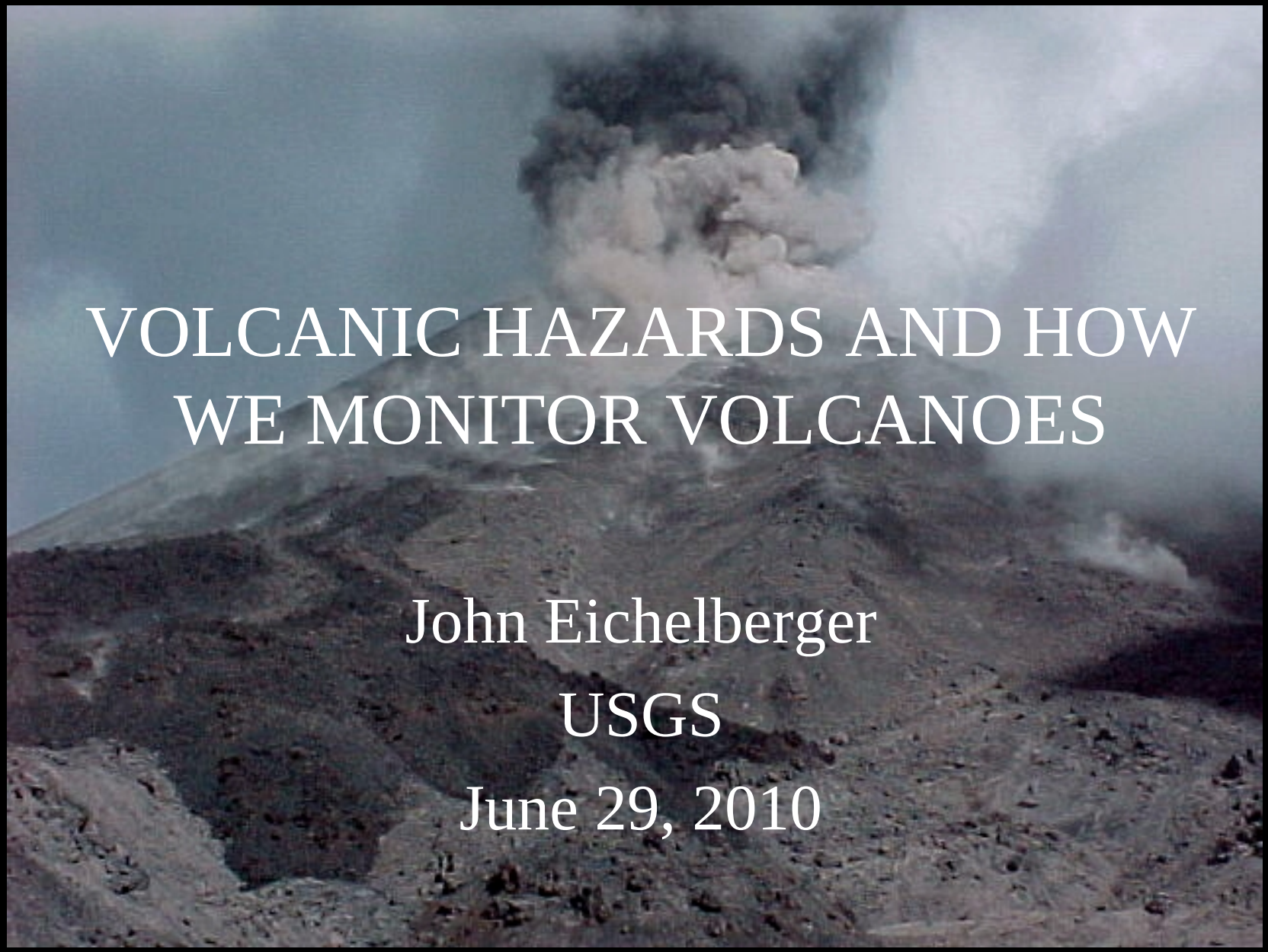


VOLCANIC HAZARDS AND HOW WE MONITOR VOLCANOES

John Eichelberger

USGS

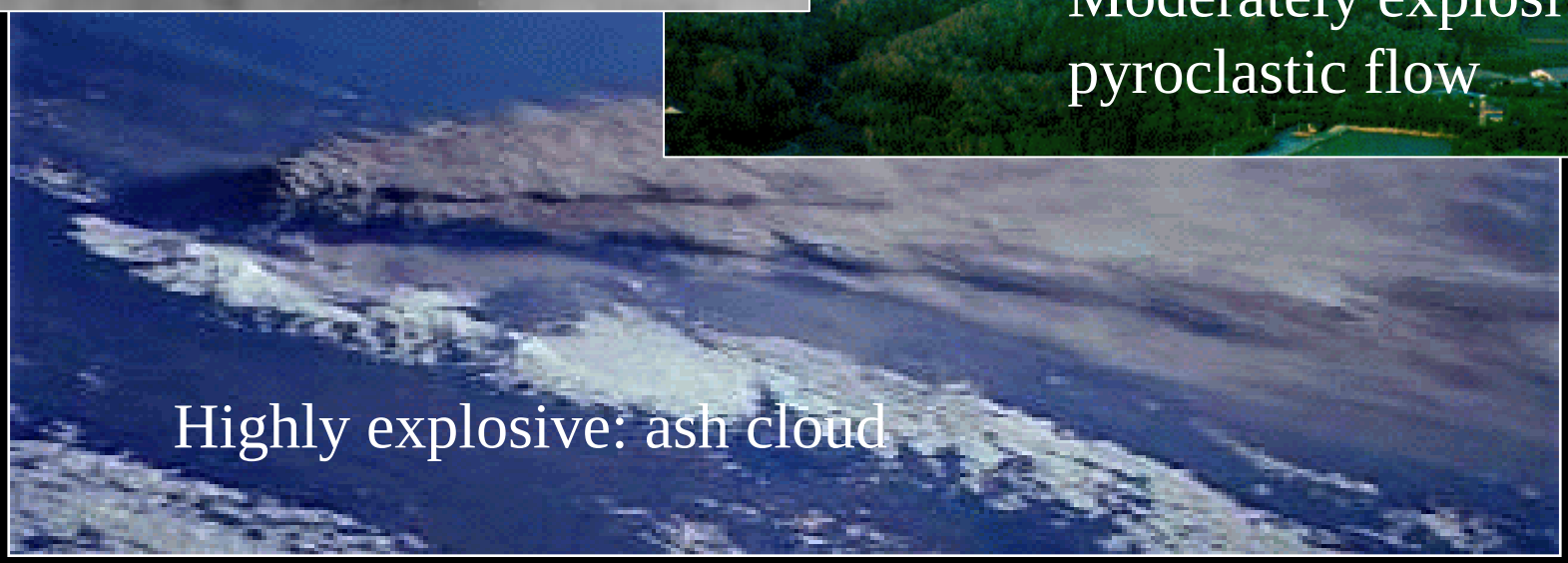
June 29, 2010

Outline

- Kinds of eruptions and their effects
- Monitoring techniques
- Hazard mitigation: Putting it all together


Non-explosive: lava


Moderately explosive:
pyroclastic flow


Highly explosive: ash cloud

Earthquake – Eruption comparison

- Happens without warning (except at a distance)
- Over in an instant, then smaller aftershocks
- Response and recovery begin after event

- Warning signs may appear a year in advance
- Some warnings are false
- Eruptions can go on for years
- Evacuations may be long term or permanent
- Crisis response may begin before the event
- Forecasting the end of eruption is not now possible

In both cases, government and community planning before a disaster are very important.

- Ash clouds

Redoubt, Alaska 2009


Redoubt, Alaska 1989

Effects and areas at risk

In-flight failure of jet engines: Alaska, Marianas, western US

- Ash falls


Homer, Alaska 2009


Anchorage, Alaska 2009


Kodiak, Alaska 1912

Darkness, respiratory problems, machine wear, airport closures, building collapse (extreme case): Alaska, western US, Marianas

- Pyroclastic flows


Shimabara, Japan 1991


Katmai, Alaska 1912

Complete destruction near volcano: western US, Alaska, Marianas

- Lava flows


Kilauea, Hawaii 1990


Kilauea, Hawaii 1990

Complete destruction near volcano: Hawaii (Big Island), western US

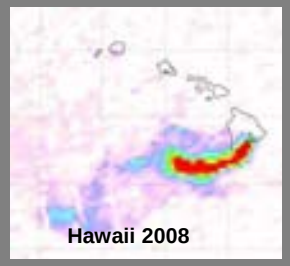
The Hazards (continued)

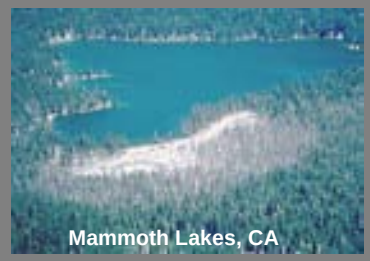
Effects and areas at risk

- Lahars (mudflows)

Inundation and destruction in valleys: Alaska, Cascade Range

- Toxic gas





Health threat (fatalities in CA), damage to plants and agriculture, air quality degradation: Hawaii; Marianas; Long Valley and Yellowstone calderas

- Explosions

Flying projectiles can cause burns, trauma, death: Hawaii, Yellowstone

Put people and volcanoes together, and we have a problem.

Usu Volcano, Hokkaido, March 2000

- The risk from eruptions increasing, not because volcanoes are becoming more active but because more people are living near them.

1,931 years of progress since 79 AD:

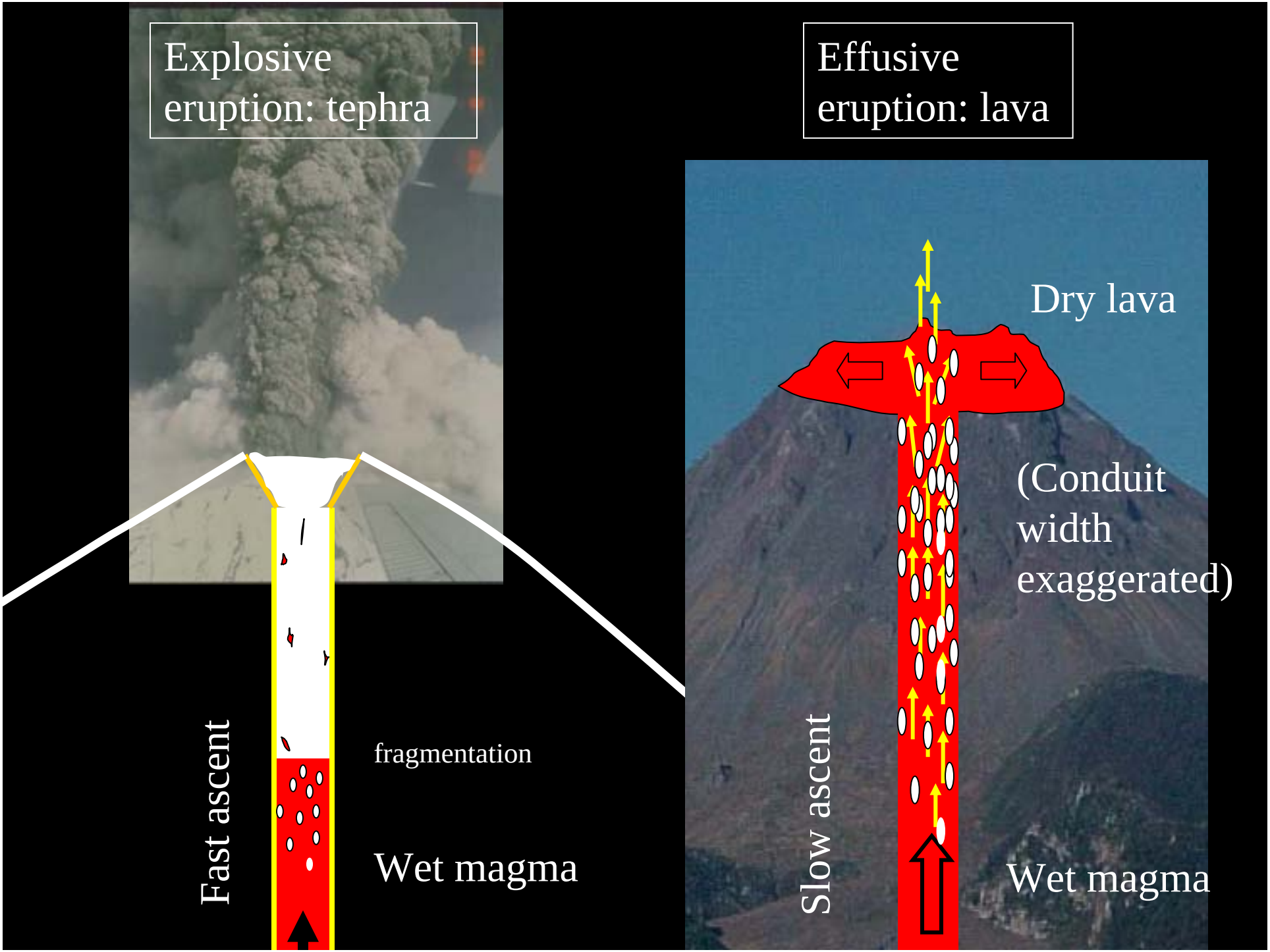
Bay of Naples from crater rim of Vesuvius

Vesuvius rises behind Pompeii

ROLES OF TWO SIMPLE INGREDIENTS IN MAGMAS:

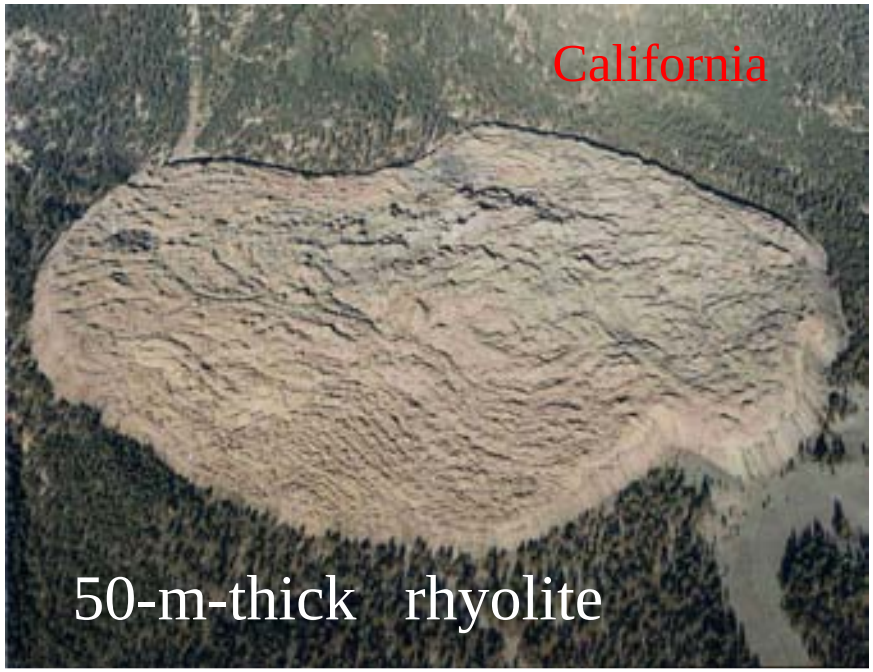
- SiO_2 “silica” - viscosity

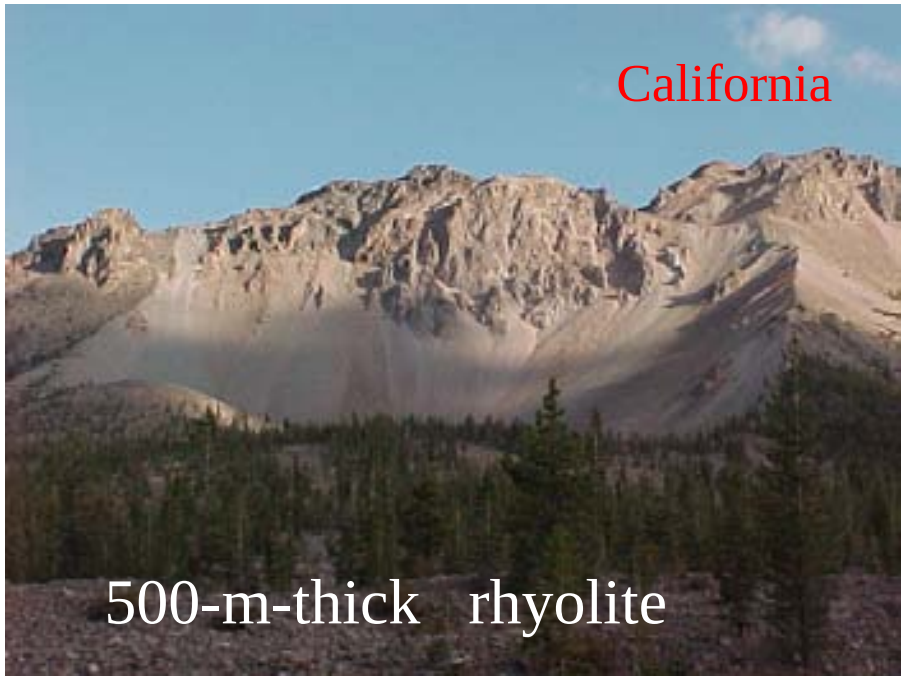
- H_2O “water” - explosiveness


Explosive eruption: tephra
Effusive eruption: lava
Dry lava
(Conduit width exaggerated)
Fast ascent
fragmentation
Wet magma
Slow ascent
Wet magma

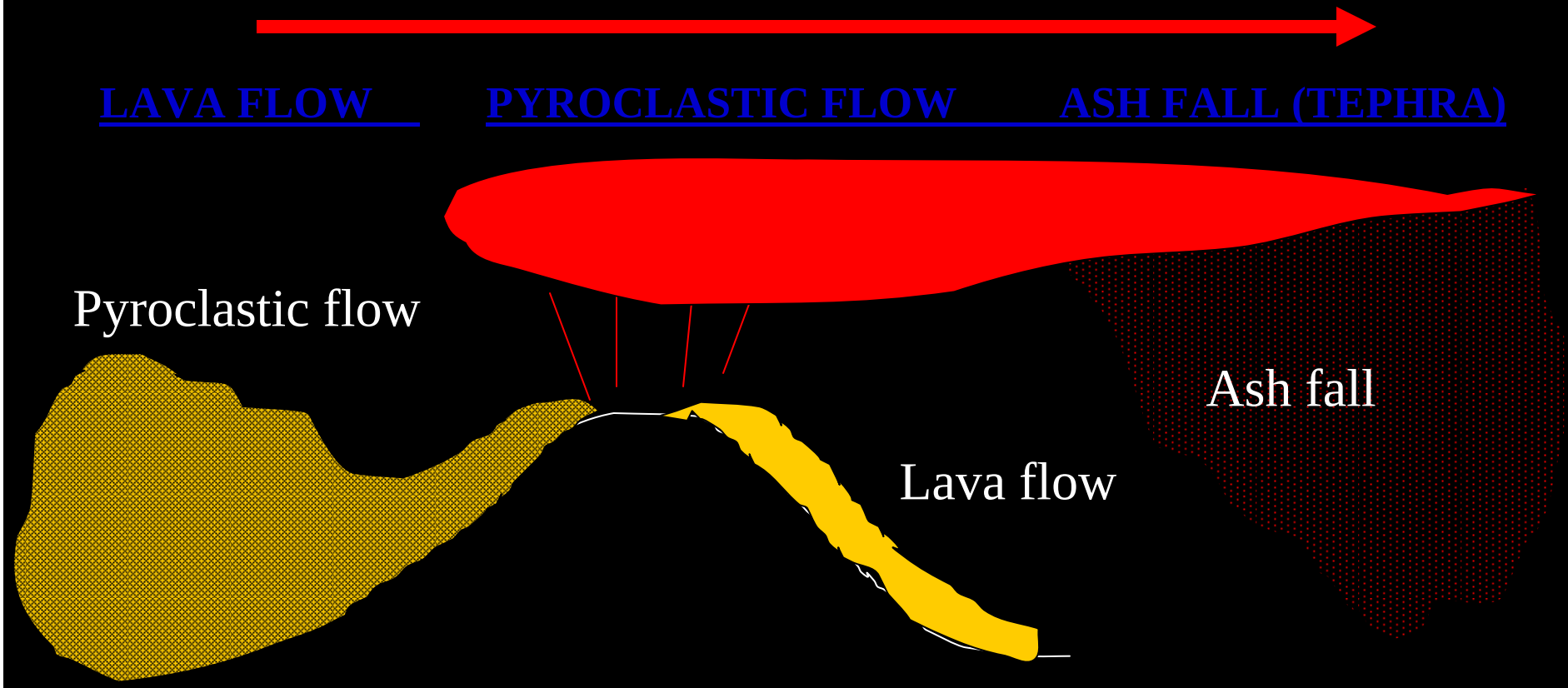

Hawaii
0.5-m-thick basalt


Kamchatka
5-m-thick andesite

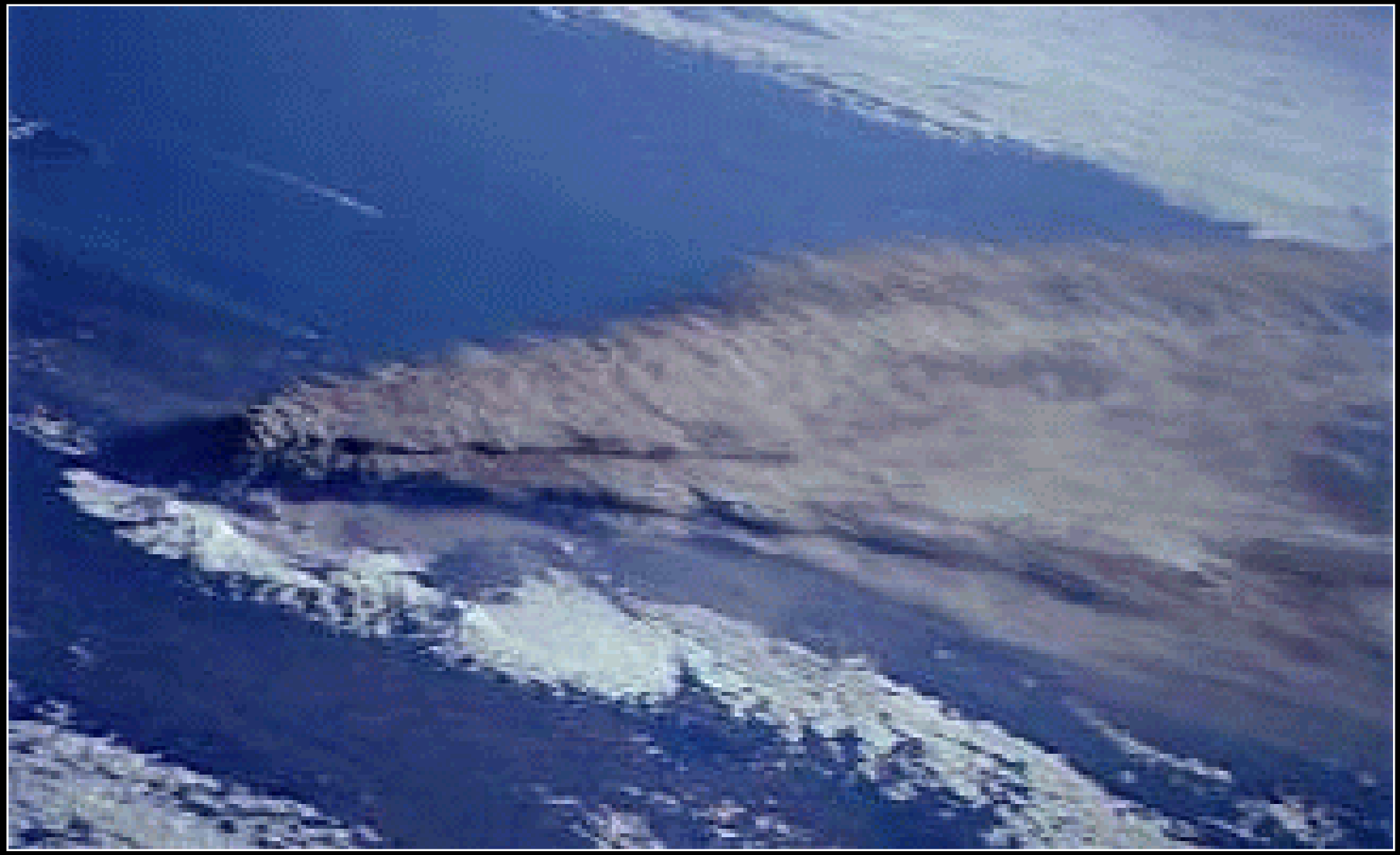

California
50-m-thick rhyolite


California
500-m-thick rhyolite

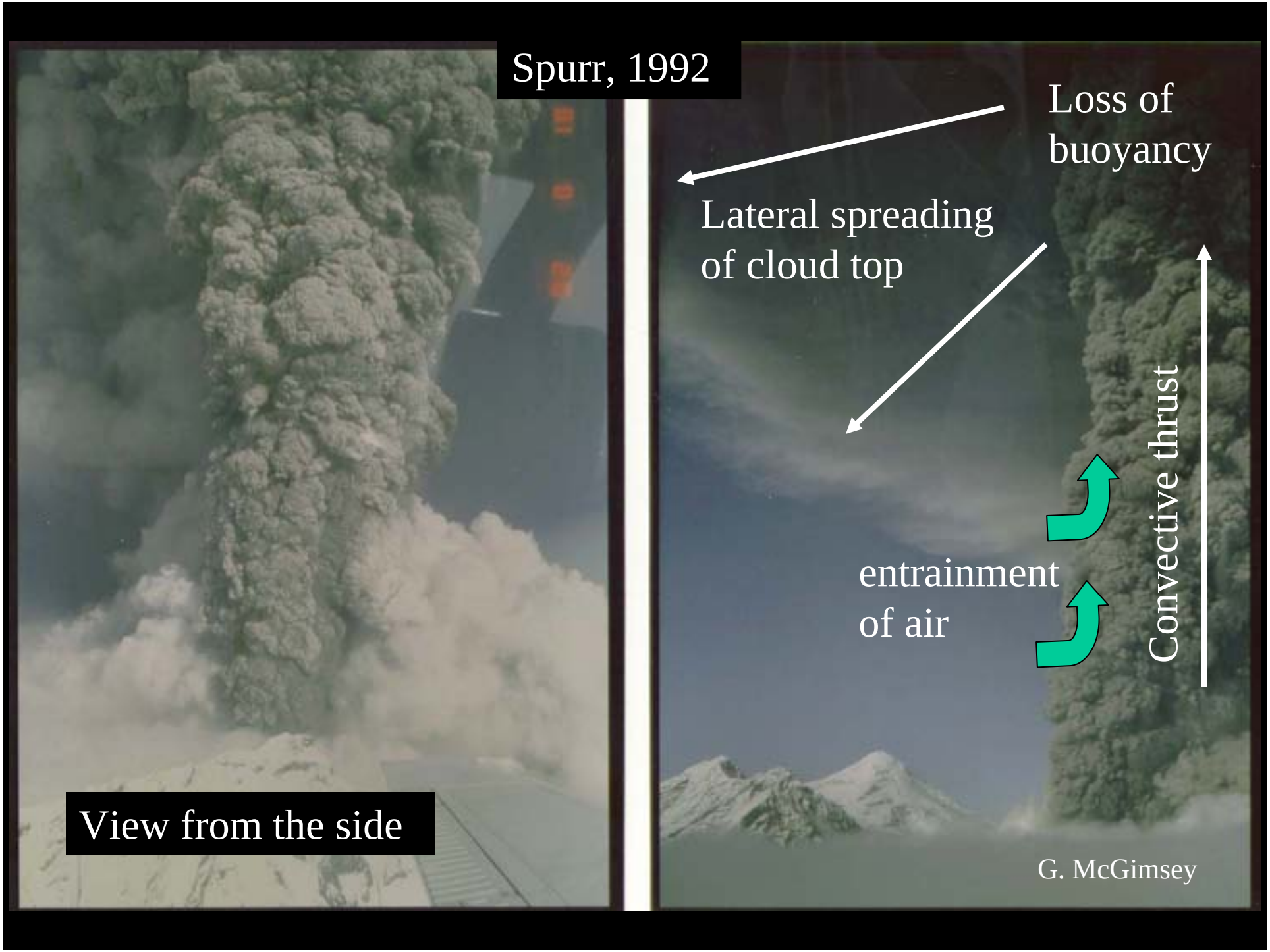
INCREASING EXPLOSIVENESS

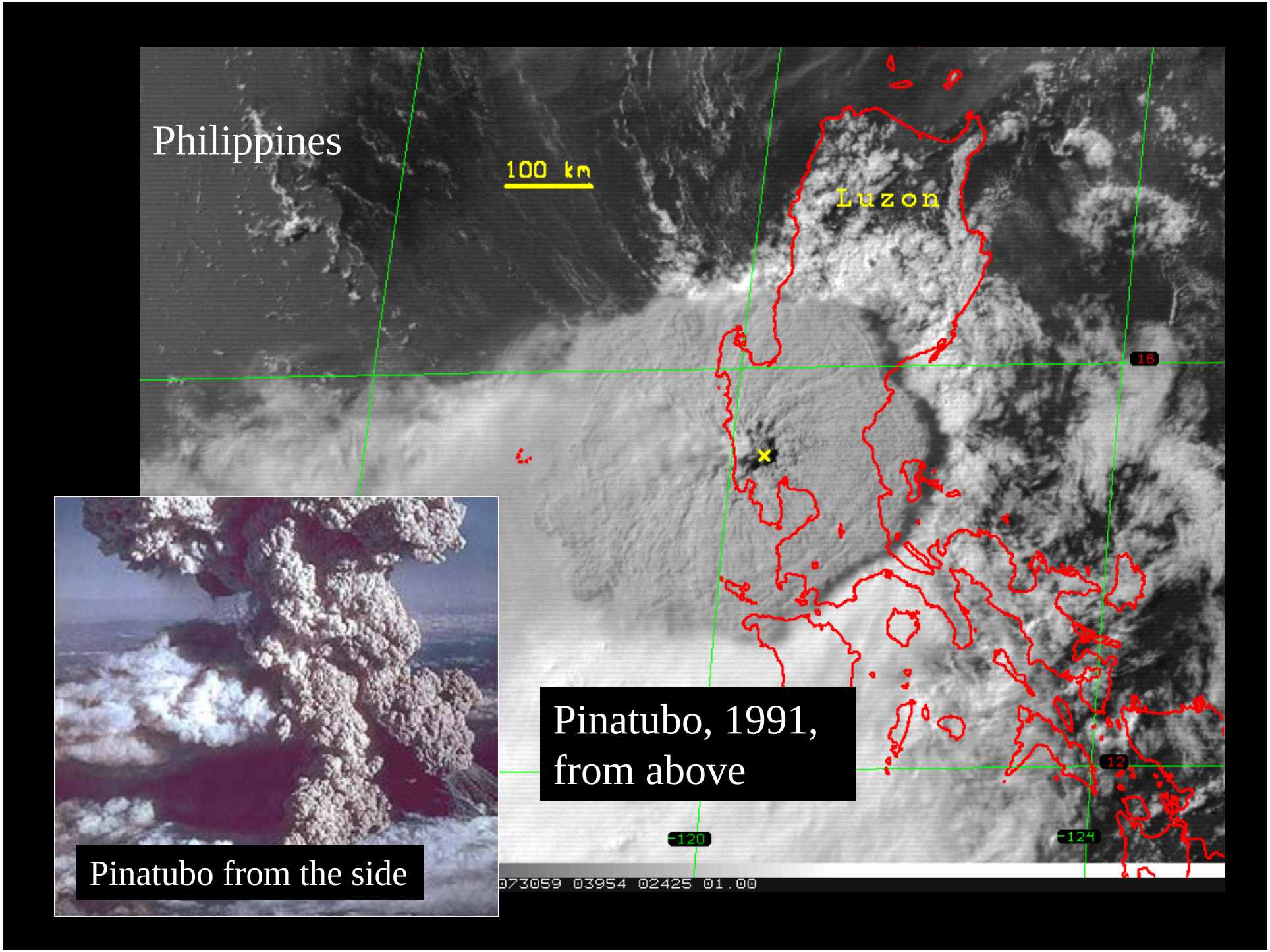


- Ash eruptions



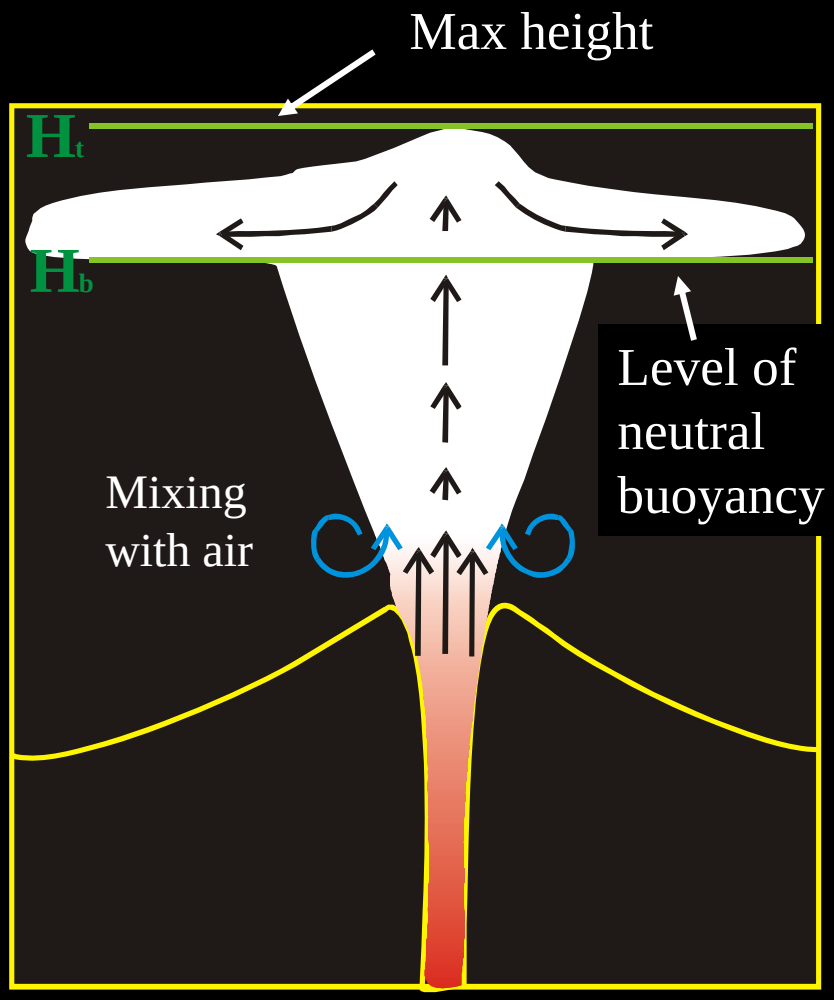
Kliuchevskoi, Kamchatka from Space Shuttle


Spurr, 1992
Loss of buoyancy
Lateral spreading of cloud top
entrainment of air
Convective thrust
View from the side
G. McGimsey


Philippines
100 km
Luzon
16
12
-120
-124
073059 03954 02425 01.00
Pinatubo, 1991,
from above
Pinatubo from the side

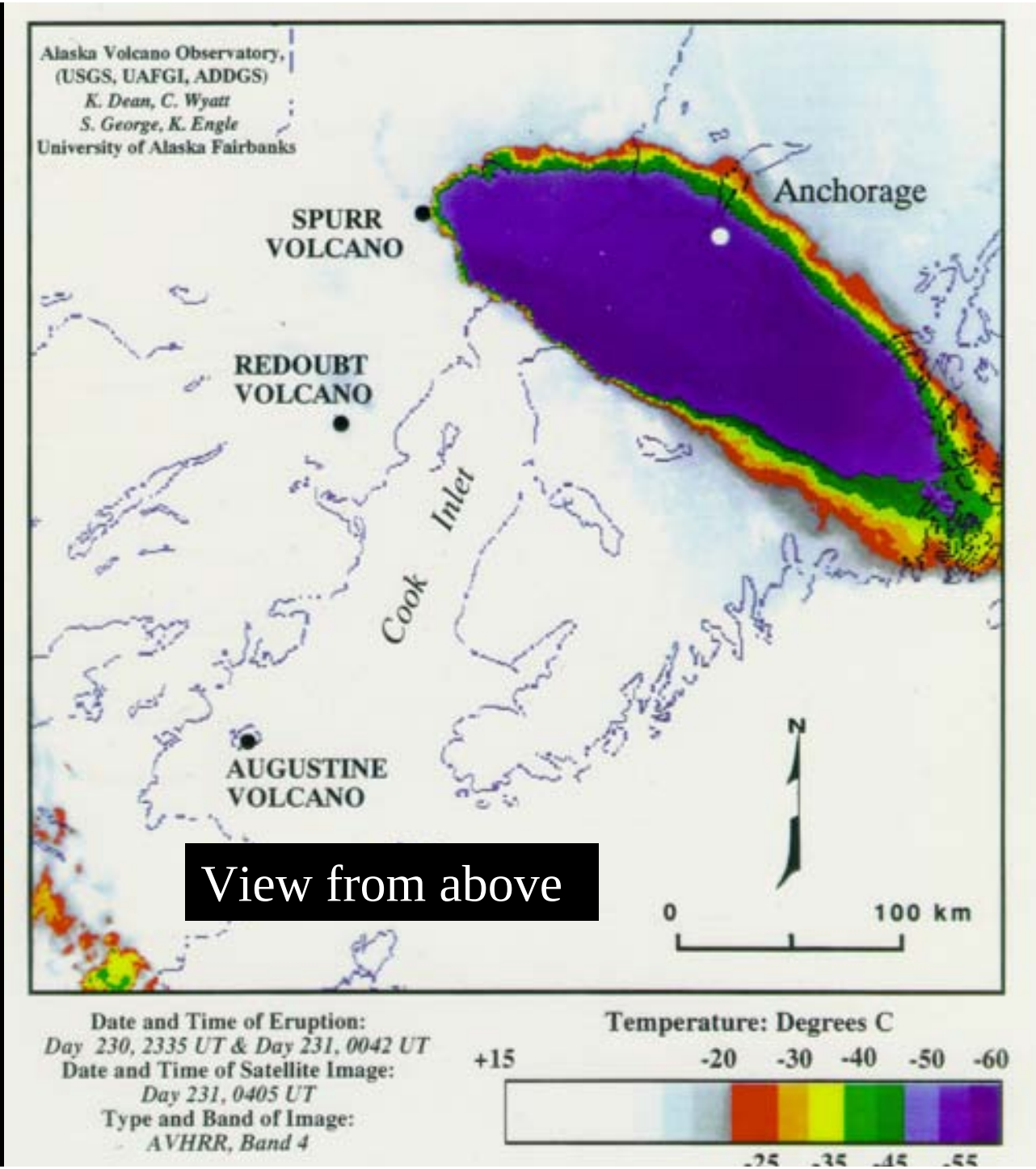
How high do columns get?

- Air mixes with the erupting ash+ steam mixture.
- The air is rapidly heated, causing it to expand and making the column.
- The maximum height depends on rate of heat release (size, velocity, and initial temperature 0f "burner" – like getting a hot-air balloon to fly high).
- Large eruptions send plumes to 100,000 ft (20 miles, 30 km).



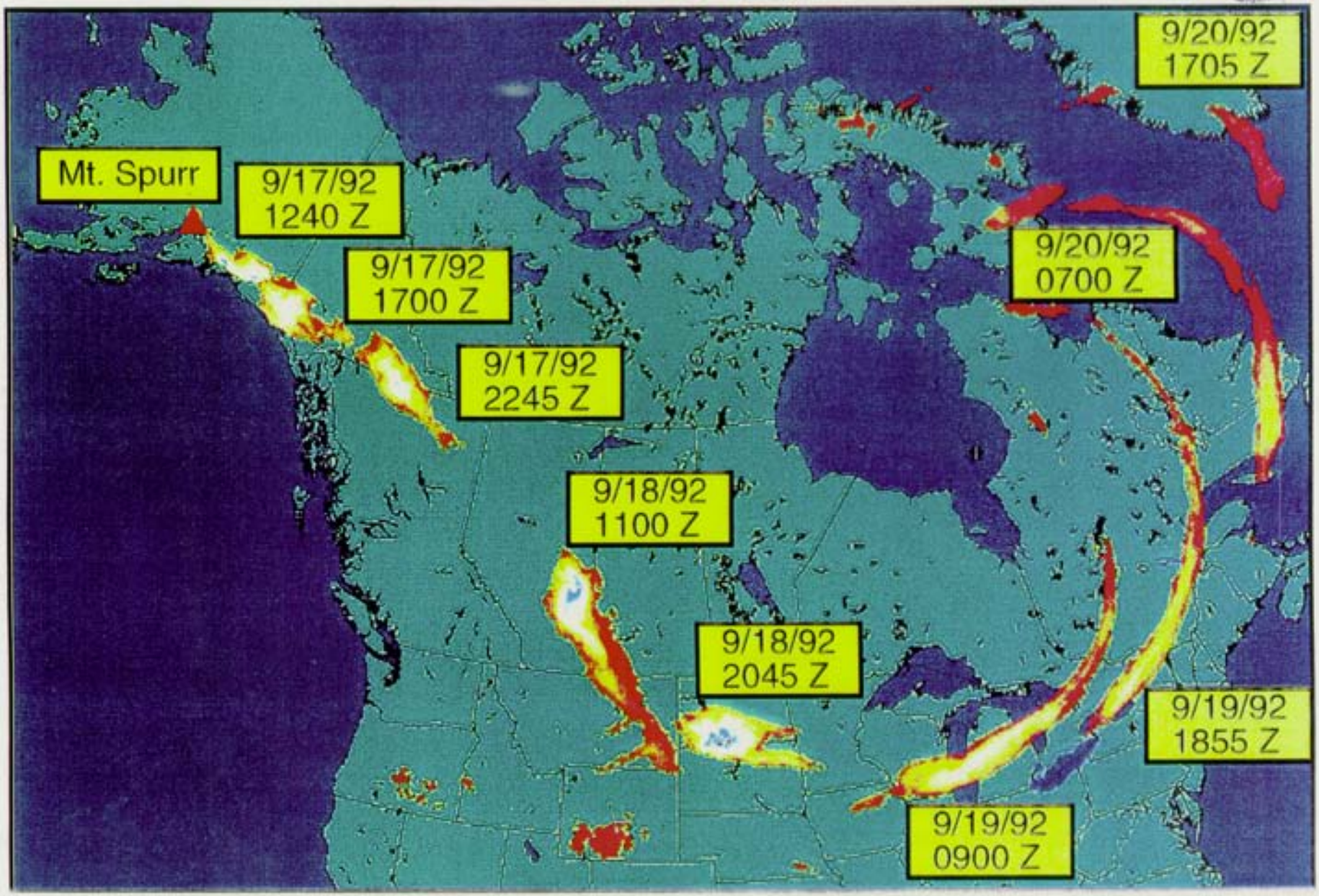
Ben Andrews

Satellite image of Spurr's ash cloud, 4 hours after the start of its eruption on 8/18/92. The cloud shows as a very cold region because it is very high. The eruption has just stopped and the cloud is drifting away from the vent.



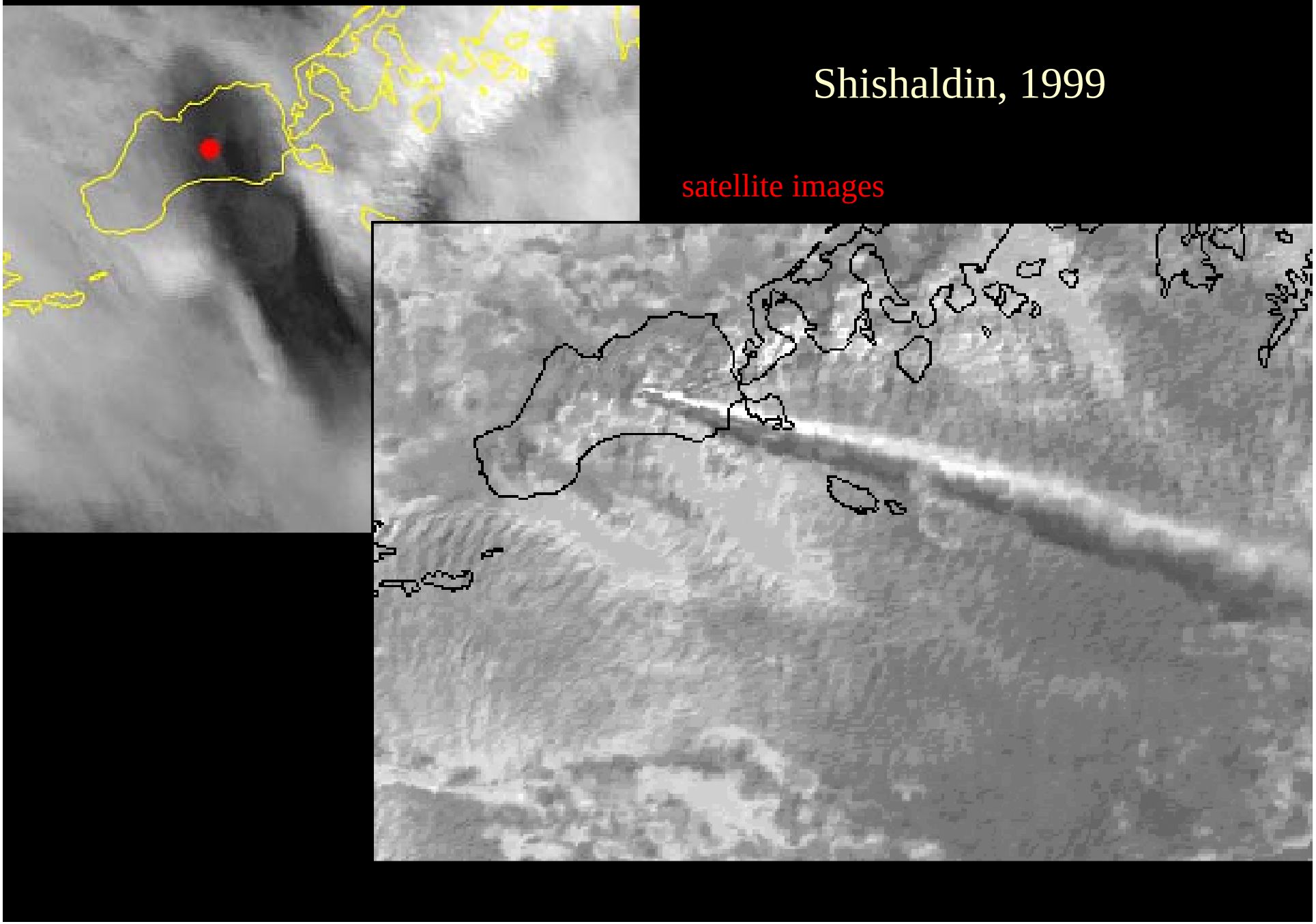
USGS
science for a changing world

Satellite Tracking of Mt. Spurr Volcanic Ash Cloud



Shishaldin, 1999

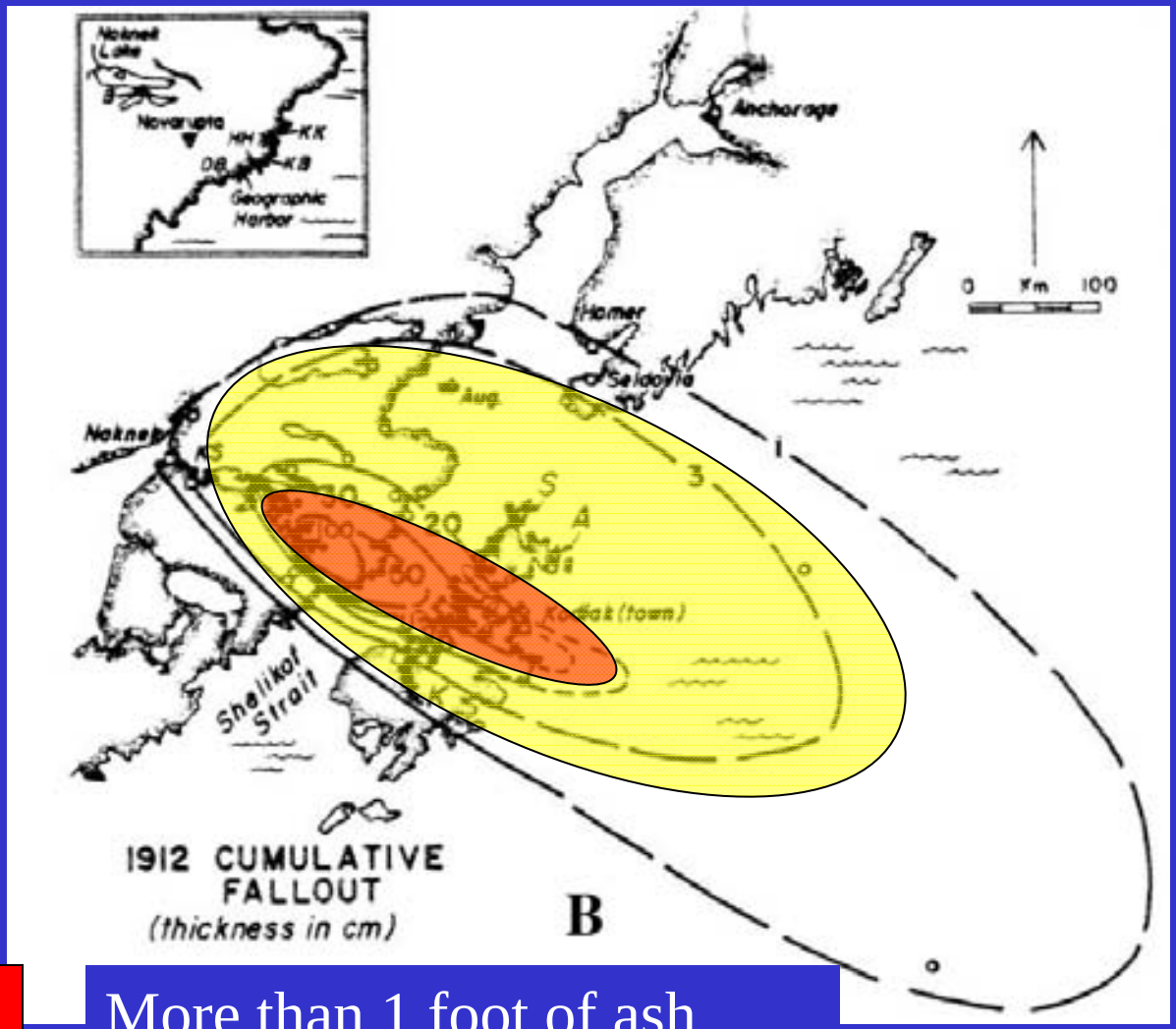
satellite images



Small fragments are called ash.

Kliuchevskoi, Kamchatka

Aniakchak, Alaska



More than 1 foot of ash

More than 1 inch of ash

KODIAK, Summer 1912

Photograph by George C. Martin

ASH-LADEN TREES NEAR KODIAK, AUGUST 26, 1912

The branches bending to the ground made a tent under every tree.

Photograph by W. J. Erskine

ASH PILE FROM A ROOF, KODIAK

It looks very much like snow as it lies on the ground but, being in reality pulverized rock of great weight, it did much damage.

Layers of ash and pumice falls near Usu Volcano, Hokkaido, Japan

ASH ERUPTIONS

- Usually survivable, except in large eruptions and special circumstances.
- Ash clouds can cause in-flight engine failure, interference with avionics, abrasion of aircraft, even hundreds of kilometers from the volcano.
- Ash falls blanket the ground uniformly like snow, with decreasing thickness and particle size with distance from vent.

Near the volcano:

- Building collapse (large events).

Far from volcano:

- Interference with power generation and transmission.
- Contamination of water supply.
- Damage to machinery and computers.
- Respiratory problems.
- Damage to agriculture.
- Along with associated pyroclastic flows, ash fall from Chichon Volcano, Mexico, killed 2000 people in 1982.

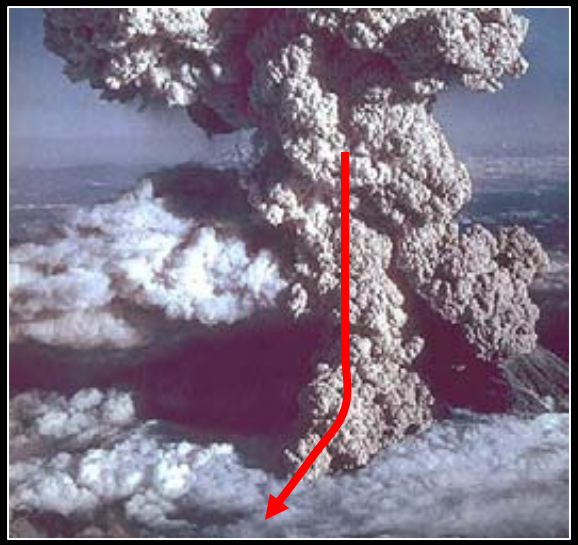
Globally:

- Very large eruptions cause a few years of climate cooling, with potential for famines.

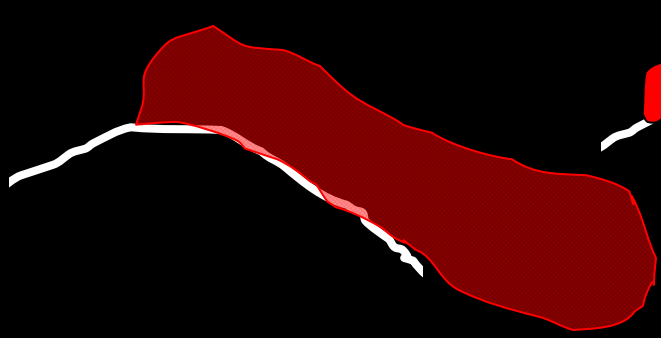
- Pyroclastic flows

Origin of pyroclastic flows

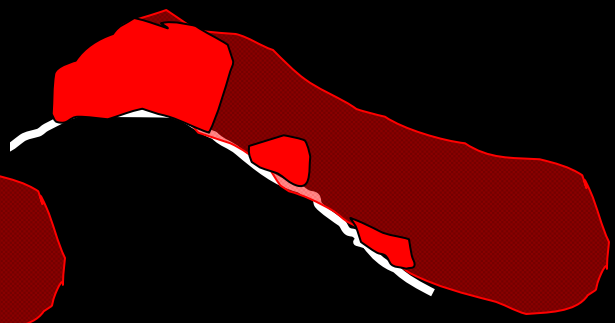
Column collapse



Lack of column



Dome collapse



PYROCLASTIC FLOWS

Like lava:

- Heat is retained
- Follow valleys

Unlike lava:

- Move fast
- Fragmental

Like ash falls

- Fragmental

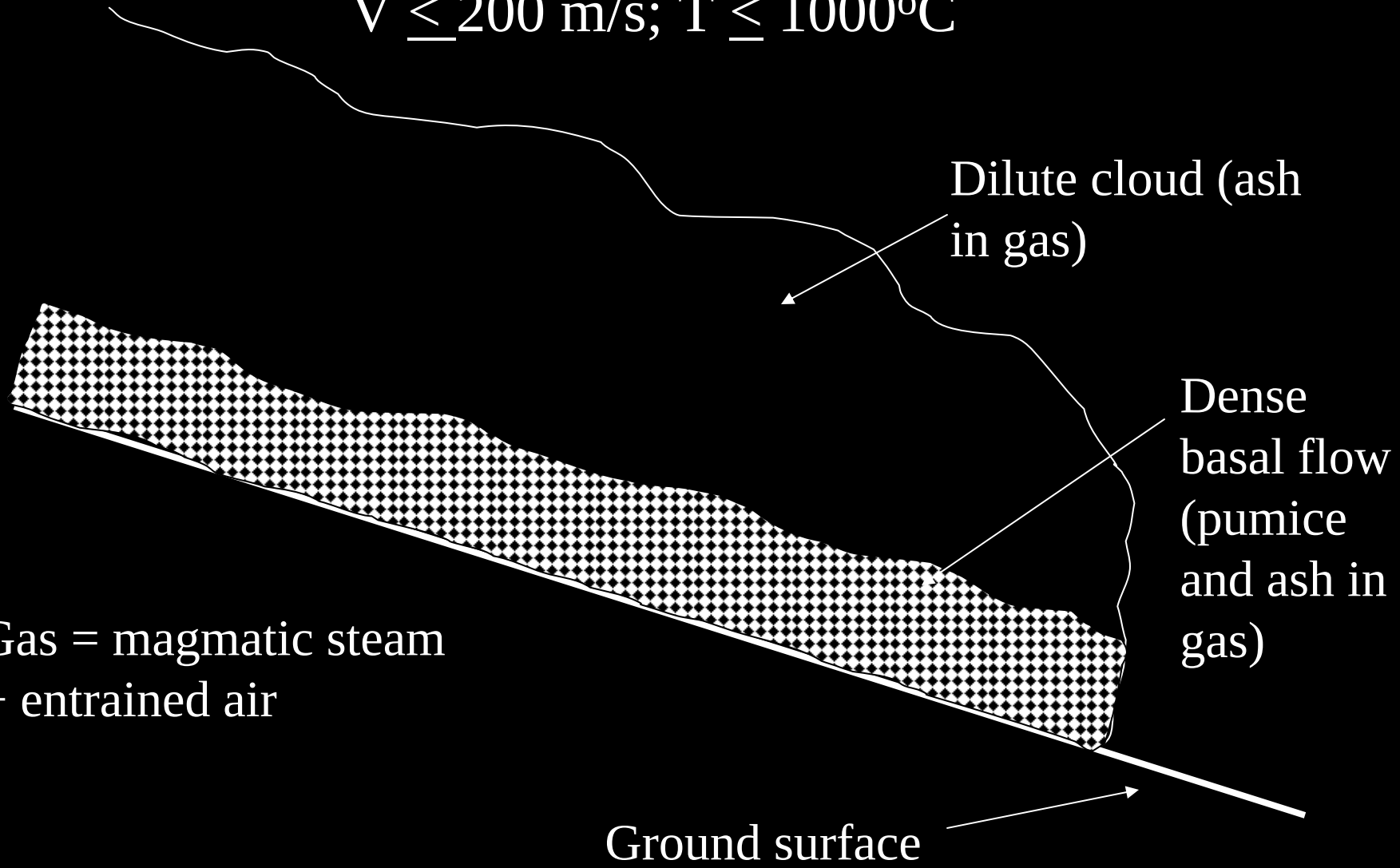
Unlike ash falls

- Heat is retained
- Follow valleys
- Unsorted

Pyroclastic flow sweeps down into the outskirts of Shimabara

Pyroclastic flows:

$V \leq 200$ m/s; $T \leq 1000^{o}C$



Pyroclastic flow overlying ash and pumice falls, Shikotsu Caldera, Hokkaido, Japan

Contact between flow (above) and fall (below) deposits.

ASH FALL DEPOSIT

The tree was buried upright in falling pumice. Its outer portion was charred. Coins are about the size of a US quarter.

Tops of the trees, which stood above the ash fall deposit, were knocked over by later pyroclastic flows. The downed trees point away from the vent, in this case a few tens of kilometers away.

WELDING:

Compaction of the hot deposit following emplacement.

non-welded

welded

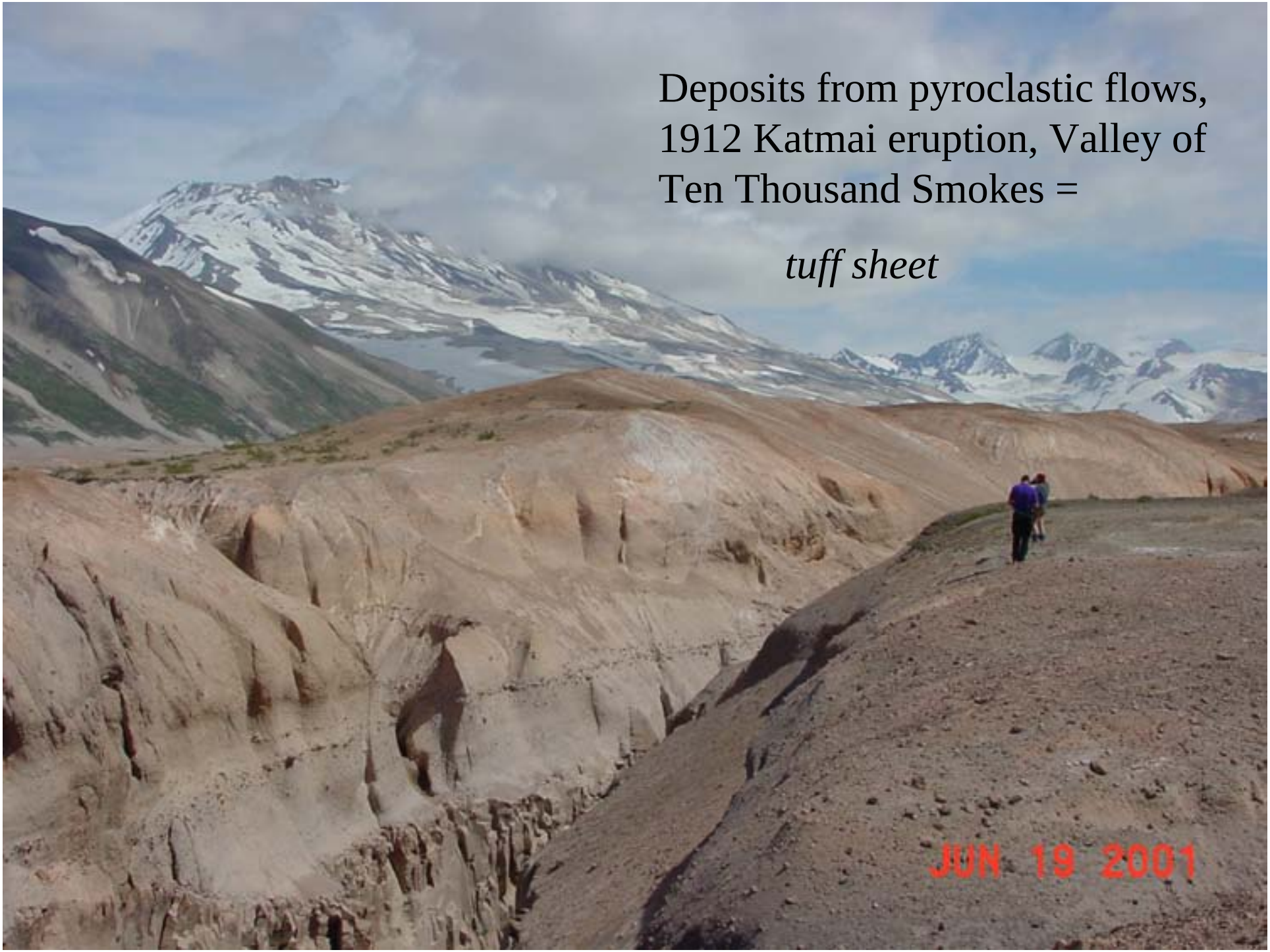

Montserrat, BWI

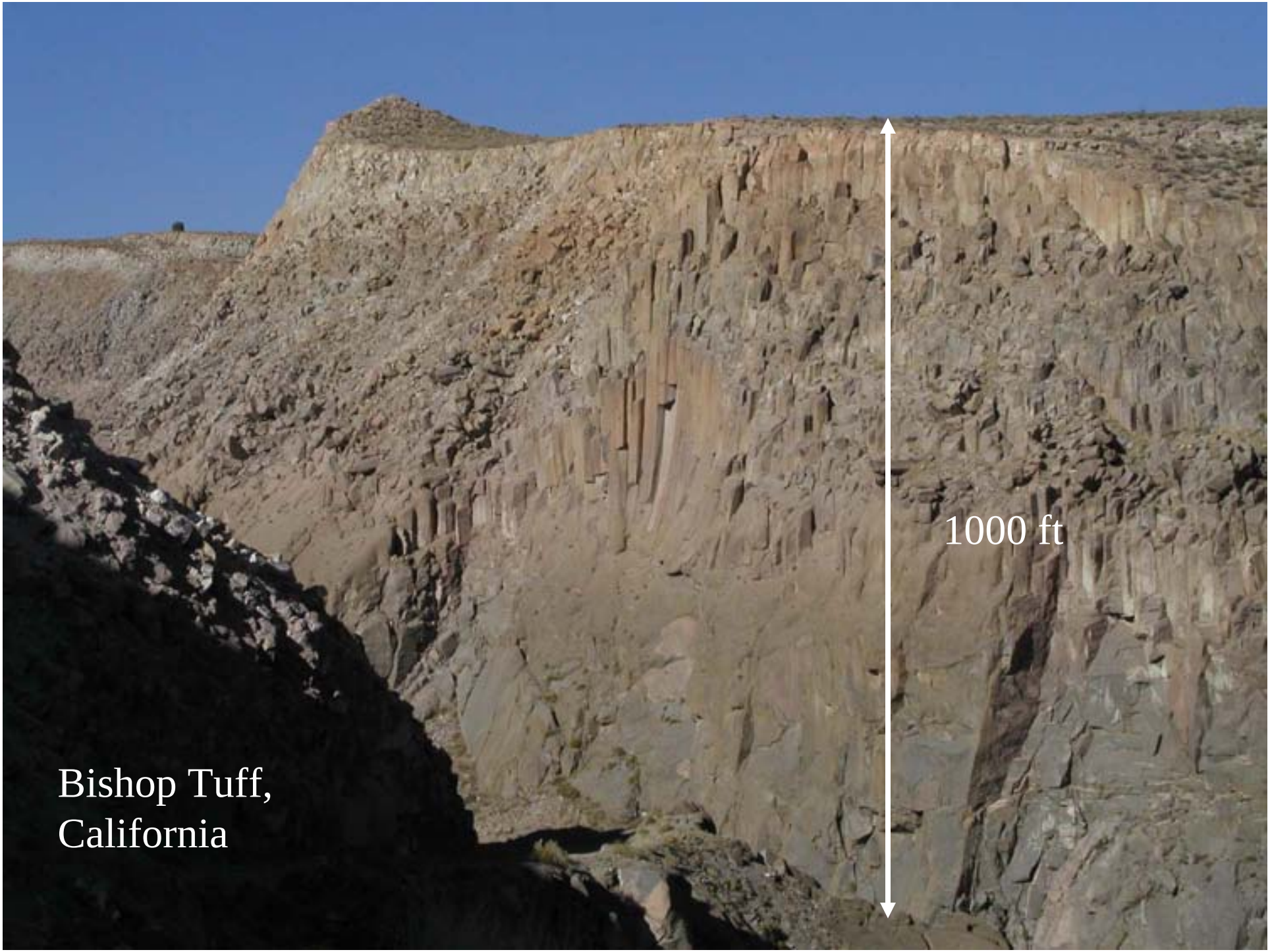
A thick pyroclastic flow deposit, Aniakchak Caldera, Alaska

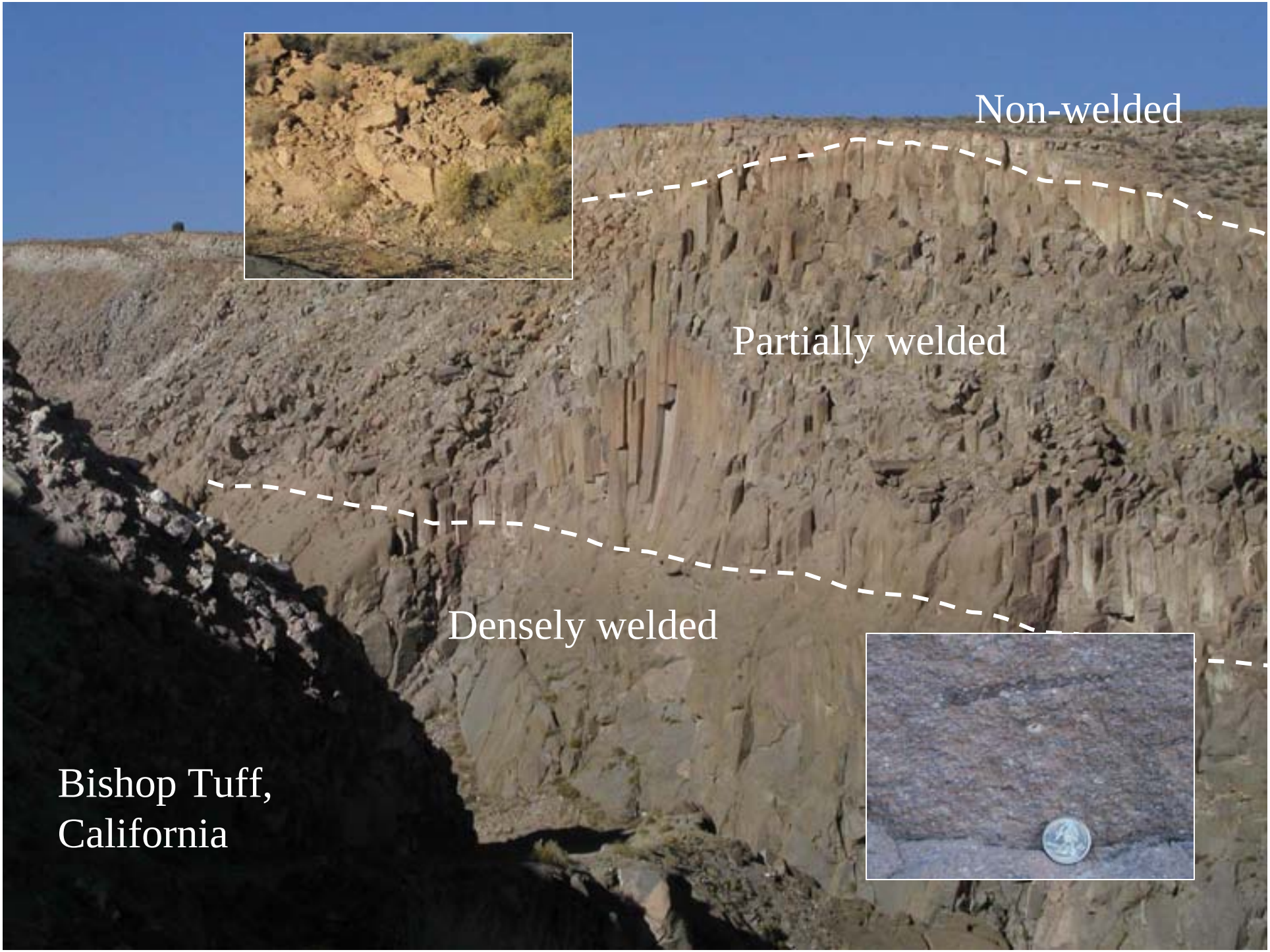
Pyroclastic flow deposit - mixture of pumice and ash, Aniakchak

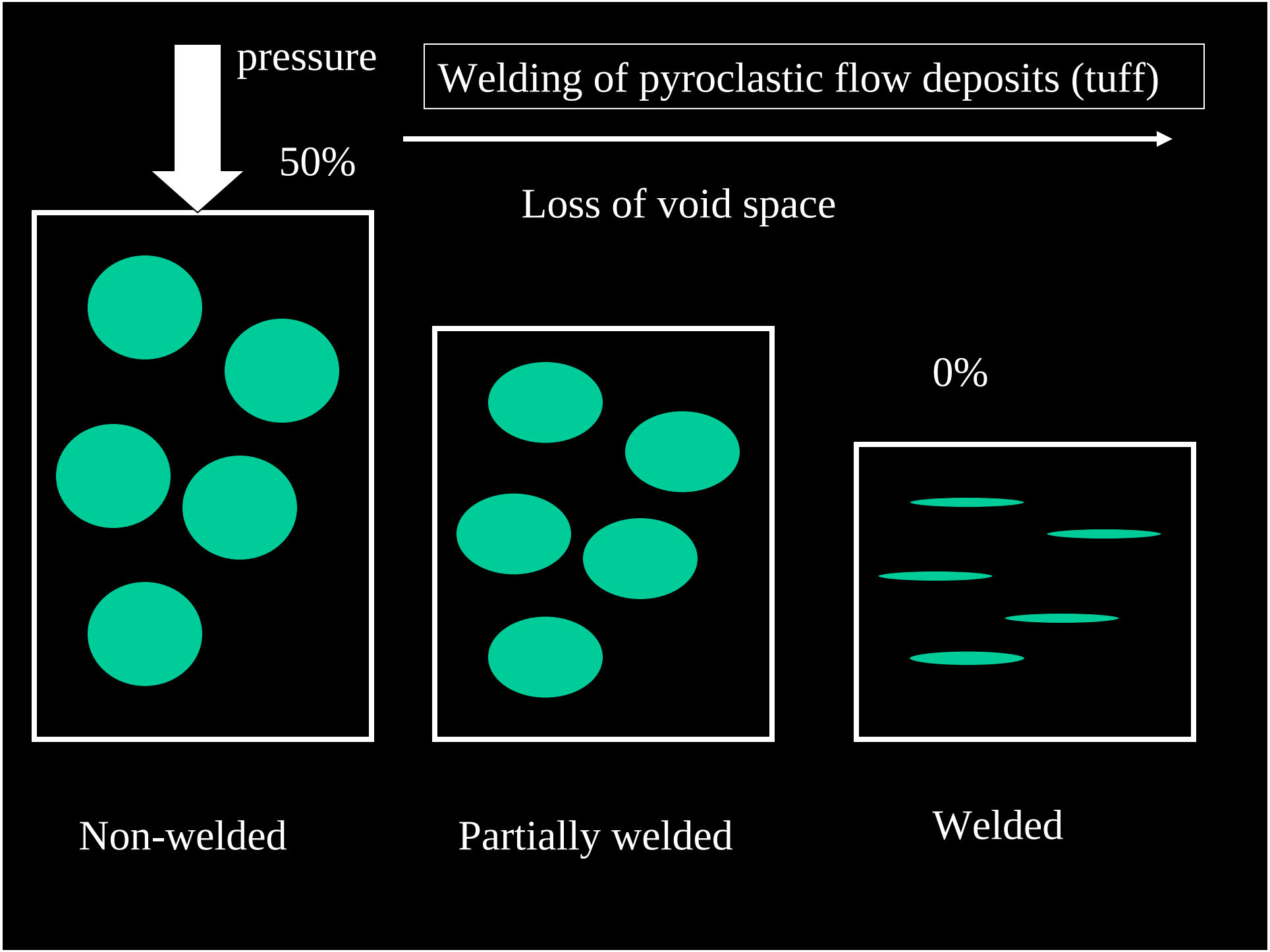

JUN 19 2001
Tuff sheet

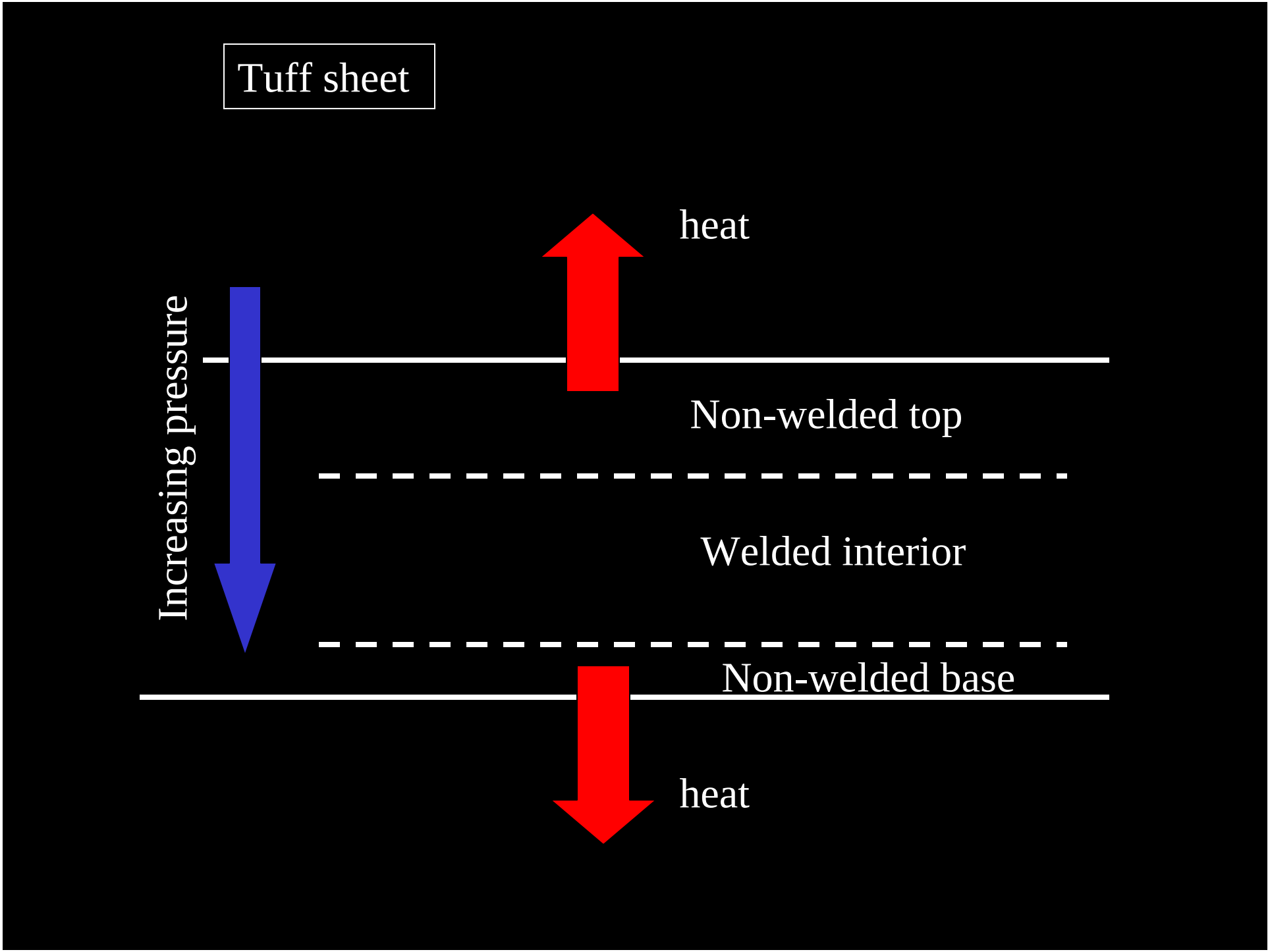
Pyroclastic flow deposit, Shikotsu Caldera, Japan


Deposits from pyroclastic flows, 1912 Katmai eruption, Valley of Ten Thousand Smokes =
tuff sheet
JUN 19 2001


1000 ft
Bishop Tuff,
California

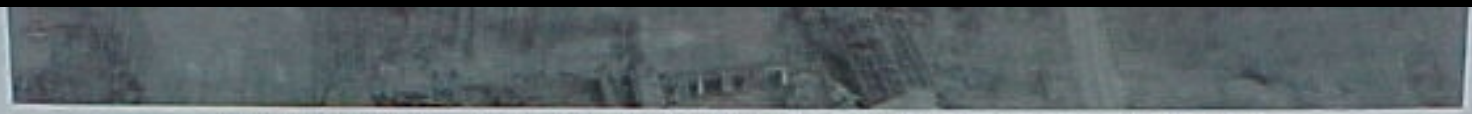

Non-welded
Partially welded
Densely welded
Bishop Tuff,
California


pressure
Welding of pyroclastic flow deposits (tuff)
50%
Loss of void space
0%
Non-welded
Partially welded
Welded


Tuff sheet
heat
Increasing pressure
Non-welded top
Welded interior
Non-welded base
heat


Unzen Volcano, Japan

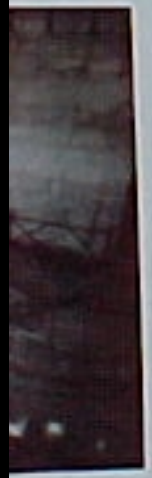
Elementary school hit by edge of pyroclastic flow



焼失後の学校（平成3年9月18日）　提供 ㈱ナガサキフォトサービス

平成3年9月15日大火砕流（役場屋上）

1年生教室（全焼）



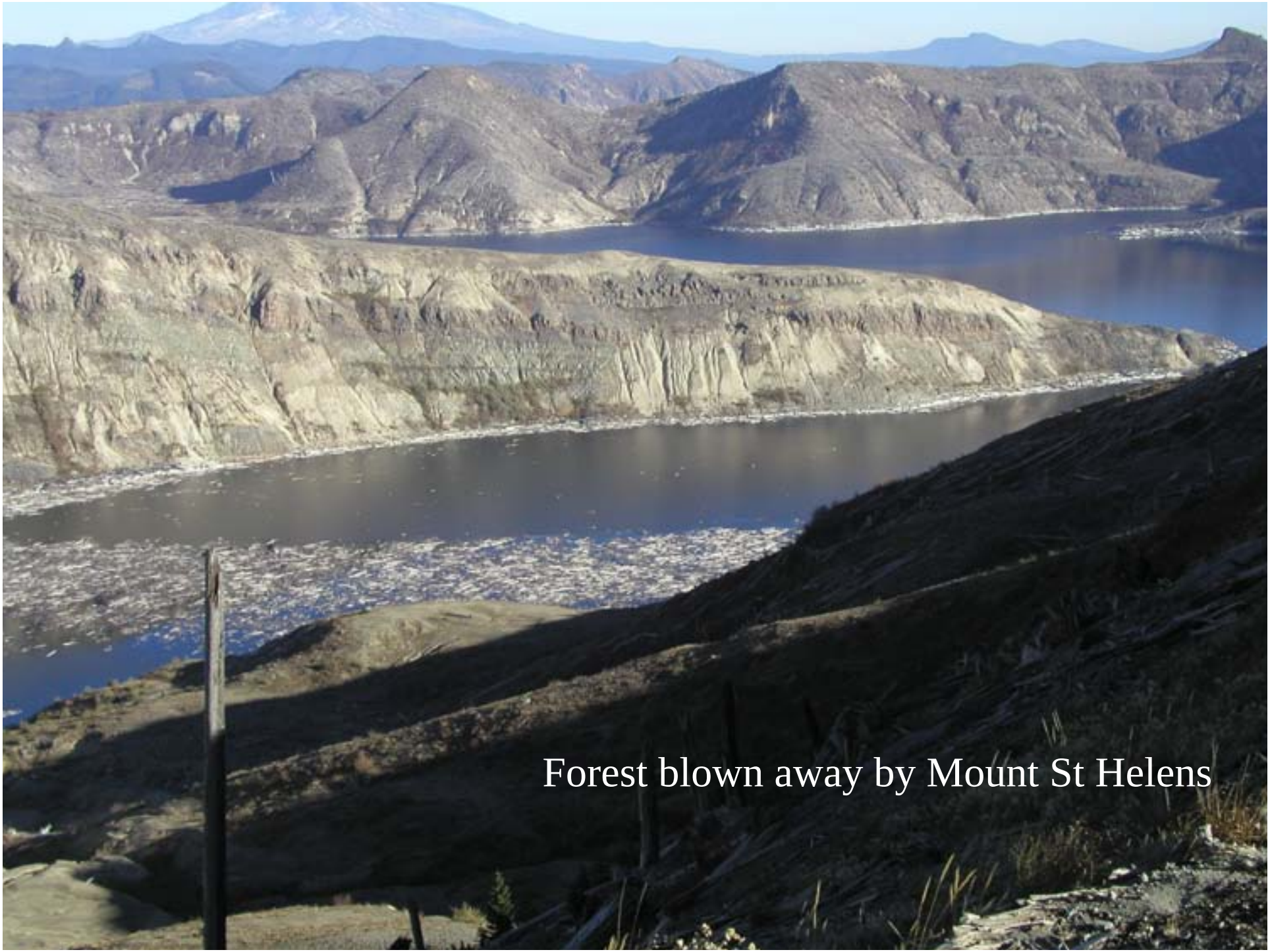
家庭科室（流しコンロ）

2年生教室（部分焼）

Antiquarium - Cast of a watchdog from the House of Orpheus.

Antiquarium - Cast of a mule-driver.

from pyroclastic flows that buried Pompeii



Forest blown away by Mount St Helens

http://www.montserratvolcanoobservatory.info/index.php?option=com_content&view=category&layout=blog&id=130&lang=en

El Chichon, 1982

St Pierre 1902

30,000 dead

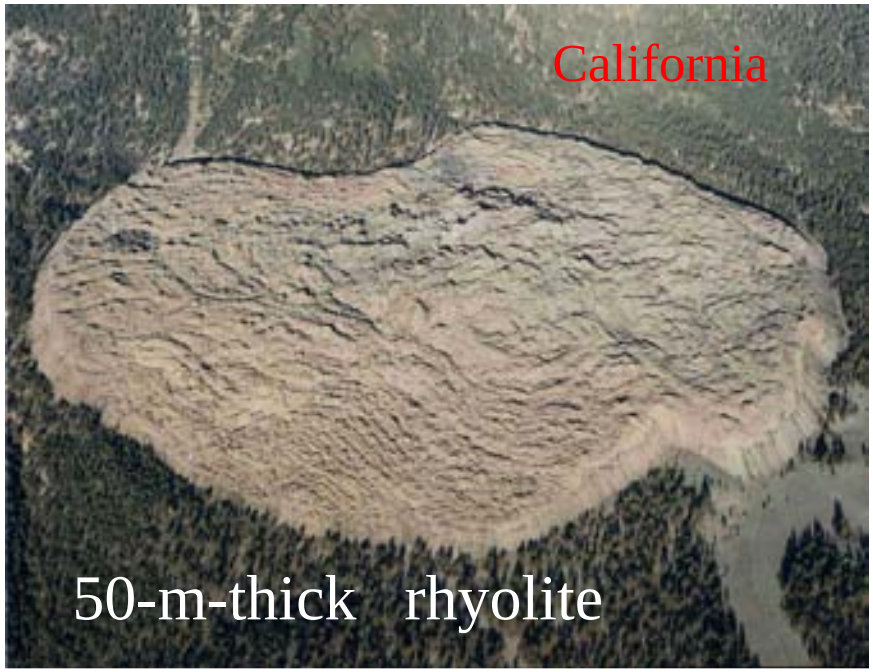
Pyroclastic flows

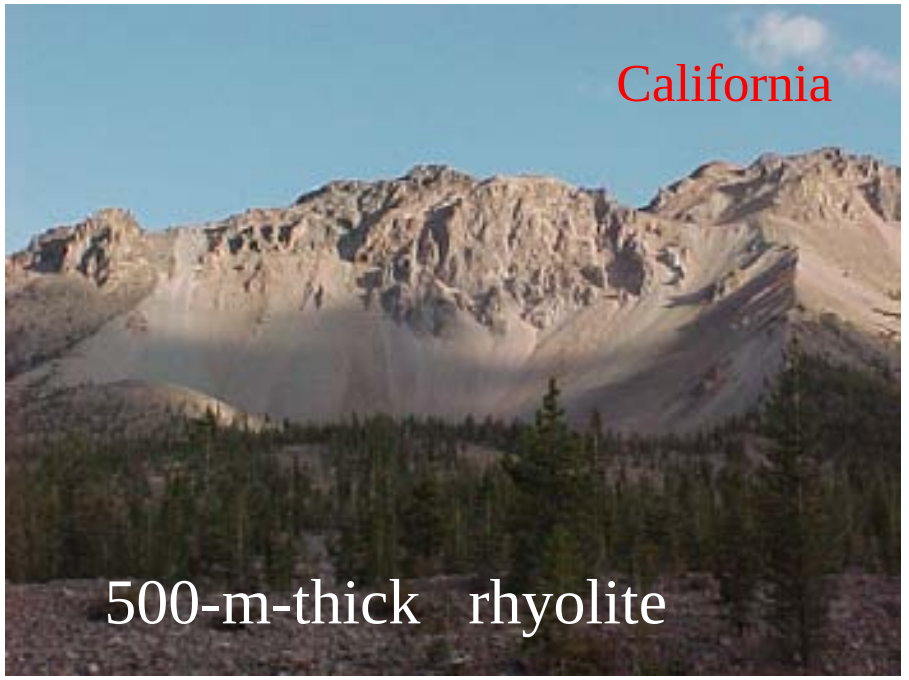
- Cause complete or nearly complete destruction and death.
- High speed and high temperature – impossible to escape.
- Generally keep to valley floors.
- Can travel 20 – 30 km from volcano.
- Responsible for deaths on Pompeii (79 AD) and St Pierre, Martinique (30,000 people, 1902).

- Lava flows


Hawaii
0.5-m-thick basalt

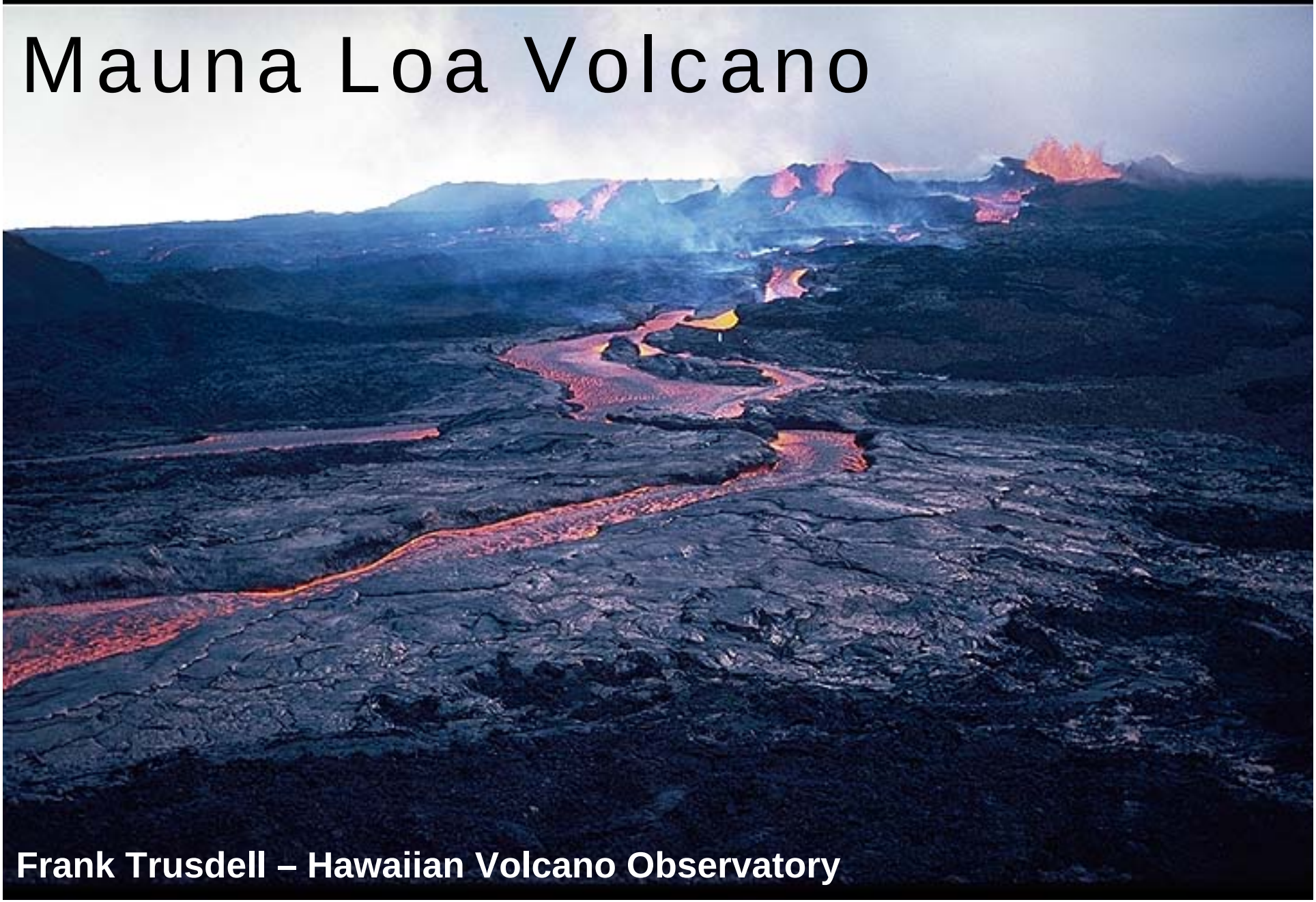

Kamchatka
5-m-thick andesite


California
50-m-thick rhyolite


California
500-m-thick rhyolite

Assessing Lava Flow Hazards of

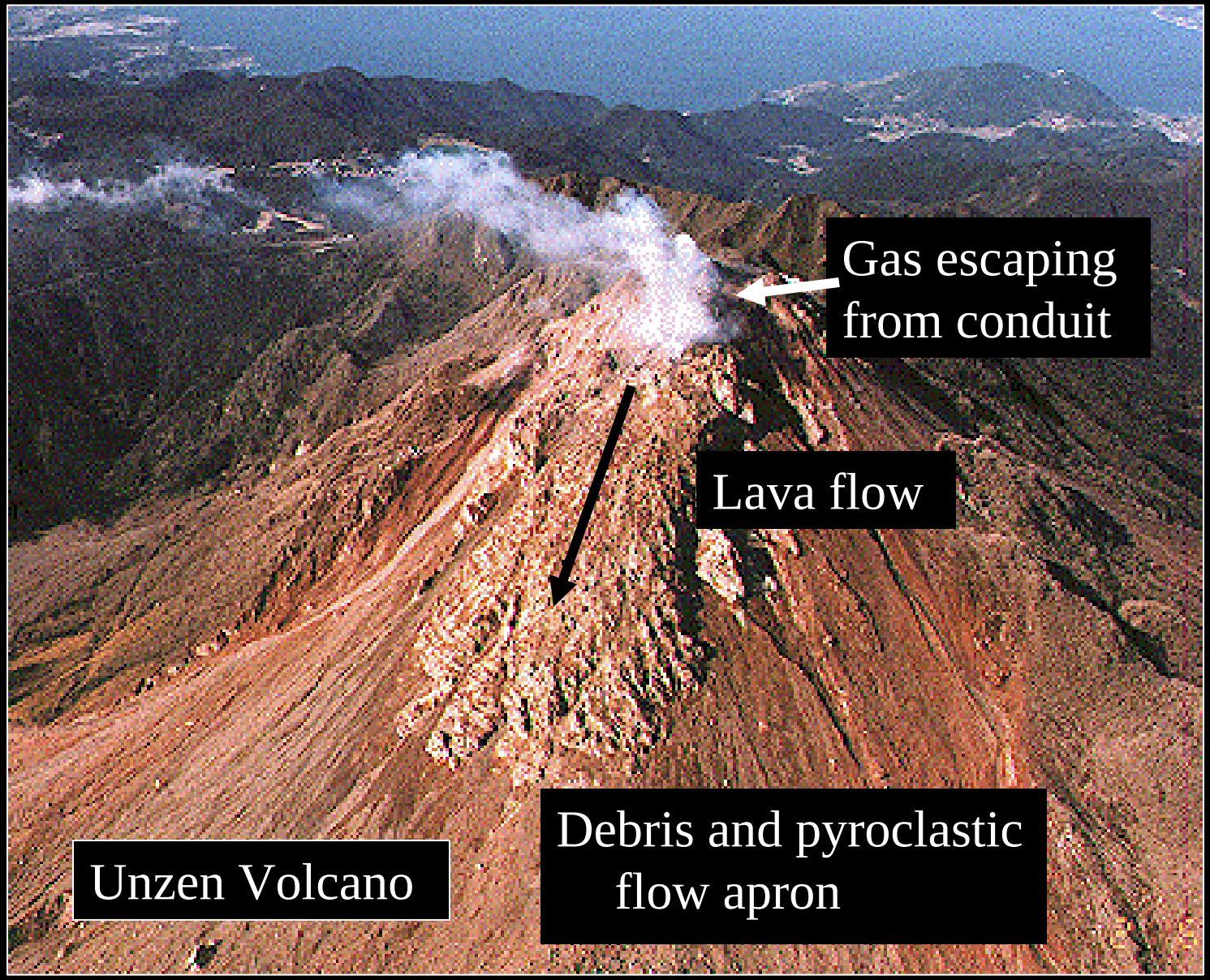
Mauna Loa Volcano



Frank Trusdell – Hawaiian Volcano Observatory

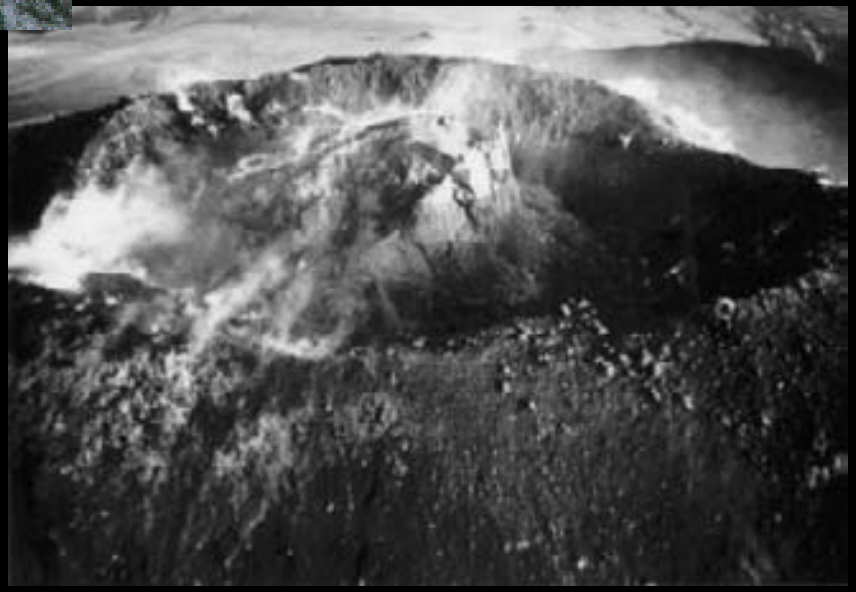

HVO
FEDERAL EMERGENCY MANAGEMENT AGENCY
USGS
science for a changing world
COUNTY OF HAWAII
STATE OF HAWAII


Unzen Volcano, Japan


Gas escaping from conduit
Lava flow
Debris and pyroclastic flow apron
Unzen Volcano

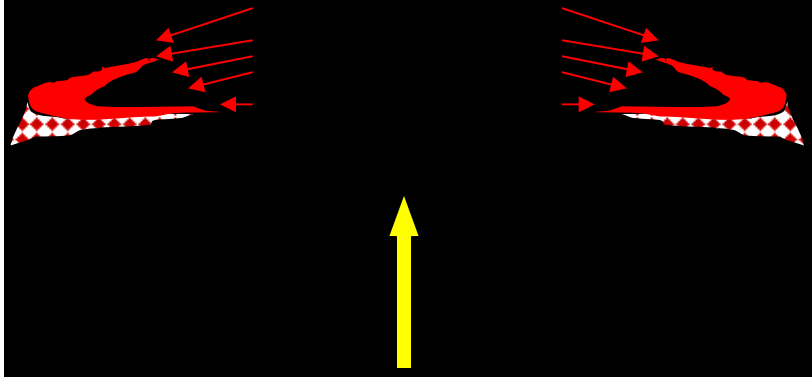
Unzen Dome, 5/91

Trident Dome, c. 1970
(later destroyed)



Katmai

Chaiten


low flux


July 1, 2006
USGS


August 2, 2006
USGS