Inquiry-based Brain Teasers on Lava
Craters of the Moon National Monument & Preserve
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> Melander, Sonja. Inquiry-based Brain Teasers on Lava. Geoscientists-In-the-Parks document, 2013-CRMO. National Park Service, Denver, Colorado.

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# BRAIN TEASERS

*Inquiry-based Exercises for Young Scientists*

## STOP 1: ʻAʻā Lava Flow

**GO TO** *Go to the Spatter Cones Trail parking lot. Go to the southern end of the parking lot by the trailheads. Find the outcrop pictured below.*

## BACKGROUND

*This exposure shows the inside of a single ʻaʻā flow. ʻAʻā flows are a type of lava flow which have sharp, jagged, uneven pieces of cooled lava on the surface that make a "clinkering" noise as they hit each other.*

## OBSERVE

*Look at the way the texture of the lava changes in different parts of the lava flow. Write your observations in the space below.*

## THINK

*Why is the bottom of the flow made of the same sharp, clinkery lava as the top? Can you think of an analogy of how this lava flows? Write your answer in the space provided below.*

# STOP 2: Lava Buds

GO TO → *Go on the Spatter Cones Trail.*

## BACKGROUND

*When hot, sticky, frothy globs of lava are thrown from a volcanic vent, they can land nearby on the ground and "glue" to each other to build a spatter cone. Individual globs can contain a lot of dissolved gas and puff up like popcorn.*

## OBSERVE

*Look closely at the lava that makes up the cone. Notice the small blobs of lava that seem to ooze out of the pieces of spatter, like the one pictured above. This is called lava budding. Try to find a lava bud that you can see the inside of. Also look for hollow spatter globs. Write your observations in the space below.*

## THINK

*How do you think the lava buds formed? Write your answer in the space provided below.*

# STOP 3: Snow Cone

GO TO → *Go on the Snow Cone Trail.*

## BACKGROUND

*Temperatures at Craters of the Moon range from -30 $^0$F in the winter to over 100 $^0$F in the summer. In winter, snow covers the terrain, making it look like the Arctic. In summer, the surface of lava flows can reach temperatures over 150 $^0$F from solar heating.*

## OBSERVE

*Look inside Snow Cone. What do you see? Write your observations in the space below.*

## THINK

*Why do you think there is still snow in the bottom of the cone when it is hot outside? Write your answer in the space provided below.*

# STOP 4: Slow Motion

GO TO

*Stay on the Snow Cone Trail. Look at the trees on the slopes of North Crater to the northwest. If you have a compass, you can look along a bearing of 330 degrees to locate them.*

## BACKGROUND

*Usually trees grow straight up and symmetrically to receive the most sunlight. But sometimes environmental factors and geologic processes can change this.*

## OBSERVE

*Some of the trunks of the trees growing on the side of the cinder cone have an L-shape. This is called an "elbow." Also, many of the trees are flagged, which means that branches grow mostly on one side of the tree. Observe as much as you can and write your observations in the space below.*

## THINK

*What might have caused the trees to grow with an elbow? Also, propose an explanation as to why a lot of the trees are flagged. Write your answer in the space provided below.*

# STOP 5: Laidlaw Butte

**GO TO**

*Stay on the Snow Cone trail. Take a look at Laidlaw Butte, pictured here. If you have a compass, you can look along a bearing of 195 degrees to locate it.*

## BACKGROUND

*Craters of the Moon contains different types of volcanoes, with different shapes and sizes. Cinder cones form when blobs of highly gas-charged lava are thrown from a vent, quickly solidify into sharp glassy rock and fall down on the ground, making a pile around the vent(s). Shield volcanoes form through the buildup of lava flows that flow away from the eruptive fissure. Some shield volcanoes can be many miles in diameter.*

## OBSERVE

*Take a look at Laidlaw Butte and observe as much as you can about its size and shape. Write your observations in the space below.*

## THINK

*What kind of volcano do you think Laidlaw Butte is? Why? Write your answer in the space provided below.*

# STOP 6: The White Stuff

**GO TO** *Stay at the top of the North Crater trail. Look inside the crater.*

## BACKGROUND

*Not everything we see on the rocks here is formed during a volcanic eruption. Over time rock can interact with its environment to form new features.*

## OBSERVE

*Look into the crater and find the areas with white stuff that make a crust on some of the lava rocks. Observe the area and look for any signs of animals. Write your observations in the space below.*

## THINK

*What do you think the white stuff is? How do you think it formed on the outside of the lava? Is it used by any animals? If so, explain what makes you think so. Write your answer in the space provided below.*

# BRAIN TEASERS *Inquiry-based Exercises for Young Scientists*

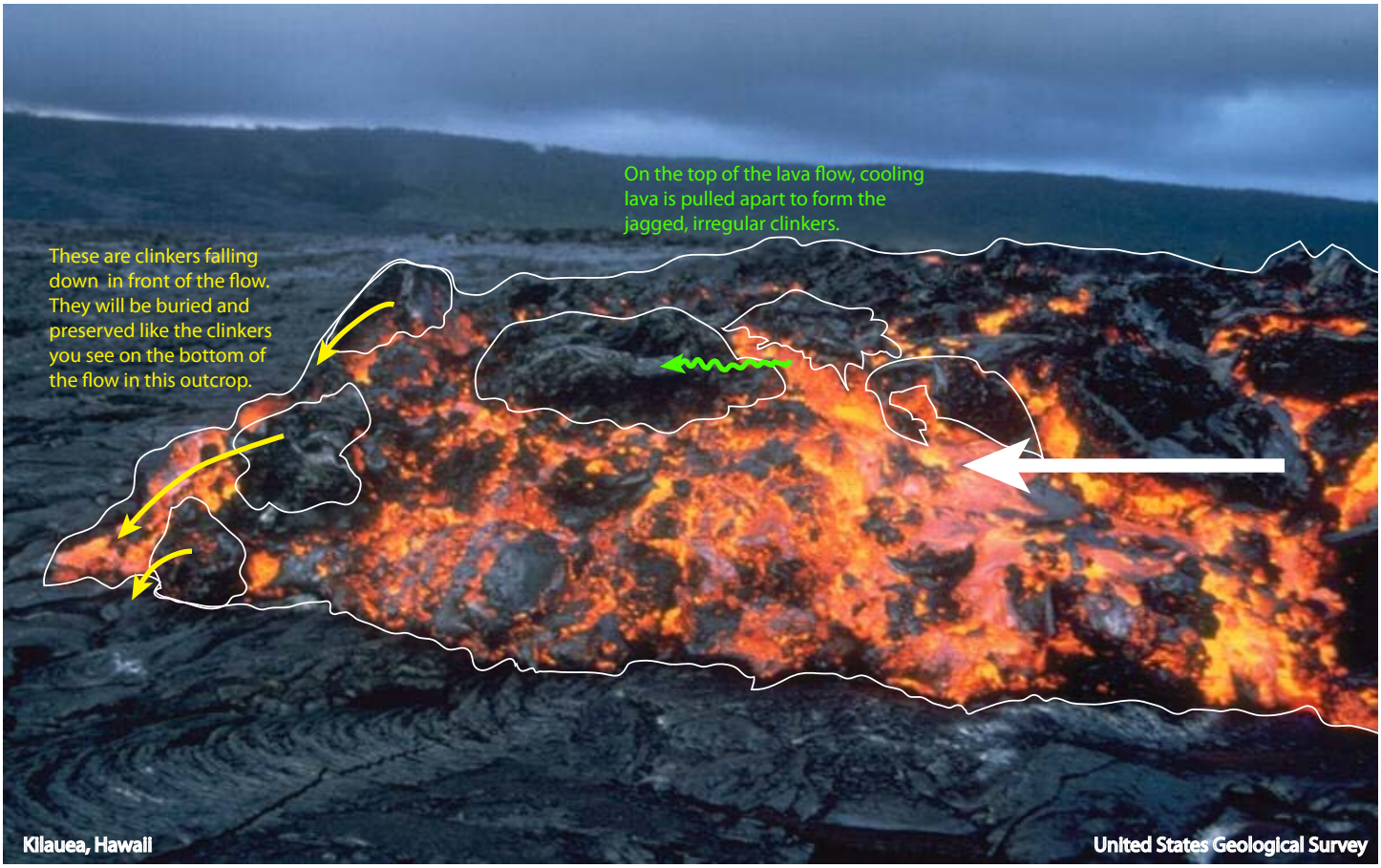
## *Teachers' Guide*

## STOP 1: 'A'ā Lava Flow

***ANSWER*** *The sharp, jagged, clinkery material is formed as lava on the top of the flow is ripped apart, tumbled, and cools. As an a'a' flow moves, the clinkers on top of the lava flow fall down onto the ground just ahead of the advancing flow. The flow moves over and on top of these clinkers. The clinkers remain solid and keep their shape. When the lava flow stops, clinkers are found both on top of and on the bottom of the a'a' flow. The middle of the flow is dense and solid, because it formed as the liquid lava stopped flowing and cooled.*

***ANALOGY*** *You can think of the lava flow as a conveyer belt in a factory or the tread on a bulldozer. The liquid lava carries the clinkers and drops them off at the end of the conveyer belt (the front of the lava flow).*

***IN THE CLASSROOM*** *Watch this process in real-time, visit: http://www.youtube.com/watch?v=P8w6vA/cFxE*



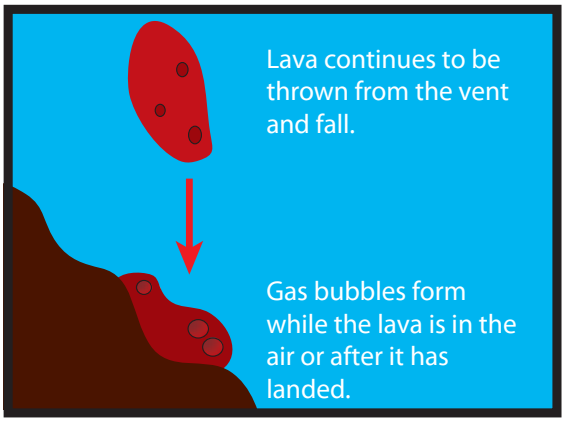
# STOP 2: Lava Buds

***ANSWER*** *When lava is ejected from a spatter cone, it contains a lot of dissolved gas. The gas can form bubbles in the lava, both while it is moving through the air and after it has landed on the spatter cone. These gas bubbles can expand and stretch the lava, and even force remaining liquid out , forming lava buds and the preserved bubbles (called "vesicles") that can be observed in the globs of lava.*

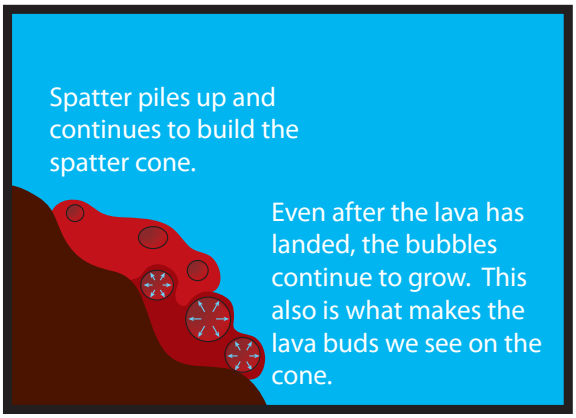
***ANALOGY*** *You can think of this like popcorn. Gas inside the popcorn puffs it up, forming lots of little bubbles inside it and some on the outside.*

***IN THE CLASSROOM*** *Watch a spatter cone being built: http://www.youtube.com/watch?v=Yf9-NvgOP8Y*

A closer look...




A bit later...

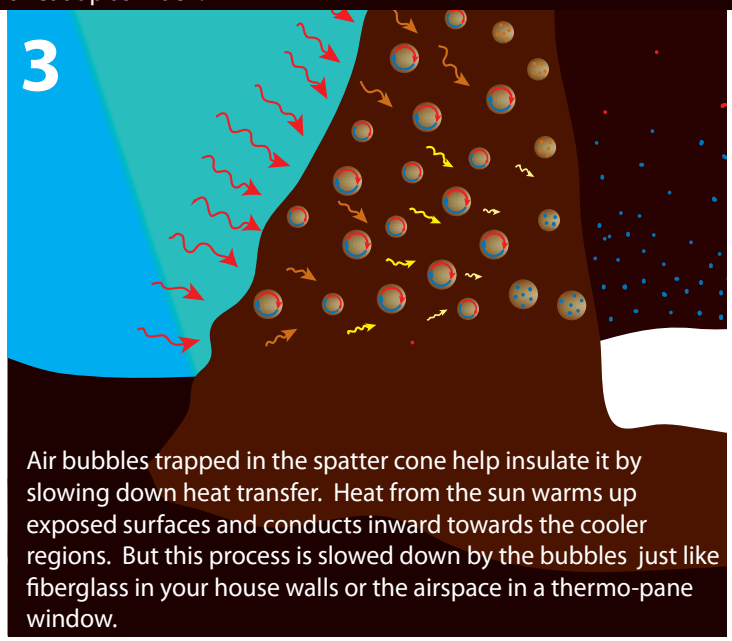


# STOP 3: Snow Cone

***ANSWER*** *There are several reasons why the bottom of Snow Cone stays cold enough to keep snow in it year-round.*

1. *The bottom of Snow Cone does not receive much direct sunlight.*
2. *The cold air at the bottom of Snow Cone stays at the bottom because it is denser than warm air.*
3. *The vesicles in the spatter cone lava slow down heat transfer.*

***ANALOGY :*** *1 is analogous to why it feels so good to be in the shade on a hot, sunny day. 2 is analogous to why your basement is cooler than your house attic during summer. It's also how a hot air balloon works. 3 is analogous to neoprene, the stuff wetsuits that divers use are made of. Neoprene fabric also has tiny bubbles in it that slow heat transfer to keep the diver insulated.*

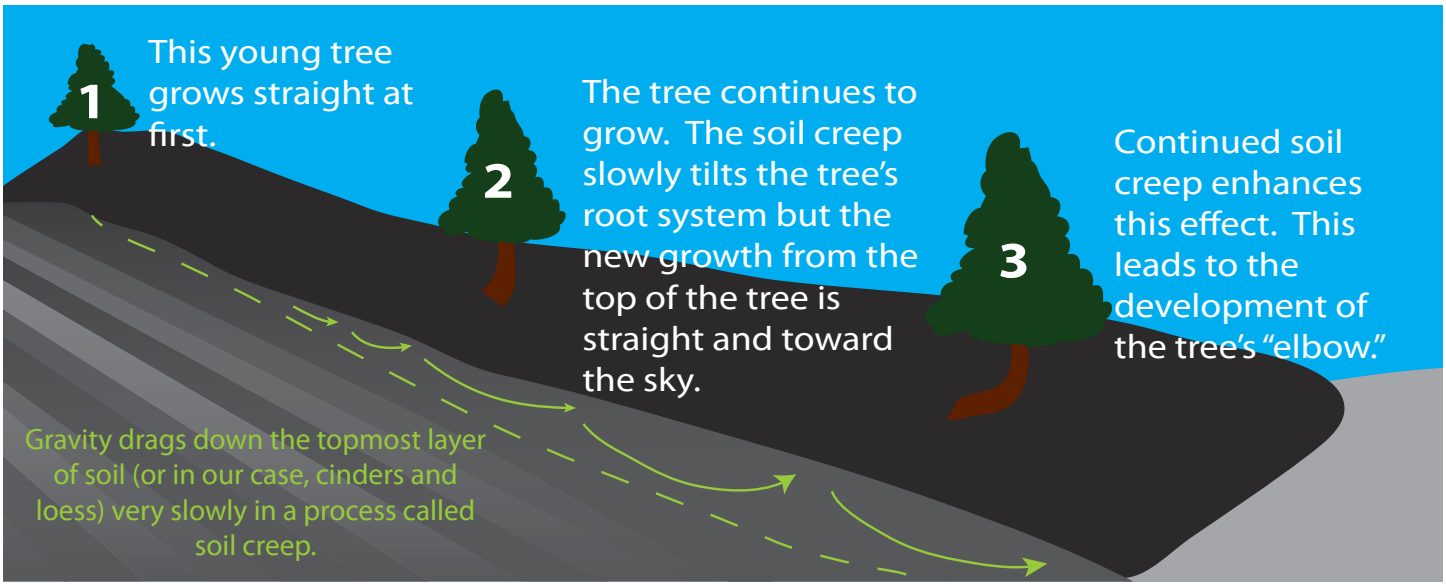


# STOP 3: Slow Motion

## Trunk Elbows

***ANSWER*** *The elbows on the trunks of trees growing on a slope like our cinder cones are caused by soil creep on the slope. Soil creep is like a very slow landslide where gravity slowly drags the top layers of soil downslope. As the soil creeps, it tilts the tree on the slope. The tree continues to grow upwards and so over time it develops a round "elbow" at its base.*

***ANALOGY*** *Just like a plant will grow and bend towards the light, trees have a geotrophic response to gravity and try to grow vertically.*

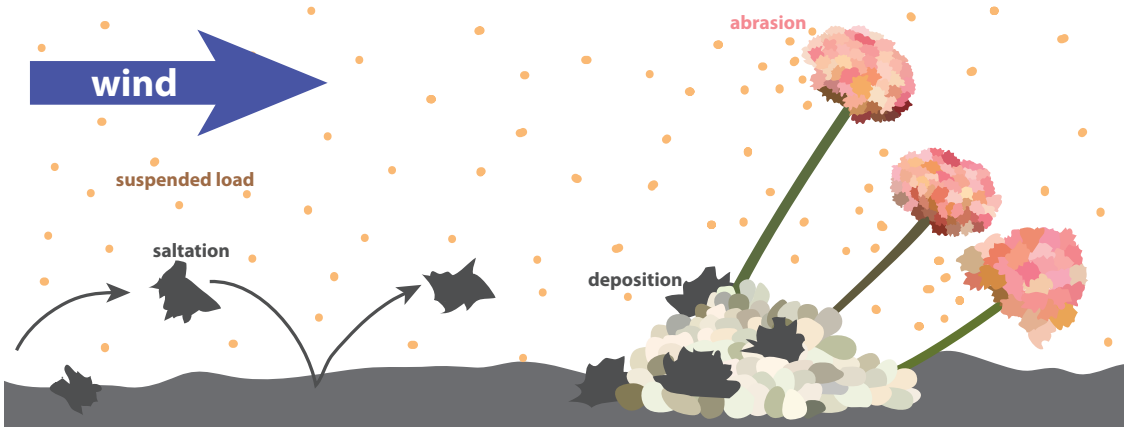



## Flagged Trees

***ANSWER*** *Many of the trees at Craters of the Moon are flagged (their branches grow primarily on one side). This is because of the windy environment they grow in. Wind carries particles in the air and when they hit an object, they can abrade it slowly. This is a type of mechanical weathering.*
*Terminal buds at the end of the branch are abraded, preventing them from growing in the upwind direction. Wind at Craters of the Moon usually blows from the west/southwest, so this side of the trees typically has fewer or smaller branches.*

***ANALOGY*** *Over time, particles carried by the wind act like sandpaper on objects.*

*The figures on the next page diagram this process with real-world examples, including some from a windstorm that struck Craters of the Moon in June 2013. You can see sediment being carried by the wind in the first picture. Pictures 2, 3, 4, and 5 show the effects of the storm and long-term sediment transport, including flagging of trees, partial burial of dwarf buckwheat, the formation of ripples on Inferno Cone, and the effect of abrasion on a stake.*



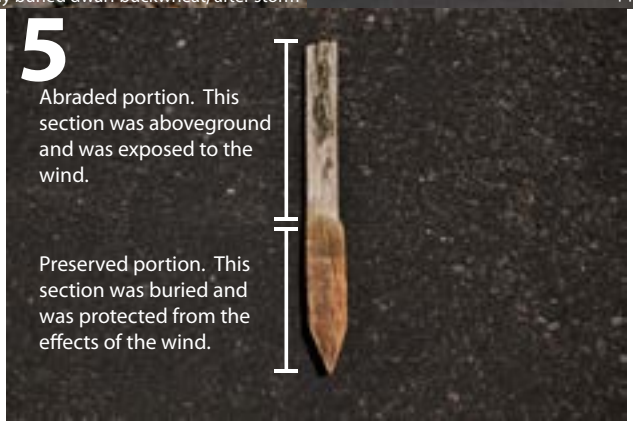

During heavy winds, cinders and other particles can be transported by the wind. Very small particles, like loess, can be carried in the wind. This is called **suspended load**. When these particles hit objects, they can knock off tiny pieces of the object and erode it in a process called **abrasion**. The wind causes bigger, denser particles like cinders to bounce along the ground. This is called **saltation**. When they reach an low point or an object that blocks its motion, they can stop moving and stay where they are. This is called **deposition**. If we see cinders in odd places, like in the leaves of the dwarf buckwheat, we know it might be evidence of high winds and sediment transport.

June 2013 wind storm, view from Visitor Center

Flagged and partially buried limber pine, after storm

Partially buried dwarf buckwheat, after storm

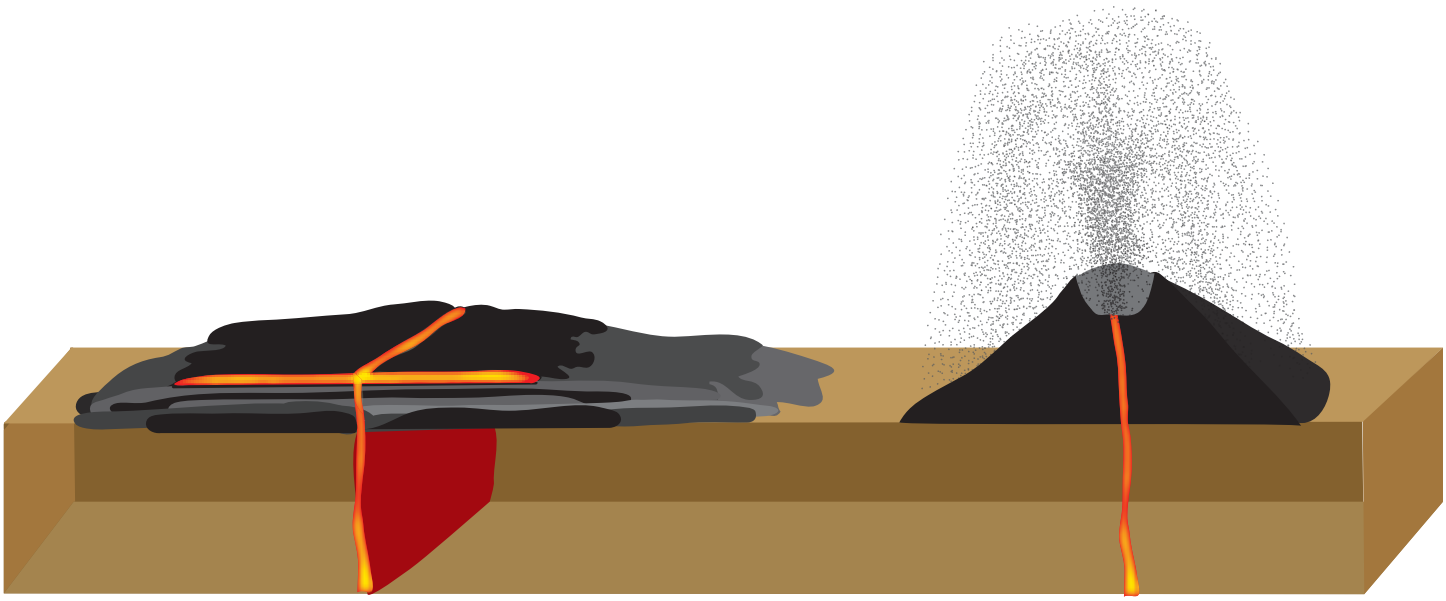
Ripple marks on Inferno Cone, after storm



## STOP 4: Laidlaw Butte

***ANSWER*** *Laidlaw Butte is a shield volcano. You can tell it is a shield volcano and not a cinder cone by its broad, elongate shape. But don't be fooled by its broad shape, shield volcanoes can be very tall if enough lava flows build up! Mauna Loa on Hawaii's Big Island is a total of 17 kilometers (about 10.5 miles) tall, which is taller than Mt. Everest!*

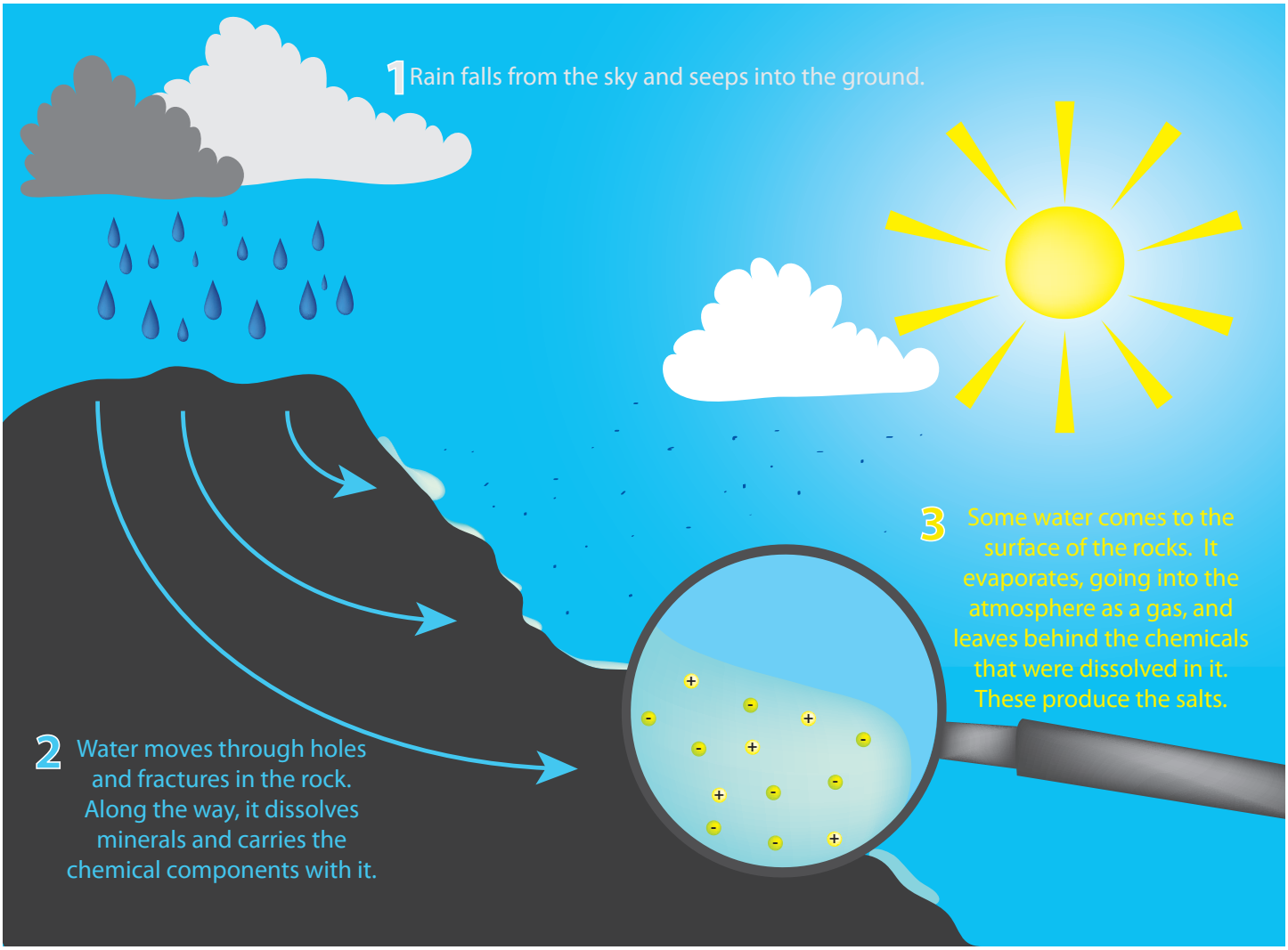
***ANALOGY*** *Shield volcanoes resemble a stack of pancakes. Each lava flow is another pancake on the stack. The top of the pancake stack will always have a broad shape, but the stack itself can get very tall. Cinder cones have much steeper slopes because the normal angle of repose for cinders is 30°. They can be even steeper if armored with spatter.*



Shield Volcano Cinder Cone

# STOP 5: The White Stuff

***ANSWER*** *The white stuff you see on the walls of the cinder cone are actually salt crystals. The animal tracks (game trails) you see leading to these areas are there because animals like to lick the salt and get nutrients from it. Rain falls from the sky and seeps into the ground. Then, the water moves within the rock through vesicles and cracks. Along the way, the water dissolves minerals from the rock and sediment (like loess). Eventually some of the water seeps out of holes. Here at Craters of the Moon, water evaporates much faster than it seeps to the surface. As the water evaporates, it becomes highly concentrated in the dissolved minerals. When the concentration is high enough, crystals form. This is called precipitation. Eventually all of the water evaporates, leaving nothing but the crystals. Minerals formed in this way are called evaporites.*

***ANALOGY*** *Ever left a bowl of chicken soup in the kitchen sink for too long? If you leave it there long enough, the bowl gets coated in yellow powder. Those were the particles in the broth that were left after the water evaporated away.*

*Ever made salt water when you've had a sore throat? When you have a little bit of salt, you can stir it in and dissolve it. However, if you put too much salt in, it won't dissolve anymore because it is too concentrated in the dissolved salts!*