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Scenarios for Historic San Francisco Bay Region Earthquakes

by

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Abstract

Thirteen moment magnitude $M \geq 6.2$ earthquakes have occurred in the San Francisco Bay region since 1936 (Bakun, 1999). Rupture scenarios for the 12 M < 7 shocks are based on analyses of Modified Mercalli intensity data (Bakun, 1998) and other geological and geophysical information. The scenarios are shown as black-and-white maps in this report and in color at *http://quake.wr.usgs.gov/~bakun/SFScenarios.html*.

Description of Scenario Maps

Bakun and Wentworth (1997) developed a method for the analysis of Modified Mercalli intensity (*MMI*) values that results in an intensity magnitude M_I that has been calibrated to equal M in the mean. $M = 2/3 * \log M_0 - 10.7$, where M_0 is the seismic moment in dyne-cm (Hanks and Kanamori, 1979). Bakun and Wentworth (1997) also defined a root-mean square function *rms* $[M_I]$, geographic contours of which bound the earthquake epicenter at different levels of confidence. Bakun (1999) applied this analysis strategy to the MMI observations for historic earthquakes in the San Francisco Bay region and produced maps of M_I and rms $[M_I]$.

The maps of M_I and rms $[M_I]$ from Bakun (1999) are shown on the scenario maps as dashed and solid contours respectively. The rms $[M_I]$ contours correspond to the 50% (innermost solid contour), 67%, 80%, 90%, and 95% -confidence levels (outermost solid contour) for location. There is a 0.5 chance that the epicenter lies within the 50% confidence contour, *etc*. Geographic locations of MMI data are shown as small dots. The intensity center, shown as a triangle, is the source location that best satisfies the MMI data, *i.e.*, where rms $[M_I]$ is minimum. Epicenters are shown as large dots. The Quaternary faults shown are younger than 700 ka (Jennings, 1992).

Rupture length *L*, the rupture width *W*, and the mean slip $\langle u \rangle$ over the rectangular scenario rupture plane were selected so that $M_0 = \mu * L * W * \langle u \rangle$, where $\mu = 30$ Gpa. The scenario fault ruptures are shown as elongated rectangles of length L along the fault specified in the scenario. W, which measures the depth extent of the rupture, is not represented on the scenario maps. The placement of the scenario ruptures on the faults are consistent with the rms $[M_I]$ contours and other information, as described in the scenario map captions.

References

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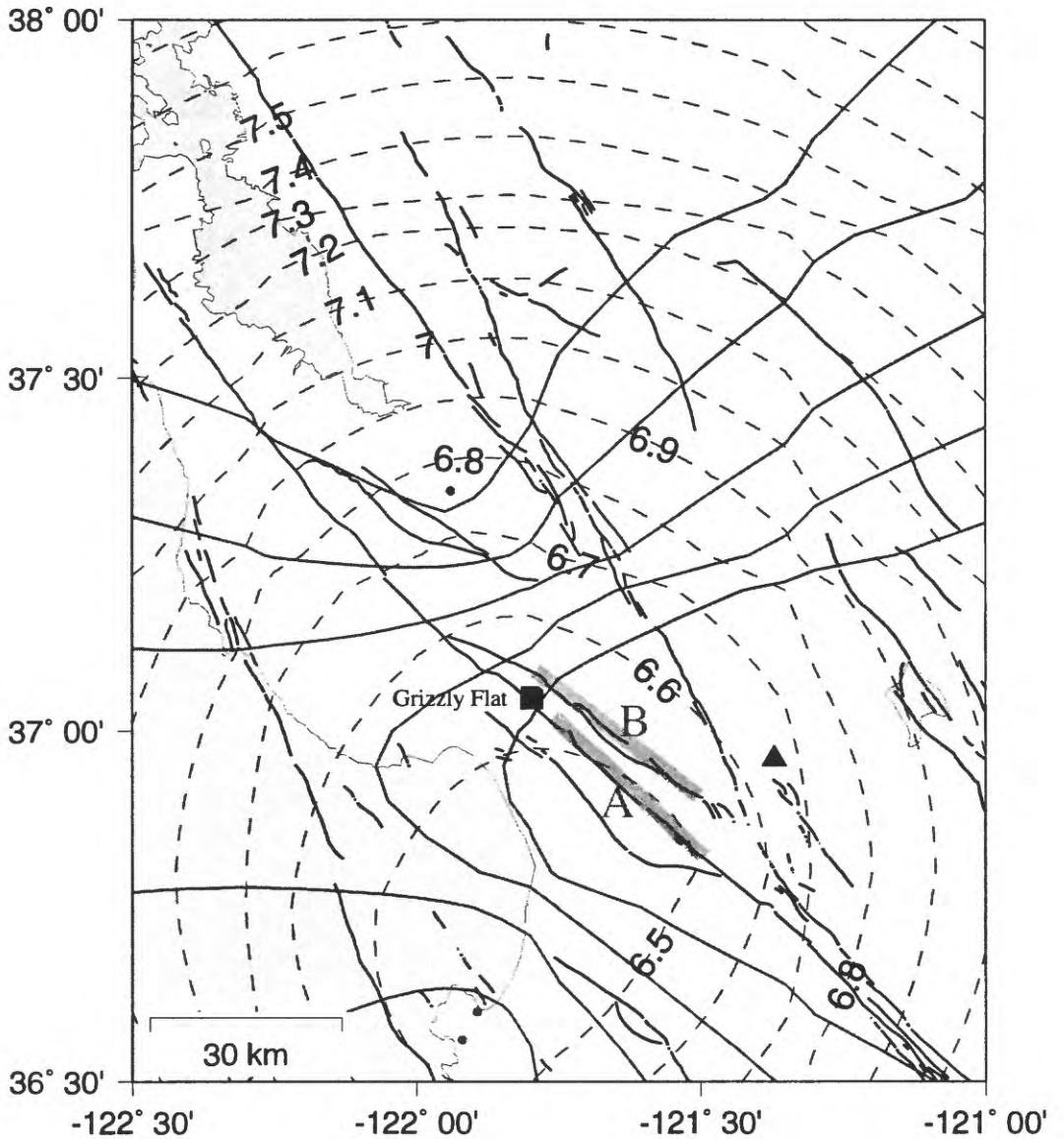
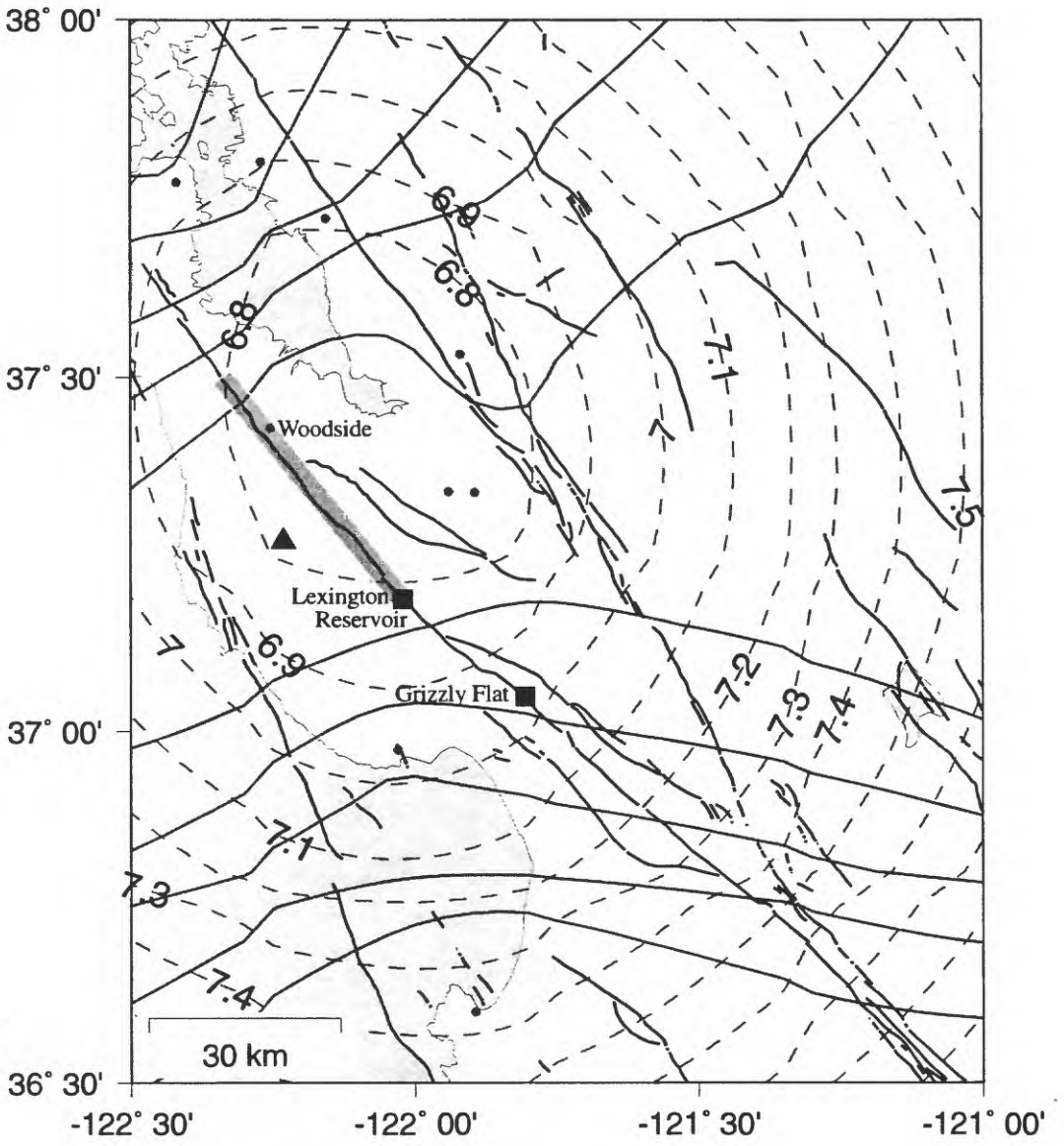
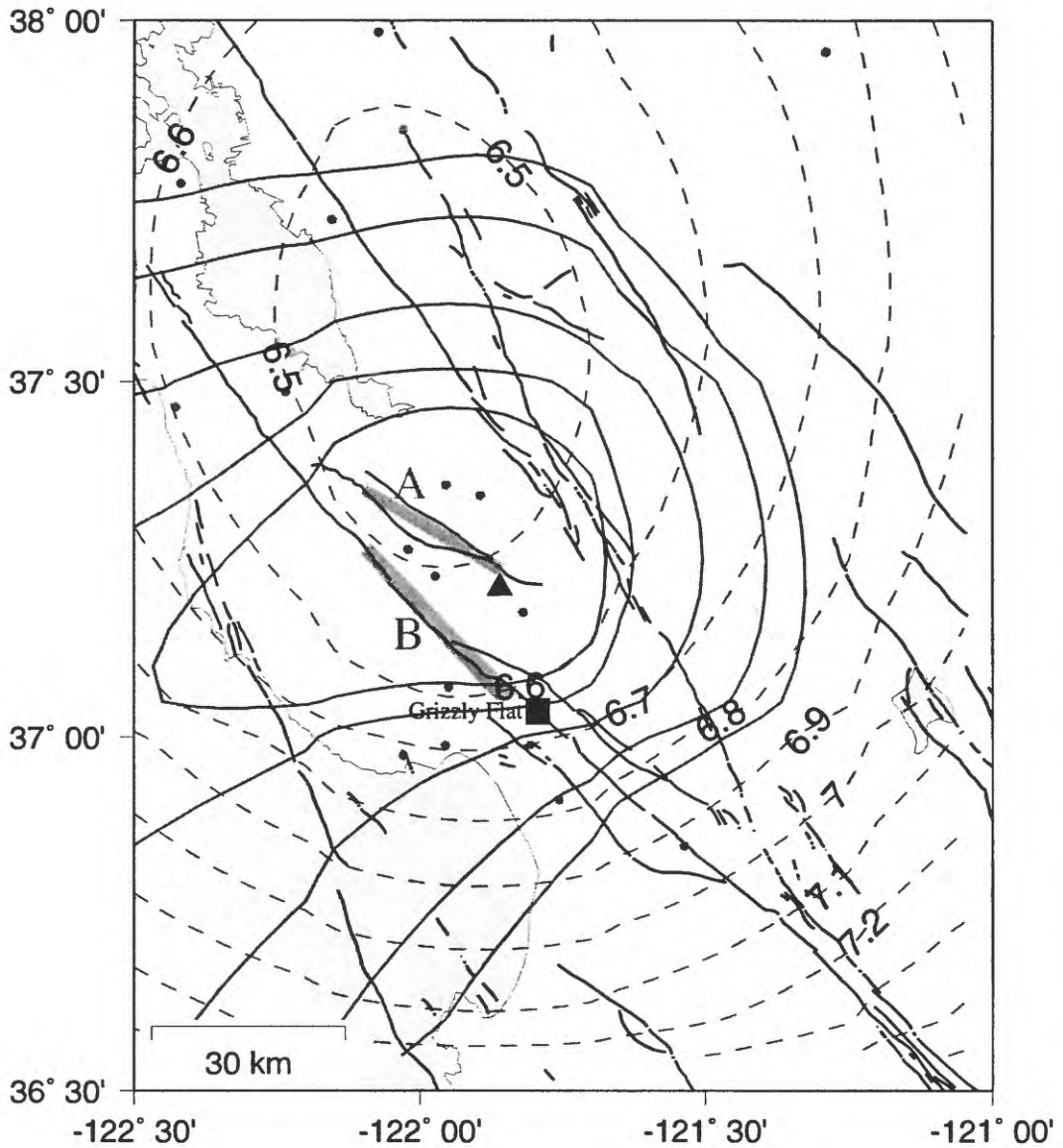


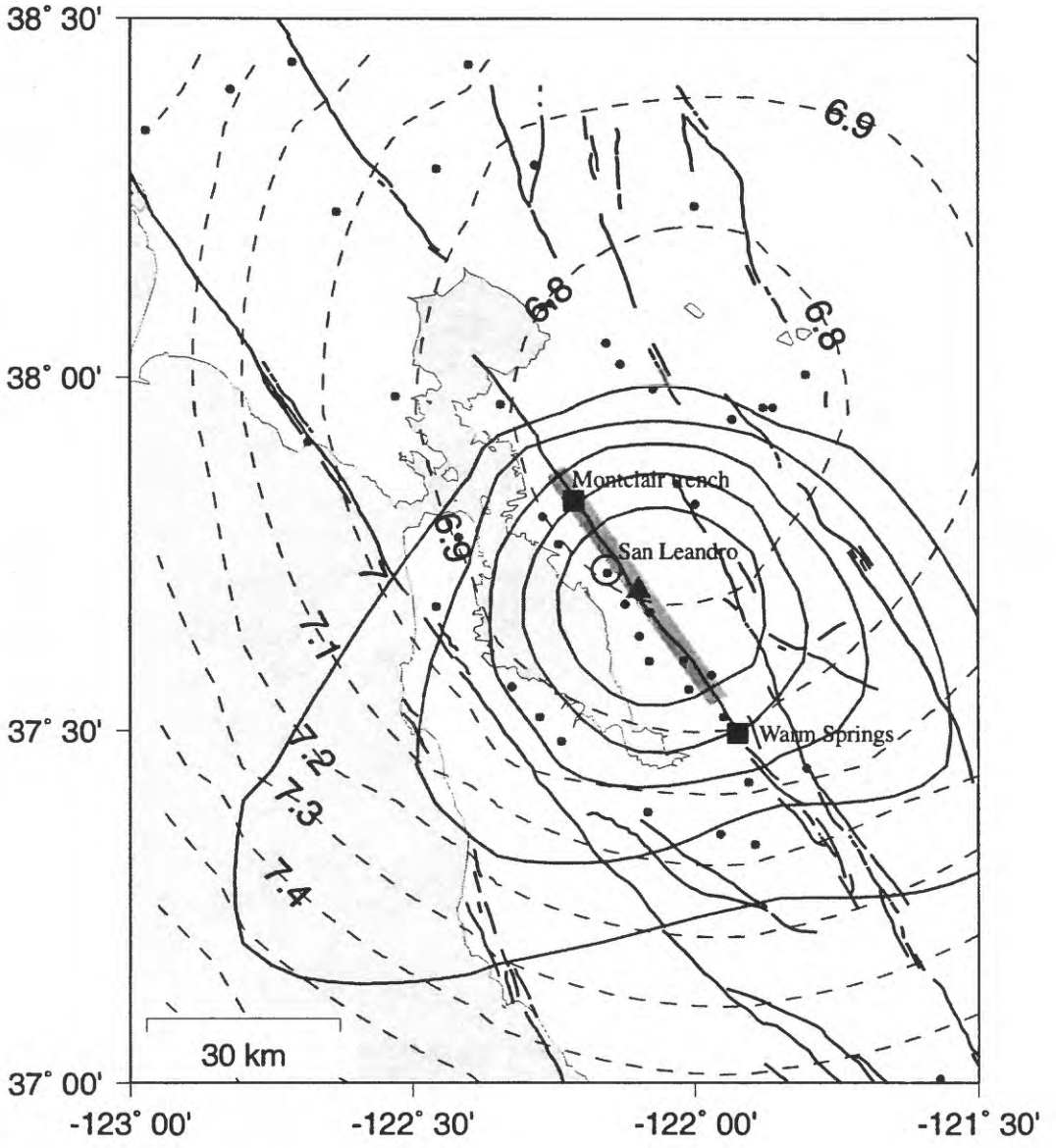
10 June 1836. M = 6.5 (95% confidence range 5.9-7.0) shock located to the east of Monterey Bay. The location of the intensity center is poorly constrained. Two scenarios: A) a 33-km-long strike-slip rupture of the San Andreas fault extending from south of San Juan Bautista to south of the Grizzly Flat trench site (Schwartz *et al.*,1999). B) a 33-km-long strike-slip rupture of the south end of the Sargent fault. Depth extent = 10 km and mean slip = 0.6 m for both scenarios.



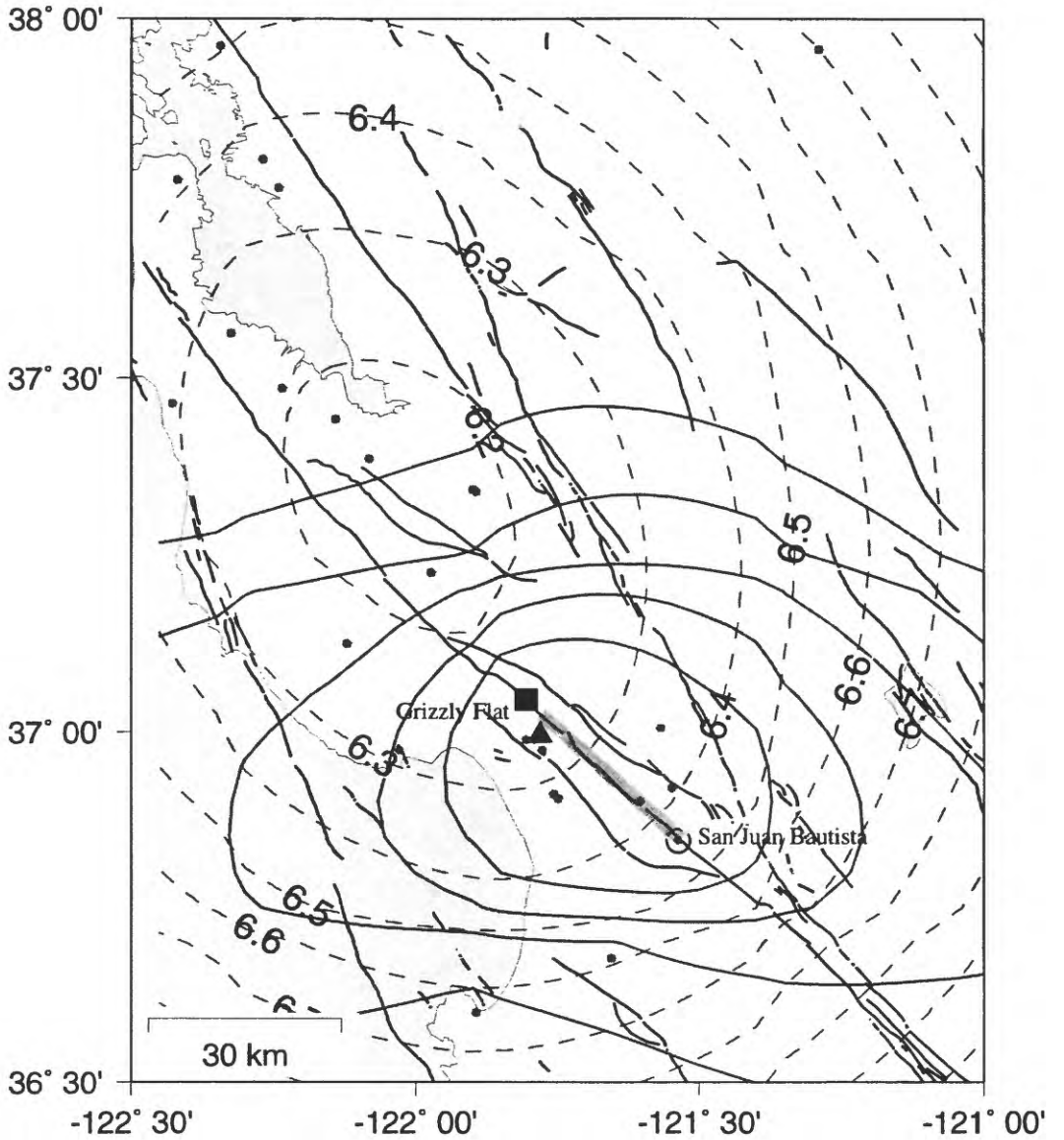
June 1838. M = 6.8 (95% confidence range 6.3-7.2) shock located on the Peninsula section of the San Andreas fault. The 45-km-long strike-slip rupture extends from Lexington Reservoir to 10 kilometers northwest of Woodside. The rupture crosses the trenches at Filoli near Woodside where Hall *et al.* (1999) reported 1.6 ± 0.7 m of slip in 1838. The scenario rupture does not cross the Grizzly Flat trench site where Schwartz *et al.* (1999) found no distinct evidence for 1838 slip. Depth extent = 10 km and mean slip = 1.5 m.



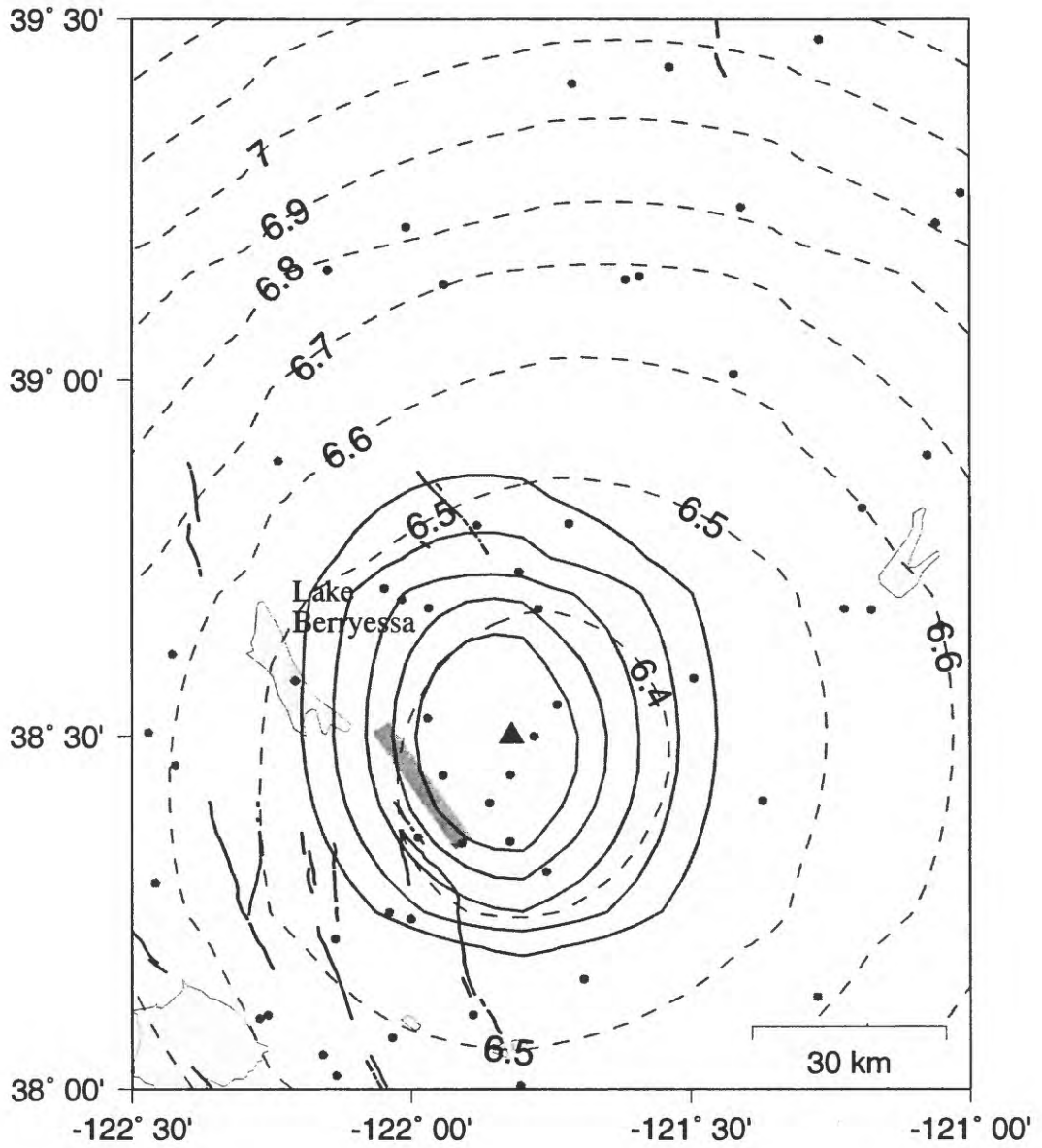
8 October 1865. M= 6.5 (95% confidence range 6.2-6.8) shock located to the north of the 1989 Loma Prieta earthquake. Two scenarios: A) a 25-km-long thrust on the Monte Vista fault system. Depth extent = 14 km and mean slip = 0.6 m. B) a 33-km-long strike slip rupture on the section of the San Andreas fault to the north of the Loma Prieta rupture. Depth extent = 10 km and mean slip = 0.6 m. The scenario rupture does not cross the Grizzly Flat trench site where Schwartz *et al.* (1999) found no distinct evidence for 1865 slip.



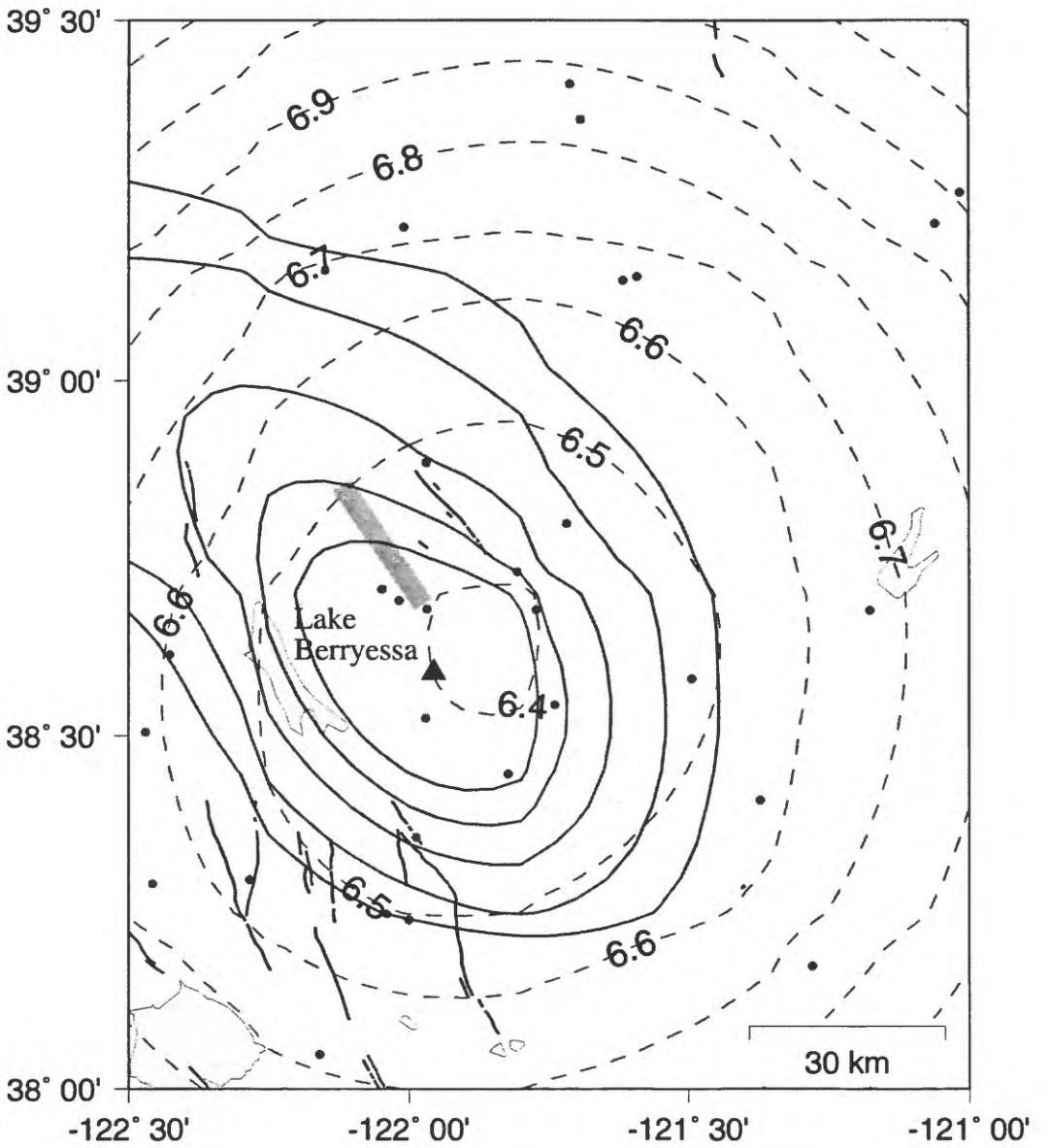
21 October 1868. M= 6.8 (95% confidence range 6.5-7.0) shock located on the Hayward fault. Ground rupture observed from Warm Springs through San Leandro and perhaps as far north as Mills College in Oakland. Lienkaemper *et al.* (1995) report a few decimeters of inferred 1868 slip in a trench at Montclair in north Oakland. The 45-km-long strike-slip rupture extends from a few km north of Warm Springs to a few km north of the Montclair trench. Depth extent 10 km and mean slip = 1.5 m.



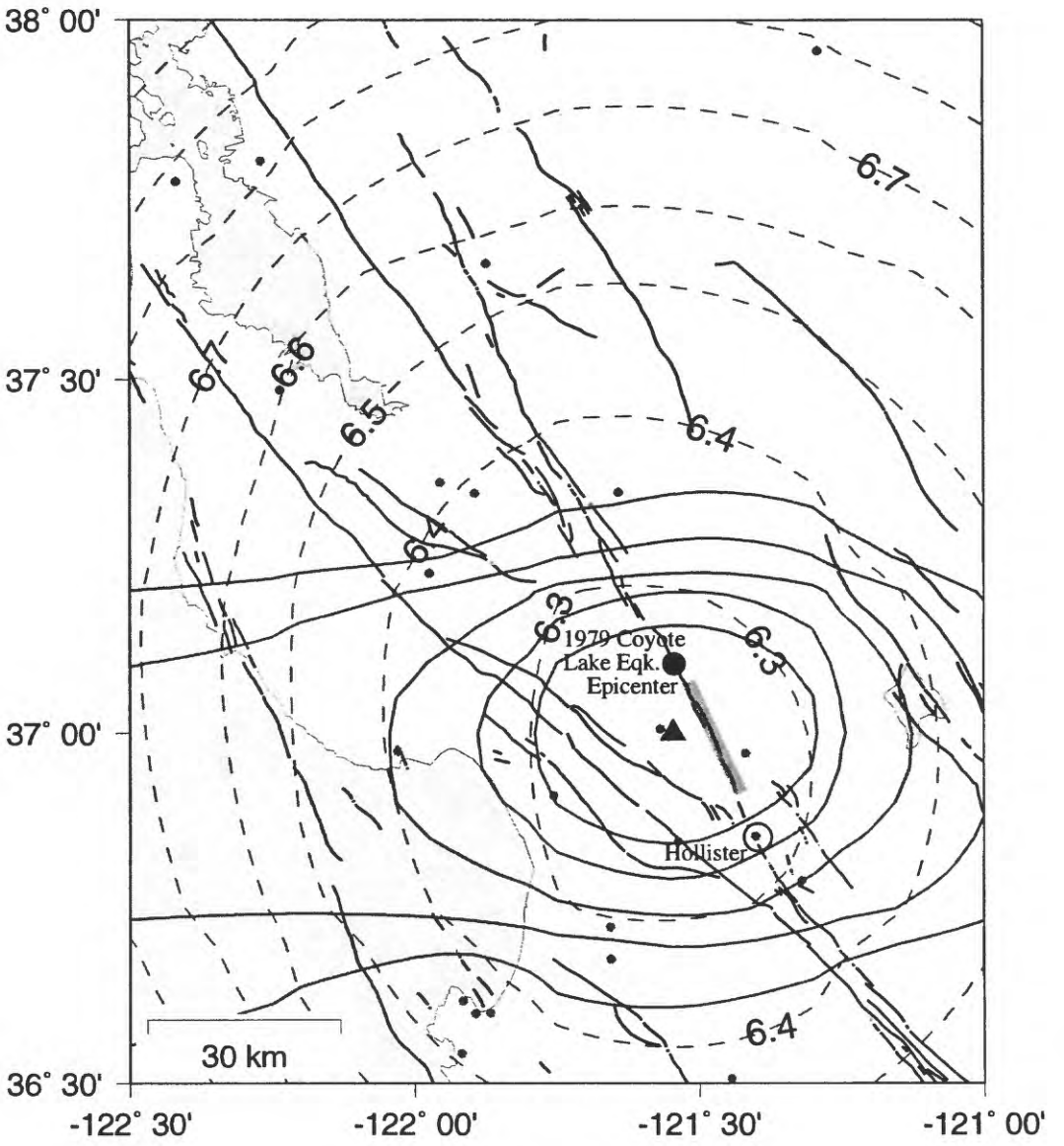
24 April 1890. M= 6.3 (95% confidence range 6.0-6.5) shock located on the San Andreas fault. The 30-km-long strike-slip rupture extends from San Juan Bautista north to a few km south of the Grizzly Flat trench site. Depth extent = 10 km and mean slip = 0.4 m.



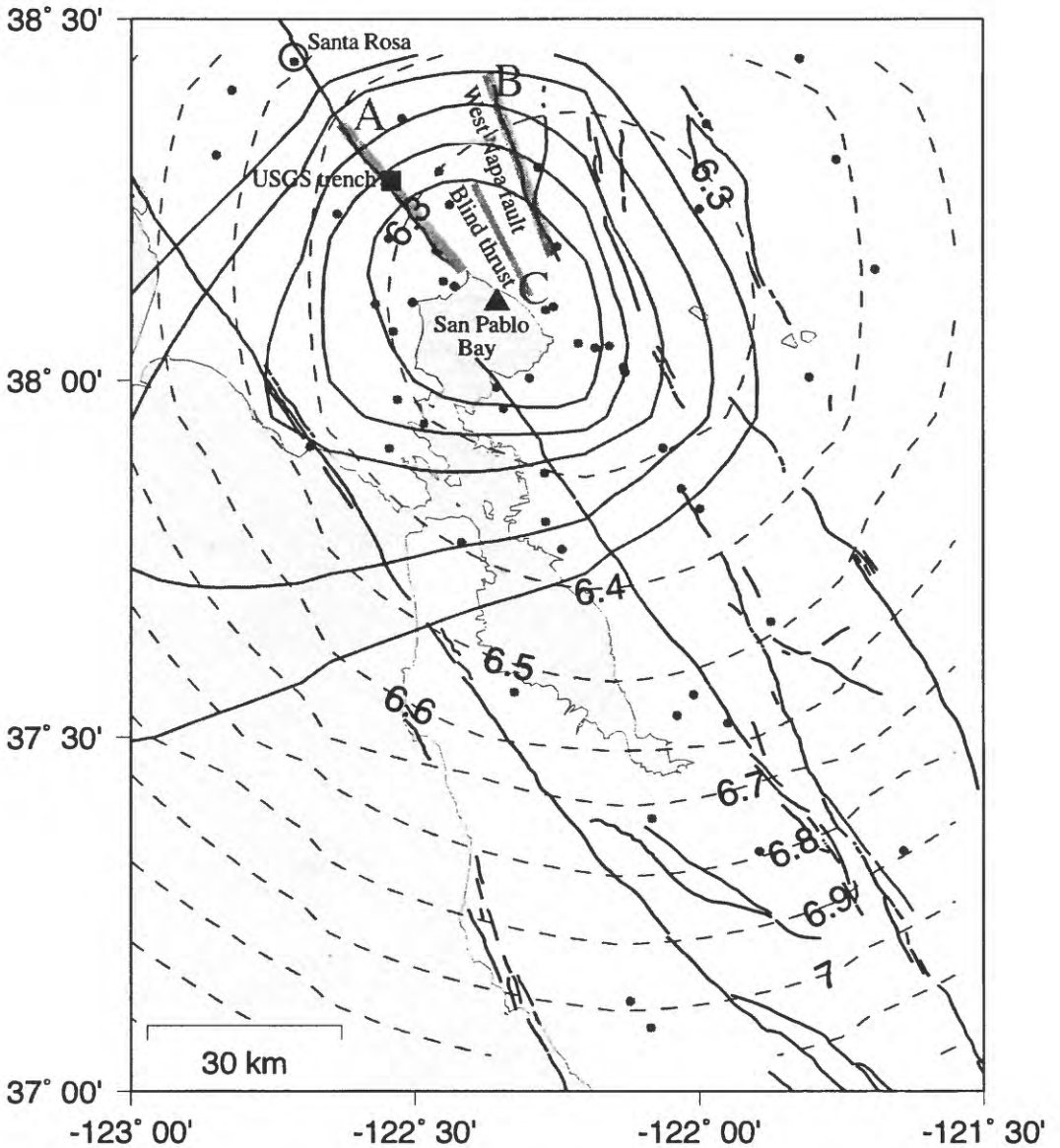
19 April 1892. M= 6.4 (95% confidence range 6.1-6.6) shock located on a segment of the Great Valley thrust. The 25-km-long thrust is located southeast of Lake Berryessa. Depth extent = 12 km and mean slip = 0.5 m.



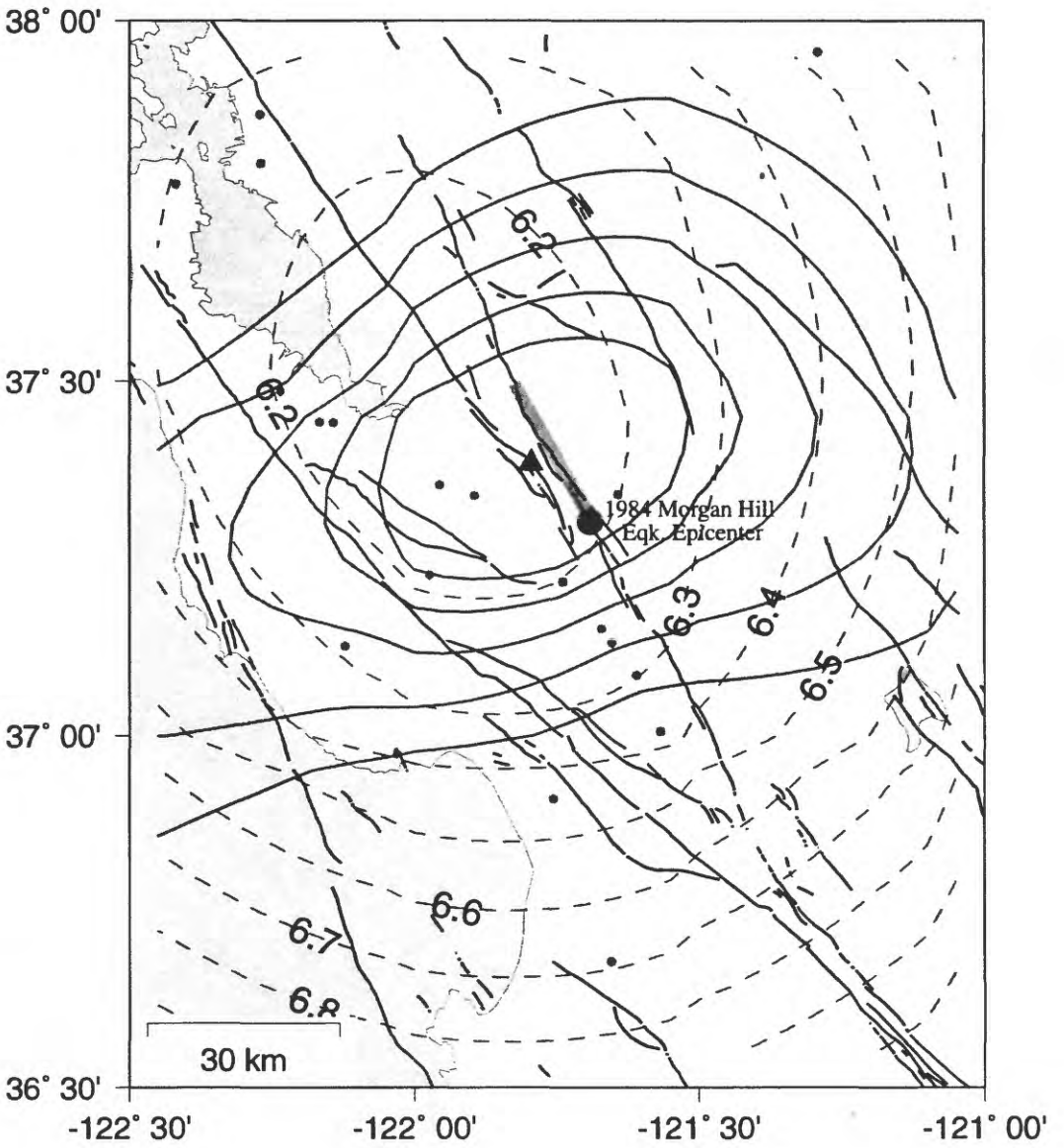
21 April 1892. M= 6.4 (95% confidence range 6.1-6.6) shock located on a segment of the Great Valley thrust. The 25-km-long thrust is located northeast of Lake Berryessa. Depth extent = 12 km and mean slip = 0.5 m.



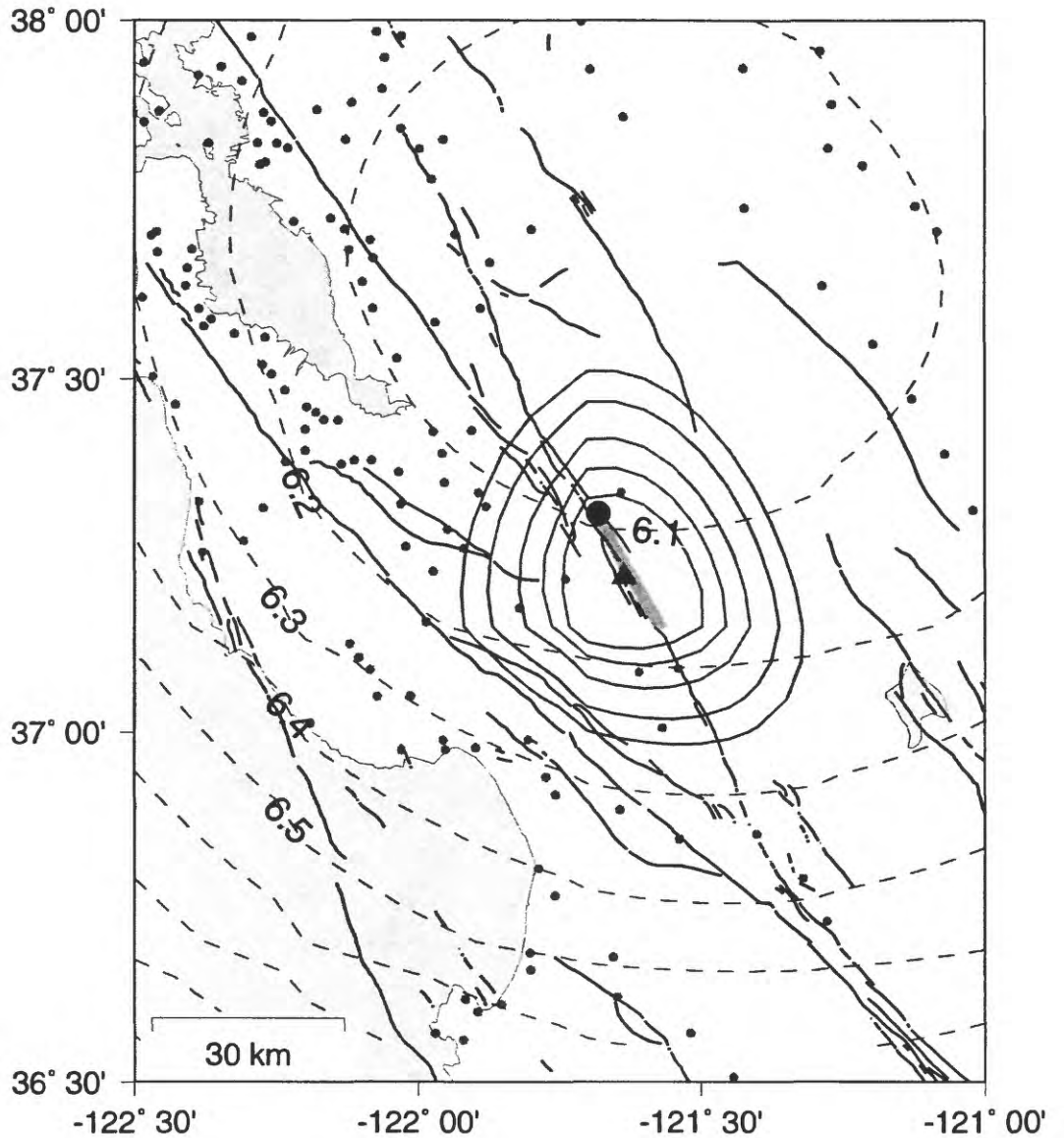
20 June 1897. M = 6.3 (95% confidence range 6.0-6.5) shock located on the southern Calaveras fault. Fissures were observed on the Pacheco Pass Road to the south of the 1979 Coyote Lake earthquake rupture. The 20-km-long strike-slip rupture extends from south of the Coyote Lake rupture to a few km north of Hollister. Depth extent = 10 km and mean slip = 0.5 m.



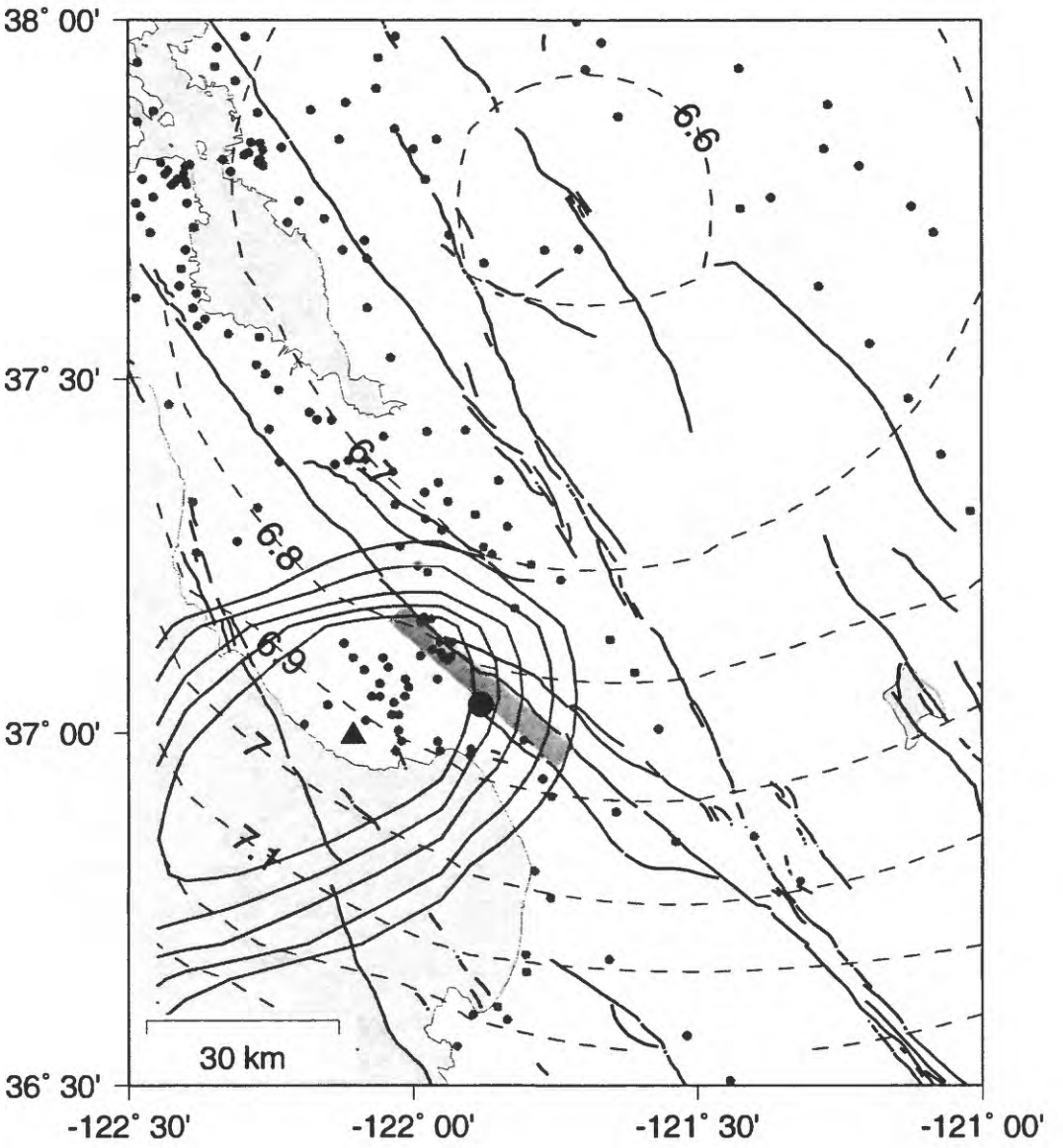
31 March 1898. M=6.3 (95% confidence range 6.0-6.5) earthquake located near San Pablo Bay. This event caused a seiche in San Francisco Bay (Toppozada *et al.*, 1992) so it is likely located near or beneath San Pablo Bay. The 1898 event was not seen in the USGS trench across the Rodgers Creek fault east of Petaluma, but slip during an M = 6.3 shock could easily be missed in the trench. Three scenarios: A) a 30-km long strike-slip rupture on the south end of the Rodgers Creek fault. Depth extent = 10 km and mean slip = 0.4 m. B) a 30-km long strike-slip rupture on the south end of the West Napa fault. Depth extent = 10 km and mean slip = 0.4 m. C) a 20-km long thrust on a blind-thrust fault east of San Pablo Bay. Depth extent = 12 km and mean slip = 0.5 m.



1 July 1911. M = 6.2 (95% confidence range 5.9-6.4) shock located on the southern Calaveras fault to the northwest of the 1984 Morgan Hill earthquake. The rupture zones of the 1911 and 1984 earthquakes may have overlapped. The 25-km-long strike-slip rupture extends northwest from the 1984 epicenter. Depth extent = 10 km and mean slip = 0.33 m.



24 April 1984. M = 6.2 Morgan Hill earthquake located on the southern Calaveras fault. The 20-km-long strike-slip rupture extends southeast from the epicenter. Depth extent = 10 km and mean slip = 0.33 m.



18 October 1989. M= 6.9 Loma Prieta earthquake located in the southern Santa Cruz Mountains. The 35-km-long oblique thrust extends southwest of the San Andreas fault (Wald *et al.*, 1991). Depth extent = 15 km and mean slip = 1.7 m.