VOLCANOES

"I don't know where I'm-a-gonna go. . ."

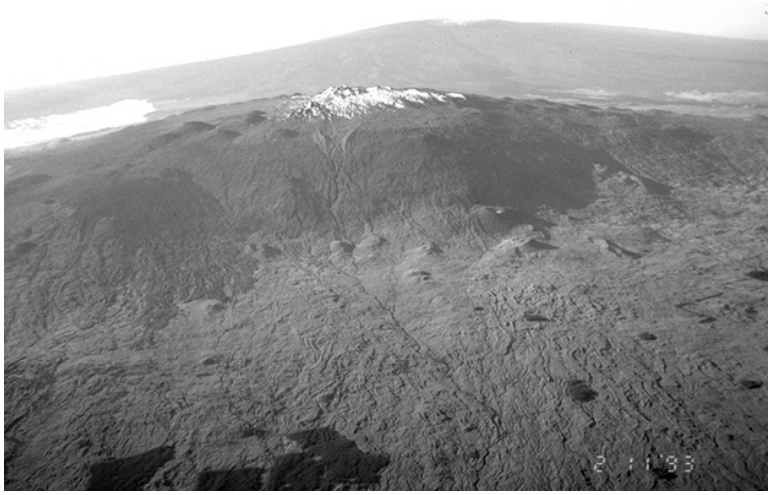
Basic Types of Volcanoes. . .

- Shield volcanoes
- Stratovolcanoes (a.k.a. *composite volcanoes*)
- Cinder cones
- Lava domes
- Calderas
- Flood basalts

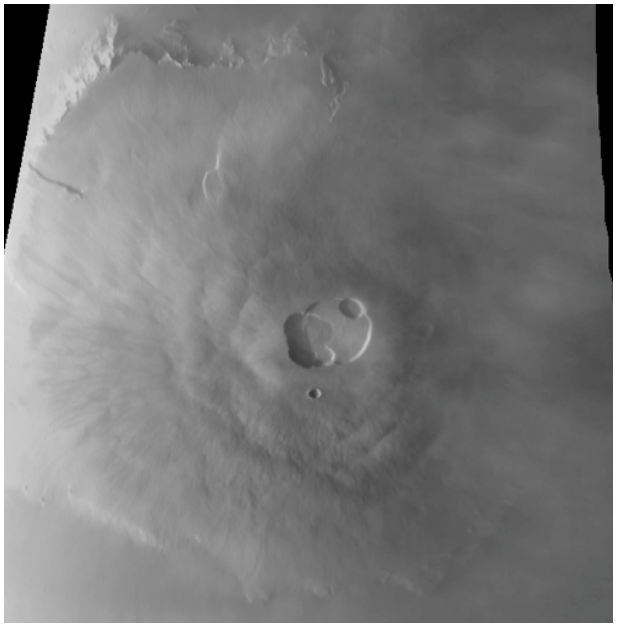
Shield Volcanoes

- Low, broad, rounded appearance (like a shield)
- Formed mostly by eruptions of mafic lavas
- Located at hot spots, mid-oceanic rifts—anywhere that magma is derived from deep in the crust
- Classic example: The Hawaiian islands

Mauna Kea, Hawaii: a classic shield volcano



Another shield volcano: Sierra Grande, near the town of Clayton, New Mexico

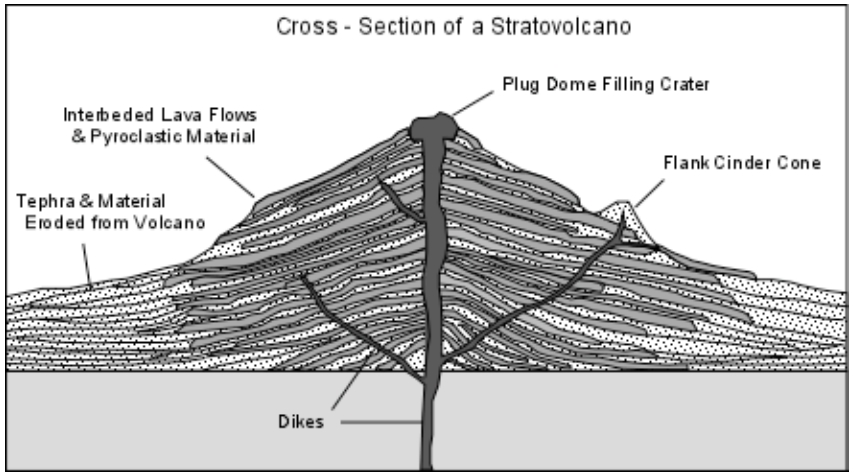


And the largest volcano of all, Olympus Mons, is a shield volcano. (It happens to be on Mars, not Earth. It's 16 miles high and as large as the state of Arizona.)

Stratovolcanoes

- Large, steep-sided conical volcanoes
- Formed of alternating layers of lava flows and *tephra*
- Magma is usually felsic—making it much more viscous
  - Because felsic magma doesn't flow easily, stratovolcano eruptions are much more explosive and much more dangerous than shield volcano eruptions
- Associated with subduction zones
- Classic examples: Mt. St. Helens, Mt. Rainier, Mt. Fuji, Krakatau. . .

Diagram of a cross-section through a stratovolcano



Mt. Rainier, in Washington state, is a classic stratovolcano.

So is Mt. Shasta, California.

So is Mt. Fuji, Japan.

So is Mt. St. Helens, shown here one day before the great eruption of May 18, 1980. . .

. . . and, from the same camera angle, several months *after* the May 18 eruption—having lost 1,314 feet of elevation and gained a 2,084-foot deep crater.

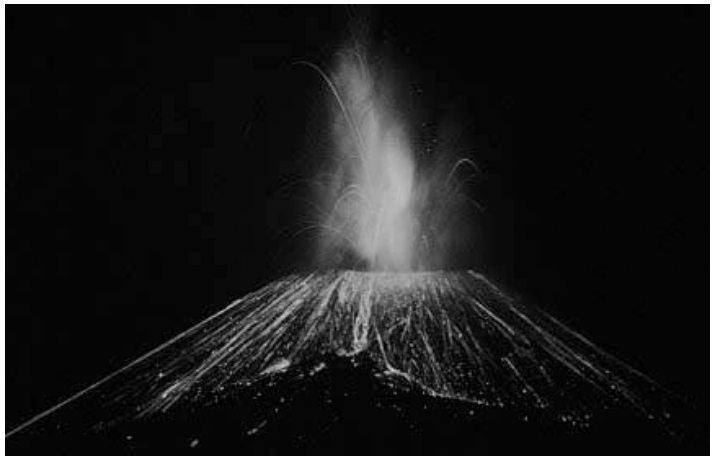
Cinder Cones

- Relatively small (few hundred to thousand feet), conical, symmetrical
- Formed, basically, as a pile of volcanic cinders (solidified blobs of lava)
  - May form on the flanks of other volcanoes
  - Often form clusters, in "fields" of volcanic activity
- Form in one "burst" of activity and then don't erupt again
- Classic examples: Capulin, New Mexico; Paricutín, Mexico

Capulin Volcano, northeastern New Mexico

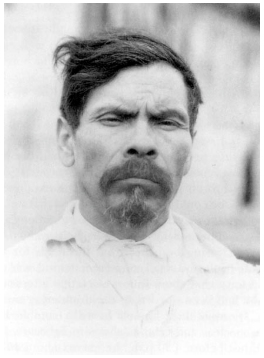
Wizard Island is a cinder cone that formed inside the crater of a large stratovolcano, Mt. Mazama, Oregon (Crater Lake)

Paricutin, in the state of Michihuacan, Mexico, is a famous cinder cone—it is one of the few volcanoes whose entire formation was documented from beginning to end.



Paricutin erupted (out of a fissure in the middle of the cornfield of a farmer named Dionisio Pulido) beginning on February 20, 1943. Within 16 hours of the eruption starting, the cone of scoria and tephra was 10 meters high. It grew to a final height of 425 meters (1400 feet). .

Dionisio Pulido describes how the eruption of Paricutin began



"At 4 p.m., I left my wife to set fire to a pile of branches when I noticed that a crack, which was situated on one of the knolls of my farm, had opened. . . and I saw that it was a kind of fissure that had a depth of only half a meter. I set about to ignite the branches again when I felt a thunder, the trees trembled, and I turned to speak to Paula; and it was then I saw how, in the hole, the ground swelled and raised itself 2 or 2.5 meters high, and a kind of smoke or fine dust—grey, like ashes—began to rise up in a portion of the crack that I had not previously seen . . . Immediately more smoke began to rise with a hiss or whistle, loud and continuous; and there was a smell of sulfur."

Eruptions continued to 1952, as did multiple lava flows out of the base of Paricutin, which buried most of two nearby towns. This partially buried church is all that's left of the town of San Juan Parangaricutiro. (Fortunately, everyone evacuated in time; only three people were killed by Paricutin.)

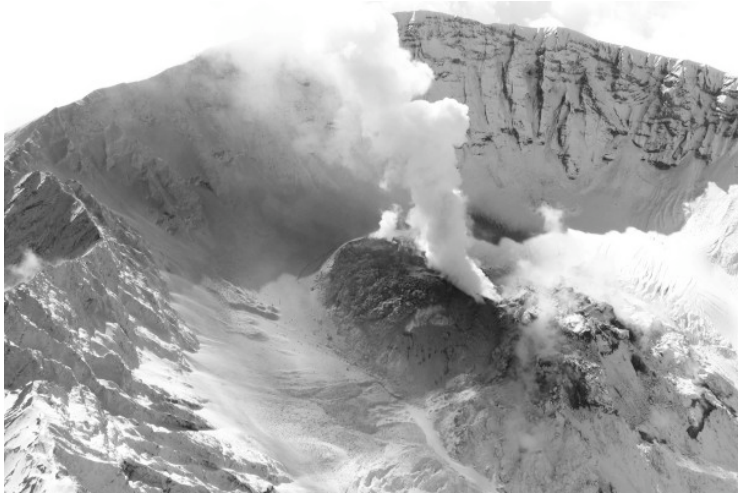
Paricutin itself has been quiet since 1952 and will not erupt again. (However, Paricutin is one of many cinder cones and other volcanoes in the area; it's not impossible that another volcano will someday erupt in the region.)

Lava Domes

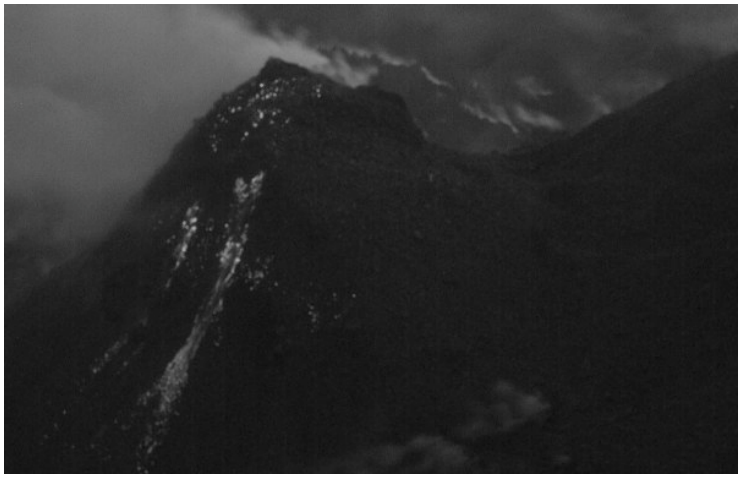
- Small, bulbous "pileups" formed by very viscous felsic lava
  - Lava dome eruptions generally don't have enough gas pressure to be truly violent
- Lava domes often appear on the craters and sides of stratovolcanoes (there is one that recently formed inside the crater of Mt. St. Helens, for example)
- Not extremely dangerous, but if a dome collapses it can trigger a pyroclastic flow

In 1912, a stratovolcano called Novarupta erupted on the Katmai Peninsula of Alaska (largest eruption of the 20th century). Today, there is a lava dome (center of the picture) on top of the vent.

In October 2004, a new lava dome began forming inside the crater of Mt. St. Helens. (Another one had formed in 1980-1986)



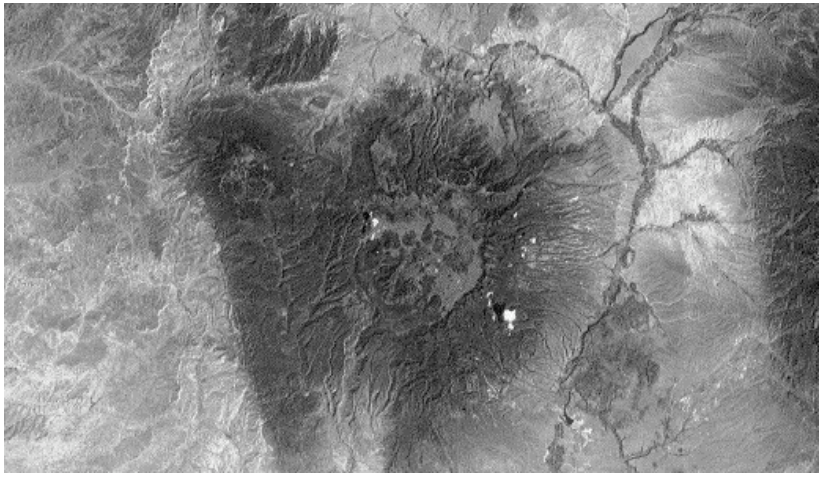
The Mt. St. Helens dome is still growing. . . this close-up image of the new dome was taken on September 6, 2005.



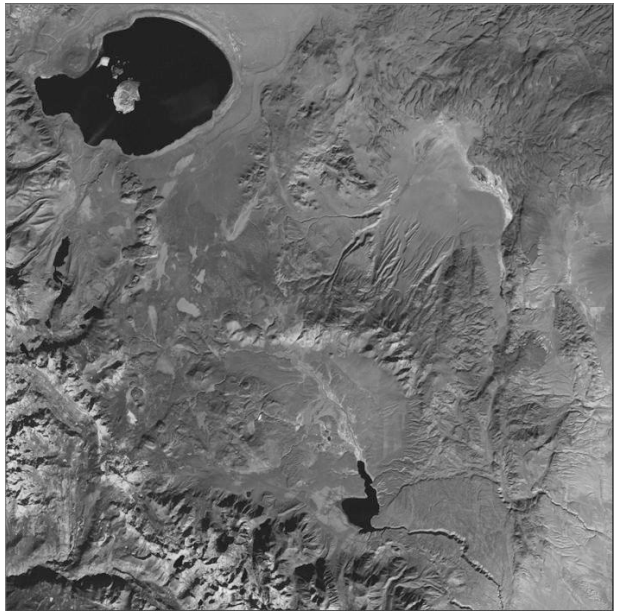
Calderas

- Formed when an underground magma chamber vents quickly, and then the roof of the chamber collapses in
- Often linked to a continent passing over a hot spot
- *Huge* volcanoes, and fortunately, very rare—no large caldera has erupted in recorded history
  - Small calderas may form atop other volcanoes (e.g. the crater atop Mt. Mazama, a.k.a. Crater Lake, Oregon)
- Classic examples: Yellowstone, Wyoming; Valles Caldera, New Mexico; Long Valley, California

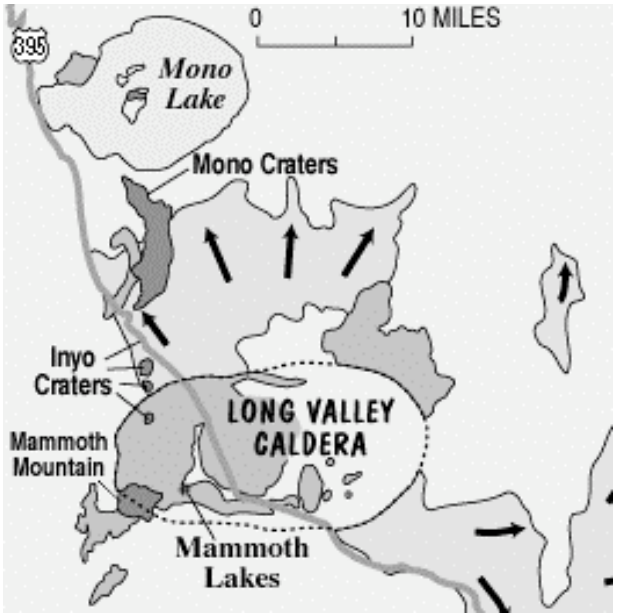
Satellite image of the Valles Caldera, New Mexico. Diameter of the caldera is 14 miles.

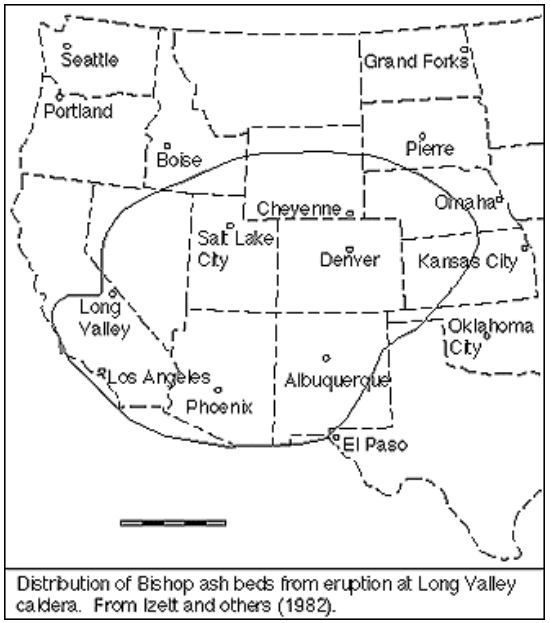


Satellite image of the Long Valley Caldera, Sierra Nevada Mts., near Mammoth Lakes, eastern California. The caldera (below the center of the picture) is 10 miles wide and 20 miles long.



Map of the Long Valley Caldera, Sierra Nevada Mts., eastern California. Yellow = ash from eruption; beige = later volcanic deposits. (The last eruption was 780,000 years ago. . . new activity began in the early 1980s.)

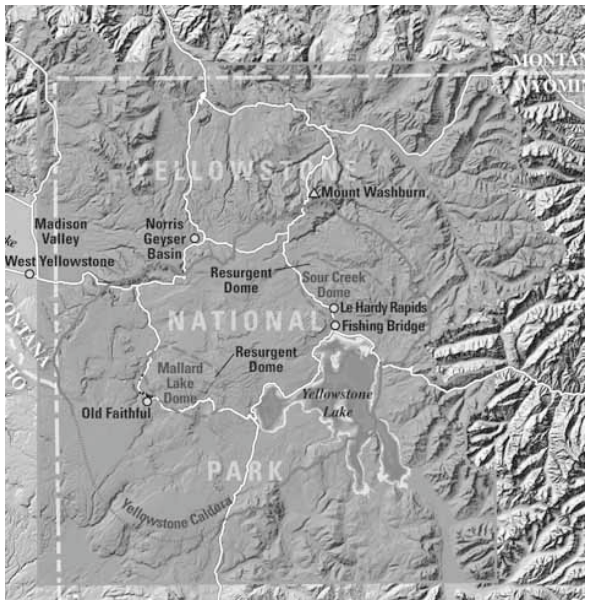




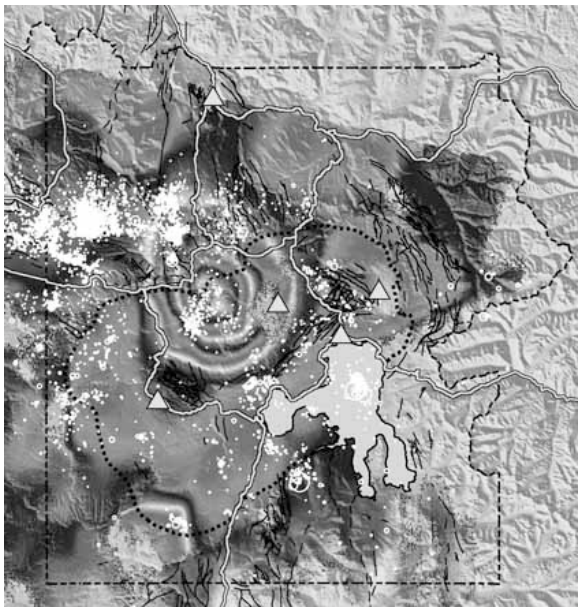
Distribution of Bishop ash beds from eruption at Long Valley caldera. From Izett and others (1982).

The last eruption of the Long Valley Caldera put out 150 cubic miles of ash—which formed beds of tuff as far away as Nebraska.

<u>Much of Yellowstone National Park is a caldera</u>, 53 miles by 28 miles across, long. It formed 640,000 years ago, erupting out 240 cubic miles of ash and lava. Later lava flows have buried the old floor and parts of the old wall.



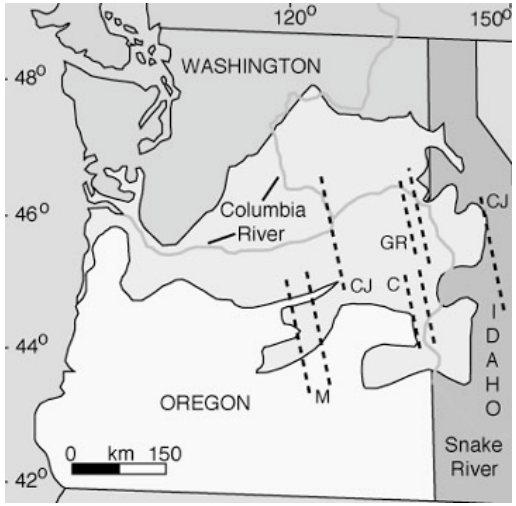
Very sensitive satellite-based radar measurements can detect ground uplift. The "bull's-eye" is a region where the ground has been rising (as much as one inch in four years), probably because of a buildup of magma. . .



Flood Basalts

- Formed when mass quantities of mafic lavas pour from rifts in the ground
  - Large flood basalts cover thousands of square miles with deposits hundreds or thousands of feet thick
- No recorded eruptions in human history
- Classic examples: Deccan Traps, south India; Columbia River basalts, Washington- Oregon-Idaho; Siberian Traps, Russia

Map of the Columbia River Flood Basalts



Aerial view of the Columbia River flood basalts

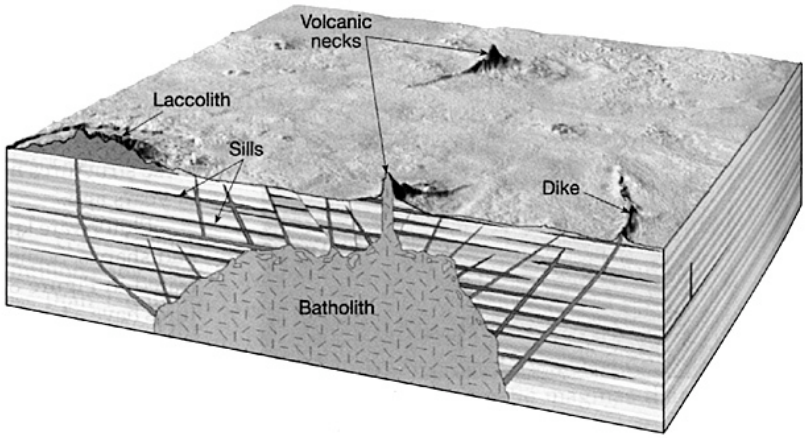
Cross-section eroded through the Columbia River flood basalts

Map of the Siberian Traps, the largest volcanic eruption in Earth history (245 million years ago; 4 million cubic km of lava and ash, in a layer up to 6500 meters thick)

How to Build a Mountain

- We've already talked about *island arcs* and *hot-spot volcanism* as ways to build mountain ranges. . .
- Other mountain ranges result from massive intrusive magma movements
  - By definition, these never erupt. . .
  - But they can create large bulges in the crust—which often erode away later to expose the intrusive igneous rock mass
  - These masses of intrusive igneous rocks may form *batholiths, laccoliths,* etc.

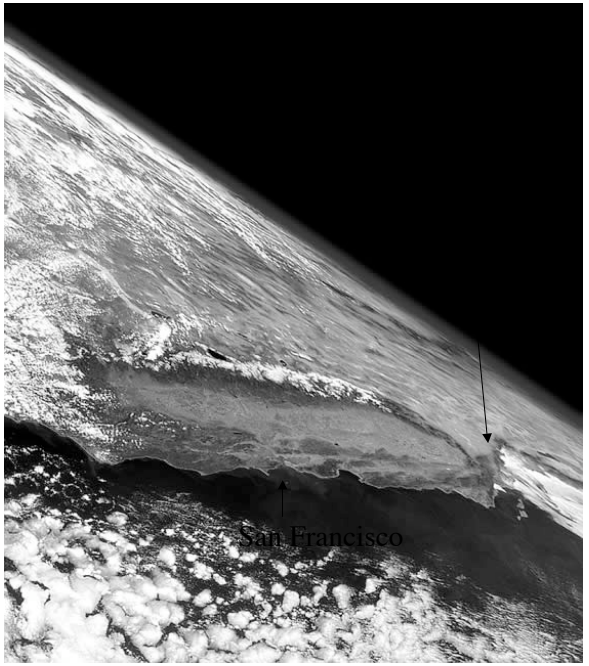
Magma intrusions may solidify into different types of rock bodies, classified by position and shape.



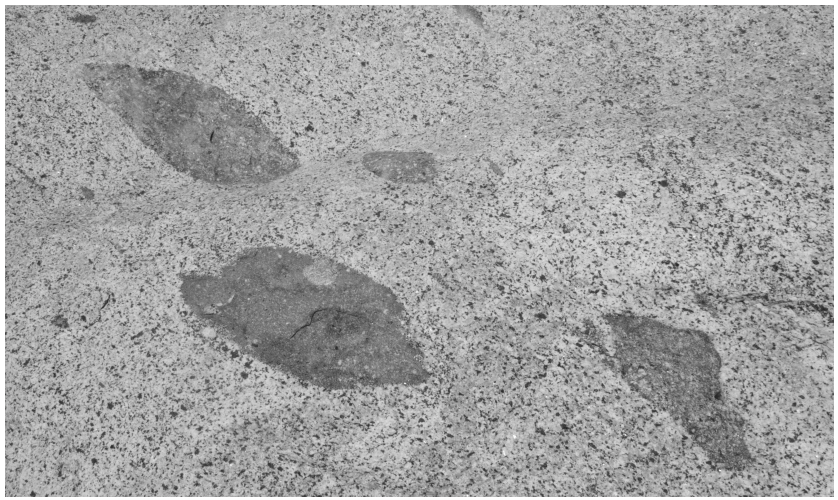
An exposed *laccolith*: Bear Butte, Wyoming

An exposed *batholith*: the Sierra Nevada Mts., California

The Sierra Nevada Mts. are 350 miles long and are visible in this photograph taken from space as the long white feature in the center. . . they are a single gigantic batholith.



Magma may contain lumps of the surrounding rock, which get trapped in the cooling intrusive rock, like pecans in a piece of fudge. These are *xenoliths*, seen here in an outcrop of granite.



A *discordant* intrusive feature (that is, not parallel to the rock beds that it intrudes) is a *dike*. (Hance Rapids, Grand Canyon, Arizona)

A *concordant* intrusive feature (parallel to the rock layers that it intrudes) is a *sill*. (Ellesmere Island, Northwest Territories, Canada—the thick dark band is the sill)