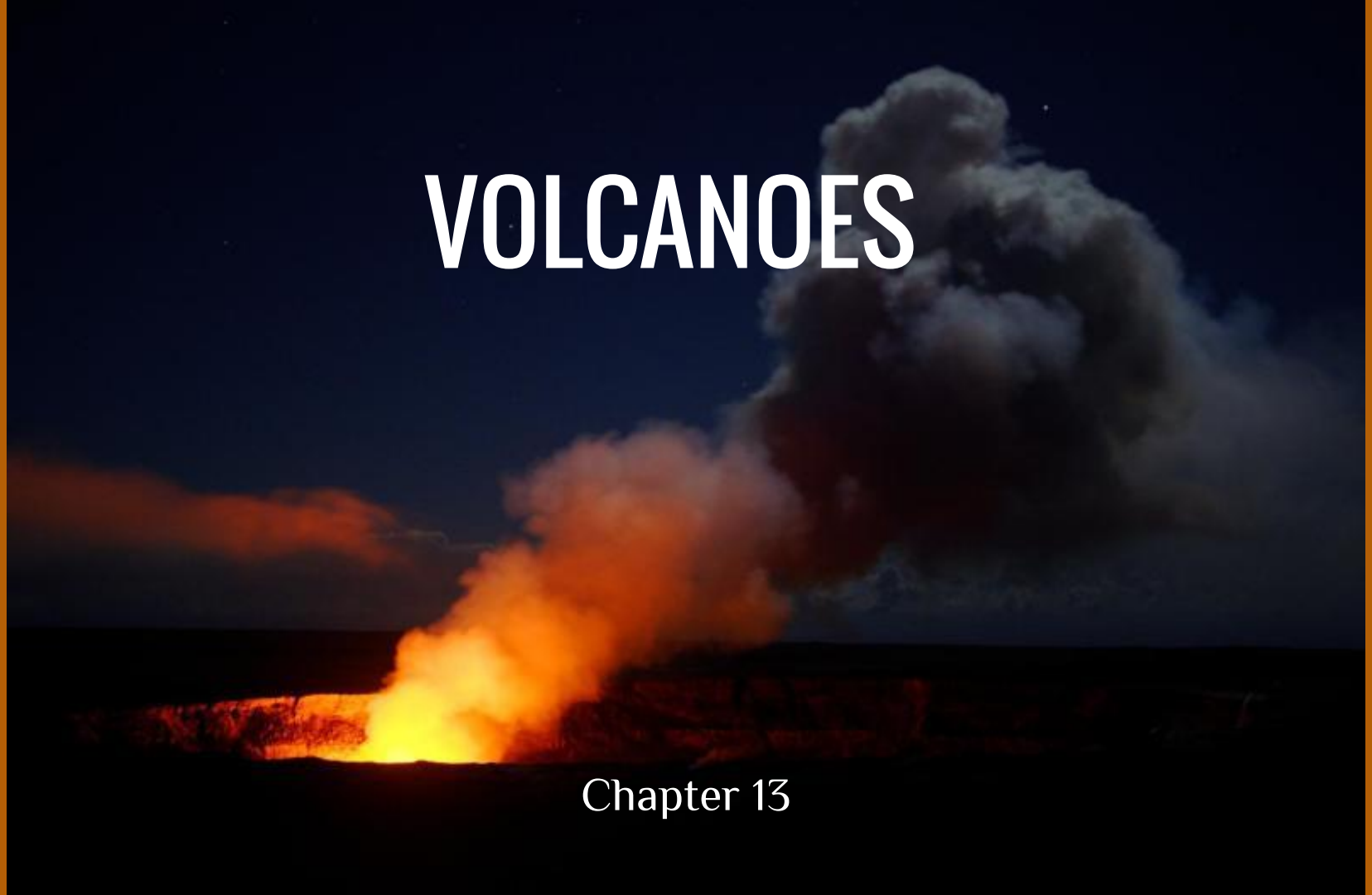


VOLCANOES

Chapter 13

Vocabulary

1. magma
2. volcanism
3. lava
4. vent
5. volcano
6. Ring of Fire
7. island arc
8. volcanic arc
9. fissure
10. hot spot
11. mantle plume
12. intrusion
13. pluton
14. dike
15. batholith
16. mafic
17. felsic
18. viscosity
19. pahoehoe
20. aa
21. blocky lava
22. pyroclastic material
23. volcanic ash
24. volcanic dust
25. lapilli
26. volcanic bombs
27. volcanic blocks
28. crater
29. caldera

I. Volcanoes & Plate Tectonics

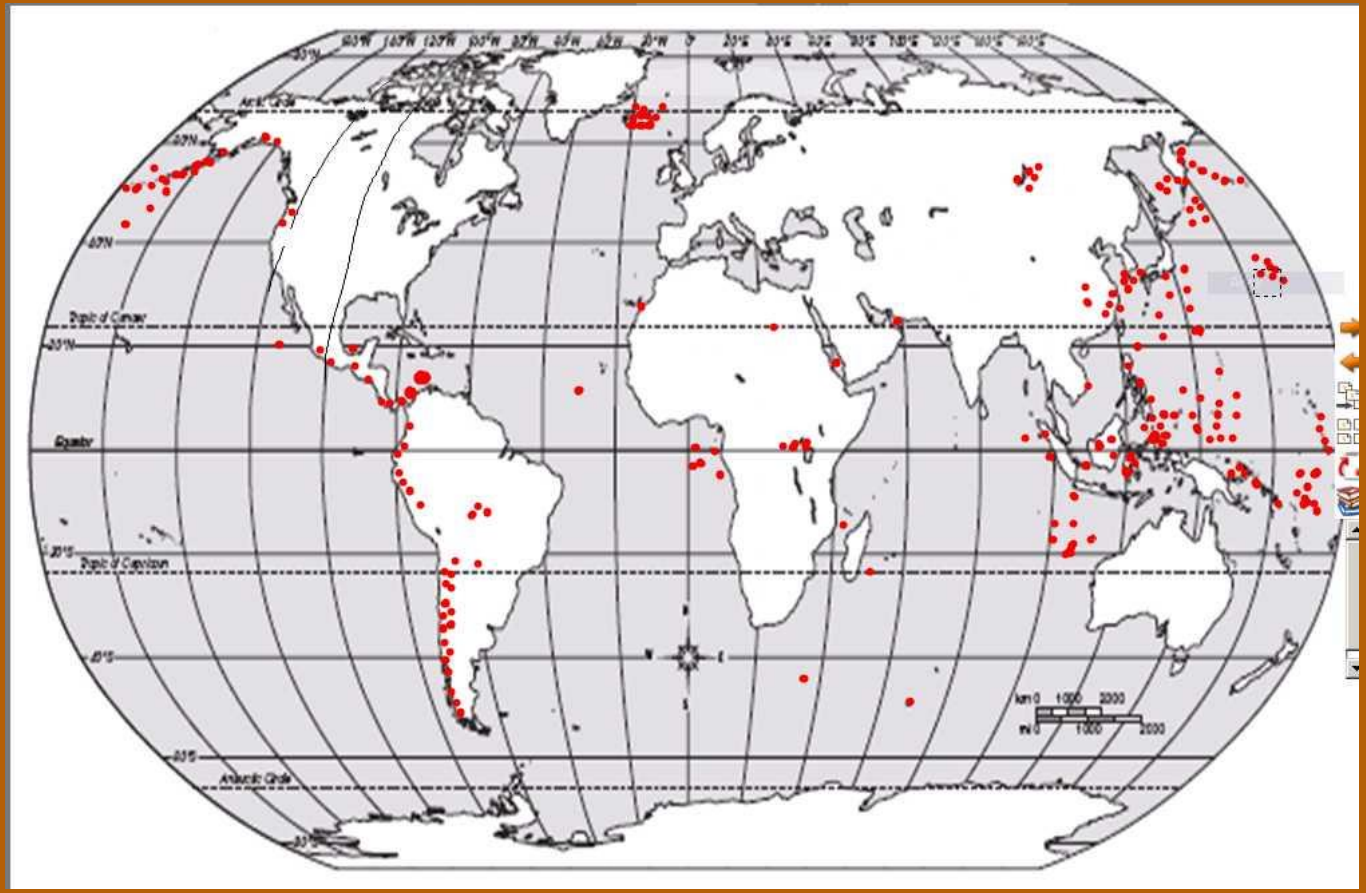
A. Background

1. Magma: liquid rock formed under Earth's surface from melting crust & mantle
    a. Three conditions under which magma forms:
        i. When temperature of rock is greater than the melting point of minerals in rock → rock melts!
        ii. Pressure in rock decreases, leads to decrease in melting point → rock melts!
        iii. Addition of fluids (ex: H_2O) leads to decrease in melting point of minerals → rock melts!

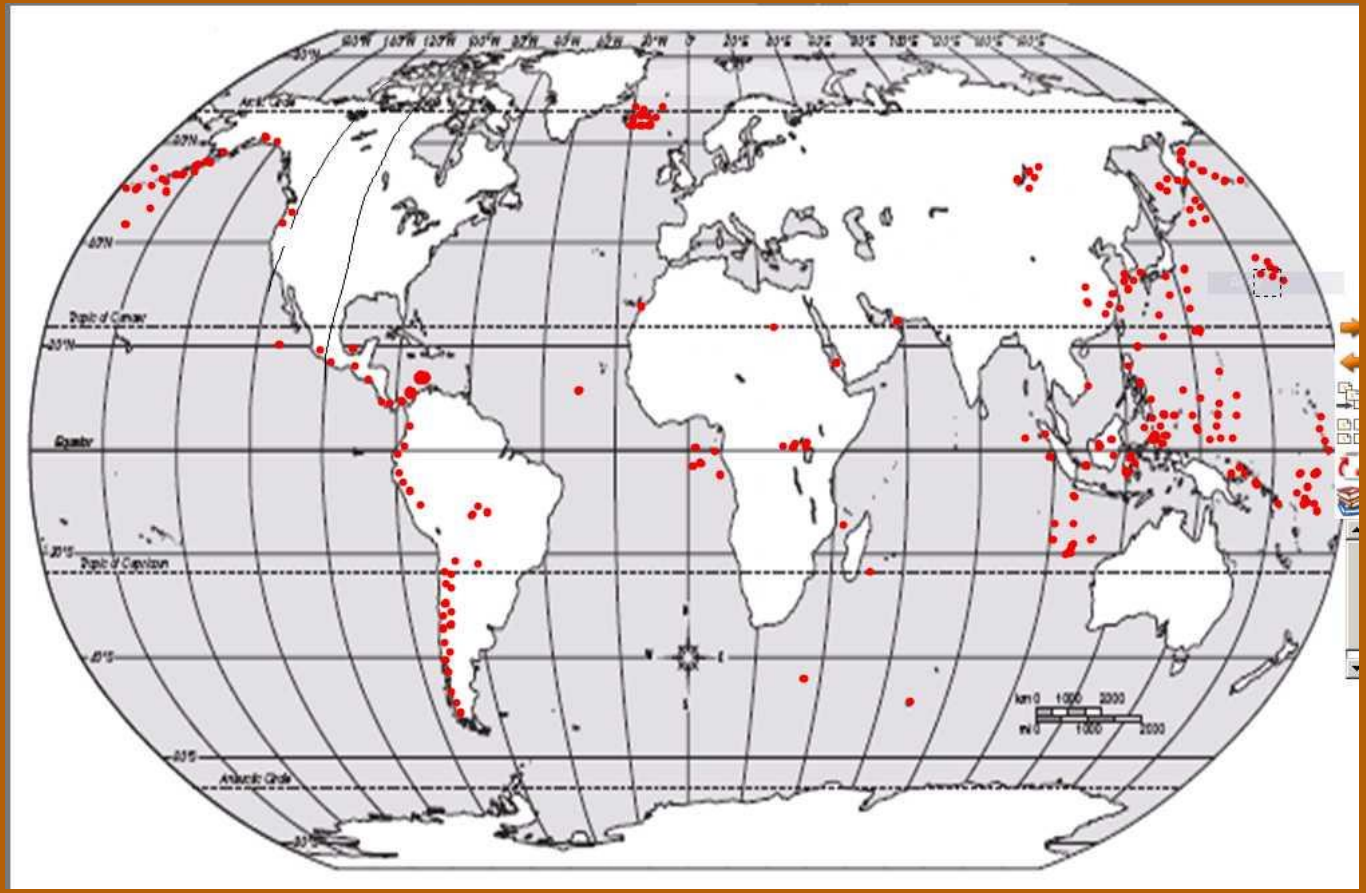
**NOTE: magma is *underground* and not the same thing as lava!

2. Volcanism: any activity that involves the movement of magma onto Earth's surface
    a. Magma is less dense than crust, so it rises up through the crust
    b. Rising magma can gain more material in two ways:
        i. Melt surrounding rock to add more material
        ii. Push through cracks in rock, causing chunks of rock to break off & fall into the magma, thereby melting & adding more material
3. Lava: magma that has reached Earth's surface, usually through a *vent*
4. Volcano: vent or fissure in Earth's surface through which magma & gases are expelled

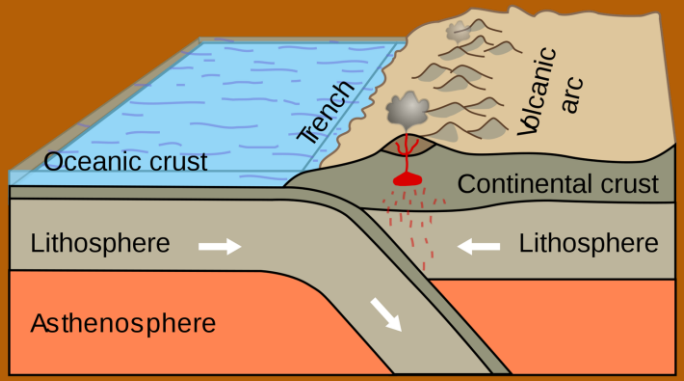
B. Volcanic Zones: usually occur along... _____

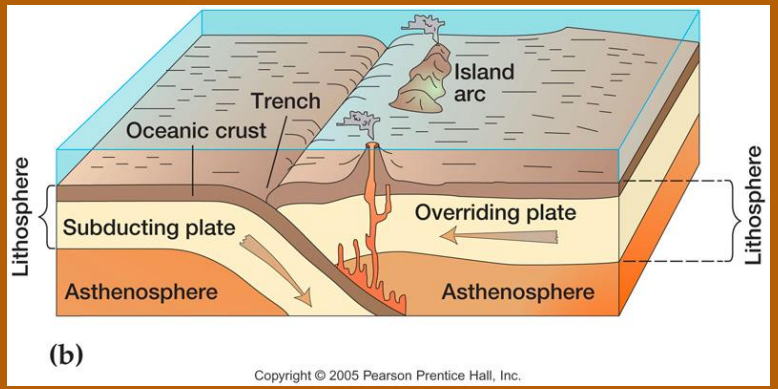


A. Volcanic Zones: usually occur along convergent & divergent boundaries



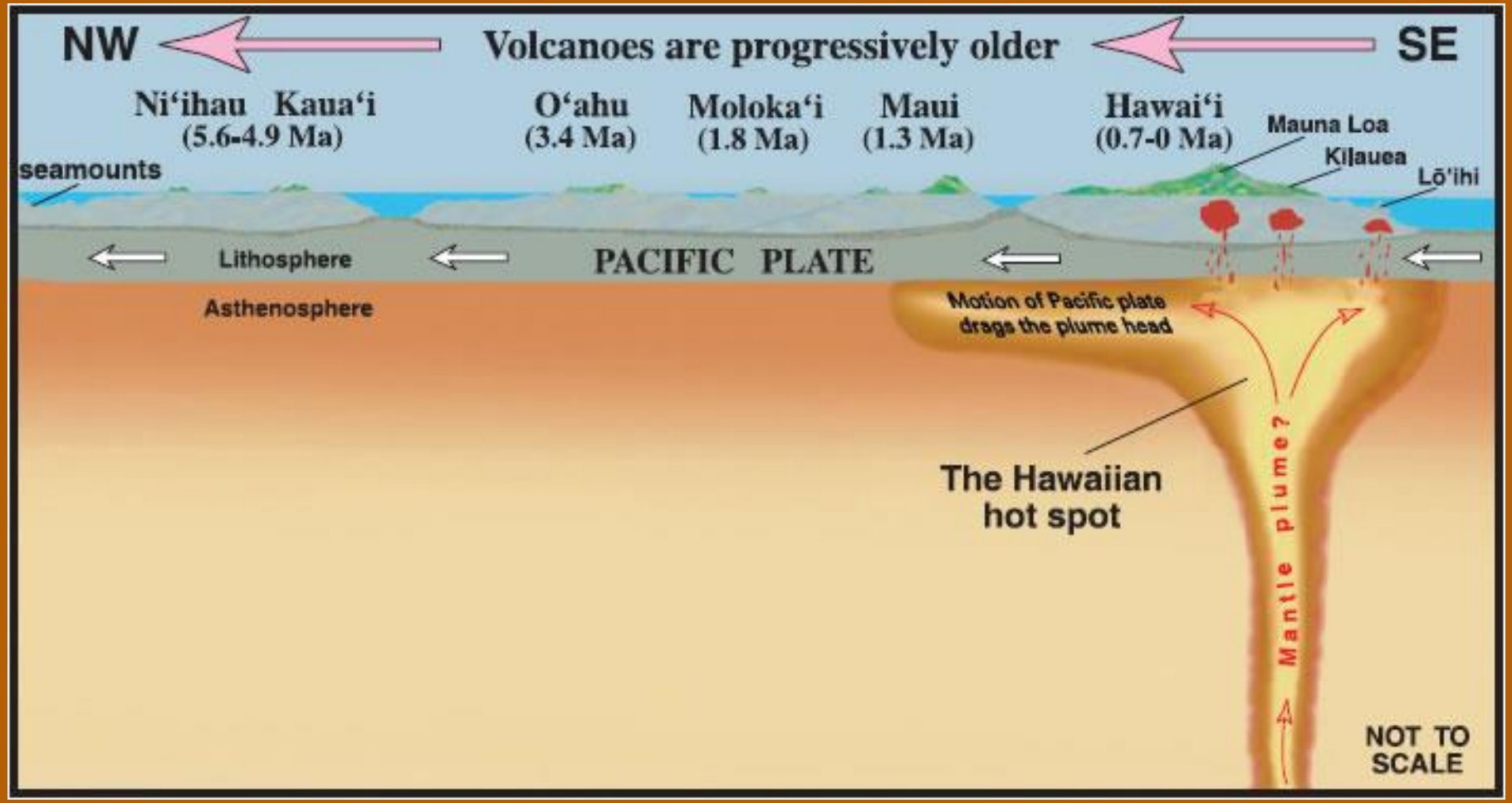
1. Subduction Zones: area where one tectonic plate moves under another
    a. Oceanic plate moves under another plate (can be oceanic or continental), forming a *trench* on the ocean floor
    b. Oceanic plate continues to sink into mantle, adding water & other rock
    c. Melting point of rock decreases & forms magma
    d. Magma rises through crust & erupts
    e. Lines of volcanoes form along edge of tectonic plate, parallel to trench
        i. Called a *volcanic arc* at oceanic-continental boundary (example: Cascade volcanic arc in Pacific NW US)
        ii. Called an *island arc* at oceanic-oceanic boundary (example: Aleutian Islands between Alaska & Siberia)





2. Mid-Ocean Ridges: area where oceanic plates move apart
    a. Plates pull apart
    b. Magma flows upward along the rift zone
    c. Magma adds material to mid-ocean ridge
    d. After erupting, lava cools (rapidly due to presence of water) & creates new lithosphere along the rift
        i. *Pillow lava*: type of volcanic rock that cools very quickly & cracks in the process, allowing more magma to come through & repeat the process
    e. Magma continues to erupt, producing underwater volcanoes
    f. Iceland is located on two plates -- the North American, moving west, and the Eurasian, moving east
        i. Middle of the country contains large fissures (cracks through which lava flows)
        ii. This makes Iceland very volcanically active

3. Hot Spots: areas of volcanism within the interiors of lithospheric plates
    a. Most form where *mantle plumes* (columns of very hot, solid material from deep mantle) rise & reach the lithosphere
    b. Once plume reaches the lithosphere, it spreads out -- magma rises to the surface, breaking through the crust & forming an interior volcano
    c. Mantle plumes are practically stationary, since the mantle itself doesn't drift like plates do
    d. As the plate above the plume moves, the volcano is relocated away from it & its activity eventually ceases
    e. Meanwhile, back at the mantle plume, a new volcano forms on the crust that is now above it!
    f. Example: Hawaiian-Emperor Seamount Chain (includes state of Hawaii)


NW
Volcanoes are progressively older
SE
Ni'ihau Kaua'i
(5.6-4.9 Ma)
O'ahu
(3.4 Ma)
Moloka'i
(1.8 Ma)
Maui
(1.3 Ma)
Hawai'i
(0.7-0 Ma)
Mauna Loa
Kilauea
Lō'ihi
seamounts
Lithosphere
PACIFIC PLATE
Asthenosphere
Motion of Pacific plate
drags the plume head
The Hawaiian
hot spot
Mantle plume?
NOT TO
SCALE

C. Intrusive Activity

1. *Intrusions* form when magma rises through cracks, but cools & solidifies inside the crust before it reaches the surface
    a. Cooled intrusive magma forms igneous rock structures called *plutons*, which vary in size & shape
    b. Plutons are exposed when the surrounding softer rock erodes away
    c. Types:
        i. *Dikes*: small plutons; range from a few centimeters to several kilometers
        ii. *Batholiths*: larger, cover an area of at least 100 km^2

II. Volcanic Eruptions

A. Types of Magma

1. Mafic: magma rich in magnesium & iron, dark in color
    a. Cools to form *basaltic* rock
    b. Commonly found in oceanic crust
2. Felsic: rich in light-colored silicate material, therefore has a light color
    a. Cools to form *rhyolitic* rock
    b. Commonly found in continental crust

B. Types of Eruptions

1. Viscosity: magma's resistance to flow
    a. Determined by magma's composition
    b. Low viscosity magma is NOT resistant to flow & has a runny consistency – mafic magma
    c. High viscosity magma is VERY resistant to flow & stickier– felsic magma

2. Quiet Eruptions
    a. Occur from oceanic volcanoes due to the low density of mafic lava, which allows gases to easily escape
3. Lava Flows
    a. Form when mafic lava cools rapidly & forms a crust on the surface of the lava flow
    b. Classified based upon appearance of crusted layer:
        i. Pahoehoe: forms from hot, fluid lava flowing even after the crusted-over surface forms; smooth, wrinkly, & ropy texture
        ii. Aa: forms when crusted-over surface deforms rapidly or becomes too thick to “wrinkle” like pahoehoe; differences are due to gas content & rate/slope of lava flow
        iii. Blocky lava: higher silica content & more viscous than aa; causes cooled lava to break into large chunks while hot lava still flows underneath – leads to blocky appearance

4. Explosive Eruptions
    a. Occur in continental volcanoes
        i. Due to presence of felsic lava, which is cooler, stickier, & contains more trapped gases like water vapor & CO_2
    b. During an eruption, dissolved gases escape
    c. This causes solid particles & magma to shoot into the air more violently, like shaking a pop can

C. Pyroclastic Materials

1. Definition: fragments of rock that form during a volcanic eruption – this is what comes out of the volcano, aside from lava
2. Classified according to size:
    a. Volcanic dust: less than 0.25 mm in diameter
    b. Volcanic ash: 0.25–2 mm in diameter; usually ends up on land surrounding volcano, but may reach Earth's upper atmosphere & travel
    c. Lapilli: 2–64 mm in diameter; fall near vent
    d. Volcanic bombs: formed by large amounts of lava being thrown into the air & cooling into a roundish shape
    e. Volcanic blocks: formed from solid rock being thrown from the volcanic vent; can be size of small house!

D. Types of Volcanoes
   1. After erupting, volcanoes form cone-like structures above ground from the cooled lava & pyroclastic material
   2. crater: funnel-shaped pit at the top of the vent
   3. Three types of volcanoes:
      a. Shield: broad at base, gently sloping sides
         i. Formed from quiet eruptions with mafic lava
         ii. Example: Hawaiian Islands are shield volcanoes formed from a hot spot
      b. Cinder Cone: very steep slopes, smallest
         i. Formed from small explosive eruptions
         ii. Made of pyroclastic material
      c. Composite: alternating layers of hardened lava flow & pyroclastic material
         i. Formed from quiet eruptions, producing small lava flows, as well as explosive eruptions, depositing pyroclastic material
         ii. Usually develop to form large volcanic mountains

E. Calderas
   1. Definition: large, circular depression formed when magma chamber under a volcano partially empties, causing the ground above to sink
   2. Example: Crater Lake in Oregon is a lake formed in the caldera left by Mount Mazama collapsing thousands of years ago

F. Predicting Volcanic Eruptions
   1. Small earthquakes in a volcanically active zone may indicate a volcanic eruption
      a. Can be caused by pressure from magma, increasing temperature, fracturing of Formed from quiet eruptions with mafic lava
   2. Movement of magma within a volcano may cause it to bulge outward in certain locations; can be detected by special instruments
   3. Some volcanoes demonstrate regular patterns of activity which can be studied along with daily measurements to predict eruptions
      a. Not completely reliable because many volcanoes haven't been studied long enough to determine a pattern