HAWAIIAN EARTHQUAKES

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PLATE TECTONICS

15 major tectonic plates

- Convergent Boundary (Nazca Plate & South American Plate)
- Divergent Boundary (African Plate and Arabian Plate)
- Transform Boundary (Pacific Plate & North American Plate)
HAWAIIAN EARTHQUAKES

Global seismic centres in 1975–99: earthquakes of magnitude 5.5 and greater

Circle size is proportional to earthquake magnitude.

Illustration by Encyclopedia Britannica, Inc.
Hawaii is one of the seismically most active states in the U.S. All Hawaiian earthquakes are ultimately associated with the unique tectonics that result from the growing volcanoes. There are 2 depth distributions:

**Shallow earthquakes**
(< 13 km depth)
mostly in the crust

**Deep earthquakes**
(> 13-60 km depth)
mostly in the mantle
The USGS operates a seismic network to monitor earthquakes, with particular focus on volcano monitoring.
The USGS Hawaiian Volcano Observatory (HVO) locates about 5,000-10,000 earthquakes each year.
Volcanic Earthquakes
Tectonic Earthquakes
M 7.7 Kalapana EQ (1975)
M 7.9 Kau EQ (1868)
Accompanied by local tsunamis
(15 m maximum)
HVO locates about 1,000 deep (> 13 km) earthquakes each year.

Deep background seismicity is common, indicating fault zones.
The Kiholo Bay earthquake was a large, deep mantle earthquake. Past large historic earthquakes of this type likely included 1871 Lanai, 1938 Maui, and 1929 Hualalai. The 1973 M 6.2 Honomu earthquake also occurred at 40 km depth.
M6.7 Hawaii Earthquake of 15 October 2006

Epicentral Region

EXPLANATION

* 15 Oct 2006
2006 Earthquakes
Earthquakes 1868 - 2005
- 3 - 3.99
- 4 - 4.99
- 5 - 5.99
- 6 - 6.49
M >= 6.5

Quaternary Faults
AGE
- <150 years
- <1,000
- <130,000
FOCAL MECHANISMS

Strike-slip

Normal (Dilatation)

Reverse (Compression)

View from Above ("Beach Ball")
The weight of the islands load and stress/bend the brittle lithosphere, generating stresses that drive earthquake faulting in the mantle [Pritchard et al., 2007].

[Watts and Ten Brink, 1989]
SEISMOGRAMS

USGS Strong-motion instrument seismogram at Waimea (on the Big Island)

Figure A-1: SM records for Waimea Fire Station during Mw6.7 Kiholo Bay earthquake.
SEISMIC WAVES

P wave
(Pressure, Primary)

S wave
(Shear, Secondary)

Surface Wave
M6.7 Kiholo Bay EQ recorded at a seismometer on Kauai

S & Surface waves

M6.0 Mahukona EQ
USGS ShakeMap for the Kiholo Bay Earthquake
USGS
Intensity Maps of Historic Earthquakes

- 2006 Mw 6.7
- 1951 Ms 6.9
- 1929 Ms 6.5
AFTERSHOCKS
Aftershocks for the Kiholo Bay Earthquake
Summary of Kiholo Earthquake Damage (Robertson et al., 2006; Chock, 2006):

Kawaihae harbor (liquefaction and lateral Spreading, structural damage)
Engineered buildings (e.g., Mauna Kea Hotel)
Non-engineered buildings (e.g., Kalahikiola Church)
Residential structures
Roadways, rockfalls, and landslides
Dams and irrigation ditches
Bridges (e.g., Kealakaha stream bridge)
Nonstructural damage (medical facility in Honokaa, Waikaloa Elementary School)
The cost of Hawaii natural disasters

2006 Kiholo Bay earthquake: >$200 million
2004 flood: $100 million
1992 Hurricane Iniki: $2 billion

1983 Kaoiki earthquake: $7 million
1975 Kalapana Earthquake: $4 million (2 tsunami deaths)
1973 Honomu Earthquake: $4 million
1946 Alaska tsunami: $26 million, 159 deaths
1868 Ka’u earthquake (46 tsunami deaths, 31 landslide/liquefaction related deaths)

Recent HAZUS simulations of possible Hawaiian earthquakes:

M 7 Maui earthquake: $\sim1$ billion

M 7 Kona earthquake: $\sim1$ billion (earthquake alone)
PLUME

Plume-Lithosphere Undersea Melt Experiment
Detected and located by HVO and observed on PLUME
Discovered 1,500 new earthquakes using PLUME

New and improved view of seismicity along the Hawaiian island chain

Seismicity in mantle around Maui and Molokai

Occasional earthquakes around Oahu and Kauai