

VULCANISM, VOLCANOES and VOLCANIC HAZARDS

Dr. Danang Sri Hadmoko

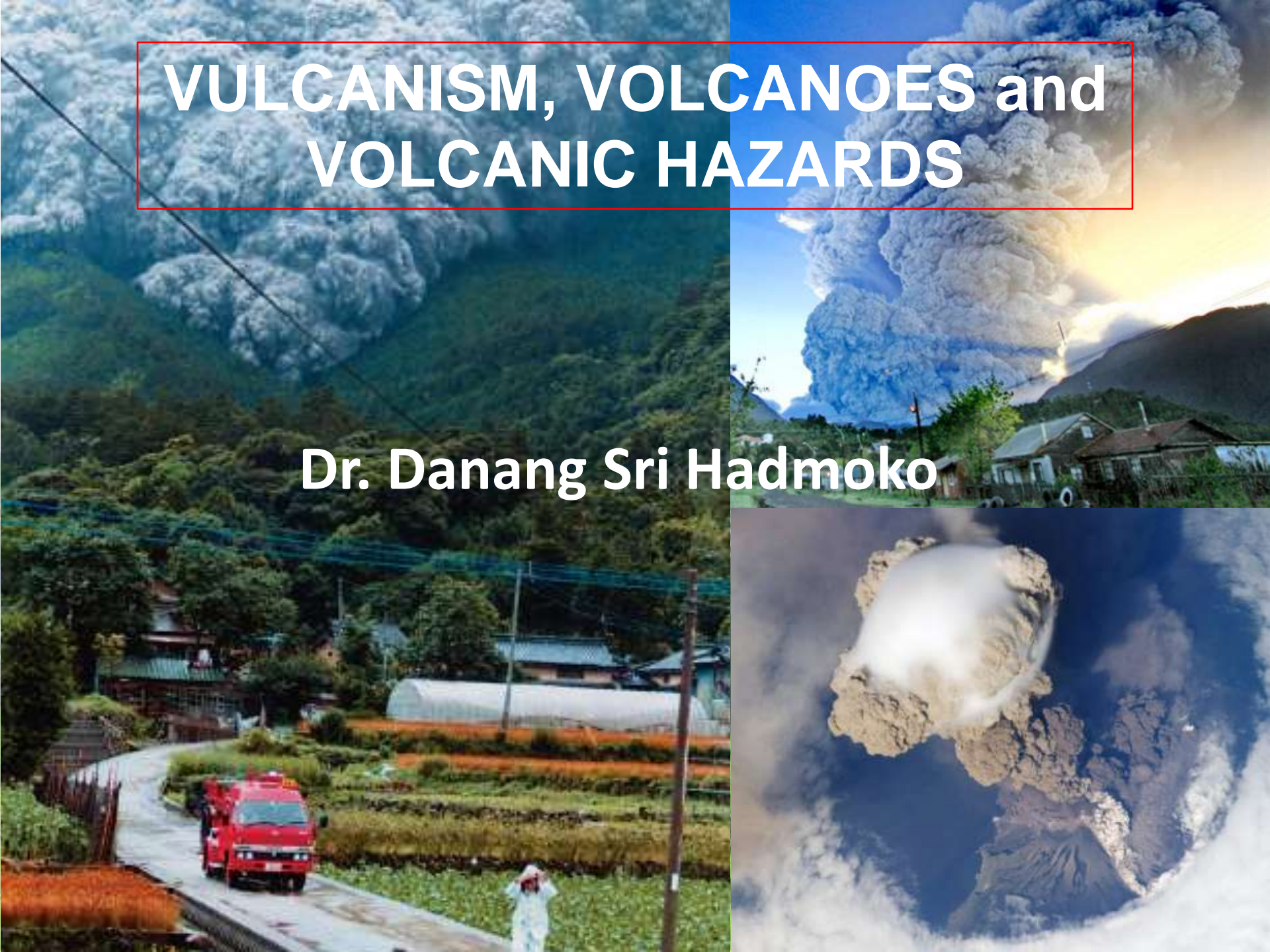


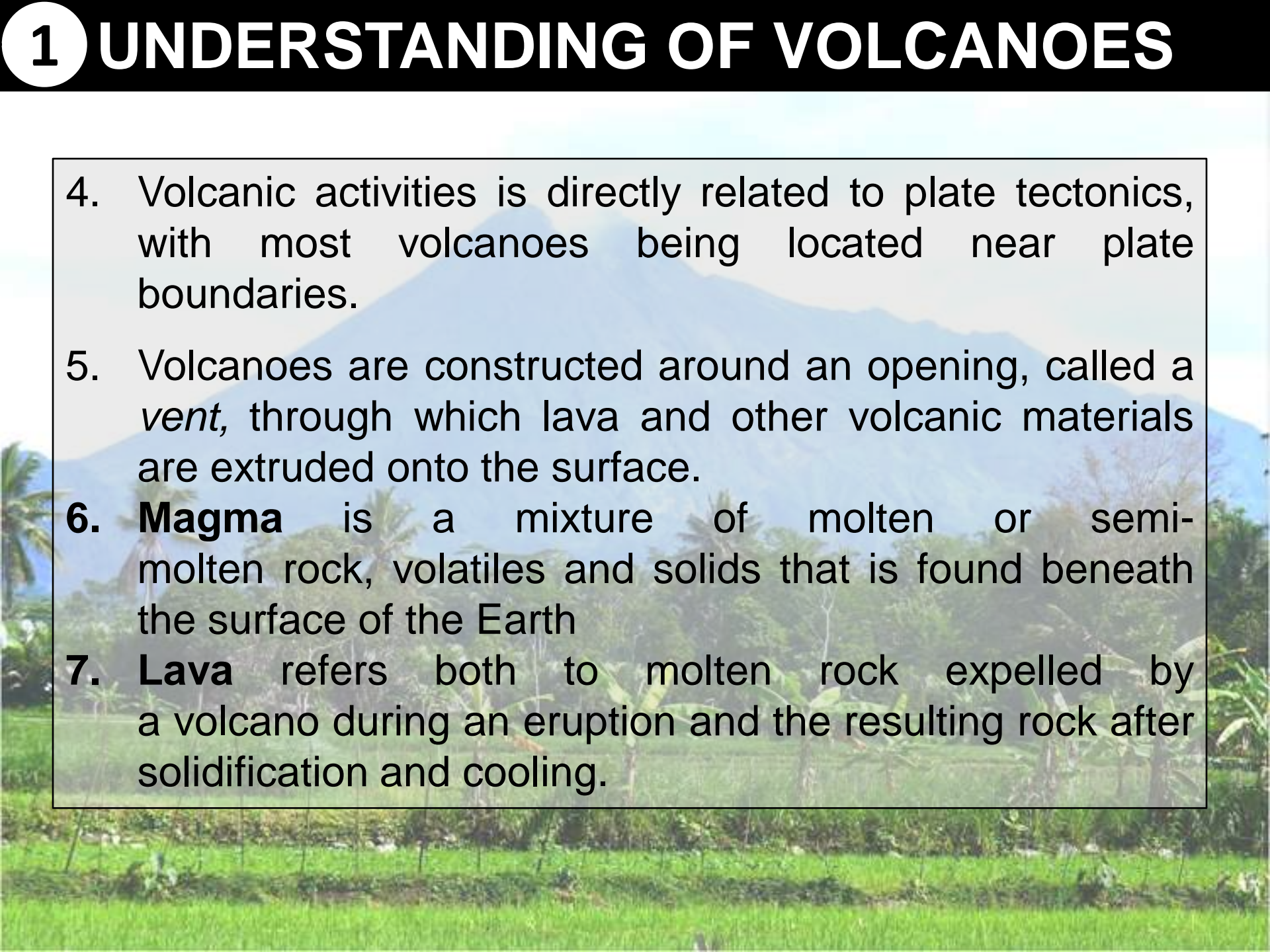
TABLE OF CONTENT

1. Understanding of volcanoes, volcanic developments and tectonic activities
2. Type of volcanoes
3. Parts of the volcanoes
4. Type of eruptions
5. Products of volcanic eruption
6. Volcanic hazards

1 UNDERSTANDING OF VOLCANOES

1. Volcanism is the process of eruption of magma onto the surface of the Earth.
2. A volcano is typically cone-shaped mountain formed at vent from which magma erupt.
3. Volcanism is related to the phenomena where lava, pyroclastics and volcanic gases erupt through a vent.
4. It includes all phenomena related to the magma raising through the crust and form volcanic rocks on the surface.

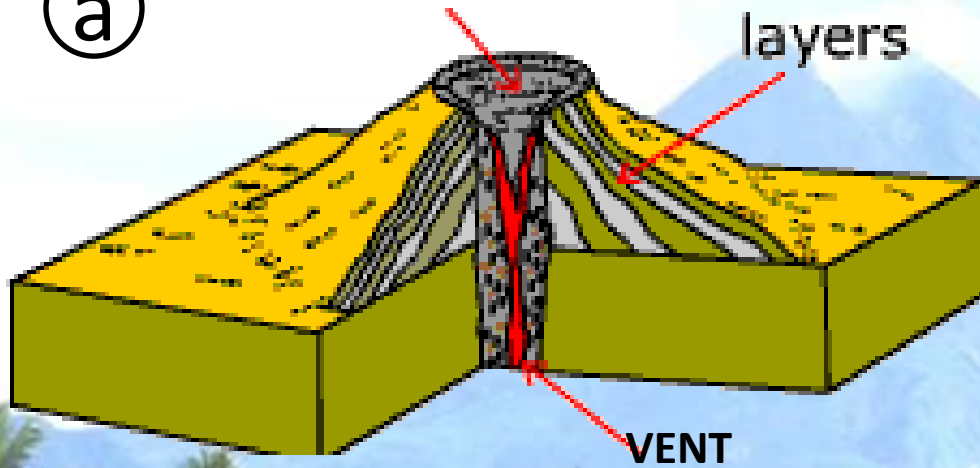
1 UNDERSTANDING OF VOLCANOES

- 
4. Volcanic activities is directly related to plate tectonics, with most volcanoes being located near plate boundaries.
 5. Volcanoes are constructed around an opening, called a *vent*, through which lava and other volcanic materials are extruded onto the surface.
 6. **Magma** is a mixture of molten or semi-molten rock, volatiles and solids that is found beneath the surface of the Earth
 7. **Lava** refers both to molten rock expelled by a volcano during an eruption and the resulting rock after solidification and cooling.

1

MAGMA, LAVA and VENT

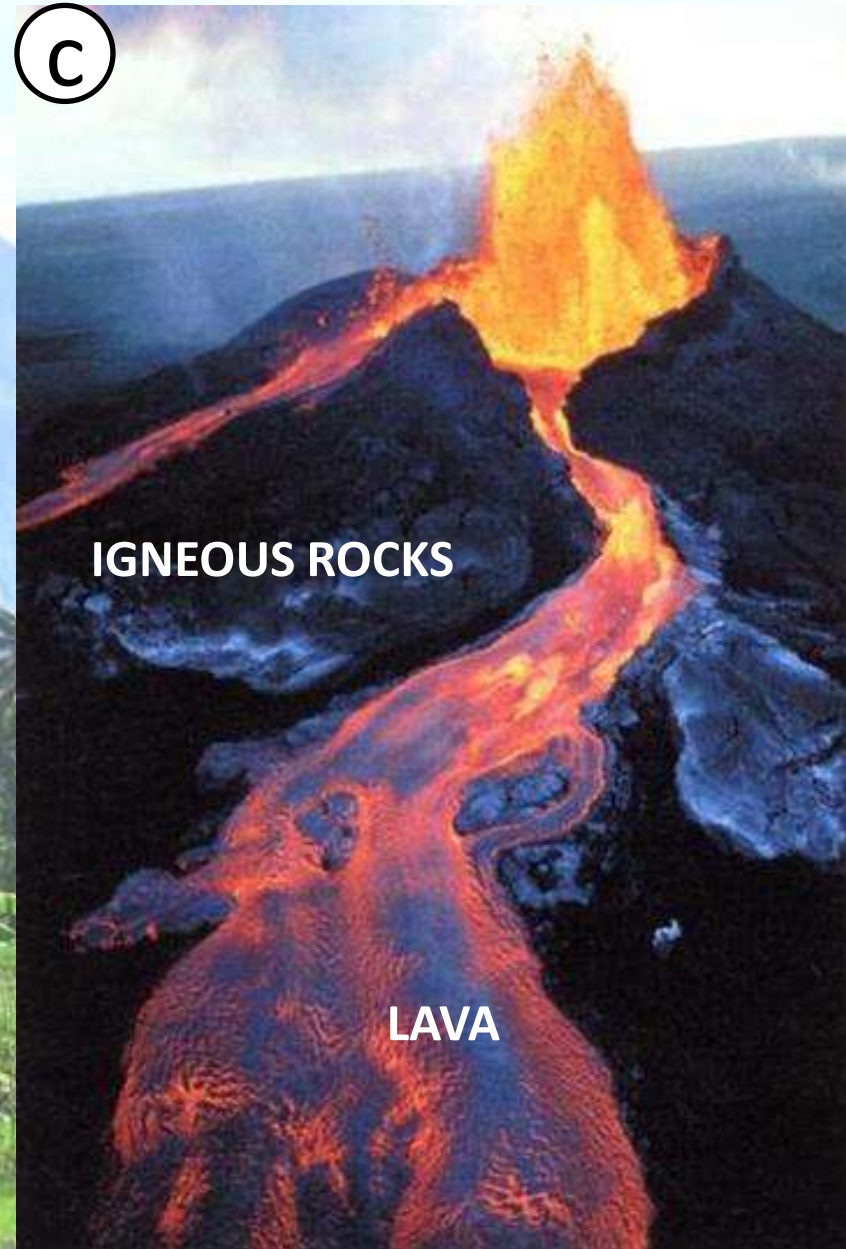
(a)



(b)



(c)



1

MAGMA PROPERTIES AND BEHAVIOR

The volcanic eruption depends on how fluid the magma is (**its viscosity**), the quantity of water vapor and other gases it contains (**its volatiles**), and type and amount of magmas (**its volume**) that erupt.

Most magmas come from the asthenosphere, the weak layer that underlies the lithospheric plates

Magma is composed of **melted silicate rocks** and **dissolved gases**. Silica (SiO_2), the most abundant chemical compound in silicate minerals, is the primary constituent of magma.

The three major types of magma—*basaltic*, *andesitic*, and *rhyolitic*—vary in their silica content

Basaltic magma is low in silica (around 50 percent), and **andesitic** and **rhyolitic** magma are high in silica (60 percent to 70 percent).

1

MAGMA PROPERTIES AND BEHAVIOR

1

PROPERTIES OF MAGMA

3

2

VOLATILES

The content of gasses

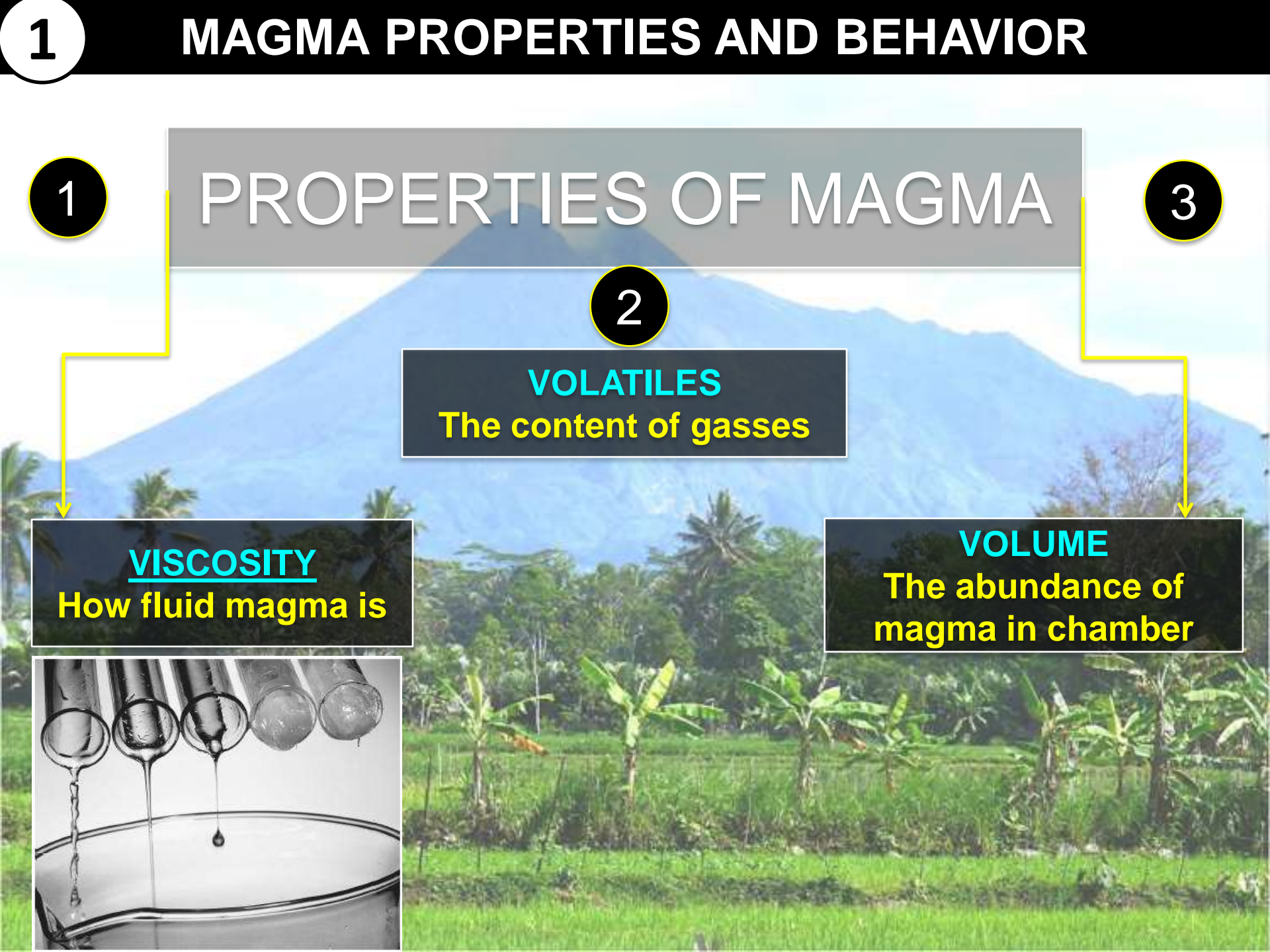
VISCOSITY

How fluid magma is



VOLUME

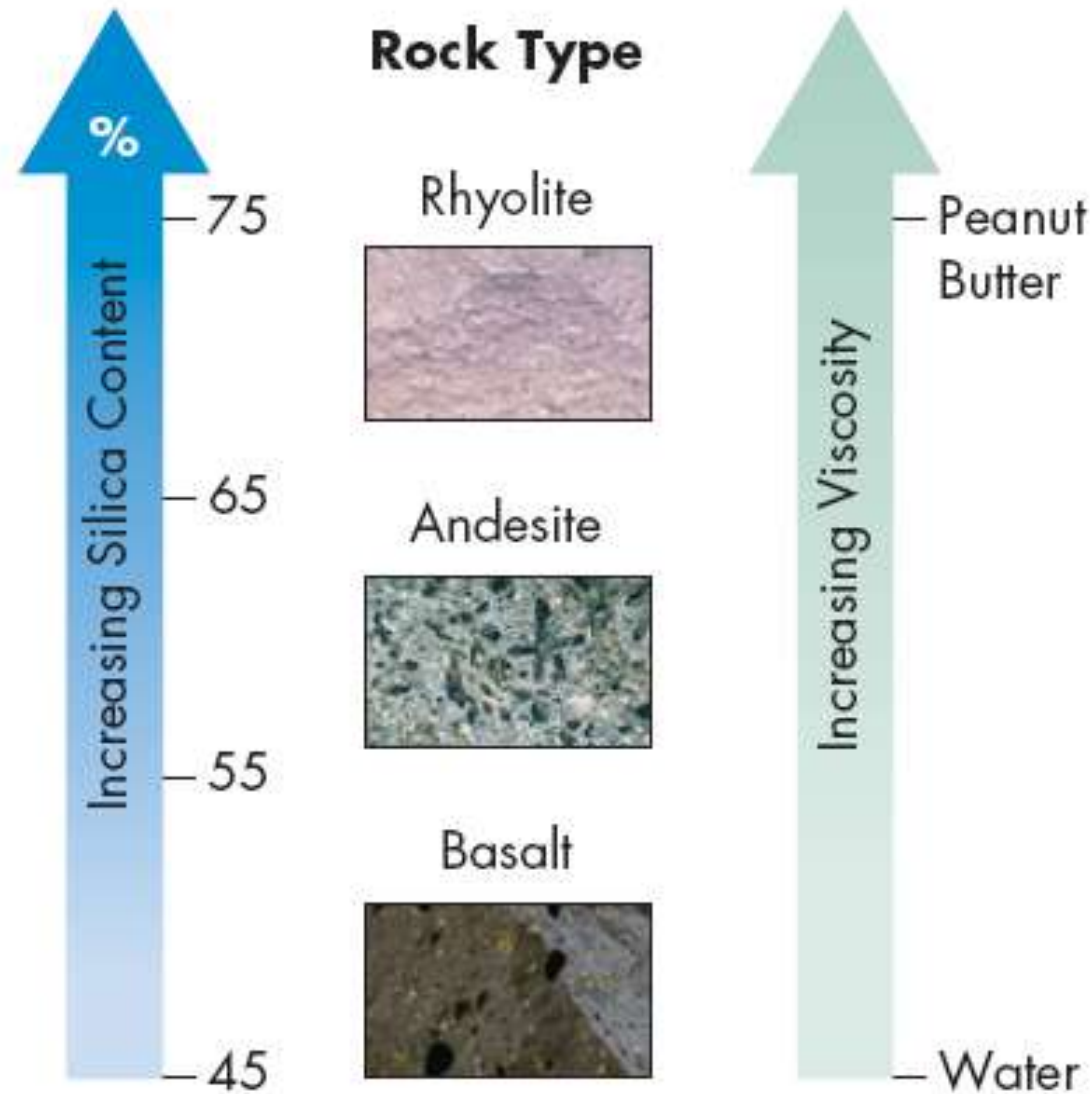
The abundance of magma in chamber



VISCOSITY

How fluid magma is

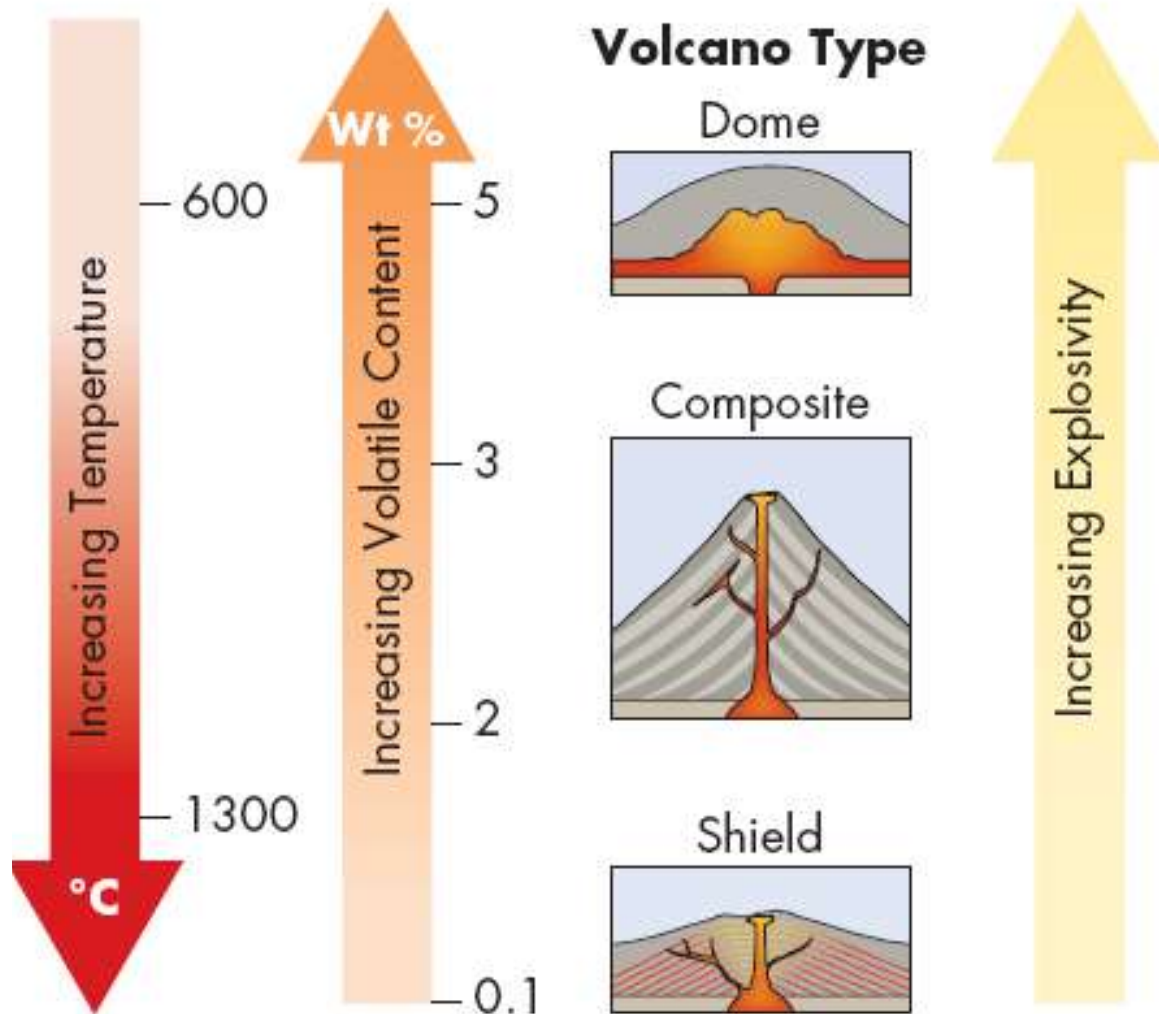
- **Viscosity** Greater amounts of silica make it more difficult for magma to flow. Resistance to flow in fluids is called *viscosity*.
- **Rhyolitic lava flows** have high viscosity, move slowly, may be a hundred feet thick, are generally restricted to the vent region, and form steep-sided domes.
- **Basaltic lava flows** can move rapidly, are often thin (< 3m or 10 ft.), and may travel 10s of kilometers from the vent.



VOLATILES

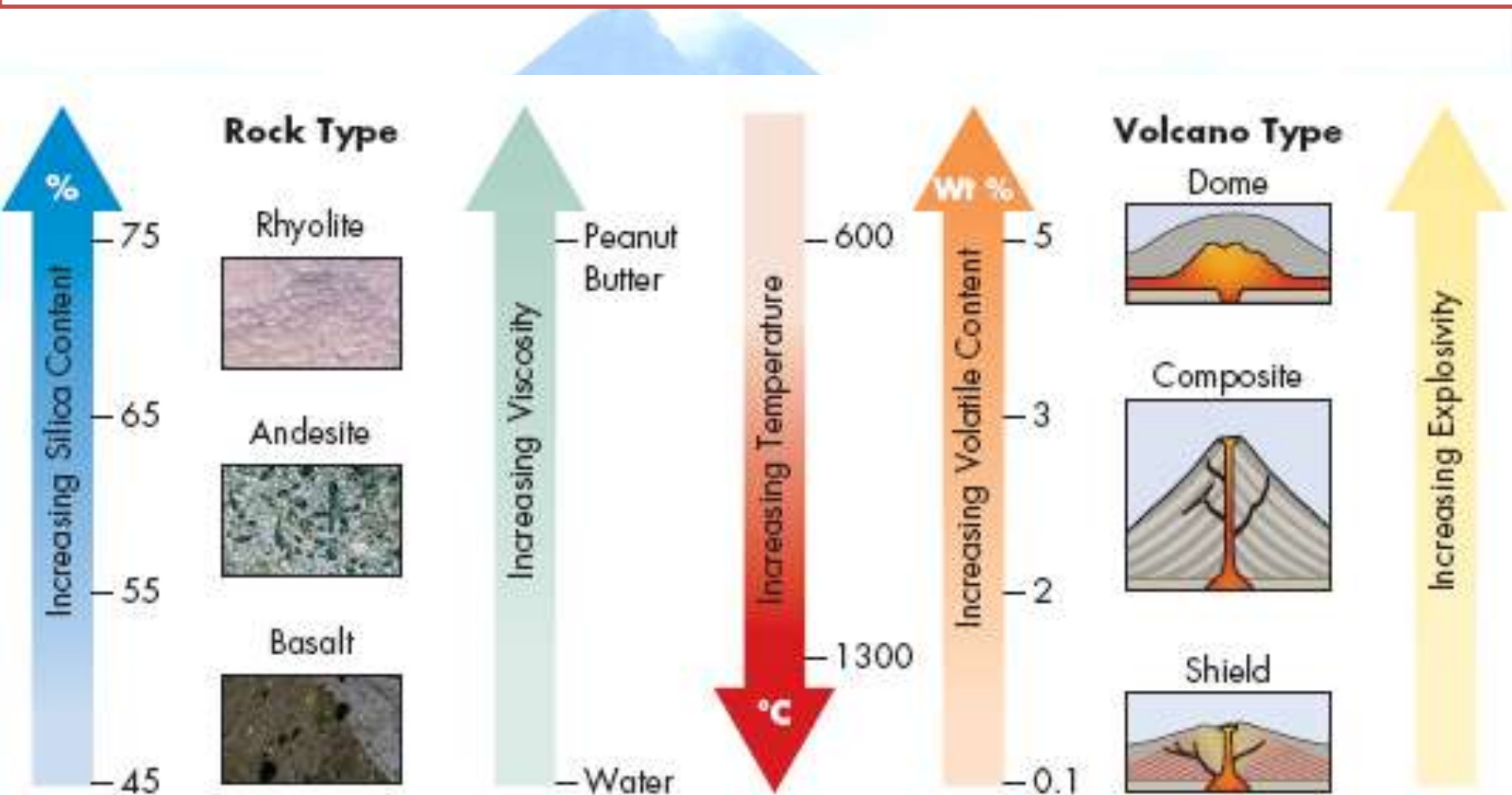
The content of gasses

- **Volatile content** increases with increasing **silica content**.
- **Andesitic-to-rhyolitic** magma has more dissolved gas (2–5 weight percent) than **basaltic magma** (<1 wt. %)
- Thus, volcanoes with andesitic-to rhyolitic magma are more explosive eruptions than volcanoes erupting basaltic lava.



VOLCANO CHARACTERISTICS

The eruptive character, shape, and type of volcano



The causes of volcanic activity are directly related to plate tectonics

1

Mid-ocean ridges and continental rifts

2

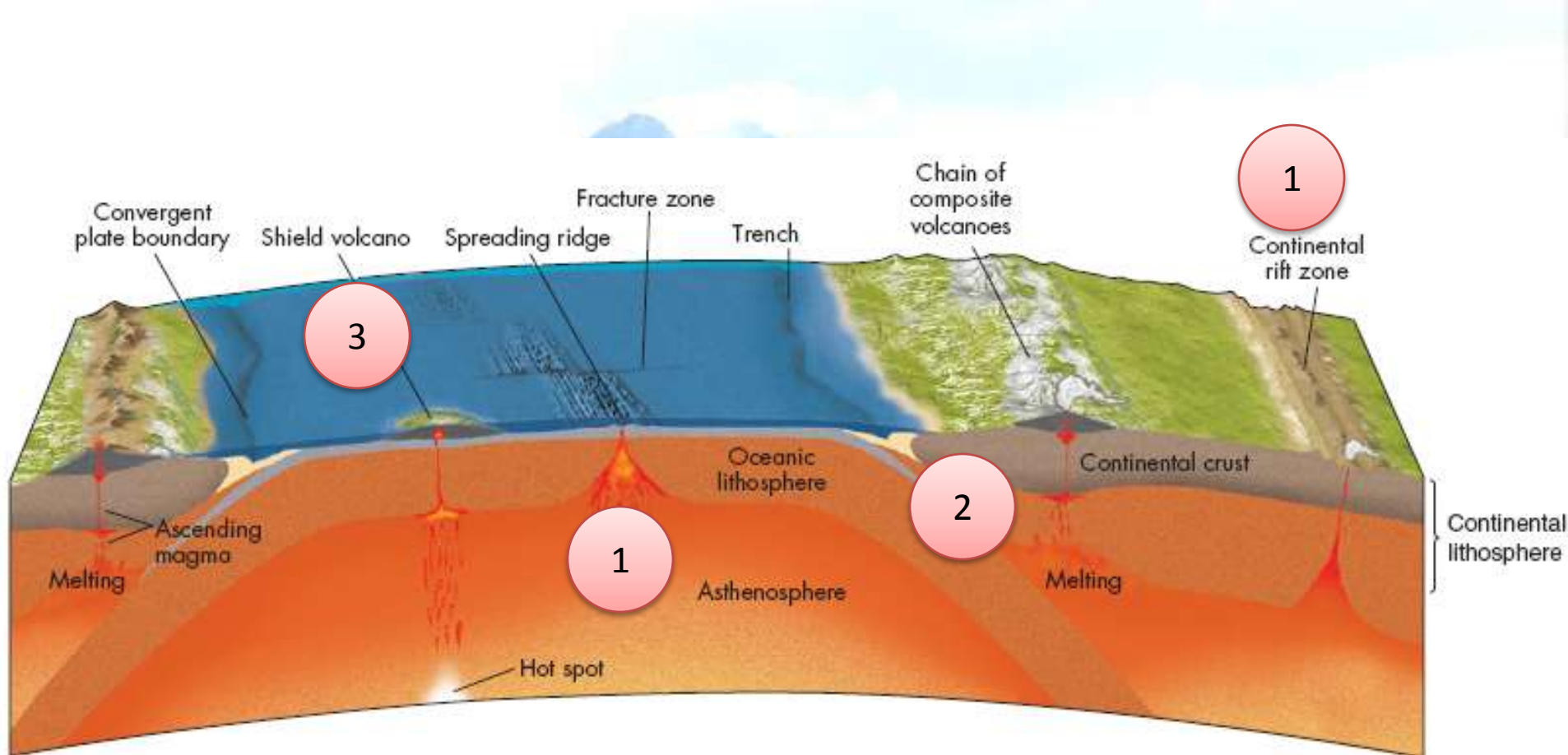
Subduction zones

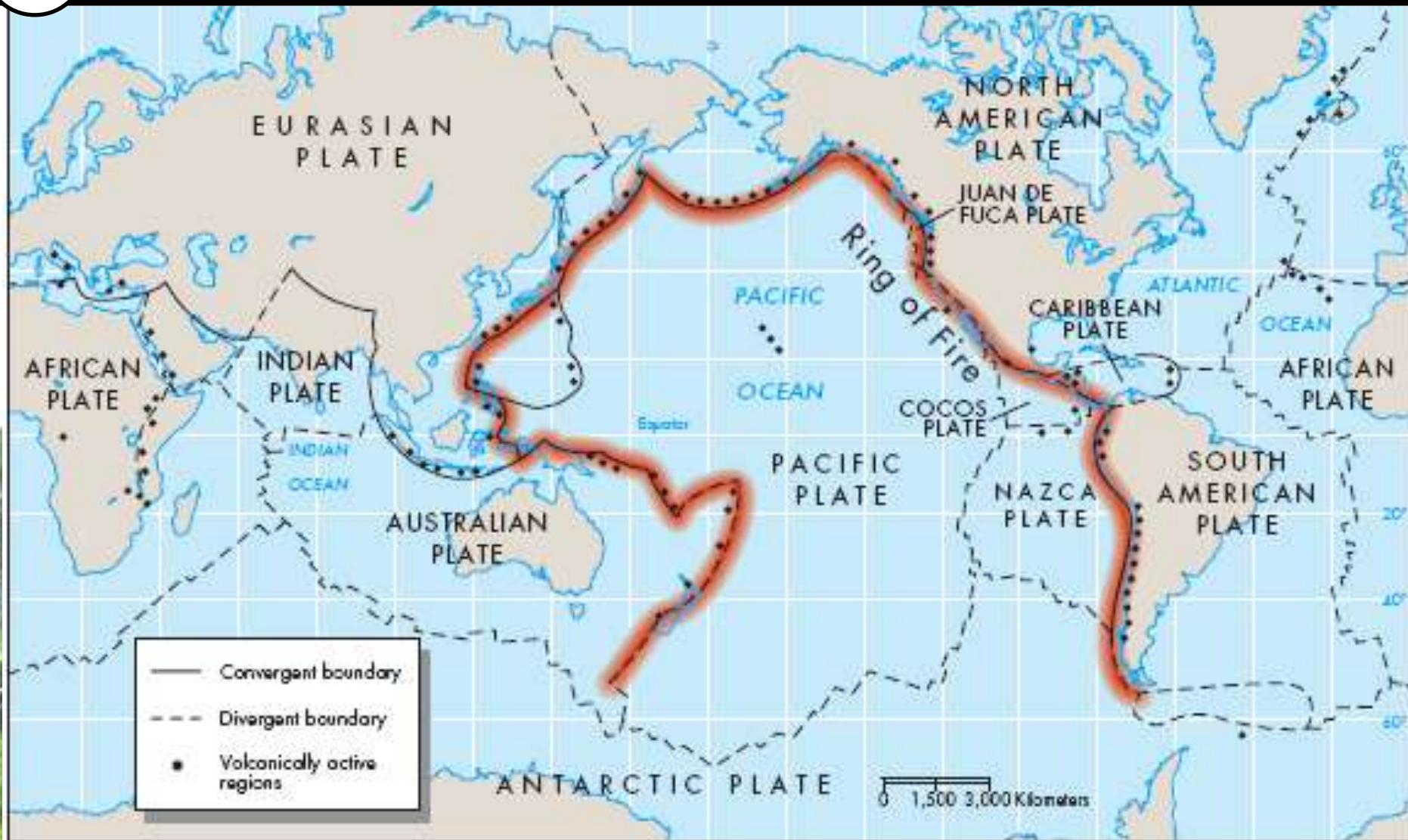
3

Hot spots beneath the oceans

4

Hot spots beneath continents





Approximately two-thirds of all active volcanoes on Earth are located along the “**Ring of Fire**” that surrounds the Pacific Ocean

The causes of volcanic activity are directly related to plate tectonics

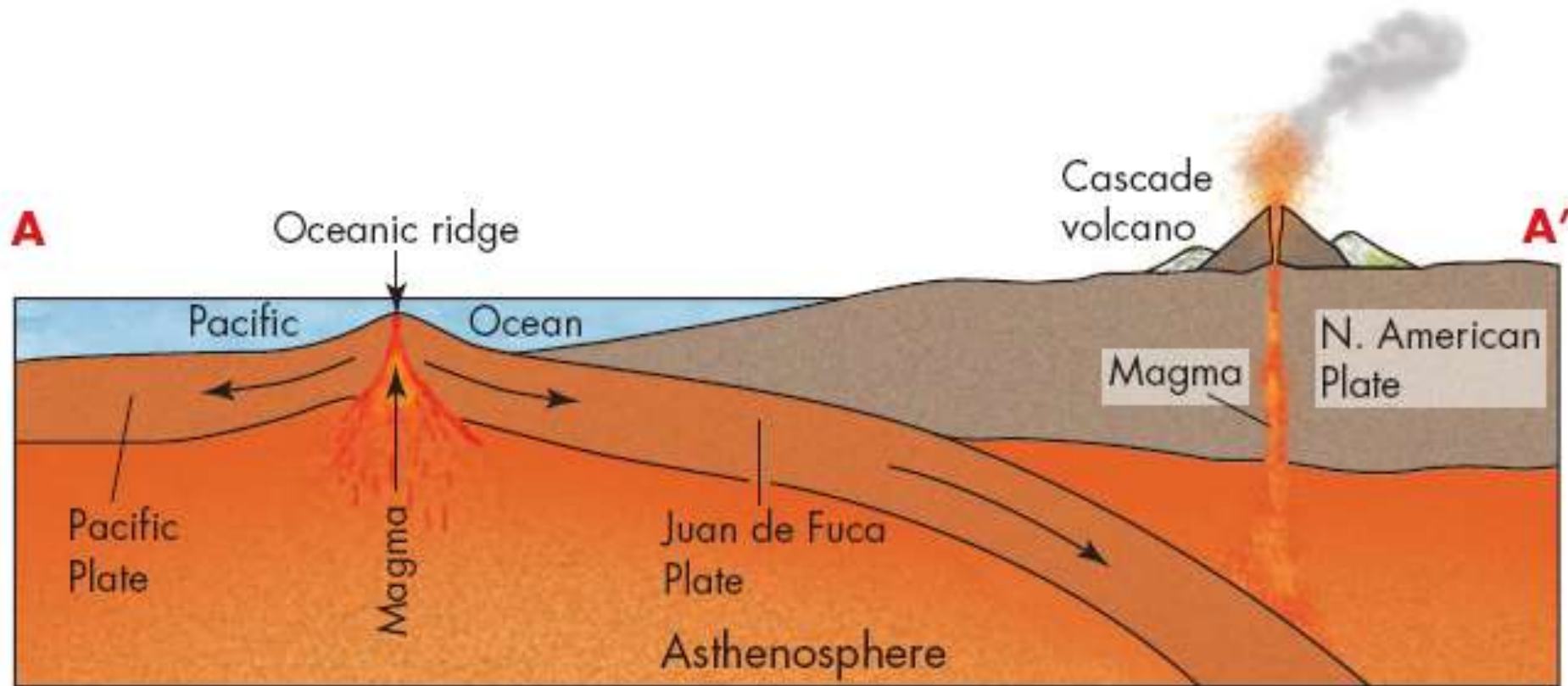
Mid-ocean ridges and continental rifts

1. Volcanism at mid-ocean ridges produces **basaltic magma** derived directly from the asthenosphere.
2. Approximately **three-quarters** of all lava erupted on Earth is extruded from undersea mid-ocean ridges.
3. This magma mixes very little with other materials except basaltic oceanic crust.
4. Therefore, the resultant lavas are composed almost entirely of low-viscosity *basalt*.
5. *Where these* spreading ridges occur on land, **shield** volcanoes are formed and large rifts occur.

Subduction zones

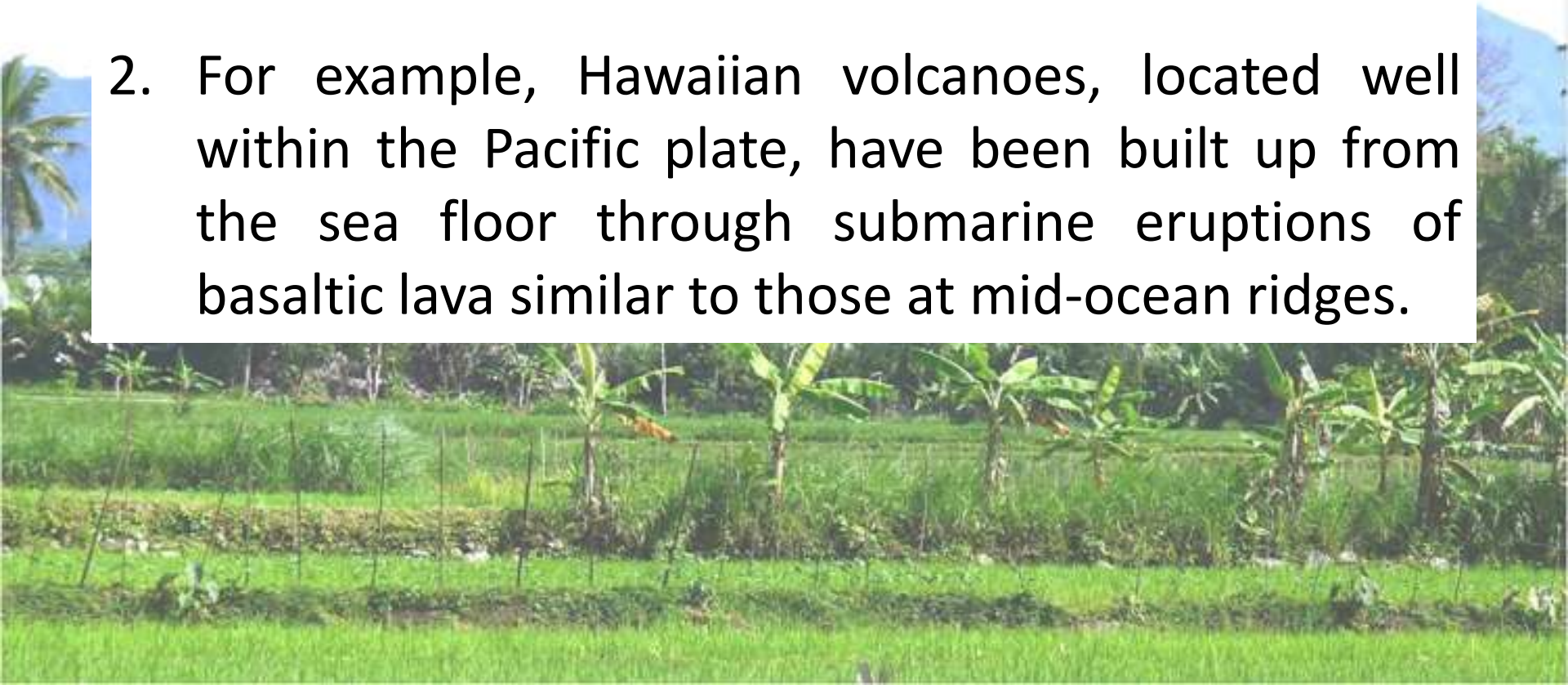
1. Composite volcanoes are associated with subduction zones and thus are the most common type found around the Pacific Rim.
2. These volcanoes are commonly andesitic in composition and have silica content intermediate between basaltic oceanic crust and the more silica-rich continental crust.
3. The higher silica content and higher volatile content make these volcanoes explosively unpredictable.
4. More than 80 percent of the volcanic eruptions in historic times have come from volcanoes above subduction zones.

Subduction zones

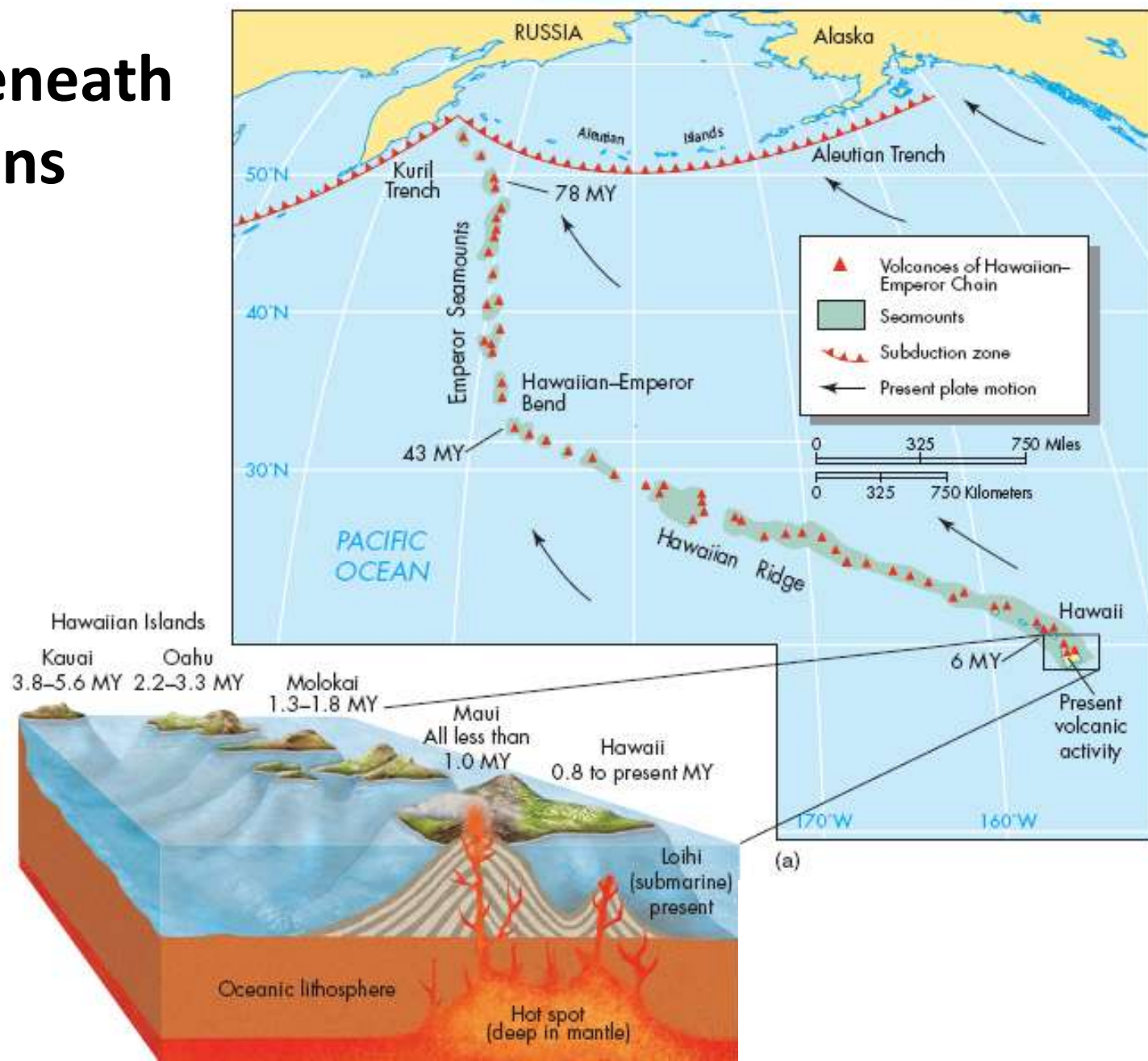


Hot spots beneath the oceans

1. Shield volcanoes are formed above hot spots in the oceanic lithosphere.
2. For example, Hawaiian volcanoes, located well within the Pacific plate, have been built up from the sea floor through submarine eruptions of basaltic lava similar to those at mid-ocean ridges.



Hot spots beneath the oceans

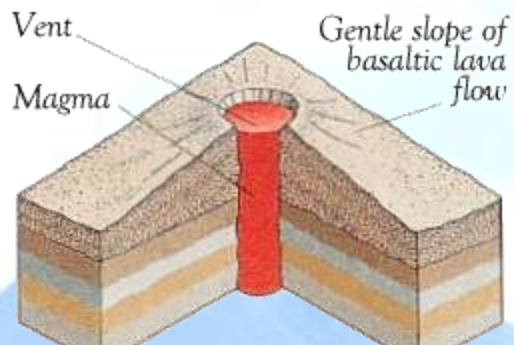


Hot spots beneath continents

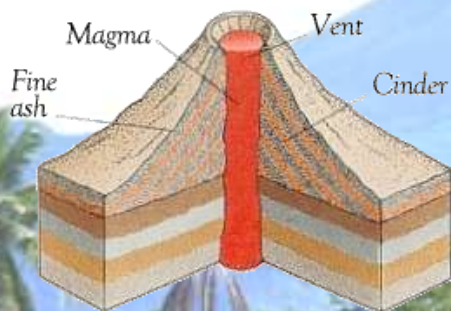
1. Caldera-forming eruptions occur in this tectonic setting.
2. They may be extremely explosive and violent, and they are associated with rhyolitic magma.
3. Rhyolite has a high silica content produced when rising magma from the asthenosphere melts and mixes with felsic continental crust.



TYPES OF VOLCANOES



Shield Volcano



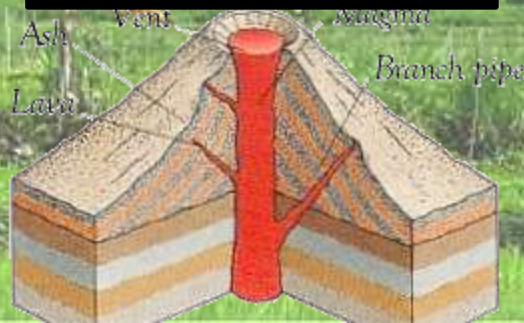
Cinder-cone



Volcanic-Dome



Composite Volcano



Types of Volcanoes

Volcano Type	Shape	Eruption Type
Shield volcano	Gentle arch, or shield shape, with shallow slopes; built up of many lava flows	Lava flows, tephra ejections
Composite volcano, or stratovolcano	Cone-shaped with steep sides; built of lava flows and pyroclastic deposits	Combination of lava flows and explosive activity
Volcanic dome	Dome shaped	Highly explosive
Cinder cone	Cone shaped with steep sides and summit crater	Tephra (mostly ash) ejection



TYPES OF VOLCANOES

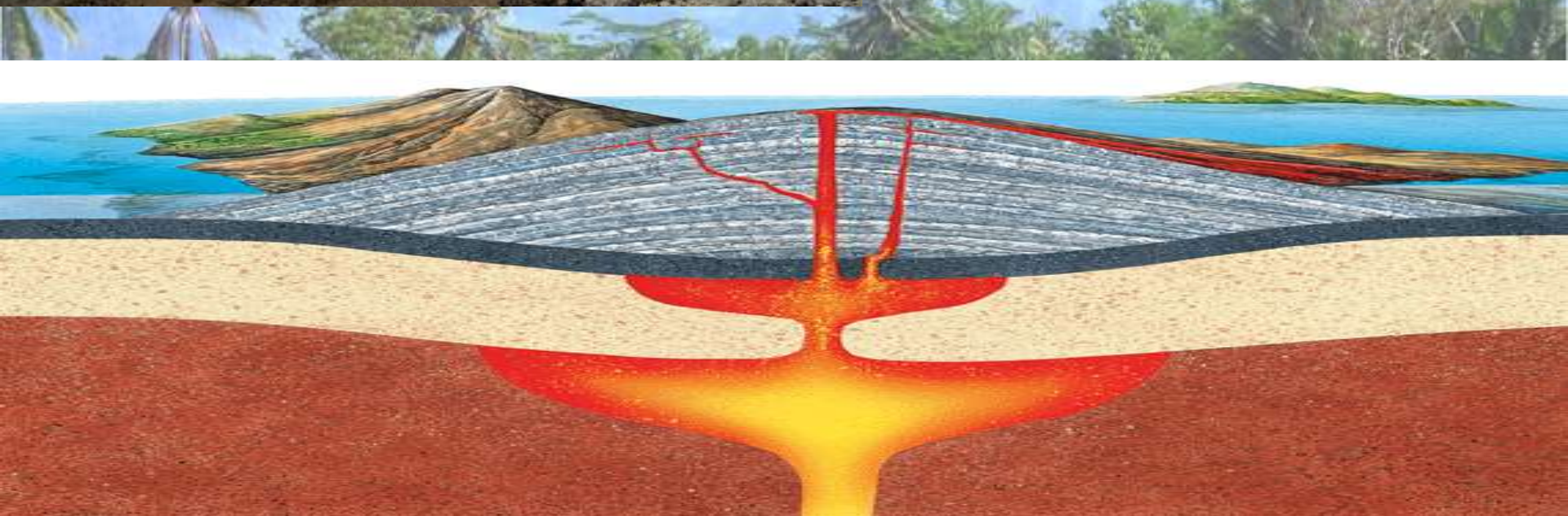
TYPE OF VOLCANO	FORM OF VOLCANO	SIZE	TYPE OF MAGMA	STYLE OF ACTIVITY	EXAMPLES
Basalt plateau	Flat to gentle slope	100,000 to 1,000,000 km ² in area; 1 to 3 km thick	Basalt	Gentle eruption from long fissures	Columbia River Plateau
Shield volcano	Slightly sloped, 6° to 12°	Up to 9000 m high	Basalt	Gentle, some fire fountains	Hawaii
Cinder cone	Moderate slope	100 to 400 m high	Basalt or andesite	Ejections of pyroclastic material	Parícutín, Mexico
Composite volcano	Alternate layers of flows and pyroclastics	100 to 3500 m high	Variety of types of magmas and ash	Often violent	Vesuvius, Mount St. Helens, Aconcagua
Caldera	Cataclysmic explosion leaving a circular depression called a caldera	Less than 40 km in diameter	Granite	Very violent	Yellowstone, San Juan Mountains



Shield Volcano

1. The largest volcanoes in the world are **shield volcanoes**
2. They are common in the Hawaiian Islands, Iceland, and some islands in the Indian Ocean.
3. Shield volcanoes generally have non-explosive eruptions because of low viscosity and low volatile content of their basaltic magma.
4. When a shield volcano erupts, lava tends to flow down the sides of the volcano rather than exploding violently.
5. Accumulations of thousands of thin basaltic lava flows construct the broad gentle slopes of the volcano (6 – 12 degree of slopes).
6. Although shield volcanoes are much wider than they are tall, they are still among the tallest mountains on Earth when measured from their bases, which are often located on the ocean floor.

Shield Volcano

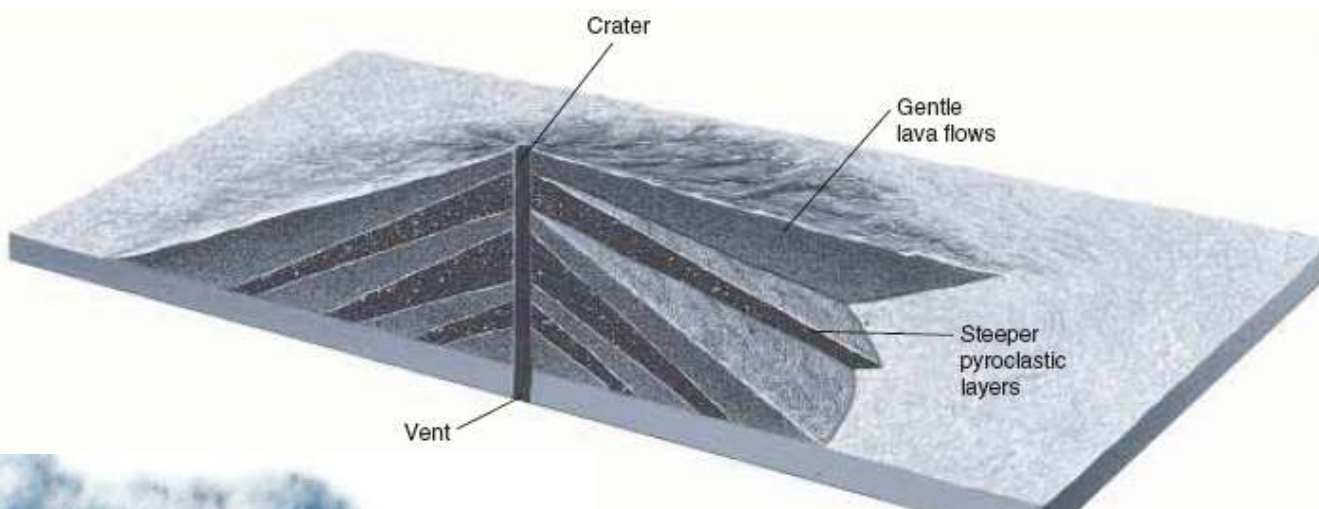


Composite Cone / Stratovolcanoes

1. **Composite cones**, sometimes called **stratovolcanoes**, form over a long time by repeated lava flows and pyroclastic eruptions.
2. The hard lava covers the loose pyroclastic material and protects it from erosion.
3. The magma of composite volcanoes is generally more viscous and has a higher volatile content than that of shield volcanoes.
4. It is resulting in a mixture of explosive activity and lava flows.
5. As a result, these volcanoes, also called *stratovolcanoes*, are composed of layers of both pyroclastic deposits and lava flows.
6. Composite volcanoes erupt a variety of lava types from basalts to lavas that are intermediate between andesite and rhyolite.

TYPES OF VOLCANOES

Composite Cone / Stratovolcanoes



Cinder-Cone

1. Characterized by basalt materials, small size, low viscosity, steep sides, and moderate volatile content.
2. Built up by the accumulation of tephra near a volcanic vent, **cinder cones** are relatively small volcanoes composed of nut- to fist-sized pieces of vesicular red or black lava.
3. They erupt when rising basaltic magma encounters near-surface groundwater, and escaping steam coughs cinders of bubbly molten lava out of a vent.
4. These cinders fall around the vent and build a loose, steep-sided pile.
5. Tephra from extinct cinder cones is the “lava rock” used widely in commercial landscaping. Also called *scoria cones*, cinder cones are common on the flanks of larger volcanoes, along normal faults, and along cracks or fissures.

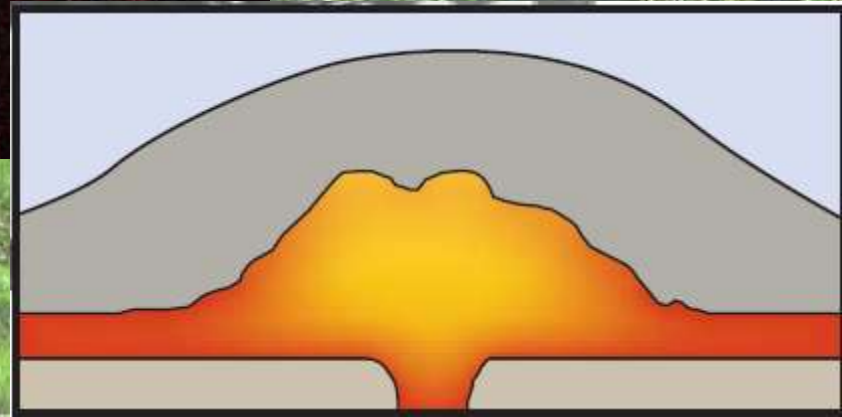
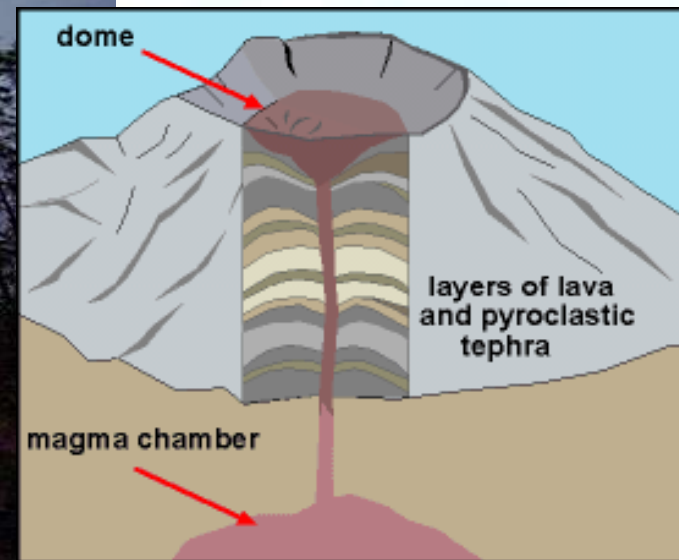
TYPES OF VOLCANOES

Cinder Cone



Volcanic-Dome

1. Volcanic domes are rhyolitic volcanoes characterized by their small-to-moderate size, high magma viscosity, steep flanks and low to moderate volatile content.
2. Rhyolite and dacite magmas sometimes erupt with little steam, they emerge slowly and quietly expand over months or years.
3. **Volcanic Domes** characterized by highly viscous magma, **volcanic domes**, sometimes exhibit highly explosive eruptions.

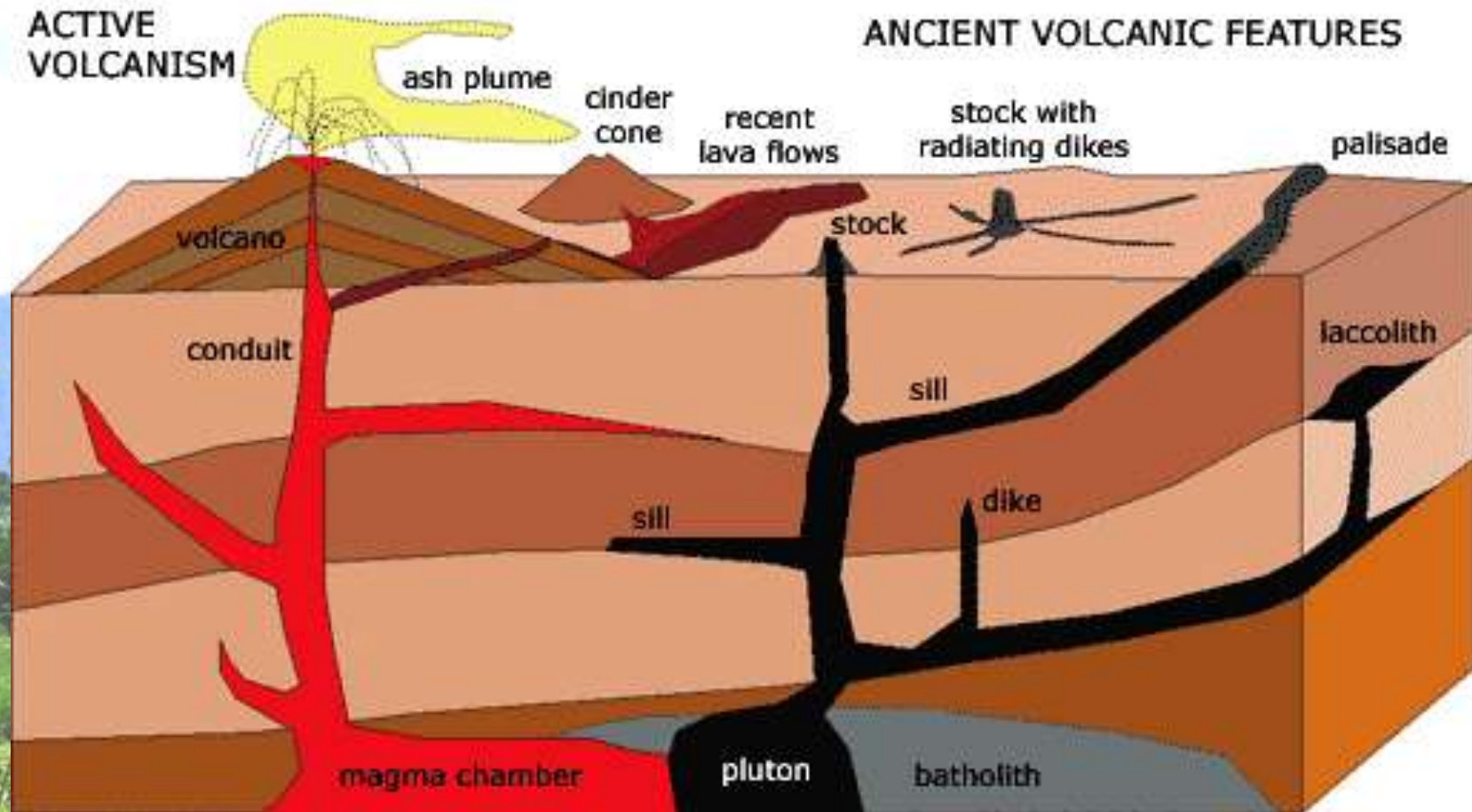
Volcanic-Dome

Pluton

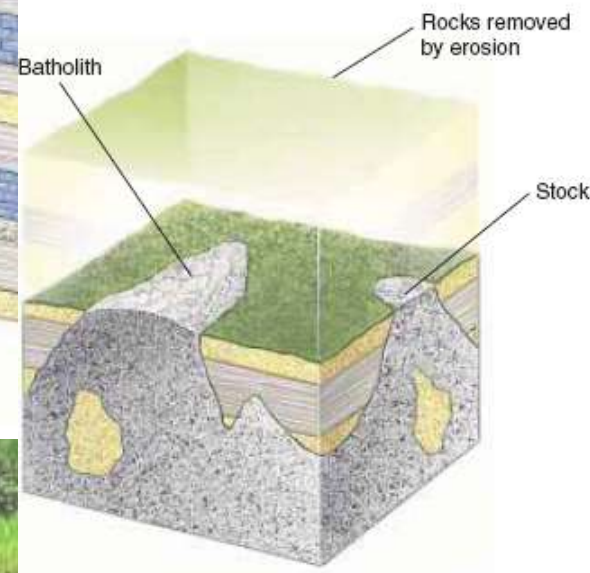
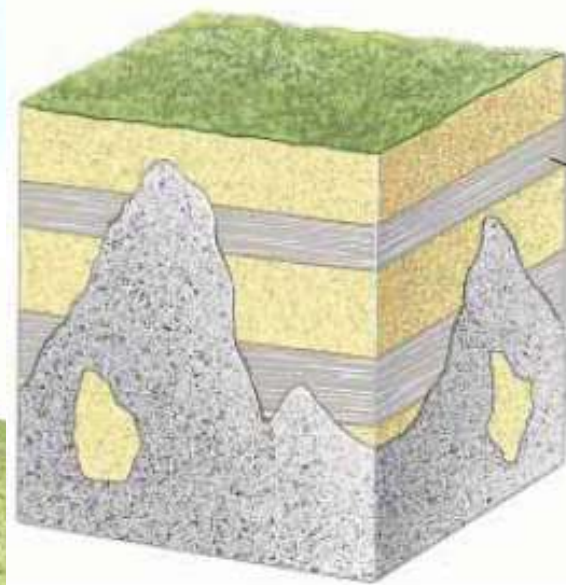
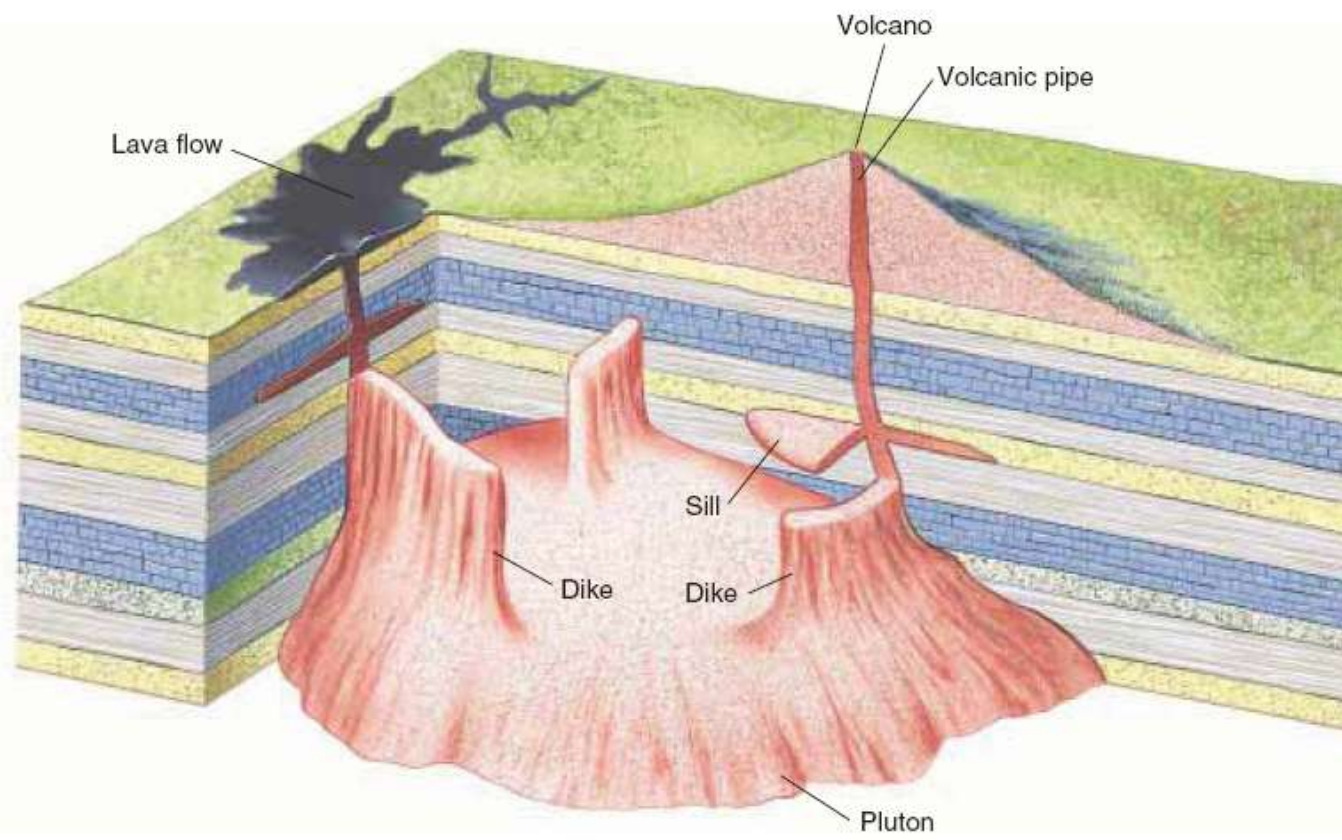
1. **Pluton** is a body of intrusive igneous rock (called a **plutonic rock**) that is crystallized from magma slowly cooling below the surface of the Earth.
2. Plutons include batholiths, stocks, dikes, sills, laccoliths, lopolith, and other igneous bodies.
3. In practice, "pluton" usually refers to a distinctive mass of igneous rock, typically several kilometers in dimension, without a tabular shape like those of dikes and sills.



Pluton



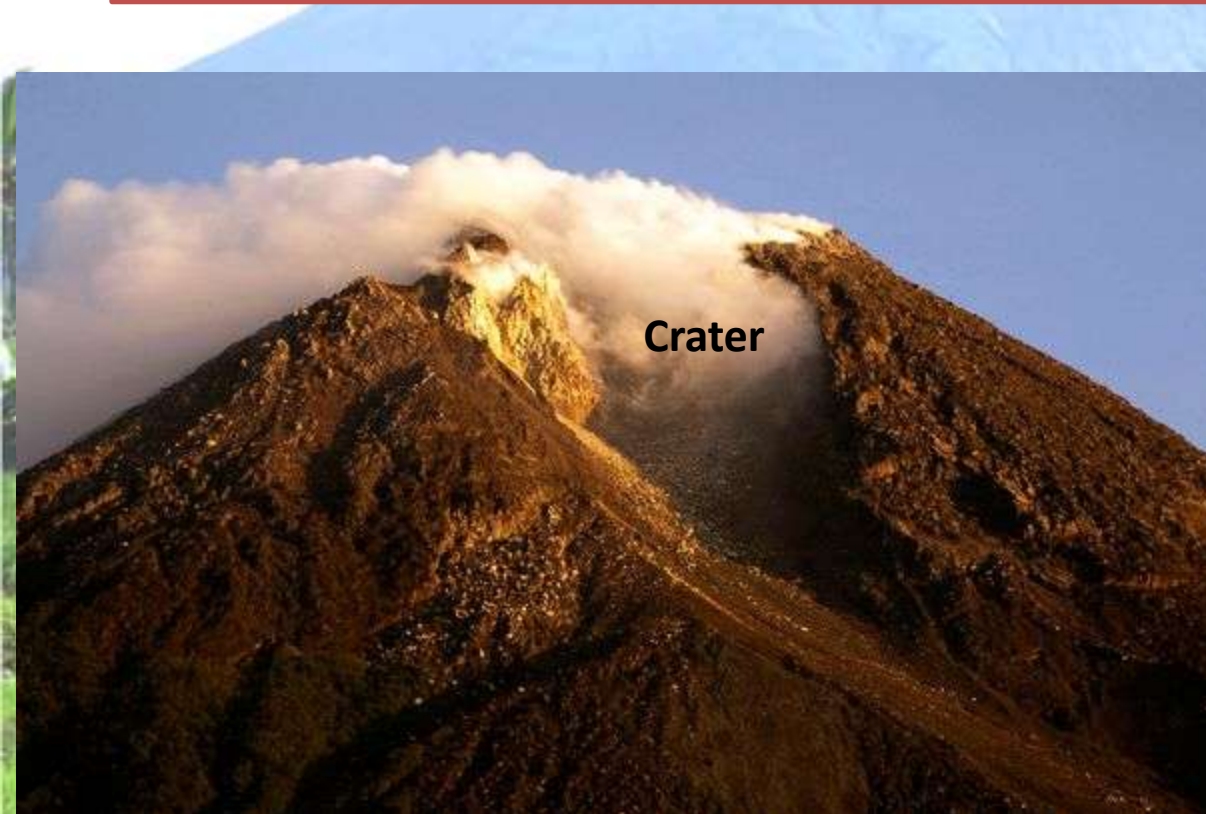
Pluton



1. A **batholith** is a **pluton exposed over more than 100 square kilometers** of the Earth's surface.
2. A large batholith may be as much as 20 kilometers thick, but an average one is about 10 kilometers thick.
3. A **laccolith** is a sheet intrusion that has been injected between two layers of sedimentary rock. The pressure of the magma is high enough that the overlying strata are forced upward, giving the laccolith a dome or mushroom-like form with a generally planar base.
4. A **stock** is similar to a batholith but is exposed over less than 100 square kilometers.
5. A **dike is a tabular, or sheetlike, intrusive rock that forms** when magma oozes into a fracture (Fig. 5–6). Dikes cut *across sedimentary layers or other features in country rock* and range from less than a centimeter to more than a kilometer thick.
6. A dike is commonly more resistant to weathering than surrounding rock.
7. Magma that oozes between layers of country rock forms a sheetlike rock *parallel to the layering, called a sill*.

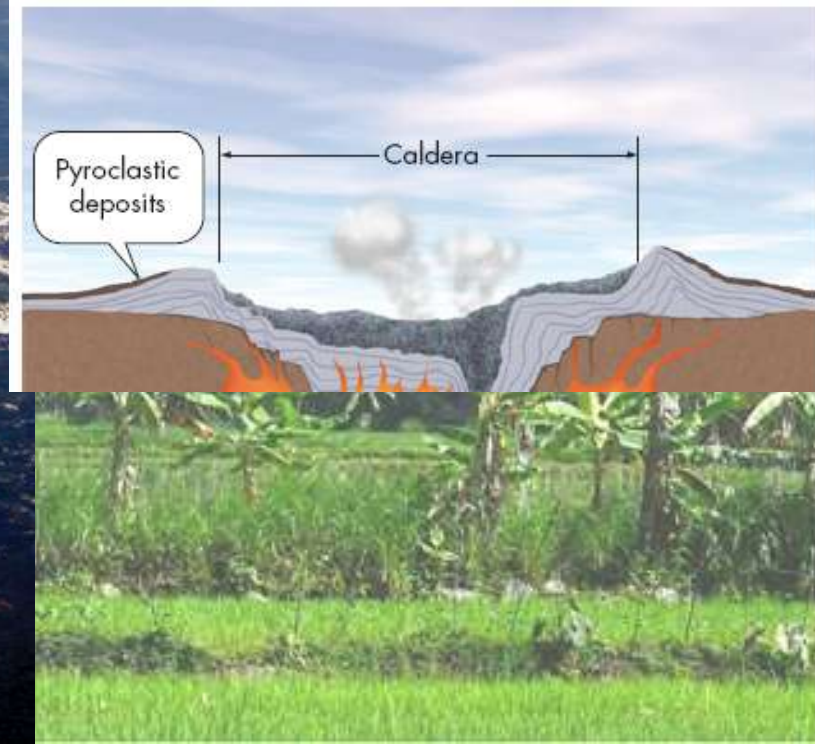
Craters

1. Craters are depressions commonly found at the tops of volcanoes, which form explosively during the eruption, removing the upper portion of the volcanic cone.
2. They are usually a few kilometers (around a mile) in diameter.

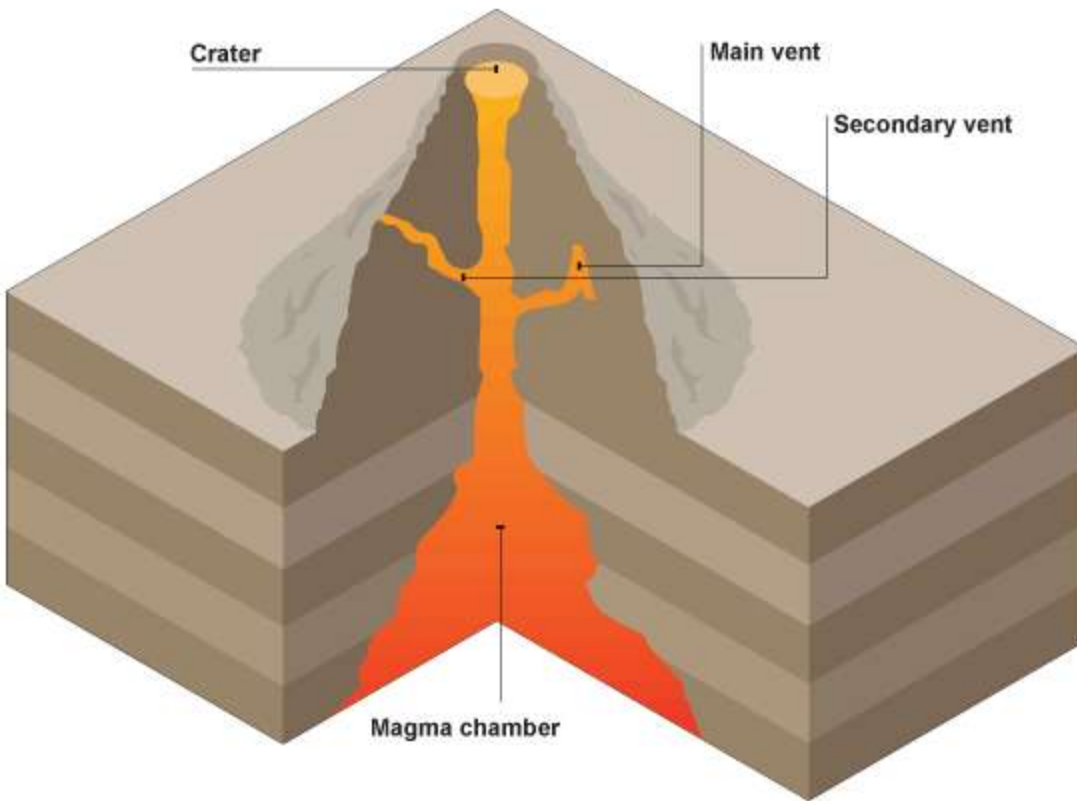


Caldera

1. Gigantic depressions formed during explosive ejection of magma and subsequent collapse of the upper cone.
2. Calderas may be 20 or more kilometers in diameter and contain volcanic vents as well as other volcanic features such as gas vents and hot springs



Vent



1. A **volcanic vent** is any **opening through** which lava and pyroclastic debris are erupted.
2. Vents may be roughly circular or they may be elongated cracks called *fissures*.
3. Some extensive fissure eruptions have produced huge accumulations of nearly horizontal lava flows called *flood basalts*.

VOLCANIC ERUPTION

Effusive Eruption

1. Characterized by the outpouring of [lava](#) onto the ground caused by low pressure of magma.
2. [Lava flows](#) generated by effusive eruptions vary in shape, thickness, length, and width depending on the type of lava erupted, discharge, slope of the ground over which the lava travels, and duration of eruption.

Explosive Eruption

1. An **explosive eruption** is a [volcanic](#) term to describe a violent, explosive type of [eruption](#).
2. Eruption is driven by gas accumulating under great pressure.
3. Driven by hot rising [magma](#), it interacts with [ground water](#) until the pressure increases to the point at which it bursts violently through the over mantle of rock.
4. In many cases, the rising magma will contain large quantities of partially dissolved gas.

Product of volcanic materials

Table 6-2	Generalized Products of Volcanoes		
	LAVA	PYROCLASTIC MATERIAL (ASH, PUMICE, OTHER FRAGMENTS)	LAHARS
DEFINITION	Molten magma that flows out and onto Earth's surface	Fragments and shreds of solidified magma blown out of a volcano. May be deposited by a pyroclastic flow or by air-fall ash	Volcanic ash and other fragments transported downslope with water (mudflows)
GENERAL CHARACTERISTICS	Molten magma that solidifies as coherent sheets or broken jumbles of volcanic rock	Fragments range from less than 2 mm ash to tens of cm. across. Larger pieces may be broken from older volcanic rocks on the sides of the vent.	Angular to rounded; unsorted particles from mud to boulders



Product of volcanic materials

LAVA FLOWS

1. A **lava flow** is one of the most familiar products of volcanic activity.
2. Lava flows result when magma reaches the surface and overflows the central crater or erupts from a volcanic vent along the flank of the volcano.
3. The three major types of lava take their names from the volcanic rocks they form: basaltic—by far the most abundant of the three—andesitic, and rhyolitic.



TYPE OF LAVA FLOWS: PAHOEHOE



- Lava flows can be quite fluid and move rapidly or be relatively viscous and move slowly. Basaltic lavas, which have lower viscosity and higher eruptive temperatures, are the fastest and can move 15–35 km/h.
- These lavas have a smooth, sometimes ropey surface texture when they harden.
- Because of their low viscosity, basalt flows spread out easily and solidify on gentle slopes.



TYPE OF LAVA FLOWS: AA



A-A

1. As the lava cools, it becomes more viscous and may move only a few meters /day.
2. These flows have a blocky surface texture after hardening .



With the exception of some flows on steep slopes, most lava flows are slow enough for people to easily move out of the way as they approach.

Explosive Eruption: Phreatic eruption

1. A phreatic explosion takes place when the temperature of the water system rises, leading to the vapour pressure exceeding the load of overburden.
2. Such phreatic explosions are generally associated with strato-volcanoes since they often contain alternating layers of relatively permeable and impermeable rocks, which inhibit the flow of groundwater.
3. These explosions may eject pyroclastic material.

Explosive Eruption: Phreato-magmatic eruption

- A phreatomagmatic eruption is an explosive water-magma interaction.
- Large amounts of steam and magmatic gases are emitted.
- It is very common for a large explosive eruption to have magmatic and phreatomagmatic components.

TYPES OF ERUPTION

PYROCLASTIC ACTIVITY

Pyroclastic activity refers to explosive volcanism in which tephra is physically blown from a volcanic vent into the atmosphere.

1. **Pyroclastic Flows** are **Some of the most lethal aspects of** volcanic eruptions.
2. **They are** avalanches of hot pyroclastic materials—ash, rock, volcanic glass fragments, and gas—that are blown out of a vent and move rapidly down the sides of the volcano.
3. Pyroclastic flows are also known as ash flows, hot avalanches, or *nuée ardentes* (French for “glowing clouds”).
4. Pyroclastic flows may be as hot as hundreds of degrees Celsius and move as fast as 160 km per hour down the sides of a volcano, incinerating everything in their path.

1. A **pyroclastic surge** is a fluidized mass of turbulent gas and rock fragments which is ejected during some volcanic eruptions.
2. It is similar to a pyroclastic flow but it has a lower density or contains a much higher proportion of gas to rock ratio.
3. It more turbulent and allows it to rise over ridges and hills rather than always travel downhill as pyroclastic flows do.

3

TYPES OF ERUPTION

PYROCLASTIC FLOWS AND SURGES



3

TYPES OF ERUPTION

ASH FALL IMPACTS: VESUVIUS at POMPEII



THANK YOU

