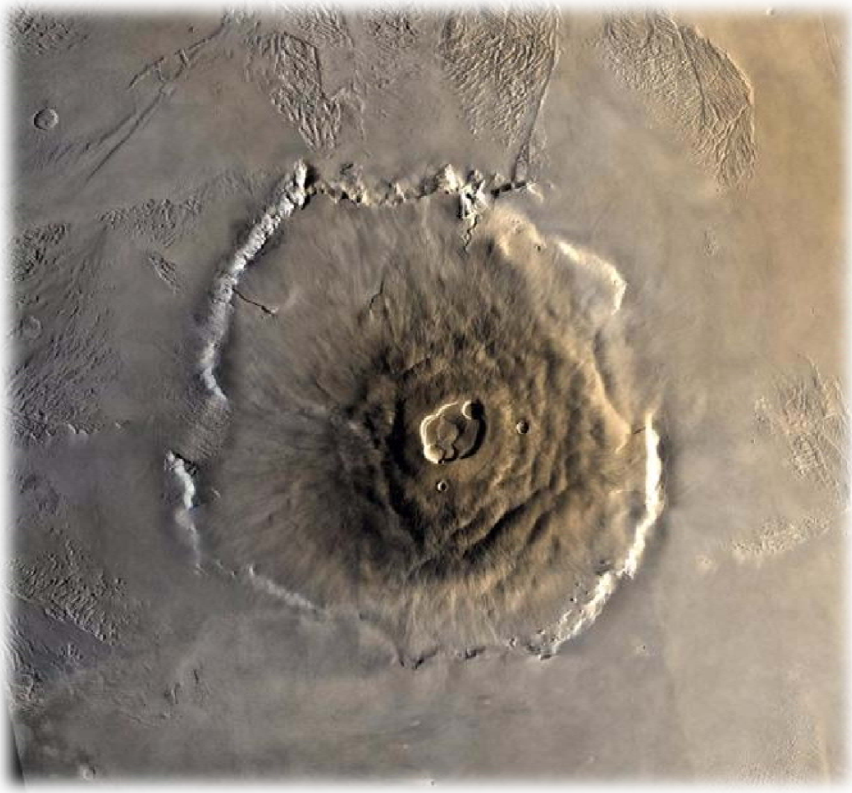
VOLCANOES IN THE SOLAR SYSTEM

Educational Experiences for K-12 in the Earth and Planetary Sciences - Module 6

C. T. Adcock and E. M. Hausrath,
NASA | Nevada NASA Space Grant Consortium | University of Nevada, Las Vegas - Department of Geoscience



SOLAR SYSTEM VOLCANOES - MODULE 6

1. Introduction

The objective of the *Solar System Volcanoes* module is to learning about volcanoes, not just on Earth, but throughout our solar system, and what volcanoes mean for life on Earth and elsewhere. Educators or presenters may use these resources how they wish (within the CC license terms), however, the order and approach presented here has been tested and used previously with success.

2. Learning Objectives

- Learning the basics about volcanoes
- Learning about volcanoes throughout our solar system.
- The implications for volcanoes to life.
- Encourage participants to consider STEM fields like Space or Planetary Science as possible career choices.

3. Materials

3.1. Presentation

- Material are included for the presentation in PDF format. More materials can be found on the internet at places like those on the included resource sheet. PPT versions of the slides can be obtained from C. T. Adcock at Christopher.Adcock@unlv.edu

3.2. For the Hands-on Exercise (group activity)

- The hands-on part of the presentation is at the presenter's discretion. Past presentations have made use to passing around and identifying fossils, baking soda volcanoes, or the "challenge" on the last slide of the included presentation in the form of a drawing and presentation.

3.3. Packet

- There are 2 poster sizes in the packet. In the past we have printed 11x17 posters for students and the larger version as a class room example.

4. Activities

4.1. The Presentation

Mission data obtained from the NASA PDS, Planetary Photojournal, and visualizations from the Eyes on the Solar System product are used in a short presentation before a group activity. In the following pages are "slides" and notes that can used by the presenter as needed, but ***PLEASE*** keep credits intact. They are currently in order for a short presentation or as handouts. For availability of the original .ppt slides, contact C. T. Adcock (see title page of presentation).

4.2. The Hands-on Activity

- The hands-on part of the presentation is at the presenter's discretion. Past presentations have made use to passing around and identifying fossils, baking soda volcanoes, or the "challenge" on the last slide of the included presentation in the form of a drawing and presentation.

Sample questions:

Q: Is Earth the only planet or moon with volcanoes?
A: Nope

Q: What is the largest volcano in the solar system?
A: Olympus Mons on Mars

Q: What do volcanoes have to do with life?
A: They provide the energy and materials required for some life to persist - and may have played a role in the origin of life on Earth and elsewhere.

Q: Are all volcanoes the same?
A: No - they are different in shape and what the erupt.

4.3. The Wrap Up

- We have previously included stickers and the 11x17 poster as an "Experience Reminder" for students. A small inexpensive souvenir that helps young participant remember the module experience. We have used sharks teeth, fossils, and (when available) NASA pins.

Notes for slide presentation.

Slide 1: Title slide for: **Exploring Space: Volcanoes and life in other places.** NASA artist's conception of a human mission to Mars (1989 painting by Les Bossinas of NASA Lewis Research Center NOS)

Slide 2. Outline

Slide 3: Overview of Mt. St. Helens eruption. The eruption resulted in the deaths of 57 people, and laid flat over 160 square miles of old growth forest.

Slide 4: Blank diagram of a volcano. Labels for parts appear on the poster. C. T. Adcock image

Slide 5: Types of volcanoes and details. C. T. Adcock image compiled from USGS and other public domain data

Slide 6: Outline: How can volcanoes help us search for life on other worlds?

- Volcanoes are an energy source and also introduce gasses life can use into the atmosphere.
- Areas around volcanoes can drive hot springs which can be great places for life to originate or exist.
- Some volcanoes (like cryovolcanoes or mud volcanoes) can contain signs of life in the form of organic molecules.

Slide 7: Though life started early on our planet, it was slow to become complex life, and even slower to leave our oceans. Image: The Silurian Sea by Zdenek Burian, 1957, from Prehistoric Animals, by Dr. Joseph Augusta, Zdenek Burian (Illustrator), 1963, Paul Hamlyn press; 1st Edition.

Volcanic activity may have helped early life. For example, in the deep see there are volcanically driven vents and animals use both the heat and chemistry from these deep sea vents to survive.

Slide 8: Other planets and moons have volcanoes. Left: Olympus Mons - largest volcano in our solar system. It's on Mars and is a shield volcano. Middle: Ice volcanoes on Enceladus**. They erupt water particles with organic compounds in them - possibly life related.** Right Top and Middle: Volcanoes on the moon Io. Io is one of the most volcanically active objects in our solar system. NASA Images

Slide 9: The body in this slide is Europa which has a subsurface ocean. **Was there life in the subsurface ocean of Europa just under a thick layer of Ice? Is it still there? What would it look like? How would we explore for it. This is an active mission in development at NASA. Would undersea volcanoes supply the energy needed for subsurface life on Europa?** NASA Images

Slide 10: Trilobite fossil from Earth. This is a sign of past life on Earth.

Slide 11: Diatom Microfossil image from a scanning electron microscope. Diatoms are single-celled algae that have a cell wall of silica. They are another sign of past (and present) life - in this case - on Earth. The original authors of the paper this image was in (Wickramasinghe, N. C., et al. "Fossil diatoms in a new carbonaceous meteorite." arXiv preprint arXiv:1303.2398 (2013)) claimed these to be from meteorites. However, further study has shown this to be false.

SLide 12: The Little "worm" shapes were at one point thought to be fossils and signs of past life. But the rock, Allan Hills 84001, is a meteorite from Mars. **Today, we think these were probably naturally formed minerals, potentially from a hydrothermal system that was driven by volcanic processes, rather than actual fossils.** But they sure look like fossils! Image: Gibson, Everett K., et al. "The case for relic life on Mars." Scientific American 277.6 (1997): 58-65.

Slide 13: Does Mars have what it takes? **Life needs certain compounds to persist. Mars seems to have had everything required at one point.** NASA Image - Artist rendering of water on martian surface.

Slide 14: What would life on another world be like? The images are from Disney in the lets 1950's and are for analysis and discussion by the class. They are part of a video entitled "Mars and Beyond."

Slide 15: Challenge. Come up with a planet. Document it's unique qualities (mostly ocean, really hot or cold, very long days and nights, etc...). What would life there be like? The image is of an Anomalocaris, a creature that lived on Earth ~500 million years ago, and grew to be about 1 meter long. Image: Katrina Kenny & Nobumichi Tamura

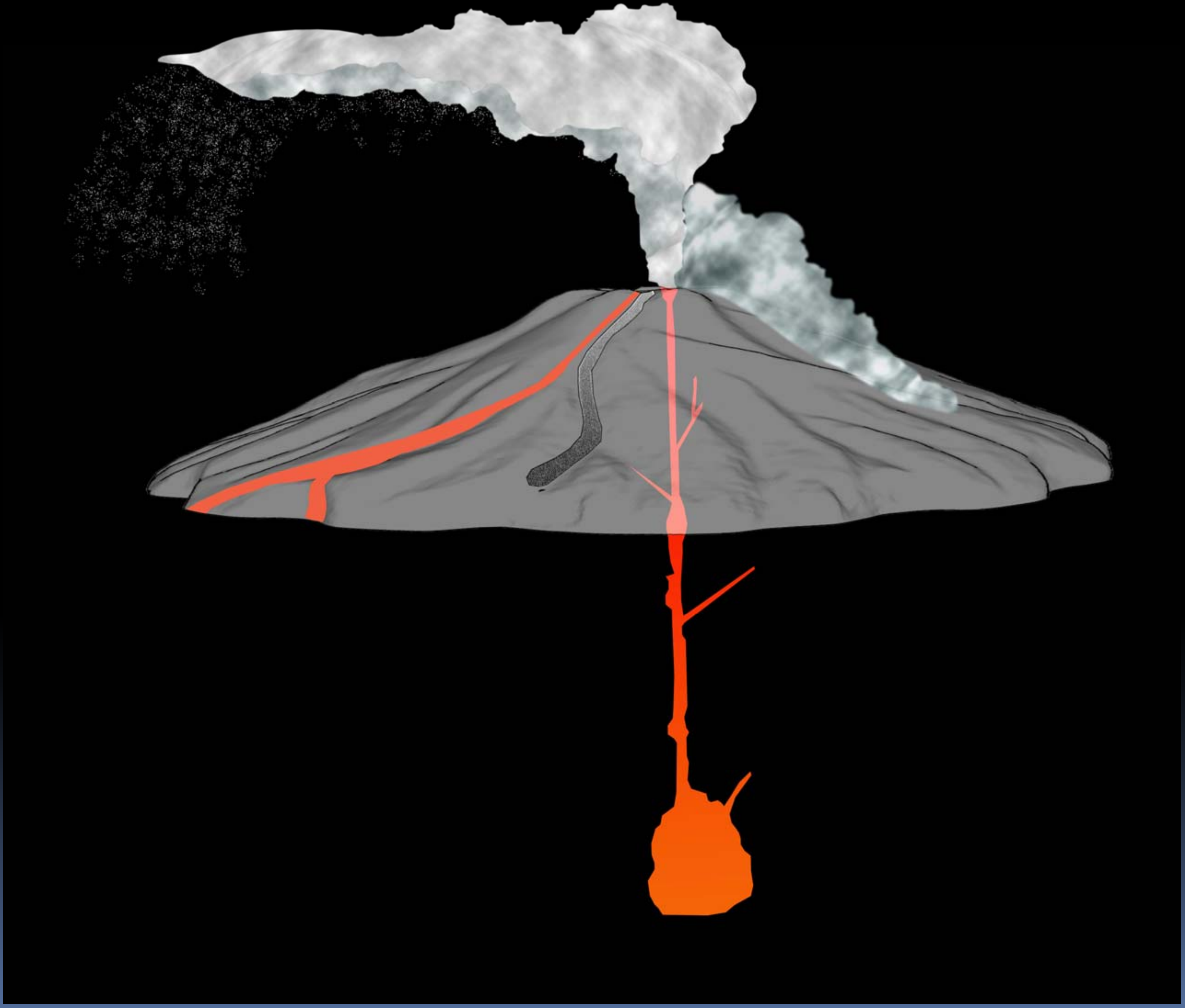
EXPLORING SPACE: VOLCANOES AND LIFE IN OTHER PLACES.

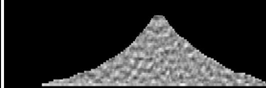
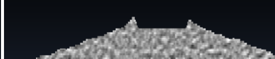
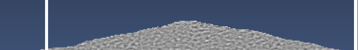
Outline

- Volcanoes!
- Volcanoes in space
- Volcanoes and life on other planets
- How do we look for life?
- Questions?

Volcanoes: Destructive Forces

On May 18th, 1980, Mount. St. Helens, in Washington state, erupted violently. The eruption ejected nearly 4.2 cubic kilometers (1 cubic mile) of ash, magma, and debris into the air and shortened the mountain by 395 meters (1300 feet). The images above were both taken from Johnston's Ridge. USGS images (Harry Glicken) NO LAVA!



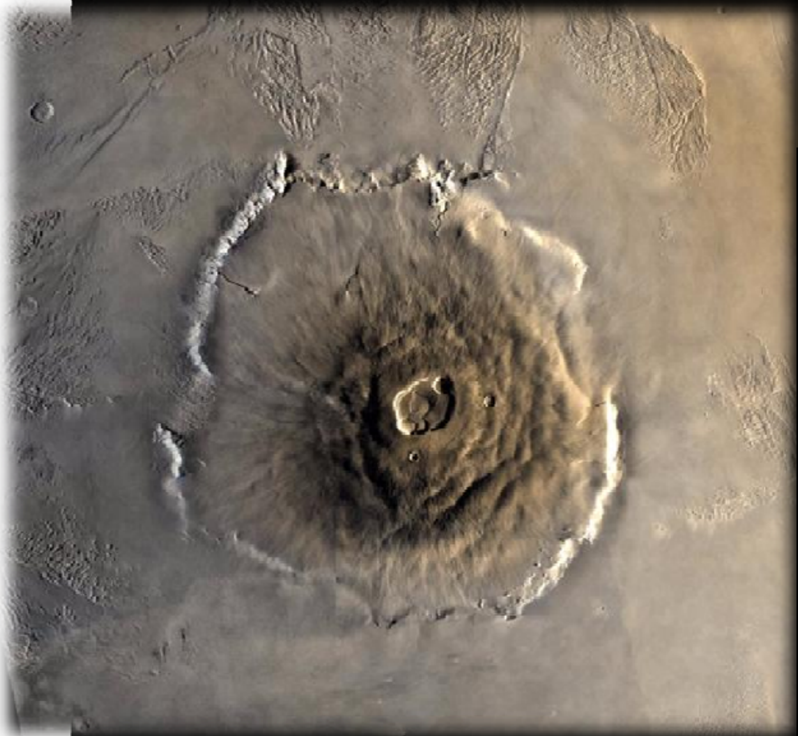
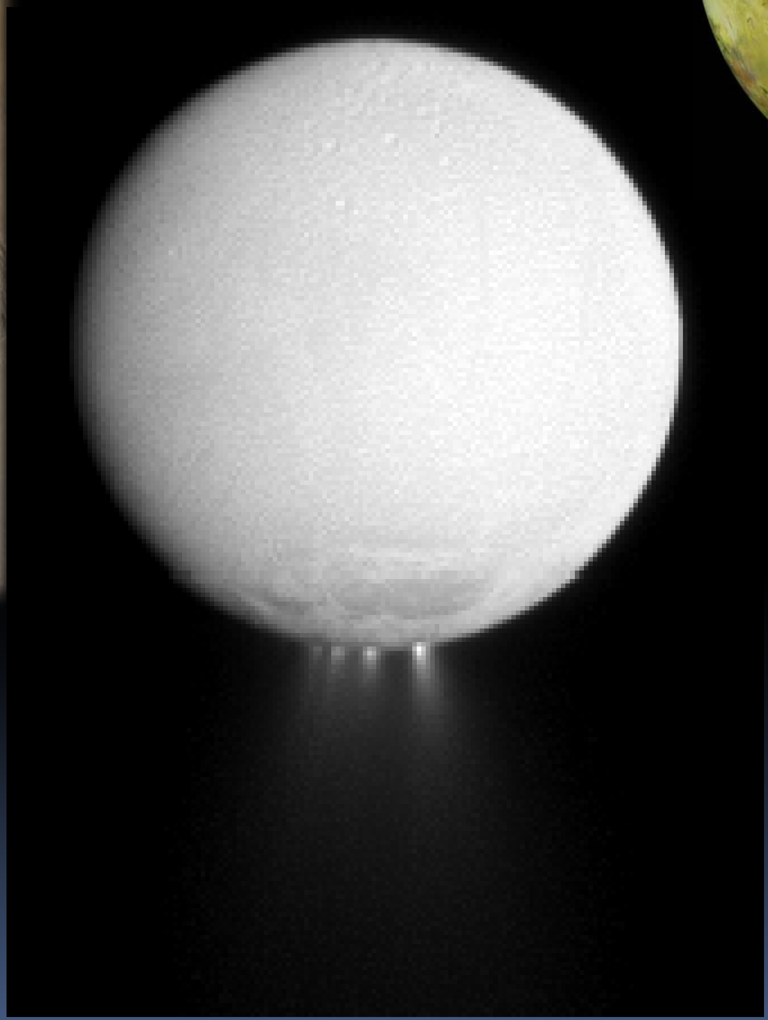
Type	Characteristics	Examples	Sketches
Fissure or Flood	Very liquid lava; flat broad flows emitted from fissures or fractures	Columbia River Plateau, Washington, Oregon, and Idaho	
Cinder Cone	Explosive lava cools in the air to fall down as cinders, eventually building a cinder cone.	Mount Tabor, Oregon	
Composite or Stratovolcano	Can erupt more viscous (thicker) lavas or explosive pyroclastic debris.	Mount St. Helens and Mount Hood, Washington	
Caldera	Very large composite volcano with a caldera resulting from collapse after an explosive period.	Crater Lake, Newberry Caldera	
Shield	Erupt thin flowing basalt lavas that eventually build into a broad cone.	Hawaiian Volcanoes	

Life on Other Worlds and Volcanoes???

- Could there be (or have been life) on other planets in our solar system?
- What do Volcanoes have to do with life?
- How would we look for it?
- What would it be like?

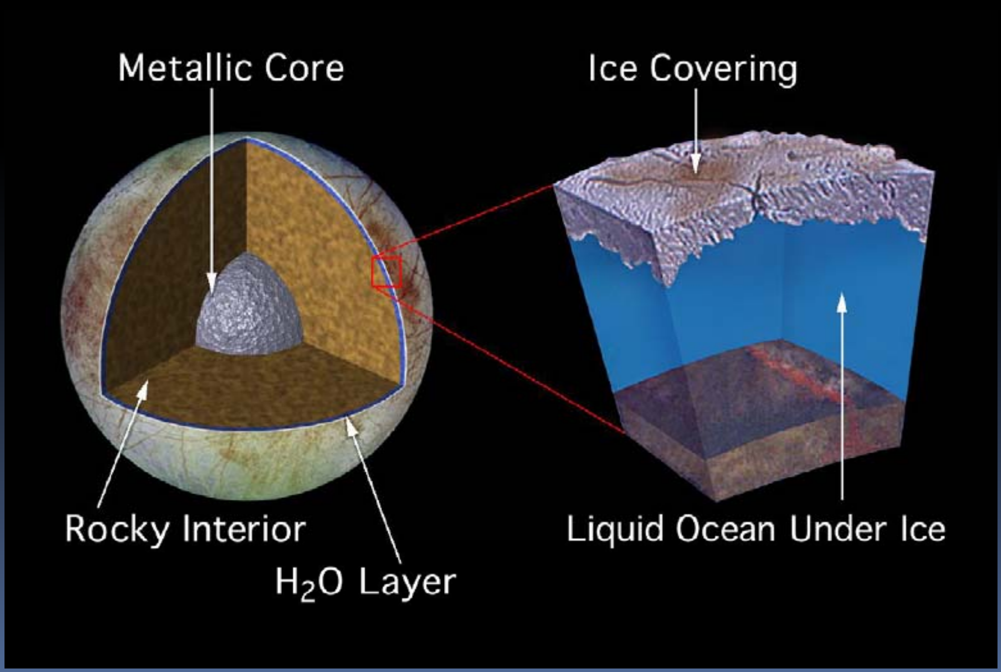
Life on Earth

- Spent more than a billion years on our oceans

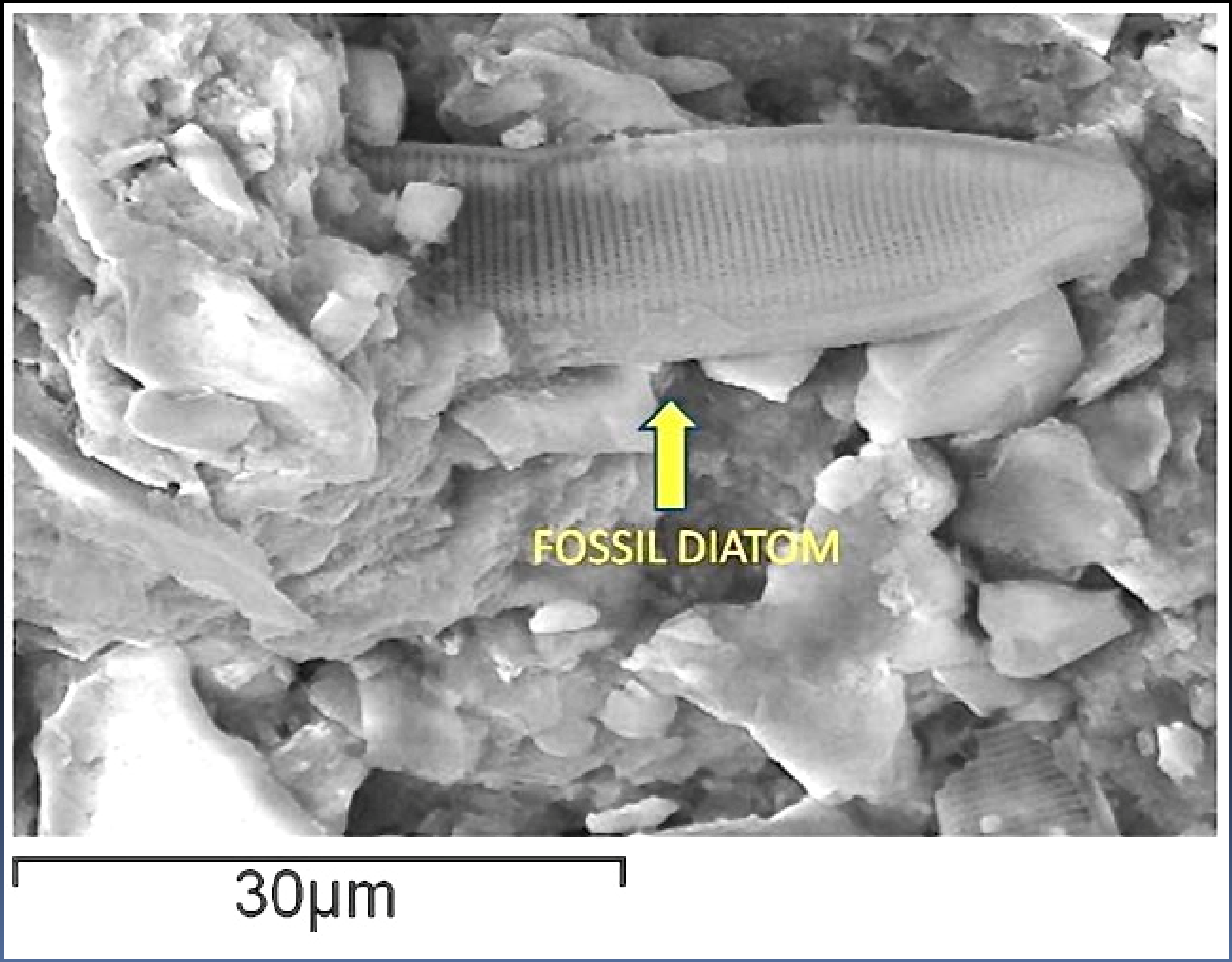
Life on Other Worlds

- How to look for life:
  - We study planets in our own Solar System
  - Especially those that may have (or had) water.
  - Or Active Tectonics (Volcanoes!) – ENERGY!

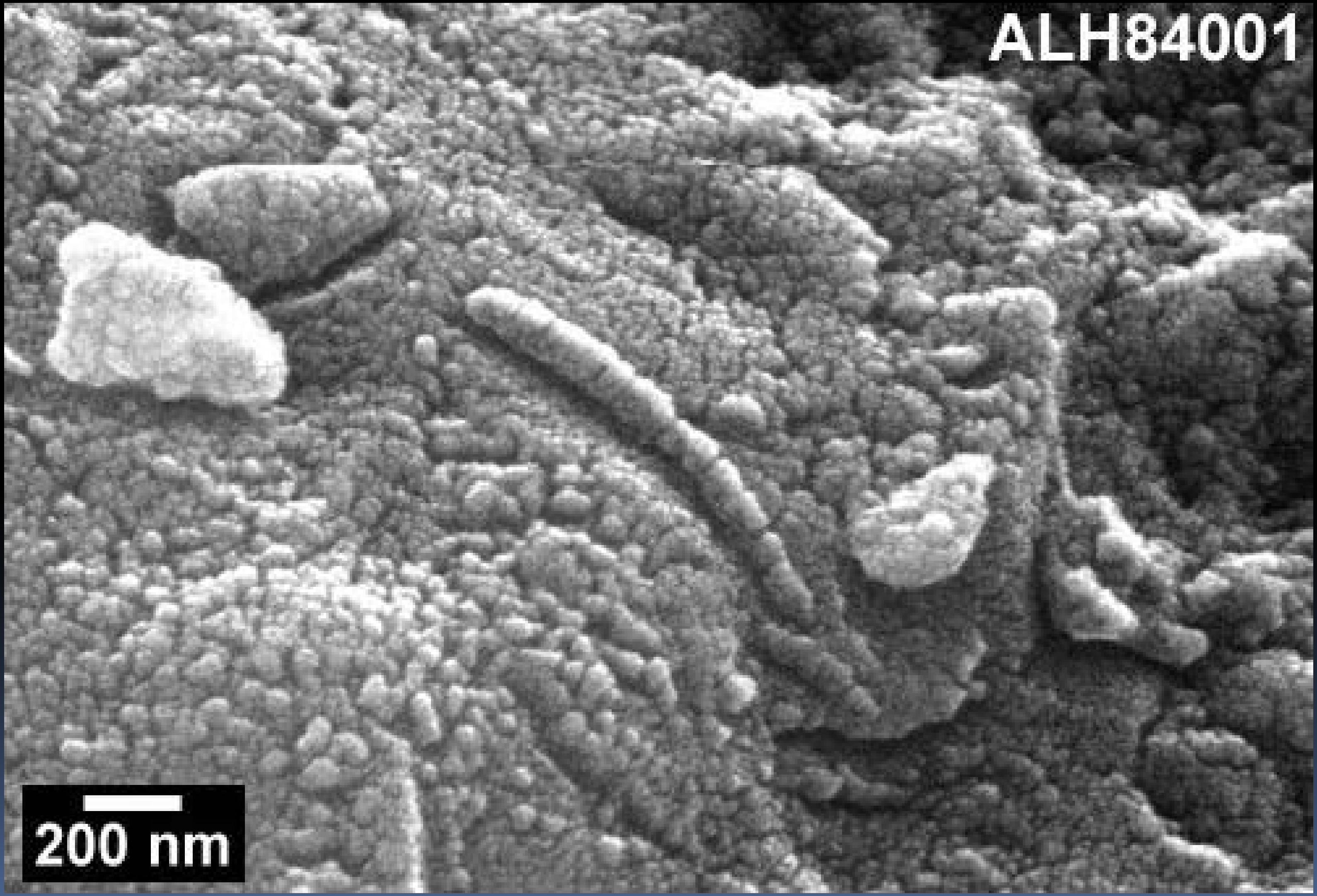


Signs of Past Life

Signs of Past Life



Signs of Past Life

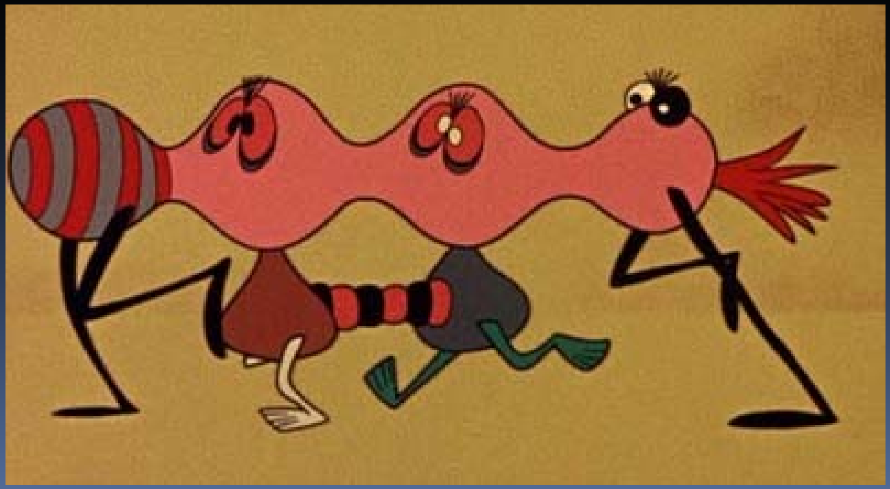


Signs of Past Environments

- We know there was water on Mars.
- Are the other building blocks there?

What might life look like?

- What would alien life be like?
- How might we look for it?
- What if it was already gone? What would you look for?



What would your alien look like?

Volcanoes in the Solar System

Nevada NASA Space Grant Consortium

UNLV | Department of GEOSCIENCE
University of Nevada, Las Vegas • 4505 S. Maryland Pkwy • Las Vegas, NV 89154-4010

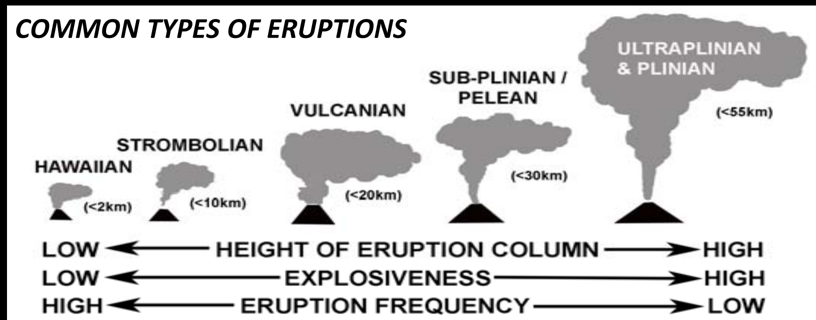
Earth's Volcanoes

There are many different types of volcanoes and volcanic eruptions. Some volcanoes erupt more violently than others, and some more frequently than others

COMMON TYPES OF VOLCANOES

Type	Characteristics	Examples	Sketches
Fissure or Flood	Very liquid lava; flat broad flows emitted from fissures or fractures	Columbia River Plateau, Washington, Oregon, and Idaho	
Cinder Cone	Explosive lava cools in the air to fall down as cinders, eventually building a cinder cone.	Mount Tabor, Oregon	
Composite or Stratovolcano	Can erupt more viscous (thicker) lavas or explosive pyroclastic debris.	Mount St. Helens and Mount Hood, Washington	
Caldera	Very large composite volcano with a caldera resulting from collapse after an explosive period.	Crater Lake, Newberry Caldera	
Shield	Erupt thin flowing basalt lavas that eventually build into a broad cone.	Hawaiian Volcanoes	

Table drawn after Allen, 1975, Volcanoes of the Portland Area, Oregon, Ore-bin, v. 37, no. 9



Drawn from Cas and Wright, 1988, Volcanic Successions - Modern and Ancient, Unwin Hyman, London, 528 p.

On May 18th, 1980, Mount. St. Helens, in Washington state, erupted violently. The eruption ejected nearly 4.2 cubic kilometers (1 cubic mile) of ash, magma, and debris into the air and shortened the mountain by 395 meters (1300 feet). The images above were both taken from Johnston's Ridge. USGS images (Harry Glicken)

Basic Volcano Features

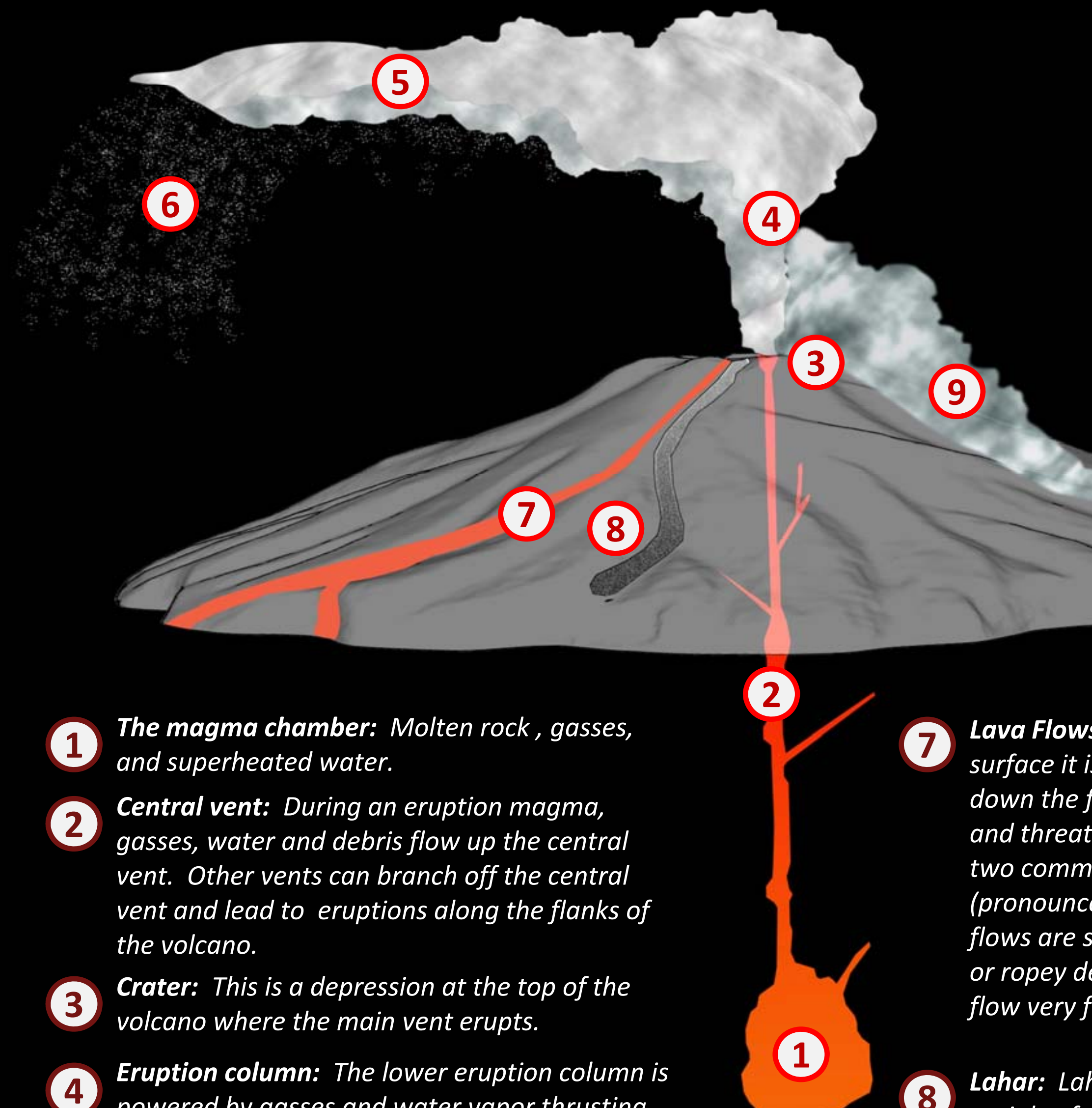
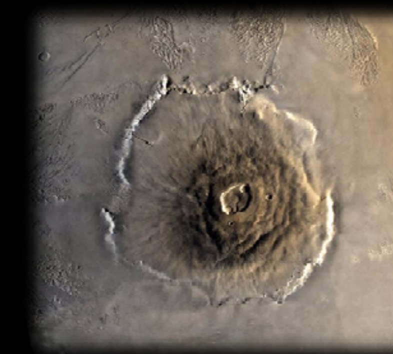


Diagram by C. T. Adcock (2014), modeled after a USGS diagram by Venezky, Myers, and Driedger (2009)

1. ***The magma chamber:*** *Molten rock , gasses, and superheated water.*
2. ***Central vent:*** *During an eruption magma, gasses, water and debris flow up the central vent. Other vents can branch off the central vent and lead to eruptions along the flanks of the volcano.*
3. ***Crater:*** *This is a depression at the top of the volcano where the main vent erupts.*
4. ***Eruption column:*** *The lower eruption column is powered by gasses and water vapor thrusting from the central vent. Higher up in the column convective thrust takes over powered by the heat of the erupted gasses. The more gasses and water in the magma, the higher the column can be.*
5. ***Downwind plume.*** *Hot gasses and pyroclastic material (such as pumice, ash, and tiny pieces of volcanic rock) can reach many tens' of thousands of feet into the atmosphere. The materials is then carried by the wind away from the volcano as a plume.*
6. ***Fallout:*** *As the gasses cool, ash and other tiny debris fall from the plume to the ground as ash falls. Ash falls can create deposits on the surface that are meters thick.*
7. ***Lava Flows:*** *When magma comes to the surface it is called lava. Lava can flow down the flanks of a volcano and beyond and threaten anything in its path. There are two common types of lava , 'A'ā (pronounced "ah-ah") and pahoehoe. 'A'ā flows are slow moving and produce clumpy or ropey deposits. Pahoehoe flows can flow very fast, up to 60 km/h (40 mph).*
8. ***Lahar:*** *Lahars are debris flows consisting mainly of pyroclastic materials and water. They occur when part of the volcano collapses. They can travel over 95 km/h (60 mph). They look like muddy rivers but the material flowing in them is more dense than concrete. They follow topography and can be very dangerous to any towns in their path.*
9. ***Pyroclastic flows:*** *These are quickly flowing clouds of ash and fine particles that can happen during an active eruption. They flow with gravity down the sides of volcanoes but do not follow topography. The can move as fast 700 km/h (450 mph).* They are very dangerous and can bury entire towns!

Solar System Volcanoes

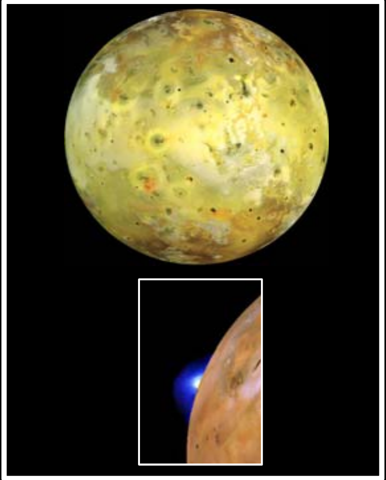
Earth is not the only place volcanoes form. Venus and Mars both have volcanoes, and Mercury probably does as well. A number of moons, including Jupiter's moon Io and Saturn's moon Enceladus, have volcanoes.



JPL/NASA Viking 1 orbiter image PIA02982.

Olympus Mons on Mars (left) is the largest known volcano in the solar system. This volcano is about 600 km (373 mi) in diameter and 24 km (15 mi) tall. It's so large it would not fit with in the borders of Nevada!

Jupiter's moon Io (right) is the most volcanically active body in our solar system. The yellow color of the moon comes from sulfur erupted to the surface from many active volcanoes. The Voyager 1 spacecraft caught an image of an active eruption on the horizon of the Io (blue plume in boxed image).



JPL/NASA Viking 1 orbiter image PIA02982.

JPL/NASA Cassini-Huygens spacecraft. Image *PIA12733*

Enceladus is one of Saturn's moons and has cryo-volcanism. In the image on the left you can see active cryo-volcanoes erupting mainly water from the southern hemisphere. It is thought that under the icy surface there is an ocean.

RESOURCES AND ACKNOWLEDGEMENTS:

More information can be found at volcanoes.usgs.gov, and photojournal.jpl.nasa.gov. Poster by C. T. Adcock. This material is based upon work supported by the National Aeronautics and Space Administration under Grant No. NNX10AN23H issued through Nevada Space Grant.

Volcanoes in the Solar System

Nevada NASA Space Grant Consortium
UNLV | Department of GEOSCIENCE

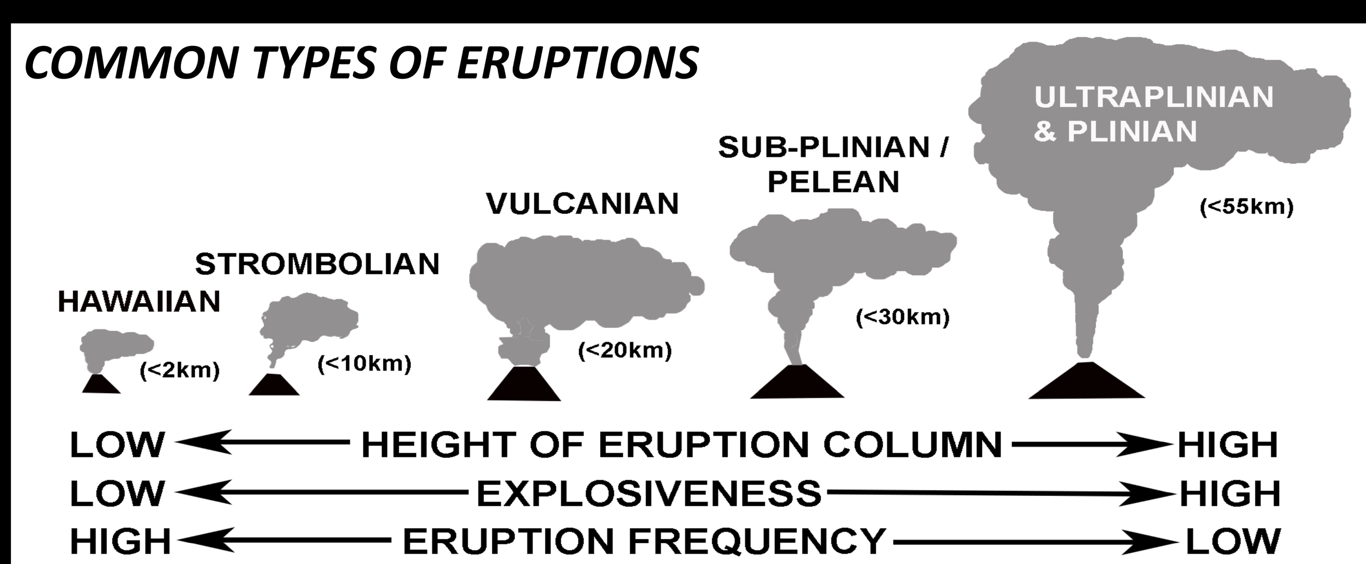
Earth's Volcanoes

There are many different types of volcanoes and volcanic eruptions. Some volcanoes erupt more violently than others, and some more frequently than others.

COMMON TYPES OF VOLCANOES

Type	Characteristics	Examples	Sketches
Fissure or Flood	Very liquid lava; flat broad flows emitted from fissures or fractures	Columbia River Plateau, Washington, Oregon, and Idaho	
Cinder Cone	Explosive lava cools in the air to fall down as cinders, eventually building a cinder cone.	Mount Tabor, Oregon	
Composite or Stratovolcano	Can erupt more viscous (thicker) lavas or explosive pyroclastic debris.	Mount St. Helens and Mount Hood, Washington	
Caldera	Very large composite volcano with a caldera resulting from collapse after an explosive period.	Crater Lake, Newberry Caldera	
Shield	Erupt thin flowing basalt lavas that eventually build into a broad cone.	Hawaiian Volcanoes	

Table drawn after Allen, 1975, Volcanoes of the Portland Area, Oregon, Ore-bin, v. 37, no. 9



Drawn from Cas and Wright, 1988, Volcanic Successions - Modern and Ancient, Unwin Hyman, London, 528 p.

On May 18th, 1980, Mount. St. Helens, in Washington state, erupted violently. The eruption ejected nearly 4.2 cubic kilometers (1 cubic mile) of ash, magma, and debris into the air and shortened the mountain by 395 meters (1300 feet). The images above were both taken from Johnston's Ridge. USGS images (Harry Glicken)

Basic Volcano Features

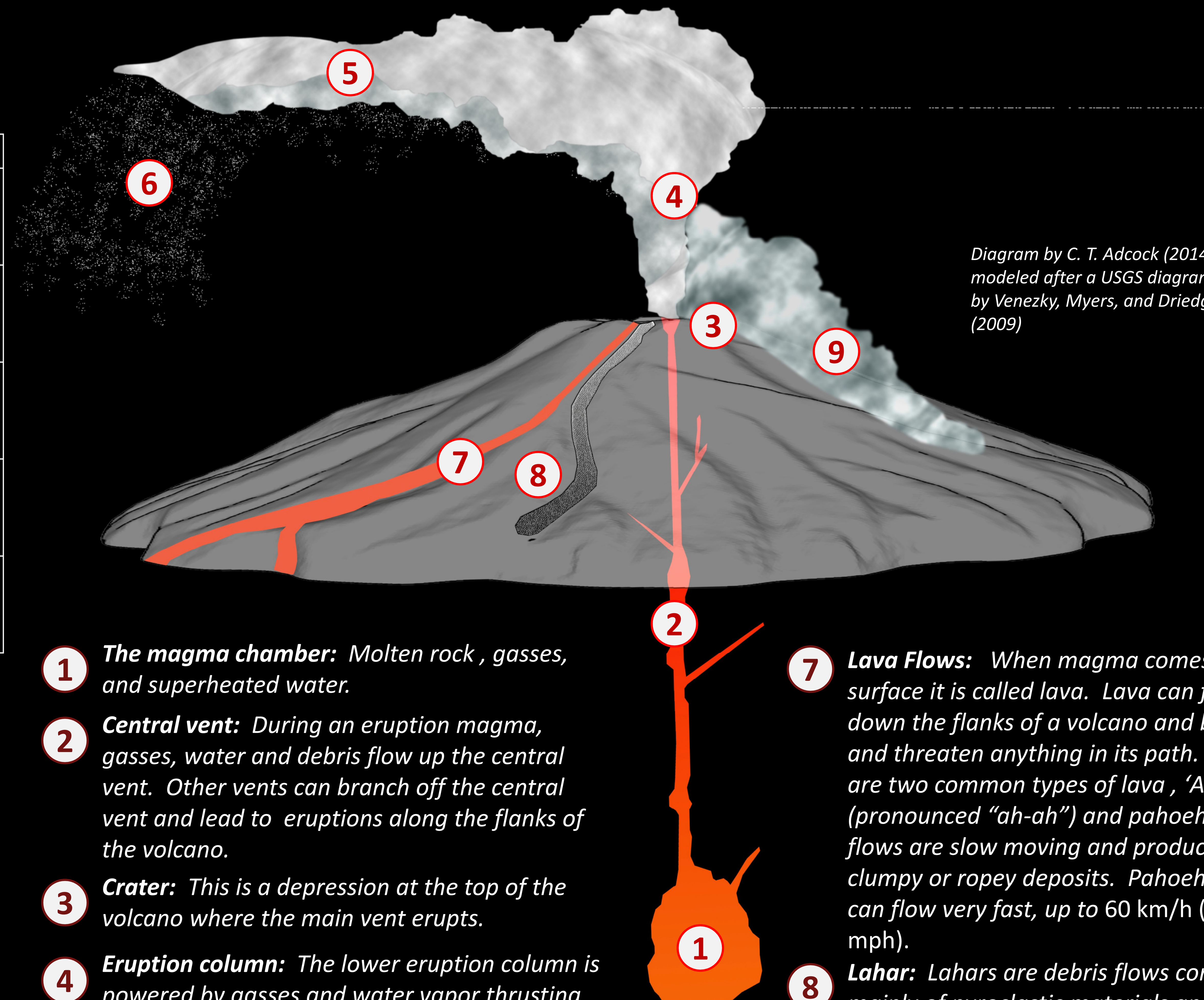
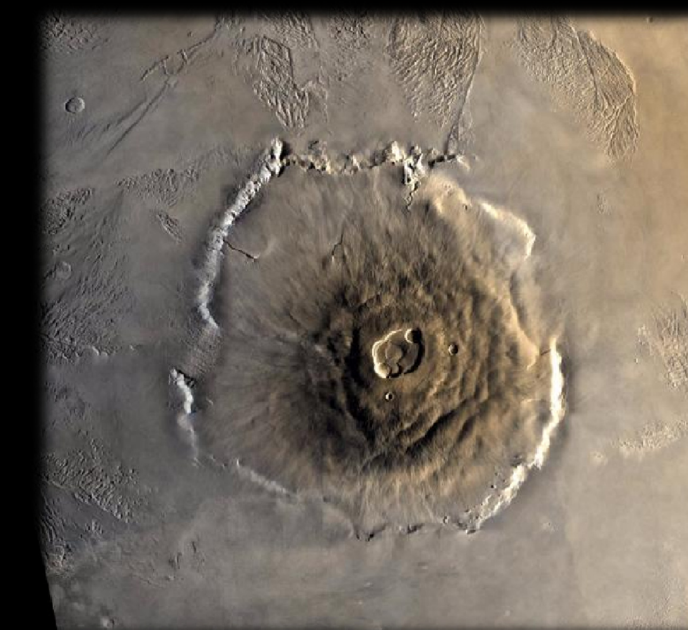


Diagram by C. T. Adcock (2014), modeled after a USGS diagram by Venezky, Myers, and Driedger (2009)

1. ***The magma chamber:** Molten rock , gasses, and superheated water.*
2. ***Central vent:** During an eruption magma, gasses, water and debris flow up the central vent. Other vents can branch off the central vent and lead to eruptions along the flanks of the volcano.*
3. ***Crater:** This is a depression at the top of the volcano where the main vent erupts.*
4. ***Eruption column:** The lower eruption column is powered by gasses and water vapor thrusting from the central vent. Higher up in the column convective thrust takes over powered by the heat of the erupted gasses. The more gasses and water in the magma, the higher the column can be.*
5. ***Downwind plume.** Hot gasses and pyroclastic material (such as pumice, ash, and tiny pieces of volcanic rock) can reach many tens' of thousands of feet into the atmosphere. The materials is then carried by the wind away from the volcano as a plume.*
6. ***Fallout:** As the gasses cool, ash and other tiny debris fall from the plume to the ground as ash falls. Ash falls can create deposits on the surface that are meters thick.*
7. ***Lava Flows:** When magma comes to the surface it is called lava. Lava can flow down the flanks of a volcano and beyond and threaten anything in its path. There are two common types of lava , 'A'ā (pronounced "ah-ah") and pahoehoe. 'A'ā flows are slow moving and produce clumpy or ropey deposits. Pahoehoe flows can flow very fast, up to 60 km/h (40 mph).*
8. ***Lahar:** Lahars are debris flows consisting mainly of pyroclastic materials and water. They occur when part of the volcano collapses. They can travel over 95 km/h (60 mph). They look like muddy rivers but the material flowing in them is more dense than concrete. They follow topography and can be very dangerous to any towns in their path.*
9. ***Pyroclastic flows:** These are quickly flowing clouds of ash and fine particles that can happen during an active eruption. They flow with gravity down the sides of volcanoes but do not follow topography. The can move as fast* 700 km/h (450 mph). They are very dangerous and can bury entire towns!

Solar System Volcanoes

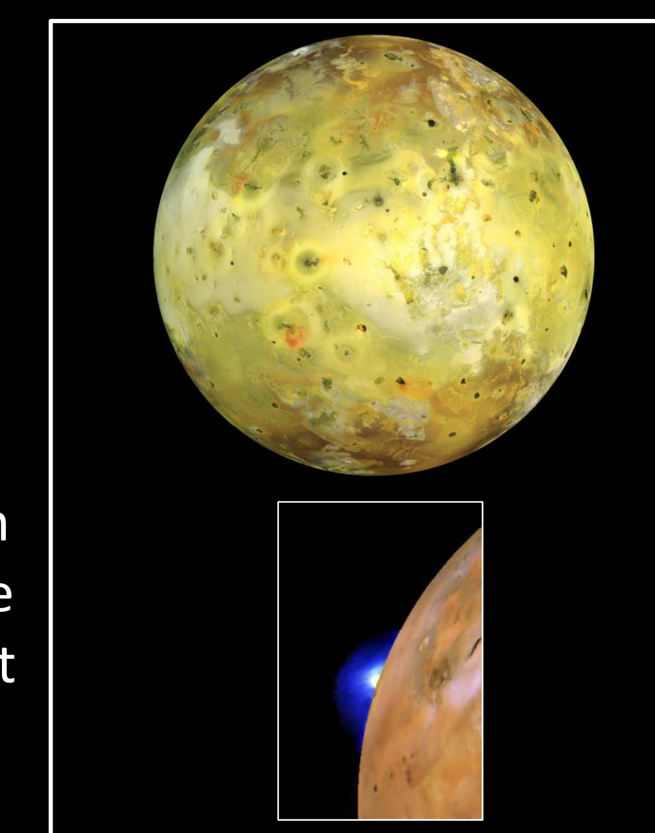
Earth is not the only place volcanoes form. Venus and Mars both have volcanoes, and Mercury probably does as well. A number of moons, including Jupiter's moon Io and Saturn's moon Enceladus, have volcanoes.



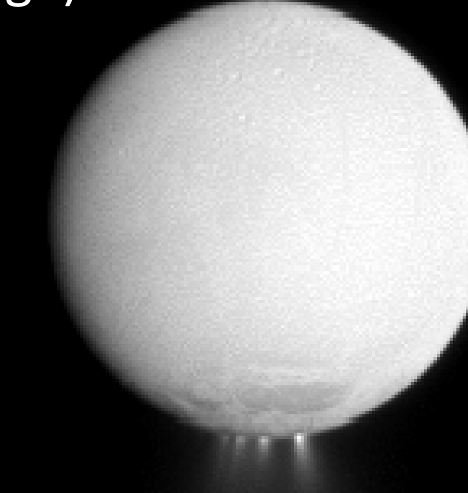
JPL/NASA Viking 1 orbiter image PIA02982.

Olympus Mons on Mars (left) is the largest known volcano in the solar system. This volcano is about 600 km (373 mi) in diameter and 24 km (15 mi) tall. It's so large it would not fit with in the borders of Nevada!

Jupiter's moon Io (right) is the most volcanically active body in our solar system. The yellow color of the moon comes from sulfur erupted to the surface from many active volcanoes. The Voyager 1 spacecraft caught an image of an active eruption on the horizon of the Io (blue plume in boxed image).



JPL/NASA Viking 1 orbiter image PIA02982.



JPL/NASA Cassini-Huygens spacecraft. Image *PIA12733*

Enceladus is one of Saturn's moons and has cryo-volcanism. In the image on the left you can see active cryo-volcanoes erupting mainly water from the southern hemisphere. It is thought that under the icy surface there is an ocean.

RESOURCES AND ACKNOWLEDGEMENTS:
More information can be found at volcanoes.usgs.gov, and photojournal.jpl.nasa.gov. Poster by C. T. Adcock. This material is based upon work supported by the National Aeronautics and Space Administration under Grant No. NNX10AN23H issued through Nevada Space Grant.

EDUCATIONAL EXPERIENCES FOR K-12 IN THE EARTH AND PLANETARY SCIENCES

UNLV Department of GEOSCIENCE
University of Nevada, Las Vegas • 4505 S. Maryland Pkwy • Las Vegas, NV 89154-4010
Nevada NASA Space Grant Consortium

For information, contact Christopher Adcock, adcockc2@unlv.nevada.edu

More Adventure and Resources:

Explore scales of the solar system:
http://www.exploratorium.edu/ronh/solar_system/
If the moon were only a pixel – what would the Solar System be like? Check it out here!
http://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html