

# Magma is a complex mixture of liquid, solid and gas

**Liquid** molten silicate

**Solid** early-formed minerals

**Gas**

Generally 0.1% to 5% of the magma by weight, but can be as much as 15%

>90% of the gas in magma is water vapor or carbon dioxide

Influences viscosity and melting point

# Viscosity: how easily a liquid or fluid flows

**High viscosity:** the liquid/fluid flows slowly under an imposed stress

**Low viscosity:** the liquid/fluid flows rapidly under the same imposed stress

For example, regular coffee has *low viscosity* as compared with Silly Putty, which has *high viscosity* at room temperature and pressure

# Magma viscosity varies due to...

**Temperature:** hotter magma has lower viscosity

**Composition:** less silica results in lower viscosity

**Dissolved water content:** more dissolved water, lower viscosity

**Gas bubbles:** fewer bubbles, lower viscosity

# Origin of Magma

**Partial melting of the upper mantle** produces mafic magmas that crystallize to form mafic rock like *basalt* and gabbro.

**Partial melting of the crust** tends to produce *felsic magmas* that crystallize to form *felsic rock* like *rhyolite* and granite.



# **Mafic magmas result in...**

**shield volcanoes with broad  
bases and gentle slopes**

**eruptions that are often  
spectacular, but are not explosive**

**flows that might extend far  
beyond the vent or fissure**

**Felsic** magmas result in...

**composite/strata volcanoes**  
with narrow bases and steep  
slopes

eruptions that are often explosive  
and quite dangerous

flows that might not extend past  
the volcano's flanks

# **Effects of volcanoes on humans**



Nix Olympica (Olympus Mons), Mars

Hawaii (Mauna Loa), Earth

Mt. Everest (Chomolungma), Earth



no vertical exaggeration

Tibetan Plateau



5x vertical exaggeration





## Geothermal energy





## **Contributor to the early history of life on Earth**



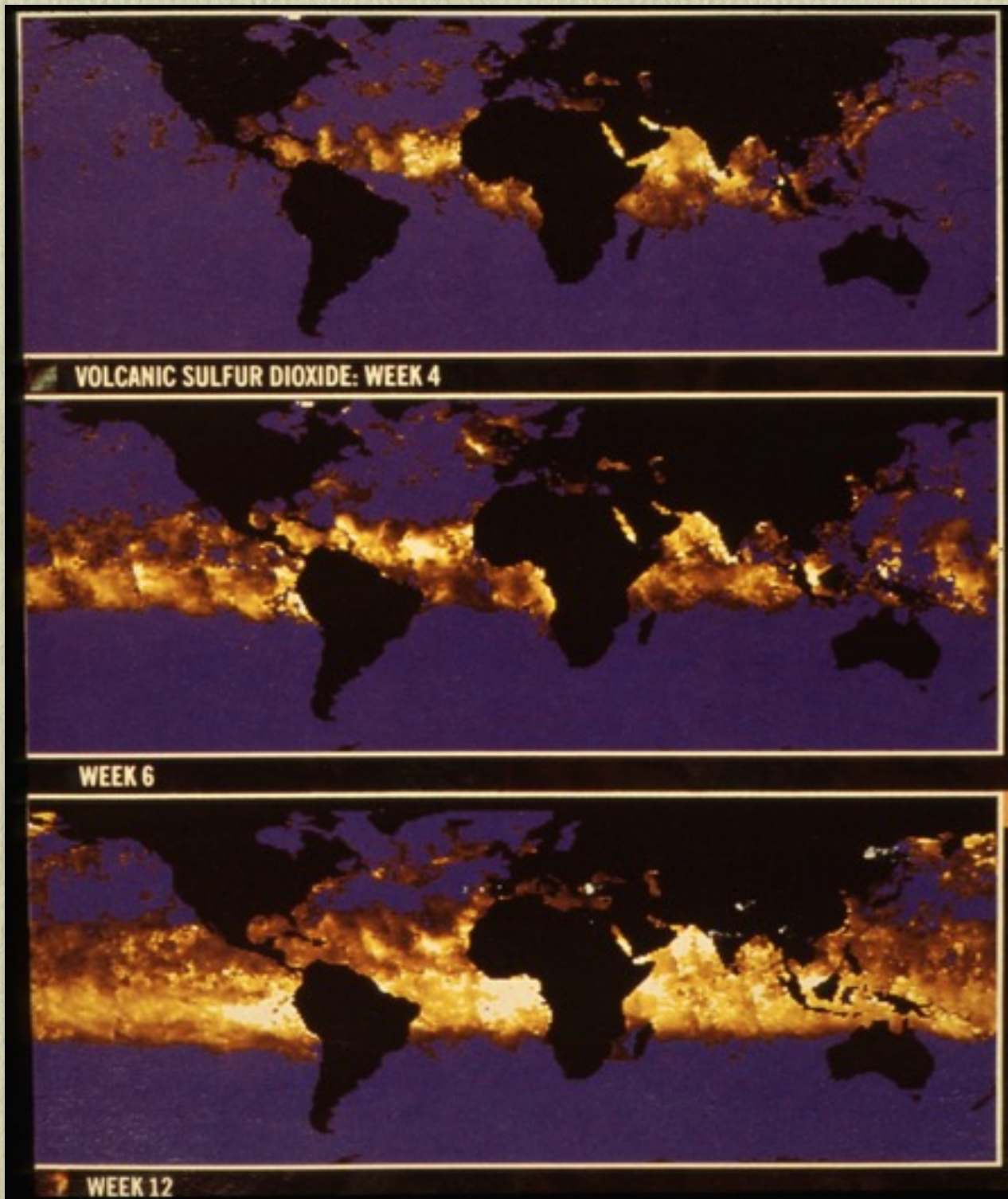
# **Effect on atmosphere, hydrosphere and climate**

- **Source of much of Earth's atmosphere**
- **A source of water on Earth**
- **Major contributor to acid rain**
- **Contributor of “greenhouse gases” to atmosphere**
- **Volcanic dust and Earth's albedo**



# **Hazards associated with volcanoes**





Satellite monitoring of the spread of volcanic sulfur dioxide around Earth after the 1991 eruption of Mt. Pinatubo in the Philippines. NOAA images by Robert Cary













Small eruption on April 10, 1980. The bulge is in the middle-right of the picture.



USGS volcanologist  
Dave Johnston using a  
Correlation Mass  
Spectrometer to analyze  
gas emitted by Mt. St.  
Helens prior to its  
eruption on May 18,  
1980.





Dave Johnston preparing for an aerial gas-sampling mission over Mt. St. Helens





Coldwater Camp, May 1980













Dave Johnston resting at Coldwater II on May 17, 1980





Mt. St. Helens from Goldwater Ridge, taken the day before the eruption. Photo by Harry Glicken.

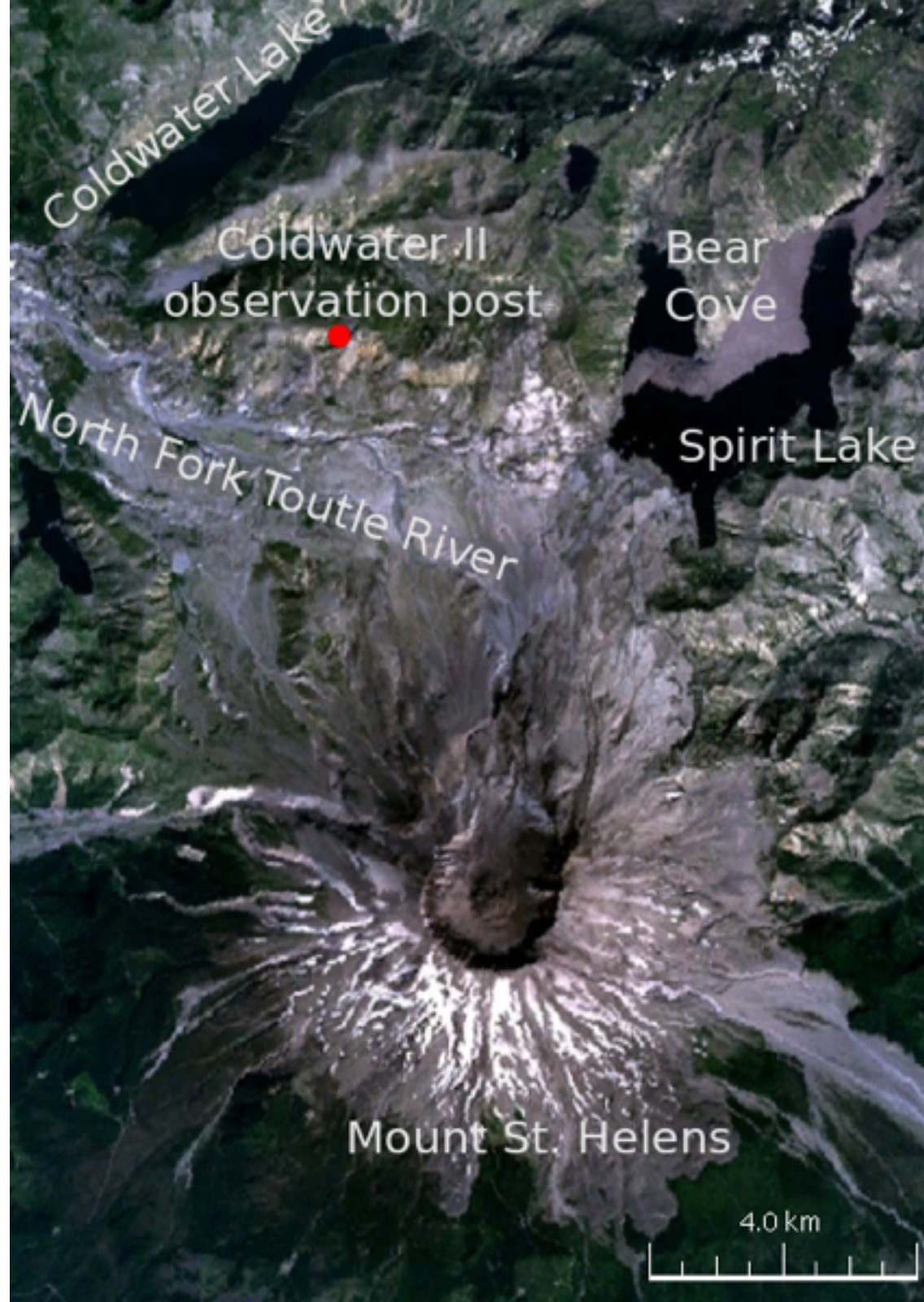






Mt. St. Helens from Goldwater Ridge, 4 days after the eruption.  
Photo by Harry Glicken.





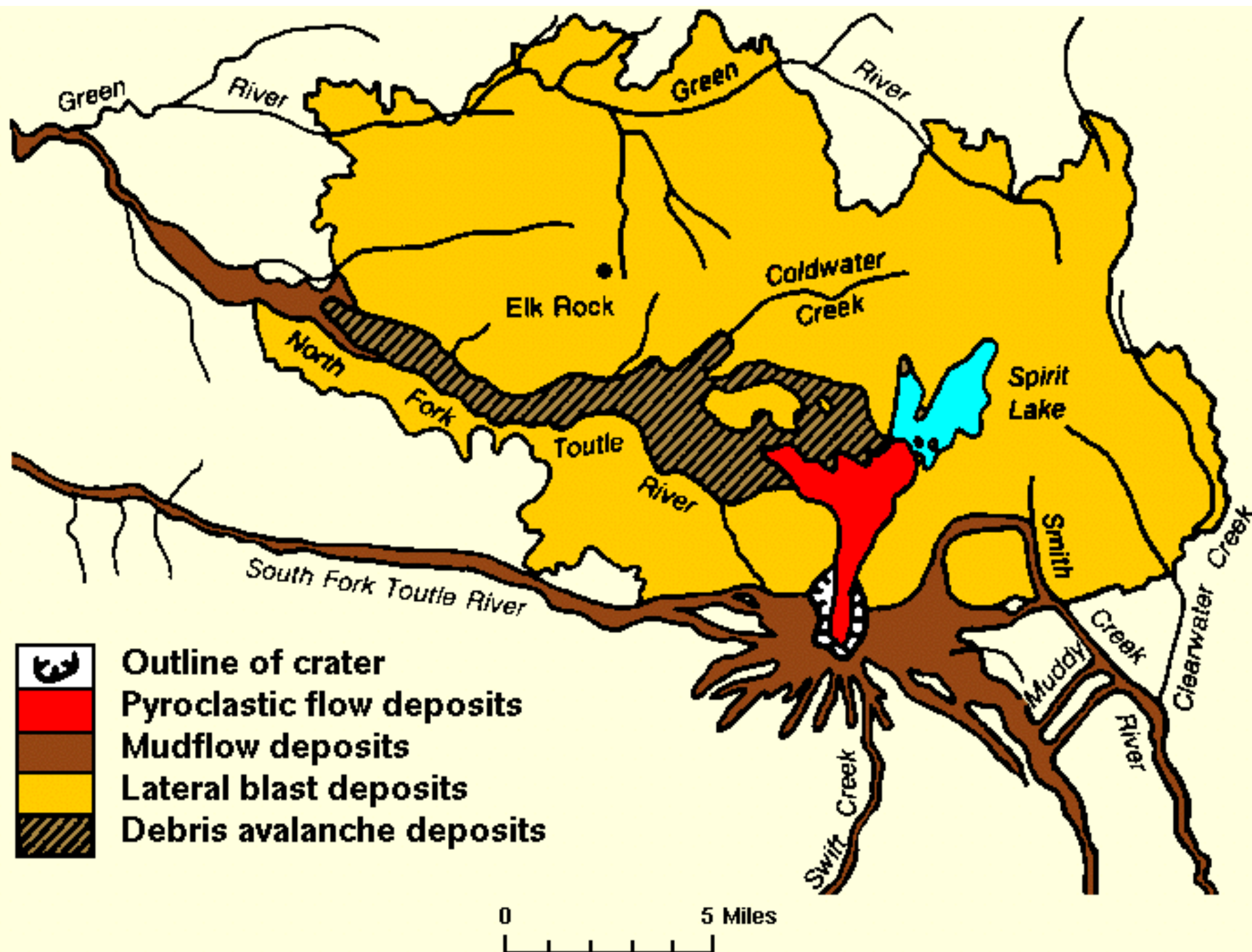












[http://youtu.be/  
njV9skilgB4](http://youtu.be/njV9skilgB4)





Trees in the direct blast zone were snapped off and blown away, and the ground was scorched.

https://  
www.youtube.com/  
watch?v=zVD5tSFGJPU





October 2004 eruption

# Measuring Volcanic Gas with UV Spectrometers

Measuring sulfur gas from a volcano  
using solar ultra-violet radiation

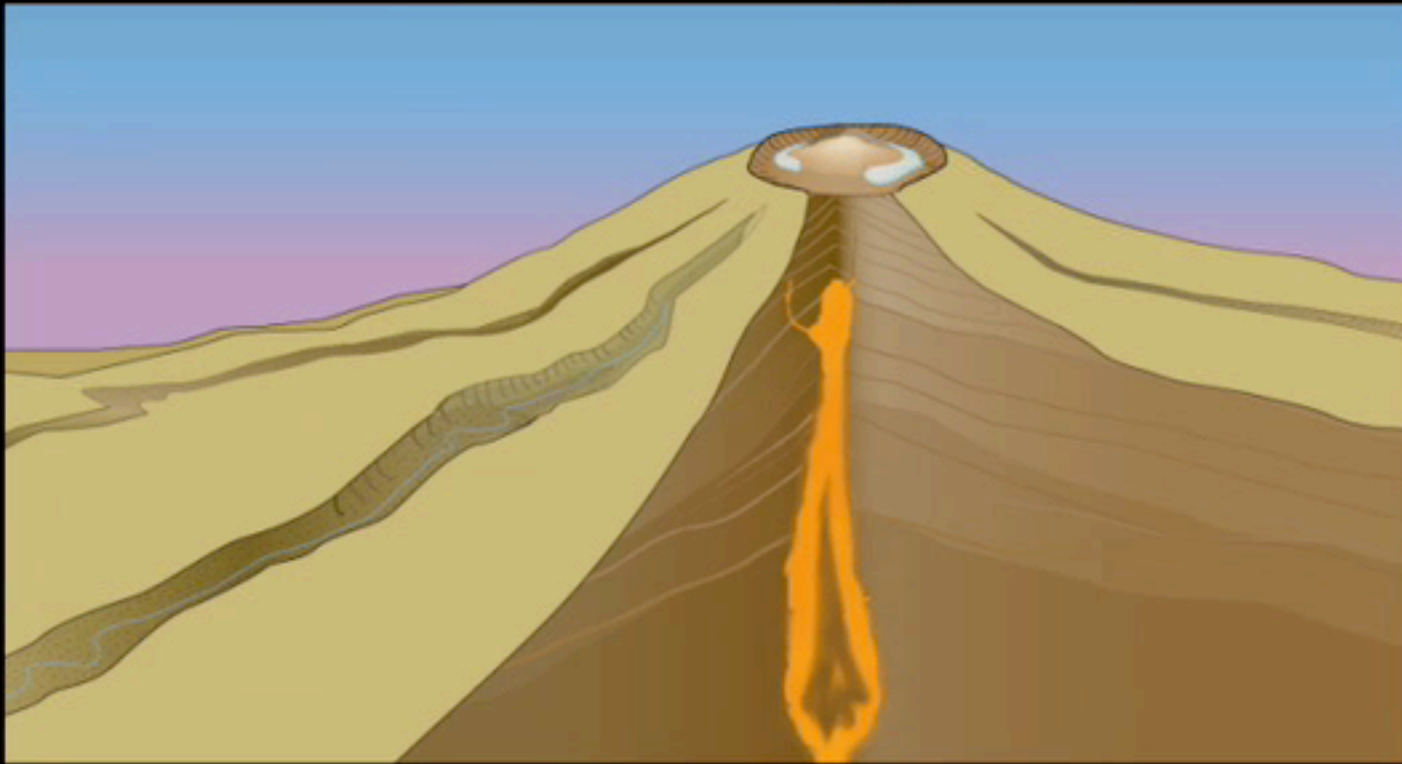
Changes in the gas composition or emission rate of  $\text{SO}_2$  and other gases, may be related to variation in magma supply rate, change in magma type, or modifications in the pathways of gas escape induced by magma movement.

Volcanic gas rises through cracks in the rock.

Gases include  $\text{SO}_2$ ,  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ ,  $\text{HCl}$ ,  $\text{HF}$ ,  $\text{CO}$ , & others.



# Volcanic Earthquakes



Continuous release of seismic energy induced by the movement (injection or withdrawal) of magma





## Monitoring volcanic activity at Mount St. Helens with tiltmeters and GPS stations

Narrated by Dan Dzurisan, U.S. Geological Survey





<http://www.unavco.org/instrumentation/networks/status/pbo>













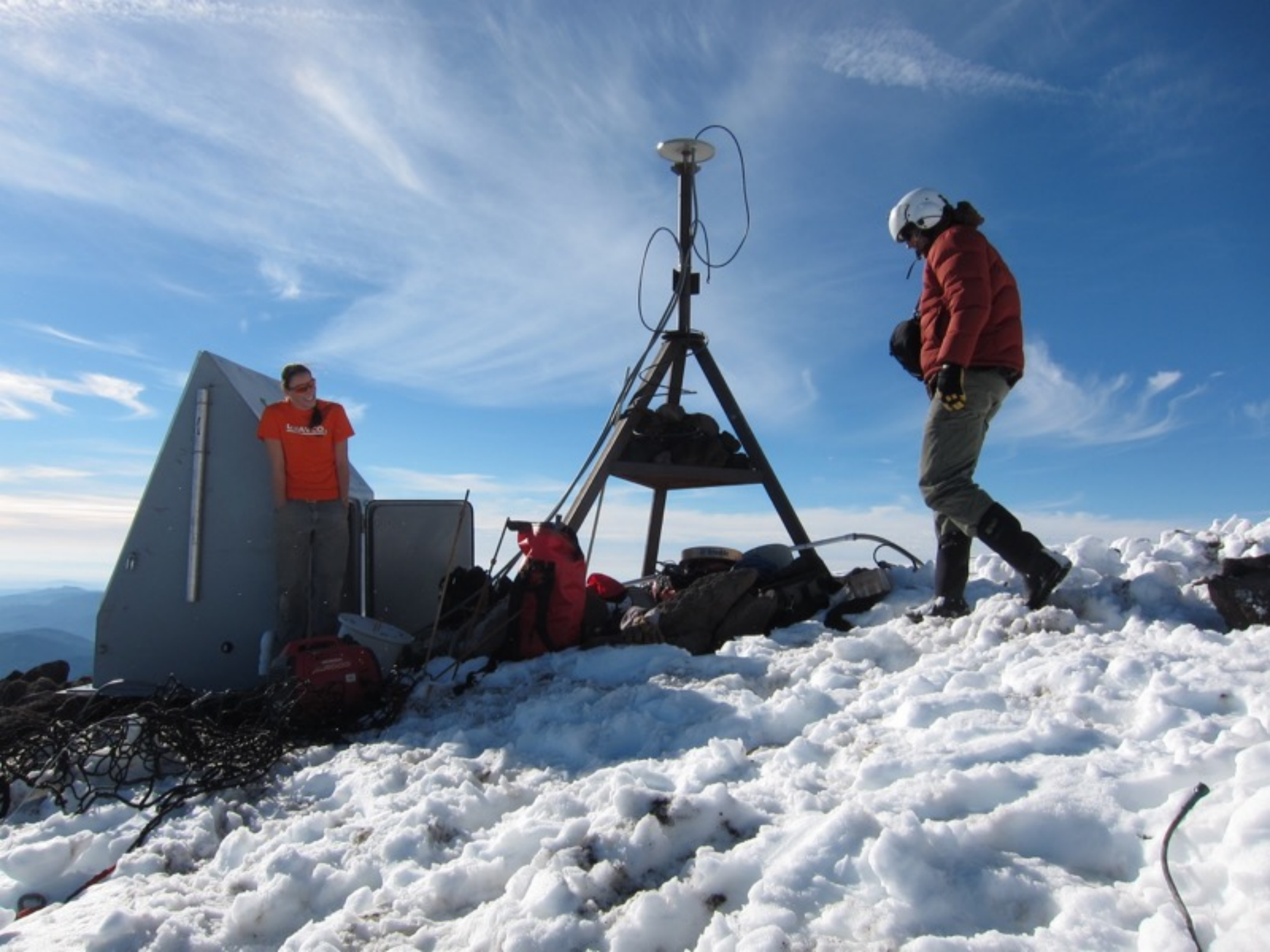




















**Geologists' warnings were not heeded before the eruption and consequent debris flows from Nevado del Ruiz, Columbia, in 1985. Approximately 22,000 people died. From Newson, 1998.**





Volcanologist Stan Williams, Arizona State University





Galeras Volcano, with the city of Pasto, Columbia, in the foreground.





Some of the field trip participants to the crater of Galeras Volcano, near Pasto, Columbia, January 14, 1993.













In the eruption of January 14, 1993, six scientists died. Stan Williams, who was on the east rim of the crater, survived.



# SURVIVING GALERAS

A photograph of a volcano erupting with a large plume of white smoke or ash against a blue sky. The volcano is dark and conical, and the smoke is thick and billowing.

STANLEY WILLIAMS  
AND FEN MONTAIGNE

# **Other Volcanic Hazards**

- **Floods related to melting snow or ice (jökulhlaup)**
- **Damage to motors and other mechanical devices by ash**
- **Earthquakes**
- **Tsunamis**
- **Poisonous gas**
- **Famine, destruction of water supply, failure of transportation and communication**



ash-fall tuff



**tuff**



angular  
clasts

1 cm

**tuff**



# Pyroclastic Breccia

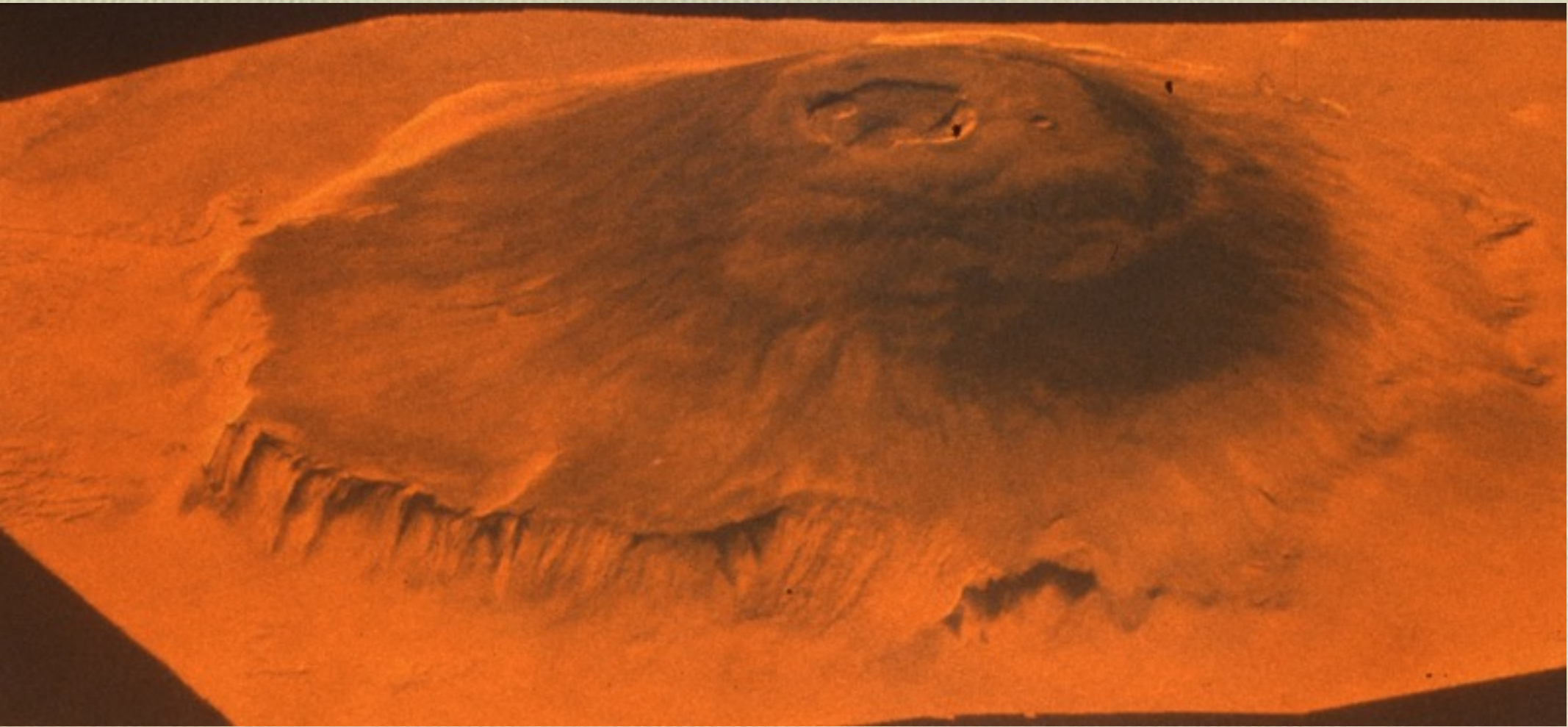




# **Some Types of Volcanoes**

- **Shield volcanoes**
- **Stratavolcanoes or composite volcanoes**
- **Cinder cones**
- **Domes**
- **Volcanic “plateaus”**





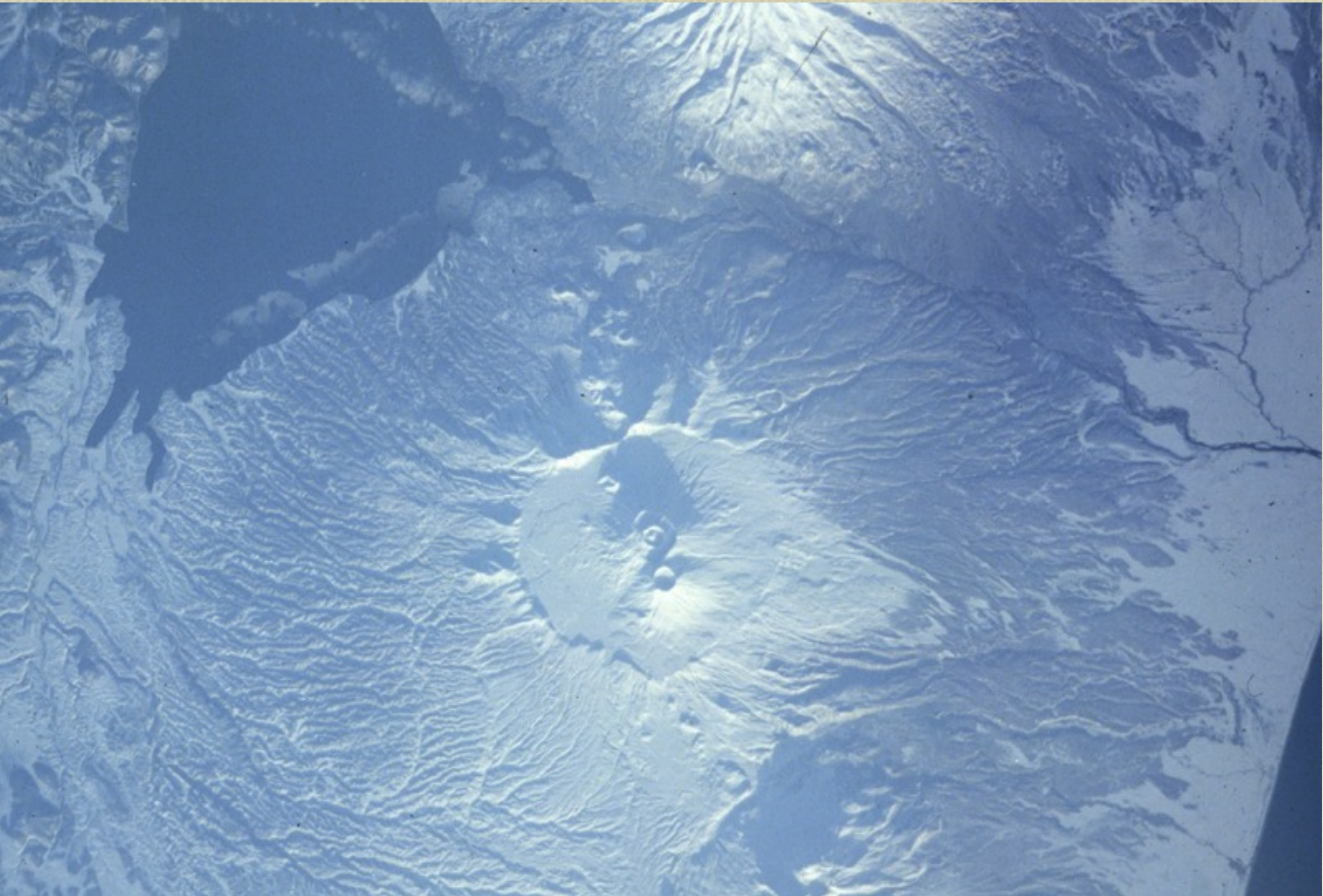
Olympus Mons shield volcano, Mars  
The largest known mountain in the Solar System



# Mt. Hood, Oregon









# ***Extrusive* Igneous Rock Bodies and Flow Forms**





Ship Rock, New Mexico: a volcanic neck



