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# A Review of the Seismicity of the California Islands

**Gerald W. Simila**
Department of Geological Sciences
California State University
Northridge, CA 91330

**Abstract** - The historic seismicity of the California Islands region is represented by several significant events including the 1812 (M=7.1) earthquake which occurred near Santa Barbara, the 1812 event (M=6.9) near San Juan Capistrano, and M=5.9-6.0 earthquakes in 1862 near San Diego and 1883 near Santa Barbara. Recent activity (1900-1988) is generated by both onshore and offshore faults for M=5.0-6.0 events. Analysis of focal mechanisms by various investigators indicated both strike-slip and reverse faulting which are produced by NE-SW stresses associated with the plate motions.

## Introduction

The California Islands are located in the southern California Continental Borderland which is represented by a 250 km wide offshore region with northwest-trending faults and deep sedimentary basins. Various tectonic models have been proposed for the formation of the Borderland including strike-slip faulting, folding, rifting and pull-apart basins. During late Miocene time, an episode of marine transgression and basin subsidence dominated the coastal region (Vedder & Howell 1980). Paleomagnetic evidence indicates that several of the California Islands in the Santa Barbara Channel have rotated 90° clockwise since the Miocene epoch (Luyendyk *et al.* 1985). In conjunction with the right-shear system of the San Andreas, convergent wrench tectonics is also a possible mechanism for basin development (Howell *et al.* 1980). The seismic slip rates of the faults in offshore region also contribute to the general motion between the North American and Pacific plates (Anderson 1979). Evaluation of the seismicity distribution and associated focal mechanisms reveal the current stress patterns.

## Regional Seismicity

The general seismicity pattern of the California Islands is presented in Figure 1. All events with magnitude (M) greater than or equal to 4.5 are shown for 1900-1988 and larger significant events for pre-1900. The epicenter plot generally represents earthquakes with M=4.5-7.1. Selected events (M=6.0+) are listed in Table 1. Several regions of moderate activity and associated large magnitude events are evident for certain fault zones. The major event is the 1812 Santa Barbara Channel earthquake with M=7.1 (Toppozada *et al.* 1981). The estimates of the location uncertainties for the pre-1900 epicenters are 50-100 km by Toppozada *et al.* (1981). Uncertainties for events (1932-1970) are 5-15 km and 5 km after 1970 (Hileman & Hanks 1975). The spatial distribution of earthquakes shows a general correlation with certain active fault zones which is reviewed from previous investigations (Yerkes *et al.* 1981; Legg 1987).

**Historical Seismicity (1800-1900):** Reliable accounts regarding earthquake history of southern California start from about 1800 based on the Spanish missionary reports (Townley & Allen 1939). The historic seismicity and felt reports of the California Islands region are reviewed from the investigations by Toppozada & co-workers (1981). The following earthquake descriptions, locations and magnitudes are taken from their report.

The most significant event is the 21 December 21 1812 (M=7.1) earthquake. The missions Santa Barbara and Purisima

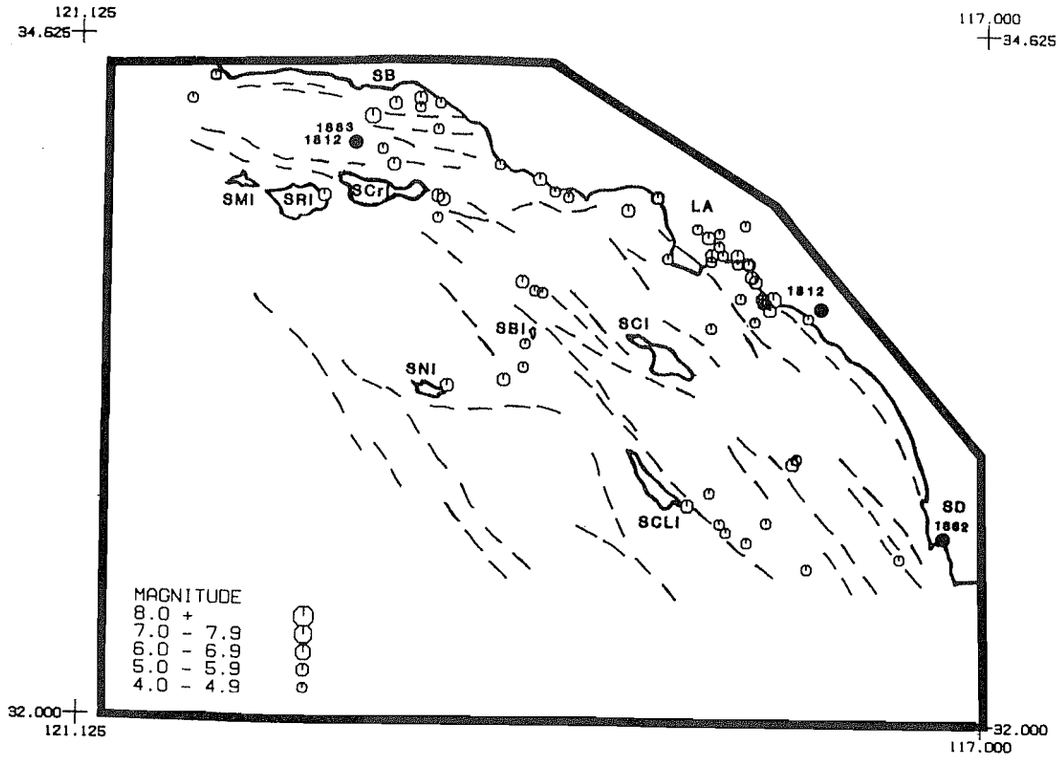


**Figure 1.** Seismicity of the California Islands and coastal region (1900-1988, M=4.5+). Location abbreviations: Los Angeles (LA), San Clemente Island (SCLI), San Diego (SD), San Miguel Island (SMI), San Nicolas Island (SNI), Santa Barbara (SB), Santa Barbara Island (SBI), Santa Catalina Island (SCI), Santa Cruz Island (SCrI), Santa Rosa Island (SRI). Locations of specific historic earthquake indicated by solid dots. Faults selected from Real & co-workers (1978).

Conception (approximately 15 km northeast of Pt. Arguello) were severly damaged. Toppozada & co-workers (1981) reviewed the intensity reports, and proposed that the location was centered in the Santa Barbara Channel. Just a few days earlier on 8 December 1812, an earthquake (M=6.9) was felt from San Fernando to San Diego which destroyed the mission at San Juan Capistrano. Also near the San Diego region, a M=5.9 event occurred on 27 May 1862. On 5 September 1883, an event (M=6.0) also located in the Santa Barbara Channel produced minor damage in Santa Barbara and was felt from Los Angeles to San Luis Obispo. Due to the lack of instrumental data, the earthquake epicenters are poorly defined and are located from the interpretation of the intensity data (Toppozada *et al.* 1981).

**Recent Seismicity (1900-1988):** The recent regional seismicity of the California Islands was reviewed for general patterns and specific moderate to large earthquakes using data from various investigations (Hamilton *et al.* 1969; Hileman & Hanks 1975; Real *et al.* 1978; Toppozada *et al.* 1978; Lee *et al.* 1979; Legg 1987).

**Santa Barbara Channel:** The Santa Barbara Channel region and associated islands is the most active section of offshore southern California. On 29 June 1925 a M=6.2 earthquake occurred near Santa Barbara (Richter 1958; Hamilton *et al.* 1969; Olsen & Sylvester 1975). On 1 July



**Table 1.** Significant earthquakes (M>6.0) California Islands Region.

| Date | Magnitude | Location | Comments | References |
|---|---|---|---|---|
| 08 Dec. 1812 | 6.9 | 33.7N 117.9W | San Juan Capistrano | A |
| 21 Dec. 1812 | 7.1 | 34.2N 119.9W | Santa Barbara Channel | A |
| 05 Sept. 1883 | 6.0 | 34.2N 119.9W | Santa Barbara Channel | A |
| 29 June 1925 | 6.2 | 34.3N 119.8W | Santa Barbara | B |
| 11 Mar. 1933 | 6.3 | 33.6N 117.9W | Long Beach | B |

A = Toppozada & co-workers (1981)
B = Real & co-workers (1978)

1941, a M=5.9 earthquake occurred east of Santa Barbara (Real *et al.* 1978). The 1 April 1945 (M=5.4) event is located near the eastern part of Santa Rosa Island.

An earthquake swarm of 63 minor earthquakes occurred in the Santa Barbara Channel during the time period 26 June-3 August 1968. The maximum magnitude event (5 July) was M=5.2. The epicenter pattern was associated with a broad, high-standing fault block in the channel midway between Santa Cruz Island and Santa Barbara. Studies of the fault-plane solutions indicted that oblique-slip motion occurred along a northwest-striking fault (Sylvester *et al.* 1970). On 13 August 1978, a M=5.1 event occurred southeast of Santa Barbara. The focal mechanism indicated reverse faulting with a NE-SW compressive stress (Corbett & Johnson 1982).

Three events [18 February 1926 (M=5.0);26 August 1954 (M=4.8) and 6 August 1973 (M=5.0)] have occurred near the eastern end of Santa Cruz Island associated with the faults bounding the northwestern part of the Santa Monica Basin. The interpretation focal mechanism for the 1973 event was right lateral motion along a northwest trending plane or left slip along a northeast plane (Yerkes & Lee 1979). Eastward,the Pt. Mugu earthquake (M=5.9; Real *et al.* 1978) occurred on 21 February 21 1973. The main shock focal mechanism was reverse faulting along a E-W trending fault (Lee *et al.* 1979).

**Santa Barbara and Santa Catalina Islands:** Southwest of Santa Barbara Island, the October 1969 events (max M=5.1) indicated reverse faulting focal mechanisms along a northwest orientation (Legg 1987). Corbett (1984) analyzed the 4 September 1981 (M=5.2) event north of Santa Barbara Island. His prefered fault plane solution showed right lateral motion for a N42°W strike direction associated with the aftershock distribution.

The San Pedro Basin, east of Catalina Island, exhibits a moderate level of seismicity, but of smaller magnitudes (Real *et al.* 1978; Legg 1987). The most significant earthquake of this area occurred on 11 March 1933 (M=6.3) which caused major damage in the Long Beach-Los Angeles area. This event and associated aftershocks were produced by the Newport-Inglewood fault (Richter 1958).

**San Nicolas and San Clemente Islands:** The San Nicolas region has a low level of moderate magnitude activity which is emphasized by the 18 November 1947 (M=5.0) event (Legg 1987). In contrast, the San Clemente Island area and associated faults generate significant seismicity. The largest event was on 12 December 1951 (M=5.9) near the southwest tip of the island. Focal mechanism studies showed right lateral motion, but with a component of normal slip of faulting (Legg 1987). Analysis of the 11 July 1981 (M=4.3) event indicated strike slip motion (Simila 1986). Eastward towards the coastline, the Palos Verdes-Coronado fault and associated San Diego trough generate moderate magnitude earthquakes. The recent 13 July 1986 event (M=5.3) indicated reverse faulting along a northwest trend (Pacheco & Nabelek 1988).

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