

# **CALIFORNIAN EARTHQUAKE CYCLES**

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**Abstract.** This paper presented the 20, 56 and 60 year cycles in the timing of major Californian earthquakes over that past 200 years. Record state earthquakes for the southern half of the USA clustered in a 9/56 year grid, based on double 56 year sequences. This effect could also be established for the San Andreas and the North Anatolian Faults. Interestingly, US and Western European financial panics exhibited a similar double sequence effect for the 1760 to 1940 era. Such phenomena are hypothesised to arise from weak lunisolar tidal harmonics activating critical events in seismology and finance. The great unknown was how this process actually functioned. If a large quake is going to occur in south western North America then in the year commencing April 2018 would be the most likely timing.

**Keywords.** 9/56 year, cycle, earthquakes, record, US states, double sequence, California.

### Introduction

A 9/56 year cycle was first established in the timing of major US and Western European financial crises since 1760 (McMinn, 1986, 1993). This cycle was then extrapolated to earthquakes in various regions and countries around the world. McMinn ([2011a](#), [2011b](#)) noted that earthquakes in south western North America clustered within the 9/56 year grid. This paper expanded upon these findings to present the 20 year, 56 year and 60 year cycles in Californian earthquake activity. Record state earthquakes in south western North America also occurred preferentially in 9/56 year grids. These could be combined in a ‘double sequence’ pattern that was also applicable to the whole of southern USA from California to the Atlantic south east. This effect was also applicable to major earthquakes along the San Andreas and North Anatolian Faults. However, these examples were uncommon as most historic seismic catalogs failed to correlate with a grid based on double sequences.

The 9/56 year cycle consists of a grid with intervals of 56 years on the vertical (called sequences) and multiples of 9 years on the horizontal (called subcycles). The 56 year sequences have been numbered in accordance with McMinn (1993), with 1817, 1873, 1929, 1985 being designated as Sequence 01; 1818, 1874, 1930, 1986 as Sequence 02 and so forth. McMinn (Appendix 2, 2002) presented the full numbering. The year of best fit has been adopted in the accompanying tables and appendices.

The key catalog for major earthquakes ( $M \geq 6.9$ ) in California – Nevada – Baja California was based on Ellsworth (1990) (see **Appendix 1**) and this was the basis for much of the analysis. The main reference source for the record earthquakes for US states was the [US Geological Survey](#). Some states were given two record quakes and both were included in the appraisal. Data on Arizona earthquakes was referenced from the [Arizona Earthquake Information Center](#).

## 20, 56 & 60 Year Cycles

The year 1812 marked the beginning of two key 56 and 60 year cycles in Californian seismic history (see **Table 1**). The 56 year cycle corresponded to Sequence 52 in the 9/56 year grid.

<b>Table 1</b>		
<b>CALIFORNIAN EARTHQUAKES - 56 YEAR CYCLE</b>		
<b>8.5 months commencing October 15 M ≥ 6.8</b>		
<b>Date</b>	<b>M</b>	<b>Event</b>
Dec 08, 1812	7.0	Wrightwood
Dec 21, 1812	7.0	Santa Barbara Channel
Oct 21, 1868	6.9	Hayward Fault
Jun 29, 1925	6.8	Santa Barbara
Nov 08, 1980	7.2	West of Eureka
<b>CALIFORNIAN EARTHQUAKES - 60 YEAR CYCLE</b>		
<b>9 months ending December 21 M ≥ 6.9</b>		
Dec 08, 1812	7.0	Wrightwood
Dec 21, 1812	7.0	Santa Barbara Channel
Mar 26, 1872	7.6	Owens Valley
Dec 21, 1932	7.3	Cedar Mountain NV
Apr 25, 1992	6.9	Cape Mendocino
Jun 28, 1992	7.2	Landers

Sequence 52 was also very important in a world context, because it experienced many records in the Americas and Western Europe (see **Appendix 3**).

The 60 year cycle in **Table 1** can be broken down into a 20 year series (see **Table 2**). This was not consistent as there were no major events in 1832, 1852, 1912 and 1972 ( $M \geq 7.0$ ). The 11 years in the cycle represented 5% of the 215 years to 2015, yet they contained 29% of the seismic events ( $M \geq 6.9$ ) listed in **Appendix 1** for California – Nevada – Baja California.

<b>Table 2</b>				
<b>20 YEAR SEISMIC CYCLE IN SOUTH WESTERN NORTH AMERICA</b>				
<b>Calendar Years</b>				
<b>Year</b>	<b>Mth</b>	<b>Day</b>	<b>M</b>	<b>Location</b>
1812	12	08	7.0	Wrightwood, CA.
1812	12	21	7.0	Santa Barbara Channel, CA.
1832	-	-	-	No quakes $M \geq 6.5$ .
1852	11	29	6.5?	Volcano Lake, MX (a).
1872	03	26	7.6	Owens Valley (b). 3rd rank quake for Sn CA.
1892	02	24	7.0	Laguna Salada, Equal 4th rank quake for BC.
1892	04	19	6.6	Vacaville, Nn CA.
1912	07	11	6.2	Lockett Tanks. Equal 1st rank quake for AZ.

1932	12	21	7.2	Cedar Mountain. 2nd rank record for NV.
1932	07	07	6.8	La Libertad, BC.
1952	07	26	7.7	Kern County. 2nd rank record for Sn CA.
1972	-	-	-	No quakes $M \geq 6.5$ .
1992	04	25	7.2	Petrolia (b). Equal 3rd rank for Nn CA.
1992	06	28	7.3	Landers. Equal 4th rank for Sn CA.
2012	04	12	7.0	San Luis. Equal 4th rank for BC.
(a) This event occurred near the CA - AZ - MX border, with the presumed epicenter being sited at Volcano Lake, MX.				
(b) Two aftershocks ( $M \geq 6.6 \leq 6.9$ ) occurred in the weeks after each of these events.				
<b>Abbreviations:</b> Sn CA – Southern California, Nn CA – Northern California, NV – Nevada, BC – Baja California, AZ – Arizona and MX - Mexico.				

### South Western North America - Record State Earthquakes

Major Californian earthquakes ( $M \geq 6.9$ ) clustered selectively within the 9/56 year grid, as presented in **Appendix 2** (McMinn, [2011a](#)). Numerous record earthquakes for various states in south western North America appeared in the same layout (see **Table 3**), even though it comprised a mere 9% of the complete 9/56 year grid.

<b>Table 3</b> <b>9/56 YEAR CYCLE: RECORD STATE EARTHQUAKES IN</b> <b>SOUTH WESTERN NORTH AMERICA 1800–2015</b> <b>Year beginning April 15</b>								
Sq 25		Sq 34		Sq 43		Sq 52		Sq 05
				1803	+9	1812	+9	1821
1841	+9	1850	+9	1859	+9	<b>1868</b> Apr02	+9	1877
1897	+9	<b>1906</b> Apr18 <b>1906</b> Jul16 <b>1906</b> Nov15	+9	<b>1915</b> Oct03	+9	1924	+9	1933 <b>1934</b> Mar12
1953	+9	1962	+9	1971	+9	1980	+9	1989
2009 <b>2010</b> Apr04	+9	2018						
<b>Record State Earthquakes</b> Sq 05 – Record for Utah (M 6.6. Mar 12, 1934). Sq 25 - Record for Baja California (Mexicali. M 7.2. Apr 4, 2010). Sq 34 - Record for Northern California (San Francisco. M 8.25. Apr 18, 1906). Sq 34 - Record quakes for New Mexico happened on July 16 and November 15 in 1906 (both M 5.8). Sq 43 - Record for Nevada (Pleasant Valley. M 7.3. Oct 3, 1915).								

<b>Other Events of Interest</b>
Sq 43 - 2nd rank quake for Baja California (Volcano Lake. M 7.1. Nov 21, 1915). Sq 52 - Record US volcanic eruption (ex-Alaska) (Mt St Helens, May 18, 1980).
<b>Main Source of Raw Data:</b> US Geological Survey.
<b>Source:</b> McMinn (2011a, 2011b).

State records pre 1920 in south western North America clustered in another 9/56 year grid (see **Table 4**), which comprised 20% of the complete 9/56 year cycle. There was overlap between **Tables 3 & 4** as some April episodes appeared in both patterns.

<b>Table 4</b>									
<b>9/56 YEAR CYCLE: ADDITIONAL RECORD QUAKES IN</b>									
<b>SOUTH WESTERN NORTH AMERICA</b>									
<b>Year ending April 31</b>									
Sq 16	Sq 25	Sq 34	Sq 43	Sq 52	Sq 05	Sq 14	Sq 23	Sq 32	Sq 41
									1857 Jan09
			1859	1868 Apr02	1877	1886	1895	1904	1913 1912 Aug18
1888 1887 May03	1897	1906 Jan25 1906 Apr18	1915	1924	1933	1942	1951	1960	1969
1944	1953	1962	1971	1980	1989	1998	2007	2016	
2000	2009	2018							
<b>Record State Earthquakes</b>									
Sq 16 – Record for the Mexican state of Sonora (Bavispe. M 7.5. May 3, 1887), located to the south of Arizona.									
Sq 34 – Record for Northern California (San Francisco. M 8.25. Apr 18, 1906).									
Sq 34 – Equal 1st rank for Arizona (Flagstaff. M 6.2. Jan 25, 1906).									
Sq 41 – Record for Southern California (Fort Tejon. M 8.25. Jan 9, 1857).									
Sq 41 - Equal 1st rank quake for Arizona (Lockett Tanks. M 6.2. Aug 18, 1912).									
Sq 52 - Record for Hawaii (M 7.9. Apr 2, 1868).									
Sq 52 - Record for western USA (ex-Alaska) (Great Cascadia quake. M 9.0. Jan 26, 1700).									
<b>Other Earthquakes of Interest</b>									
Sq 05 – 2nd rank for Nevada (Cedar Mountain. M 7.2. Dec 21, 1932).									
Sq 25 – 2nd rank for Southern California (Kern County. M 7.7. Jul 26, 1952).									
Sq 32 – 4th rank for Arizona (Freedonia. M 5.5. Jul 21. 1959).									
Sq 50 - Equal 2nd rank quake for Northern California (Eureka. M 7.3. Jan 31, 1922).									
<b>Main Sources of Raw Data:</b> US Geological Survey, <a href="#">Arizona Earthquake Information Center</a> .									

A 9/56 year clustering was also observed for the biggest earthquakes in Baja California and Sonora, located in the north west of Mexico (see **Table 5**).

<b>Table 5</b> <b>9/56 YEAR CYCLE: RECORD QUAKES IN</b> <b>BAJA CALIFORNIA &amp; SONORA</b> <b>Year beginning August 1</b>					
<b>Sq</b> <b>25</b>	<b>Sq</b> <b>34</b>	<b>Sq</b> <b>43</b>	<b>Sq</b> <b>52</b>	<b>Sq</b> <b>05</b>	<b>Sq</b> <b>14</b>
					1886 <b>1887</b> May03
1897	1906	<b>1915</b> Nov21	1924	1933	1942
1953 <b>1954</b> Apr29	1962	1971	1980	1989	1998
<b>2009</b> Aug03 <b>2010</b> Apr04	2018				
<p align="center"><b>Record State Earthquakes</b></p> <p align="center">Sq 14 – Record for Sonora (Bavispe. M 7.5. May 3, 1887).  Sq 25 – 2nd rank quake for Sonora (M 6.9. Aug 3, 2009).  Sq 25 – Equal 1st rank quake for BC (M 7.2. Apr 29, 1954).  Sq 25 – Equal 1st rank quake for BC (Mexicali. M 7.2. Apr 4, 2010).  Sq 43 – 4th rank quake for BC (Volcano Lake. M 7.1. Nov 21, 1915).</p> <p align="center">NB: Ellsworth (1990) failed to list the 1954 Gulf of Mexico quake (M 7.2).  Ellsworth (1990) gave the magnitude of the 1892 Laguna Salada quake as M 7.0.  Other sources have given this figure as M 7.2 (Hough &amp; Elliot, 2004), which would  make it an equal 1st rank quake for Baja California. The latter magnitude has been  used in the table.</p>					
<b>Source of Raw Data:</b> US Geological Survey.					

### **Southern USA – Record State Earthquakes**

Record seismic episodes for the southern USA (Texas – Oklahoma to the Atlantic south east) also fell preferentially in the 9/56 year grid given in **Table 6**. This table overlapped with the layout for south western North America in **Table 4**.

<b>Table 6</b> <b>9/56 YEAR CYCLE: RECORD STATE QUAKES IN SOUTHERN USA</b> <b>Year ending September 15</b>
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Sq 52	Sq 05	Sq 14	Sq 23	Sq 32	Sq 41	Sq 50	Sq 03
						1808	1817
1812 <b>1811</b> Dec16	1821	1830	1839	1849	1857	1866	1875
1868	1877	<b>1886</b> Sep01	1895	1904	1913	1922	<b>1931</b> Aug16 <b>1930</b> Oct19
1924	1933	1942	1951	1960	1969	1978	1987
<b>1980</b> Jul27	1989	1998	2007	<b>2016</b> Sep03			
<p><b>Record State Earthquakes</b></p> <p>Sq 03 – Record for Louisiana (M 4.2. Oct 19, 1930).  Sq 03 - Record for Texas (Valentine. M 5.9. Aug 16, 1931).  Sq 14 – Record for South Carolina (Charleston. M 7.1. Sep 1, 1886).  Sq 32 – Equal 1st rank quake for Oklahoma (M 5.6. Sep 3, 2016).  Sq 52 – Record for Arkansas (M 7.9. Dec 16, 1811).  Sq 52 – Record for Kentucky (M 5.0. Jul 27, 1980).</p> <p><b>Record Earthquake Anomalies</b></p> <p><b>Alabama</b> – M 5.1. Oct 18, 1916.  <b>Florida</b> – Intensity VI. Feb 6, 1780.  <b>Florida</b> – Intensity VI. Jan 13, 1879.  <b>Georgia</b> – Intensity V. Mar 5, 1914.  <b>North Carolina</b> – Intensity VII. Feb 21, 1916.  <b>Mississippi</b> - Intensity VI. Dec 17, 1931.  <b>Oklahoma</b> – Equal 1st rank quake. M 5.6. Nov 6, 2011.  <b>Tennessee</b> - M 5.0. Aug 17, 1865.</p>							

### California to Atlantic South East – Double Sequence Effect

**Tables 3 & 4** have been combined in the 9/56 year arrangement in **Appendix 4**, in which the ‘year of best fit’ was extended to two years beginning April 1. Most record quakes for the states between California and the Lower Mississippi River appeared within this grid, the only exceptions being Oklahoma (equal 1st rank) and Colorado.

Taking the entire southern half of the USA (California to Atlantic south east), there were five state records not falling in **Appendix 4** (significant  $p < .01$ ).

### A Double Sequence Effect?

Other examples of a double sequence effect may be given. Of the 21 seismic events ( $M \geq 6.5$ ) occurring along the San Andreas Fault zone since 1800, 17 happened selectively in the double sequence layout in **Table 7** (significant  $p < .01$ ). This was unlikely to arise by

chance and was based on the listing by Toppazada et al (2002). All 9 major quakes ( $M \geq 7.0$ ) happened in this pattern.

<b>Table 7</b> <b>9/56 YEAR CYCLE: QUAKES IN THE SAN ANDREAS FAULT ZONE</b> <b>1800 – 2000 <math>M \geq 6.5</math></b> <b>Two years ending December 31</b>												
Sq 25	Sq 34	Sq 43	Sq 52	Sq 05	Sq 14	Sq 23	Sq 32	Sq 41	Sq 50	Sq 03	Sq 12	Sq 21
								1801	1810	1819	1828	1837 <b>1836</b> 0610
		1803	<b>1812</b> 1208 <b>1812</b> 1221	1821	1830	1839 <b>1838</b> 06??	1848	<b>1857</b> 0109	1866 <b>1865</b> 1008	1875	1884	1893 <b>1892</b> 0224 <b>1892</b> 0528
1841 <b>1840</b> 0118	1850	1859	<b>1868</b> 1021	1877	1886 <b>1885</b> 0412	1895	1904	1913	1922	1931	<b>1940</b> 0519	1949
1897	<b>1906</b> 0519	1915	1924	1933	1942	1951	1960	1969 <b>1968</b> 0409	1978	<b>1987</b> 1124	1996	2005
1953	1962	1971	1980 <b>1979</b> 1015	<b>1989</b> 1017	1998	2007	2016					
2009	2018											
<b>Historic Earthquakes – San Andreas Fault Zone</b>												
Date		M	Location									
18121208		7.3	Wrightwood									
18121221		7.1	Los Angeles, Ventura and Santa Barbara									
18360610		6.5	Santa Clara									
183806??		7.4	San Francisco Peninsula									
18400118		6.5	San Juan Bautista									
18570109		7.9	Great Tejon earthquake									
18651008		6.5	Southern Santa Cruz Mountains									
18681021		7.0	Hayward Fault									
18850412		6.5	Lonoak									
18900209		6.8	Pajaro Gap									
18920224		7.3	Laguna Salada BC									
18920528		6.5	San Jacinto fault									
18980415		6.7	Fort Bragg-Mendocino									
18991225		6.7	San Jacinto and Hemet									
19060418		7.8	Great San Francisco quake									
19180421		6.8	San Jacinto									
19400519		7.1	Imperial Valley									
19680409		6.6	Borrego Mountain									
19791015		6.5	Imperial Valley									
19871124		6.6	Superstition Hills									
19891018		7.1	Loma Prieta									



Earthquakes in **RED** occurred in **Table 7**.  
**Source of Raw Data:** Topozada et al (2002).

Of the 44 major North Anatolian Fault (NAF) earthquakes since 1700 ( $M \geq 6.7$ ), some 32 appeared in the grid shown in **Table 8**, in contrast to an expected 22 (significant  $p < .01$ ). For the 1700 to 1920 era, 84% of the events happened in the table (significant  $p < .001$ ). The raw data was sourced from Bohnhoff et al (2016) (see **Appendix 5**).

<b>Table 8</b>													
<b>DOUBLE 56 YR SEQUENCES &amp; NAF EARTHQUAKES <math>M \geq 6.7</math></b>													
<b>Two Years beginning January 1</b>													
Sq 43	Sq 52	Sq 05	Sq 14	Sq 23	Sq 32	Sq 41	Sq 50	Sq 03	Sq 12	Sq 21	Sq 30	Sq 39	Sq 48
								<b>1707</b>	1716	1725	1734	1744	<b>1752</b>
	1700	1709	1718 <b>1719</b> <b>1719</b>	1727	1736 <b>1737</b>	1745	<b>1754</b>	1763	1772	1781	1790	1799	1808
1747	<b>1756</b>	1765 <b>1766</b> <b>1766</b>	1774	1783 <b>1784</b> <b>1784</b>	1792	1801	1810	1819	1828	1837	1846	<b>1855</b>	1864
1803	1812	1821	1830	1839	1848	1857	<b>1866</b> <b>1866</b>	1875	1884	<b>1893</b> <b>1894</b>	1902	1911 <b>1912</b> <b>1912</b>	1920
<b>1859</b>	1868	1877 <b>1878</b>	1886	1895	1904	1913	1922	1931	1940	<b>1949</b>	1958	<b>1967</b>	1976
1915 <b>1916</b>	1924	1933	<b>1942</b> <b>1943</b>	<b>1951</b>	1960	1969 <b>1970</b>	1978	1987	1996	2005	<b>2014</b>		
<b>1971</b>	1980	1989	1998 <b>1999</b> <b>1999</b> <b>1999</b>	2007	2016								

Abbreviation: NAF – North Anatolian Fault.  
**Source of Raw Data:** Bohnhoff et al (2016).

Other historic catalogs were tested for a double sequence effect but did not yield significance (eg: Kamchatka, Japan, Chile – Peru, Alaska, Mexico and so forth). One could have expected this pattern to be more common in earthquake cycles, but this was not observed.

### Discussion & Conclusions

The 20, 56 and 60 year cycles in Californian earthquake activity were certainly interesting. How they integrated into overall trends for south western North America was debatable. Other seismic catalogs did not yield similar cycles and thus they may be unique to California.

The record state quakes for the southern half of the USA usually take place in the double sequences in the 9/56 year layout presented in **Appendix 4**. The states in the Mid West

and the North West were anomalous, as their record quakes did not take place selectively in this pattern for whatever reason. Curiously, record Canadian - Alaskan earthquakes by region occurred in a 36/56 year grid (see **Appendix 6**), as did record quakes for Washington state (see **Appendix 7**).

Double sequences could also be established for the San Andreas and North Anatolian faults. Other catalogs were assessed for similar patterns but significance could not be produced. There are two options to explain this dichotomy - the double sequence effect is invalid or it only shows up in a few historic seismic trends.

In seismic cycles, the intervals between major episodes are highly variable. The most famous was the Parkfield series on the San Andreas fault with quakes ( $M \geq 6.0$ ) happening roughly every 20 years – 1857, 1881, 1901, 1922, 1934 and 1966, the anomaly being 2004. In contrast, the cycles commencing in 1812 were far more precise with events ( $M \geq 6.8$ ) taking place every 56 and 60 years (see **Table 3**). The 20 year earthquake cycle in **Table 4** was less exact because four of the 11 years experienced no major event ( $M \geq 7.0$ ). The Parkfield series occurred in a limited sector of the San Andreas Fault, whereas the 56 and 60 year cycles arise in a large portion of the North American continent.

The various intervals highlighted in this paper - 9, 56 and 60 years can also be found in market trends. The 9/56 year cycle was originally established in the timing of financial distress since 1760 (McMinn, 1986, 1993), while 60 year intervals were vitally important in the timing of October panics over the past 180 years (McMinn, [2014](#)). A double sequence effect could also be established for the timing of historic US and Western European financial panics. Kindleberger (Appendix B, 1996) listed 30 major crises for the 1760 to 1940 period, of which 25 fell in the 9/56 year double sequence pattern in **Appendix 8** (significant  $p < .001$ ).

What activates the 9/56 year cycle? This grid correlates perfectly with Moon Sun cycles (McMinn, 2011a). Events clustering in the 9/56 year grid will have the lunar ascending node (LAN) in two sectors approximately  $180^\circ$  opposite in the ecliptic circle with no exceptions (1st and 2nd harmonics). For events in the same 9/56 year grid and occurring around the same time of year, apogee will be sited in three ecliptic sectors  $120^\circ$  apart, with no exceptions (3rd harmonic) (McMinn, 2011a). There is also a perfect 6th harmonic associated with LAN - Apogee angles and the ecliptic position of the Sun (McMinn, 2016). Such findings gave rise to the Moon Sun Hypothesis, in which weak Moon Sun tidal harmonics are speculated to activate critical terrestrial events such as financial panics, earthquakes and volcanic eruptions. How these forces functioned was the great unknown. Some recent papers lend support to a lunisolar seismic effect. Thomas et al (2009) and Van der Elst et al (2016) found that small deep low frequency earthquakes along the San Andreas fault could be triggered by the pull of the Moon and Sun. Additionally, Ide et al (2016) established a link between the timing of mega quakes and the maximum tidal stress at full/new Moons.

**NB.** Apogee is the point in the lunar orbit, where the Moon is the greatest distance from Earth, whereas the perigee point is the least distance. The Moon's orbit around the Earth is

inclined by about 5 degrees to the plane of the Earth's orbit around the Sun (the ecliptic). LAN is where the Moon crosses the ecliptic from south to north and the descending node is where the Moon crosses from north to south. The lunar nodes and apogee are important in terrestrial tides.

Lunisolar tidal harmonics would help explain the patterns evident for the double sequence effect for record US state earthquakes over a wide geographical area. In traditional seismology, an earthquake in California would be considered to have no relationship to an event in South Carolina. However, Moon Sun effects would mean that earthquakes are connected by time because they are activated by a common mechanism. The best example of this are the shared 54/56 year grids around the Pacific Basin, something that applied to large earthquakes in Japan – Kamchatka, Alaska and Chile – Peru (McMinn, [2014](#)).

It will be interesting to see if another major earthquake occurs in the 12 months commencing April 2018. Some 25% of the years in **Table 3** experienced at least one state record, while the 37% of the years in **Appendix 2** recorded a major earthquake in south western North America ( $M \geq 6.9$ ). If a large quake is going to occur, this year would be the most likely timing.

Cycles are evident in patterns of Californian earthquakes. These can be quite precise as the 20, 56 and 60 year seismic cycles demonstrated in this paper. Double 56 year sequences were evident for record state earthquakes for the southern half of the USA, as well as for major earthquakes along the San Andreas and North Anatolian Faults. Such patterns were both unusual and unexpected, but they yielded significance. Even so, the double sequence seismic effect may be uncommon, only appearing in a few historic catalogs. The reasons why such patterns manifest in historic trends remained unknown, although Moon Sun tidal harmonics are strongly suspected and offer the best prospects for further research.

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<b>Appendix 1</b>				
<b>MAJOR EARTHQUAKES IN CALIFORNIA - NEVADA</b>				
<b>- BAJA CALIFORNIA 1800–2015 (M ≥ 6.9)</b>				
<b>Listing by the US Geological Survey</b>				
<b>Year</b>	<b>Mth</b>	<b>Day</b>	<b>M</b>	<b>Location</b>
1812	12	08	7.0	Wrightwood
1812	12	21	7.0	Santa Barbara Channel
1838	06	??	7.0	San Francisco Peninsula
1857	01	09	8.25	Great Tejon earthquake
1868	10	21	7.0	Hayward Fault
1872	03	26	7.6	Owens Valley
1892	02	24	7.0	Laguna Salada, BC
1899	04	16	7.0	West of Eureka
1906	04	18	8.25	Great San Francisco quake
1915	10	03	7.3	Pleasant Valley, Nevada
1915	11	21	7.1	Volcano Lake, BC
1918	04	21	6.9	San Jacinto
1922	01	31	7.3	West of Eureka
1923	01	22	7.2	Cape Mendocino
1927	11	04	7.3	South West of Lompoc
1932	12	21	7.2	Cedar Mountain, Nevada

1934	12	31	7.0	Colorado River
1939*	05	02	7.0	Gulf of California, BC.
1940	05	19	7.1	Imperial Valley
1952	07	26	7.7	Kern County
1954	12	16	7.1	Fairview Peak, Nevada
1980	11	08	7.2	West of Eureka
1989	10	18	7.1	Loma Prieta
1991	08	17	7.1	West of Crescent City
1992	04	25	7.2	Cape Mendocino
1992	06	28	7.3	Landers
1994	09	01	6.9	Mendocino Fracture Zone
1999	10	16	7.2	Hector Mine
2005*	06	15	7.2	Offshore Northern California
2009*	08	03	6.9	Gulf of Mexico, BC.
2010*	04	04	7.2	Mexicali, BC
2012*	04	12	7.0	San Luis, BC.
* Inserted by author.				
<b>Main Source:</b> Ellsworth (1990).				

<b>Appendix 2</b> <b>9/56 YEAR CYCLE: MAJOR QUAKES IN</b> <b>CALIFORNIA – NEVADA – BAJA CALIFORNIA 1800 – 2010 (M ≥ 6.9)</b> <b>Year beginning April 15</b>								
Sq 25		Sq 34		Sq 43		Sq 52		Sq 05
				1803	+ 9	<b>1812</b> Dec08 <b>1812</b> Dec21	+ 9	1821
1841	+ 9	1850	+ 9	1859	+ 9	<b>1868</b> Oct21	+ 9	1877
1897	+ 9	<b>1906</b> Apr18	+ 9	<b>1915</b> Oct 03 <b>1915</b> Nov21	+ 9	1924	+ 9	1933
1953	+ 9	1962	+ 9	1971	+ 9	<b>1980</b> Nov08	+ 9	<b>1989</b> Oct18
<b>2009</b> Aug03 <b>2010</b> Apr04	+ 9	2018						
Dates in <b>RED</b> experienced major quakes (M ≥ 6.9) listed in <b>Appendix 1</b> . <b>Source:</b> McMinn (2011a).								

<b>Appendix 3</b>			
<b>SEQUENCE 52 &amp; WORLD RECORD EARTHQUAKES</b>			
<b>Year ending August 15</b>			
<b>Sq 52</b>	<b>M</b>	<b>Event</b>	<b>Record</b>
Jan 26, 1700	9.0	Great Cascadia quake	Record for western USA (ex-Alaska)
Oct 17, 1755	na	Katla volcano	Equal 1st rank eruption for Iceland
Nov 01, 1755	9.0	Great Lisbon quake	Record for Western Europe
Nov 18, 1755	6.3	Boston quake	Record for north east USA
Feb 18, 1756	6.3	Duren quake	Record German quake
Feb 12, 1812	7.9	New Madrid quake	Record for eastern USA
Mar 26, 1812	7.7	Caracas quake	Record for Venezuela
Nov 18, 1867	7.5	Puerto Rico	19th century record for Puerto Rico
Apr 03, 1868	7.9	Hawaii	Record Hawaiian quake
Aug 13, 1868	9.0	Great Arica quake	19th century record for South America
Sep 01, 1923	7.9	Tokyo quake	No record.
Jan 01, 1980	7.2	Azores	Record quake for the Azores
May 18, 1980	na	Mt St Helens volcano	Record US eruption (ex-Alaska)
NB: The record earthquake for Algeria (M 7.1. Oct 10, 1980) was slightly out by about two months.			
Source: McMinn (2011b).			

<b>Appendix 4</b>												
<b>RECORD STATE EARTHQUAKES CALIFORNIA TO ATLANTIC SOUTH EAST</b>												
<b>Two years beginning April 15</b>												
<b>Sq 06</b>	<b>Sq 15</b>	<b>Sq 24</b>	<b>Sq 33</b>	<b>Sq 42</b>	<b>Sq 51</b>	<b>Sq 04</b>	<b>Sq 13</b>	<b>Sq 22</b>	<b>Sq 31</b>	<b>Sq 40</b>	<b>Sq 49</b>	<b>Sq 02</b>
1766	1775	1784	1793	1802	1811 1216 1812 0207	1820	1829	1838	1847	1856 1857 0109	1865 0817	1874
1822	1831	1840	1849	1858	1867 1867 0424 1868 0402	1876	1885 1886 0901	1894	1903	1912 0818	1921	1930 1019 1931 0816 1931 1217
1878 1879 0113	1887 0503	1896 1897 0531	1905 1906 0125 1906 0418 1906 	1914 1915 1003 1916 0221	1923	1932 1934 0312	1941	1950	1959	1968 1969 1120	1977	1986

1934	1943	1952	1961	1970	1979 <b>1980</b> 0727	1988	1997	2006	2015 <b>2016</b> 0903			
1990	1999	2008 <b>2010</b> 0404	2017									

Record state earthquakes for California to the Lower Mississippi River have been highlighted in **RED** and include the record for Hawaii. The additional records for the US southern states have been denoted in **PURPLE**. Dates presented by YYYYMMDD.

#### **Record Earthquakes North Western Mexico**

- Sq 15 - Record for the Mexican state of Sonora (M 7.5. May 3, 1887).  
 Sq 24 – Equal 1st rank quake for Baja California (Mexicali. M 7.2. Apr 4, 2010).

#### **Record Earthquakes California to Lower Mississippi River**

- Sq 02 - Record for Louisiana (M 4.2. Oct 19, 1930).  
 Sq 02 - Record for Texas (Valentine. M 5.9. Aug 16, 1931).  
 Sq 04 - Record for Utah (M 6.5. Mar 12, 1934).  
 Sq 31 - Equal 1st rank quake for Oklahoma (M 5.6. Sep 3, 2016).  
 Sq 33 - Equal 1st rank for Arizona (Flagstaff. M 6.2. Jan 25, 1906).  
 Sq 33 - Record for Northern California (San Francisco. M 8.25. Apr 18, 1906).  
 Sq 33 - Record quakes for New Mexico happened on  
 Jul 16 and Nov 15 in 1906 (both M 5.8).  
 Sq 40 - Record for Southern California (Fort Tejon. M 8.25. Jan 9, 1857).  
 Sq 40 - Equal 1st rank quake for Arizona (Lockett Tanks. M 6.2. Aug 18, 1912).  
 Sq 42 - Record for Nevada (Pleasant Valley. M 7.3. Oct 3, 1915).  
 Sq 51 - Record for Arkansas (M 7.9. Dec 16, 1811).  
 Sq 51 - Record for Missouri (M 7.5. Feb 7, 1812).  
 Sq 51 - Record for Kansas (M 5.1. Apr 24, 1867).  
 Sq 51 - Record for Hawaii (M 7.9. Apr 2, 1868).

#### **Anomalous States**

- Equal 1st rank quake for Oklahoma (M 5.6. Nov 6, 2011).  
 Record for Colorado (M 6.5. Nov 2, 1882).

#### **Record Earthquakes South Eastern US States**

- Sq 02 - Record for Mississippi (M 4.6. Dec 17, 1931).  
 Sq 06 - Equal 1st rank quake for Florida (Intensity VI. Jan 13, 1879).  
 Sq 13 - Record for South Carolina (Charleston. M 7.1. Sep 1, 1886).  
 Sq 24 - Record for Virginia (M 5.9. May 31, 1897).  
 Sq 40 - Record for West Virginia (M 4.5. Nov 20, 1969).  
 Sq 42 - Record for North Carolina (Intensity VII. Feb 21, 1916).  
 Sq 49 - Record for Tennessee (M 5.0. Aug 17, 1865).  
 Sq 51 - Record for Kentucky (M 5.0. Jul 27, 1980).

#### **Anomalous States**

- Record for Georgia (Intensity V. Mar 5, 1914).

Record for Alabama (M 5.1. Oct 18, 1916). Equal 1st rank quake for Florida (Intensity VI. Feb 6, 1780).
<b>Main Source of Raw Data:</b> US Geological Survey.

<b>Appendix 5</b>									
<b>EARTHQUAKES ALONG THE NORTH ANATOLIAN FAULT <math>M \geq 6.5</math></b>									
<b>1700-2015</b>									
<b>Year</b>	<b>M</b>	<b>Year</b>	<b>M</b>	<b>Year</b>	<b>M</b>	<b>Year</b>	<b>M</b>	<b>Year</b>	<b>M</b>
<b>2014</b>	<b>6.8</b>	1957	7.1	<b>1916</b>	<b>7.2</b>	<b>1855</b>	<b>7.1</b>	<b>1719</b>	<b>6.7</b>
<b>1999</b>	<b>7.3</b>	1953	7.1	<b>1912</b>	<b>7.3</b>	1789	7.0	<b>1719</b>	<b>7.4</b>
<b>1999</b>	<b>7.0</b>	<b>1951</b>	<b>6.9</b>	<b>1912</b>	<b>6.8</b>	<b>1784</b>	<b>7.6</b>	<b>1707</b>	<b>6.8</b>
<b>1999</b>	<b>7.3</b>	<b>1949</b>	<b>6.9</b>	<b>1894</b>	<b>7.3</b>	<b>1784</b>	<b>7.1</b>	1705	6.7
1992	6.8	1944	7.4	<b>1893</b>	<b>6.9</b>	<b>1766</b>	<b>7.4</b>		
<b>1971</b>	<b>6.8</b>	1944	6.8	1890	7.3	<b>1766</b>	<b>7.1</b>		
<b>1970</b>	<b>7.1</b>	<b>1943</b>	<b>7.7</b>	<b>1878</b>	<b>6.7</b>	1756	6.7		
<b>1967</b>	<b>7.2</b>	<b>1942</b>	<b>7.1</b>	<b>1866</b>	<b>7.2</b>	<b>1754</b>	<b>6.8</b>		
1966	6.8	1939	7.9	<b>1866</b>	<b>6.8</b>	<b>1752</b>	<b>6.8</b>		
1964	6.8	1919	6.9	<b>1859</b>	<b>6.8</b>	<b>1737</b>	<b>7.0</b>		

Years highlighted in **RED** appeared in **Table 6**.  
**Source:** Bohnhoff et al (2012).

<b>Appendix 6</b>								
<b>36/56 YEAR CYCLE: RECORD QUAKES FOR CANADIAN REGIONS</b>								
<b>Post 1900</b>								
<b>Year beginning February 1</b>								
<b>Sq 05</b>		<b>Sq 41</b>		<b>Sq 21</b>		<b>Sq 01</b>		<b>Sq 37</b>
								<b>1909</b> May15
						<b>1929</b> Nov18	+ 36	1965
		1913	+ 36	<b>1949</b> Aug22	+ 36	<b>1985</b> Dec23	+ 36	2021
<b>1933</b> Nov20	+ 36	1969	+ 36	2005				
<b>1989</b> Dec25	+ 36	2025						

**Record Earthquakes by Canadian Regions**

Sq 01 - Eastern Canada (Offshore Newfoundland. M 7.2. Nov 18, 1929).  
Sq 01 - North western Canada (Nahanni region. M 6.9. Dec 23, 1985).  
Sq 05 - Northern Canada (Baffin Bay. M 7.3. Nov 20, 1933).  
Sq 05 – North eastern Canada (Ungava Peninsular. M 6.0. Dec 25, 1989).



Sq 21 - Western Canada (Offshore Queen Charlotte Island.  
M 8.1. Aug 22, 1949).

Sq 37 - Central Canada (Saskatchewan - US border. M 5.5. May 15, 1909).

### Other Earthquakes of Interest

Sq 36 - Record for Iceland (M 7.1. Jan 22, 1910).

Sq 29 – Equal 3rd rank quake for Washington state (Olympia. M 6.7. Apr 13, 1949).

Sq 36 - 2nd rank quake for Alaska (Rat Islands. M 8.7. Feb 4, 1965).

Sq 36 - Equal 3rd rank quake for Washington state (Puget Sound. M 6.7. Apr 29, 1965).

**Sources of Raw Data:** Canadian Geological Survey. US Geological Survey. [Icelandic Meteorological Office](#).

<b>Appendix 7</b>						
<b>36/56 YEAR CYCLE: TOP QUAKE FOR WASHINGTON STATE</b>						
<b>5 months beginning December 1</b>						
<b>Sq 20</b>		<b>Sq 56</b>		<b>Sq 36</b>		<b>Sq 16</b>
		<b>1872</b> Dec15	+ 36	1908	+ 36	1944
1892	+ 36	1928	+ 36	1964 <b>1965</b> Apr29	+ 36	2000 <b>2001</b> Feb28
1948 <b>1949</b> 0413	+ 36	1984	+ 36	2020		
2004						
<b>Record Earthquakes</b>						
Sq 56 - Equal 1st rank quake (North Cascades. M 6.8. Dec 15, 1872).						
Sq 16 - Equal 1st rank quake (Puget Sound. M 6.8. Feb 28, 2001).						
Sq 20 - Equal 3rd rank quake (Puget Sound. M 6.7. Apr 13, 1949).						
Sq 36 - Equal 3rd rank quake (Puget Sound. M 6.7. Apr 29, 1965).						
<b>Source of Raw Data:</b> US Geological Survey.						

<b>Appendix 8</b>												
<b>FINANCIAL CRISES &amp; THE 9/56 YEAR GRID 1760 - 1940</b>												
<b>Two years beginning March 1</b>												
<b>Sq 22</b>	<b>Sq 31</b>	<b>Sq 40</b>	<b>Sq 49</b>	<b>Sq 02</b>	<b>Sq 11</b>	<b>Sq 20</b>	<b>Sq 29</b>	<b>Sq 38</b>	<b>Sq 47</b>	<b>Sq 56</b>	<b>Sq 09</b>	<b>Sq 18</b>
										1760	1769	1778
				1762 <b>1763</b> 09??	1771 <b>1772</b> 0622	1780	1789	1798 <b>1799</b> 10??	1807	<b>1816</b>	<b>1825</b> 1217	1834
1782	1791 <b>1792</b> 0322	1800	1809 <b>1811</b> 01??	1818 <b>1819</b> 05??	<b>1827</b> 12??	<b>1836</b> 12??	1845	1854	1863 <b>1864</b> 01??	1872 <b>1873</b> 0509	1881 <b>1882</b> 0130	<b>1890</b> 11??

						<b>1837</b> 0510				<b>1873</b> 0919		
<b>1838</b> 12??	<b>1847</b> 1023 <b>1848</b> 03??	1856 <b>1857</b> 1014	1865 <b>1866</b> 0511	1874	1883	1892 <b>1893</b> 0726	1901	1910	1919 <b>1920</b>	1928 <b>1929</b> 1028	1937	1946
1894	1903	1912	<b>1921</b>	1930 <b>1931</b>	1939							

### Major Financial Crises 1760 – 1940

#### Listed by Kindleberger (Appendix B, 1996)

Sq 02 – Amsterdam panic (Sep 1763). Ending of Seven Years War.

Sq 02 – US panic (May, 1819).

Sq 02 – World Crisis (1931). Great Depression.

Sq 09 – British panic (Dec 17, 1825).

Sq 09 – French panic (Jan 30, 1882).

Sq 11 – British panic (Jun 22, 1772).

Sq 11 – French panic (Dec 1827). Bankruptcies in Alsace.

Sq 18 – Baring Crisis (Nov 1890).

Sq 20 – British panic (Dec 1836).

Sq 20 – US panic (May 10, 1837).

Sq 20 – US Black Wednesday (Jul 26, 1893).

Sq 22 – Bank of Belgium bankrupt (Dec 1838).

Sq 31 – British panic (Feb 1793).

Sq 31 – British panic (Oct 23, 1847).

Sq 31 – French panic (Mar 1848). Year of Revolutions.

Sq 38 – Hamburg crisis (Oct 1799).

Sq 40 – US and European panics (Oct 14, 1857).

Sq 47 – French panic (Jan 1864).

Sq 47 – World crisis (1920). After inflation.

Sq 49 – British panic (Jan 1811).

Sq 49 – British Black Friday (May 11, 1866).

Sq 49 – World crisis (1921). After inflation.

Sq 56 – World crisis (1816). Year with no summer.

Sq 56 – Austrian Black Friday (May 9, 1873).

Sq 56 – US Black Friday (Sep 19, 1873)

Sq 56 – US Black Monday (Oct 28, 1929).

#### Anomalous Panics

1797 – British panic. French invasion fears.

1815 – British panic.

1932 – World crisis. Great Depression.

1933 – US banking crisis (Mar).

1907 – US banking panic (Oct 22).