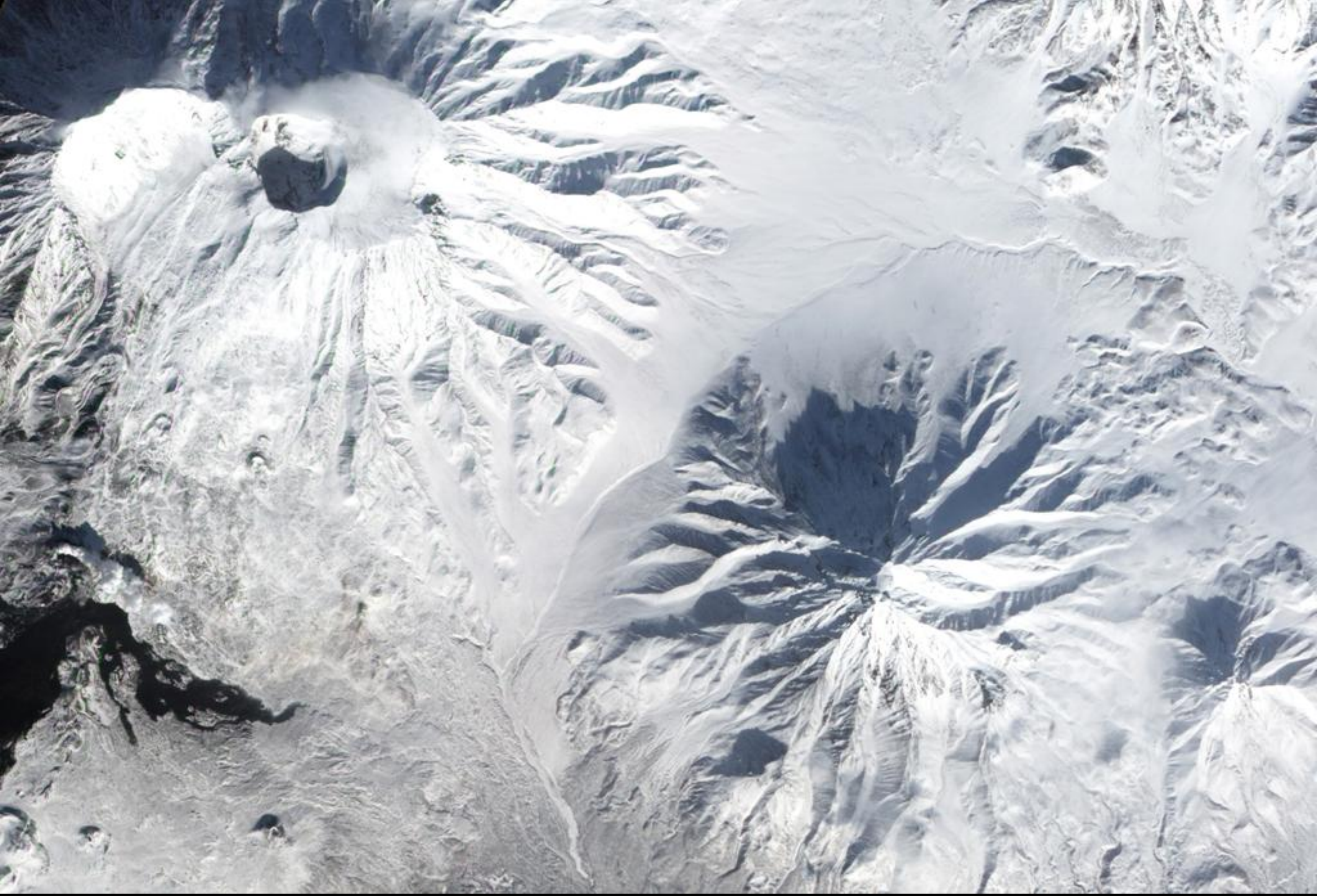
EARTH 270 – DISASTERS AND NATURAL HAZARDS (v. 2018)

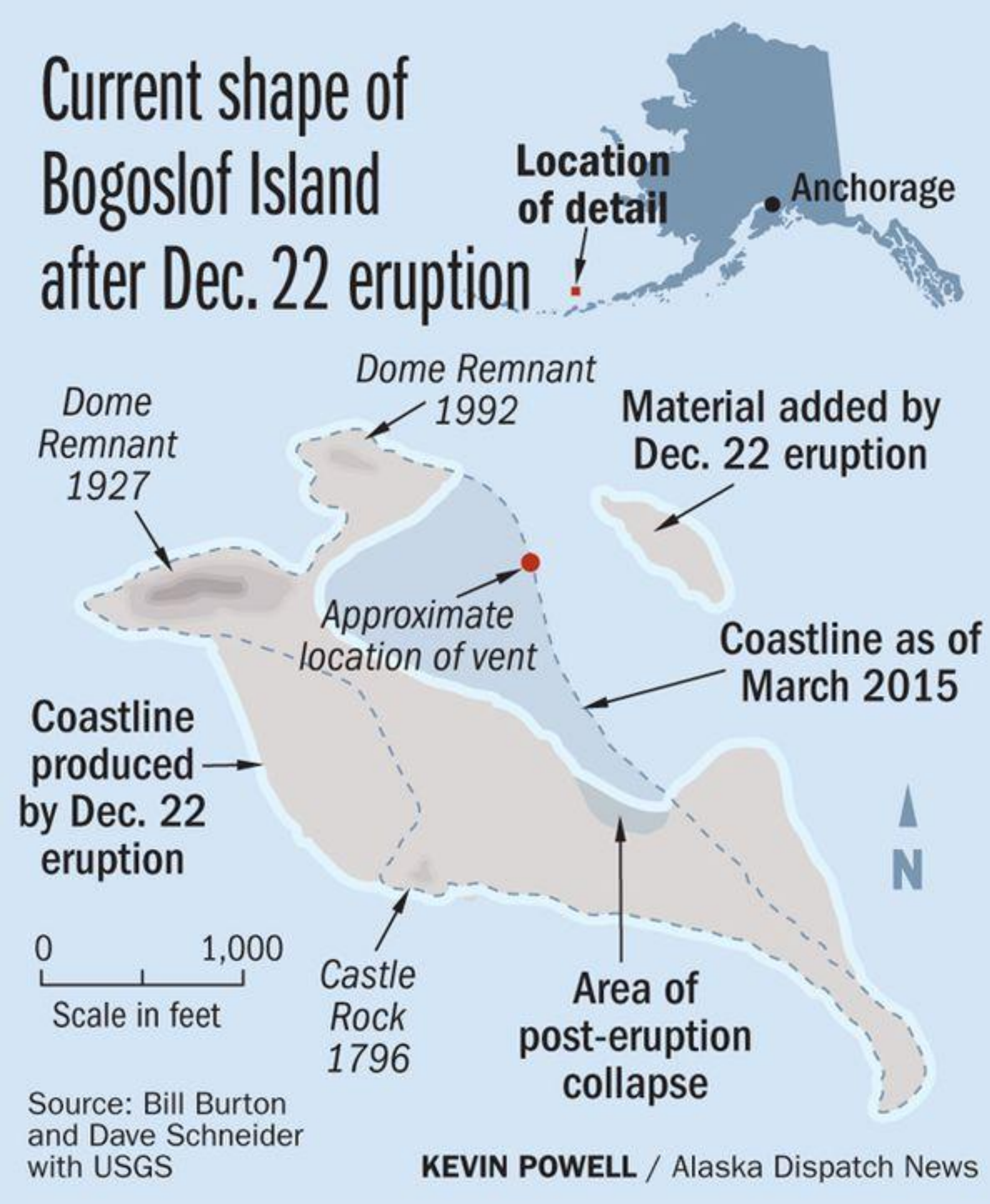
Kensennuma City, Miyagi Prefecture , Japan, March 2011

PROFESSOR S.G. EVANS, PhD, PEng (Room 303, Earth Science and Chemistry (ESC) Building)

UNIVERSITY OF WATERLOO



VOLCANOES, VULCANISM AND VOLCANIC HAZARDS 1

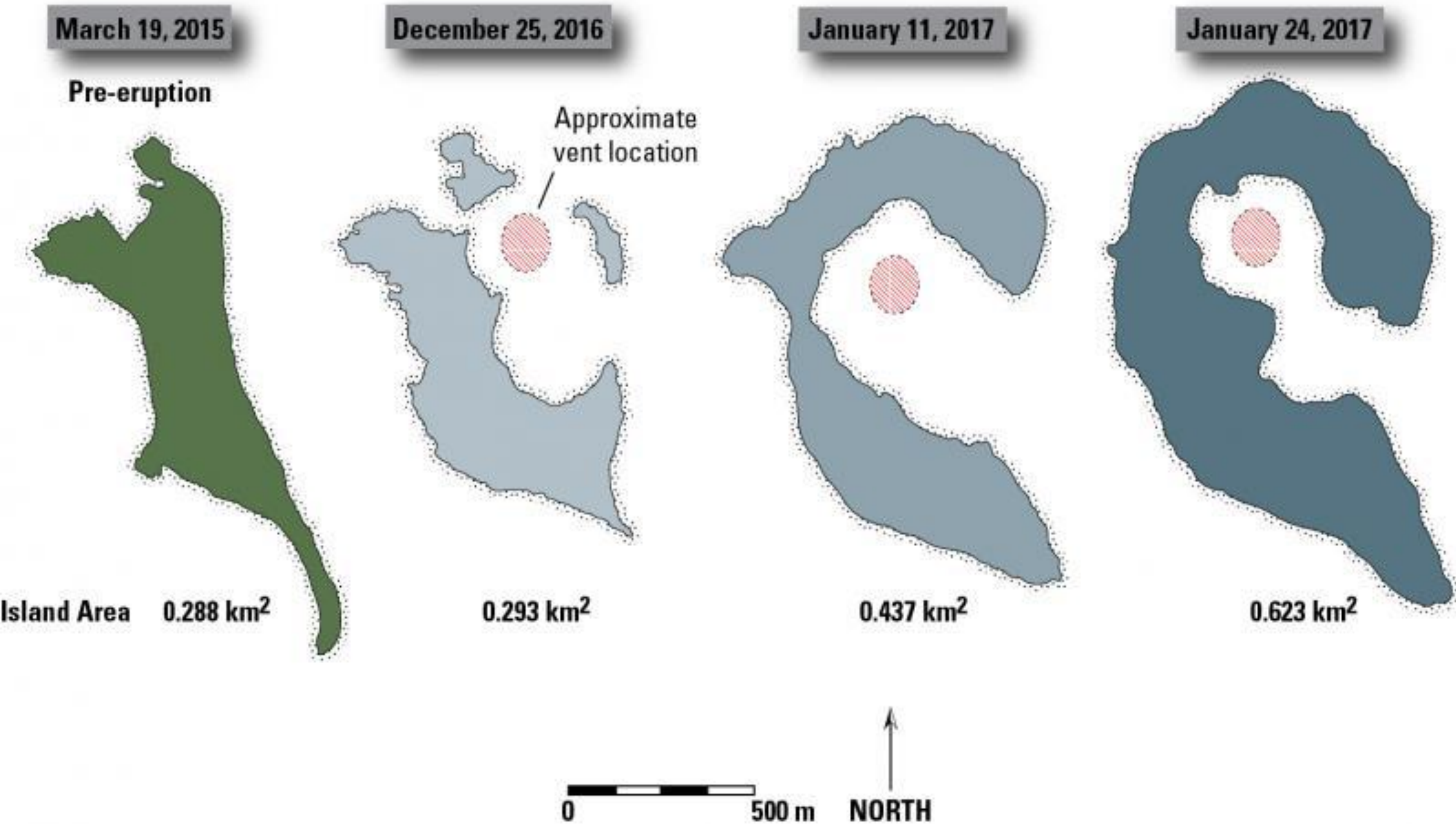


Current shape of Bogoslof Island after Dec. 22 eruption
Location of detail
Anchorage
Dome Remnant 1992
Dome Remnant 1927
Material added by Dec. 22 eruption
Approximate location of vent
Coastline as of March 2015
Coastline produced by Dec. 22 eruption
N
0
1,000
Scale in feet
Castle Rock 1796
Area of post-eruption collapse
Source: Bill Burton and Dave Schneider with USGS
KEVIN POWELL / Alaska Dispatch News

January 10, 2017

Fire Island
1883
Area removed by
submarine explosions
Dec. 2016 - Jan. 2017
1992 lava
1927 lava
Castle Rock
1796-1804
Zone of upwelling
possibly associated with
magmatic degassing and
approximate vent location
~350 m
NORTH
Fine "muddy" ash
and ballistic ejecta
draping surface

Bogoslof Island: Eruption-caused changes in island morphology



Mt. Mayon – Philippines

Mt. Mayon (Philippines) erupting in January 2018

Mt. Mayon (Philippines) erupting in January 2018

Mt. Mayon (Philippines) erupting in January 2018

ERUPTION OF COLIMA VOLCANO, MEXICO (DECEMBER 2016)

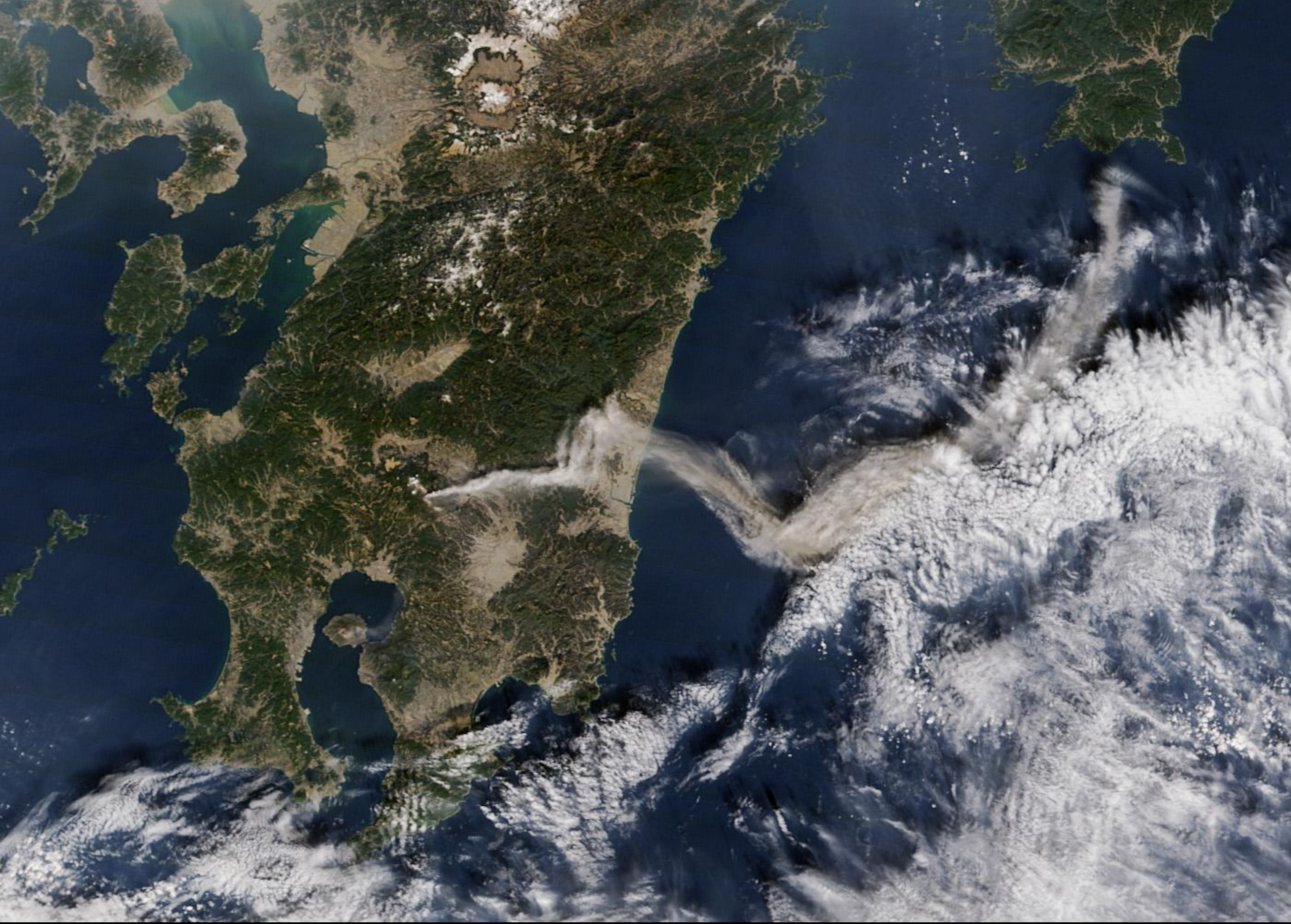
COLIMA VOLCANO (MEXICO) ERUPTING IN APRIL 2016

ERUPTION OF MT. SINABUNG, INDONESIA (NORTH SUMATRA) – MAY, 2016


Mexico City

POPOCATÉPETL ERUPTING ON MARCH 7, 2013

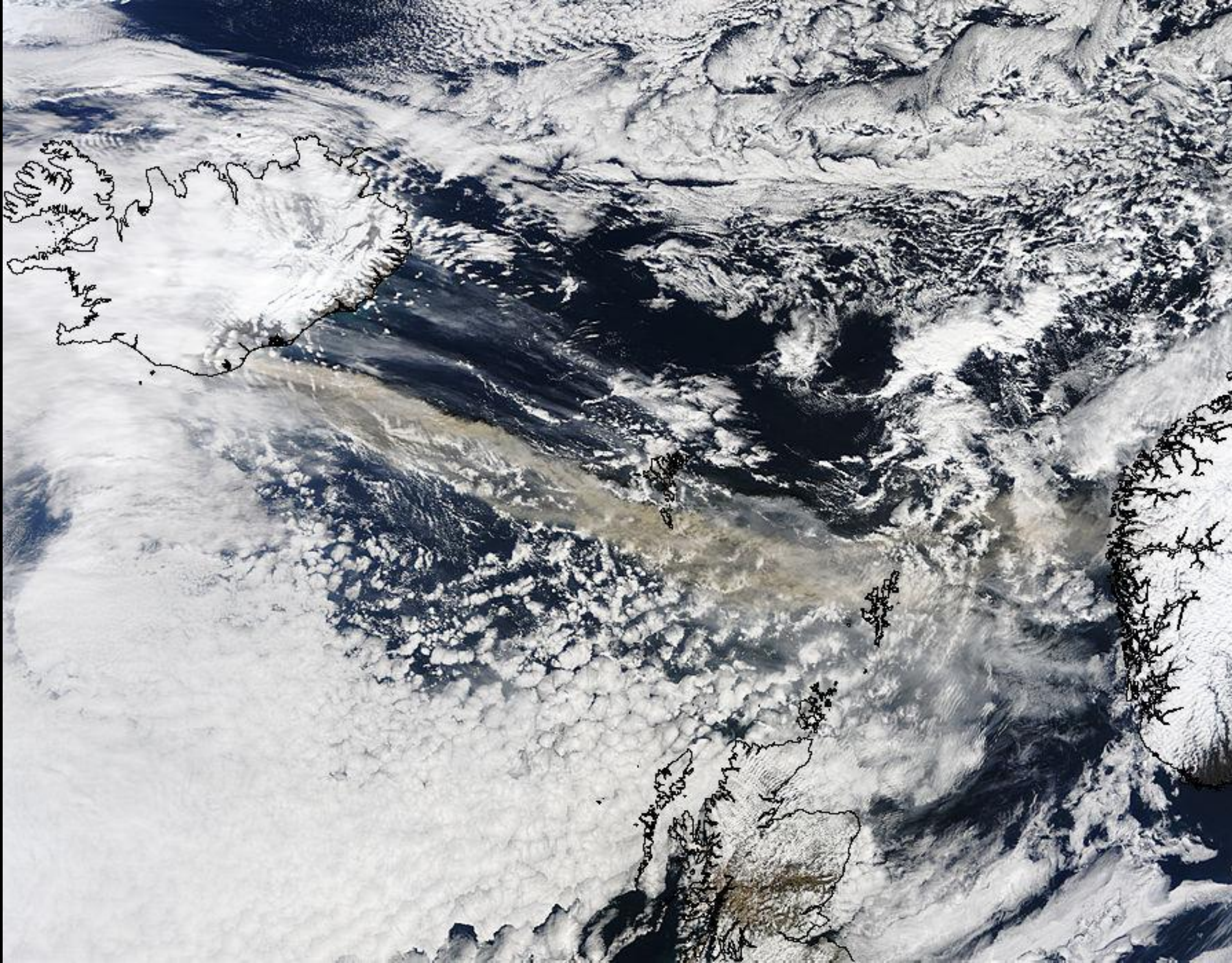
Japan’s Shinmoedake erupting Jan 27 2011



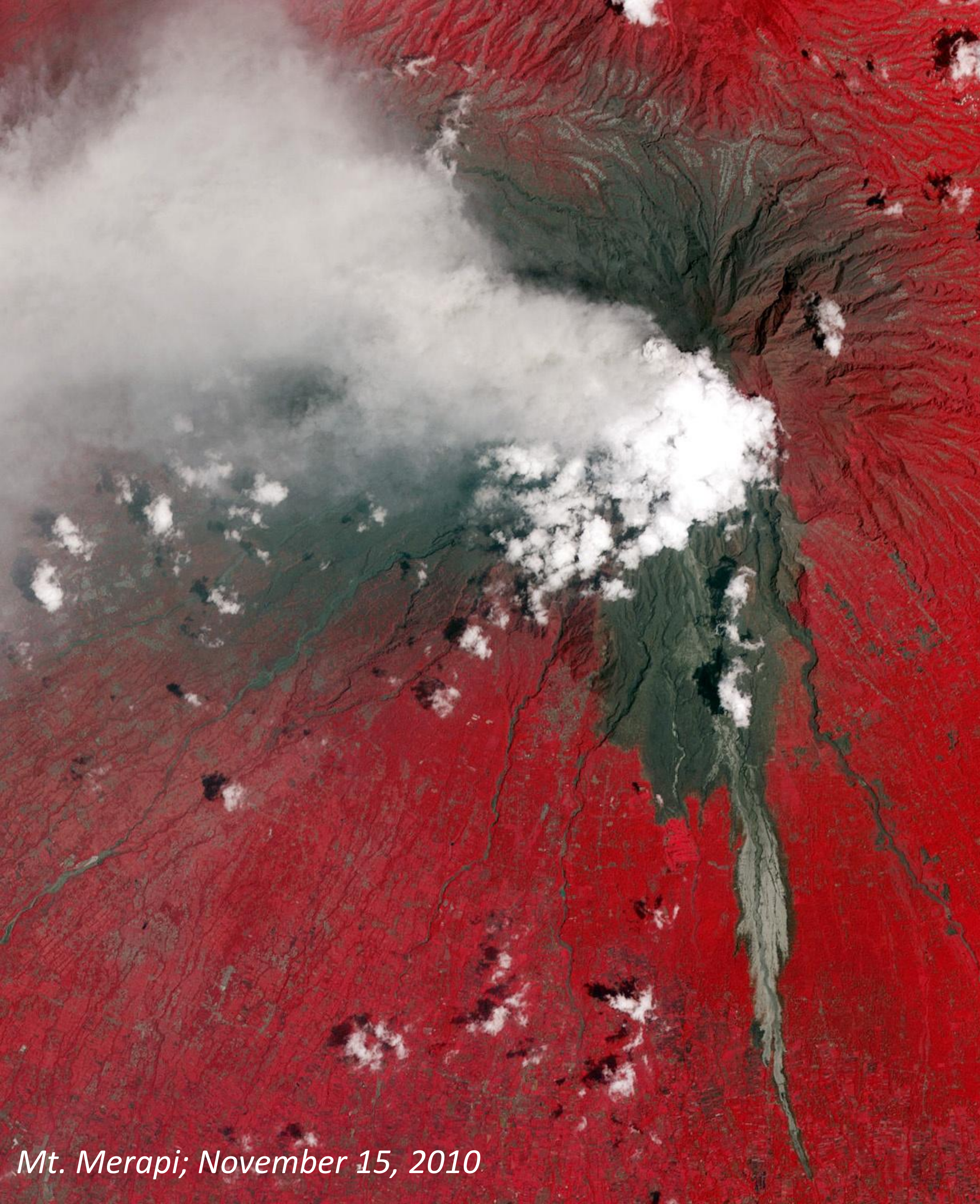
Japan’s Shinmoedake erupting, February 4, 2011

Vulcan Colima, Mexico
January 22, 2011

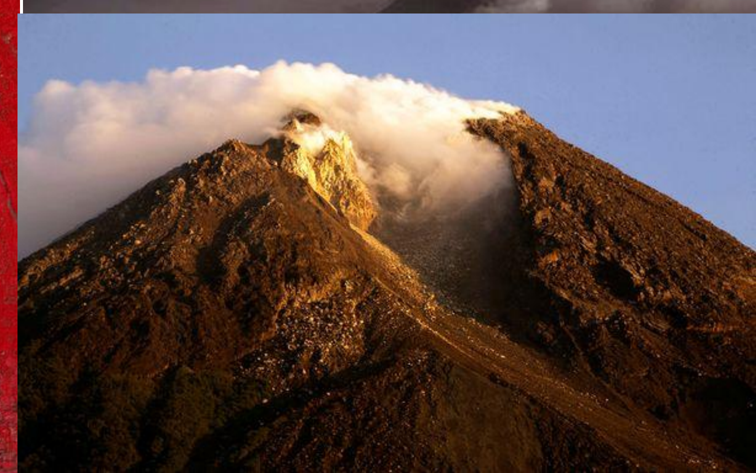
EYJAFJALLAJOKULL GLACIER ERUPTION, ICELAND, APRIL 2010



Eruption of Mount Merapi volcano, Java, Indonesia, Nov.ember 4, 2010



Mt. Merapi; November 15, 2010



Sakurajima, Japan : Feb 15, 2010

ERUPTION OF REDOUBT VOLCANO, ALASKA,
April 1990 (USGS Photo)

1997 eruption on Montserrat, West Indies

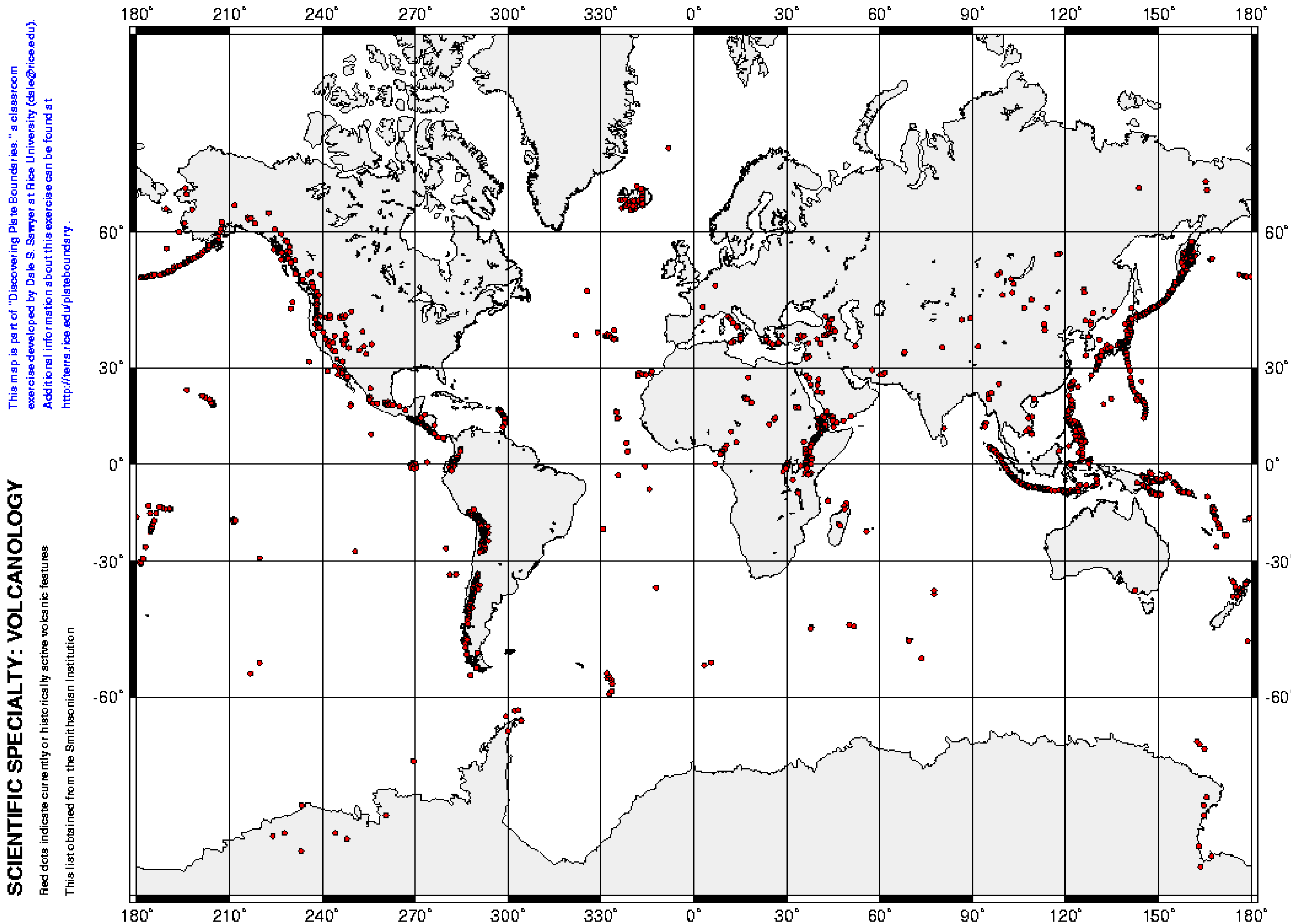
1997 eruption on Montserrat, West Indies

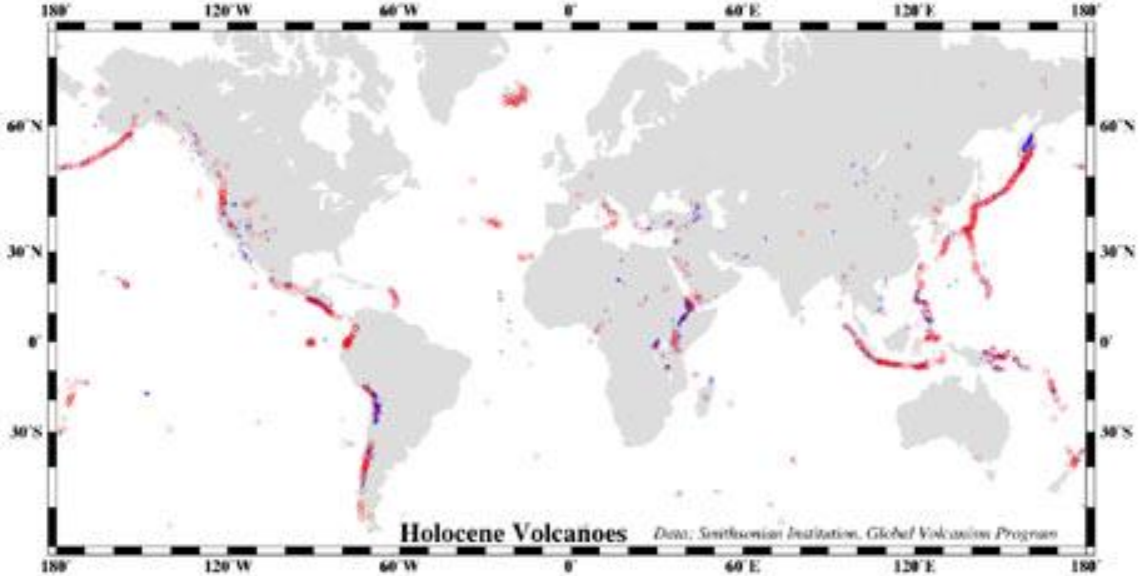
Rabaul, New Britain, Papua New Guinea

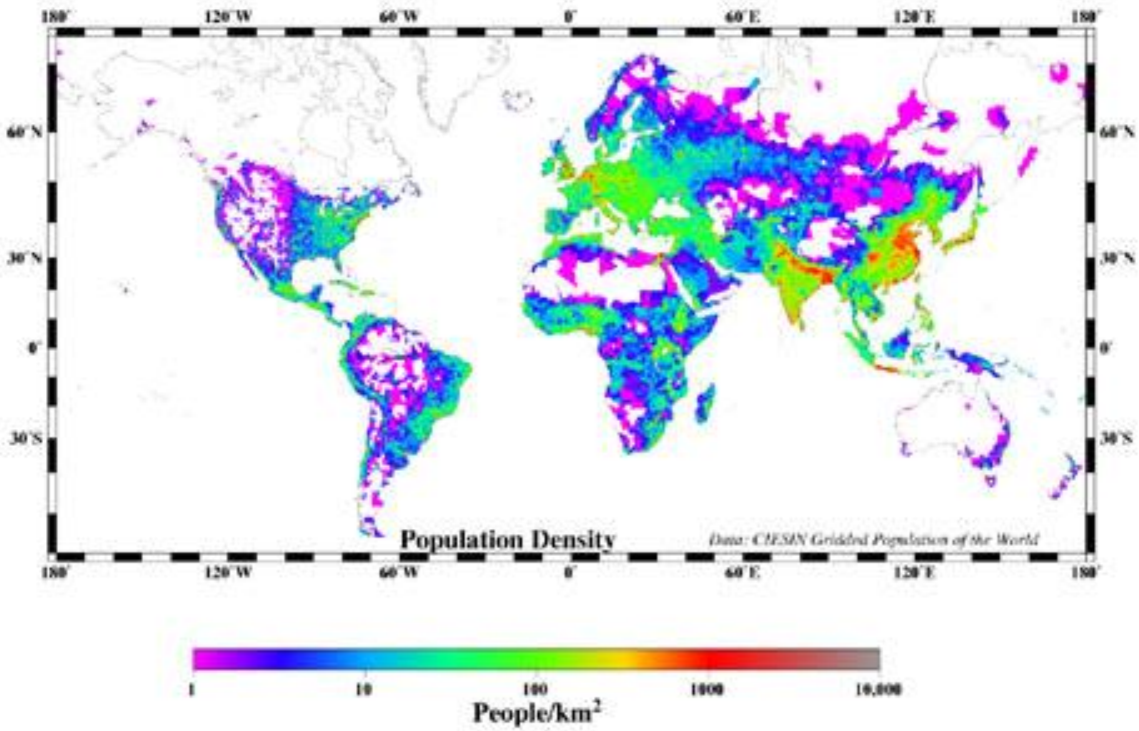
Mount Doom, Mordor

1944 VESUVIUS ERUPTION

ACTIVE VOLCANOES







VOLCANOES AND POPULATION

9% (455 M) of the world’s population live within 100 km of a historically active volcano

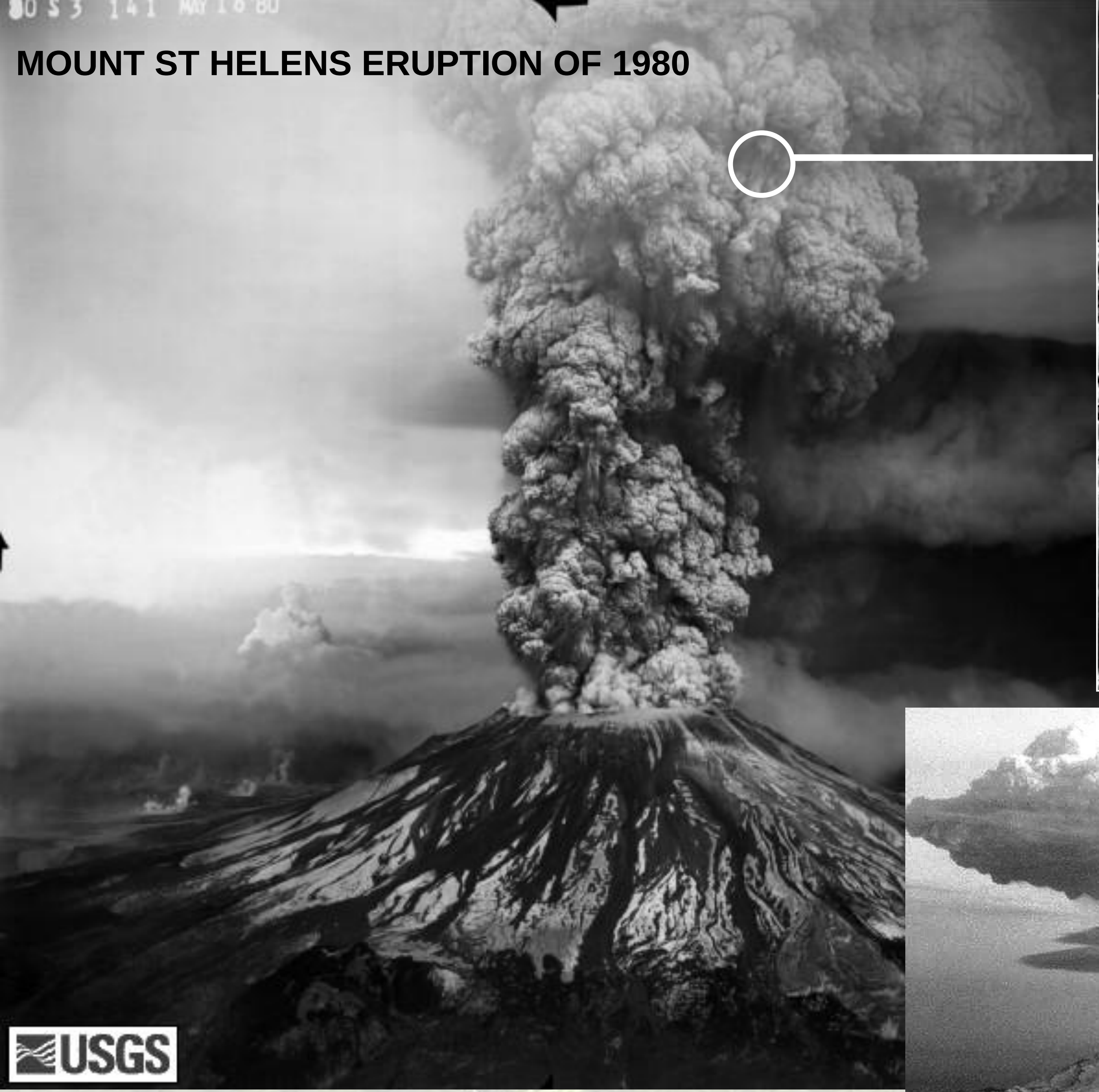
MOUNT AUGUSTINE, ALASKA

VOLCANISM is the process by which **magma** and its **associated gases** rise through the Earth's crust and are extruded onto the surface or into the air.

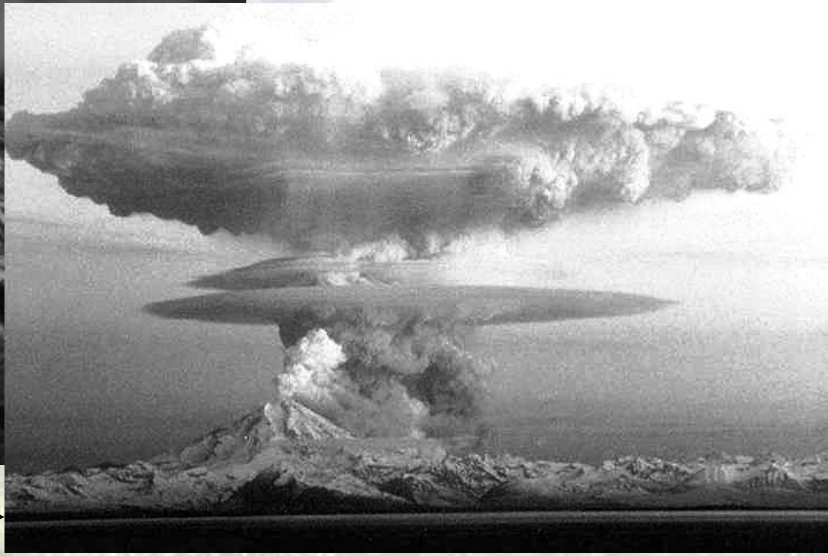
A **VOLCANO** is a landform formed by the accumulation of magma and other solid material extruded during an eruption (or eruptive phases) around a vent.


Vulcan Reventador, Ecuador

MOUNT ST HELENS ERUPTION OF 1980

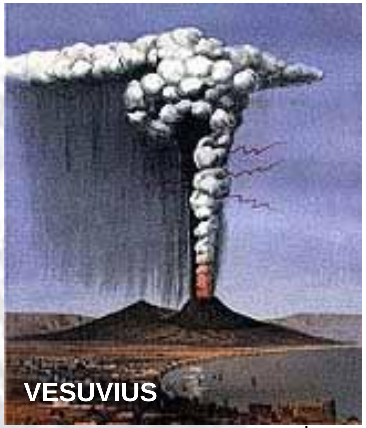


REDOUBT VOLCANO ERUPTION 1997



GLOBAL VOLCANISM PROGRAM

http://www.volcano.si.edu/index.cfm

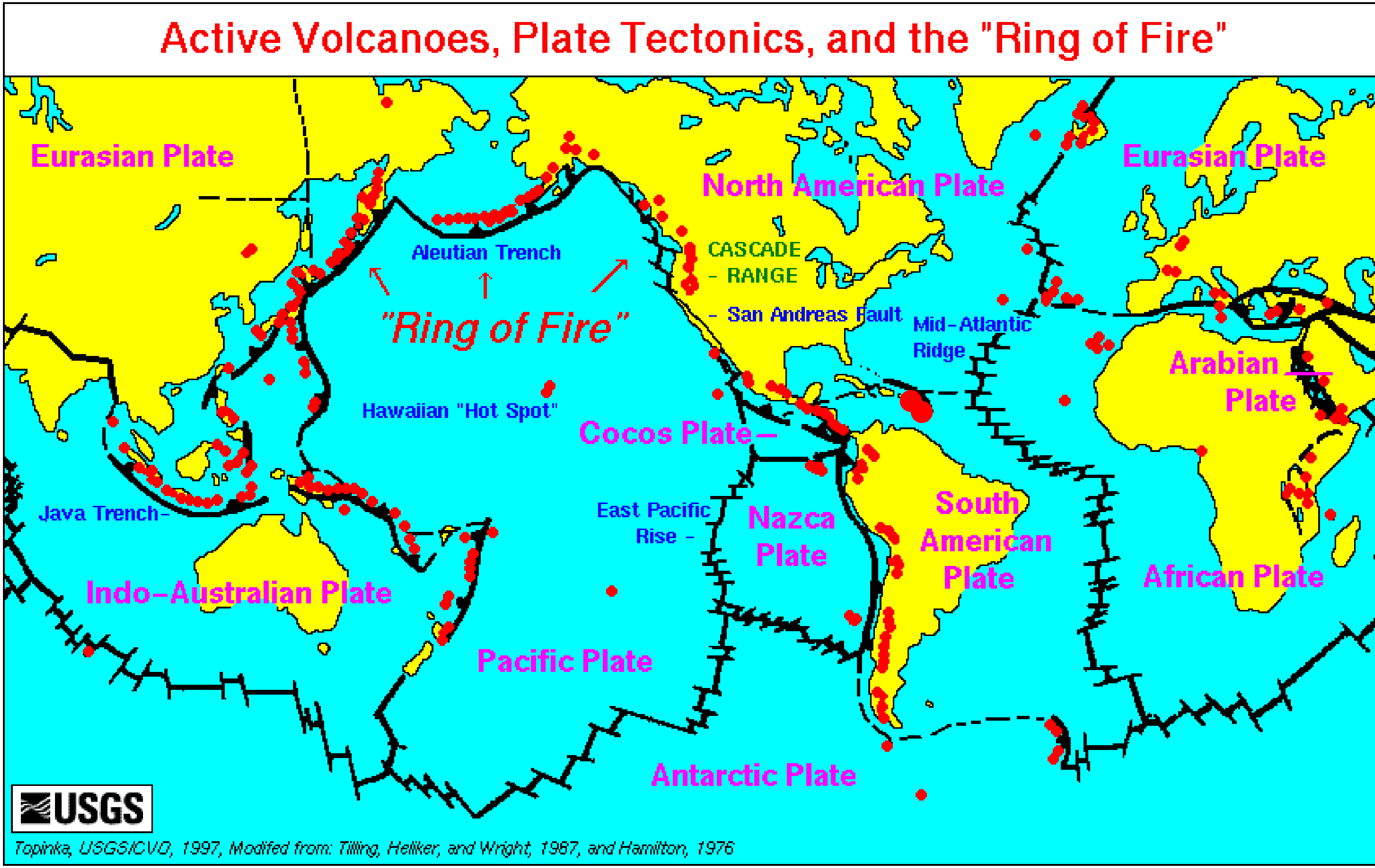


Activity Descriptors

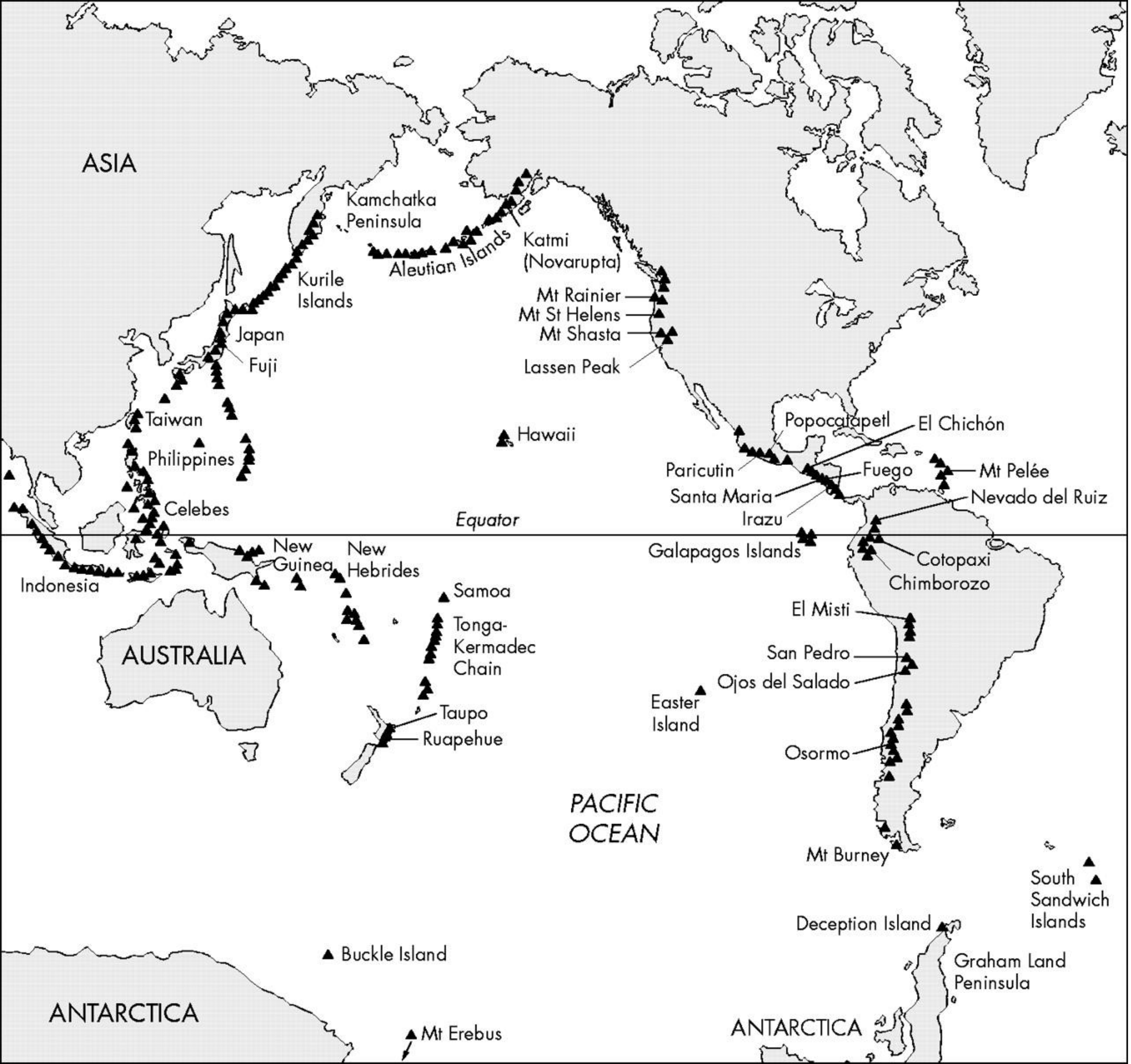
Active: erupted during historic time

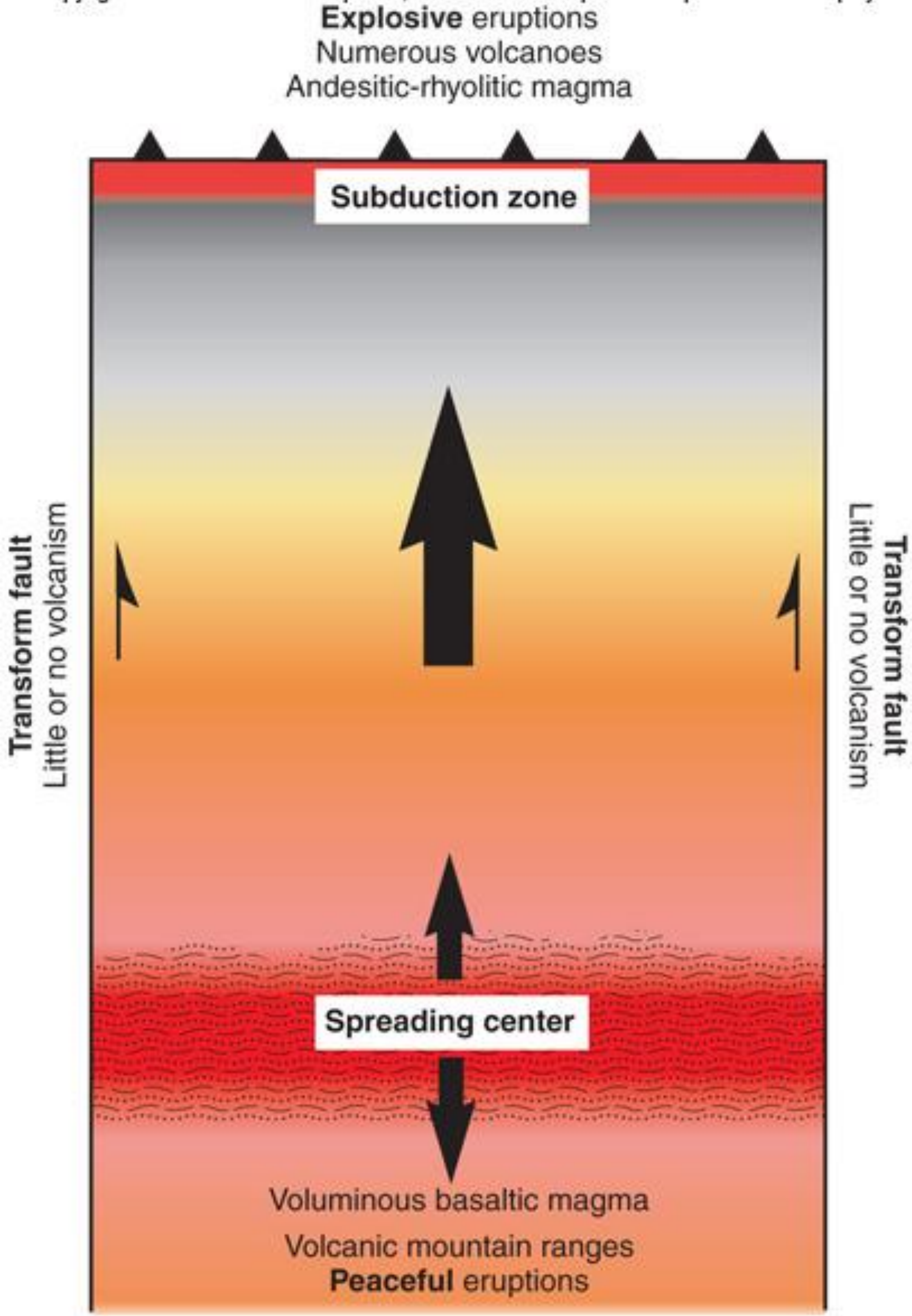
Dormant: not erupted recently, but may do so

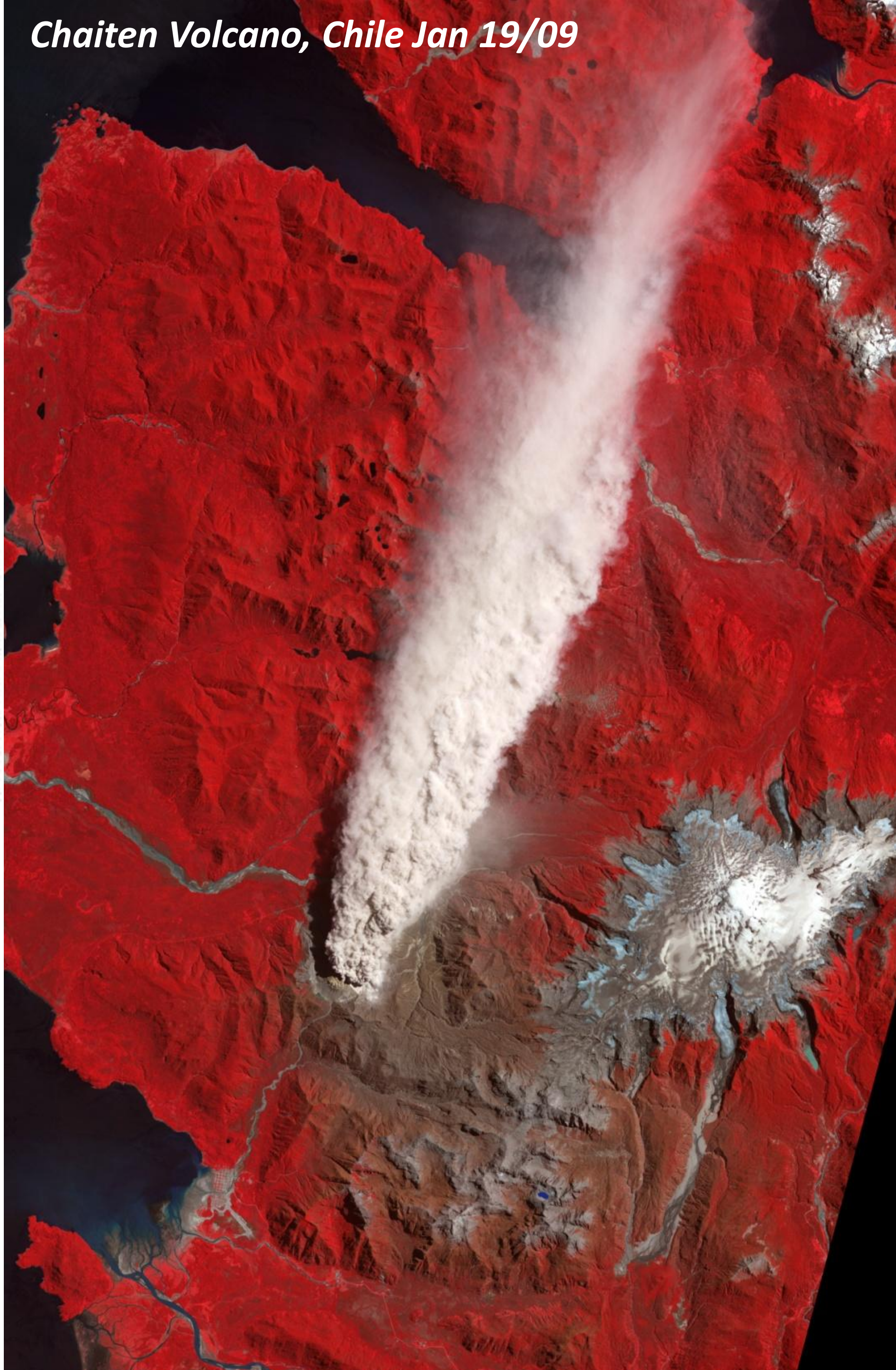
Extinct: not erupted recently, and show no evidence of doing so again


Active Volcanoes, Plate Tectonics, and the "Ring of Fire"
Eurasian Plate
North American Plate
Eurasian Plate
Aleutian Trench
CASCADE
- RANGE
"Ring of Fire"
- San Andreas Fault
Mid-Atlantic
Ridge
Arabian
Plate
Hawaiian "Hot Spot"
Cocos Plate
Java Trench
East Pacific
Rise
Nazca
Plate
South
American
Plate
African Plate
Indo-Australian Plate
Pacific Plate
Antarctic Plate
USGS
Topinka, USGS/CVO, 1997, Modifed from: Tilling, Heliker, and Wright, 1987, and Hamilton, 1976

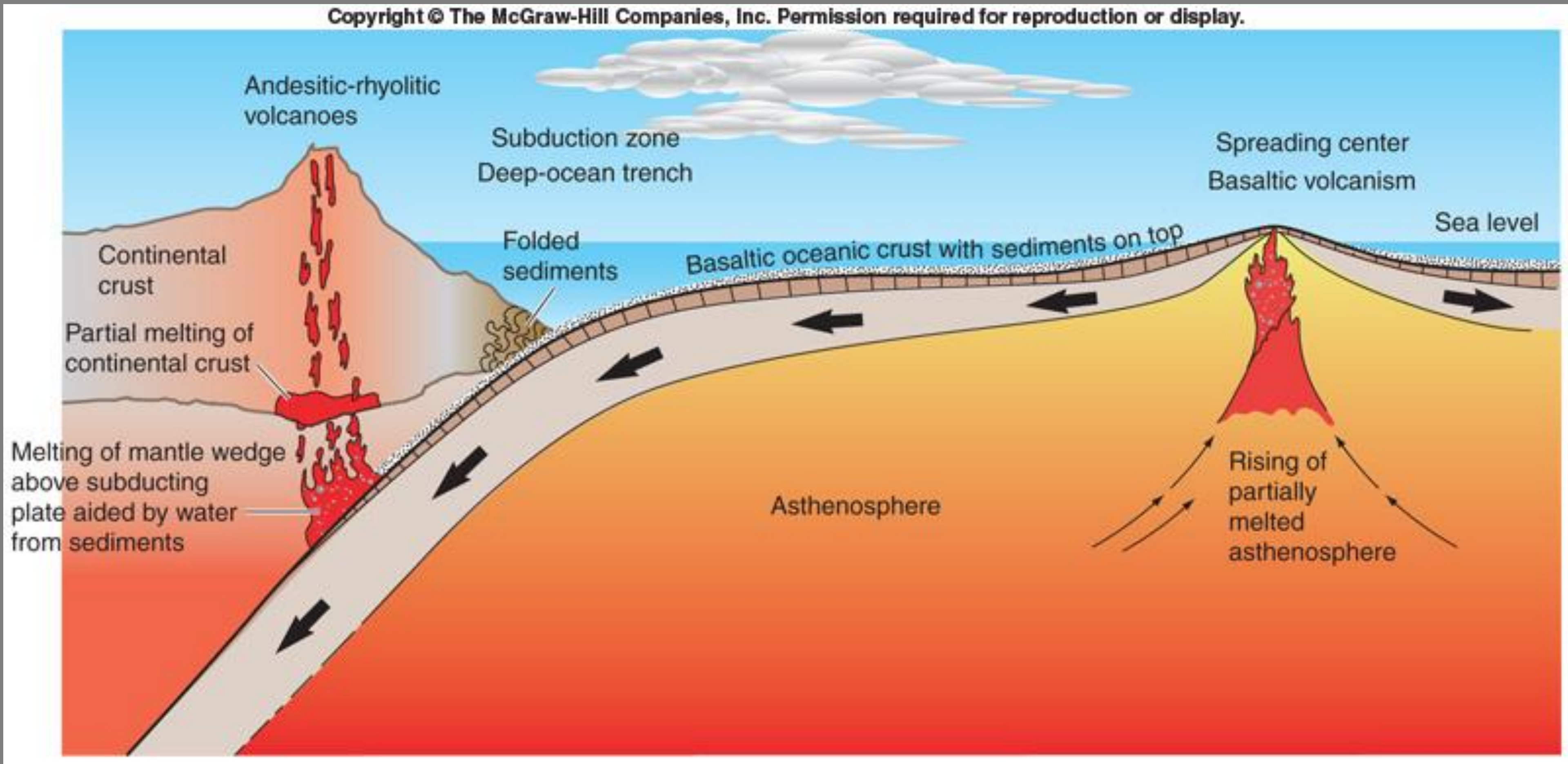
VOLCANOES OF THE PACIFIC RING OF FIRE



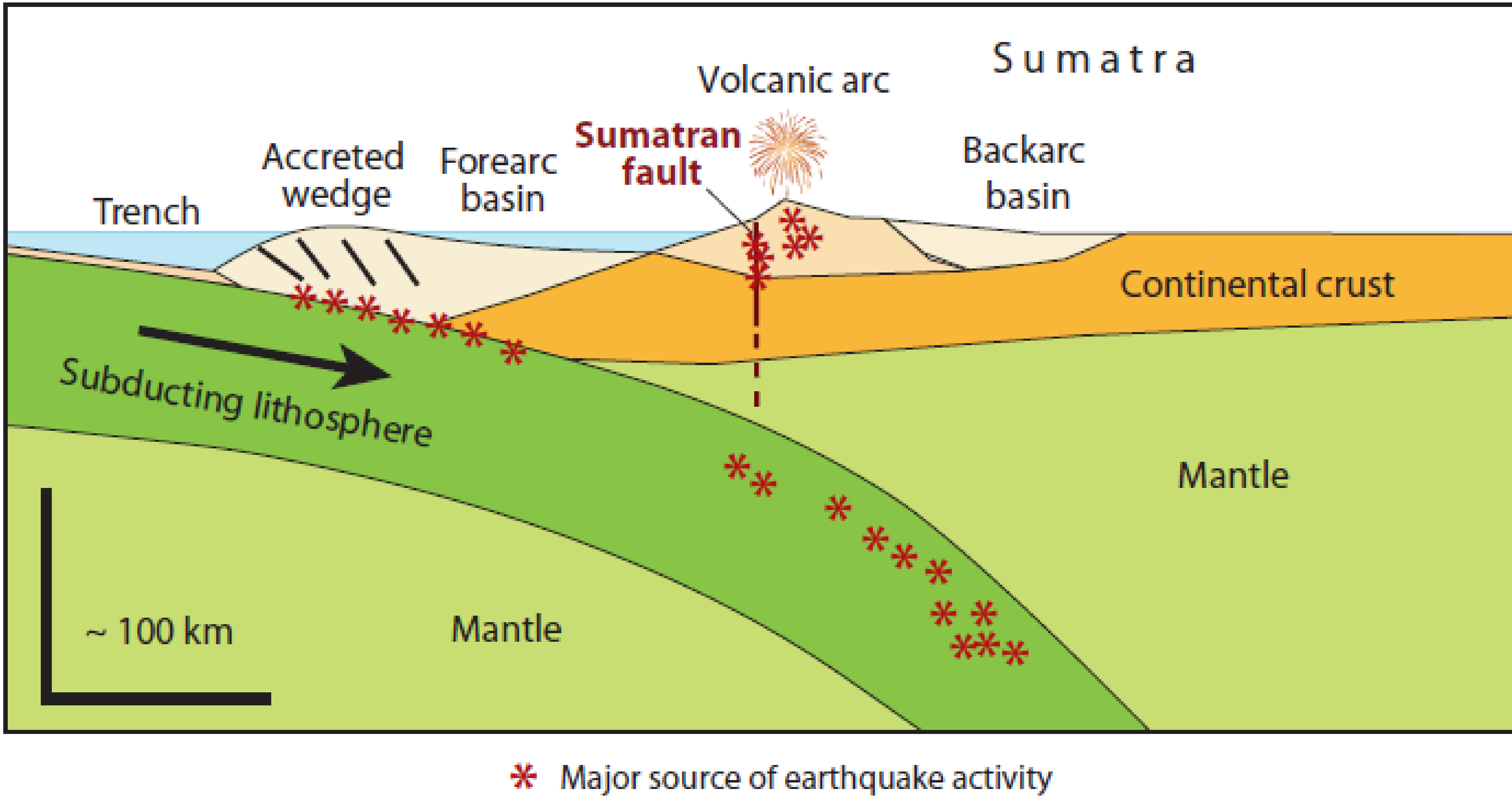

Explosive eruptions
Numerous volcanoes
Andesitic-rhyolitic magma
Subduction zone
Transform fault
Little or no volcanism
Transform fault
Little or no volcanism
Spreading center
Voluminous basaltic magma
Volcanic mountain ranges
Peaceful eruptions


Chaiten Volcano, Chile Jan 19/09

VULCANISM AND PLATE TECTONICS



EXPLOSIVE VULCANiSM PRODUCED BY PARTAIL MELTING OF CONTINENTAL CRUST IN SUBDUCTION ZONE



THE SUNDA TRENCH SUBDUCTION ZONE AND VOLCANOES IN SUMATRA AND JAVA

Major Volcanoes of Indonesia

(with eruptions since 1900 A. D.)

USGS

Topinka, USGS/CVO, 2001; basemap modified from: CIA map, 1997; volcanoes from: Simkin & Siebert, 1994

Mt Bromo, Java, Indonesia erupting late 2010

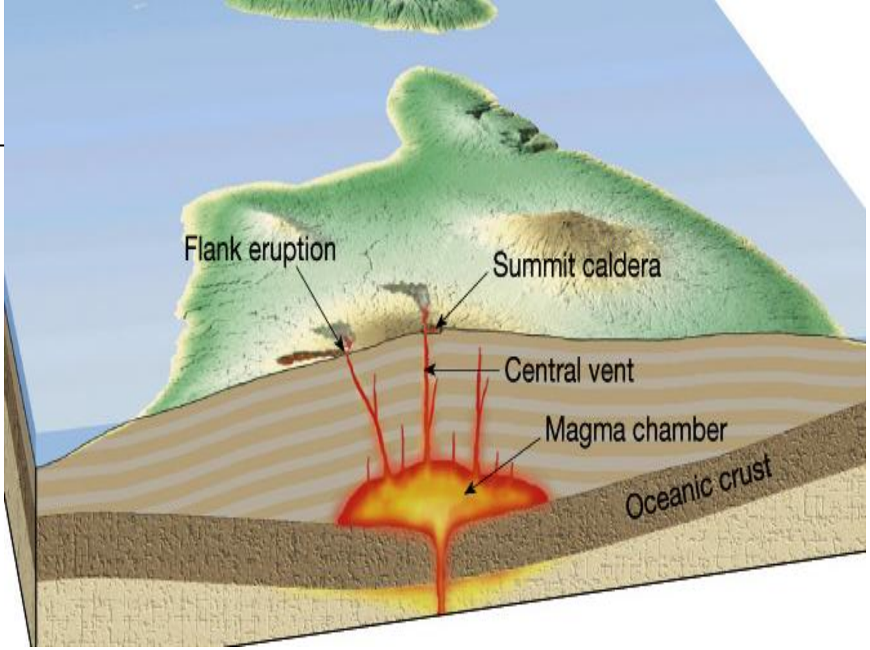
ARCHITECTURE OF VOLCANOES

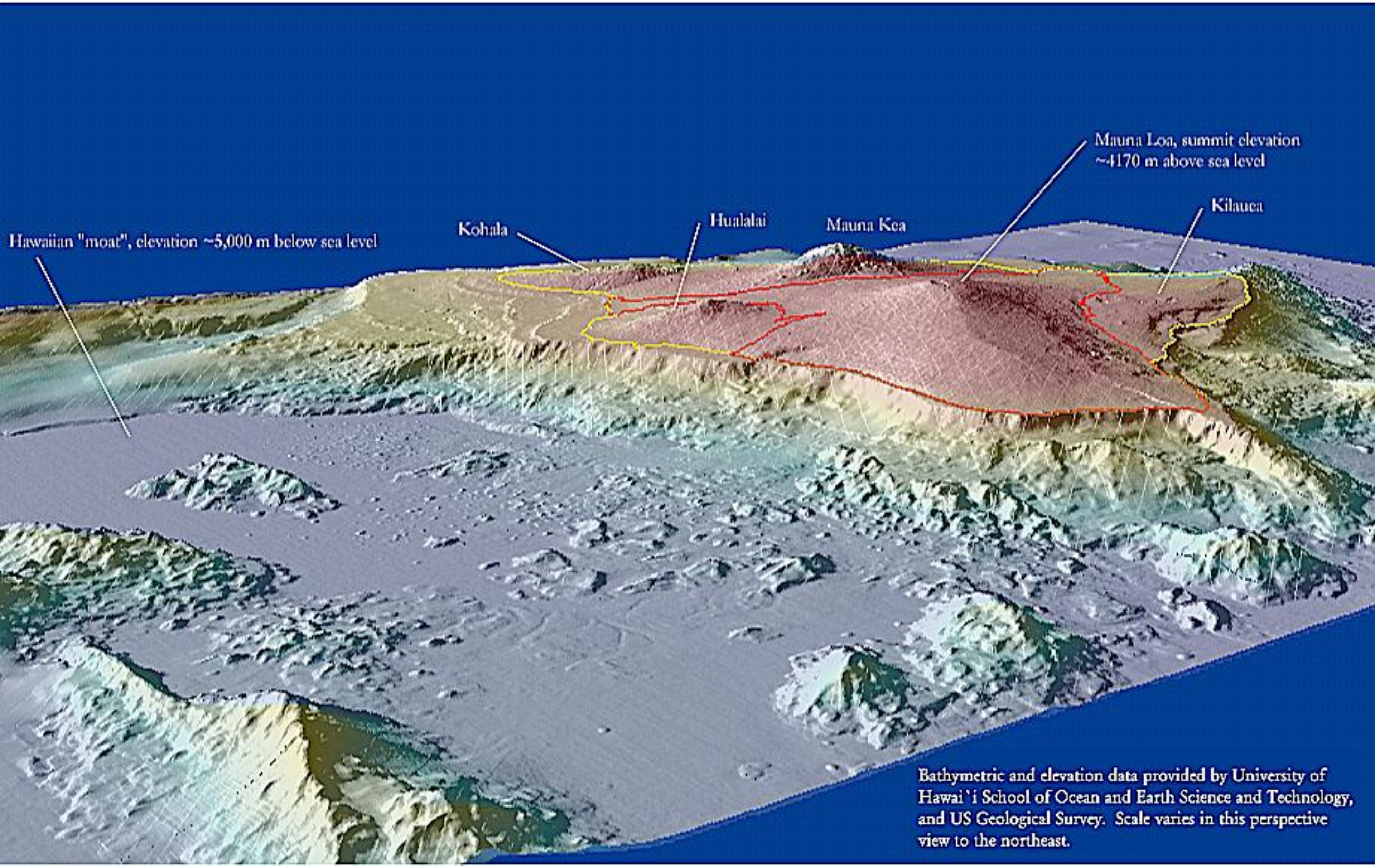
1. SHIELD VOLCANOES (BASALTIC LAVA OF LOW VISCOSITY)
2. STRATOVOLCANOES (COMPOSITE VOLCANOES) – MOST COMMON
3. CINDER CONES (PILE OF ASH AT THE ANGLE OF REPOSE)

FUJIYAMA

1. SHIELD VOLCANOES

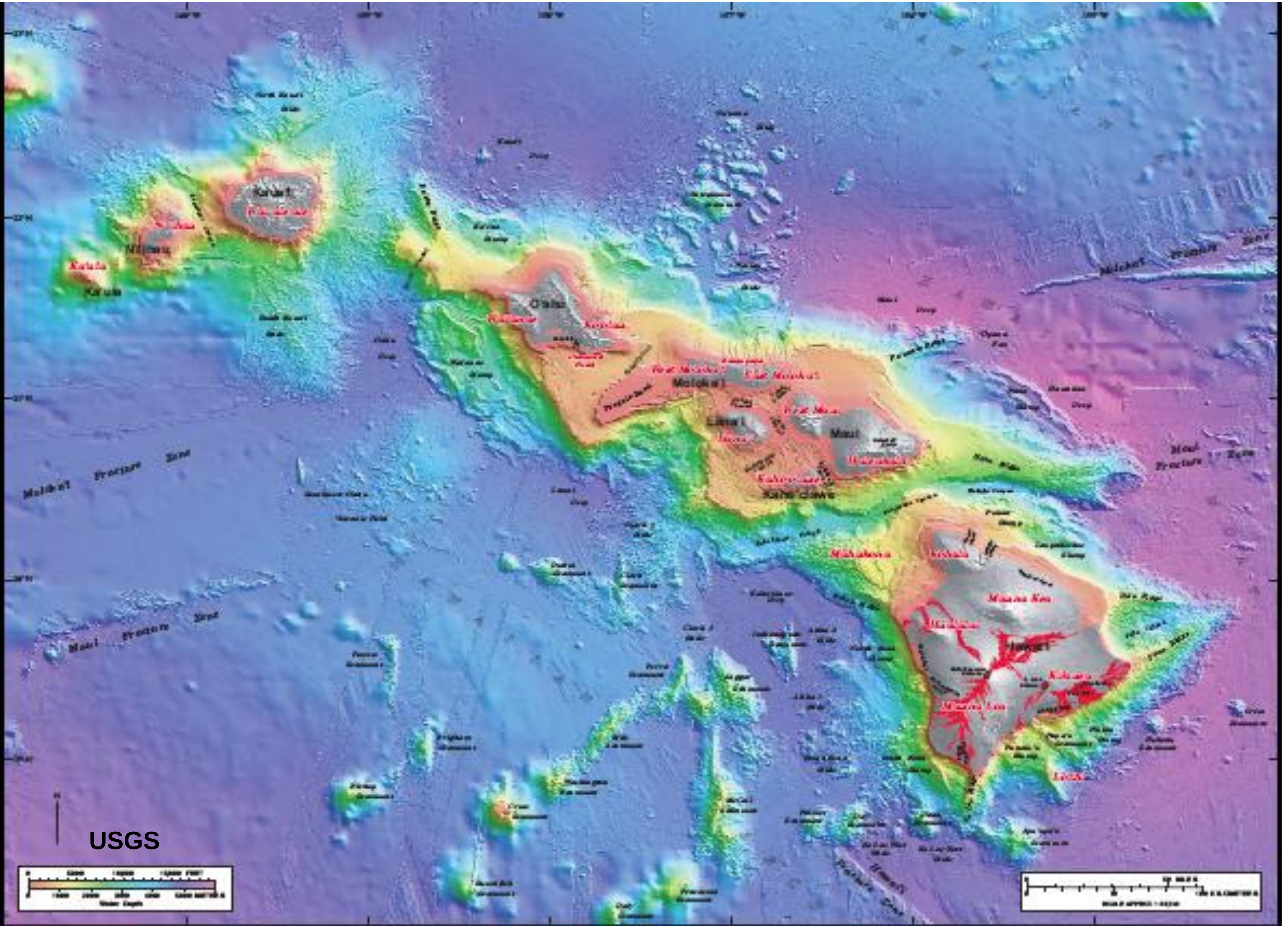
- Low gradient, rounded profiles, with gentle slopes ranging from 2 to 10^0
- Low viscosity mafic lava flows (basaltic), which spread as thin layers
- Lava extruded with **little explosive activity.**
- Most common in oceanic areas (Hawaiian Islands and Iceland)
- But slopes can generate **massive submarine landslides**



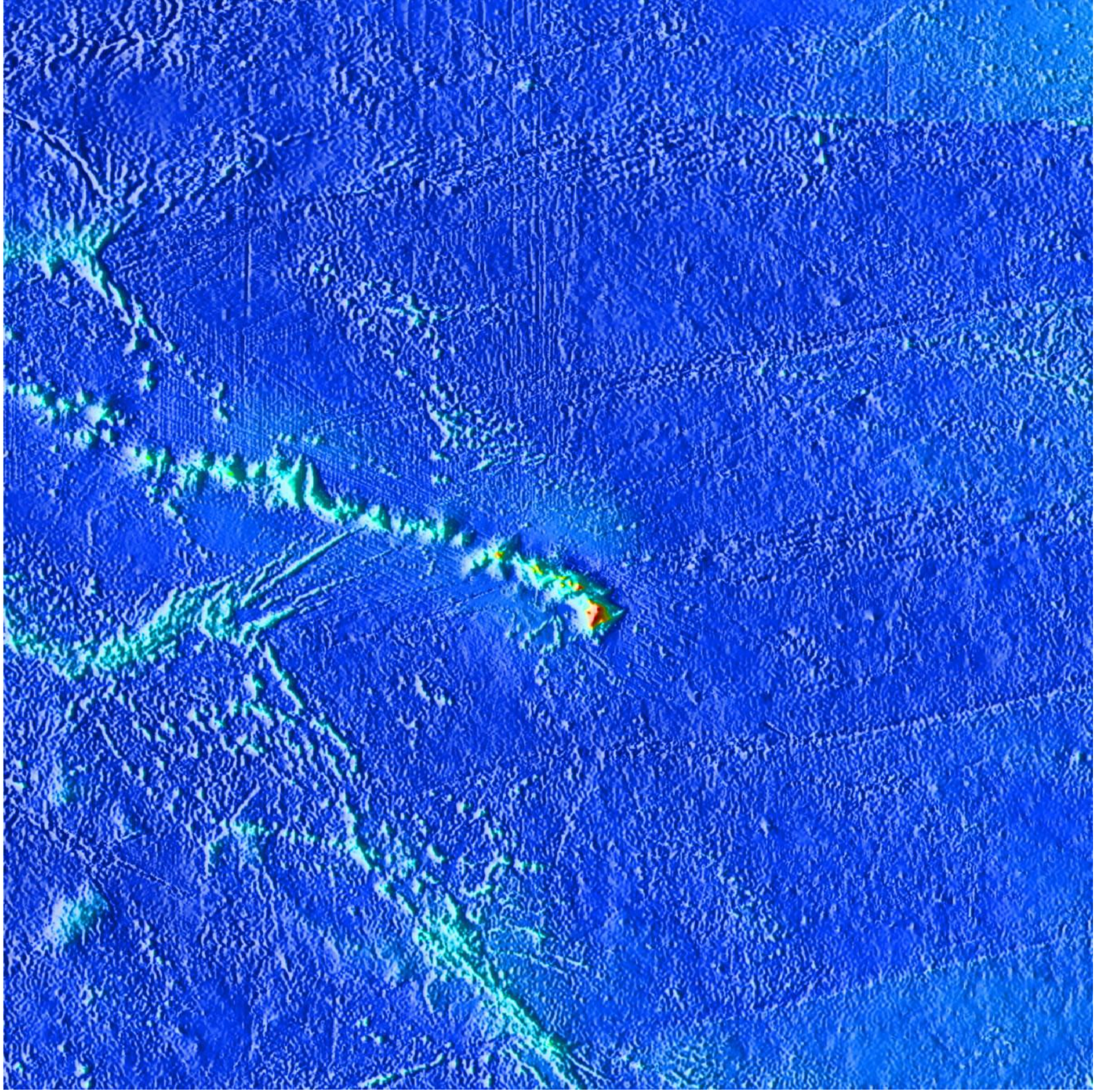


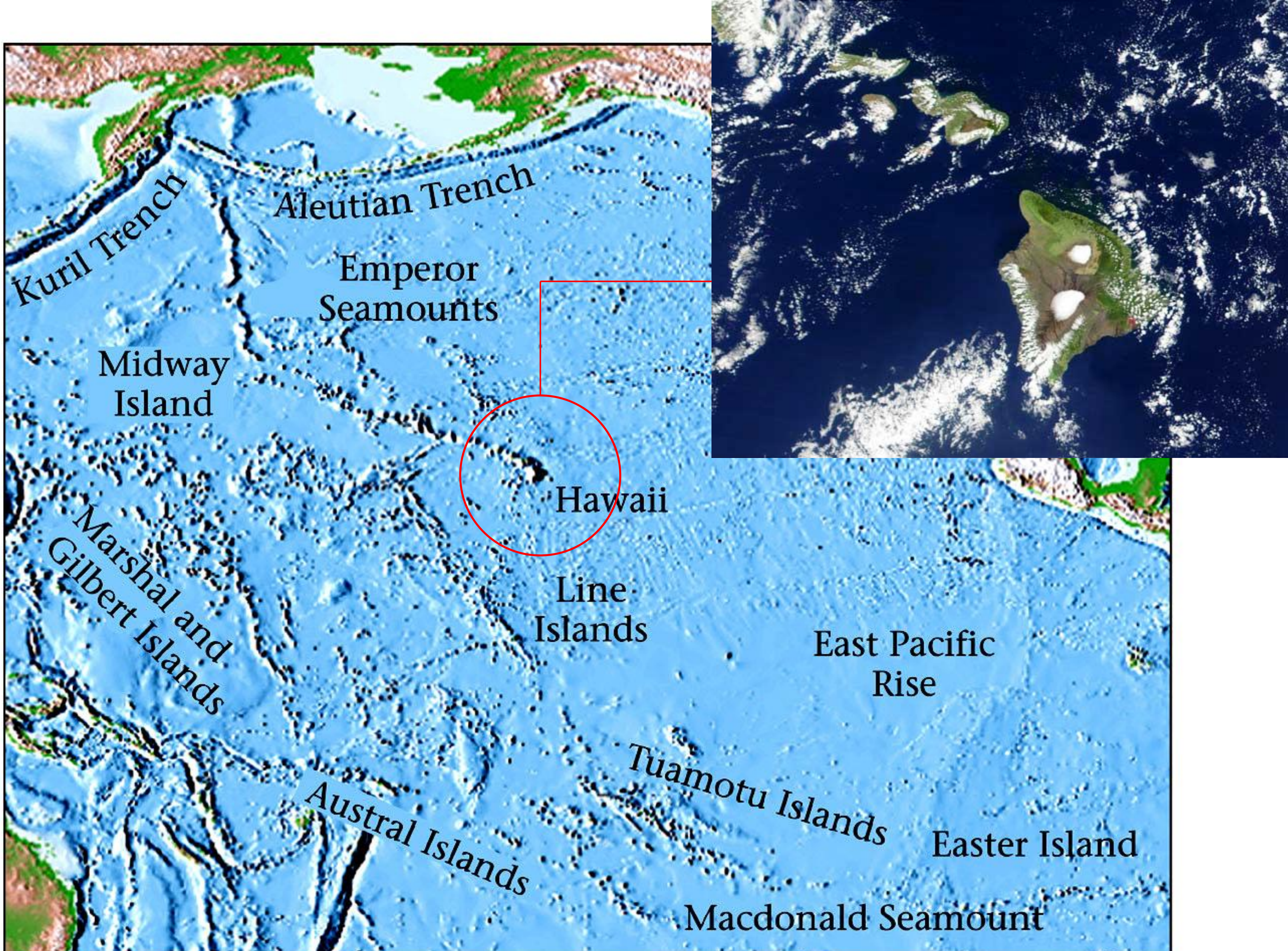
HAWAII ISLAND – THE TOP OF A MASSIVE SHIELD VOLCANO

BATHYMETRY OF THE HAWAIIAN ISLANDS – SHIELD VOLCANOES OVER A HOT SPOT



HAWAIIAN HOTSPOT VOLCANOES





HOT SPOT TRACKS – EMPEROR SEAMOUNTS

FIGURE 4.

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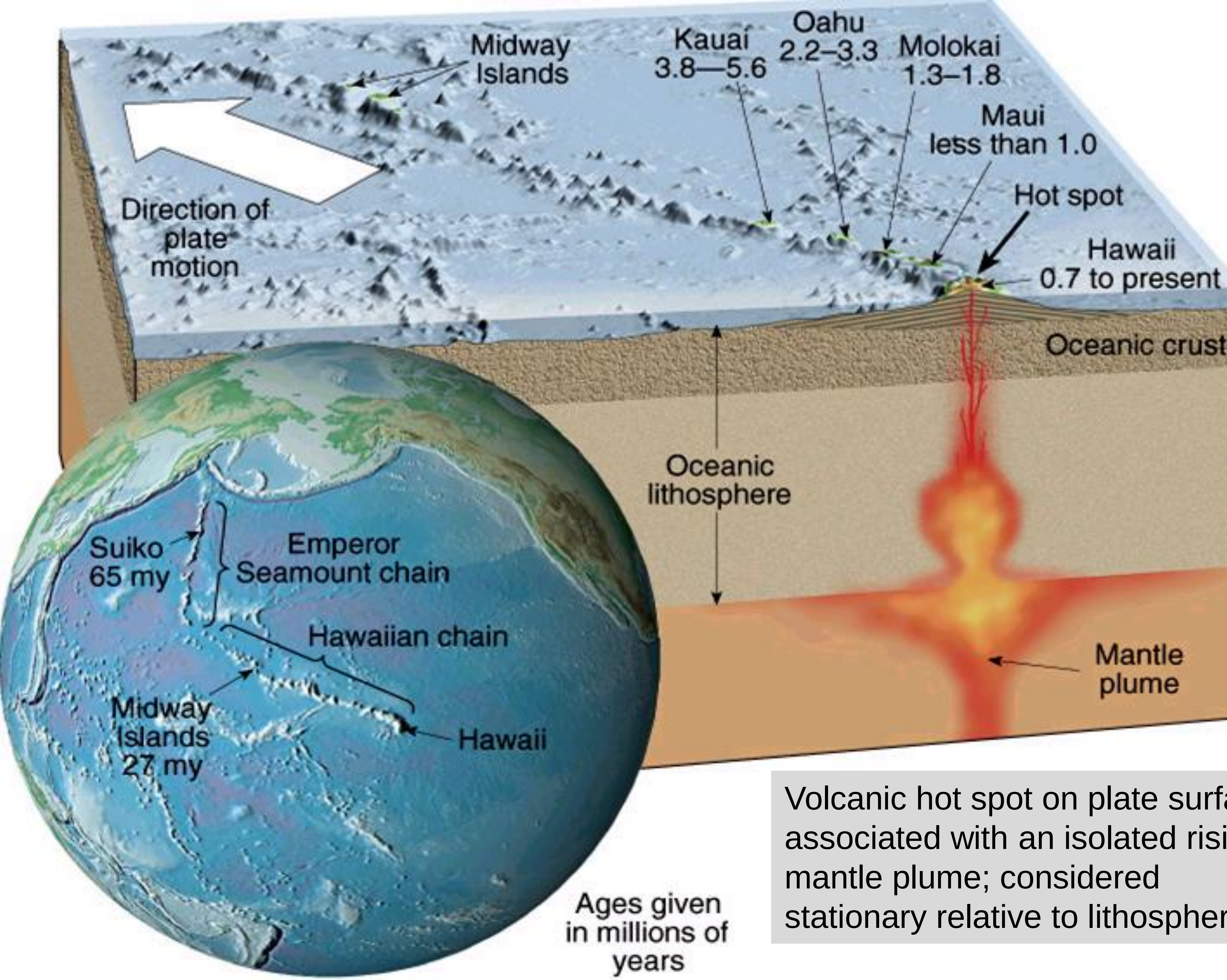
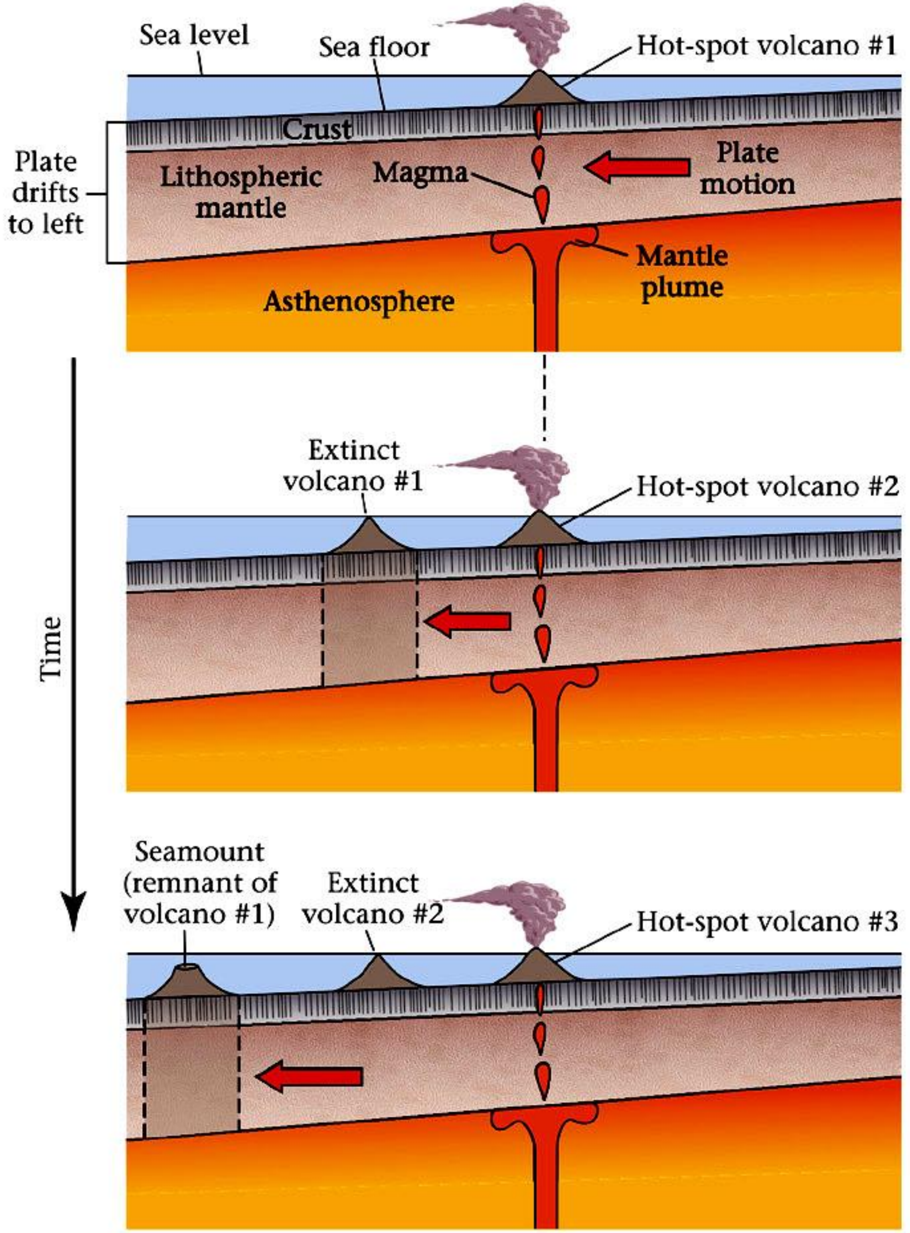


Volcanic hot spot on plate surface associated with an isolated rising mantle plume; considered stationary relative to lithosphere

PROCESS OF SEAMOUNT FORMATION AND MOVEMENT ON A MOVING PLATE ABOVE A MANTLE PLUME



(a)

FIGURE 4.23

Earth: Portrait of a Planet, 2nd Edition

HOTSPOT VOLCANOES (RED DOTS) AND THEIR TRACKS (MOST RECENT AT THE END OF THEIR TRACK)

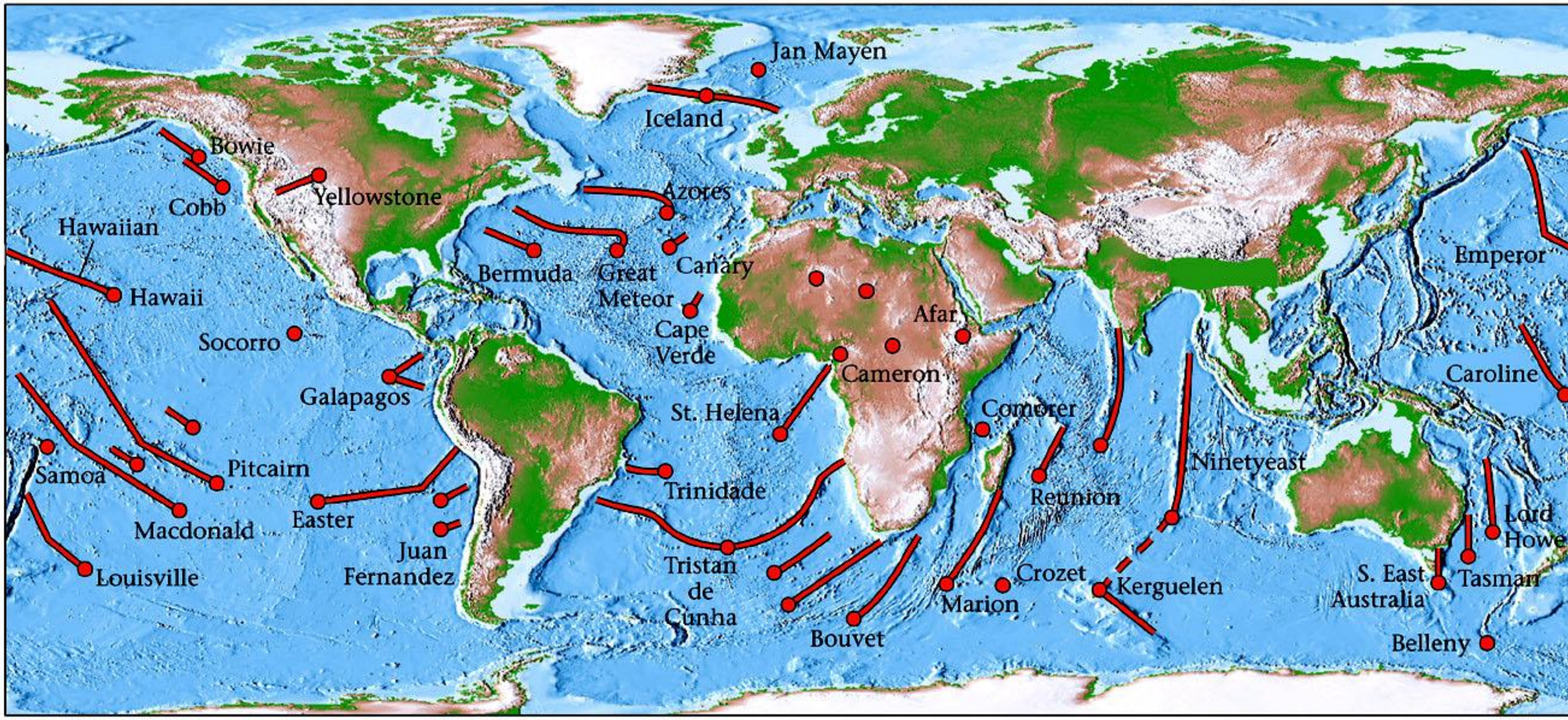


FIGURE 4.21

Earth: Portrait of a Planet, 2nd Edition

Susceptibility of mid-ocean ridge volcanic islands and seamounts to large-scale landsliding

Neil C. Mitchell
Department of Earth Sciences, Cardiff University, Cardiff, UK

Received 29 May 2002; revised 24 December 2002; accepted 28 February 2003; published 28 August 2003.

[1] With a view to assessing the incidence of large-scale landsliding, a morphologic database was created for volcanic islands and seamounts on young oceanic lithosphere. The database included 44 mid-ocean ridge seamounts, Jasper seamount and the islands of Ascension, Bouvet, Guadalupe, and several of the Galapagos and Azores Islands, supplemented with published reports from a further five volcanic edifices. The data reveal that major landslides are common on edifices taller than 2500 m but are rare in shorter edifices, implying a threshold of instability at around 2500 m. A number of causes of this threshold are discussed. For example, many structures taller than 2500 m are, or were originally, volcanic islands, and therefore their flanks probably include extensive weak hyaloclastite built up from lava-sea interactions around coasts. Compaction of hyaloclastites in larger edifices lead to regions of low permeability, which may help to explain the more deeply seated slope failures. It is intriguing that the threshold also coincides with the edifice height at which volcanic ridges become observable, a stage at

2. COMPOSITE VOLCANOES (STRATOVOLCANOES)

KLYUCHEVSKAYA VOLCANO, KAMCHATKA, RUSSIA

Mt Fuji with Shinkansen

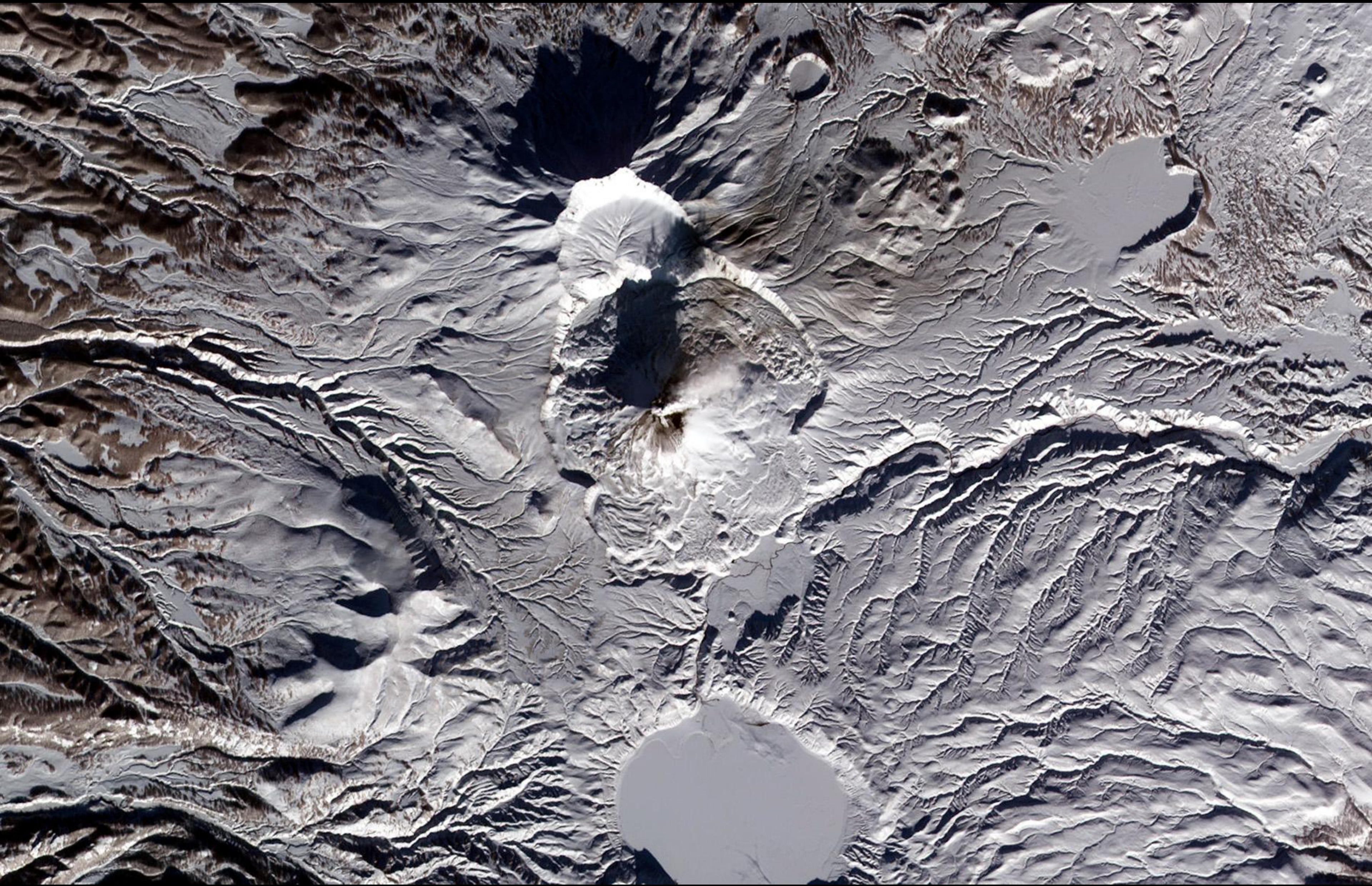
Augustine volcano, Alaska

MOUNT SINABUNG ERUPTING IN FEBRUARY 2014 (SUMATRA)

MOUNT SINABUNG ERUPTING IN FEBRUARY 2014 (SUMATRA)

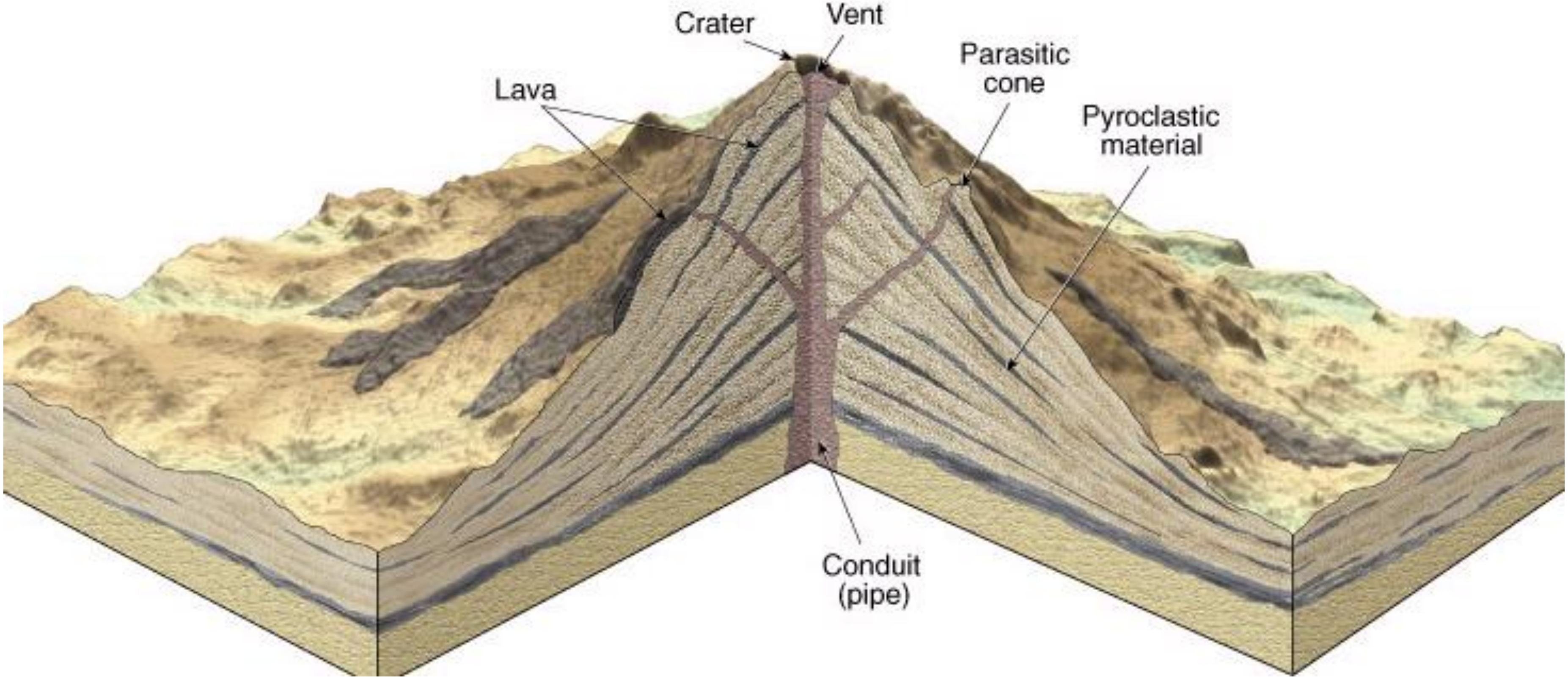
MOUNT SINABUNG ERUPTING IN FEBRUARY 2014 (SUMATRA)

Kamchatka, Russia, January 29, 2010

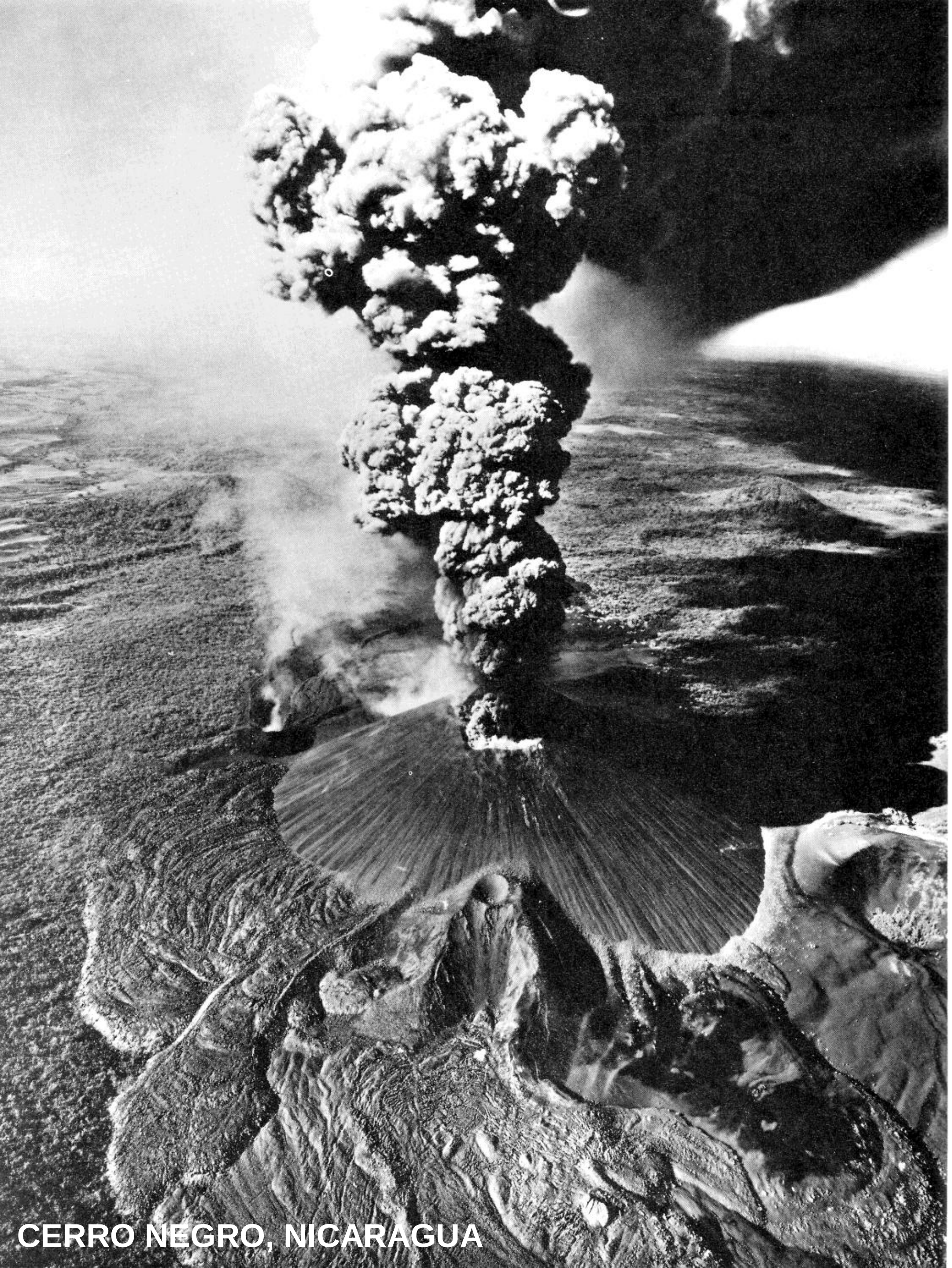


Kizimen Volcano, Kamchatka, Russia : ASTER image obtained February 25, 2011

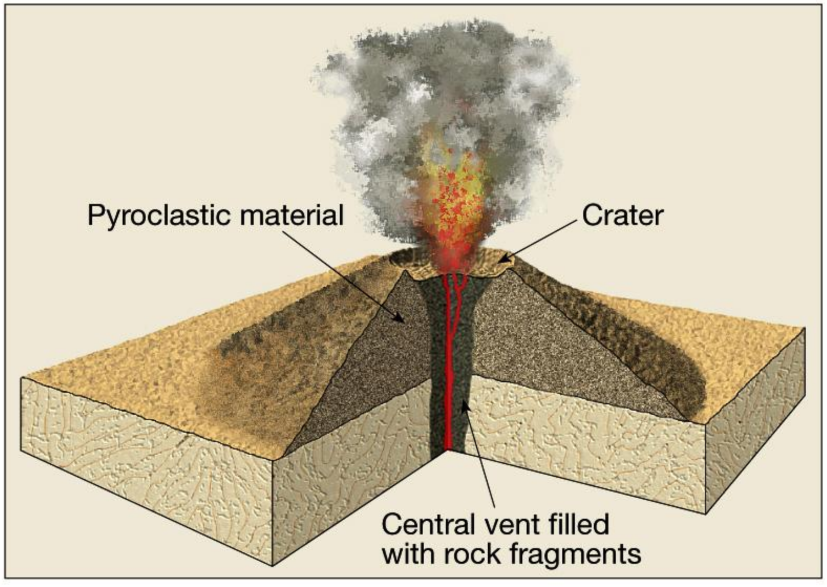
COMPOSITE VOLCANOES (STRATOVOLCANOES)



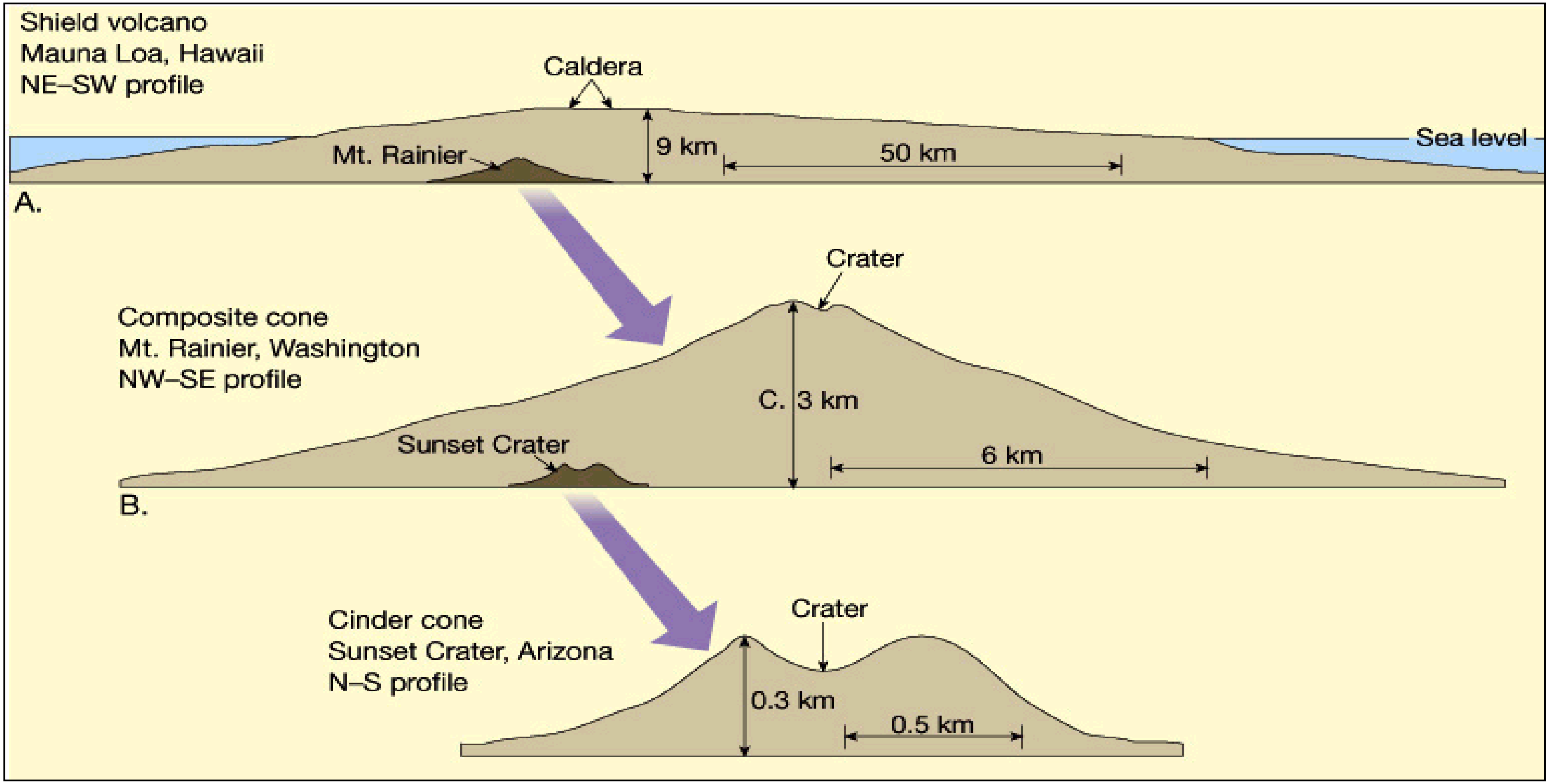
Produced by eruptions, in which explosive phases (ejection of molten materials) alternate with effusive phases (emission of streams of lava)



3. CINDER CONES



COMPARITIVE GEOMETRIES I



COMPARITIVE GEOMETRIES II

FIGURE 9.12

Earth: Portrait of a Planet, 2nd Edition

GENERAL STRUCTURE OF A VOLCANO

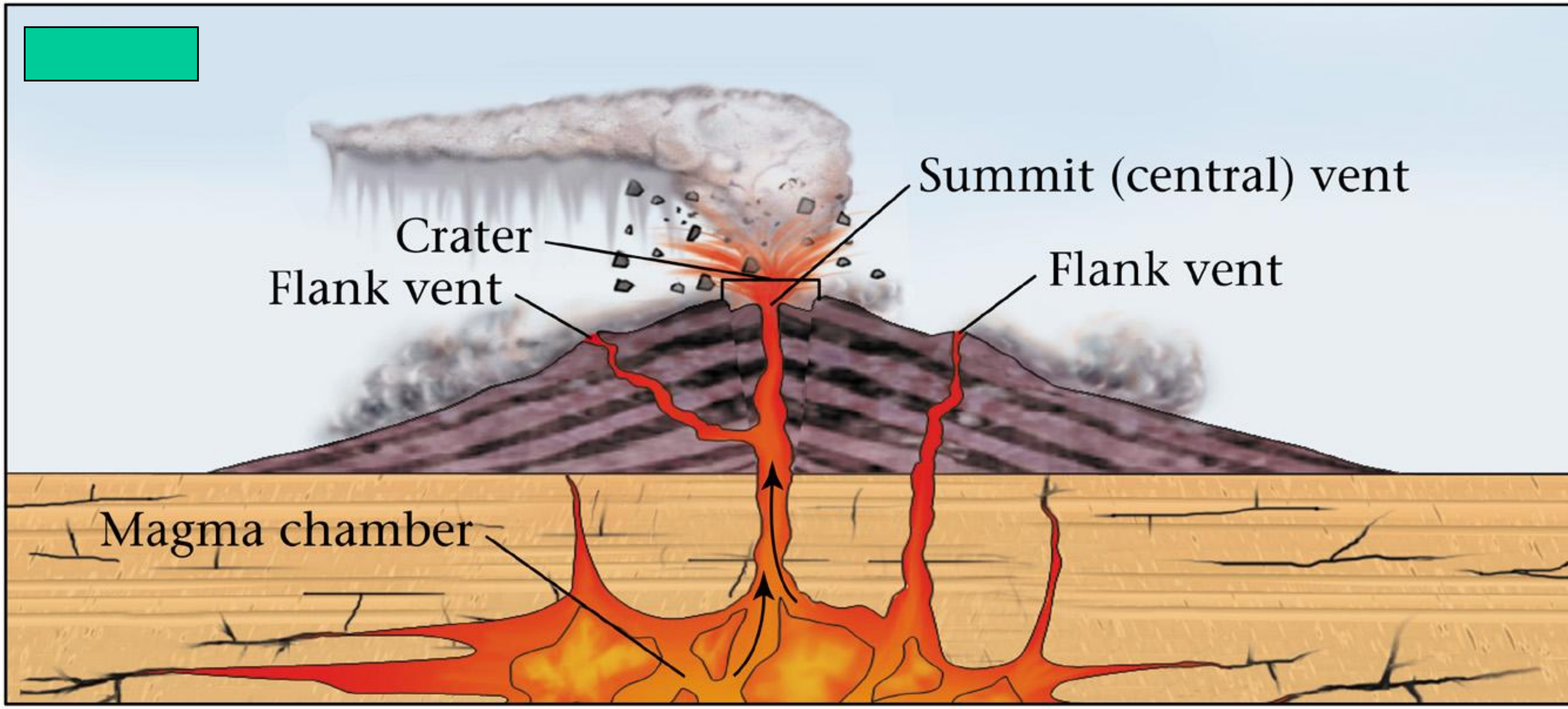


FIGURE 9.10

MAGMA I : Where Does the Magma Come From? – Melting of Rocks within the Crust / Mantle

Factors influencing melting of rocks

1. **Temperature**

   Rocks melt only at very high temperatures

2. **Composition**

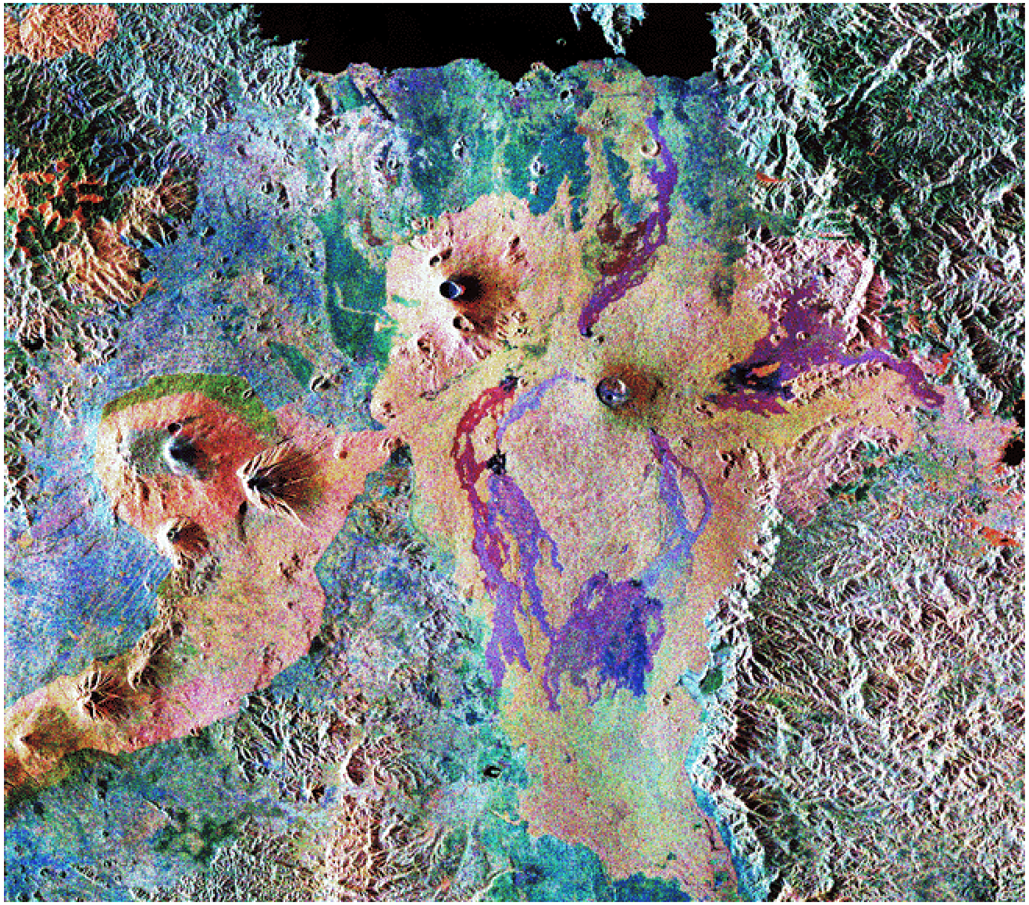
   Different minerals melt at different temperature

3. **Confining pressure**

   Increase in confining pressure increases melting temperature

4. **Water Content**

   An increase in water content lowers melting temperature

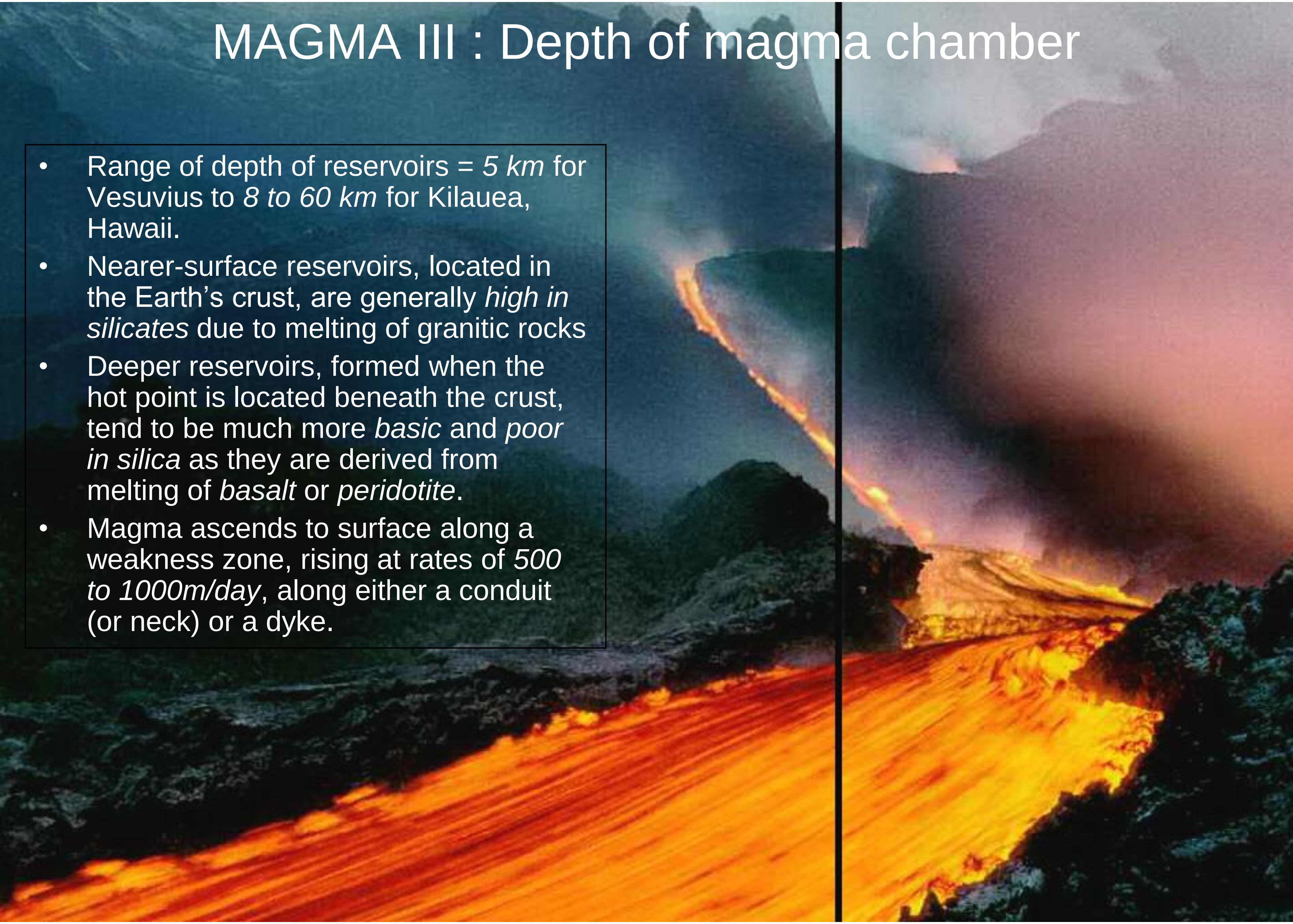


NYIRAGONGO, D R CONGO

MAGMA II : Magma Reservoir

- Reservoirs of molten silicates form beneath the Earth's surface, containing *crystals in suspension* and *volcanic gases* in solution.
- Magmas develop over the course of time. The composition of the magma *gradually differentiates*, with heavier crystals sinking to the bottom of the reservoir.
- Gases circulate in the melted matter, bringing *volatile substances* to the upper part.
- High temperature magma melts *country rock* along the margins of the reservoir, incorporating them into the mix (assimilation).
- Temperature of magma ranges from *500º to 2000ºC*, and pressure from few hundred to more than 200,000 atmospheres.

MAGMA III : Depth of magma chamber



- Range of depth of reservoirs = *5 km* for Vesuvius to *8 to 60 km* for Kilauea, Hawaii.
- Nearer-surface reservoirs, located in the Earth’s crust, are generally *high in silicates* due to melting of granitic rocks
- Deeper reservoirs, formed when the hot point is located beneath the crust, tend to be much more *basic* and *poor in silica* as they are derived from melting of *basalt* or *peridotite*.
- Magma ascends to surface along a weakness zone, rising at rates of *500 to 1000m/day*, along either a conduit (or neck) or a dyke.

STYLES OF VOLCANIC ERUPTION

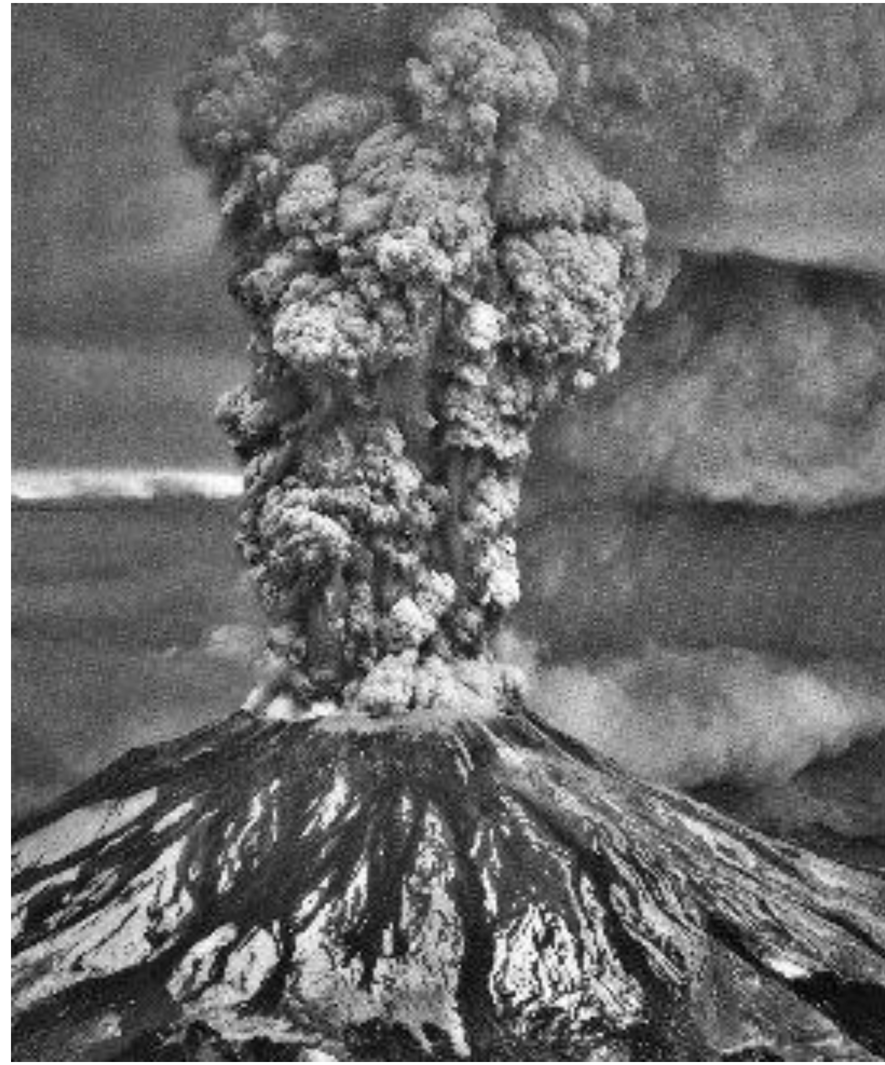
The main factors determining the **violence/explosivity** of volcanic eruption are;

1. Magma viscosity
2. Amount of dissolved gasses (volatiles)
3. The ease with which gases can escape

Factors affecting **viscosity of magma**

1. Chemical composition, especially silica, SiO_2
2. Temperature
3. Dissolved gas

Higher viscosity, more dissolved gas that cannot escape easily during magma rise create **explosive** volcanoes



Mt St Helens 1980

Vesuvius eruption in art

Augustine volcano, Alaska