Volcanic Activity

I. Origin of Magma
- A. Depth: 20 – 200 km
- B. Temperatures: ~600^{0}C - ~1600^{0}C
- C. Composition
  1. molten rock
     a. basaltic magma - 40% – 50% silica
     b. andesitic magma – 50%-60% silica
  2. gases – water vapor, CO_2, sulfur (SO_2 or H_2S), and other minor gases
- D. Melting of rocks
  1. geothermal gradient – 30^o C/km
  2. pressure and water impact melting
- E. Magma chambers/reservoirs

II. Volcanic Eruptions
- A. magma moves upward through fractures/ faults

III. Products of volcanic or fissure eruptions
- A. Liquids – lava
  1. basaltic lavas flow in thin, broad sheets
     a. pahoehoe and a'a
  2. andesitic lavas – viscous, do not flow easily
     a. associated with violent eruptions
- B. gases
  1. 70% - 95% water vapor and 14% CO_2
  2. role in violent vs quiet eruptions
- C. solids - pyroclastics
  1. upon release, superheated gases expand ~75X– pulverize rock & lava from vent
  2. dust, ash, cinders, volcanic bombs, and blocks

IV. Volcanic eruptions and volcanoes
- A. Successive eruptions from central vent resulting in mountainous accumulations of materials
- B. Stratovolcano or composite volcano - steep-sided
  1. alternating lava and pyroclastics
  2. andesitic lavas - most violent
  3. Examples – Mt. Rainier, Mt. St. Helens, Mt. Fuji, Mt. Pinatubo
- D. Cinder cone - almost exclusively pyroclastics
  1. pyroclastics
  2. not as steep as stratovolcano
  3. occur in groups; sometimes parasitic cone on flank of main volcano
  4. last phase of volcanic activity
  5. Examples: Paracutin (Mexico), Sunset Crater, AZ
- E. Shield volcano - tall and covers large area
  1. gently sloping sides - 15^0 slope or less
  2. successive lava flows with little pyroclastic
  3. Hawaii: Kilauea, Mauna Loa, Mauna Kea
     a. quiet eruptions – low silica and gas content

Mt Rainier National Park

I. History
- A. called Tahoma – Snow Mountain - by Native Americans in the area
- B. 1792 – Capt. Vancouver sailed into Puget Sound and named mountain after Rear Admiral Rainier
- C. 1899 - became national park

II. Geologic History
- A. Farallon plate: consumed except for Juan de Fuca plate - subduction zone
  1. 40 mya – landscape covered by episodes of volcanic eruptions, lava flows, and pyroclastics
  2. 12 mya - base of Mt. Rainier formed by granodiorite (white granite with dark minerals)
- B. Mt Rainier
  1. alternating layers of lava and pyroclastics began to build in early Pleistocene
  2. reached its greatest height of 16,000' ~ 75,000 years ago
  3. continuous glacial erosion steepened the mountain
  4. 6,000 years ago - eruptions blew off ~2,000' of summit; formed caldera 2 miles across
  5. 2,500 years ago - eruptions built a new cone within the caldera
  6. few eruptions since 1800's but still high heat flow
  7. highest peak in Cascade Mountain Range - ~14,410' above sea level
- C. Glaciers and activity
  1. 25 major active glaciers
     a. Nisqually Glacier – most accessible in park
     b. Emmons - 4.3 miles^2, largest area of any glacier in contiguous United States; advanced rapidly in early 1980's. That advance continues today, but at slower rate
     c. Carbon - greatest measured thickness (700 feet) and volume (0.2 cubic miles) and lowest terminus altitude (3,600 feet) of any glaciers in the contiguous 48 states
     d. Glaciers are replenished at the high snowfall zone - ~ 4000"
  2. Activity
     a. 25,000 to 15,000 years ago, glaciers covered most of Mount Rainier area and extended to present Puget Sound Basin
     b. Little Ice Age: 1650 - 1850, many glaciers on Mount Rainier advanced to their farthest extent since Pleistocene
     c. between height of Little Ice Age and 1950, glaciers lost about 1/4 of length
     d. 1950 to early 1980's - Carbon, Cowlitz, Emmons, and Nisqually Glaciers advanced in response to cooler temperatures and higher snow fall
     e. early 1980's to 1992 - many glaciers, Emmons for example, have been thinning and retreating and some advances have slowed, in response to drier conditions
- D. Glacial features - greatest single-peak glacial system in the United States
  1. moraines
  2. arêtes
  3. crags and ridges – The Cleavers
  4. cirques and cirque lakes
  5. meltwater streams
  6. steam caves
  7. ice caves – since 1990's they no longer exist

Hawaii Volcanoes National Park

I. History
   A. Polynesian voyagers ~ 2000 years ago
      1. volcanoes were center to their culture and religion – abodes of deities
         a. Maui and Hawaii were especially sacred
         b. Pele lived in Halemaumau - carried stick for digging to start eruption to build island
   B. Captain James Cook – 1778
   C. series of kings and then became American territory in 1900.
   D. 1840 was first scientific investigation – noticed degrees of erosion from SE to NW – concluded that islands were older to NW
   E. Both islands became national park in 1916 but later separated
      1. Haleakala on Maui – 1960 (2 surrounding watershed areas added in 1999 and 2009)
      2. Volcanoes – 1961
   F. International Biosphere Reserve (1980) and a World Heritage Site (1987).
   G. Volcanoes National Park encompasses 333,086 acres from sea level to 13,677' and the summits and rift zones of Kilauea and Mauna Loa.

II. Geologic History
   A. Hot spot
      1. lava associated with Hawaiian eruptions
   B. Pleistocene
      1. initial eruption on ocean floor
      2. Mauna Loa – summit and rift-zone eruptions
         a. Largest eruption 1950 – 600 million cubic yards of lava in 3 weeks
         b. Last erupted in 1984
      3. Kilauea – rift-zone, summit, lava lakes, and some violent eruptions
         a. East Rift Zone - lava flowing through the upper portion of the lava tube system and heading for the coast; not currently (January 25, 2010) entering the ocean.
         b. Lava lake in fire pit at summit – Halemaumau
            i. Level of lava has fluctuated since first appeared in 1790
            ii. Just recently erupted for the first time since 1982
         c. Kilauea Iki – 1959
         d. Kapoho – 1960
         e. Pu'u 'O'o – continuous since 1983
      4. Glaciation – small ice caps on Mauna Kea and Mauna Loa
   C. presently Loihi is forming on ocean floor off SE coast of Hawaii

Yellowstone National Park
National Park in 1872
International Biosphere Reserve in 1976
World Heritage site in 1978

I. History of Yellowstone area
   A. John Colter expedition – 1806-1808
   B. Jim Bridger first "geographer" of the region
   C. Washburn party – 1870
   D. Dr. Ferdinand Hayden – heard lecture by members of Washburn party

II. Geologic history
   A. Hot spot
      1. Crust is extraordinarily thin and allows for high heat flow
      2. Plate moves over the hot spot
      3. Accounts for hydrothermal features and volcanic eruptions in ancient times
   B. Volcanic eruptions
      1. Huckleberry Ridge Caldera Event 2 million years ago
      2. Mesa Falls Caldera Event 1.3 million years ago, smallest of the eruptions
      3. Yellowstone Caldera Event 600,000 years ago: central portion of the park exploded
         a. collapse of the volcano created a caldera 28 by 47 miles across
         b. ejected 600 cubic miles of material including ash, and hot gasses
         c. Calderas - basin-shaped volcanic depressions - remnants of explosive volcanic activity
         d. Created fractures which provided route for lava of plateau rhyolite
         e. Younger inner caldera occupied by West Thumb of Yellowstone Lake
      4. Smaller lava flows - 150,000 years ago, 110,000 years ago, and 70,000 years ago
   C. Glaciation - intermittent over last 2 million years
      2. most recent glaciation began 50,000 years ago and ended 13,000 years ago – Pinedale stage
      3. moved from Absaroka and Beartooth Mountain ranges into Yellowstone area

III. Geothermal features
   A. contains over 10,000 features including 300 – 500 active geysers (55% of world's)
   B. Fracture zones provide underground channels for circulation of hot water in thermal system
   C. Geysers – constriction in plumbing
   D. Hot springs – no constriction
      1. Colors are result of microbes/algae living in different temperature waters of the hot springs
      2. Blue color is optical effect of sky
      3. Mineral content from acidic lavas – high in silica
      4. Mammoth Hot Springs differs from others on plateau
   E. Fumaroles
      1. Gas and steam are emitted
   F. Paint Pots
      1. Limited hot water; acidic water dissolves surrounding rock - clay makes it thick and bubbly

III. Other features
   A. Yellowstone Canyon
      1. related to fracture zones and alteration of rhyolite by geothermal waters
         a. hydrothermal alteration
            i. changes mineral composition of the rhyolite – K and/or Na feldspar and quartz
               a.) formation of clay products (mud and paint pots)

ii. physical changes
a.) increase in porosity and permeability
b.) soft & friable
c.) change in color: lighter; formation of red & yellow (pyrite -> hematite and limonite)
d.) change in texture – finer grained than original

2. waterfalls are found at point of fracture ring and varying degrees of hydrothermal alteration
a. Upper Falls – outer ring – very little alteration
b. Lower Falls – inner ring – highly altered

B. Obsidian Cliff
1. Fault with 180,000-year-old lava flow forming noncrystalline volcanic glass
a. Extremely low water content and/or very rapid cooling (former is more accepted theory)
b. Presence of columnar joints indicating slow cooling
c. Swirling in obsidian indicates flow
d. Obsidian used by Native Americans as far back ago as 10,000 years

C. Buried Forests
1. Specimen Ridge
2. Petrified tree trunks, some with root system intact
3. 20 or more successive forests buried 55 – 33 mya by lava flows
4. silica in lava replaced the wood cells and petrified the trees

D. Earthquakes (www.seis.utah.edu/req2webdir/recenteqs/Maps/Yellowstone.html)
1. 1,500 to 2,500/year occur within Yellowstone National Park and its immediate surroundings
a. 1,008 in last week of July 2021
b. 2,773 in 2021
c. most are too small to be felt
2. causes
a. rising magma and hot groundwater movement
b. ancient regional faults from Teton, Madison, and Gallatin Ranges pass through park
c. large earthquakes >7 are unlikely within the Yellowstone Caldera itself
d. distance earthquakes can have an effect on Yellowstone
3. effects on geothermal features
4. Hebgen Lake earthquake – August 1959
a. Magnitude 7.5
b. Caused Madison Canyon landslide
c. Killed 28 people