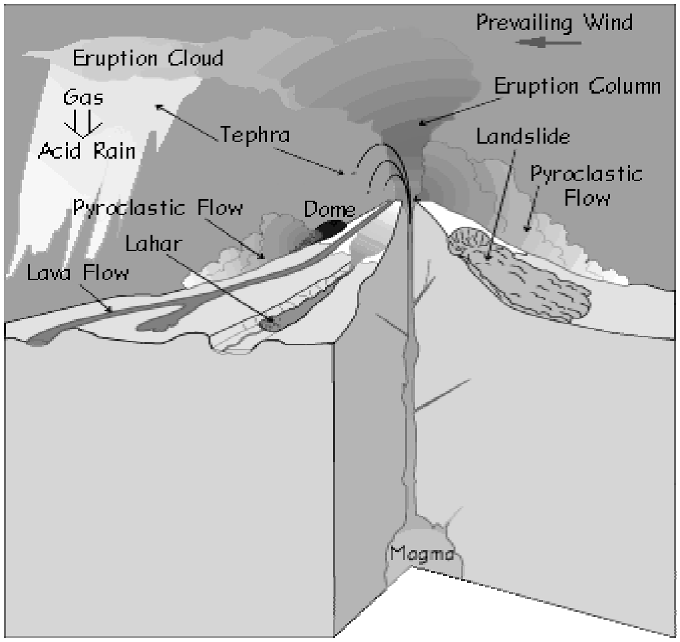
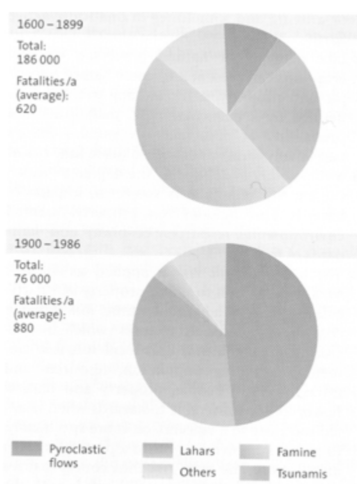
Volcanic Hazards



Major Volcanic Causes of Death



	Deaths
Lava Flows	900
Ash Falls	11,000 ?
Mud Flows	27,000
Pyroclastic Flows & Surges	55,000
Lateral Blasts	(67)??
Volcanic Gases	??
Tsunamis (Volcanic)	45,000?
Famine	123,000?
TOTAL	**262,000**

Video - Volcanic Hazards

- Was made in 1991 by Maurice and Katia Krafft for UNESCO following the unnecessary, loss of life at Nevada del Ruiz in Colombia in 1985.
- The aim was to clearly and simply illustrate volcanic hazards, so that populations living on, or close to, volcanoes could be better informed.
- Tragically the Kraffts were killed while filming on Unzen volcano, Japan in 1991.

Forecasting and Monitoring Eruptions

- <u>Long-Term</u>
  - Identification of <u>high-risk</u> volcanoes.
  - Mapping and identifying past volcanic hazards – prepare a <u>volcanic hazards map</u>.
  - Long-term forecasts
- <u>Short-Term</u>
  - Volcano monitoring in real-time.
  - Eruption forecasting and prediction.
  - Volcanic emergency management and planning – involves government and local authorities, civil defense, park or forest service.

High Risk Volcanoes

Which of the 500 or so active volcanoes, or the 1300 dormant volcanoes that have erupted in the last 10,000 years are considered high risk?

Criteria are based on:-

- Past eruptive history.
- Prevalence of explosive eruptions.
- Evidence for seismic activity or ground deformation (changes in tilt, distance, height).
- Proximity to population.

89 High risk volcanoes have been identified:-

- 42 in Southeast Asia.
- 40 in the Americas and Caribbean.
- 7 in Europe and Africa.

DANGER!!

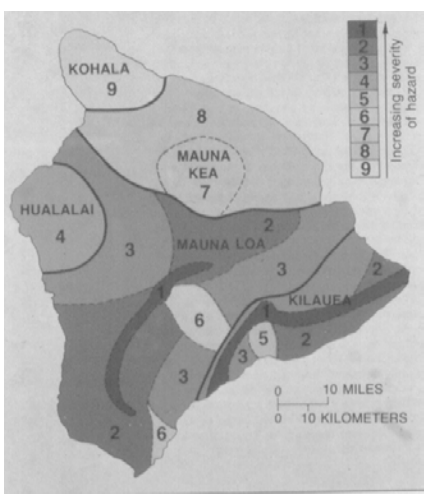
Lack of information, or a long dormant period, may exclude potentially hazardous volcanoes from this list (e.g. Mount Lamington, 1955; El Chichon, 1982).

Identifying and Mapping Volcanic Hazards

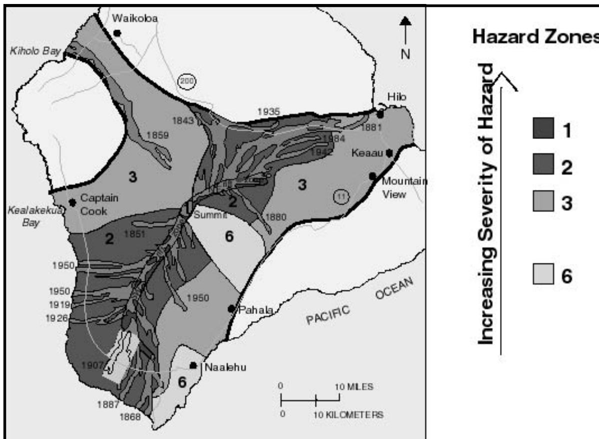
- Based on a careful study of the geological record of a volcano and the surroundings.
- Map distribution and extent of lava flows, ash-fall, pyroclastic flows and mud flows. This provides information on type and size of past eruptions.
- Dating of these events is critical in order to understand the frequency of these eruptions.
- All of this is based on the assumption that the geological past provides a useful guide to future activity.

Problem: Very few (24/89) high-risk volcanoes have been studied in such detail, particularly in under-developed countries.

Volcanic Hazard Maps



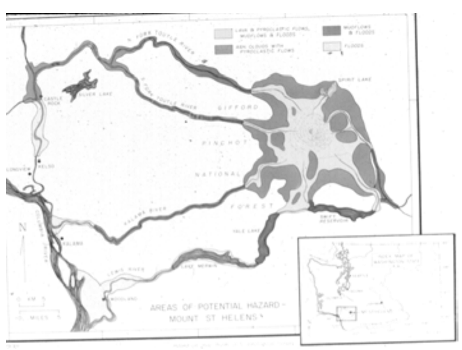
Volcanic hazard map for the island of Hawaii



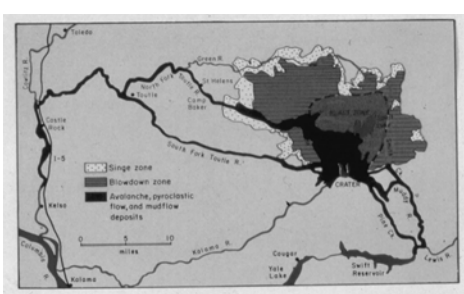
Volcanic hazard map for Mauna Loa volcano, Hawaii

Ocean View Estates (green area on hazard map) has recently been developed, despite its location in a high risk area (hazard zone 2).

Mount St. Helens Hazard Map

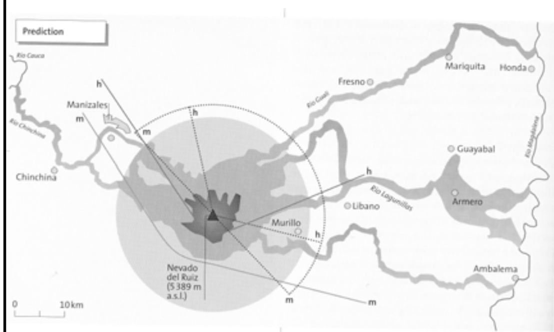


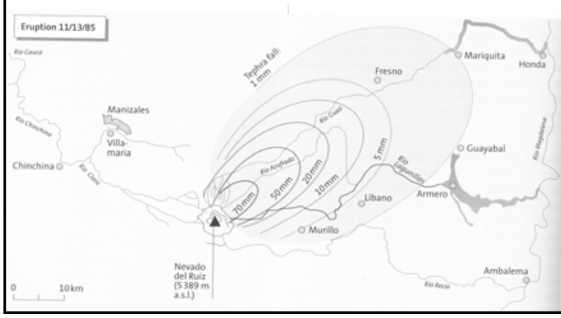
The map on the left is a hazard map for Mount St. Helens prepared in 1978, showing the expected extent of mudflows (brown), lava flows (yellow) and pyroclastic flows (orange). The authors also predicted a major eruption “before the end of the century”.



This map shows what actually happened in 1980. The prediction was pretty accurate, with respect to mud flows and pyroclastic flows, but failed to anticipate the landslide and lateral blast.

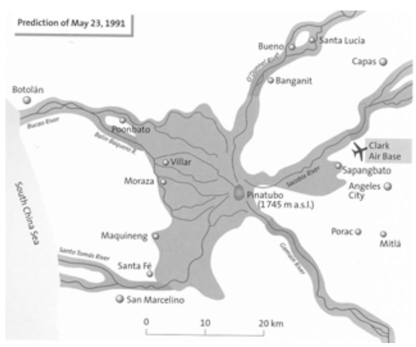
Nevada del Ruiz Hazard Map



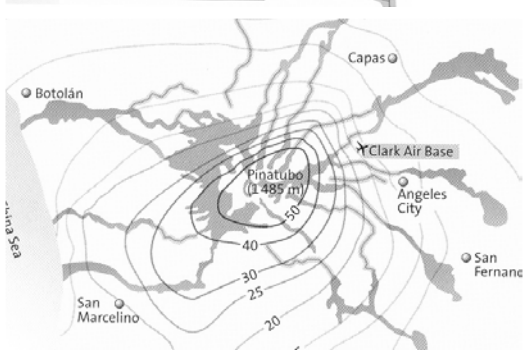


This relatively crude map was available in October, 1985, one month before the devastating mudflows that buried Armero and killed 22,000 people. Clearly, mudflows were the most serious hazards for the populated areas

Armero was built on mudflows that occurred in 1595 and 1845!



Hazard map for Pinatubo, May 23rd 1991

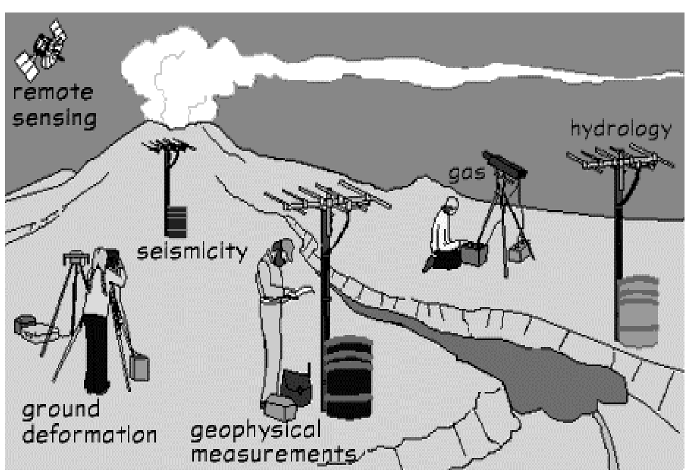


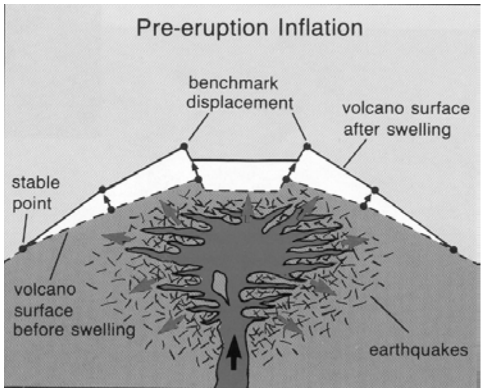
What actually happened following the June 15th 1991 eruption

Volcano Monitoring

- Most (perhaps all) volcanic eruptions are preceded by measurable physical and geochemical changes.
- Therefore, systematic monitoring provides a means to obtain short-term (hours/months) forecasts of eruptions.
- Measurements include:-
  - Seismic detection of small (M<4), shallow earthquakes beneath the volcano.
  - Measurement of ground deformation using tiltmeters and changes in distance and elevation.
  - Changes in the amount of gases (CO_2, SO_2) being released.

Volcano Monitoring Techniques

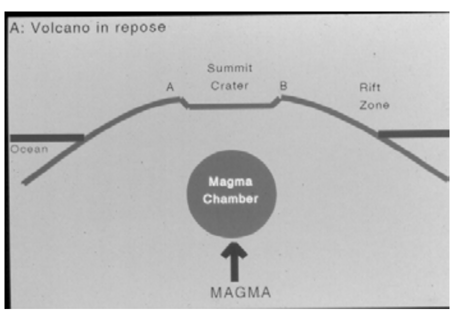


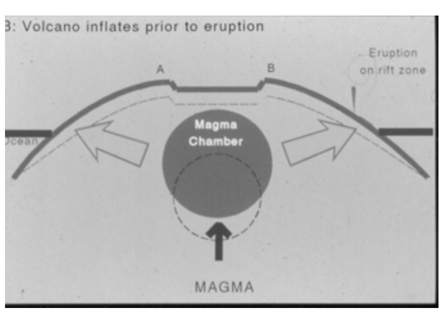


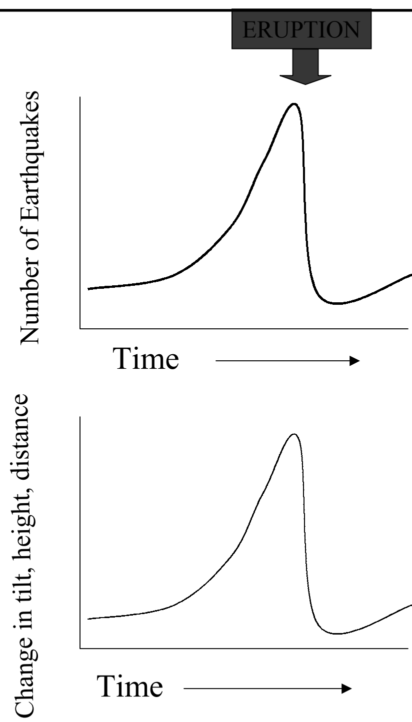
The basic philosophy behind monitoring is shown in this cartoon

Movement of magma high into the volcanic structure causes:-

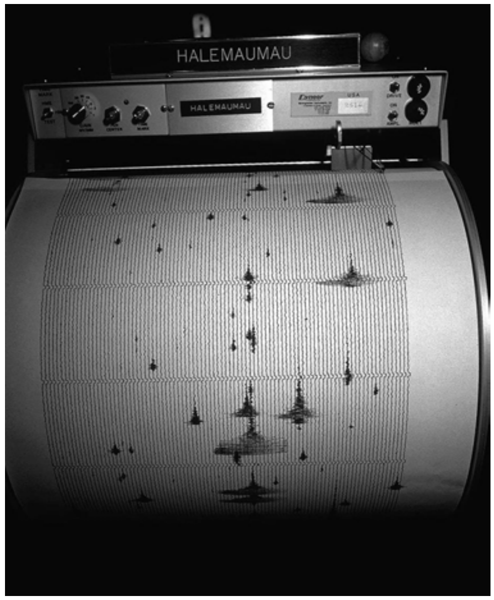
- Small earthquakes as pressure from the magma cracks surrounding rocks.
- The volcano swells or inflates, causes measurable changes in slope (tilt), distance and elevation.
- As magma approaches the surface, more gases are released.



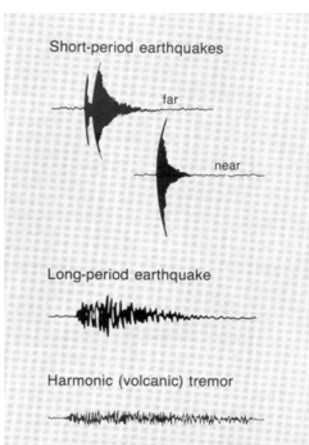




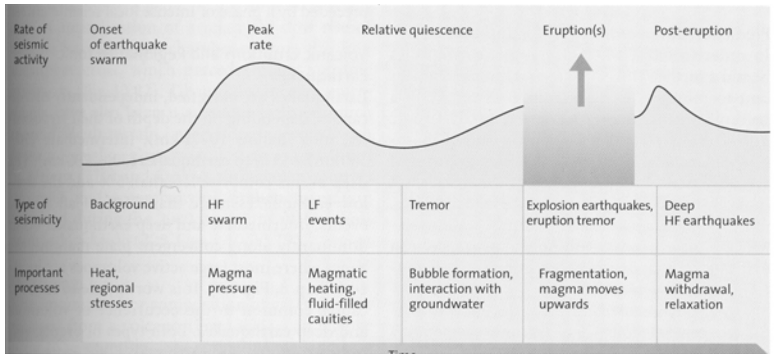
Seismograph



Seismic Activity

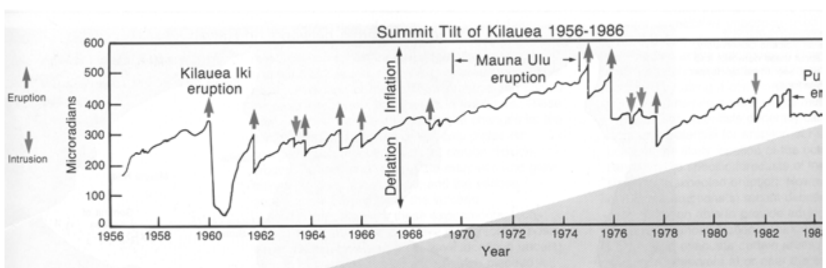


- Increase in seismic activity prior to an eruption is one of the better forecasting tools.
- Also, the nature of the quake may prove useful. The upper two examples reflect breaking rock (similar to tectonic quakes), whereas the lower two are indicative of magma movement.

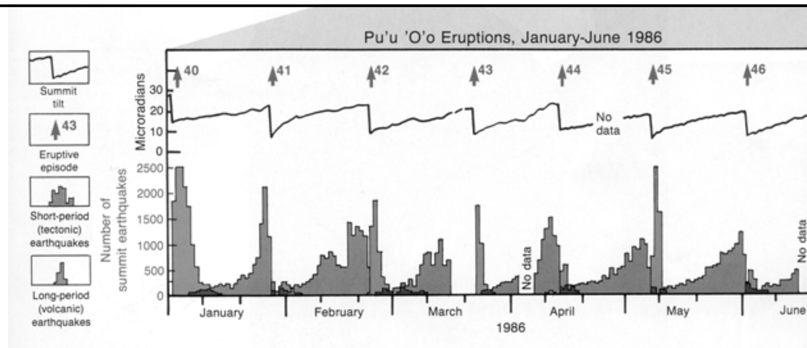


Here is an example of how the nature of earthquakes may change, in both frequency and type, leading up to, and after, the onset of an eruption. A scenario similar to this was recorded prior to the 1991 Pinatubo eruption.

Examples from Kilauea



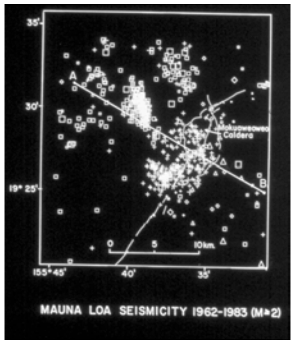
Changes in tilt at Kilauea volcano between 1956 and 1963. Note how the tilt gradually increases, then rapidly drops off when an eruption occurs (red arrow) or magma is intruded into the volcano (blue arrow).

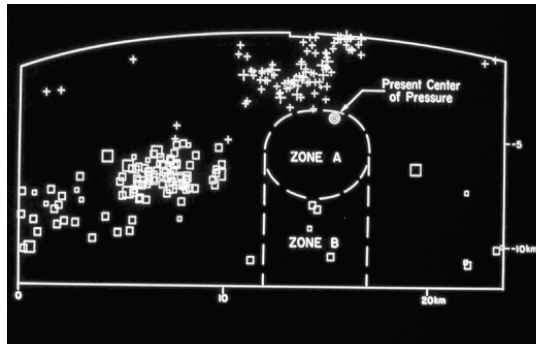


Changes in tilt and seismic activity at Puu Oo during several eruptive episodes. Note that:-

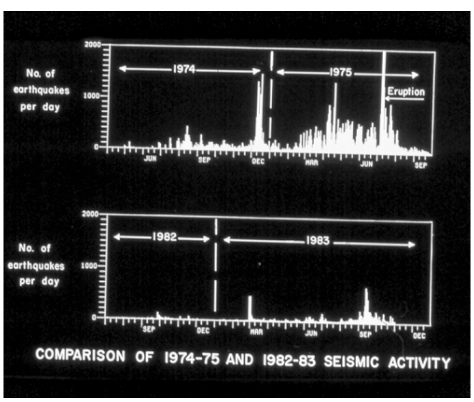
- There is an increase in tilt prior to each eruption
- The tilt rapidly declines after the eruption
- There is an increase in the number of tectonic earthquakes prior to the eruption.
- During the eruption there are long period earthquakes.

Mauna Loa Case History
1984 Eruption



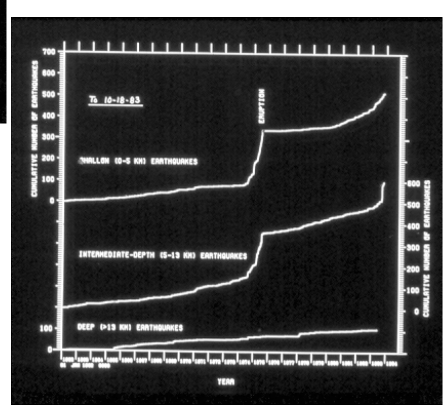


Earthquake activity at Mauna Loa between 1962 and 1983

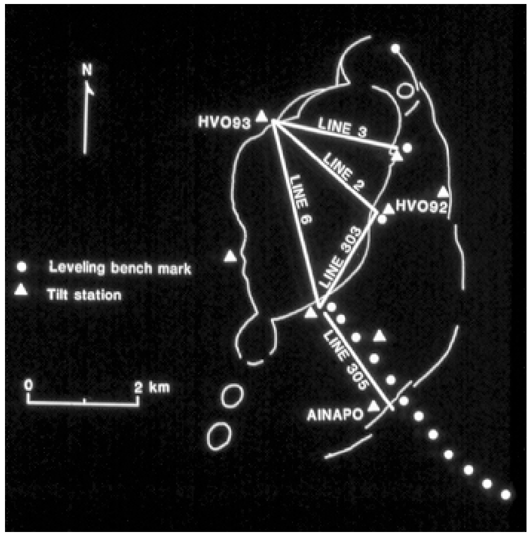


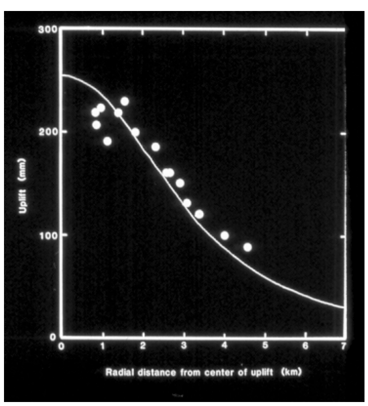
Earthquake Frequency

Cumulative Earthquake Frequency

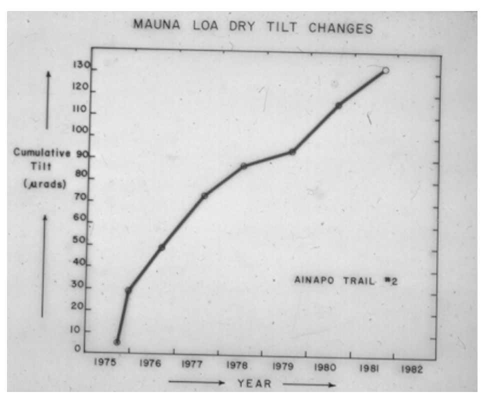


Tilt and Geodetic Stations around the Mauna Loa Caldera

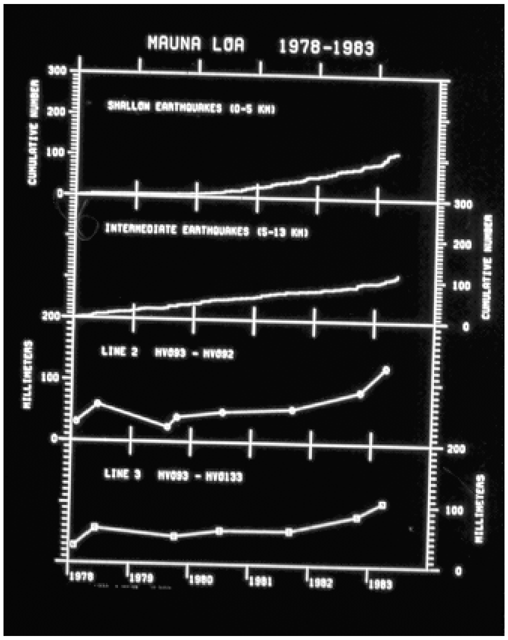




Increase in elevation from 1975 to 1982



Increase in tilt at Ainapo station from 1975 to 1982

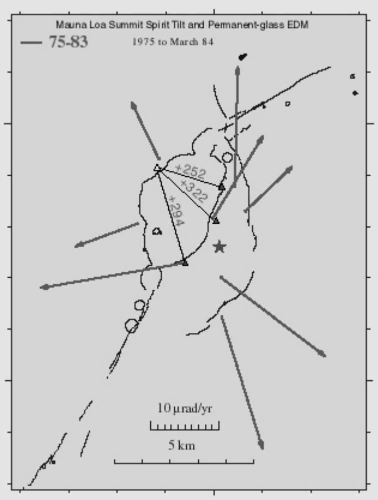


Correspondence between cumulative earthquake frequency and increase in distance across the caldera between 1978 and 1983. It was on this type of information that Decker et al., 1983 issued a forecast that Mauna Loa would probably erupt sometime within the next two years.

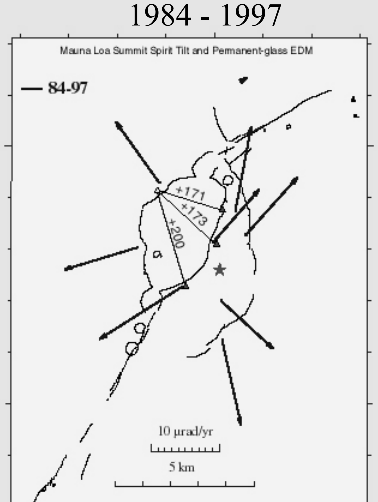
When Will The Next Eruption Occur?

Summit Tilt

1975 - 1983

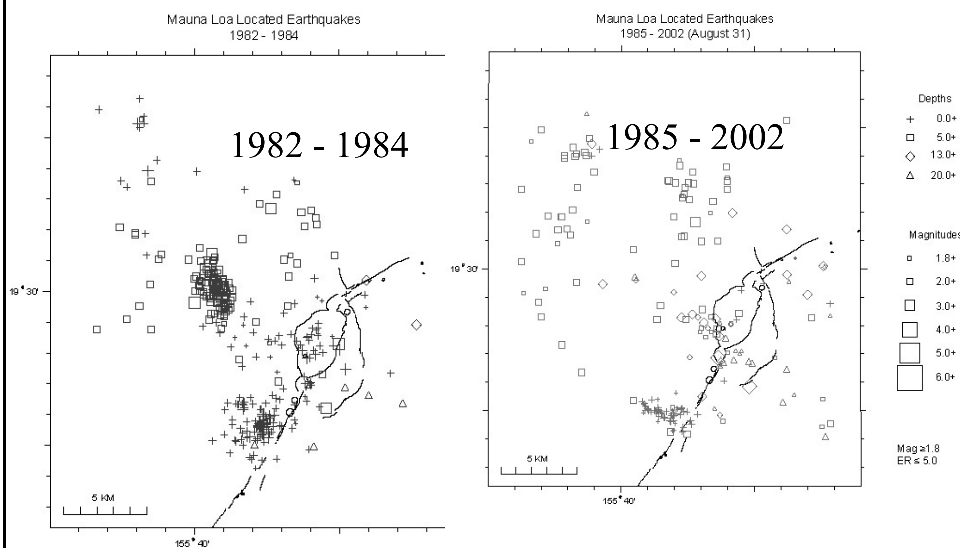


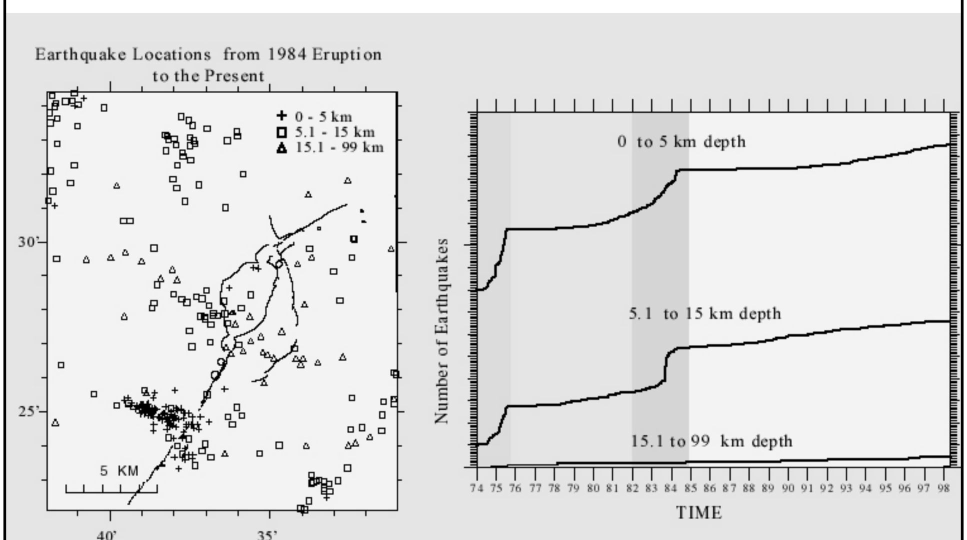
1984 - 1997

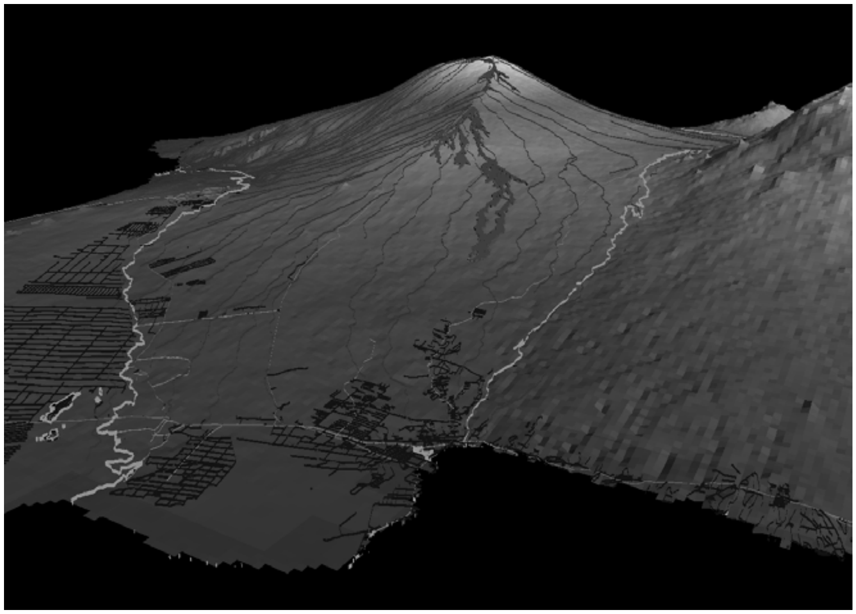


★ marks the center of inflation

Seismic Activity







Volcano Alert System

Stage	Observations	Actions
I (green)	Volcano in a normal state	None
II (yellow)	Volcano is “restless”, increase in seismicity, deformation, plumes of steam or gas **Eruption within weeks or months**	Alert authorities
III (orange)	Dramatic increase in above activity small ash and steam eruptions **Eruption within days or weeks**	Public made aware of problem Evacuation planned
IV (red)	Continuous seismic activity increased eruptive activity **Eruption within hours or days**	Evacuate public from hazard zones

Mount Pinatubo, Philippines,1991

Video - In the Path of the Killer Volcano

- Hydrothermal steam vents - potential source of energy.
- Ash and steam eruptions - volcano clearing its throat.
- Very large plinian eruption
- Ash fall - ash circles the globe and influences the climate.
- Pyroclastic flows
- Mud flows (lahars) - still going on today because of heavy rainfalls and thick unconsolidated ash
- The video clearly illustrates the dilemma facing volcanologists when monitoring a volcano and trying to predict what will happen.
- In this case the work was successful and thousands of lives were saved by timely evacuation.