Volcanoes

Flying through volcanic ash can be hazardous to your plane!

- ⇒ 1982 British Airways
- ⇒ 1989 KLM Boeing 247 from Alaskan Volcano
- ⇒ 1991 Mount Pinatubo
- ⇒ Since 1990 damage to at least 15 aircraft

Volcanoes are not all bad:

1) Esthetic beauty
2) Skiing and hiking
3) Soils can be productive

However, of course they can kill.

Who Should Worry?

In short – People who live on plate boundaries.

- ⇒ Most dangerous, convergent plate boundaries with subduction zones
- ⇒ 900/1350 volcanoes that have erupted are on the Pacific ring of fire (N.Z., Japan, Alaska, Mexico, C.A., Chile)
  - ■ Mt. Erebus of Antarctica is the farthest south
- ⇒ Other famous: Mediterranean – Vesuvius, Etna, Stromboli
  - ■ Stromboli - "Lighthouse of the Mediterranean"
- ⇒ Most active – mild eruption of fluid lava, typically at Divergent Plate Boundaries
- ⇒ 2x more volcanoes north of the equator
  - ■ Can affect world climate
  - ■ Examples: Tamboru (1815), El Chichon (1982), Mt. Pinatubo (1991)
- ⇒ Us- no one east of New Mexico (Figure 5.2 &5.3) – tectonics

Main mainland U.S. zone – Cascadia Subduction Zone

- ⇒ WA, OR, CA

"Alaska is the second most active volcanic region in the world, and Hawaii is not far behind."

Nature of the Problem

VEI – Volcanic Explosivity Index (Figures 5.4 & 5.5)

- ⇒ Related to volume of stuff erupted, height it rises, and duration of eruption
- ⇒ Mount St. Helens (1980) – Explosive to Cataclysmic – 4
- ⇒ VEI can increase with time
- ⇒ Magnitude and frequency – Yellowstone (cataclysmic book)
- ⇒ Magma's viscosity is important
  - ■ T↑, V↓ or T↓, V↑
  - ■ Silica: the more siliceous, the more viscous
  - ■ Felsic vs. Mafic and the Andesite Line
  - ■ Andesite Line: From Alaska to east of N.Z. by way of Japan and along the west coasts of N.A. and S.A.

Types of Eruptions and Volcanic Cones

"The type of volcanic eruption determines the shape of the structure or cone that is built, and by appearance alone, one can get an idea of a volcano's hazard potential."

Effusive Eruptions

1) Shield Volcanoes- built by gentle outpourings of low-silica fluid lavas
   - ⇒ Basaltic (mafic)
   - ⇒ Locations: Iceland, Galapagos, Hawaii
   - ⇒ Mauna Loa= 31,000 feet high from the bottom of the ocean
   - ⇒ Hawaii ("the big island") – built by five volcanoes
     - Mauna Loa, Mauna Kea, Kilauea
   - ⇒ New islands to southeast: Loihi: ("the long one")
     - 1000 m below sea level
     - 1996-4300 earthquakes in one month
     - Reach surface sometime around 50,000 years from now
   - ⇒ Fissure eruptions occur commonly with these volcanoes – Pu'u O'o
     - Has fed lava into the ocean since 1983, adding 500 acres
     - Destroyed 75 homes, black sand beach
     - Spectacular lava fountains 1,300 ft high (400 m)
     - Pele's hair and Pele's tears

2) Continental Flood Basalts
   - ⇒ Thick flat lying basalt flows
   - ⇒ Most famous: Columbia River Plain, Deccan Plateau (WA, OR, Idaho)
     - How? – Superplume
   - ⇒ In scale, they cover many times the area of the large volcanoes
     - When deeply eroded, they form flat "treads" – soft rock and vertical "rises" (hard rock)
     - Rocks are called traps, Swedish word for staircase (Deccan Traps, Siberian Traps)
   - ⇒ Deccan Traps (India)
     - 1-2 km thick (3,000-6,000 feet) and cover half a million Km^2
     - Superplume may be linked to dinosaurs extinction
   - ⇒ Parana of Brazil matches with Etendeka of Namibia

Explosive Eruptions

1) Stratovolcanoes or Composite Cones
   - ⇒ Built of layers of both pyroclastic material and lava
   - ⇒ Strato: ash, cinders, lava
     - Upper steep slopes: pyroclastic volcanic ejecta
     - Lower slopes: alternating layers of lava and pyroclastics
   - ⇒ Mt. Vesuvius (Italy), Mt. Fujiyama (Japan), Mt. Hood (OR), Mt. Rainer (WA), Volcan Sea Constobal (Nicaragua)
   - ⇒ Continents contaminate magma
   - ⇒ Perhaps biggest threat to humans
   - ⇒ Can erupt the whole chamber, and form a caldera (Crater Lake, Long Valley Caldera, Valles Caldera, Yellowstone has several)

2) Lava Domes or Volcanic Domes
   - ⇒ Form when bulbous masses of lava pile up around the vent because the lava is too thick and viscous.
   - ⇒ Mono Craters
   - ⇒ Inside larger volcanoes- Mt. St. Helens
   - ⇒ Mount Lessen, Mammoth Mountain., Mount Delee
   - ⇒ Extrude very Felsic lavas – rhyolite, or extrude glassy rocks like pumice or obsidian.

3) Cinder Cones
   - ⇒ Smallest and most numerous
   - ⇒ Built of pyroclastic materials – tephra (Table 5.1)
     - Blocks, Bombs, Lapilli, Ash and Dust
   - ⇒ Local: Amboy, Pisgah, Cima, Red Hill, 395
   - ⇒ Paricutia: Mexico (1943-1952)
   - ⇒ Generally "one-shot" events
   - ⇒ Many are typically mafic

Benefits of Volcanic Action
- ⇒ Most of our atmosphere and hydrosphere came from volcanism
- ⇒ Typical volcanic gases: 80% H_2O (vapor), 10% CO_2, and the rest N_2 and rarer stuff (outgassing)
- ⇒ Dental Pumice or pumice stone
- ⇒ Light-weight bricks, cinder blocks, road foundation or décor stones
- ⇒ Red Paramounts (AZ, NM) contain basalt cinders
- ⇒ Obsidian- arrowheads and tools
- ⇒ Mountain recreation
- ⇒ Geothermal Energy- Iceland and Pacific Rim

<u>Volcanic Hazards</u>

Empedocles that ardent soul- Fell into Etna and was roasted whole!

1) Lava Flows
   - ⇒ Most hazards decrease in severity from their point of origin, not lava flows
   - ⇒ Basaltic Lava Flows
     1. Pahoehoe
     2. Aa
   - ⇒ Volcanic eruptions cannot be prevented, but can be diverted.

2) Ash Falls
   - ⇒ Pliny the Elder (born A.D. 23) – died in 79 A.D. from Vesuvius – geology's first martyr
   - ⇒ Plinian Column – vertical plume of ash with a mushroom or anvil shaped head from the mountain summit
     - Can go as high as 10-15 miles (15-25 Km)
   - ⇒ Katmai (1912) – biggest one 20th
     - Acidic gases affected Seattle, WA
   - ⇒ Ash fall from gravity – closest to the cone, you're probably dead

3) Pyroclastic Flows
   ⇒ Turbulent mixtures of hot gasses and pyroclastic material that travel across the landscape with great velocity
   ⇒ Nuee Ardente – "glowing cloud"
   ⇒ Mount Pelee – two survivors (Martin, Que)
   ⇒ Mount Vesuvius – Pompeii and Herculaneum (modern city Ercolano)
   ⇒ Welded Tuffs: from when pyroclastic flows harden from their own heat

4) Lohars (Indonesian word rood)
   ⇒ Fast moving volcanic debris flow
   ⇒ Nevado del Ruiz – over 20,000
   ⇒ Potential is predictable: Mount Rainier

5) Tsunami
   ⇒ Are rare in association with volcanic activity
   ⇒ Most famous: Krakatoa (1883)
      - VEI: 6
      - 36K dead
      - Its eruption produced three islands: Krakatoa, Verlater, and Lang
      - New volcanic island has appeared

6) Weather and Climate
   ⇒ Ben Franklin is credited as the first person to connect volcanic eruptions with climate change
   ⇒ 1783 – Iceland – Laki Fissure
   ⇒ 1815 – Tambora in Indonesia: "Year without a summer"
   ⇒ Volcanic dust residence time: 1-2 years
   ⇒ Dust veils (DUI) – SO_2 produces white coatings on dust

7) Gases
   ⇒ Vog on Hawaii
      - SO_2: Can form sulfuric acid, which can kill plant life and destroy structures
      - Health Hazard?
   ⇒ CO_2 in Mammoth Mountain, CA
   ⇒ Cameroon, West Africa: say it is CO_2

Mitigation and Prediction

1) Diversion
   ⇒ Damming and diversion and bombed?
   ⇒ Iceland: Hermaey (1973)
   ⇒ Etna (1992)

2) Volcano Hazards and Risk
   ⇒ Lava flow hazard zones depending on topography
   ⇒ Kilauea's erupted almost continuously since 1983

3) Eruption Forecasting
   - ⇒ VVO: Vesuvius Volcano Observatory (oldest – 1845)
   - ⇒ HVO: Hawaiian Volcano Observatory
   - ⇒ AVO: Alaska Volcano Observatory
   - ⇒ Forecasters: Specific precursory warning sings
   - ⇒ However, volcanoes can change their behavior and even eruption style
   - ⇒ Tiltmeters and Ground Deformation Studies
   - ⇒ Volcanic earthquakes and volcanic tremors
   - ⇒ Gravimeters
   - ⇒ Satellite Inferometry
     - ■ Help of GPS
   - ⇒ Volcanologists now have extra responsibility in dealing with politics
   - ⇒ Active vs. Dormant vs. Extinct
     - ■ Active: Does not have to be erupting at the moment
     - ■ Dormant: Not erupted in resent/living memory
     - ■ Extinct: No further erupting – many cinder cones

Case Study 5.1: New Zealand

Case Study 5.2: Mount Serrat, Paradise Coast

Case Study 5.3: CO_2, Earthquakes, and Hot Water Supply