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Quasi-periodic recurrence of large earthquakes on the southern San Andreas fault

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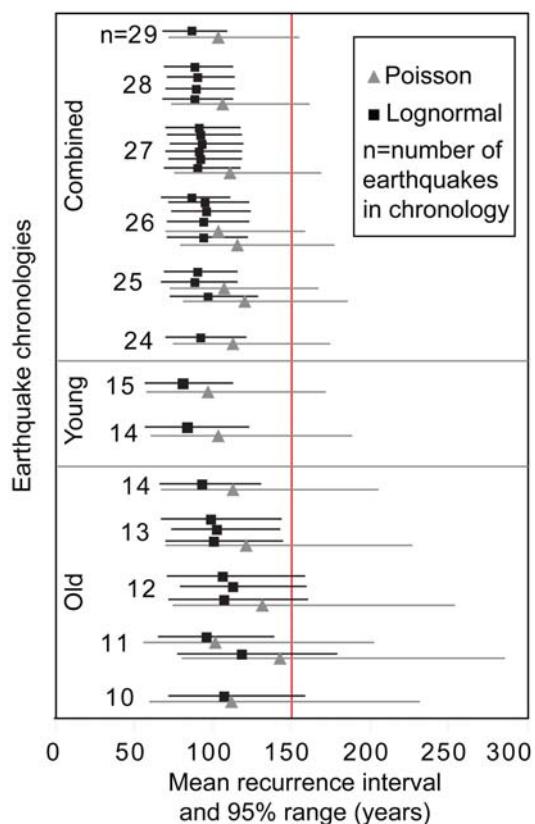


Figure DR1. Comparison of recurrence intervals for Poisson and lognormal models of various Wrightwood chronologies. When $n \geq 24$, changes in the exact membership of the chronology do not cause significant variation in the parameter estimates. Only one Poisson result per set is shown because the calculation depends simply on the total series length and number of events. The current 153-year open interval, indicated by the vertical red line, is longer than the average for any of the series. Table DR1 provides the series membership, values and ranges for all permutations.

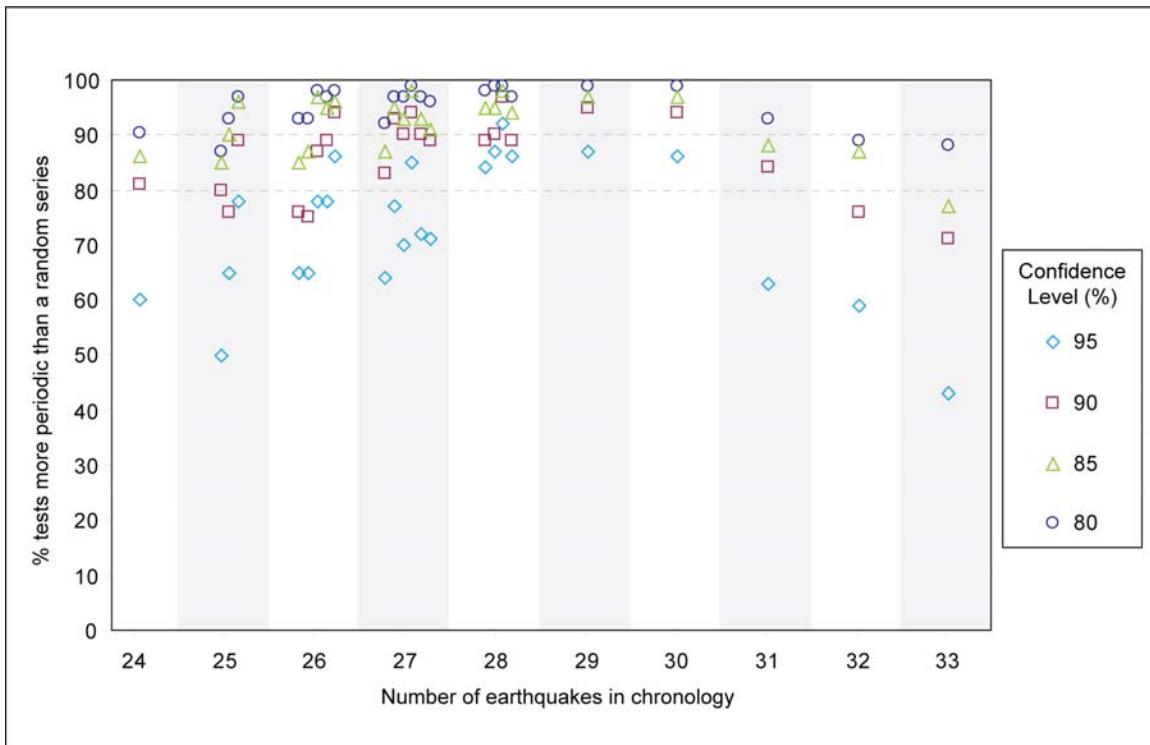


Figure DR2. Evaluation of KS test for periodicity at various confidence levels. At the 80% confidence level, most (87 to 99%) of the Monte-Carlo picks through the series are more periodic than expected from a Poisson distribution, regardless of the membership of the chronology. For comparison, at the 95% confidence level inclusion or exclusion of particular earthquakes can make a difference. For especially important earthquake series, the sensitivity of the result to an individual event might justify further site investigation. While a test level of 80% may seem less stringent than typically used in statistical tests, we note that if earthquake recurrence were random, 20% of the tests would have failed at the 80% confidence level, not 87 to 95% as found. We note also that series drawn from the 29 event master chronology, which reflects the best estimate combined event series, fail the KS test at the highest confidence levels. Further, the strength of the test is improved because the number of samples is large – hundreds of Monte-Carlo picks from the earthquake PDFs in each chronology – and thus finding a few results which do not fail is expected. Considering the range of results, we choose the 80% confidence level to evaluate all of the series because this is the highest confidence level that produces consistent results across the range of real and hypothetical chronologies.

References

- Biasi, G.P., Weldon, R.J., Fumal, T.E., and Seitz, G.G., 2002, Paleoseismic event dating and the conditional probability of large earthquakes on the southern San Andreas fault, California: Bulletin of the Seismological Society of America, v. 92, p. 2761-2781.

Cramer, C.H., Petersen, M.D., Cao, T., Toppozada, T.R., and Reichle, M., 2000, A time-dependent probabilistic seismic-hazard model for California: Bulletin of the Seismological Society of America, v. 90, p. 1-21.

Table DR1. Earthquake chronologies and calculated recurrence parameters for 36 permutations of Wrightwood paleoseismic catalogue¹

Chronology	n ³	Length (years) ⁴	Separation ⁵	Poisson			Lognormal					
				Mean (years)	95% Range	Mean (years)	95% Range	Sigma-InT ⁶	95% Range			
Master Chronology (All Wrightwood + PCT)	29	2990	105	103	72	154	86	68	109	0.61	0.49	0.84
PCT removed	28	2990	105	106	74	161	88	69	112	0.65	0.51	0.88
W520 removed	28	2990	105	106	74	161	89	70	113	0.63	0.49	0.86
W390 removed	28	2990	105	106	74	161	90	71	113	0.61	0.48	0.83
W380 removed	28	2990	105	106	74	161	88	69	112	0.63	0.50	0.87
PCT, W380 removed	27	2995	110	110	76	168	90	69	117	0.67	0.53	0.92
PCT, W390 removed	27	2995	110	110	76	168	92	72	118	0.64	0.50	0.88
PCT, W520 removed	27	2995	110	110	76	168	91	70	118	0.66	0.52	0.91
W520, W390 removed	27	2995	110	110	76	168	93	73	119	0.62	0.49	0.86
W520, W380 removed	27	2995	110	110	76	168	91	71	117	0.65	0.51	0.89
W390, W380 removed	27	2995	110	110	76	168	91	70	117	0.65	0.51	0.90
PCT, W380, W390 removed	26	3000	115	115	79	177	93	71	122	0.68	0.53	0.94
PCT, W380, W520 removed	26	3000	115	115	79	177	93	71	122	0.68	0.53	0.94
PCT, W390, W520 removed	26	3000	115	115	79	177	95	73	123	0.65	0.51	0.91
W380, W390, W520 removed	26	3000	115	115	79	177	94	72	122	0.66	0.51	0.92
PCT, W520, W390, W380 removed	25	2990	120	120	81	185	96	73	128	0.70	0.54	0.98
W350, W380, W390 removed	26	2685	105	103	70	158	86	68	110	0.61	0.48	0.85
W350, W380, W390, PCT removed	25	2685	105	107	73	166	88	68	115	0.65	0.51	0.91
W350, W380, W390, W520 removed	25	2685	105	107	73	166	89	69	115	0.62	0.48	0.87
W350, W380, W390, PCT and W520 removed	24	2685	110	112	75	174	92	70	121	0.66	0.51	0.93
<i>Extra Earthquake added between:²</i>												
W402-W410 (2555 BC)	30	2990	105	100	70	148	82	65	104	0.63	0.50	0.85
W350-W380 (2795 BC)	31	2990	105	96	68	142	78	61	99	0.67	0.53	0.90
W460-W520 (2275 BC)	32	2990	105	93	66	137	75	59	95	0.68	0.54	0.91
W8-W9 (AD 2990)	33	2990	105	91	65	132	72	57	92	0.68	0.54	0.90
WW Old Section	14	1567	n/a	112	67	205	93	67	130	0.61	0.44	1.00
W520 removed	13	1567	n/a	121	70	226	100	70	144	0.62	0.44	1.06
W390 removed	13	1567	n/a	121	70	226	102	74	142	0.57	0.41	0.97
W380 removed	13	1567	n/a	121	70	226	98	67	143	0.66	0.46	1.11
W520, W380 removed	12	1567	n/a	131	75	253	107	72	159	0.66	0.46	1.16
W520, W390 removed	12	1567	n/a	131	75	253	112	79	159	0.58	0.41	1.02
W390, W380 removed	12	1567	n/a	131	75	253	106	71	158	0.67	0.47	1.17
W520, W390, W380 removed	11	1567	n/a	142	80	285	118	78	179	0.66	0.46	1.21
W350, W380, W390 removed	11	1107	n/a	101	56	202	95	66	139	0.59	0.41	1.09
W350, W380, W390, W520 removed	10	1107	n/a	111	60	231	106	72	158	0.60	0.41	1.15
WW Young section ¹	15	1473	n/a	96	58	171	80	57	113	0.63	0.46	1.02
PCT removed	14	1473	n/a	103	61	188	83	57	122	0.70	0.50	1.15

1 Methodology and equations in Biasi et al., (2002)

2 Extra earthquakes use PDF form of W410, mean age indicated in parenthesis.

3 n = number of earthquakes in series.

4 Length of series; all chronologies include 150-year open interval.

5 Number of years linking old and young chronologies, equal to average interval of each series.

6 Standard deviation of the median interval.

Table DR2. Earthquake chronologies, KS test results, and conditional probabilities for 36 permutations of Wrightwood paleoseismic catalogue¹

Chronology	n ³	Length (years) ⁴	Separation ⁵	KS Tests ⁶		Lognormal COV ⁷	Poisson 30-year CP			Lognormal 30-year CP		
				Regularity	Cluster		Mean (%)	95% Range	Mean (%)	95% Range	Mean (%)	95% Range
Master Chronology (All Wrightwood + PCT)	29	2990	105	99	0	0.68	21	15 27	39	24 51		
PCT removed	28	2990	105	98	0	0.72	20	14 26	33	21 44		
W520 removed	28	2990	105	99	0	0.69	20	14 26	36	21 53		
W390 removed	28	2990	105	97	0	0.67	20	14 26	38	23 49		
W380 removed	28	2990	105	97	0	0.70	20	14 26	36	23 49		
PCT, W380 removed	27	2995	110	92	0	0.75	20	14 26	32	20 44		
PCT, W390 removed	27	2995	110	97.5	0	0.71	20	14 26	35	20 48		
PCT, W520 removed	27	2995	110	96.5	0	0.74	20	14 26	34	20 46		
W520, W390 removed	27	2995	110	98.5	0	0.69	20	14 26	35	21 47		
W520, W380 removed	27	2995	110	97.5	0	0.72	20	14 26	34	21 47		
W390, W380 removed	27	2995	110	96.5	0	0.72	20	14 26	34	21 47		
PCT, W380, W390 removed	26	3000	115	93	0	0.76	19	14 26	32	18 43		
PCT, W380, W520 removed	26	3000	115	89.5	0	0.77	19	14 26	35	18 43		
PCT, W390, W520 removed	26	3000	115	98	0	0.73	19	14 26	33	18 46		
W380, W390, W520 removed	26	3000	115	96	7	0.74	19	14 26	33	20 45		
PCT, W520, W390, W380 removed	25	2990	120	87	0	0.79	20	14 26	31	17 43		
W350, W380, W390 removed	26	2685	105	98	0	0.68	19	14 26	37	22 50		
W350, W380, W390, PCT removed	25	2685	105	95	0	0.73	21	14 27	36	21 52		
W350, W380, W390, W520 removed	25	2685	105	96.5	0	0.69	21	14 27	34	19 49		
W350, W380, W390, PCT and W520 removed	24	2685	110	90.5	0	0.74	19	14 26	35	19 46		
<i>Extra Earthquake added between:²</i>												
W402-W410 (2555 BC)	30	2990	105	99	0	0.70	22	16 27	38	23 53		
W350-W380 (2795 BC)	31	2990	105	91	0	0.75	22	17 28	36	23 47		
W460-W520 (2275 BC)	32	2990	105	89	0	0.77	23	17 28	35	23 47		
W8-W9 (AD 2990)	33	2990	105	88	0	0.76	23	18 29	37	25 47		
WW Old Section	14	1567	n/a	82	0	0.67	19	12 28	37	15 57		
W520 removed	13	1567	n/a	85	1	0.69	18	11 27	34	13 57		
W390 removed	13	1567	n/a	91	3	0.62	18	11 27	36	14 57		
W380 removed	13	1567	n/a	70.5	5	0.73	18	11 27	31	12 51		
W520, W380 removed	12	1567	n/a	75	0	0.74	17	9.4 26	31	11 51		
W520, W390 removed	12	1567	n/a	95	2	0.63	17	9.4 26	34	10 63		
W390, W380 removed	12	1567	n/a	75.5	30	0.75	17	9.4 26	30	10 55		
W520, W390, W380 removed	11	1567	n/a	68.5	31	0.75	16	8.3 25	28	9 45		
W350, W380, W390 removed	11	1107	n/a	79.5	8	0.65	21	11 30	36	12 60		
W350, W380, W390, W520 removed	10	1107	n/a	78	2	0.66	19	9.9 29	34	10 61		
WW Young section ¹	15	1473	n/a	80	2	0.70	21	13 30	38	20 54		
PCT removed	14	1473	n/a	60	10	0.79	20	12 29	34	16 50		

1 Methodology and equations in Biasi et al., (2002)

2 Extra earthquakes use PDF form of W410, mean age indicated in parenthesis.

3 n = number of earthquakes in series.

4 Length of series; all chronologies include 150-year open interval.

5 Number of years linking old and young chronologies, equal to average interval of each series

6 Percentage of test runs that fail (i.e. are not Poisson) at 80% confidence limit.

7 Lognormal Coefficient of Variation=SquareRoot[(exp(sigma_n)^2)-1], Cramer et al. (2000)