

Digging Deeper

TOPOGRAPHY OF VOLCANIC REGIONS

Topographic Maps

Topographic maps have **contour lines**. These are curves that connect all points at the same elevation. The **contour interval** is the difference in elevation between adjacent contour lines. A **topographic map** shows how steep or gentle a slope is. It also shows the elevation and shape of the land. **Relief** is the difference in elevation between the highest and lowest points on the map.

The following are some important points to consider when interpreting topographic maps:

- Contour lines never cross (but two or more can run together, where there is a vertical cliff).
- The closer together the contour lines, the steeper the slope.
- Contour lines for closed depressions, such as a volcanic crater, are marked with “tick marks” (short lines at right angles to the contour line) pointing downslope, into the depression.
- On most topographic maps, every fifth contour line on a map is darker and its elevation is always marked.

Magma Composition

Volcanoes are often pictured as cone-shaped mountains. However, volcanoes come in many shapes and sizes. Ice, wind, and rain can change the shape of a volcano, both between eruptions and after the volcano becomes dormant. A large eruption or giant landslide can remove the top or side of a volcano. The chemical composition of magma can have an even greater effect on the shape the volcano takes as it forms.

Magma is a mixture of liquid, melted rock, and dissolved gases. The most abundant chemical elements in magma are silicon and oxygen. As the magma cools, minerals form. Silicon and oxygen are the building blocks of the most common minerals, called silicate minerals, that form from magmas. One silicon atom and four oxygen atoms become tightly bonded together to form an ion, called the silicate ion. These combine with ions of other elements, mainly aluminum, iron, calcium, sodium, potassium, and magnesium, to form silicate minerals.

When geologists make a chemical analysis of an **igneous rock**, a rock that formed when molten materials became solid, they express the results as percentages of several “oxides,” such as SiO_2 , Al_2O_3 , or CaO . In one

Geo Words

contour lines: a line on a map that connects points of equal elevation of the land surface

contour interval: the vertical distance between the elevations represented by two successive contour lines on a topographic map

topographic map: a map showing the topographic features of the land surface

relief: the physical configuration of a part of the Earth's surface, with reference to variations of height and slope or to irregularities of the land surface

igneous rock: rock or mineral that solidified from molten or partly molten material, i.e., from magma



Geo Words

silica: material with the composition SiO_2

shield volcano: a broad, gently sloping volcanic cone of flat-dome shape, usually several tens or hundreds of square miles in extent

way, this is a fake, because real oxide minerals are a very small part of most igneous rocks. It's just a generally accepted practice. Because silicon and oxygen are the most abundant elements in magmas, the "oxide" SiO_2 , called **silica**, is the most abundant "oxide." The percentage of silica in magma varies widely. This is important to know for two reasons. First, magmas rich in silica tend to have more dissolved gases. Second, silica content affects how easily magma flows. Magmas that are rich in silica do not flow nearly as easily as magmas that are poor in silica. Because of this, silica-rich magmas are more likely to remain below the Earth's surface, at shallow depths, rather than flowing freely out onto the surface. These two factors combine to make eruptions of silica-rich magmas likely to be dangerously explosive. Here's why: As the magma rests below the surface, the dissolved gases gradually bubble out, because the pressure on the magma is much less than it was down deep in the Earth, where the magma was formed. It's just like what happens when you pour a can of soda into a glass: the carbon dioxide dissolved in the soda gradually bubbles out of solution. Unlike your soda, however, the magma is so stiff that the bubbles can't readily escape. Instead they build up pressure in the magma, and that often leads to a catastrophic explosion. The table in *Figure 1* shows how magma properties relate to magma composition.

Properties of Magma as They Relate to Magma Composition			
Magma Property	Magma Composition (percent silica content)		
	Low Silica	Medium Silica	High Silica
Silica content (% SiO_2)	~ 50	~ 60	~ 70
Viscosity	lowest	medium	highest
Tendency to form lava	highest	medium	lowest
Tendency to erupt explosively	lowest	medium	highest
Melting temperature	highest	medium	lowest
Volume of an eruption	highest	medium	lowest

Figure 1

Adapted from *Earth Science*, 7th Edition, Tarbuck and Lutgens, 1994

Types of Volcanic Landforms

When low-silica magma erupts, lava tends to flow freely and far. If it erupts from a single opening (vent) or closely spaced vents, it forms a broad **shield volcano**, as shown in *Figure 2*.

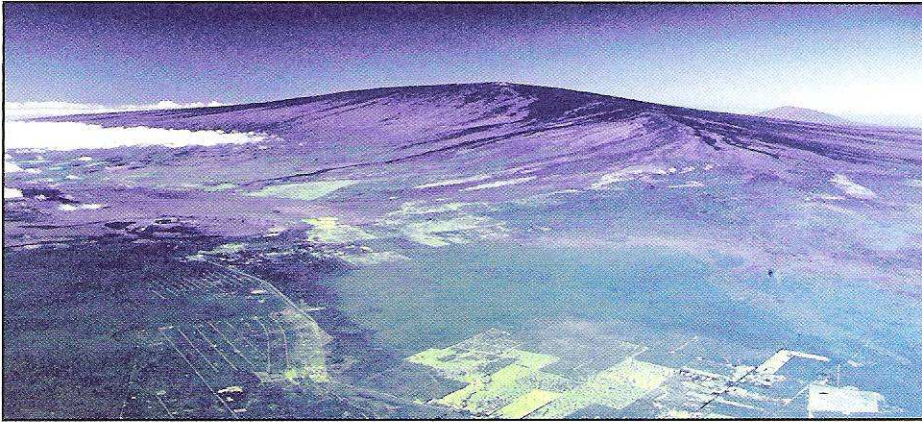


Figure 2 Volcanoes such as these are called shield volcanoes because they somewhat resemble a warrior's shield. They are formed when low-silica magma erupts.

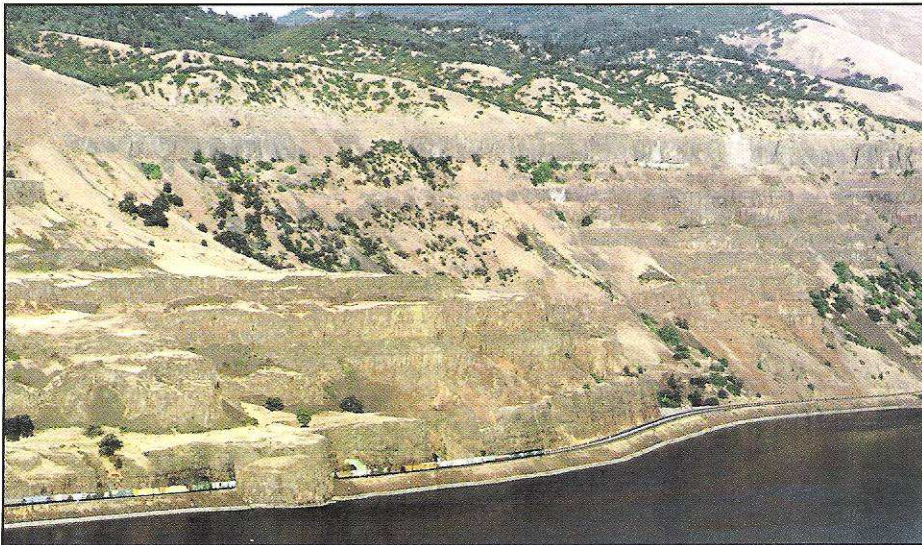


Figure 3 The eruption of low-silica magma along long, narrow openings in the Columbia Plateau flowed over a vast area. The result was a broad lava plateau that makes up the cliffs.

Silica-rich magmas are far less fluid. They often stop moving before they reach the surface. If they do reach the surface, they ooze slowly, like toothpaste squeezed out of a vertical tube. The thick, stiff lava forms volcanic domes with steep slopes, as shown in *Figure 4*. If the volcano's vent gets plugged, gases cannot escape and pressure builds up. The pressure can be released in a violent eruption that blasts pieces of lava and rock (pyroclastics) into the atmosphere.





Geo Words

composite cone (stratovolcano): a volcano that is constructed of alternating layers of lava and pyroclastic deposits

caldera: a large basin-shaped volcanic depression, more or less circular, the diameter of which is many times greater than that of the included vent or vents



Figure 4 Silica-rich magma does not flow readily and often forms a volcanic dome such as the one shown in this photograph.

A **composite cone**, as shown in *Figure 5*, forms by many eruptions of material with medium or high silica content. They erupt violently when pressure builds up in the magma. After the explosion, gooey (viscous) lava oozes out of the top. The volcano becomes quiet. Over time, pressure may build up and repeat the cycle. Composite volcanoes are tall and have steep slopes because the lava does not flow easily.



Figure 5 Composite cones include the beautiful yet potentially deadly Cascades in the northwestern United States (Shasta, Rainier, Mt. St. Helens, etc.).

When a very large volume of magma is erupted, the overlying rocks may collapse, much like a piston pushing down in a cylinder. The collapse produces a hole or depression at the surface called a **caldera**, shown in Figure 6. A caldera is much larger than the original vent from which the magma erupted.

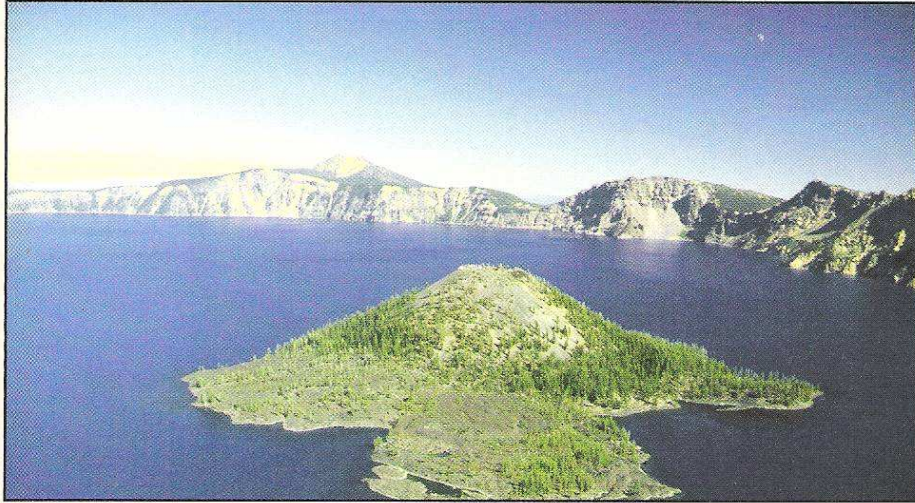


Figure 6 Calderas are deceptive volcanic structures. They are large depressions rather than conical peaks. Oregon's Crater Lake, formed nearly 7000 years ago, is an example of this type of volcano.

Check Your Understanding

1. Explain in your own words the meaning of a contour line, contour interval, relief, and topographic map.
2. Arrange corn syrup, water, and vegetable oil in order of low to high viscosity.
3. What is the silica content of magma that has a low viscosity?
4. Why do silica-poor magmas produce broad volcanoes with gentle slopes?
5. Why does high-silica magma tend to form volcanic domes with steep sides?
6. How is a caldera formed?

Understanding and Applying What You Have Learned

1. What is the contour interval on the topographic map of Mt. St. Helens?
2. Sketch a contour map of a volcano that shows:
 - a) a gentle slope
 - b) a steep slope
 - c) a nearly vertical cliff
 - d) a crater or depression at the top
3. Imagine that your paper model was a real volcano. Lava begins to erupt from the top. Shade your topographic map to show where a stream of lava would flow. Explain your drawing.
4. For the volcanoes shown in Figures 2 and 5, sketch a topographic map. Show what the volcano would look like from above. Apply the general rules for interpreting topographic maps. Include a simple legend.