



## Volcanoes Exploration Program: Pu'u 'Ō'ō

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### Measuring Seismic Activity



Seismic station STC is located a few kilometers west of Pu'u 'Ō'ō. The site consists of three sensors, including a broadband seismometer and an accelerometer in the yellow housings (bottom of photo) which are controlled by a datalogger (white housing, bottom right), as well as a short-period instrument (center top). Telemetry and power systems for the different sensors are housed in boxes near the top left and top right of the photo.

Seismology is perhaps the best known volcano monitoring technique, due to its ubiquitous use at volcanoes around the world, since almost all eruptions are preceded and accompanied by earthquake activity (although some recent research highlights examples where deformation has preceded earthquake activity, or where earthquake activity before an eruption is completely absent). Seismometers detect earthquakes by utilizing a mass suspended by a horizontal or vertical spring system, or (in modern instruments) by electrical forces. The apparatus is fixed to a stationary base, such as slab of solid bedrock, and the relative motion of the mass during an earthquake is used to measure the onset and amplitude of shaking, which can be used to determine the location, magnitude, and frequency content of an earthquake and, by inference, the mechanisms causing the earthquake.

In addition to discrete earthquakes, seismometers also measure volcanic tremor, which is essentially the background noise of a volcano. Increases in tremor usually precede and accompany volcano earthquakes, and tremor can be inferred from a single seismic station; thus, tremor measurement is a simple and useful volcano monitoring tool.

### Seismic Network at Pu'u 'Ō'ō

The [Hawaiian Volcano Observatory](#) maintains two seismometers located a few kilometers west of Pu'u 'Ō'ō. One instrument (STC short-period) is a short-period vertical sensor, sensitive to up-and-down motions caused by high-frequency earthquakes and changes in tremor. The other sensor (STC broadband), co-located with the first, is a broadband instrument capable of detecting signals over a wide range of frequencies (from short-period rock-breaking events to very-long-period earthquakes and teleseisms).

Using the [Data/Valve](#) interface, RSAM information for the vertical components of the short-period and broadband instruments can be retrieved. RSAM (Real-time Seismic Amplitude Measurement; Murray and Endo, 1992) is a measure of seismic amplitude over a given time period. When large earthquakes or seismic swarms occur, or levels of volcanic tremor increase, RSAM values will rise. It is important not to interpret RSAM solely in terms of a single process (like tremor) because RSAM does not differentiate between different types of volcanic or earthquake activity and also records other

Seismic Background Information

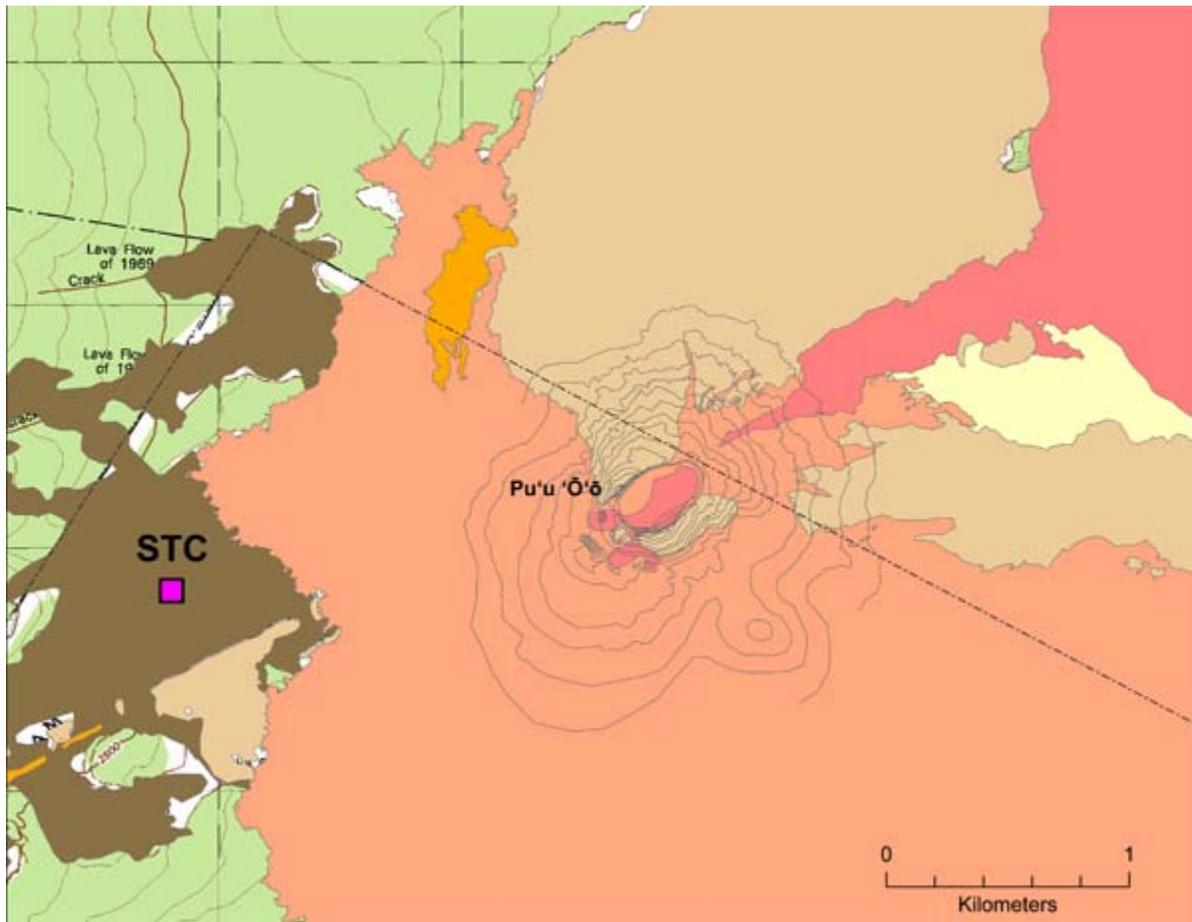
sources of ground vibration, such as wind, footsteps, high surf along the coast, and even helicopter noise. The main purpose of RSAM is to summarize seismic activity, and the technique is most useful in a relative sense. Specific examinations of seismograms and other data (for example, deformation, visual observations, gas emissions) are necessary to determine the causes of RSAM changes.

Note: This Web site does not host information about earthquake locations recorded by the HVO seismic network. For a listing and map of recent earthquakes in Hawai'i, please visit <http://tux.wr.usgs.gov/>.

**Pu'u 'Ō'ō Seismic Stations**

STC short-period: Data from this currently operational sensor are available from November 2000, and are listed under [Data/Valve](#) as 'STC\_EHZ'.

STC broadband: Data from this sensor (which is only intermittently operational as of early 2011) are available from February 2005, and are listed under [Data/Valve](#) as 'STC\_BHZ'.



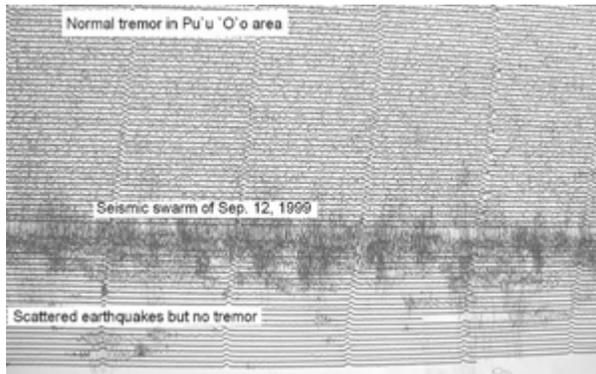
A map of the seismic network near Pu'u 'Ō'ō. Base map colors correspond to different lava flow ages. See the History section for more information.

**Data Availability**

*Dark blue filled areas correspond to periods when data is available.*

<b>STC_EHZ</b>					
<b>STC_BHZ</b>					
	2000	2001-2004	2005	2006-2010	2011/Present

## Seismic Background Information

**Example: Seismic Swarm of September 11-12, 1999**

**Part of a seismograph from the short-period vertical sensor at STC, near Pu'u 'Ō'ō, during the September 12, 1999, seismic swarm. Each horizontal line is 15 minutes, with 1 minute between each small tick mark. Notice that volcanic tremor disappeared after the seismic swarm, due to a pause in eruption following the intrusion. (1999/09/12)**

Early in the morning on September 12, 1999, volcano monitoring instruments near Pu'u 'Ō'ō detected an abrupt deflation, accompanied by a swarm of small earthquakes and volcanic tremor. These signals were utilized to infer an intrusion in Kīlauea's upper east rift zone, between the summit of the volcano and Pu'u 'Ō'ō (Cervelli and others, 2002). Deflation of both Kīlauea's summit and Pu'u 'Ō'ō, coupled with opening of the upper rift zone, indicated that magma was flowing away from both locations into a dike intrusion between Pauahi Crater and Mauna Ulu. Seismic stations along the rift zone revealed that earthquake swarms began abruptly and in unison with the strong deflation. The lack of tremor signal following the seismic activity during the intrusion indicates a pause in eruptive activity due to the temporary diversion of magma away from Pu'u 'Ō'ō.

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<b>Centers:</b>	Alaska	Cascades	Hawaii	Long Valley	Northern Mariana Islands
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URL: <http://ulua.wr.usgs.gov/vepp>

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A relatively new system, the Real-time Seismic-Amplitude Measurement (RSAM) has been developed by the USGS to summarize seismic activity during volcanic crises. This technique characterizes a volcano's changing seismicity in real time (as it is occurring) and relies on the amplitudes and frequencies of seismic signals rather than on the locations and magnitudes of the earthquakes. During a volcanic crisis, seismicity commonly reaches a level at which individual seismic events are difficult to distinguish. Analog seismic records (seismograms) provide some information, but rapid quantitative analysis is not always possible without substantially disturbing the continuity of recording. Although several real-time earthquake-detection and recording systems exist, most fail to provide quantitative information during periods of intense seismicity, which is a common situation before a volcanic eruption. Yet it is precisely during such periods that the need for timely quantitative seismic information becomes most critical. To fill this need a simple and inexpensive real-time seismic-amplitude measurement system (RSAM) was developed.

RSAM computes and stores the average amplitude of ground shaking caused by earthquakes and volcanic tremor over 10-minute intervals. Increases in tremor amplitude or the rate of occurrence and size of earthquakes cause the RSAM values to increase. Rather than focusing on individual events, RSAM sums up the signals from all events during 10- minute intervals to provide a simplified but still very useful measure of the overall level of seismic activity (Figure 9). This information is easy to plot and convey to public officials.

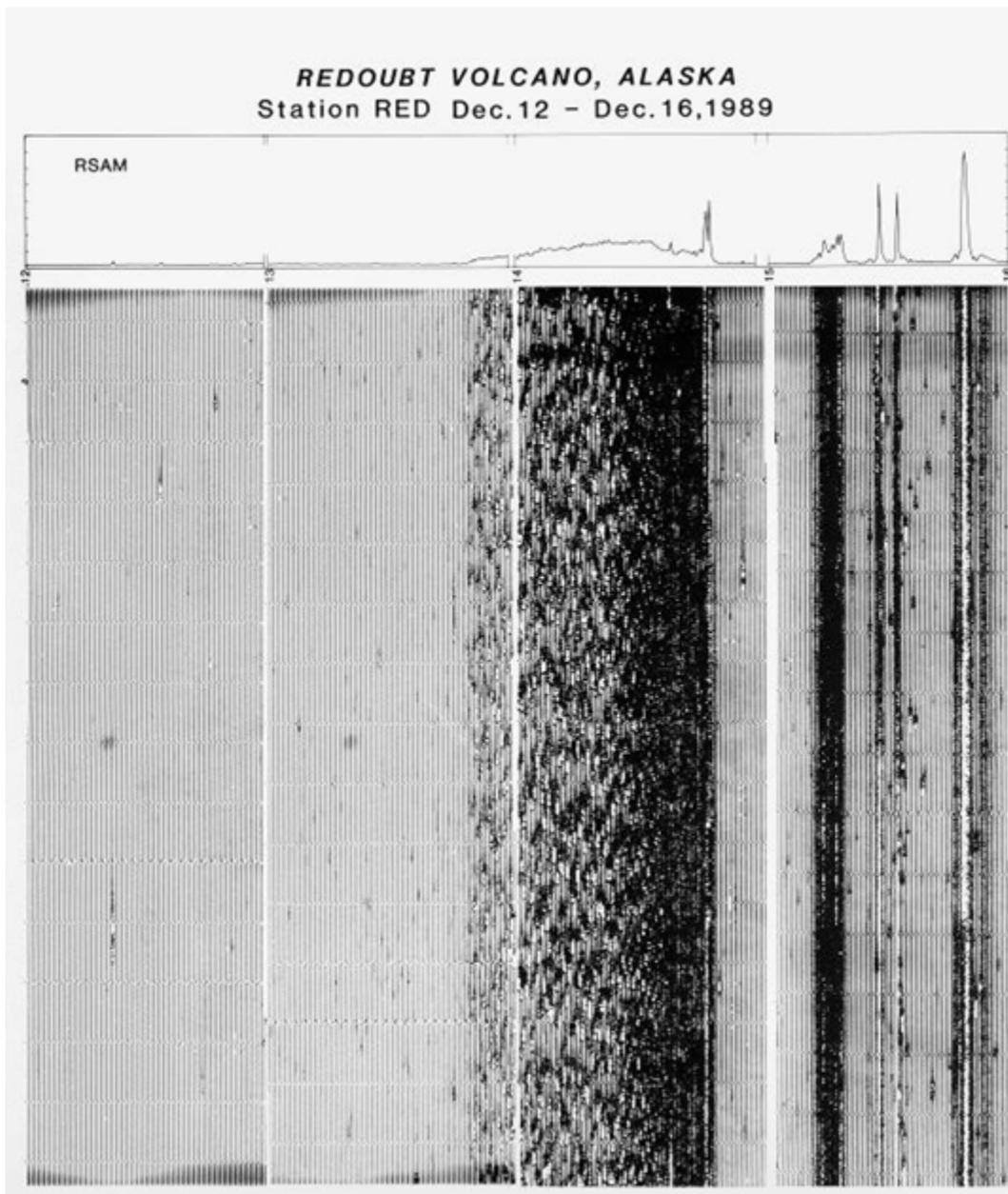


Figure 9 -- Real-Time Seismic-Amplitude Measurement (RSAM) plot. Comparison of RSAM data (top) and seismograms (bottom) shows how RSAM reduces complex seismic data to a simple line graph that correlates with ground-shaking energy. Eruptions (heavy dark lines) from Mount Redoubt occurred at 09:47 am, and 10:15 am on the 14th and 15th of December, 1989.