# Physical Volcanology

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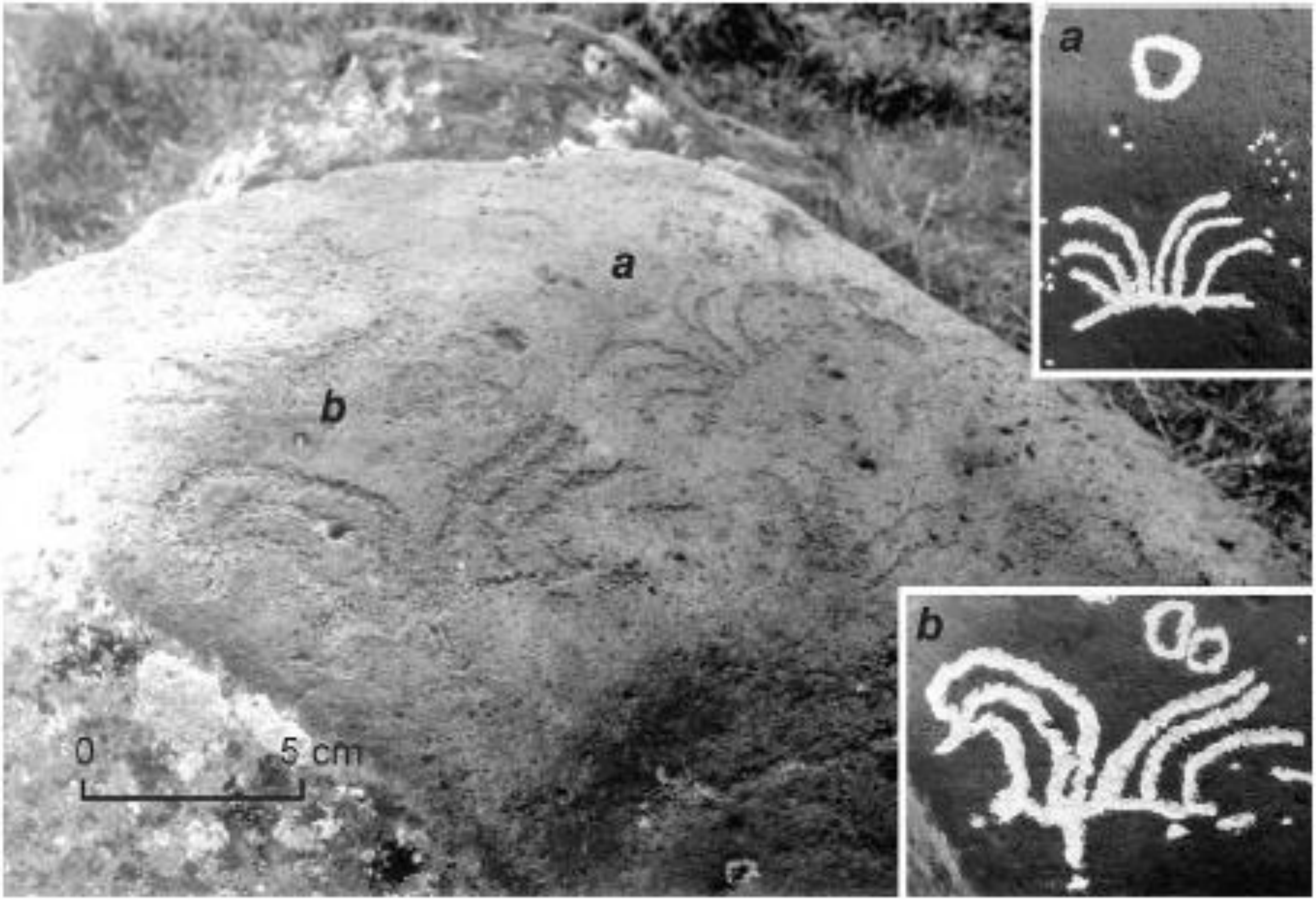
CZECH REPUBLIC
DEVELOPMENT COOPERATION

- Volcanoes, lavas
- Pyroclastic rocks
- Other volcaniclastic rocks
- Hazards and benefits




Karakhanian et al. 2002, JVGR



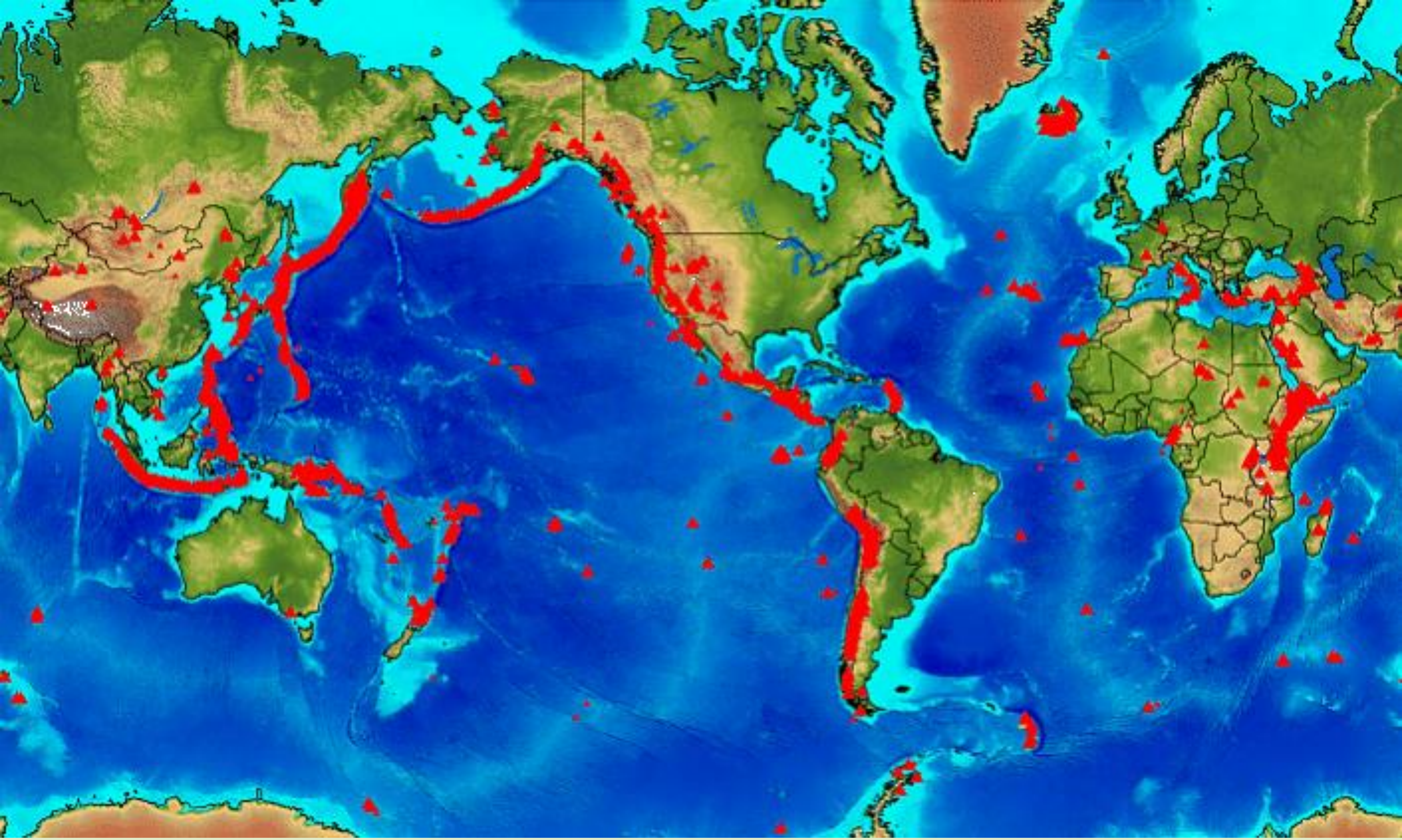
# Petroglyphs in Armenia, 5.000 BC

Source: internet

## Vesuvius, 79 AD

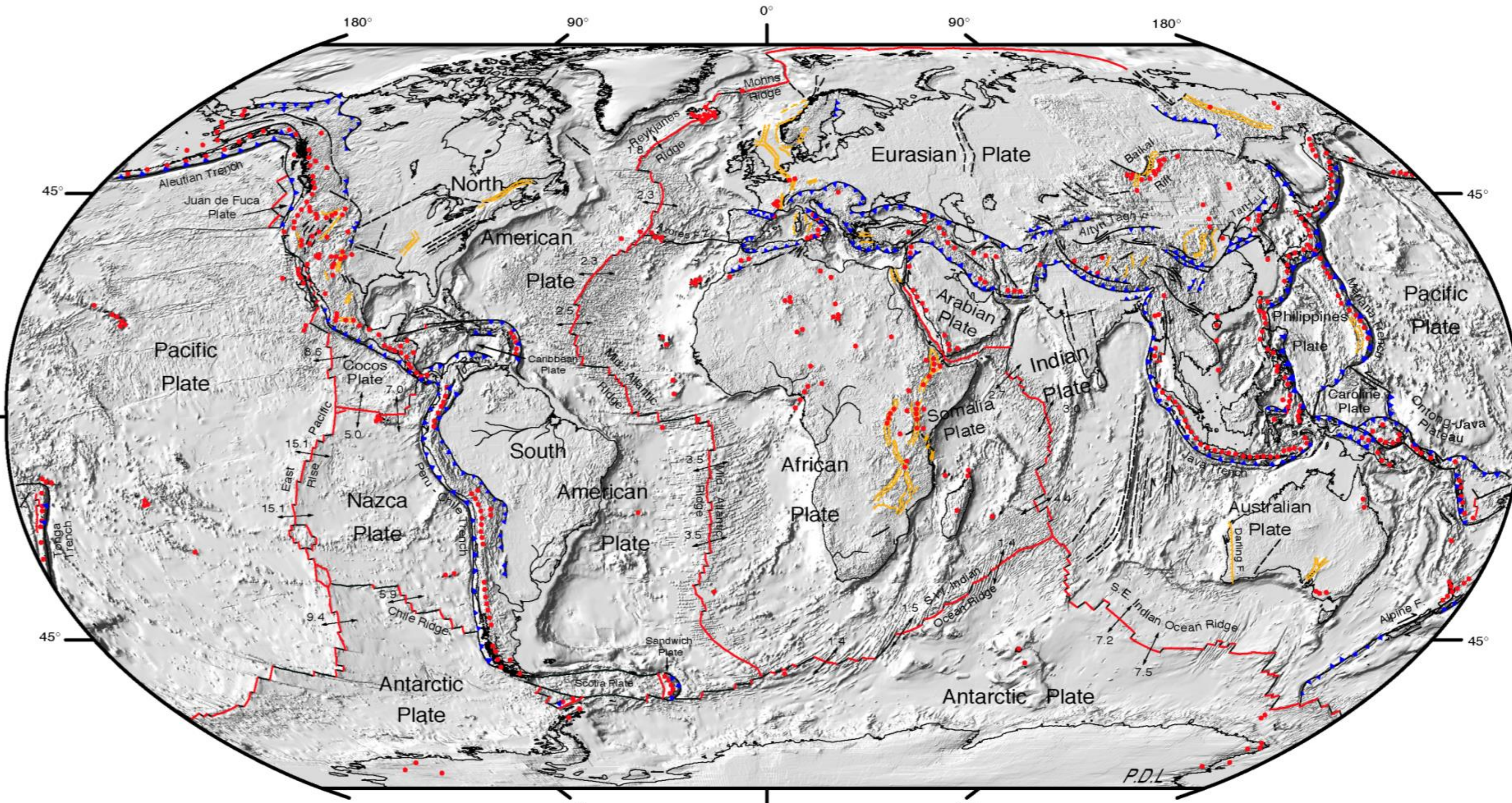
Source: internet

**Wall-paint in Chatal Huyuk, Turkey, 7.000 BC**



USGS

**Distribution of volcanoes on Earth is not random**
**Mainly follows plate-boundaries**




LEGEND

Actively-spreading ridges and transform faults

Total spreading rate, cm/year

Major active fault or fault zone; dashed where nature, location, or activity uncertain

Normal fault or rift; hachures on downthrown side

Reverse fault (overthrust, subduction zones); generalized; barbs on upthrown side

Volcanic centers active within the last one million years; generalized. Minor basaltic centers and seamounts omitted.

**DIGITAL TECTONIC ACTIVITY MAP OF THE EARTH**

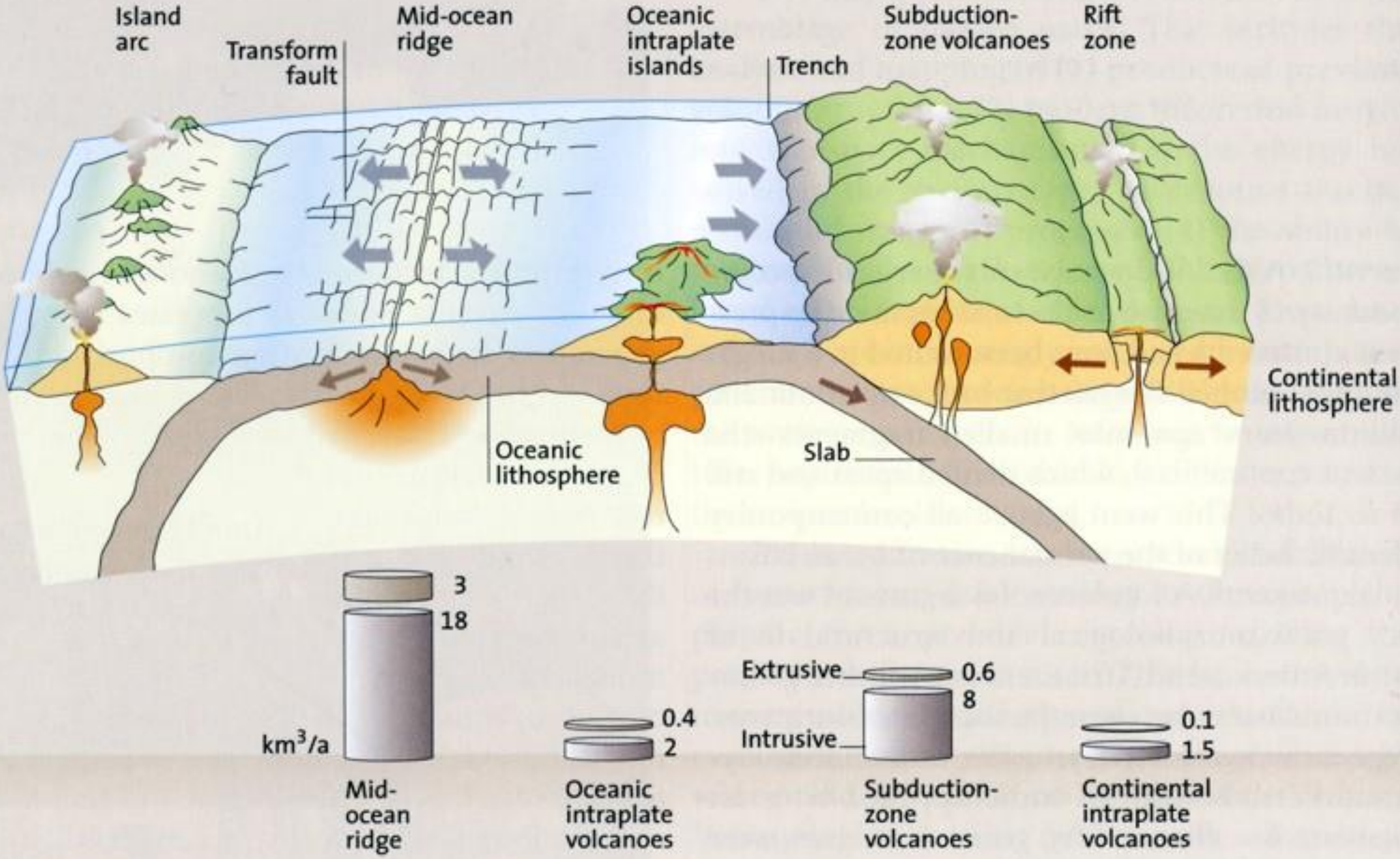
Tectonism and Volcanism of the Last One Million Years

**DTAM - 1**

NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771

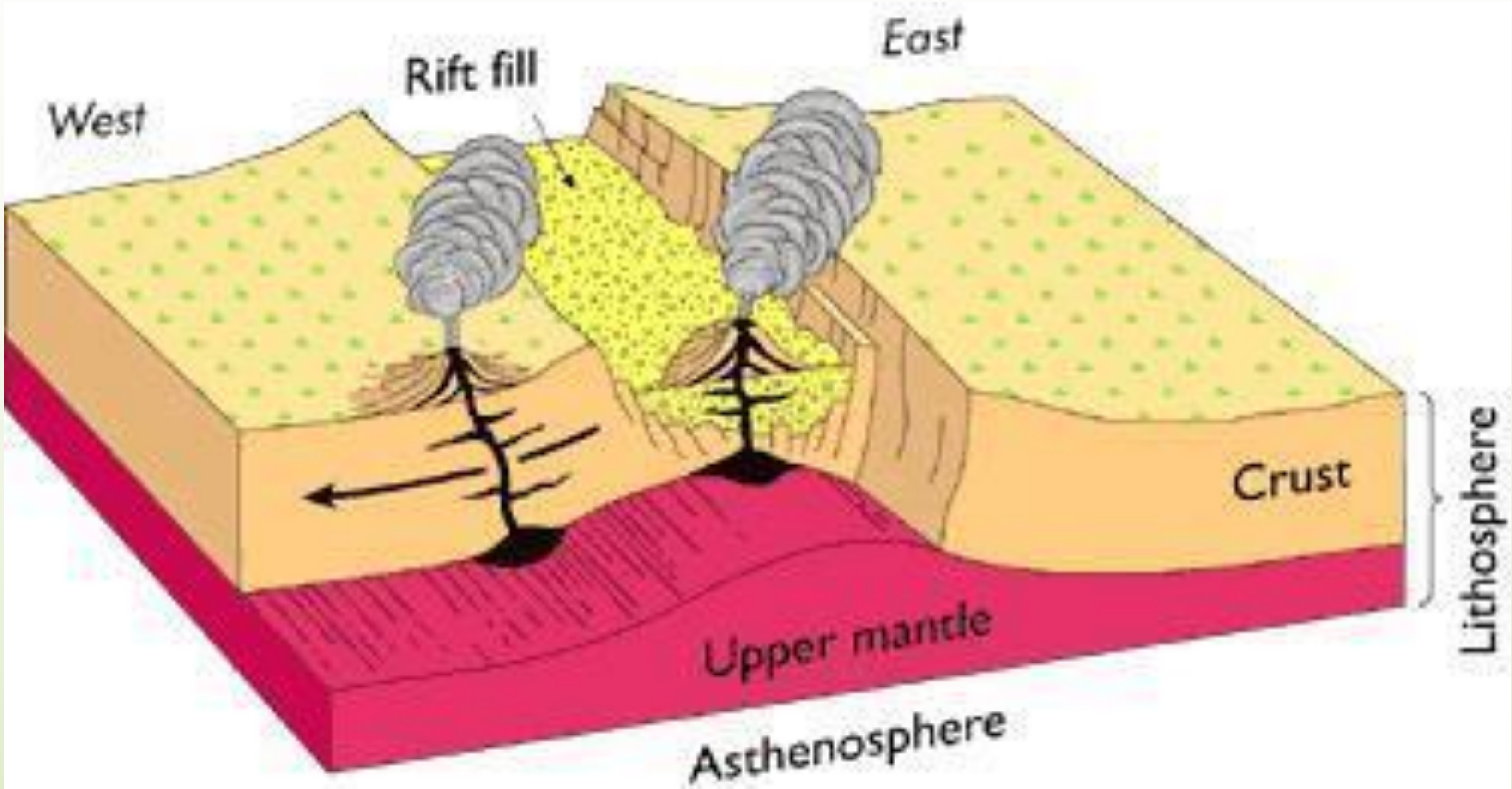
Robinson Projection
October 2002

G221.001




Schmincke: Volcanism, 2005

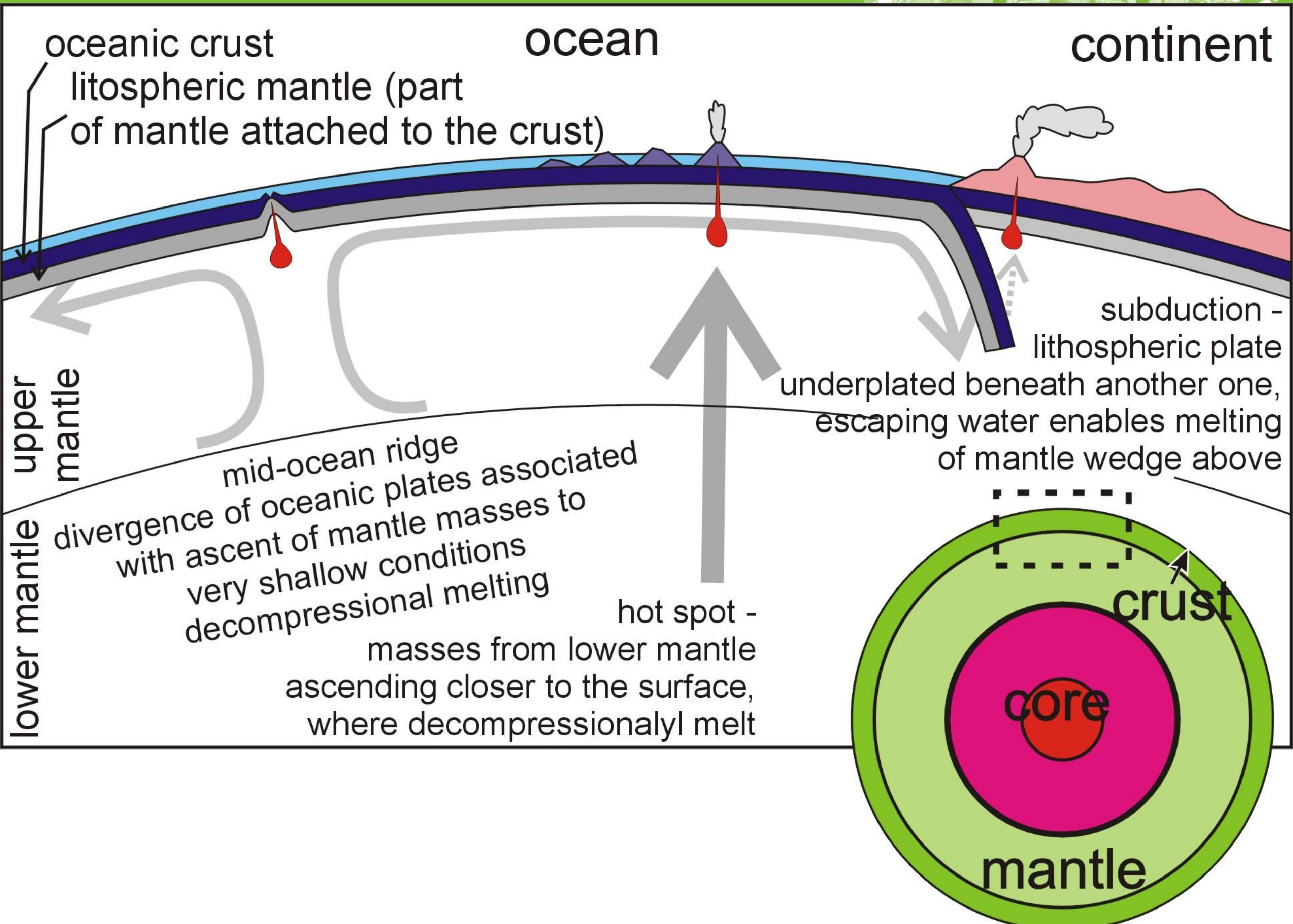
# Volcanoes occur where magmas ascend to the surface


East
Rift fill
West
Crust
Lithosphere
Upper mantle
Asthenosphere

Volcanoes need magma (molten rock) – how to get molten rock in the solid planet?

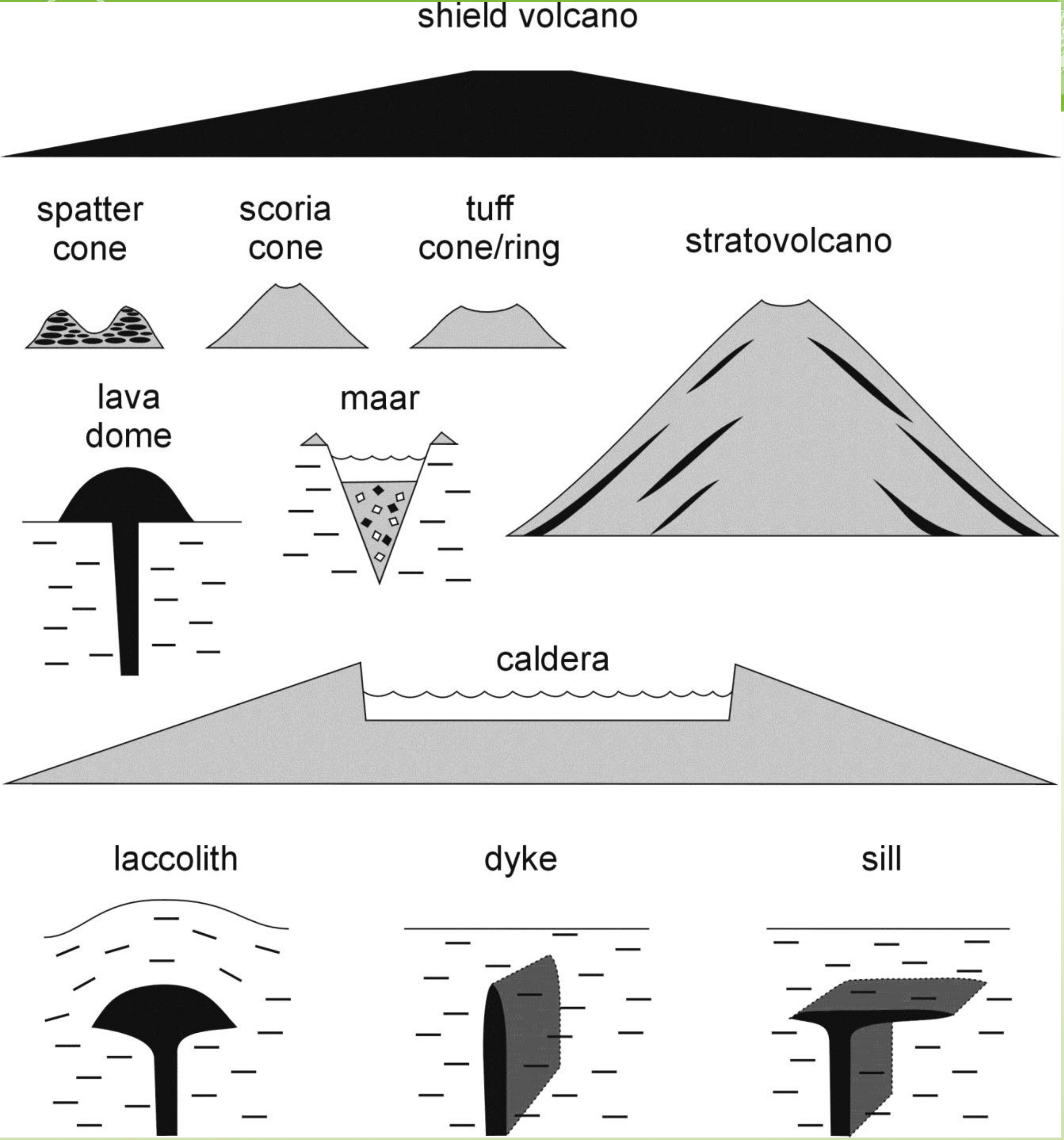
Temperature increases with depth, but the same with melting temperature

- Decompression:
  - hot spot
  - mid-ocean ridge
  - continental rift
- Hydratation:
  - subduction


oceanic crust
litospheric mantle (part
of mantle attached to the crust)
ocean
continent
upper mantle
lower mantle
mid-ocean ridge
divergence of oceanic plates associated
with ascent of mantle masses to
very shallow conditions
decompressional melting
hot spot -
masses from lower mantle
ascending closer to the surface,
where decompressionalyl melt
subduction -
lithospheric plate
underplated beneath another one,
escaping water enables melting
of mantle wedge above
crust
core
mantle

# Types of volcanoes

- Polygenetic volcanoes
  - Shield volcano
  - Stratovolcano
  - Caldera
- Monogenetic volcanoes
  - Spatter cone
  - Scoria cone
  - Tuff cone/ring
  - Maar
  - Lava dome (-complex)



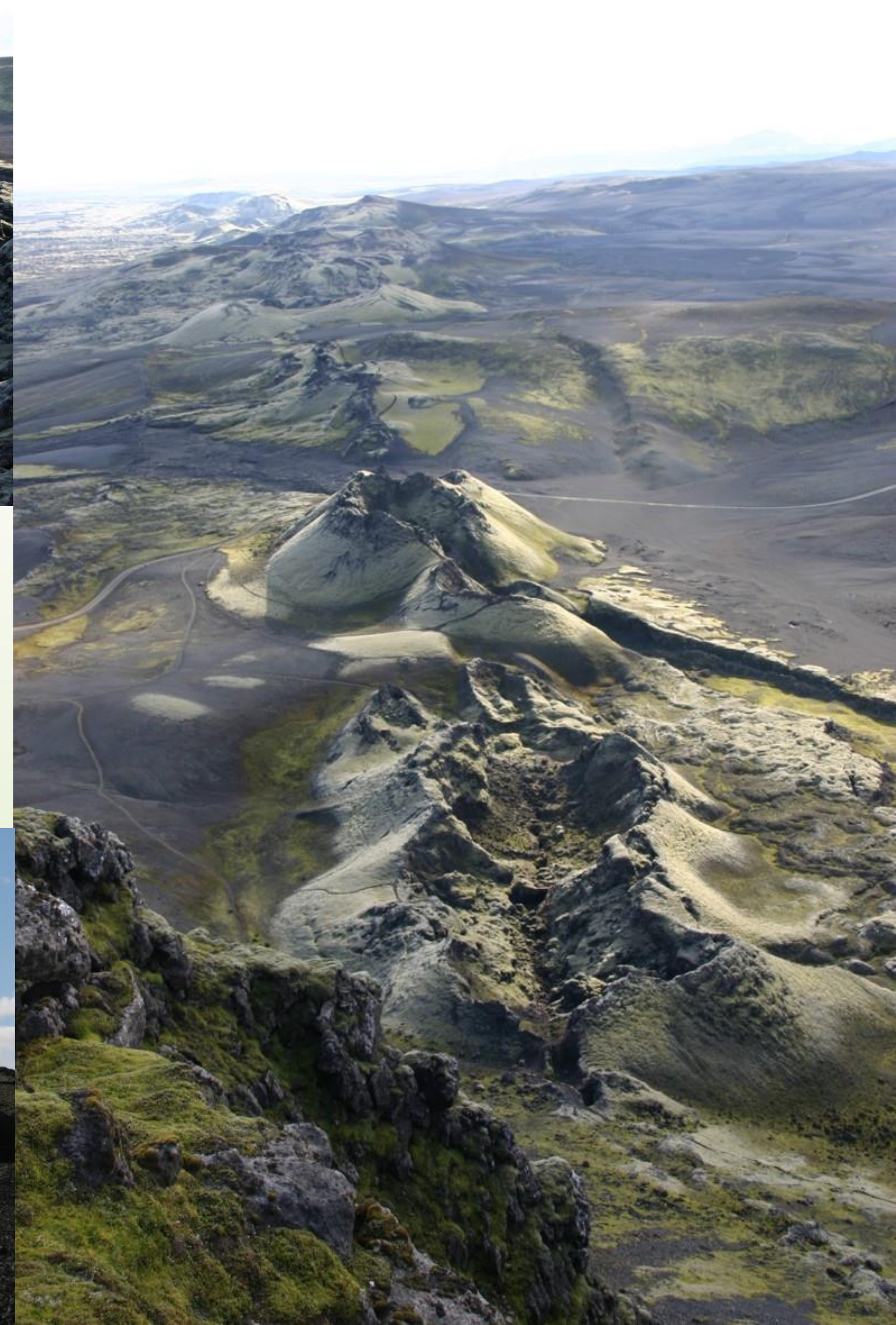

- Magma supply
- Life-span
- Physical properties of magma
- Environment


**Stratovolcanoes: San Miguel (El Salvador), Fuji (Japan)**

**Shield volcano: Mauna Loa (Hawaii),** source:internet

Caldera: Coatepeque (El Salvador)

# Spatter and scoria cones: Iceland



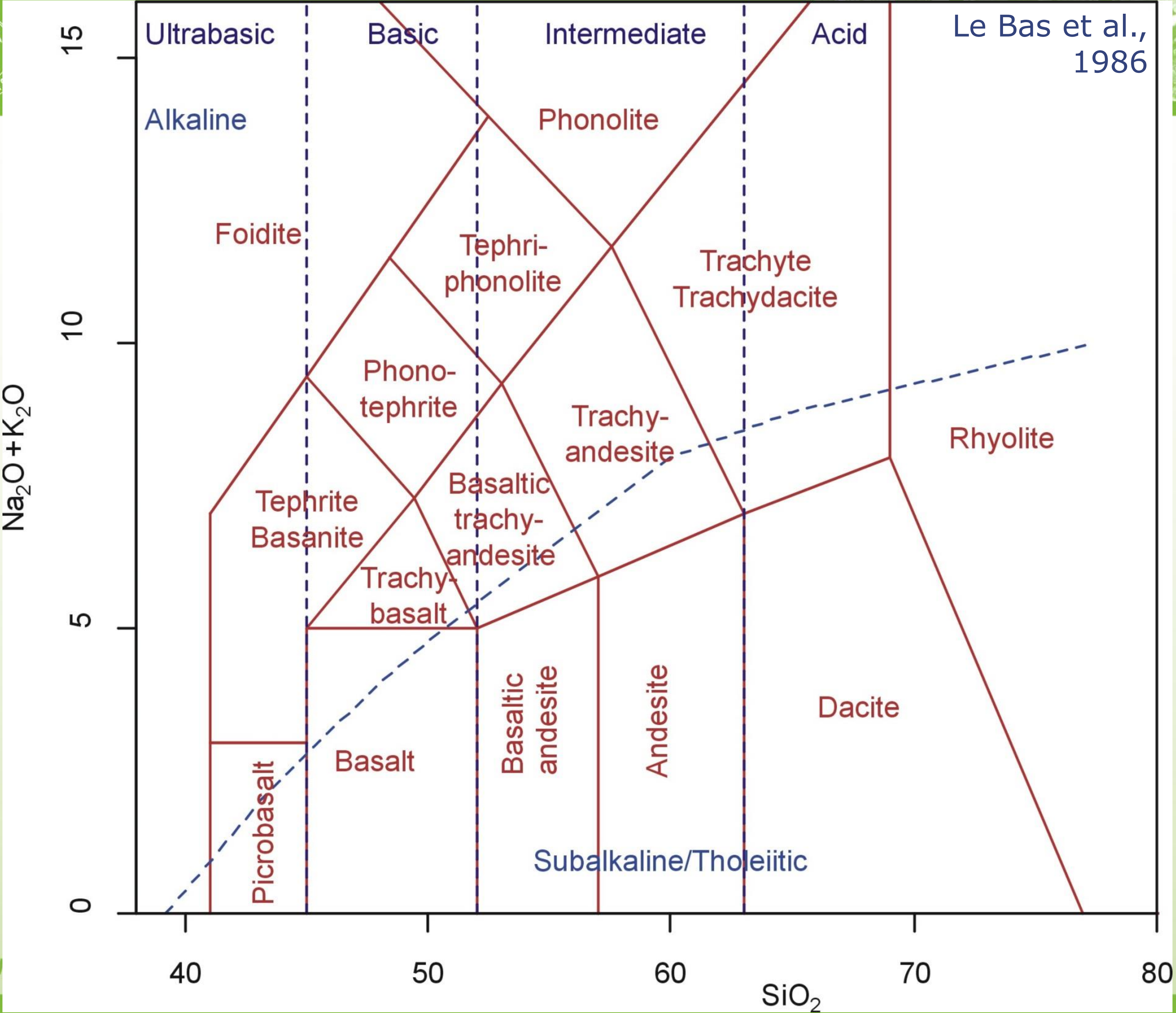
## Lava Dome: Boren (Czech Republic)

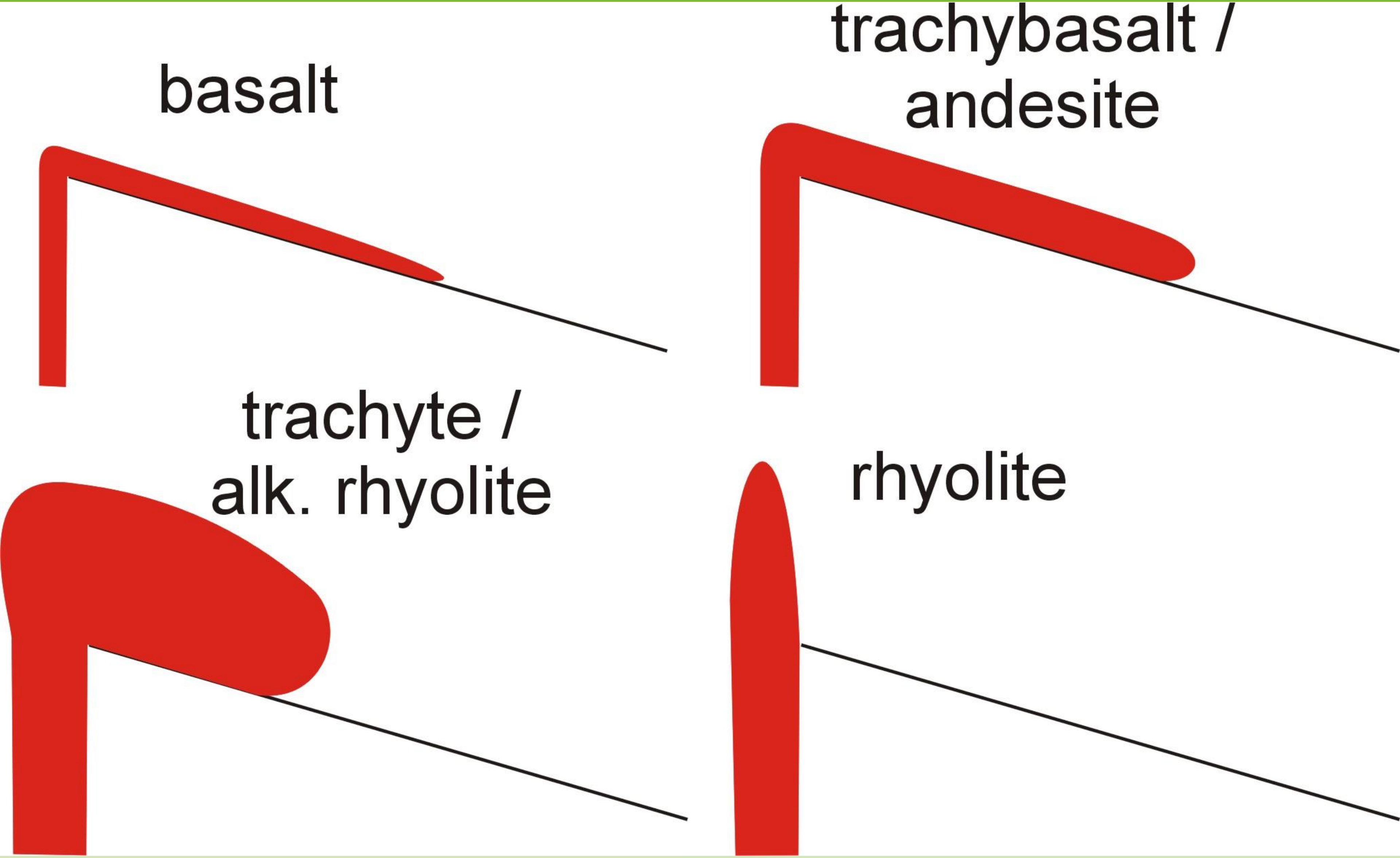
## Maar: Lake Shetan (Ethiopia)

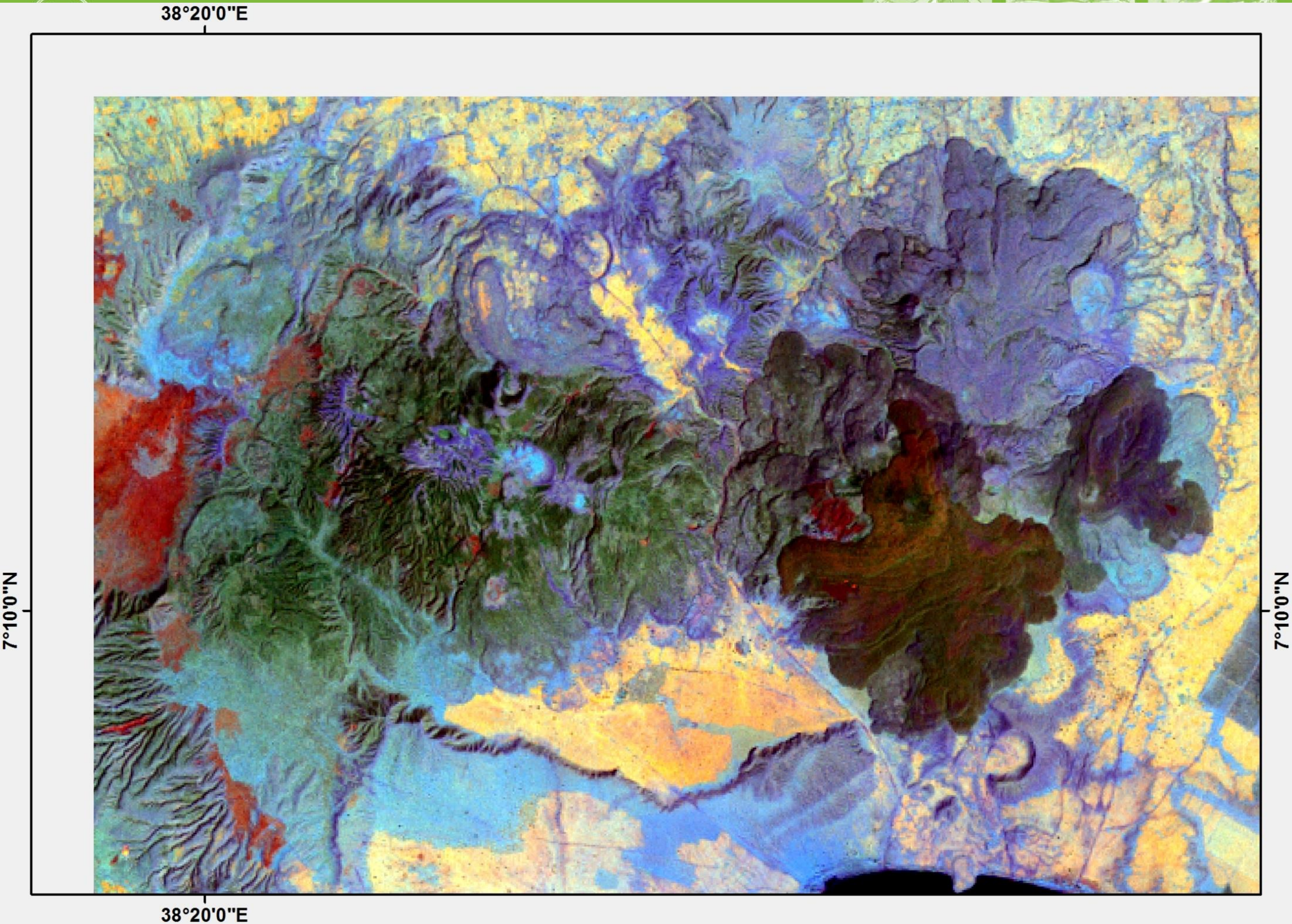

# Viscosity – crucial point for magma behaviour

Viscosity depends on:

- Composition (Si, Al – frame-builders; Mg, Ca, Na, K – frame-modifiers)
- Temperature
- Crystals, vesicles


Le Bas et al., 1986
Ultrabasic
Basic
Intermediate
Acid
Alkaline
Phonolite
Foidite
Tephri-phonolite
Trachyte Trachydacite
Phono-tephrite
Trachy-andesite
Rhyolite
Tephrite Basanite
Basaltic trachy-andesite
Trachy-basalt
Basaltic andesite
Andesite
Dacite
Basalt
Picrobasalt
Subalkaline/Tholeiitic
$Na_2O+K_2O$
$SiO_2$
0
5
10
15
40
50
60
70
80

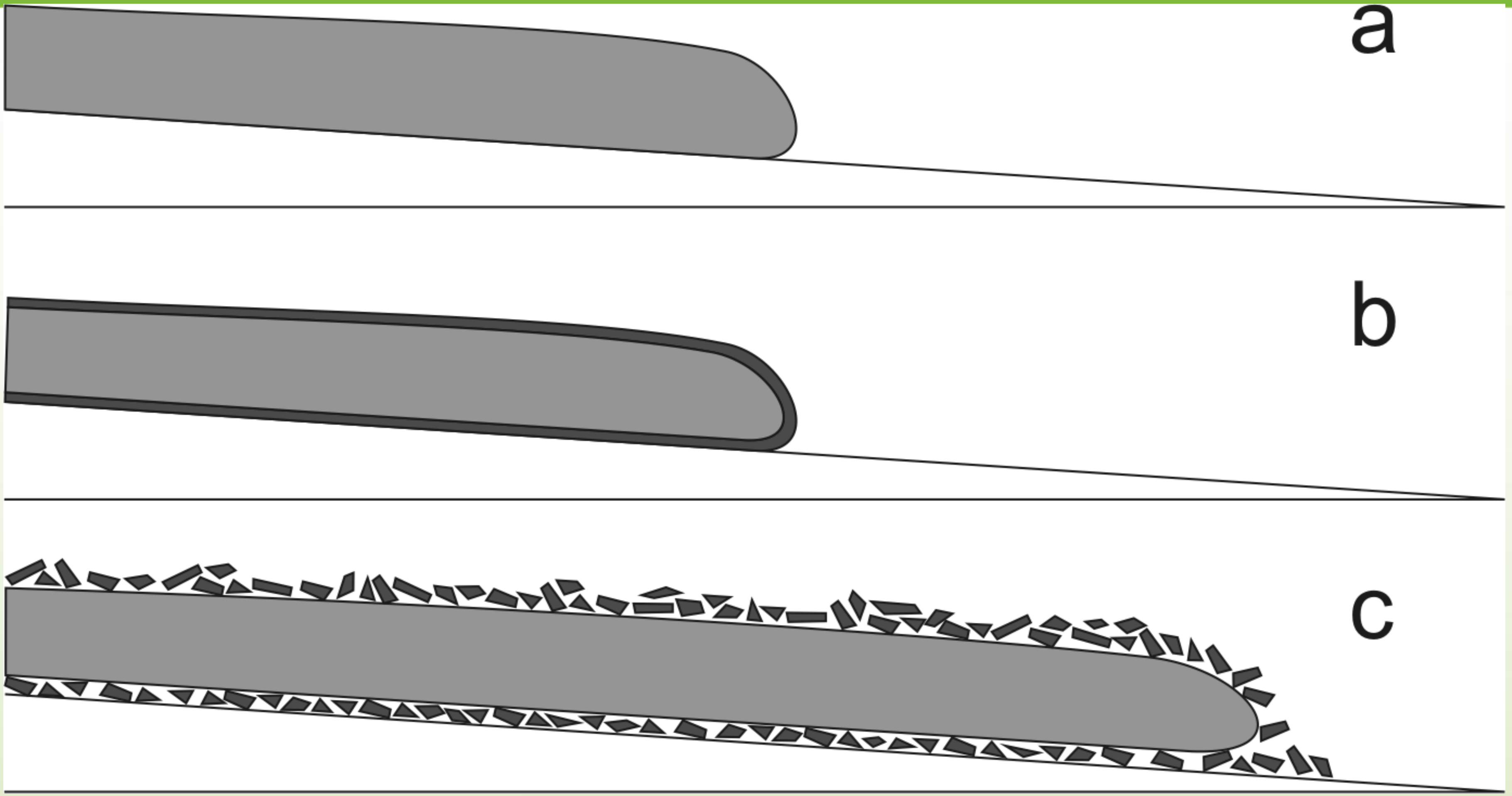

basalt
trachybasalt / andesite
trachyte / alk. rhyolite
rhyolite


38°20'0"E
7°10'0"N
7°10'0"N
38°20'0"E

# Lava tubes (tunnels)

- when still molten lava flows out of the solidified crust
- thermal insultation of lava
- effective proces to get lava far from its source

# Autoclastic fragmentation of lavas




**a) flowing lava with crust (b) formed on the chilled margins. c) the crust cannot deform and breaks**

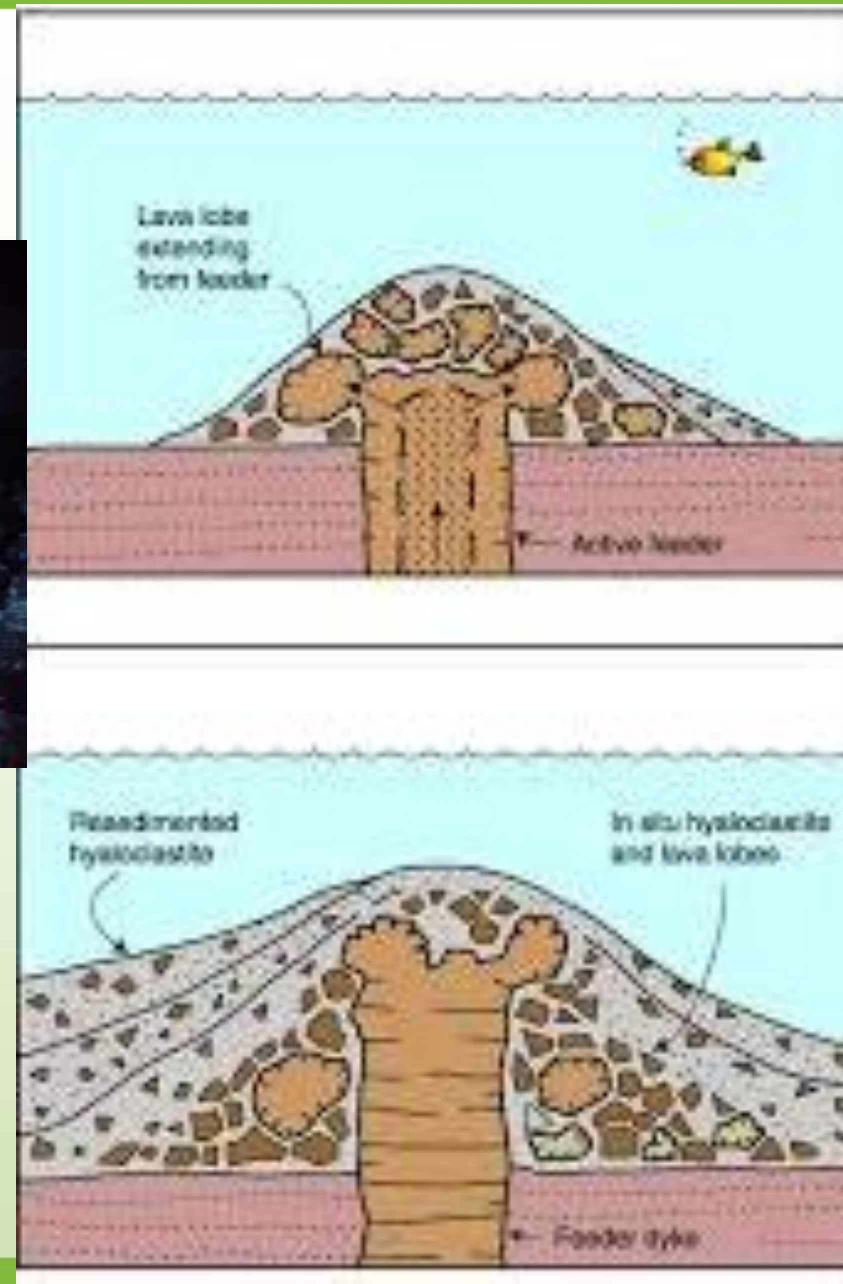
autoclastic breccias are:
- monomict (clasts of associated lava)
- clast-supported (empty voids)
- in situ (only angular clasts)
- un-sorted, spaces between clasts can be later filled with pyroclastic or sedimentary material

# Columnar jointing

- due to thermal contraction of lava
- oriented parallel to thermal gradient axes, perpendicular to cooling surfaces and fronts
- the original shape of lava body can be interpreted from arrangement of columns

# Lavas in water

Source: internet



- supercooling
- lobe-shaped “pillows“ with chilled margins
- imperfect crystallization – hyaline texture
- pillows have radial (+ concentric cracks)
- pillow lavas associated with hyaloclastites
- hyaline glass is unstable – turns to clay-minerals

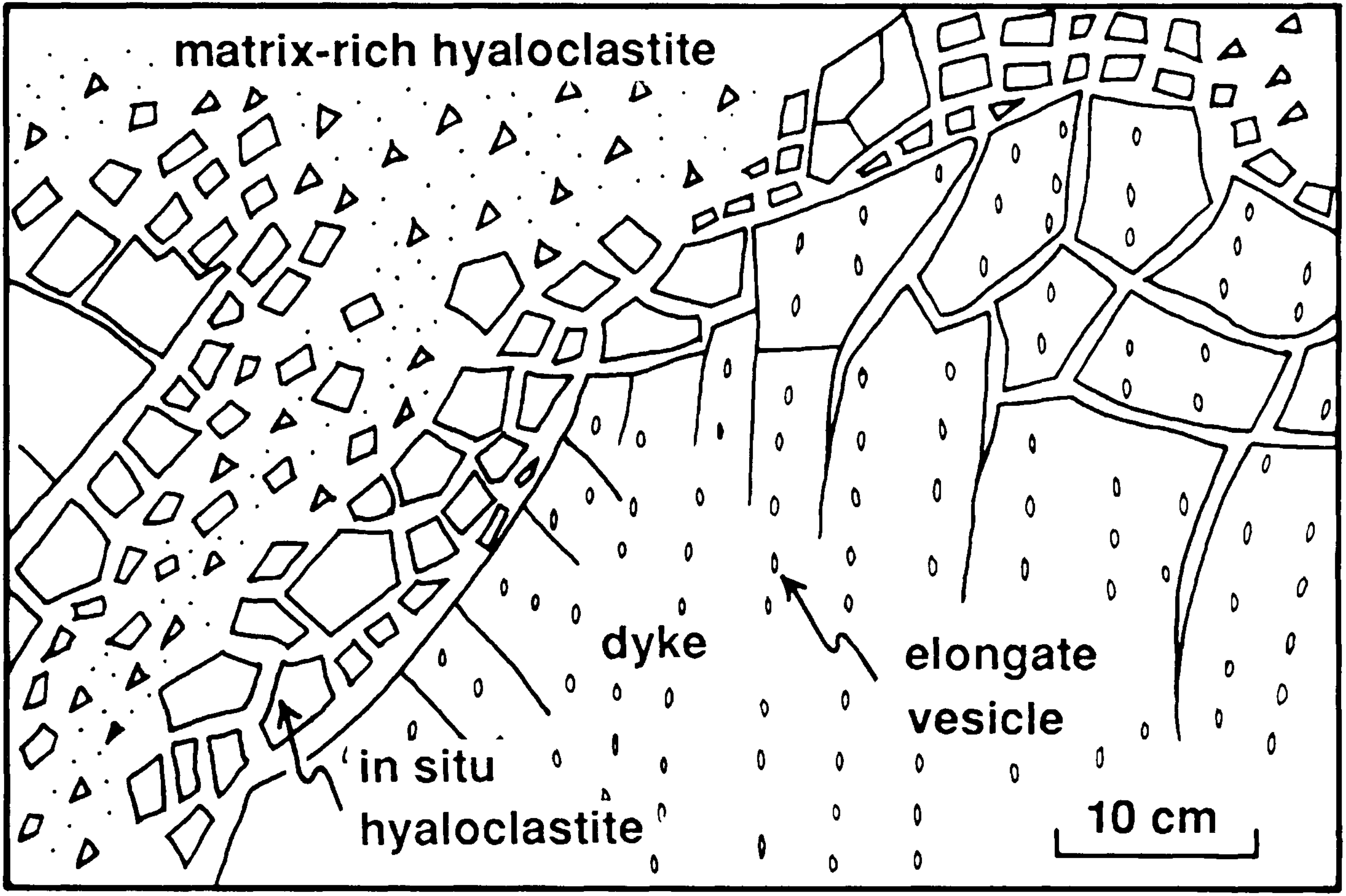
# Hyaloclastites

**- fragmentation due to shock-contraction (lava-water interaction)**

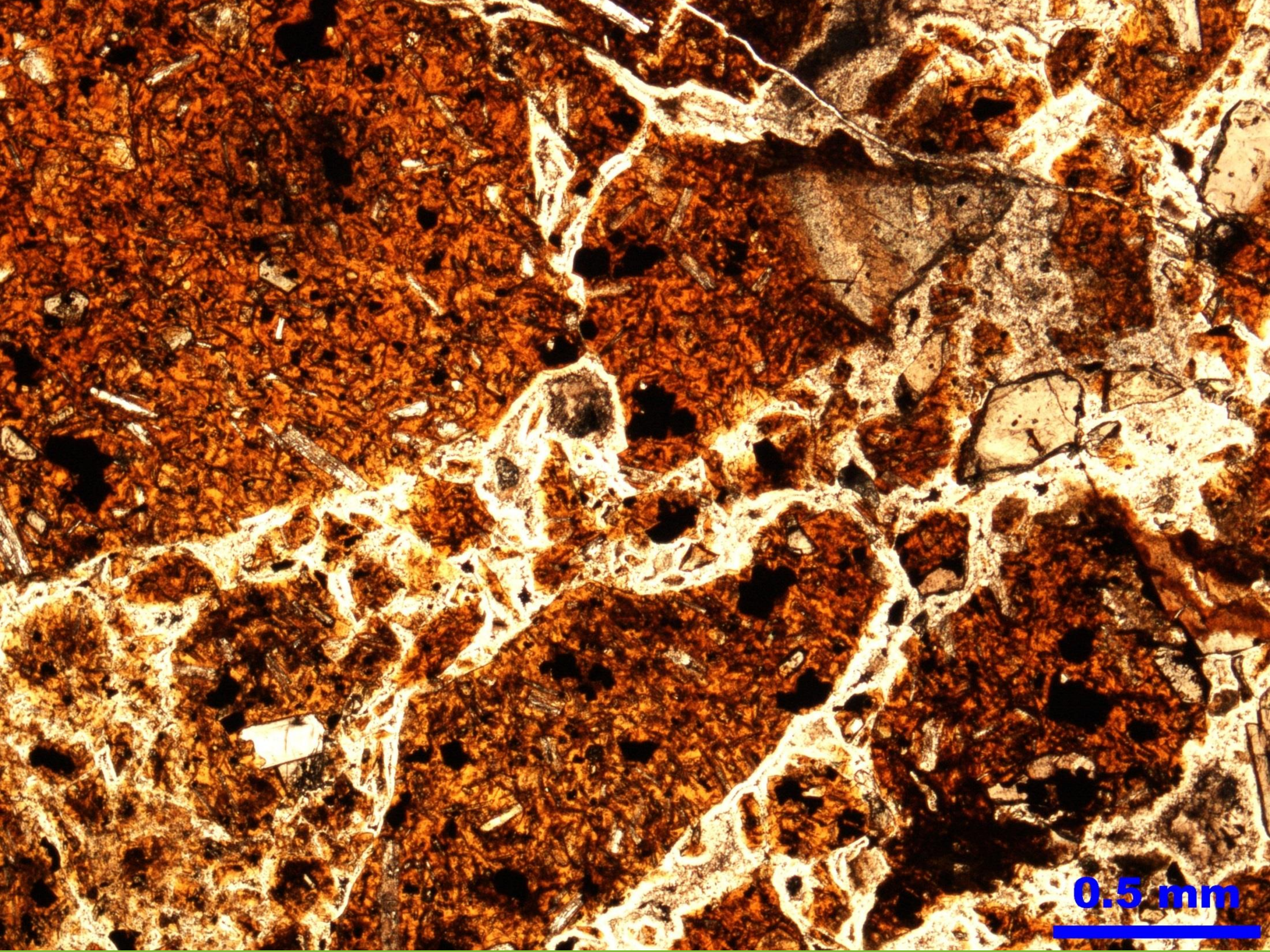
- non-vesiculated

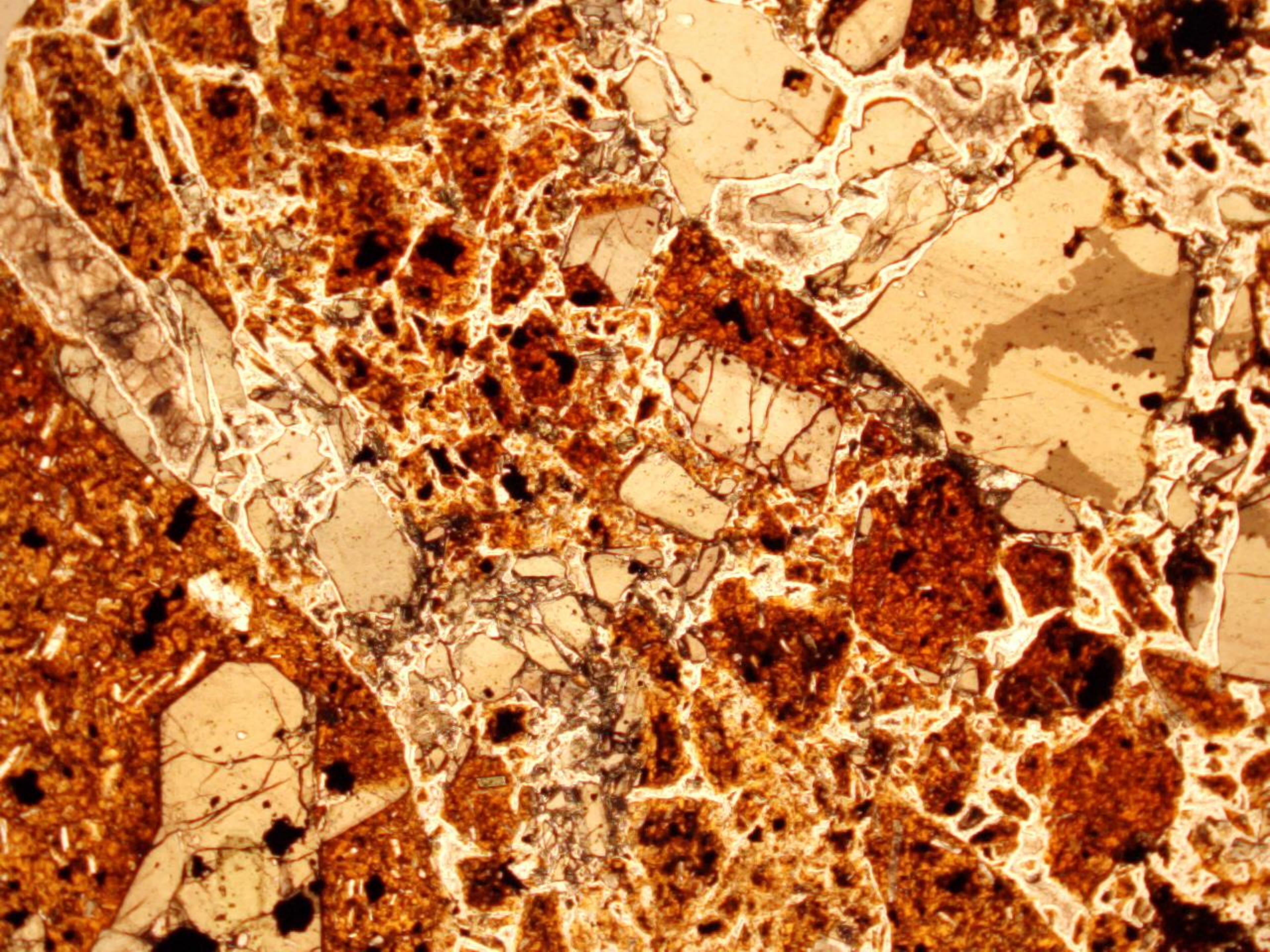
- in-situ: unsorted, clast-supported, jig-saw fit of fractures, angular fragments

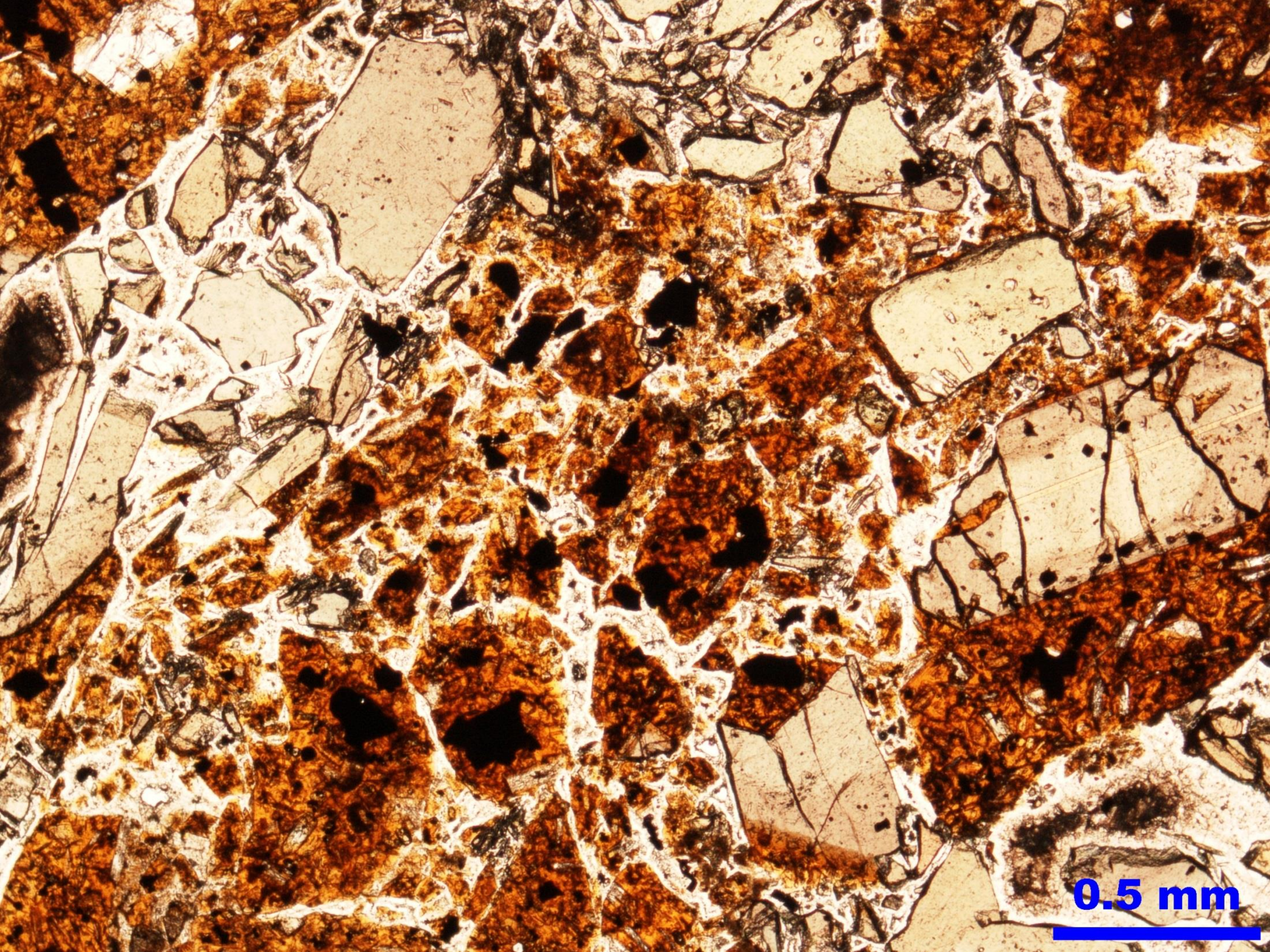
- redeposited: increasing sorting and rounding of clasts, sedimentary structures



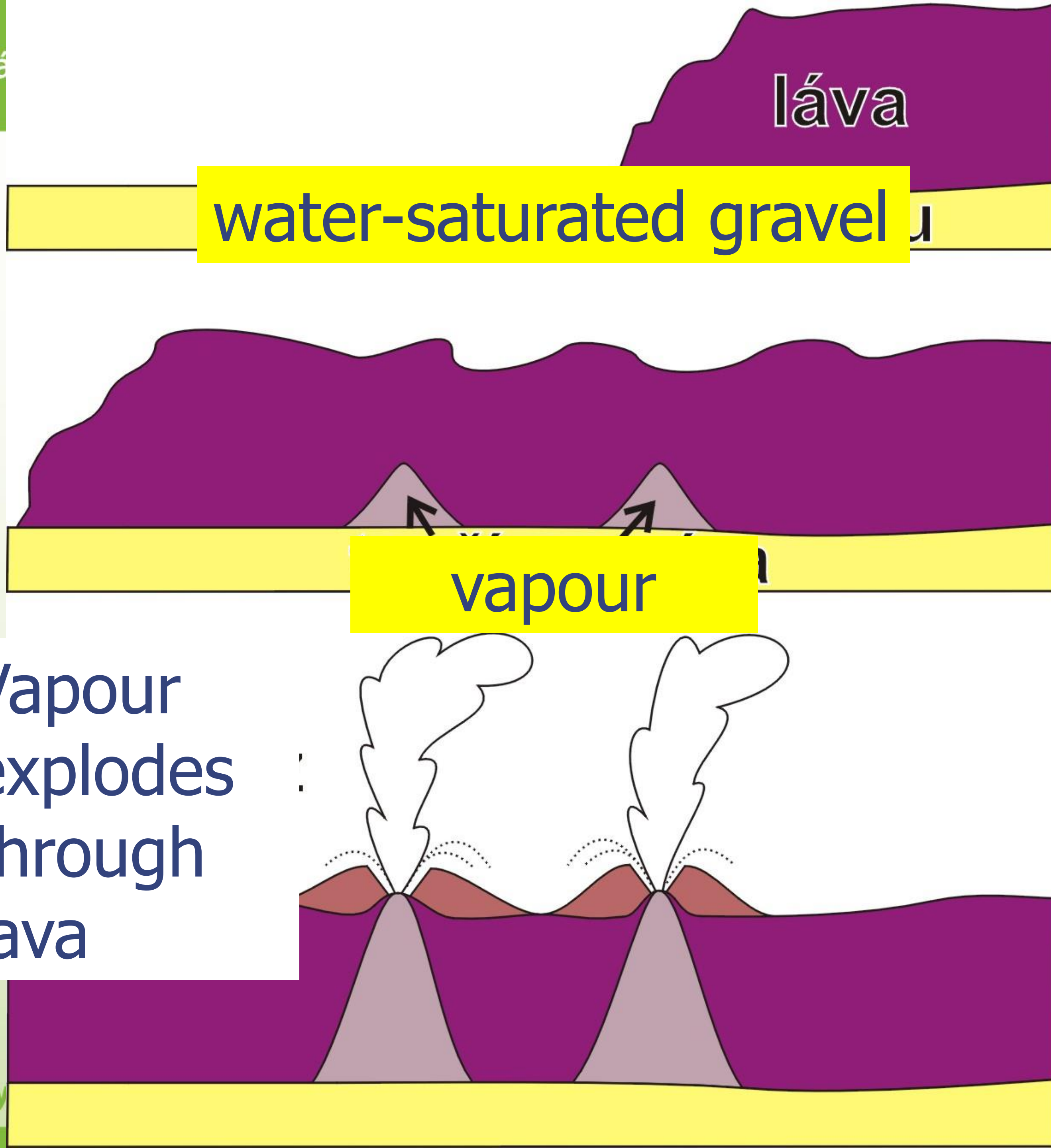

McPhie et al. 2002, CODES


0.5 mm




0.5 mm

# Root-less eruptions




Vapour explodes through lava