

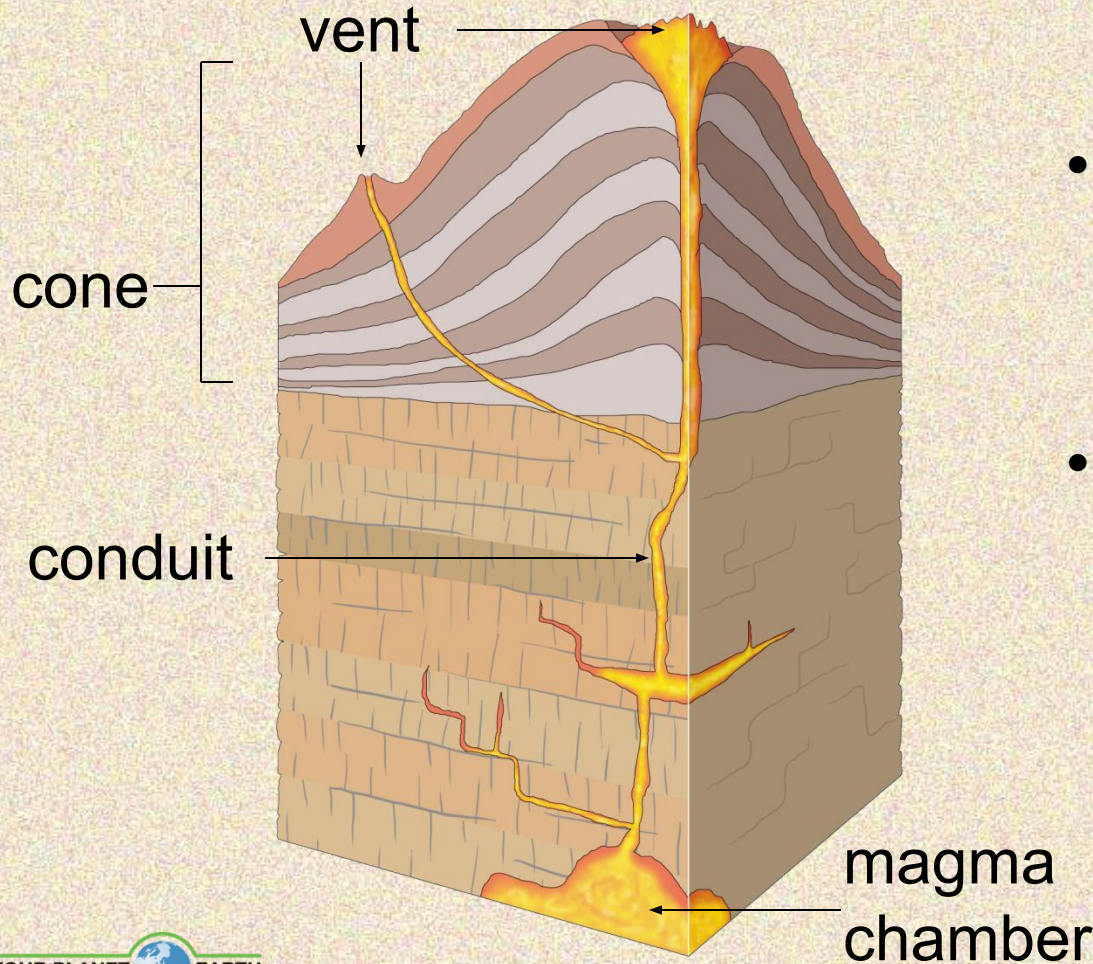


# Volcanic Eruptions and Hazards





# What is a volcano?



- A volcano is a vent or 'chimney' that connects molten rock (magma) from within the Earth's crust to the Earth's surface.
- The volcano includes the surrounding cone of erupted material.



# How and why do volcanoes erupt?

- Hot, molten rock (magma) is buoyant (has a lower density than the surrounding rocks) and will rise up through the crust to erupt on the surface.
  - Same principle as hot air rising, e.g. how a hot air balloon works
- When magma reaches the surface it depends on how easily it flows (viscosity) and the amount of gas ( $H_2O$ ,  $CO_2$ , S) it has in it as to how it erupts.
- Large amounts of gas and a high viscosity (sticky) magma will form an explosive eruption!
  - Think about shaking a carbonated drink and then releasing the cap.
- Small amounts of gas and (or) low viscosity (runny) magma will form an effusive eruption
  - Where the magma just trickles out of the volcano (lava flow).



# Explosive Eruptions

- Explosive volcanic eruptions can be catastrophic
- Erupt 10's-1000's km<sup>3</sup> of magma
- Send ash clouds >25 km into the stratosphere
- Have severe environmental and climatic effects
- Hazardous!!!



Mt. Redoubt

Above: Large eruption column and ash cloud from an explosive eruption at Mt Redoubt, Alaska

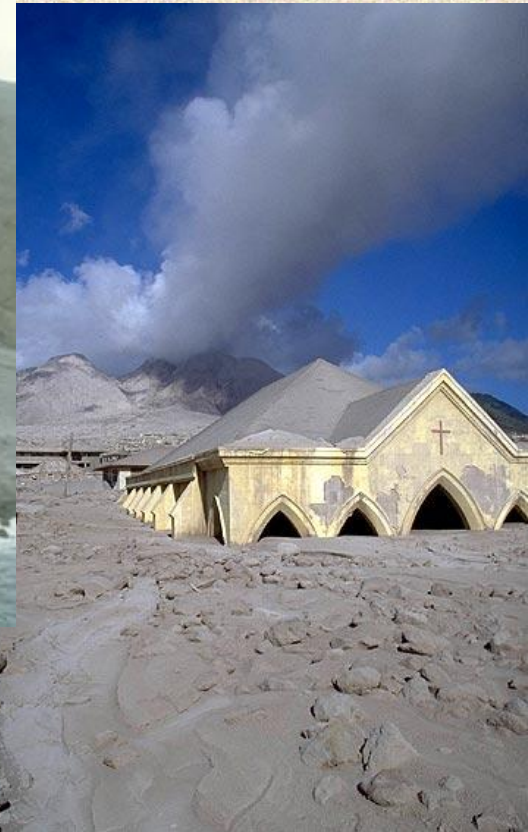


# Explosive Eruptions

- Three products from an explosive eruption
  - Ash fall
  - Pyroclastic flow
  - Pyroclastic surge



Pyroclastic flows on Montserrat, buried the capital city.





Direct  
measurements of  
pyroclastic flows  
are extremely  
dangerous!!!



# Effusive Eruptions

- Effusive eruptions are characterised by outpourings of lava on to the ground.



Hawaii

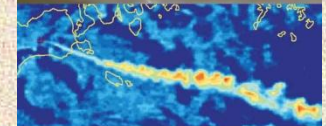
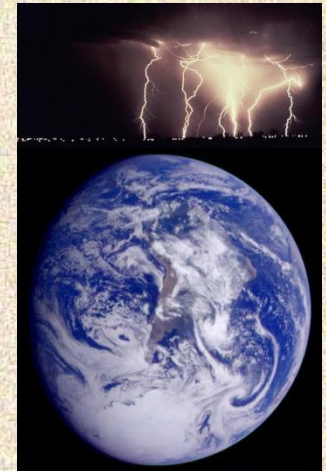




# Practical Exercise 1.

**What controls the violence of an eruption?**

**How fast is magma ejected out of the volcano?**







# Volcano Monitoring and Hazard Mitigation





# Volcanic Fatalities

- 92,000 Tambora, Indonesia 1815
- 36,000 Krakatau, Indonesia 1883
- 29,000 Mt Pelee, Martinique 1902
- 15,000 Mt Unzen, Japan 1792



Courtesy of [www.swisseduc.ch](http://www.swisseduc.ch)

But, volcanoes cause fewer fatalities than earthquakes, hurricanes and famine.



# Volcanic Hazards



Courtesy of [www.swisseduc.ch](http://www.swisseduc.ch)

- Pyroclastic flow
- Lahars/Mud flows
- Pyroclastic fall
- Lava flow
- Noxious Gas
- Earthquakes





# Pyroclastic Flow

- For example, eruption of Vesuvius in 79 AD destroyed the city of Pompeii





# Pompeii (79AD)

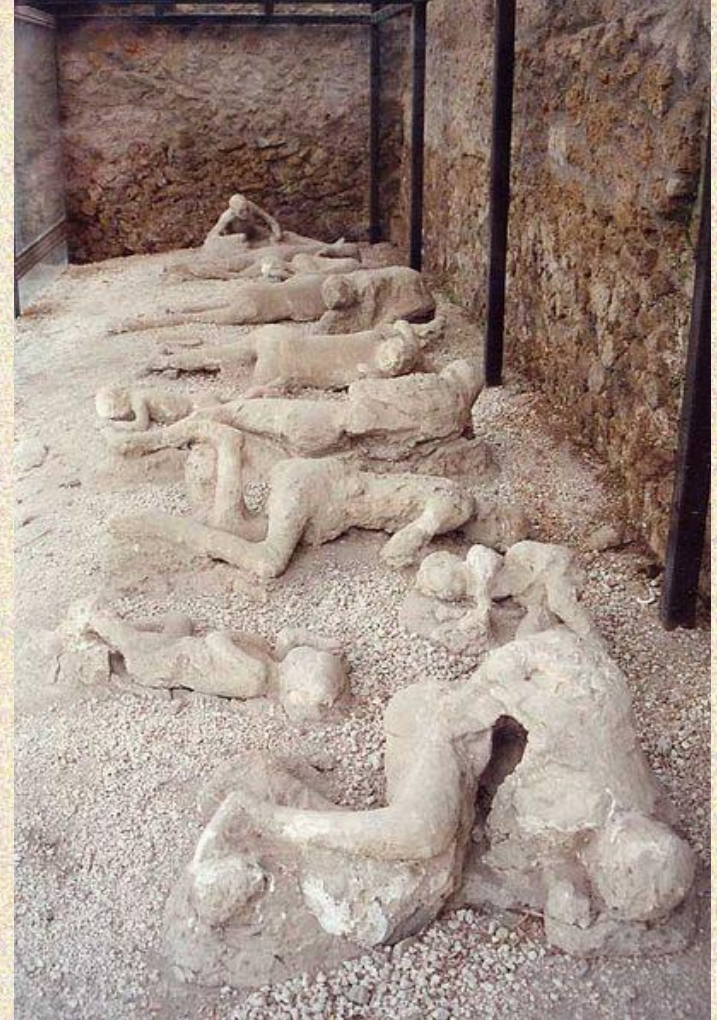
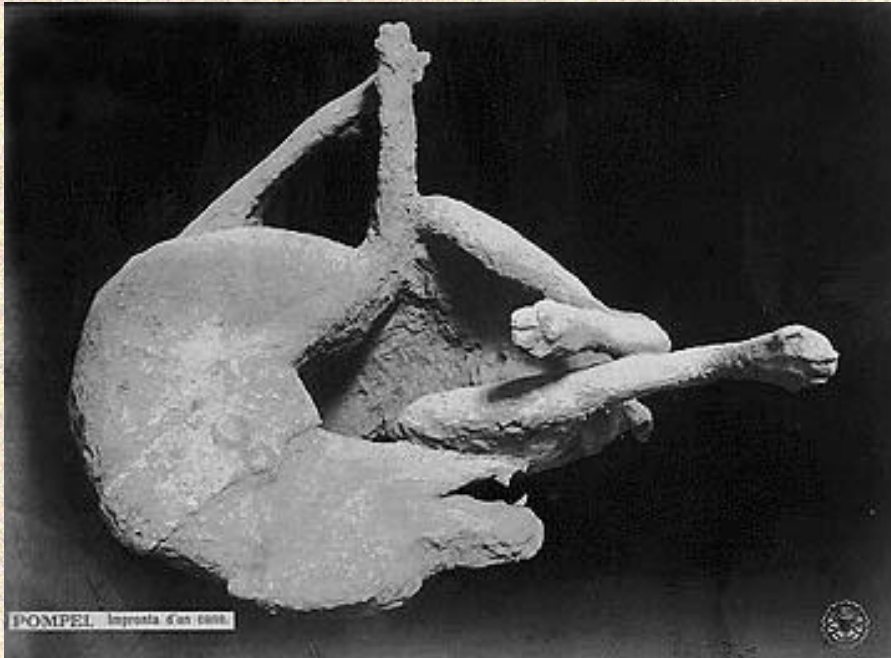


On August 24, 79AD Mount Vesuvius literally blew its top, erupting tonnes of molten ash, pumice and sulfuric gas miles into the atmosphere. Pyroclastic flows flowed over the city of Pompeii and surrounding areas.



# Pompeii (79AD)

Pyroclastic flows of poisonous gas and hot volcanic debris engulfed the cities of Pompeii, Herculaneum and Stabiae suffocating the inhabitants and burying the buildings.





# Pompeii (79AD)

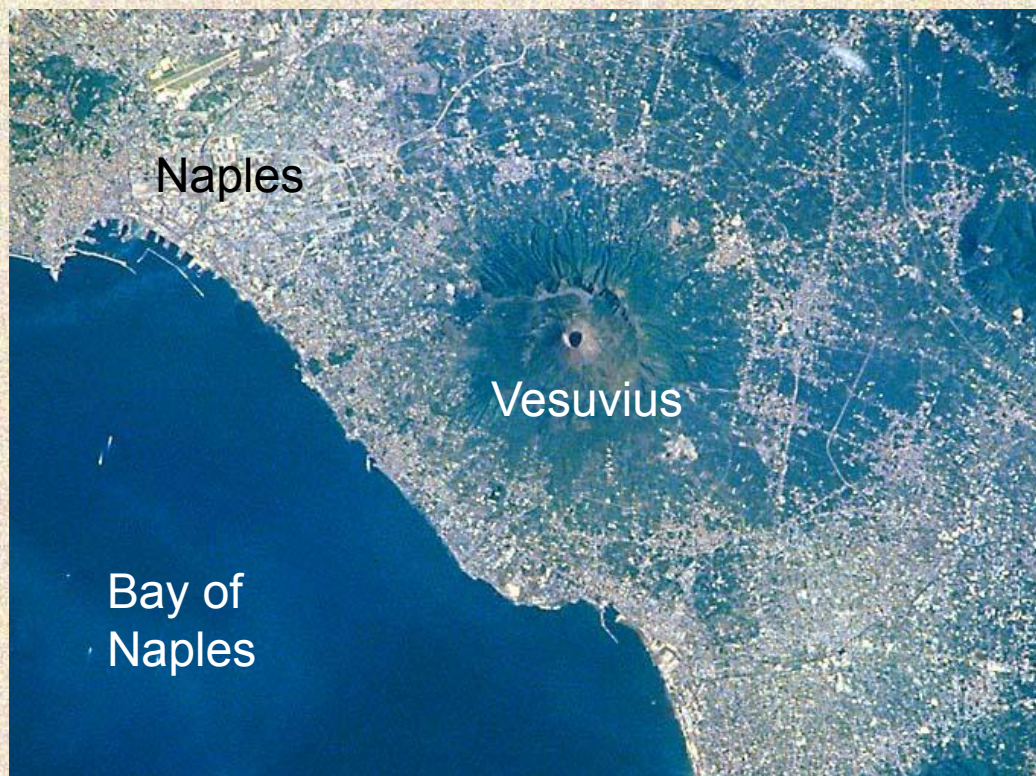


The cities remained buried and undiscovered for almost 1700 years until excavation began in 1748. These excavations continue today and provide insight into life during the Roman Empire.





# Vesuvius today



Courtesy of [www.swisseduc.ch](http://www.swisseduc.ch)

- Vesuvius remains a hazardous volcano with heavily populated flanks:
  - around 1.5 million people live in the city of Naples alone
  - Naples is situated approx. 30 km from Vesuvius
  - Pyroclastic flows can flow up to 100 km from source!





# Mt Peleé, Martinique (1902)

- An eruption of Mt Peleé in 1902 produced a pyroclastic flow that destroyed the city of St. Pierre.



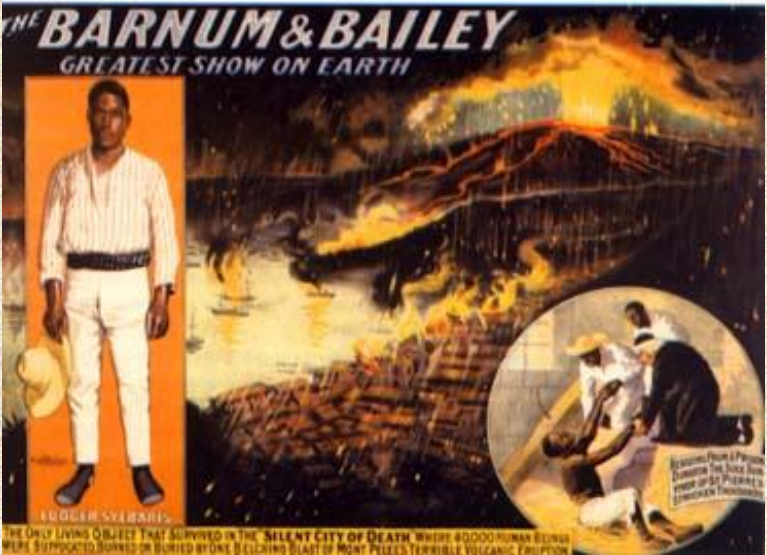
before



after



29,000 people died....  
Only 2 survived! Why?

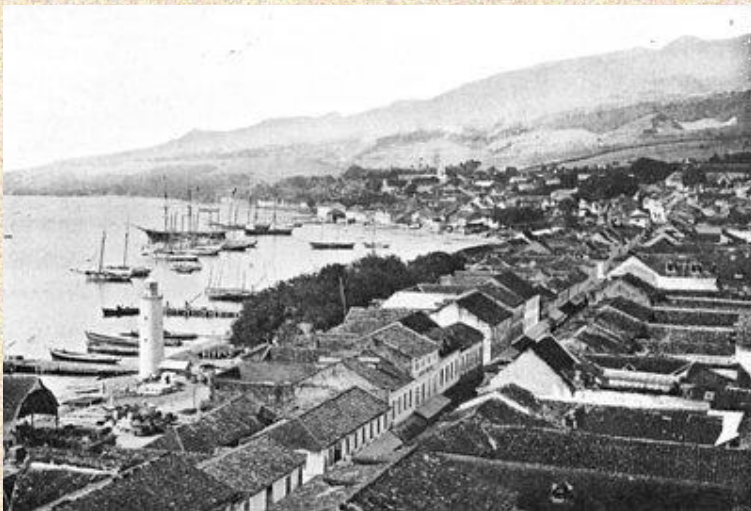




# How do pyroclastic flows cause devastation?



# Pyroclastic Flow - direct impact



Courtesy of [www.swisseduc.ch](http://www.swisseduc.ch)



# Pyroclastic Flow - burial





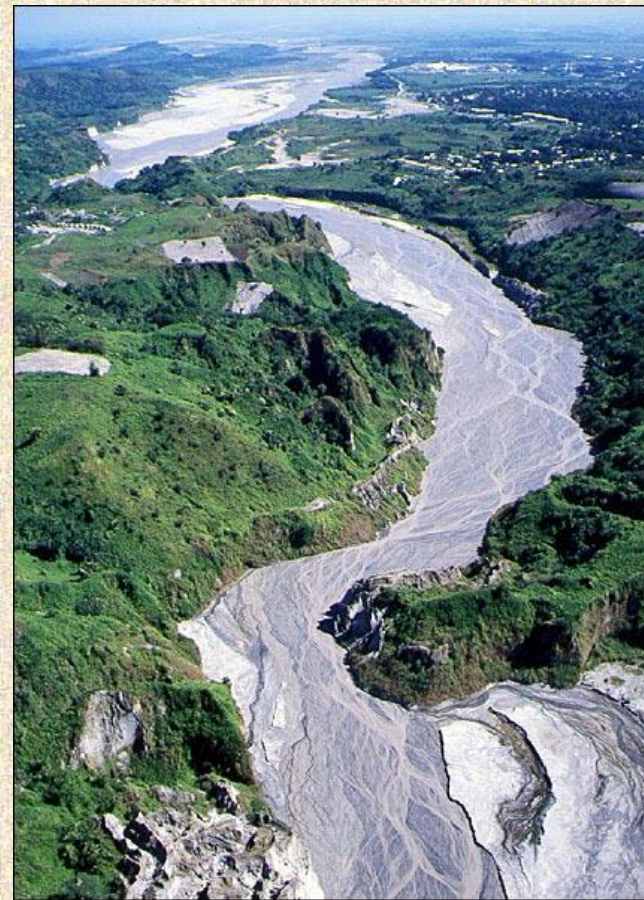
# Pyroclastic Flow - burns





# Pyroclastic Flow - lahars

- Hot volcanic activity can melt snow and ice
- Melt water picks up rock and debris
- Forms fast flowing, high energy torrents
- Destroys all in its path





# Pyroclastic Fall

- Ash load
  - Collapses roofs
  - Brings down power lines
  - Kills plants
  - Contaminates water supplies
  - Respiratory hazard for humans and animals

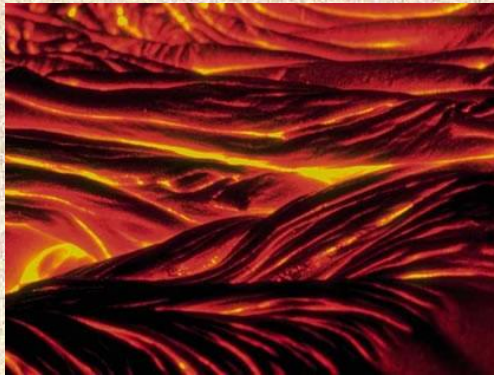






# Lava Flow

- It is not just explosive volcanic activity that can be hazardous. Effusive (lava) activity is also dangerous.





# Lava Flow - Heimaey, Iceland

- Iceland, January 23, 1973.
- Large fissure eruption threatened the town of Vestmannaeyjar.





# Lava Flow - Heimaey, Iceland

- The lava flows caught the inhabitants by surprise
- Before the eruption was over, approximately one-third of the town of Vestmannaeyjer had been destroyed





# Lava Flow - Heimaey, Iceland

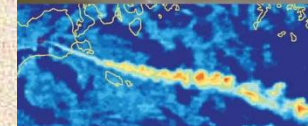
- However, the potential damage was reduced by spraying seawater onto the advancing lava flows.
- This caused them to slow and/or stop, or diverted them away from the undamaged part of the town.





# Practical Exercise 2.

## Assessing Volcanic Hazards





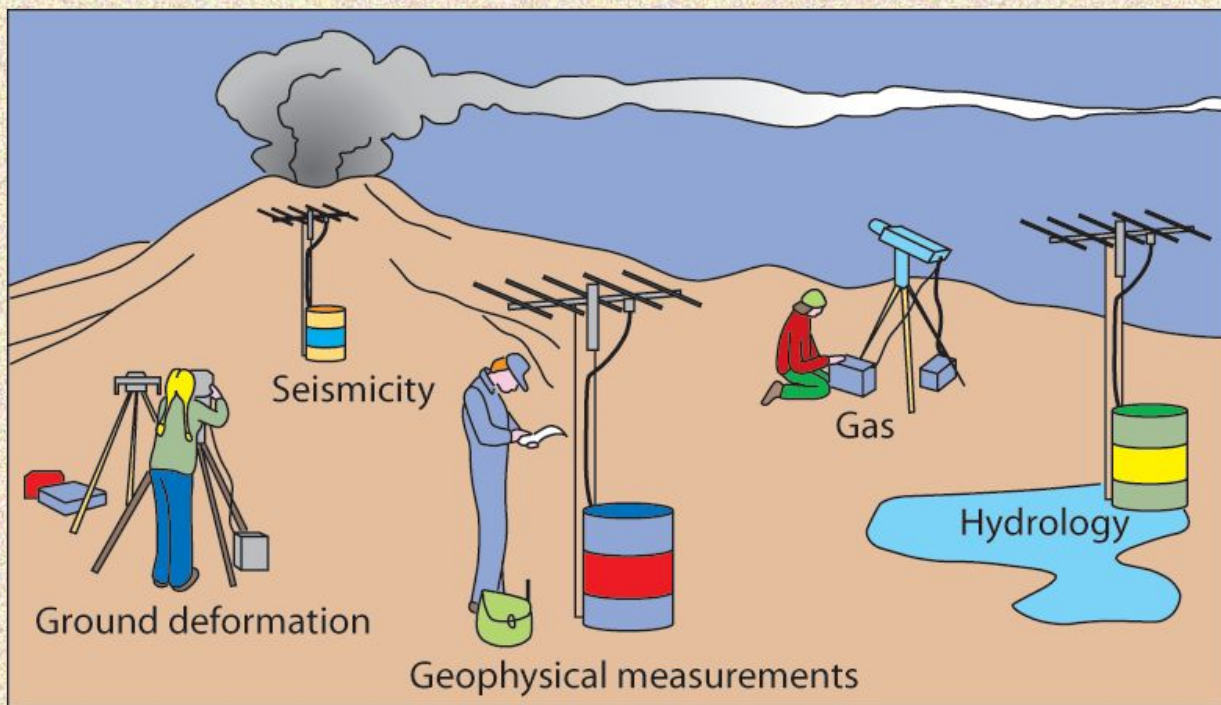
So....

How do we minimize the risk of  
active volcanoes?





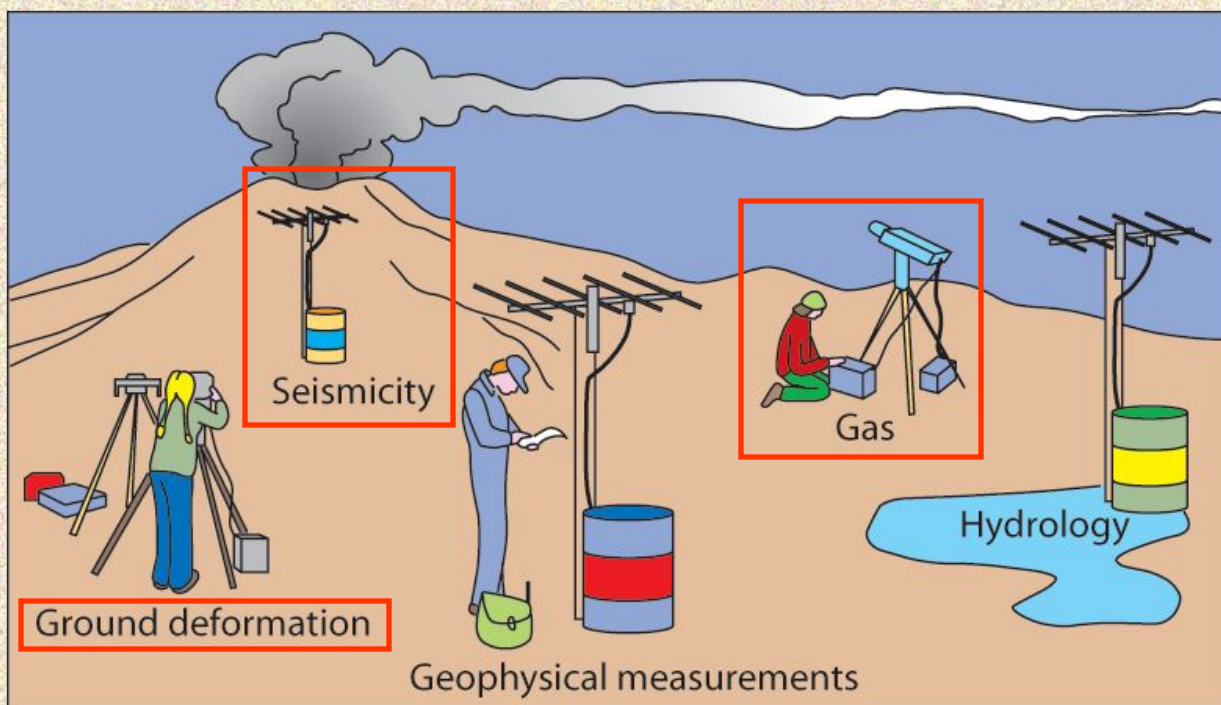
# Volcano Monitoring



Volcano Observatories are set up on all active volcanoes that threaten the human population. These are designed to monitor and potentially to predict the eruptive behaviour of the volcano in question.



# Volcano Monitoring



- Seismicity
- Deformation
- Gas Output
  - (on volcano and remote sensing techniques)

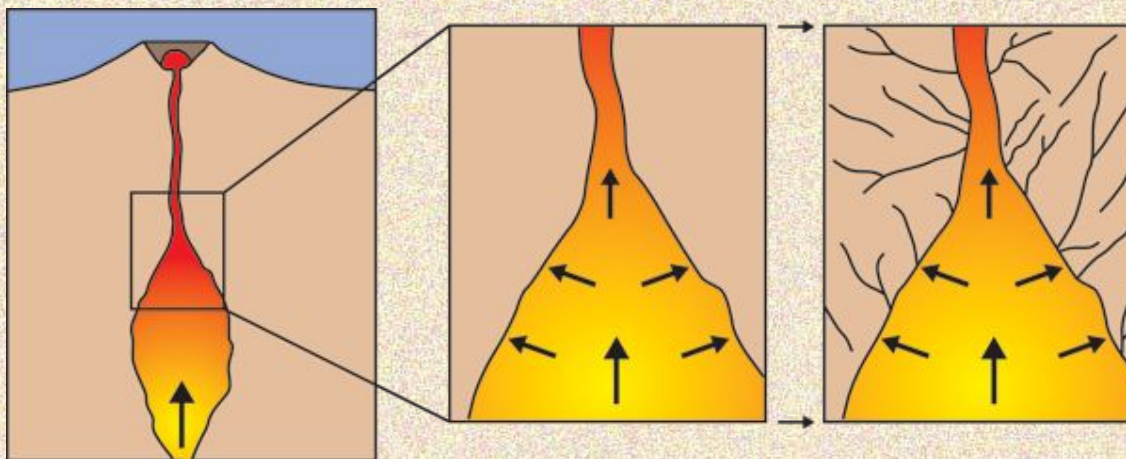
**These three things are the most important precursors to an eruption.**





# Seismic Activity

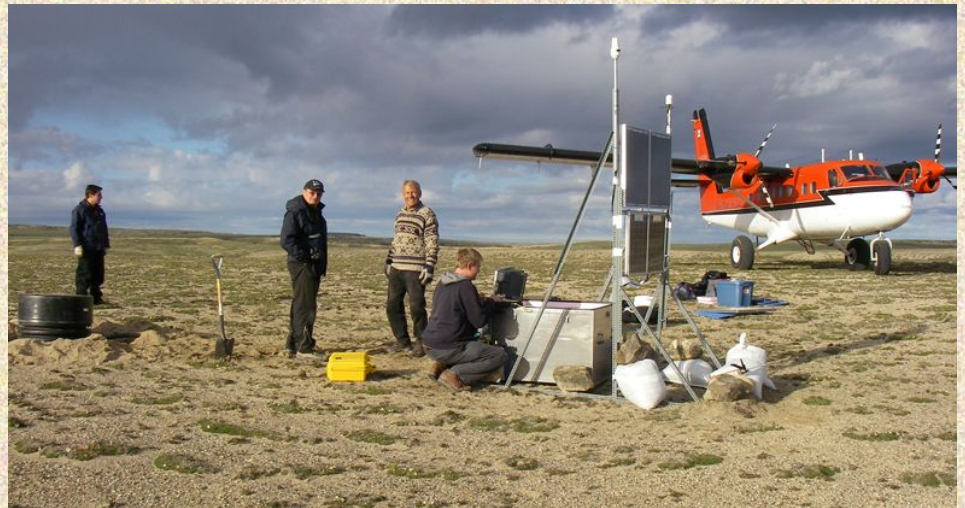
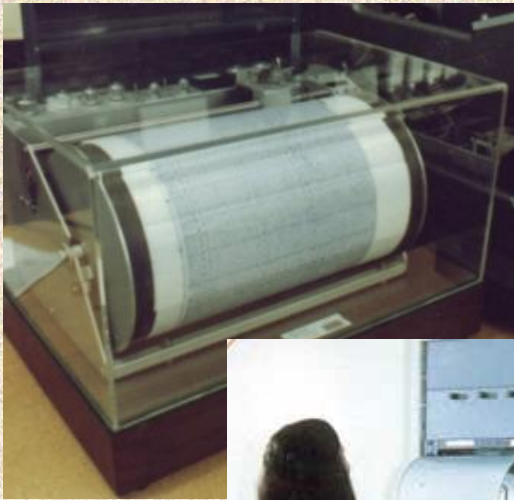
- Earthquake activity commonly precedes an eruption
  - Result of magma pushing up towards the surface
  - Increase volume of material in the volcano shatters the rock
  - This causes earthquakes





# Seismic Activity

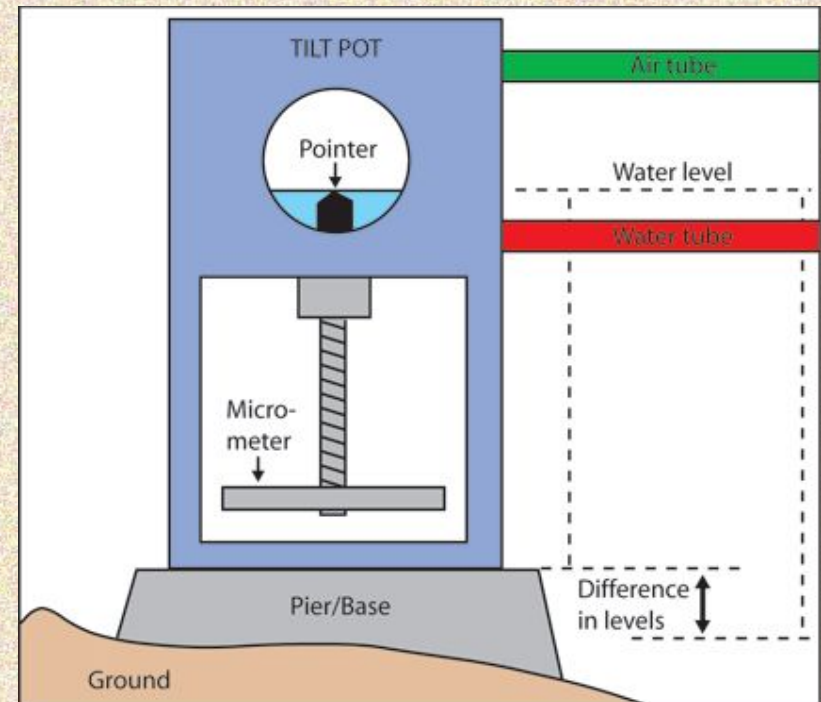
- Earthquake activity is measured by Seismographs
  - Seismographs are stationed on the flanks of the volcano
  - These record the frequency, duration and intensity of the earthquakes and report it back to the volcano observatory.





# Deformation Monitoring

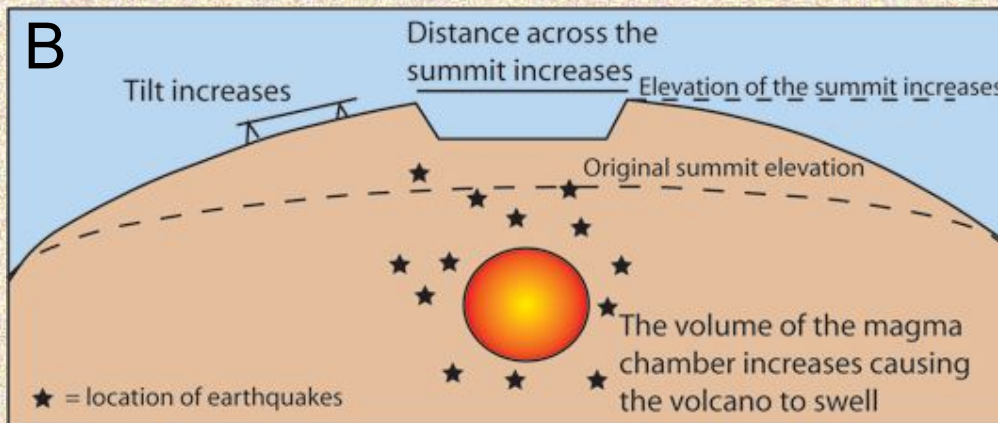
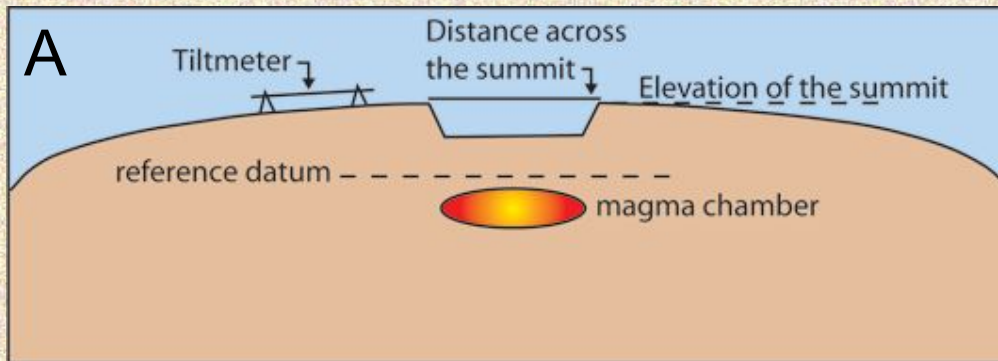
- “Tiltmeters” are used to measure the deformation of the volcano
  - The tiltmeters measure changes in slope as small as one part per million. A slope change of one part per million is equivalent to raising the end of a board one kilometer long only one millimeter!





# Deformation Monitoring

- Tiltmeters can tell you when new material enters the magma chamber.



Note the presence of earthquakes in relation to the deformation. Often it is a combination of events that fore-warns of an eruption.



# Gas Monitoring

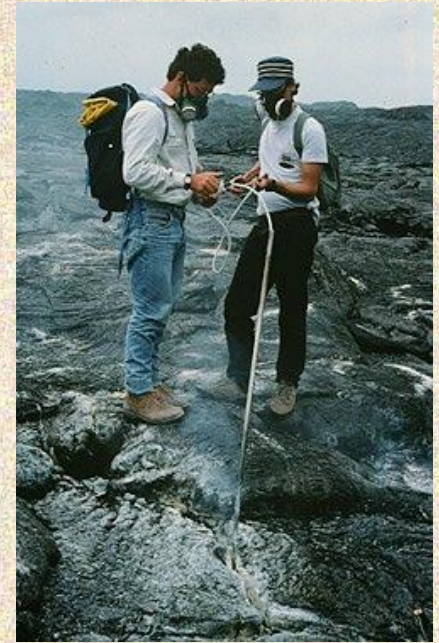
- Commonly gas output from a volcano increases or changes composition before an eruption.
  - As magma rises to the surface it releases (exsolves) much of its gas content.
  - This can be measured



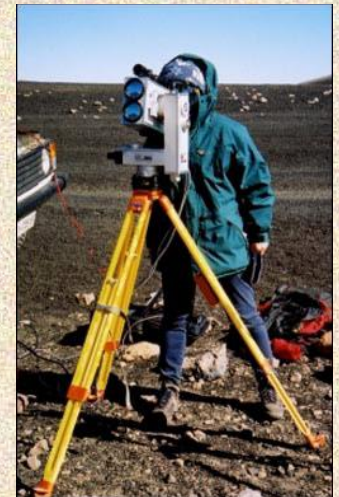
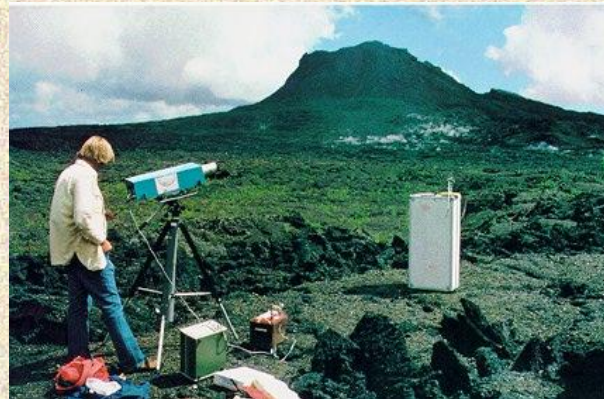


# Gas Monitoring

- Gas samples are collected from fumaroles and active vents.



- Gas levels may also be monitored by remote sensing techniques





# In Summary..

- Volcanoes are extremely hazardous.
- However, the volcano can be studied, monitored and understood.
- Each volcano is different, and offers a unique set of dangers
- Plans may be emplaced to help control potential damage.



# Post-lecture Question:

- What should geologists do about volcanic eruptions in the future?
  1. Study volcanoes to find out more about how and why they erupt
  2. Monitor the volcanoes
  3. Develop hazard mitigation plans
  4. Understand the population around volcanoes, i.e. why do people choose to live near volcanoes?
  5. Education





# Additional (Optional) Material

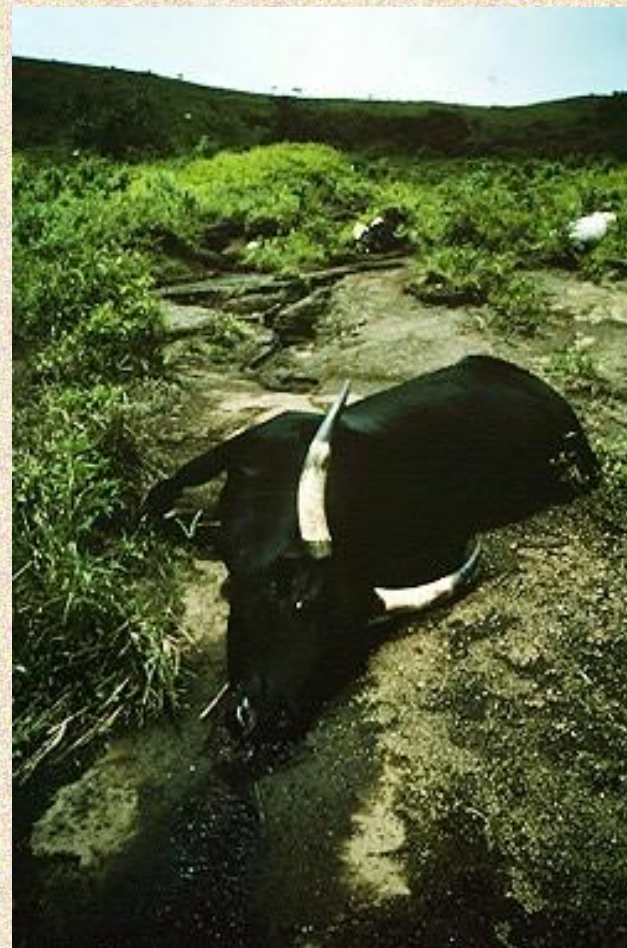


# Are there other volcano related hazards?



# Noxious Gas

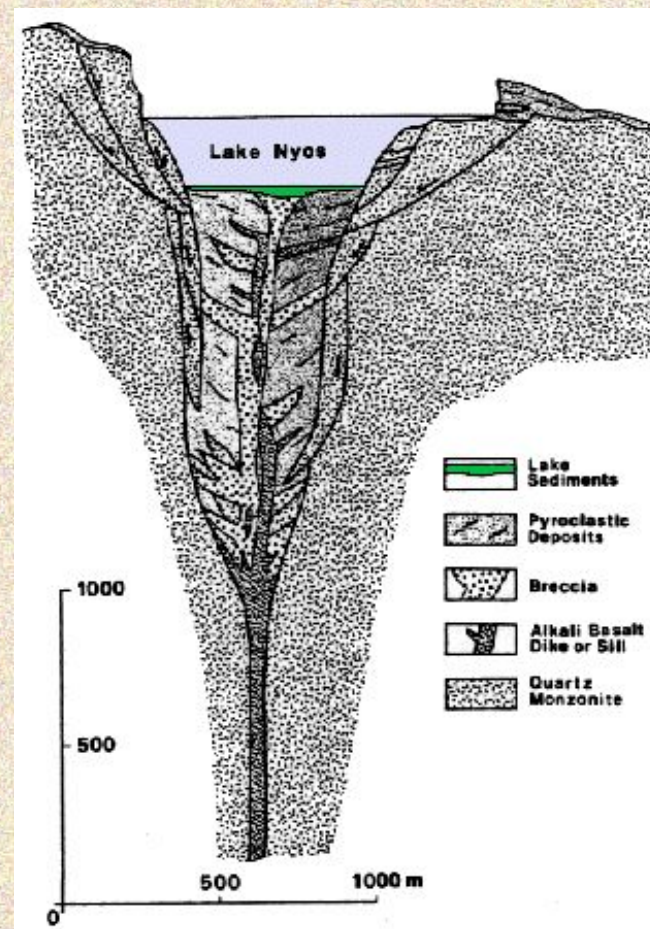
- 1,700 people living in the valley below Lake Nyos in northwestern Cameroon mysteriously died on the evening of August 26, 1986.





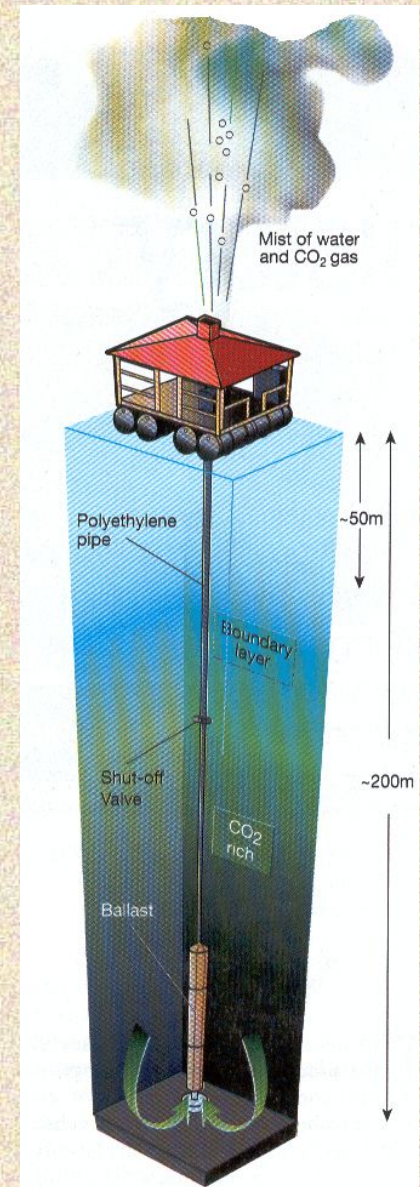
# Noxious Gas

- Lake Nyos is a crater lake inside a dormant volcano.
- The lake had become laden with carbon dioxide gas.
- This gas had suddenly bubbled out of the lake and asphyxiated nearly every living being in the surrounding valley.



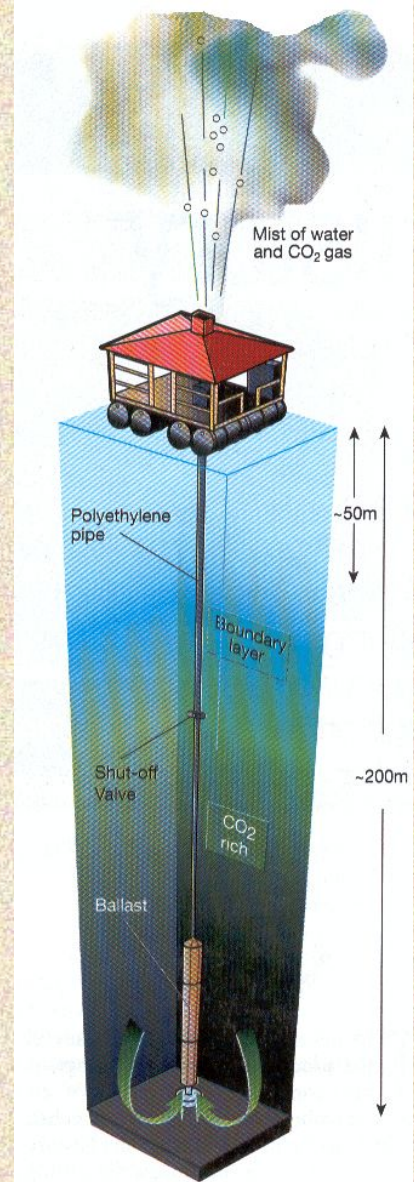
# Noxious Gas

- A management plan has been developed to remove gas from the lake to prevent a further tragedy.
- An artificial vent to the lake surface was created with pipe.
- Water is pumped from the bottom of the lake to the surface through the pipe, where it can degas.





# Noxious Gas





# Noxious Gas





# Noxious Gas

- The Lake Nyos incident was not unique.
- Two years earlier, Lake Monoun, 60 miles to the southeast, released a heavy cloud of toxic gas, killing 37 people.
- A third lake, Lake Kivu, on the Congo-Rwanda border in Central Africa, is also known to act as a reservoir of carbon dioxide and methane, which is a valuable natural gas that is gathered from the lake and used locally.





# Earthquakes

- Large volumes of magma moving through the shallow crust can cause large earthquakes.
- This can lead to building collapse, slope failure and avalanches



# Earthquakes



Destruction after a volcanic induced earthquake in Japan