon fan in Rancho Cucamonga, where it exhibits two main active strands (strands B and C of Morton and Matti, 1987), as well as a less well-expressed southern strand (Etiwanda Ave. scarp). Dolan et al. (1996) excavated a 35-m-long, 9-m-deep trench across the prominent strand C scarp. Their trench revealed two colluvial wedges along the main, 25-30°N-dipping fault zone. Each of the two main colluvial wedges resulted from ~3 m of thrust motion, placing an upper bound on the maximum displacement along the main strand C fault zone during the past few earthquakes. However, geometric relationships in the younger colluvial wedge require that it developed during a minimum of two, and probably three paleoearthquakes. The most recent event appears to have caused ~80 cm of reverse slip on strand C. Radiocarbon dating of three bulk-soil samples recovered from the two colluvial wedges yielded overlapping, calibrated calendric dates of BC 5235-4855, BC 5425-5065 (both from the younger colluvial wedge) and BC 5220-4715 (from the deeper colluvial wedge) (J. Dolan, unpubl. data). These dates provide maximum ages for the paleo-earthquakes, and indicate that the three (or four) surface ruptures recorded by these colluvial wedges occurred within the past 7,200 years. Thus, all of these earthquakes are apparently younger than the most recent surface rupture (≥8 ka; Tucker and Dolan, 2001) on the adjacent part of Sierra Madre fault. These data suggest that the Cucamonga fault commonly ruptures independently of the Sierra Madre fault. Rupture of the Cucamonga fault, by itself, would generate a M_w ~6.9 earthquake (Dolan et al., 1995). Unfortunately, unlike all of the other paleoseismologic data discussed in this data repository, the age ranges of individual Cucamonga fault surface ruptures are not available. We know only that the most recent three or four surface ruptures occurred since 7.2 ka. We have therefore not included the Cucamonga fault data in the compilation of seismic-moment release shown in figure 2 of the main text; these data are included here, however, for the sake of completeness.

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Figure Captions

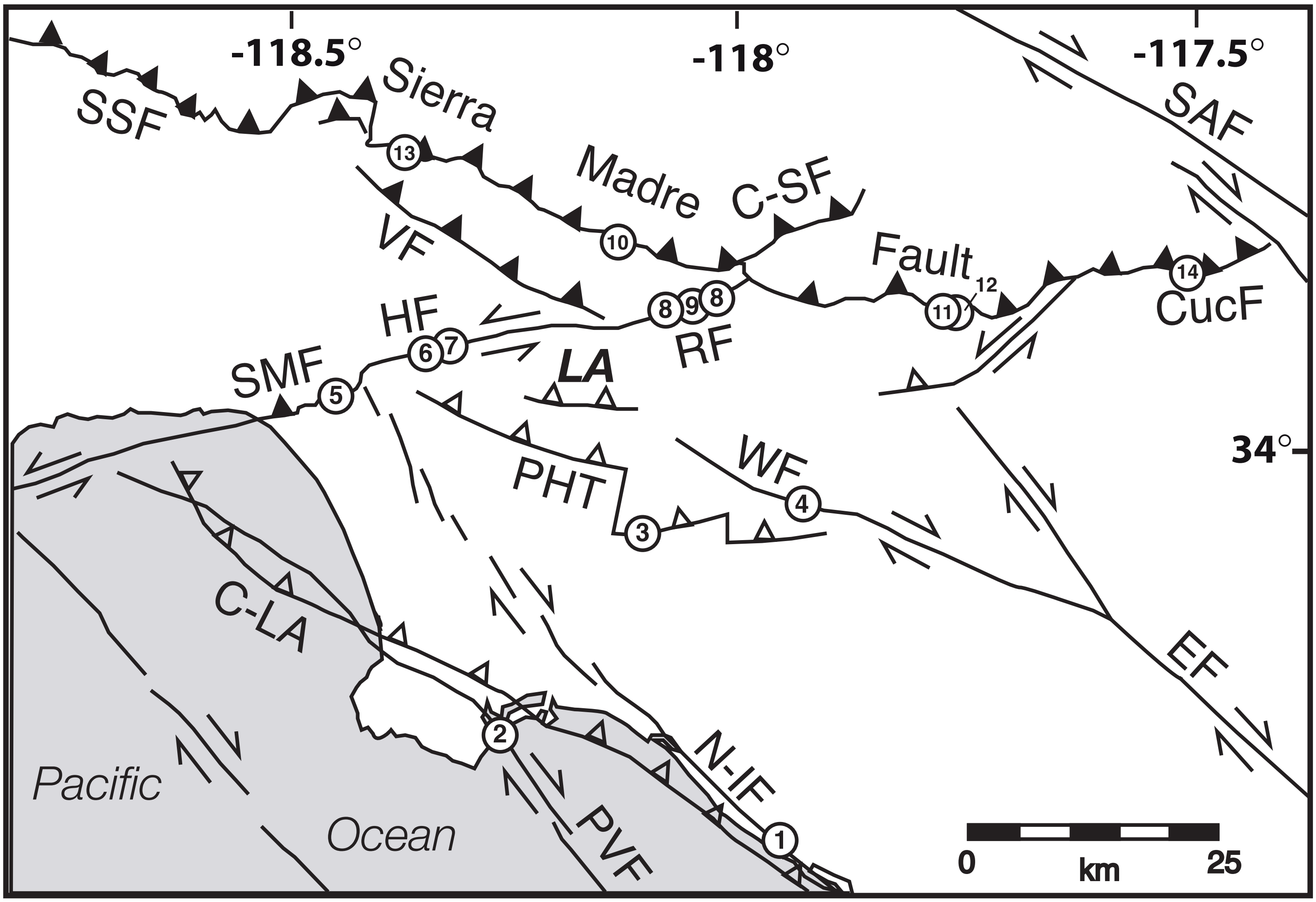
Figure DR-1 Map of greater Los Angeles region showing major active faults (modified from Dolan et al., 1997). Strike-slip faults denoted by opposing arrows. Teeth point downdip on reverse faults; solid teeth denote faults that reach the surface, open teeth show upper tip line of blind thrust ramps. Open circles with numbers show locations of paleoseismologic sites used in compilation shown in figures DR-2 and DR-3 (numbers correspond to references, as listed below). CucF is Cucamonga fault; C-LA is Compton-Los Alamitos blind thrust fault; C-SF is Clamshell-Sawpit fault; EF is Elsinore fault; HF is Hollywood fault; N-IF is Newport-Inglewood fault; PHT is Puente Hills blind thrust fault; PVF is Palos Verdes fault; RF is Raymond fault; SAF is San Andreas fault; SMF is Santa Monica fault; SSF is Santa Susana fault; VF is Verdugo fault; WF is Whittier fault; LA is downtown Los Angeles. References for numbered paleoseismologic sites: (1) Grant et al. (1997); (2) MacNeilan et al. (1996); (3) Dolan et al. (2003); (4) Patterson and Rockwell (1993); Gath et al., 1992; T. K. Rockwell, Pers. Comm. (2006); E. Gath, Pers. Comm. (2006); (5) Dolan et al. (2000a); (6) Dolan et al. (1997; 2000b); (7) Lindvall et al. (2001); (8) Weaver and Dolan (2000); (9) Crook et al., (1987); (10) Rubin et al. (1998); (11) Tucker and Dolan (2001); (12) J. Dolan, Unpubl. Data; (13) Fumal et al. (1995); T. Fumal, Pers. Comm. (2005); (14) Dolan et al. (1996); J. Dolan, Unpubl. Data.

Figure DR-2 Distribution of available paleoseismologic age data for Los Angeles-region faults used in creating figures DR-3 to DR-5. See data repository text above for detailed references to studies from which these data are taken. Horizontal columns denote different faults or sections of large faults for which paleoseismological data are available. Thin, vertical black lines show paleoseismologically determined age ranges for each event (dashed where less certain). Vertical groups of small triangles denote age ranges of probable paleoearthquakes (see repository text for discussion). Thick black rectangles extending downward from top of figure show durations of elapsed time since most recent earthquake on different faults based on paleoseismological and historical data. Wide vertical gray bars show periods for which data are not currently available. Wide vertical bars with diangonal hatching show approximate age ranges of of geomorphically defined periods of fault quiescence. Small black circles at top of image denote occurrnce of several moderate-magnitude earthquakes, with date of occurrence and moment-magnitude (Mw). SMF is Santa Monica fault. HF is Hollywood fault. RF is Raymond fault (collectively, these faults constitute the Santa Monica-Hollywood-Rymond fault system discussed in text). WF is Whittier fault. N-IF is Newport-Inglewood fault. PVF is Palos Verdes fault. PHT is Puente Hills blind thrust fault. CucF is Cucamonga fault. “East”, Cent”, and “West” refer to data from the eastern, central, and western parts of the Sierra Madre fault, respectively.

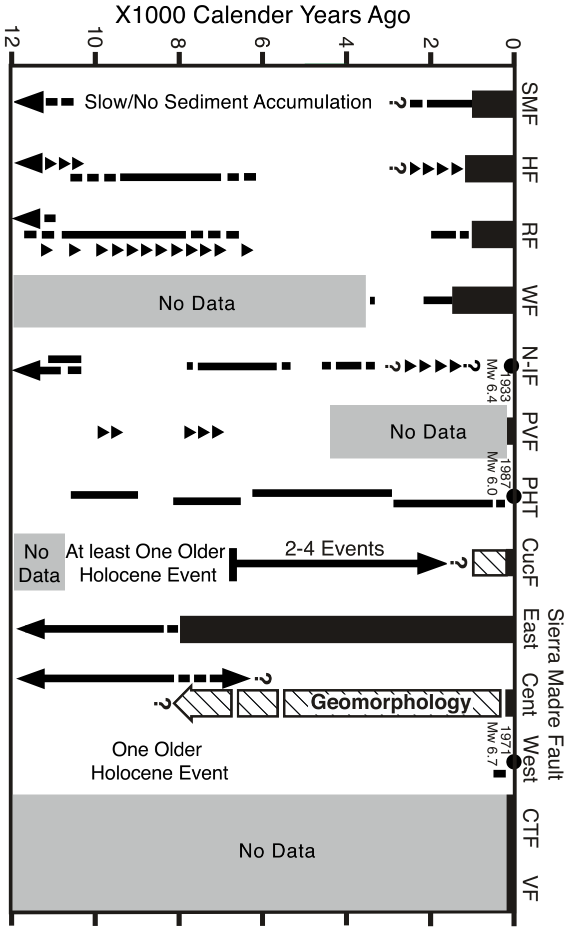
Figure DR-3 Compilation of data from the Los Angeles-region fault network showing ages and estimated seismic moment (M_o) release in individual paleoearthquakes (Crook et al., 1987; Patterson and Rockwell, 1993; Fumal et al., 1995; Dolan et al., 1996; 1997; 2000a; 2000b; 2003; McNeilan et al., 1996; Grant et al., 1997; Rubin et al., 1998; Weaver and Dolan, 2000; Lindvall et al., 2001; Tucker and Dolan, 2001) (following methodology of Rockwell et al [2000]). Vertical axis shows probability of M_o release per year; horizontal axis shows paleoseismologically defined age ranges for individual earthquakes.

Figure DR-4 Same data as in Fig. DR-2, except plotted using simple, rectangular “boxcar” age-moment distributions, rather than the Gaussian distributions shown in Fig. DR-2. Whereas the Gaussian distribution function used in Fig. DR-2 will emphasize the center of the allowable age range for each event, the “boxcar” distribution function shown in Fig. DR-3 assigns an equal probability to all ages within the allowable age ranges for each earthquake. Note that all major peaks and troughs in moment release are discernible on both figures, demonstrating that both methods yield similar results. Thus, the clusters are not an artifact of the use of Gaussian probability distribution functions in the methodology of Rockwell et al. (2000).

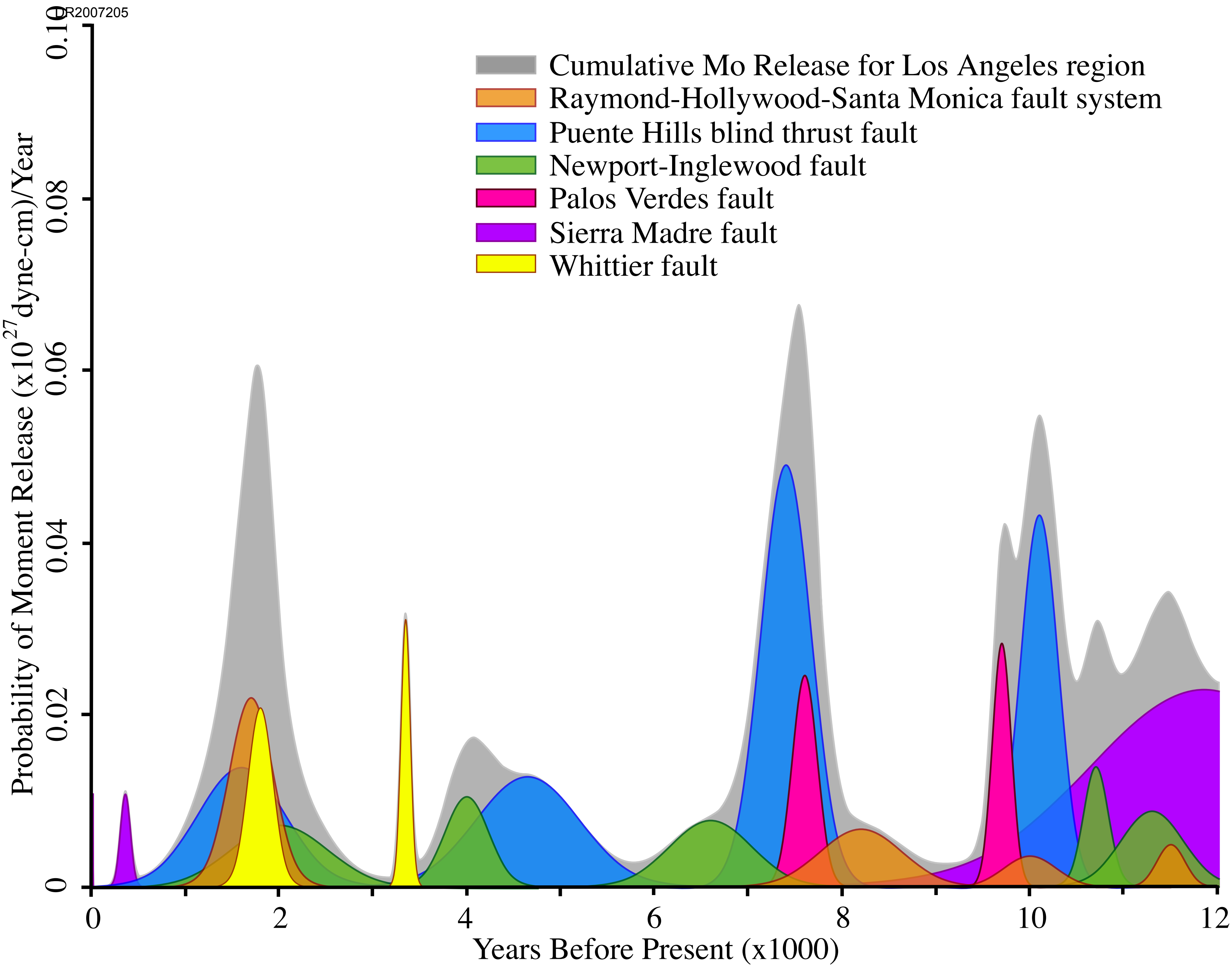
Figure DR-5 Comparison of cumulative seismic moment release through time for fault networks in the Los Angeles region (pink) and the Mojave Desert part of the eastern California shear zone (blue), plotted using simple, rectangular "boxcar" age-moment distributions, rather than the Gaussian distributions shown in Fig. 2 of the main text. As in our similar comparison between Figs. DR-2 and DR-3, note that all of the major features discernible on the 'Gaussian' version of this figure (shown in the main text as Fig. 2), especially the alternation of moment release in the two fault networks, are also discernible on this version of the figure. As in Fig. 2 of the main text, the vertical axis shows probability of M_o release per year, whereas the horizontal axis shows paleoseismologically defined age ranges of cumulative M_o release for faults in each regional network. Yellow horizontal bars denote paleoseismologically defined ages of Garlock fault surface ruptures (Dawson et al., 2003).


-118.5°
-118°
-117.5°
34°
Sierra
Madre
Fault
SSF
SAF
C-SF
VF
HF
RF
LA
CucF
SMF
WF
PHT
C-LA
EF
N-IF
PVF
Pacific
Ocean
0
km
25
1
2
3
4
5
6
7
8
9
10
11
12
13
14

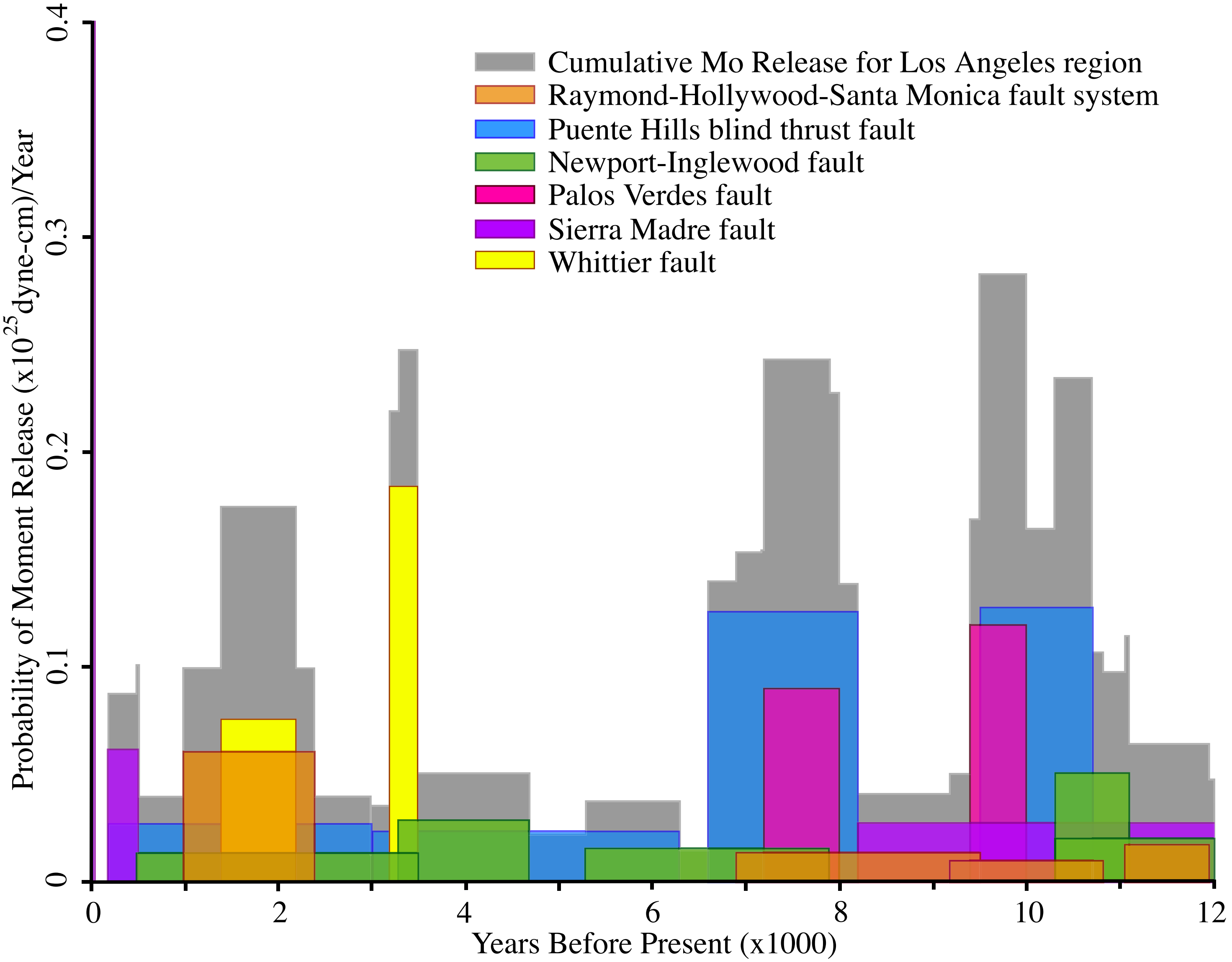
DR2007205



X1000 Calender Years Ago
12
10
8
6
4
2
0
Slow/No Sediment Accumulation
SMF
HF
RF
No Data
WF
N-IF
1933 Mw 6.4
No Data
PVF
1987 Mw 6.0
PHT
No Data
At least One Older Holocene Event
2-4 Events
CucF
East
Geomorphology
Cent
One Older Holocene Event
1971 Mw 6.7
West
Sierra Madre Fault
No Data
CTF
VF

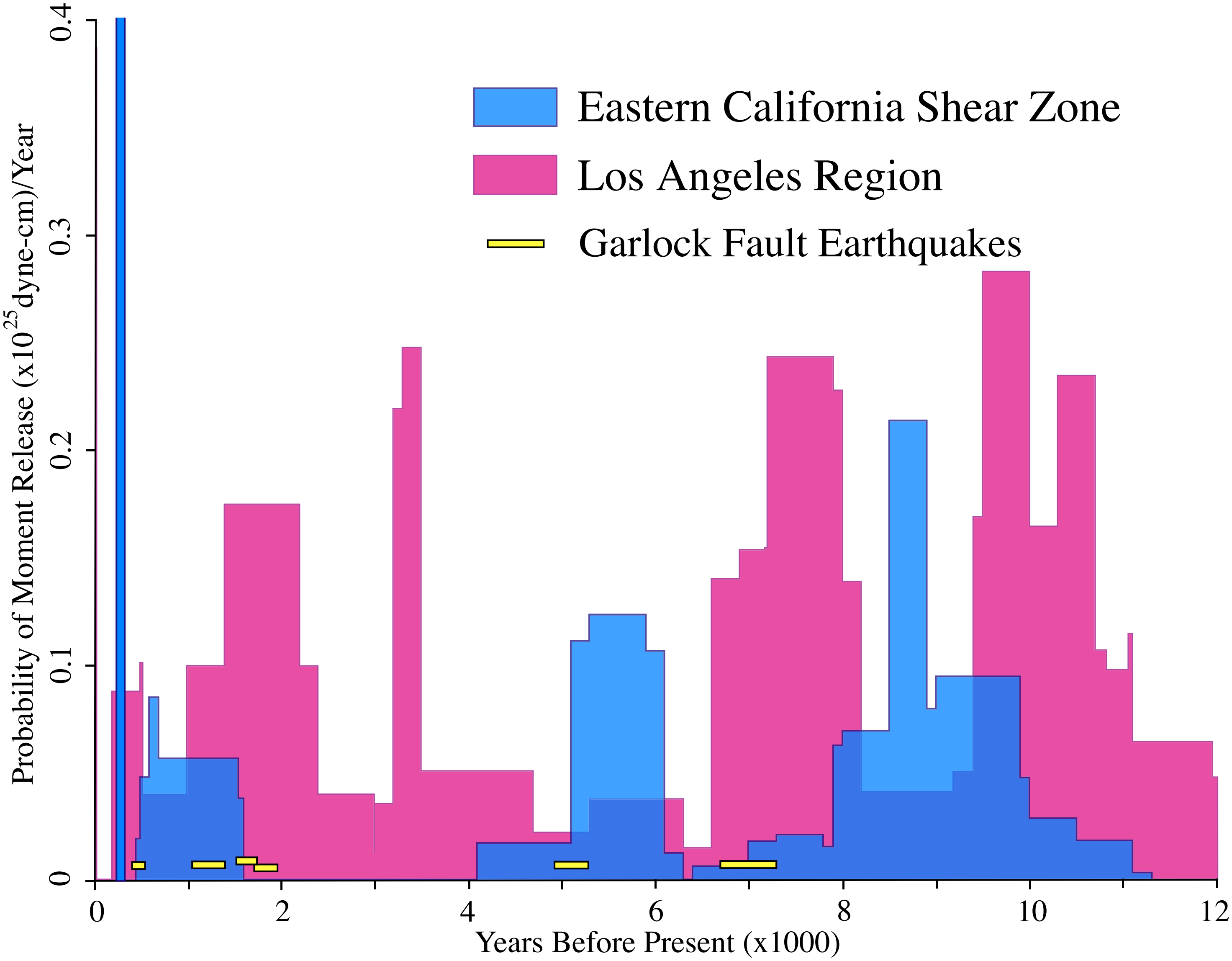

DR2007205
Cumulative Mo Release for Los Angeles region
Raymond-Hollywood-Santa Monica fault system
Puente Hills blind thrust fault
Newport-Inglewood fault
Palos Verdes fault
Sierra Madre fault
Whittier fault
Probability of Moment Release (x10^27 dyne-cm)/Year
0
0.02
0.04
0.06
0.08
0.10
0
2
4
6
8
10
12
Years Before Present (x1000)

DR2007205



Cumulative Mo Release for Los Angeles region
Raymond-Hollywood-Santa Monica fault system
Puente Hills blind thrust fault
Newport-Inglewood fault
Palos Verdes fault
Sierra Madre fault
Whittier fault
Probability of Moment Release (x10^25 dyne-cm)/Year
0
0.1
0.2
0.3
0.4
0
2
4
6
8
10
12
Years Before Present (x1000)

DR2007205



Eastern California Shear Zone
Los Angeles Region
Garlock Fault Earthquakes
Probability of Moment Release (x10^25 dyne-cm)/Year
0
0.1
0.2
0.3
0.4
0
2
4
6
8
10
12
Years Before Present (x1000)