# Seismicity Source Zones and Comments on $M_{max}$

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NSHMP Update of the Hawaii Seismic Hazard Model Workshop

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https://earthquake.usgs.gov/hazards/

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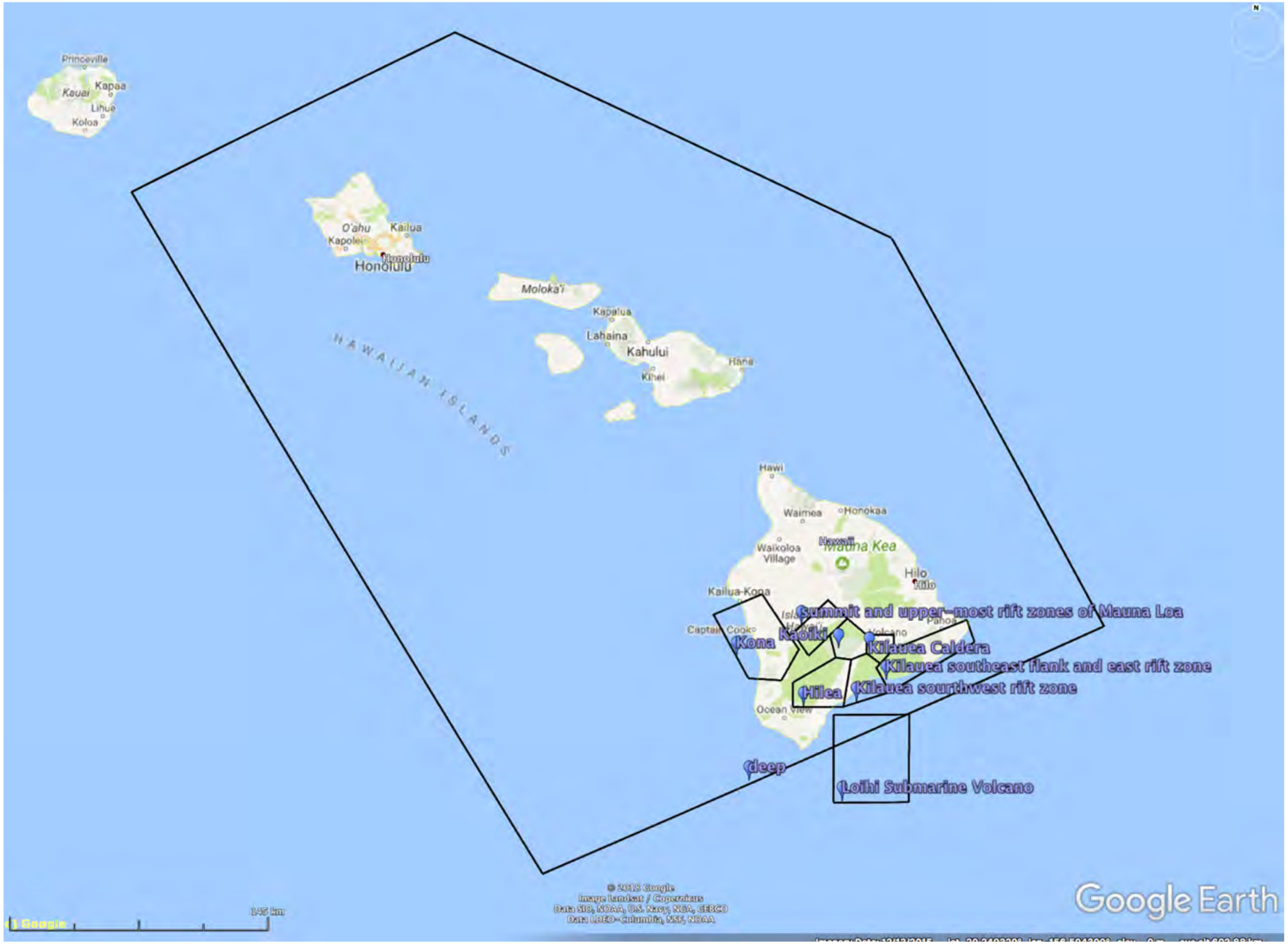
# Proposed Zones for Update of the Hawaii Seismic Hazard Model

## Shallow

| | |
|---|---|
| ZKON | Kona |
| ZHIL | Hilea |
| MSUM | Mauna Loa Summit and uppermost rift zones |
| ZKAO | Kaoiki |
| KCAL | Kilauea Caldera |
| KSWR | Kilauea SW rift zone |
| KSEF | Kilauea SE flank and E rift zone |
| ZLOH | Loihi submarine volcano |

## Deep

| | |
|---|---|
| Deep | Deep |



Comments on $M_{max}$

## Updated view of 1975-NOV-29 earthquake, Nettles and Ekstrom [2004]

Bulletin of the Seismological Society of America, Vol. 94, No. 2, pp. 422–429, April 2004

# Long-Period Source Characteristics of the 1975 Kalapana, Hawaii, Earthquake

by Meredith Nettles and Göran Ekström

**Abstract** The 1975 Kalapana, Hawaii, earthquake occurred under the highly mobile south flank of Kilauea Volcano. It has been interpreted variously as a normal-faulting earthquake, a thrust-faulting earthquake, and a landslide. Primary evidence for the landslide model has been the failure of previous faulting models to explain the observed Love-wave radiation pattern and the tsunami amplitudes generated by the Kalapana event. Here, we present a reanalysis of the long-period, digital seismic data for this event. Centroid-moment-tensor analysis shows that the seismic radiation pattern can be explained well by thrust faulting on a plane dipping shallowly landward. The seismic moment of $3.8 \times 10^{20}$ N m ($M_W$ 7.7) that we determine is approximately twice as large as earlier estimates. The geometry and seismic moment of the focal mechanism determined here are consistent with the observed tsunami amplitudes. Inversion of long-period body-wave waveforms shows that the earthquake source duration (~72 sec) is unusually long for an earthquake of this size.



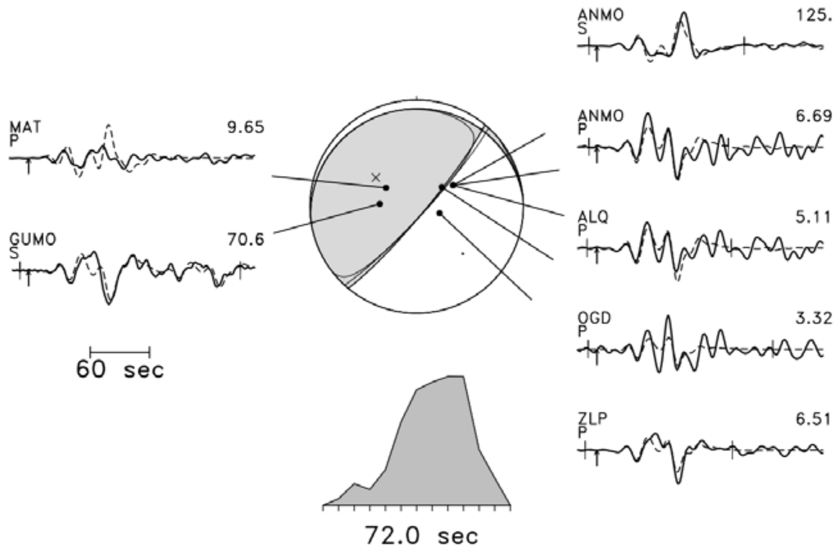



Figure 4. Results of body-wave analysis of the Kalapana earthquake. Long-period data seismograms are shown as solid lines; the calculated synthetic seismograms are shown as dashed lines. The wave type (*P* or *S*) is given below the name of each station. The maximum amplitude (in microns) for each trace is shown at right of each seismogram. Short vertical bars show the time window included for each station; where the bars are missing (MAT), the seismogram was not included in the inversion. The arrows show the arrival times of the *P* and *S* waves, as explained in the text. Shaded focal mechanism is that determined by inversion of the long-period body waves; the focal mechanism shown in outline only is that from the CMT inversion. The retrieved source time function is shown at the bottom of the plot. The depth of the earthquake was held fixed at 10 km in this inversion.

$M_W = 7.7$

Comments on $M_{max}$

Estimated magnitudes of historical earthquakes, Wyss and Koyanagi [1992]

# Isoseismal Maps, Macroseismic Epicenters, and Estimated Magnitudes of Historical Earthquakes in the Hawaiian Islands

By MAX WYSS and ROBERT KOYANAGI

U.S. GEOLOGICAL SURVEY BULLETIN 2006

**Table 1.** Destructive earthquakes in Hawaii County since 1868 ($I_{max}$≥VIII)

[Intensity (I) is as defined by the Modified Mercalli Intensity Scale (appendix 2). Magnitude: $\mathbf{M}_S$, surface-wave magnitude; $\mathbf{M}_L$, local magnitude. Sources for magnitude values: GR, Gutenberg and Richter (1954); GS, U.S. Geological Survey; HVO, Hawaiian Volcano Observatory; PAS, California Institute of Technology]

| Date | Epicenter location | Maximum intensity | Magnitude | Number of deaths | Damage |
|---|---|---|---|---|---|
| March 28, 1868 | Southern Hawaii | IX | 7 | 0 | Extensive in Southern Hawaii. |
| April 2, 1868 | Southern Hawaii | XII | 7.9 | 81 | More than 100 houses destroyed, tsunami. |
| October 5, 1929 | Hualalai | VIII | 6.5 | 0 | Extensive in Kona. |
| August 21, 1951 | Kona | VIII | 6.9$\mathbf{M}_S$ (GR) | 0 | Extensive in Kona. |
| April 26, 1973 | North of Hilo | VIII | 6.1$\mathbf{M}_S$, 6.2$\mathbf{M}_L$ (GS) (HVO) | 0 | Extensive in Hilo, $5.6 million. |
| November 29, 1975 | Kalapana | VIII | 7.1$\mathbf{M}_S$, 7.2$\mathbf{M}_S$ (GS) (PAS) | 2 | Extensive in Hilo, $4.1 million. |
| November 16, 1983 | Kaoiki fault | IX | 6.7$\mathbf{M}_S$, 6.6$\mathbf{M}_L$ (GS) (HVO) | 0 | Extensive damage in Southern Hawaii, more than $6 million. |
| June 25, 1989 | Kalapana | VII | 6.2$\mathbf{M}_S$, 6.1$\mathbf{M}_L$(GS) (HVO) | 0 | Southeast Hawaii almost $1 million. |
| 1834–1983 | 14 earthquakes | ≥VI | | | |

Comments on $M_{max}$

Estimated magnitudes of historical earthquakes, Wyss and Koyanagi [1992]

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Magnitudes and locations of historical earthquakes are based on macroseismic information, in combination with macroseismic and instrumentally-derived information from modern earthquakes.

# Comments on $M_{max}$

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ISOSEISMAL MAPS

1868

Intensity VIII extends over half the island

Intensity V extends to East Oahu

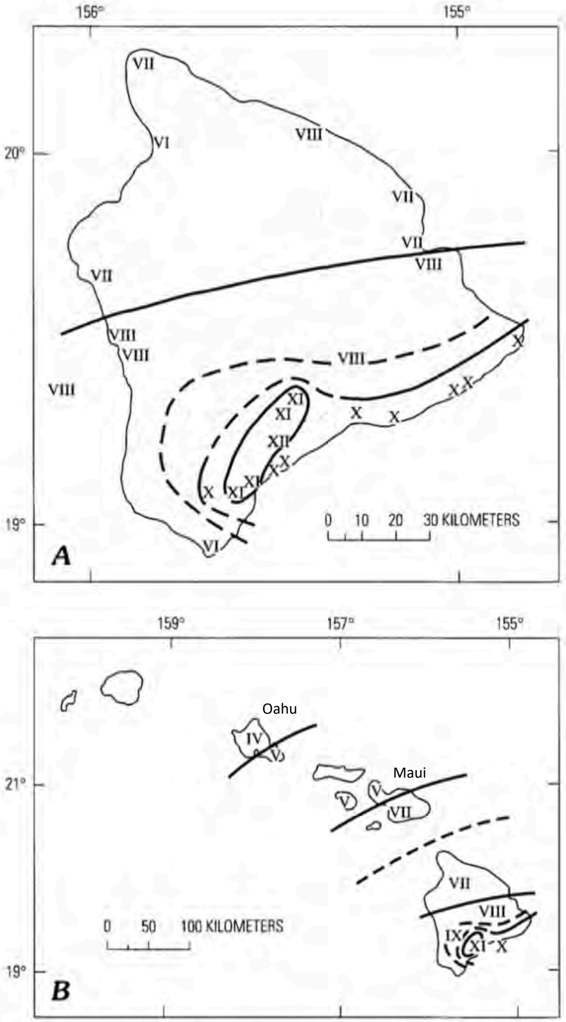


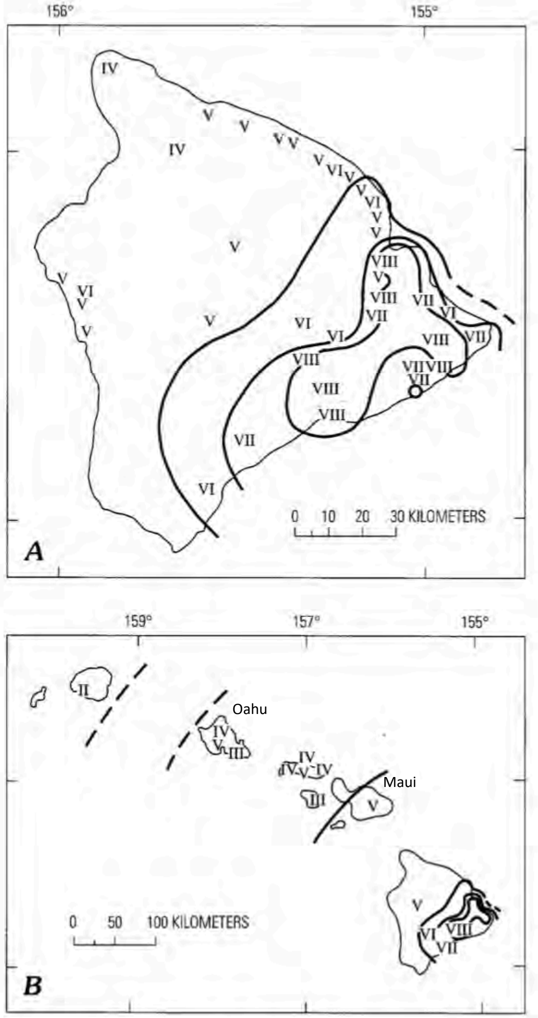

**Figure 46.** Isoseismal maps for the earthquake of April 2, 1868. *A*, Island of Hawaii. *B*, Hawaiian Islands. The isoseismals for the island of Hawaii shown in *B* are defined by the data in *A*. (For additional explanation see figure 2.)

1975

$M_W$ 7.7

Intensity VIII extends over 20% (?) of island

Intensity V extends to central Maui




**ure 6.** Isoseismal maps for the earthquake of November 29, '5. *A*, Island of Hawaii. The epicenter (open circle) does not ncide with the area of highest intensities. *B*, Hawaiian nds. The isoseismals for the island of Hawaii shown in *B* are ined by the data in *A*. (For additional explanation see fig- ... 2.)

# Comments on $M_{max}$

- Some basis to suggest revisiting historical earthquake magnitudes, given updated magnitude for 1975 Kalapana earthquake, as well as additional observations from earthquakes recorded since Klein and others [2001]

- Preliminary estimates of $M_W$ for 1868 earthquake as high as $M_W$ 8.1 – 8.2

- How might this influence specification of $M_{max}$ going forward?