Geotektonik – Global Tectonics

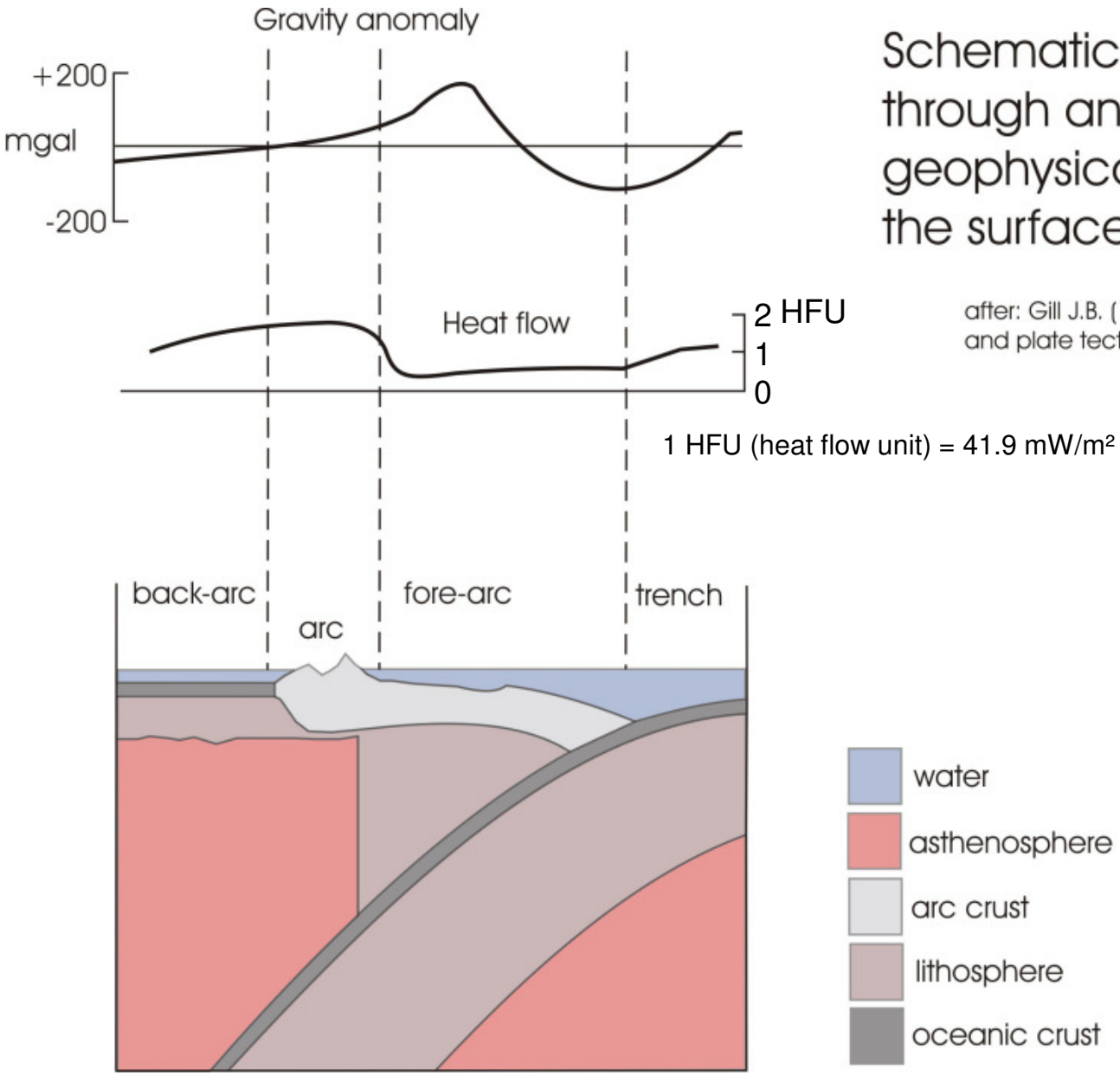
CHAPTER 9

convergent plate boundaries

arc magmatism

the **magmatic arc** is located about 100 to 150 km above the Benioff zone; the width of the arc-trench gap thus depends on the inclination of the subducted slab

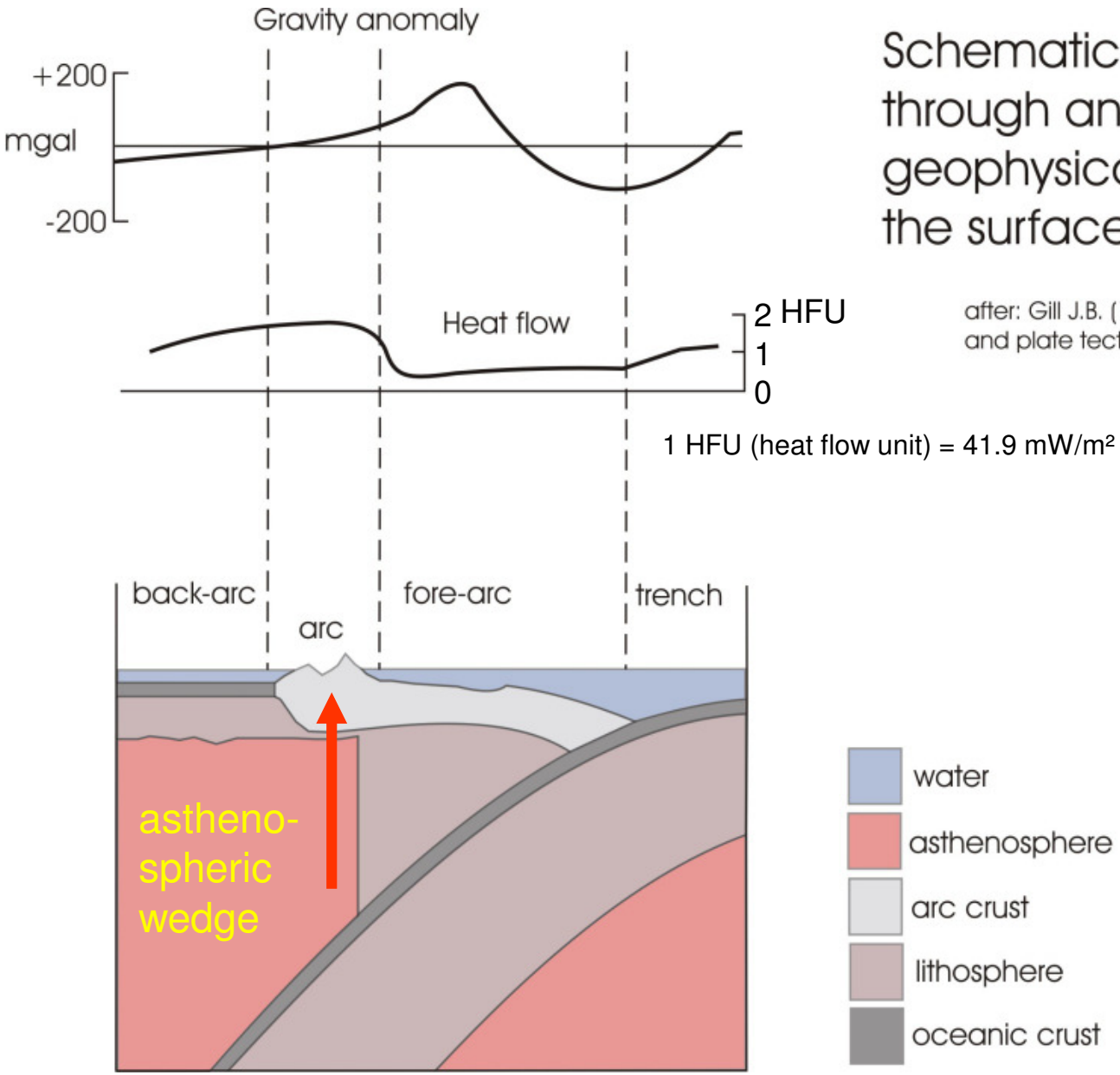
Schematic cross section through an island arc and geophysical signature at the surface



after: Gill J.B. (1981): Orogenic andesites and plate tectonics. Springer (Berlin), 358 pp.

1 HFU (heat flow unit) = 41.9 mW/m²

Schematic cross section through an island arc and geophysical signature at the surface



after: Gill J.B. (1981): Orogenic andesites and plate tectonics. Springer (Berlin), 358 pp.

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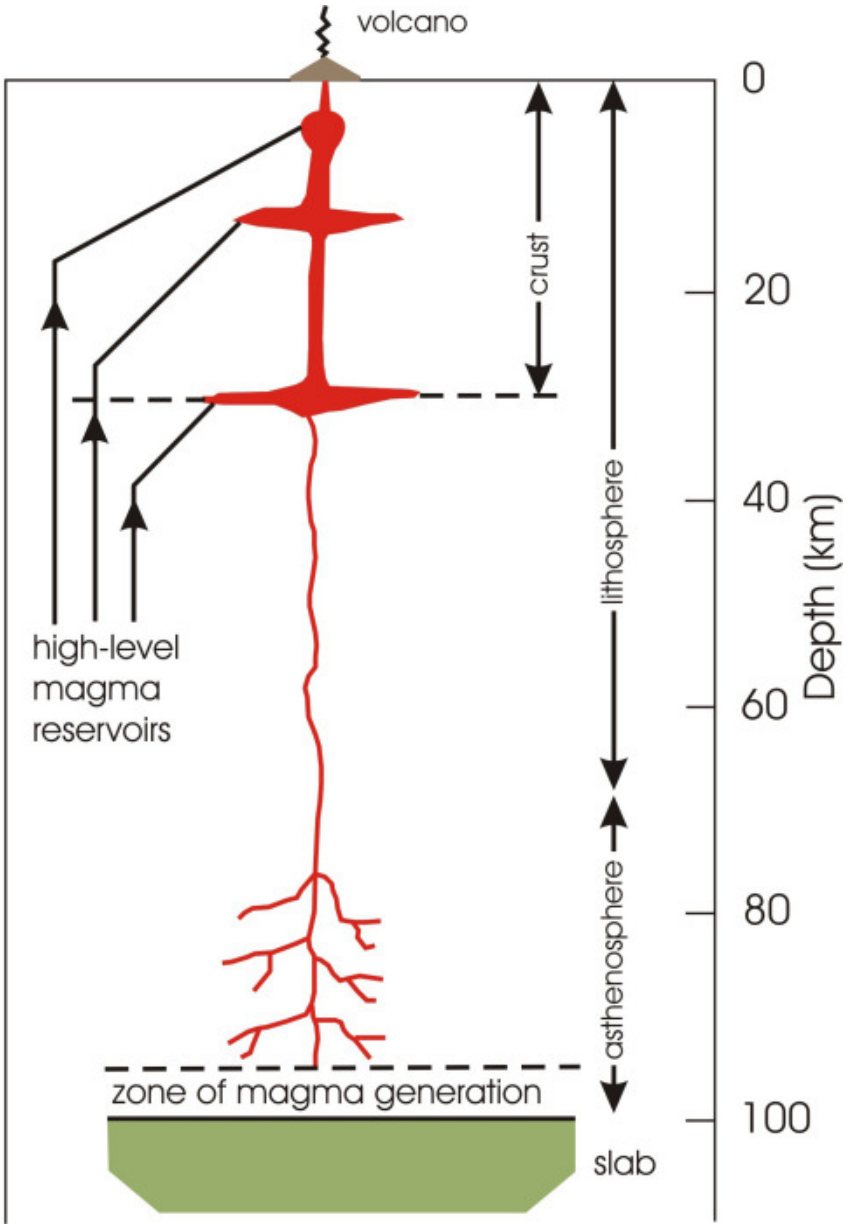
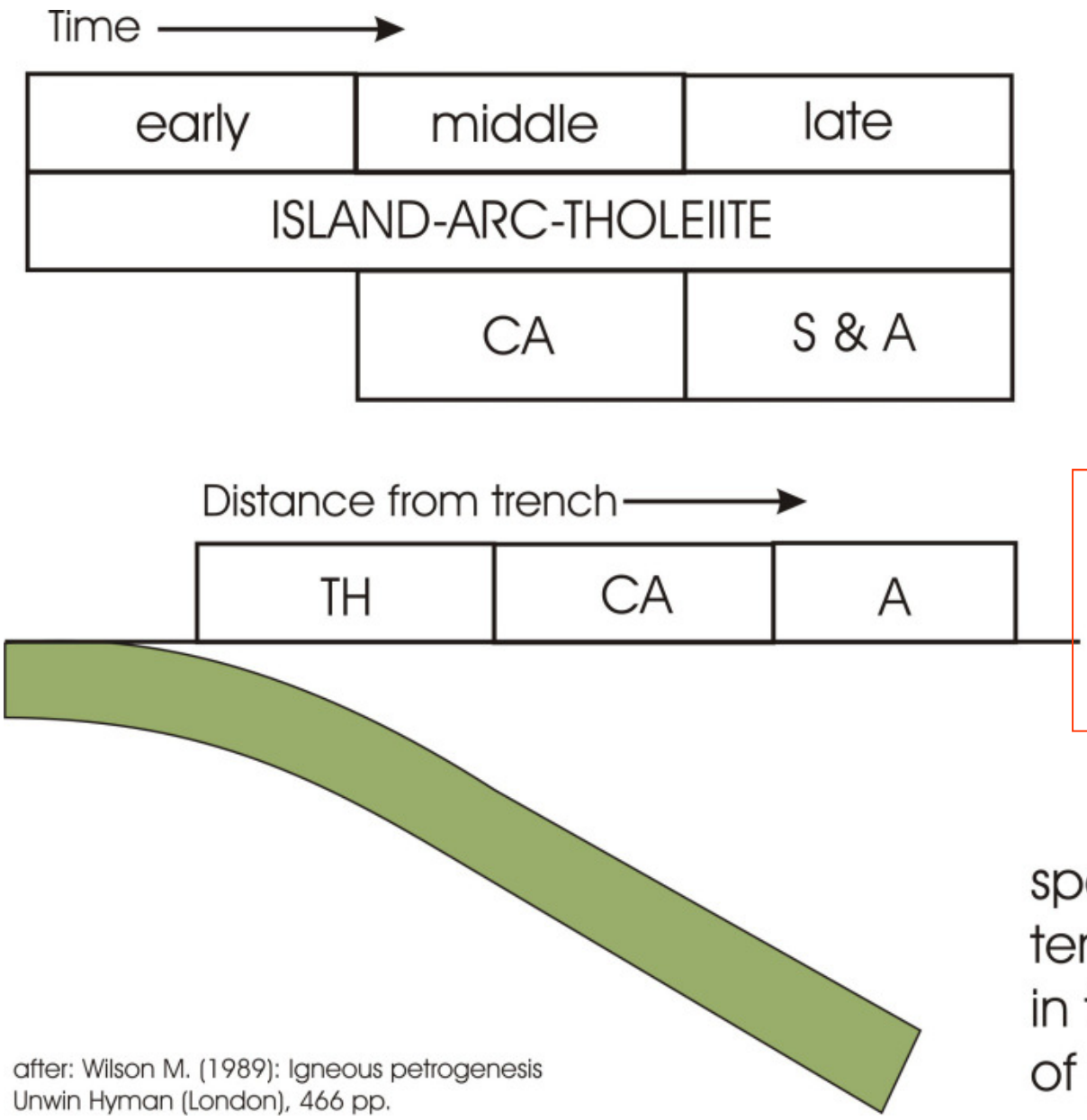
Magma reservoir systems beneath a mature island arc

after: Gill J.B. (1981): Orogenic andesites and plate tectonics. Springer (Berlin), 358 pp.



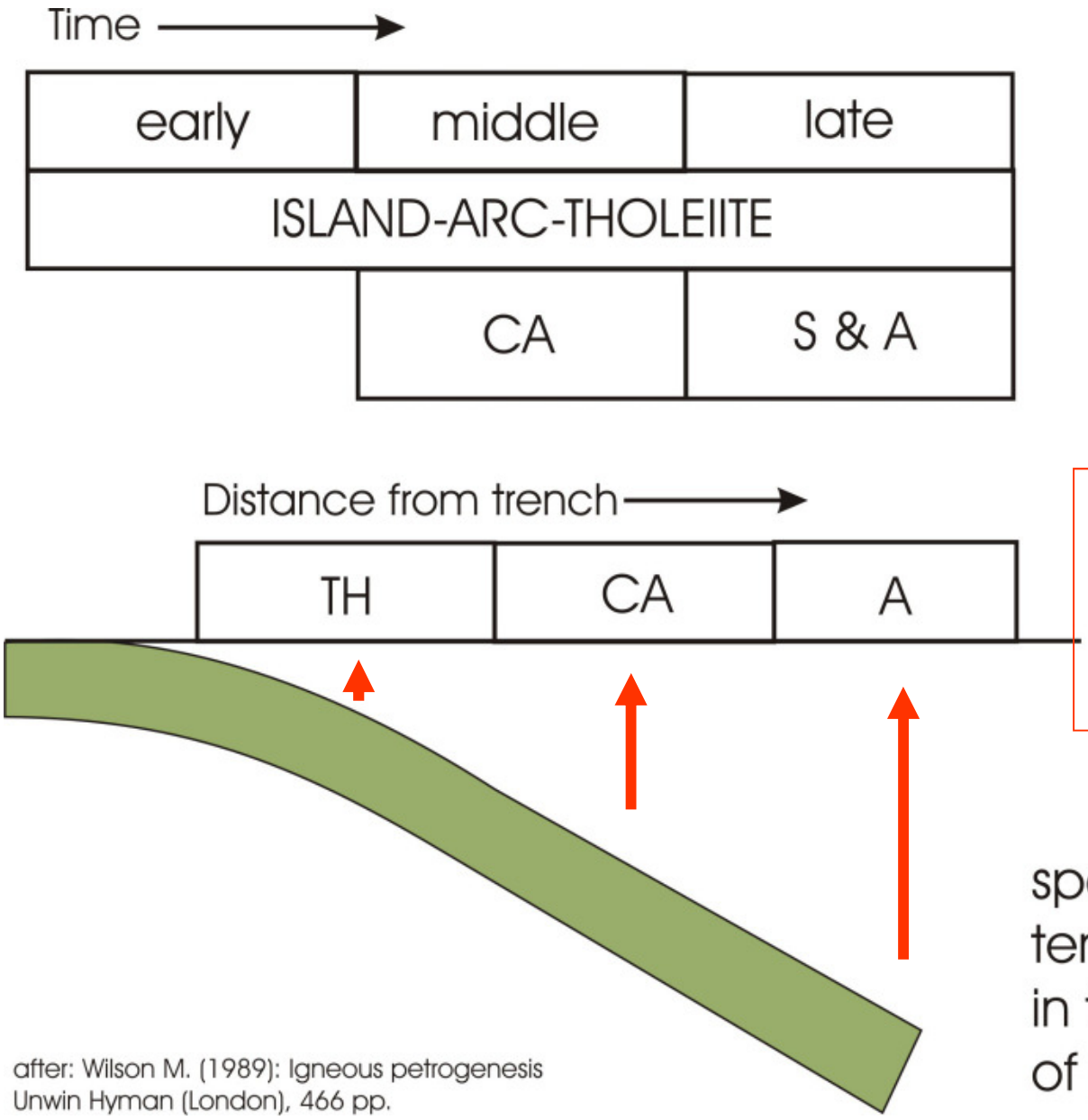


after: Wilson M. (1989): Igneous petrogenesis
Unwin Hyman (London), 466 pp.

evolution in time

composition as a function of depth of source region

spatial and temporal variations in the composition of island arc magmas



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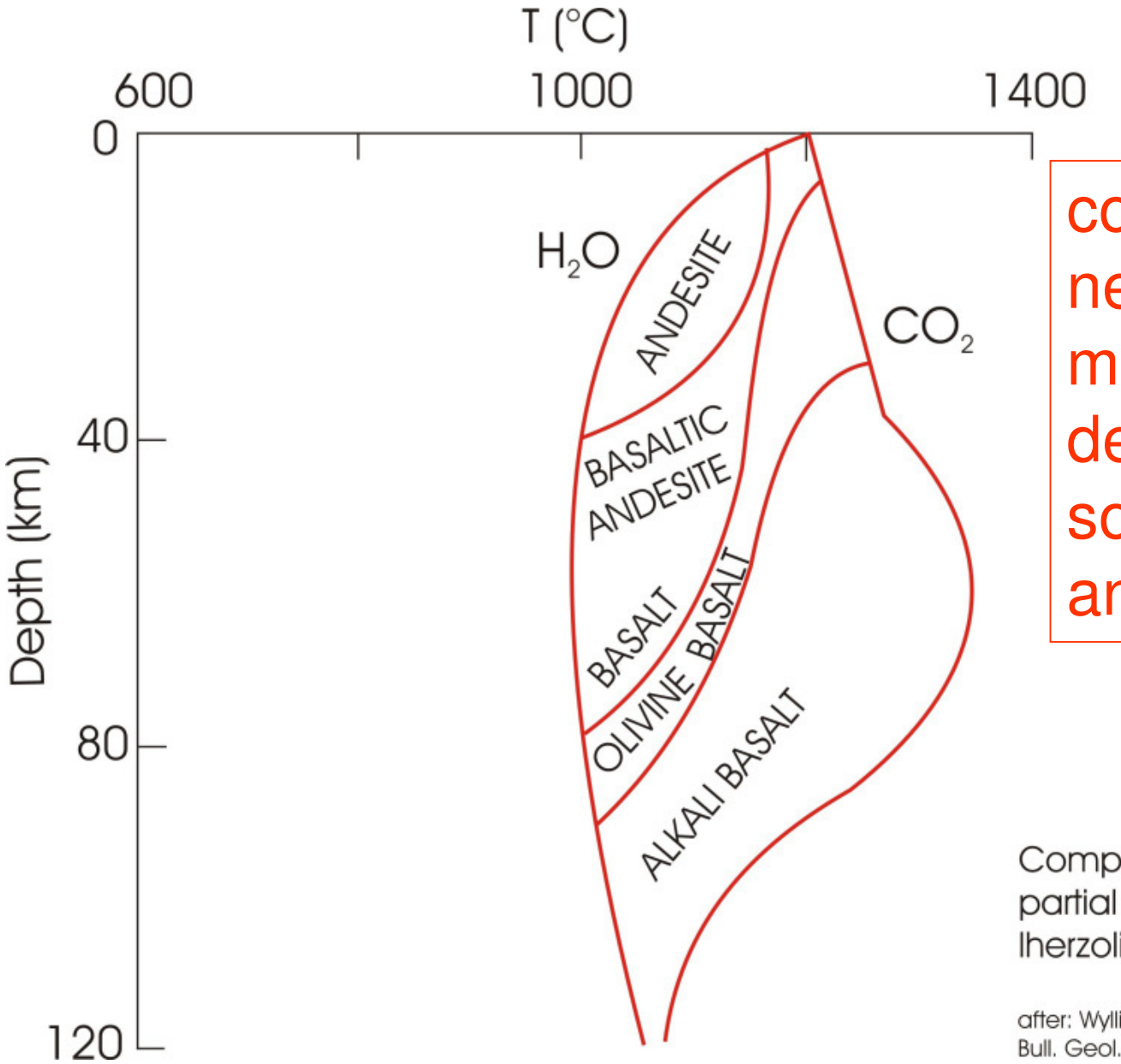


composition of near-solidus mantle melts dependent on source region and volatiles

Composition of near-solidus partial melts in the system lherzolite-H_2O-CO_2

after: Wyllie P.J. (1982)
Bull. Geol. Soc. Am. 93: 468-476

arc volcanism is characterized by

- intermediate to silicic magma (e.g. andesites and dacites) in addition to basalt
- explosive Plinian eruptions
- stratovolcanoes (composite or complex volcanoes) with a spacing between 50 and 100 km

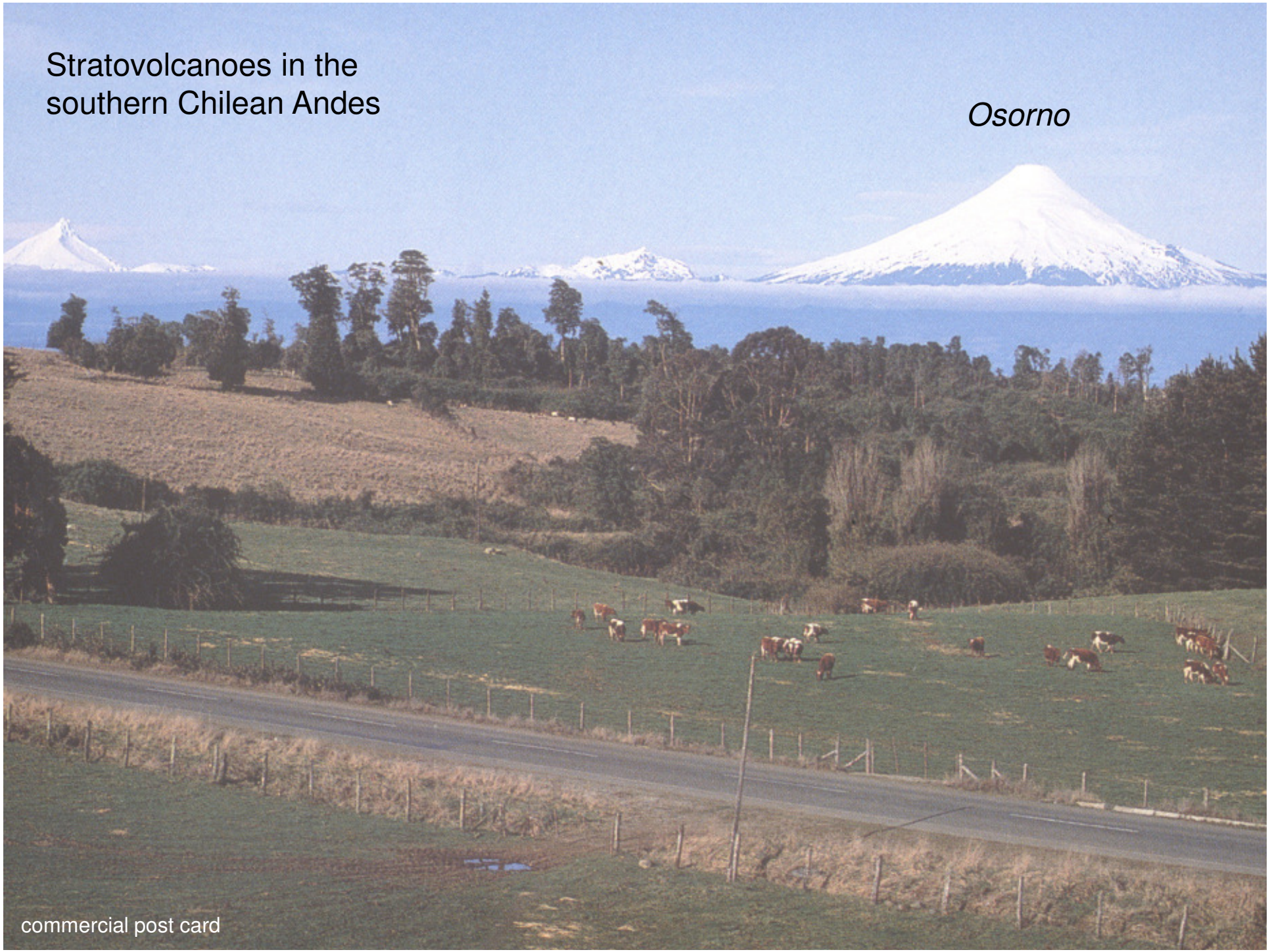
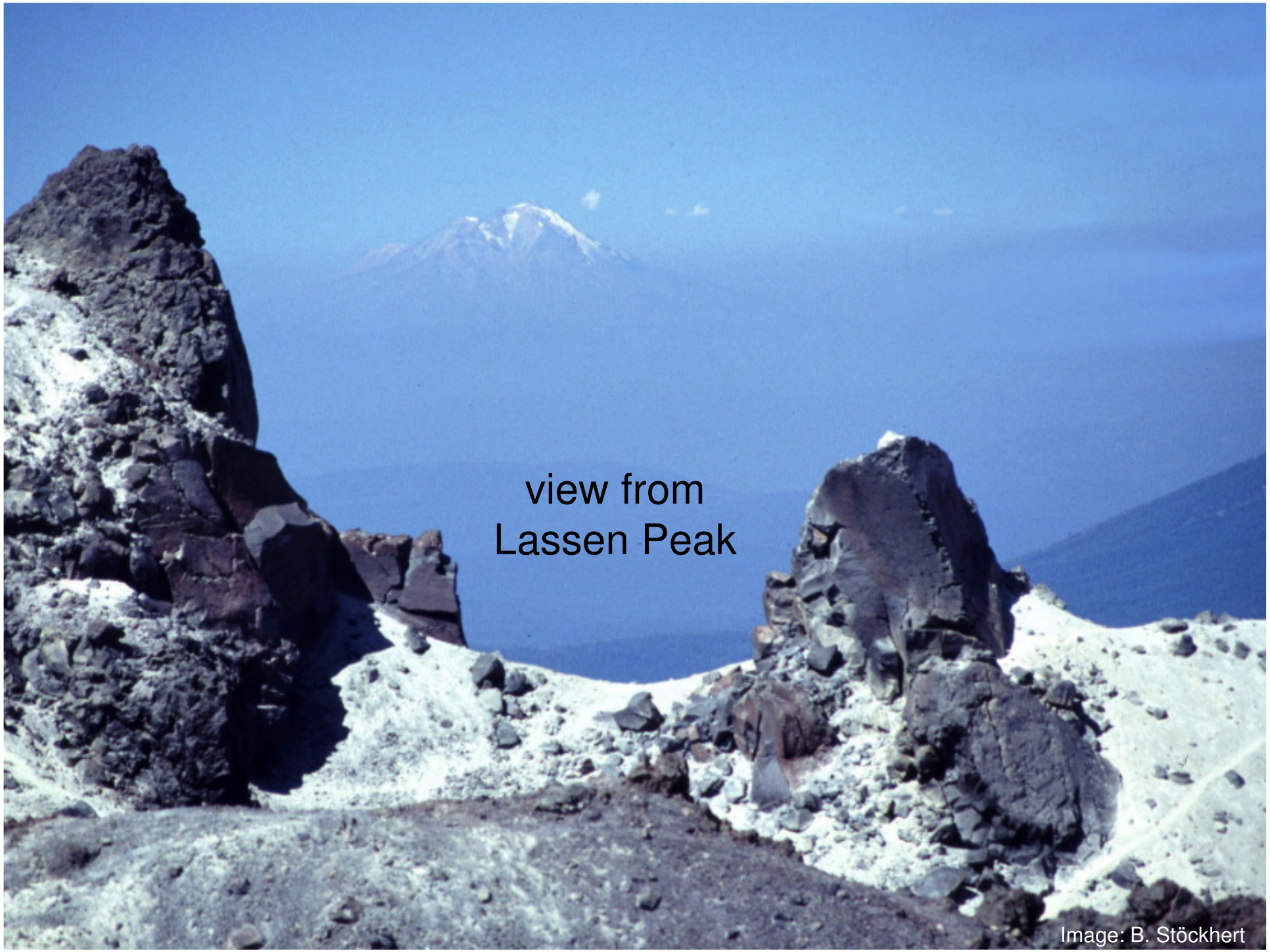
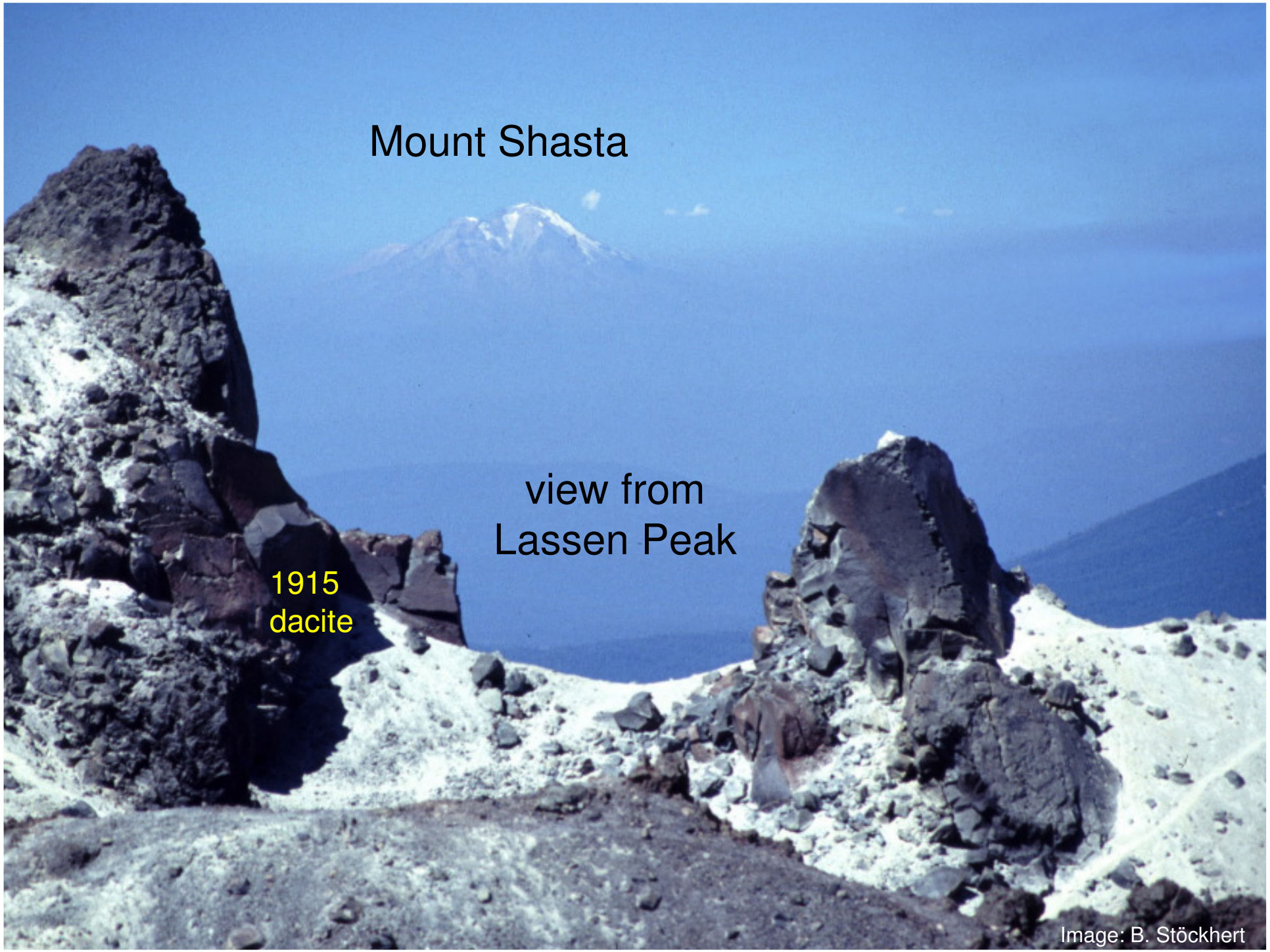

Stratovolcanoes in the
southern Chilean Andes
Osorno
commercial post card


Image: B. Stöckhert

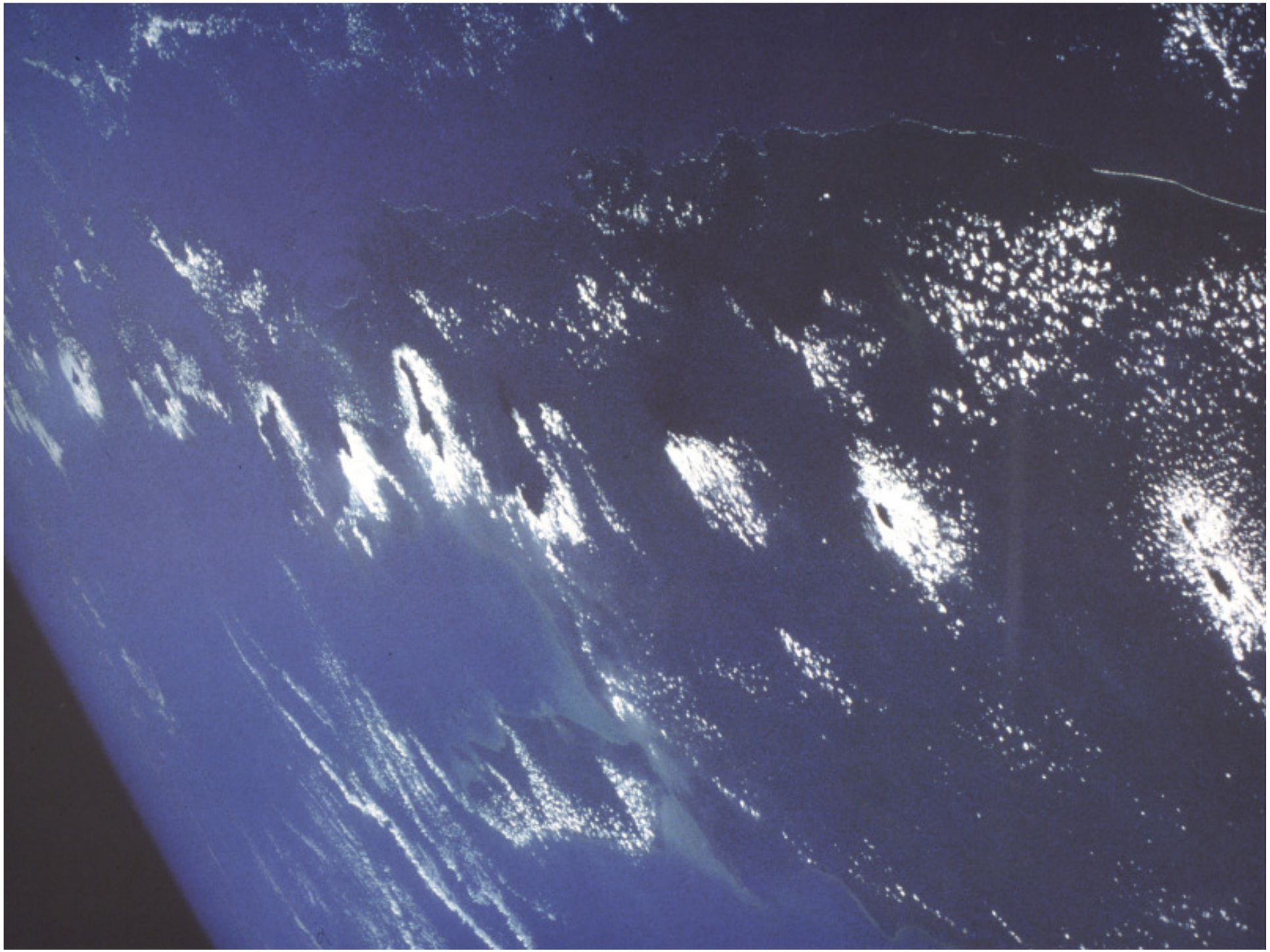

view from
Lassen Peak
Image: B. Stöckhert

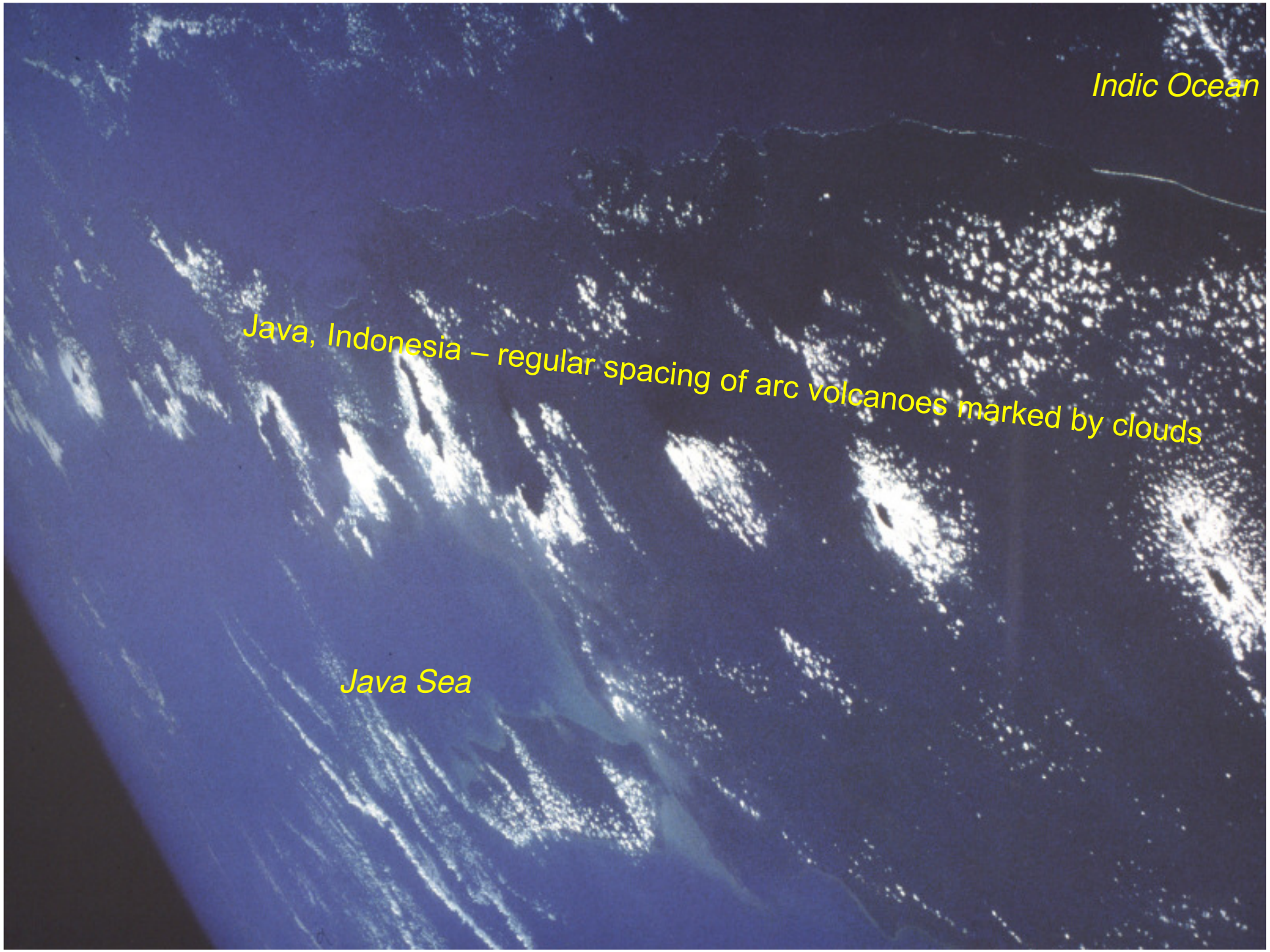

view from
Lassen Peak
1915
dacite
Image: B. Stöckhert


Mount Shasta
view from
Lassen Peak
1915
dacite
Image: B. Stöckhert


distance 120 km
Mount Shasta
view from
Lassen Peak
1915
dacite
Image: B. Stöckhert

the distance between arc volcanoes is
typically between about 50 and 100 km



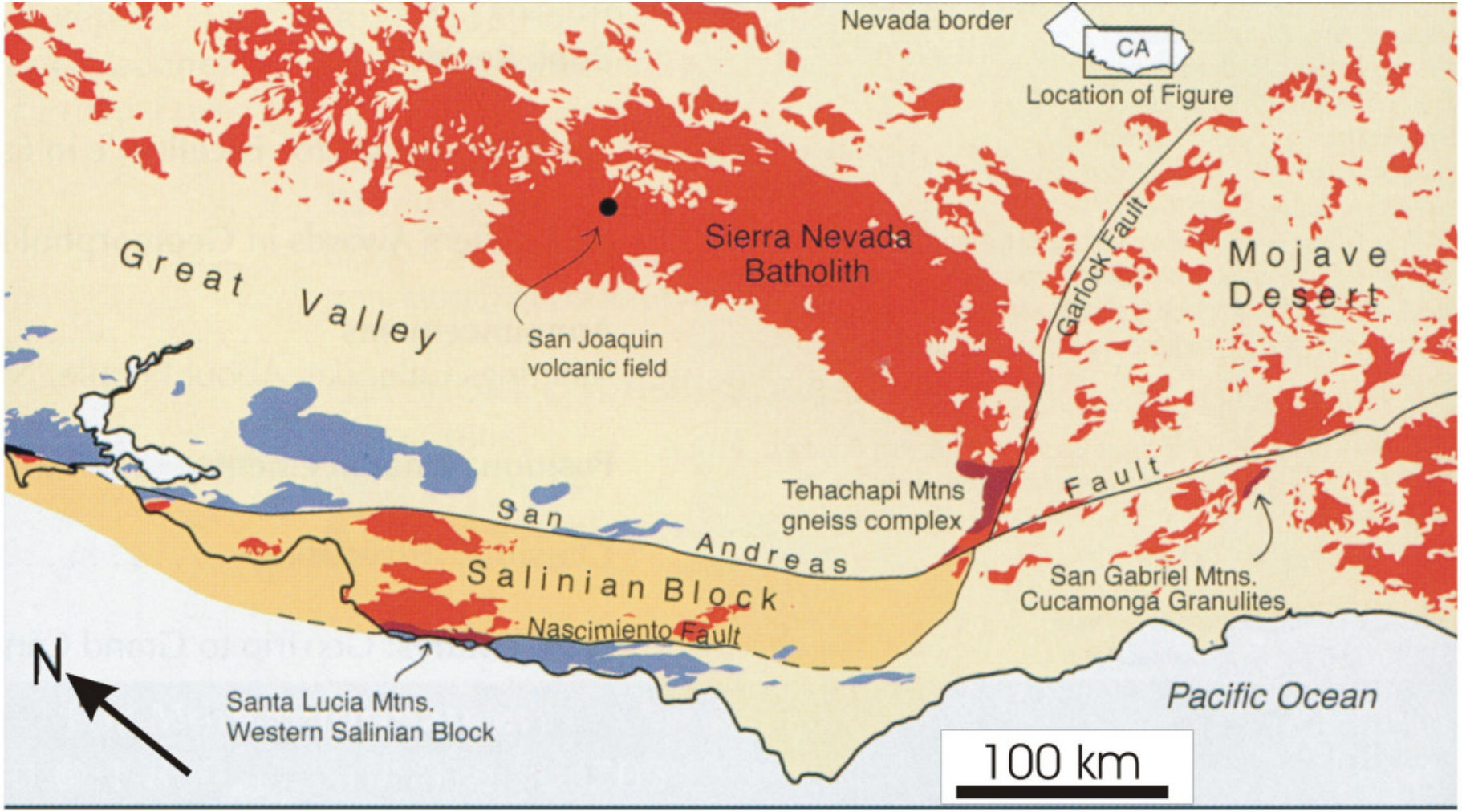

Indic Ocean
Java, Indonesia – regular spacing of arc volcanoes marked by clouds
Java Sea

the deeper levels of the magmatic arc are supposed to contain about 5 to 15 times the volume of the volcanic rocks as plutonic rocks (solidified in magma chambers)

these can be exposed as huge batholiths

Sierra Nevada Batholith (late Cretaceous arc)

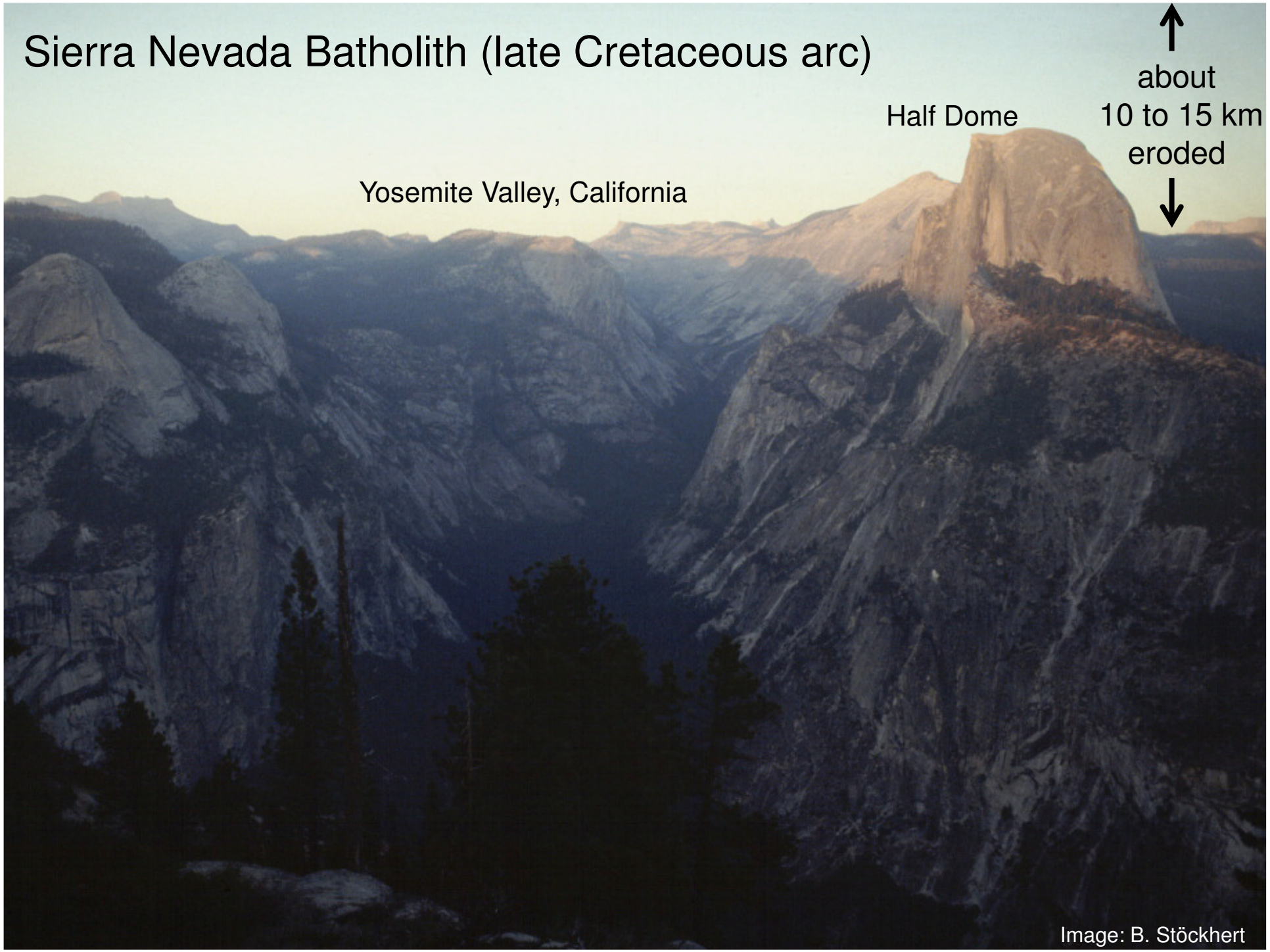
map from Ducea M. (2001) GSA Today 11/11



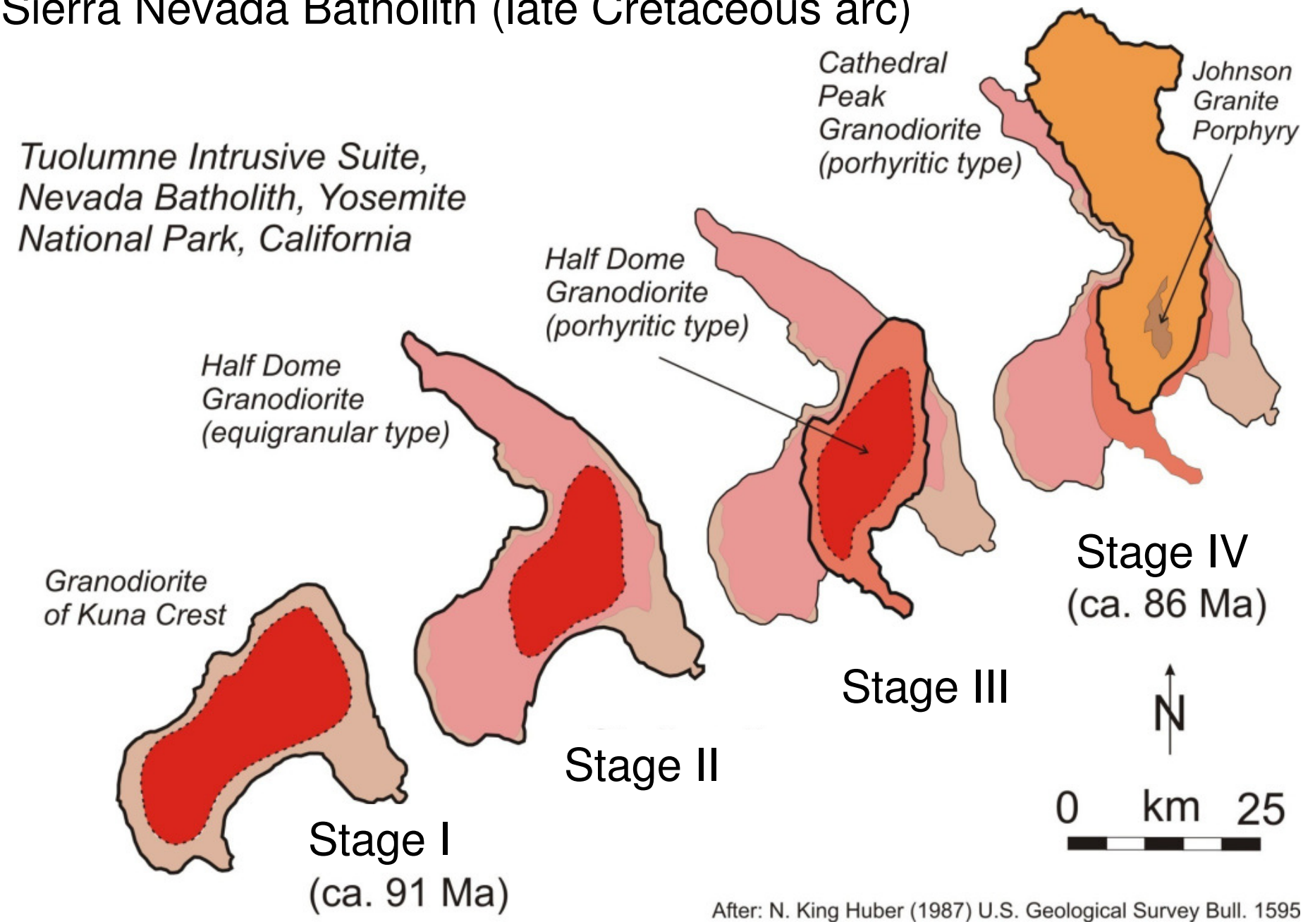
Plutonic rocks of Mesozoic age (magmatic arc)

Country rock of Mesozoic medium to high grade metamorphism

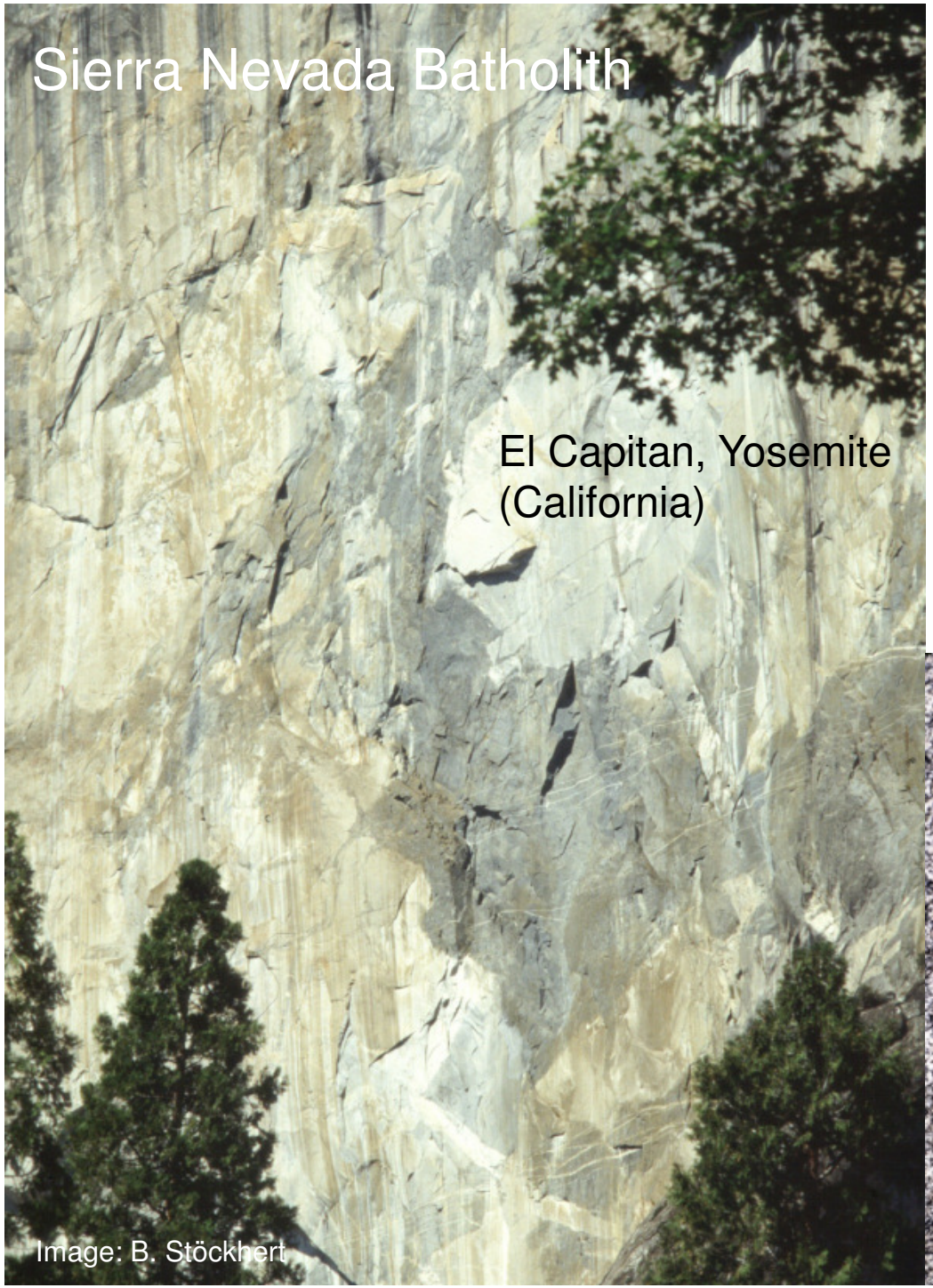
Franciscan Melange


Sierra Nevada Batholith (late Cretaceous arc)
Half Dome
about
10 to 15 km
eroded
Yosemite Valley, California
Image: B. Stöckhert

Sierra Nevada Batholith (late Cretaceous arc)



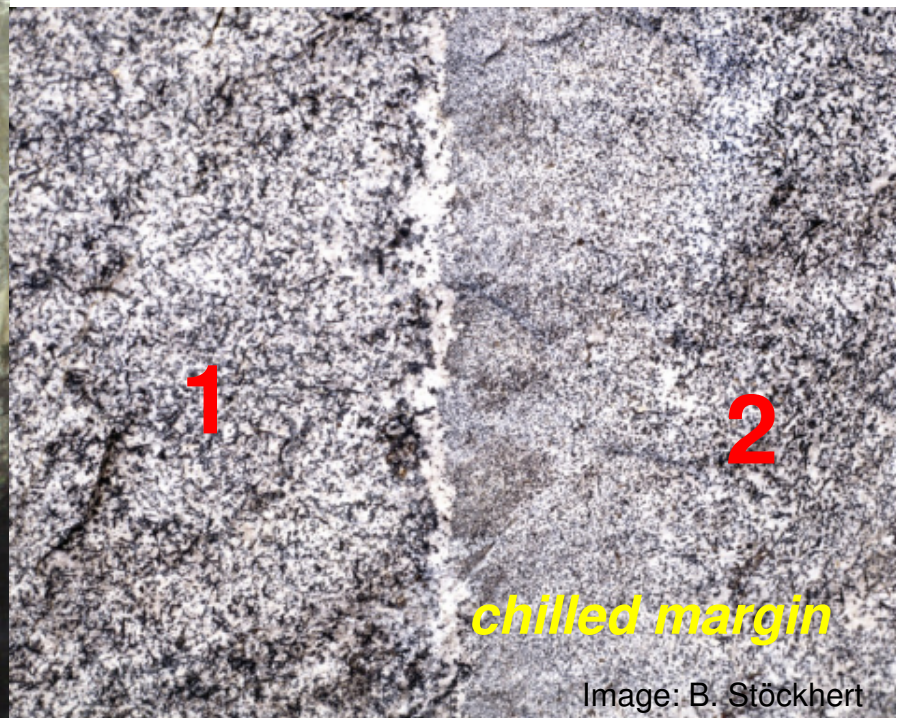
After: N. King Huber (1987) U.S. Geological Survey Bull. 1595



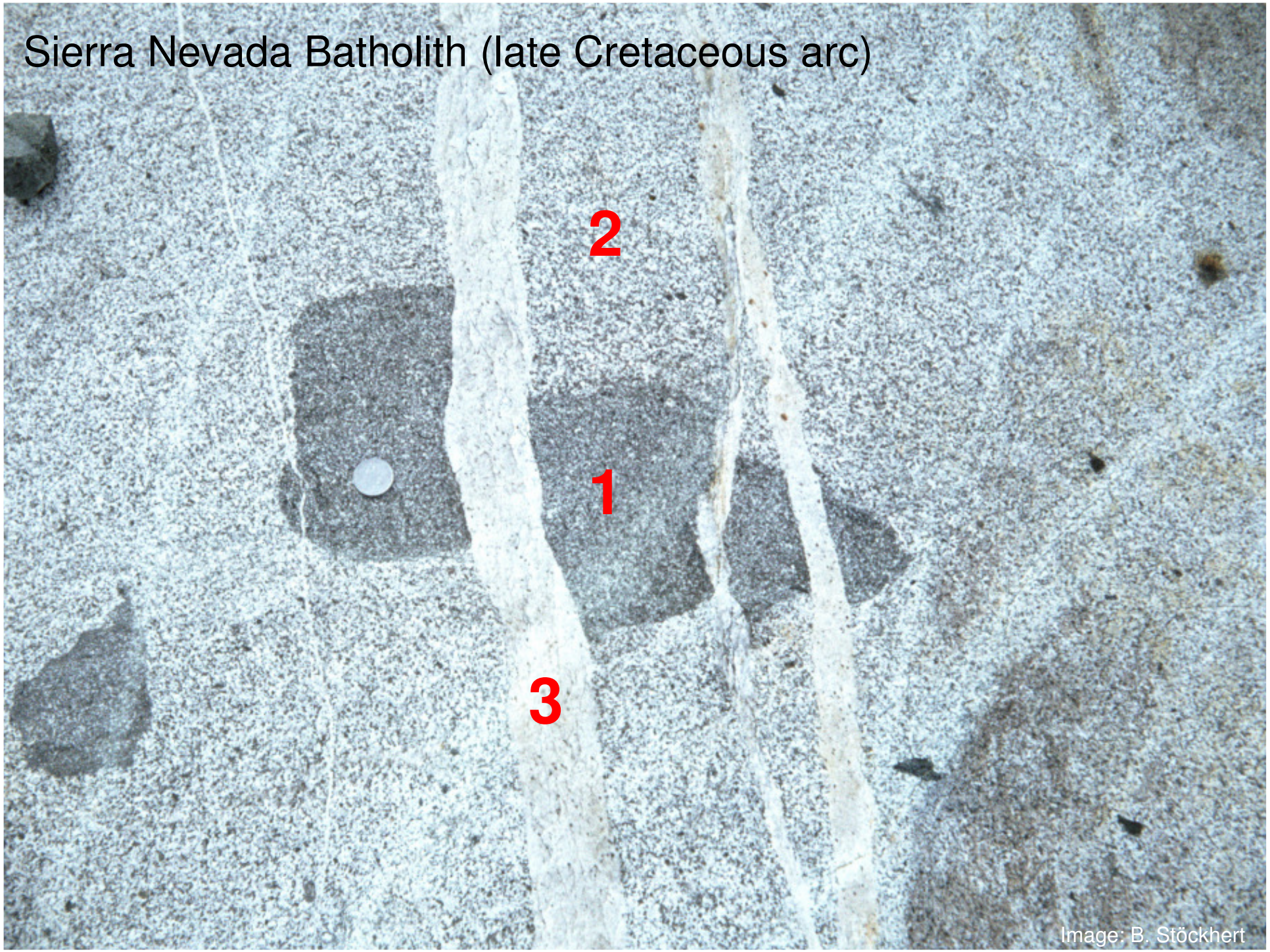
Batholiths are composed of a sequence of calc-alkaline granitoid intrusions, with diameters typically between about 10 and 30 km, each representing an individual magma chamber.

Emplacement can be by stoping or ballooning

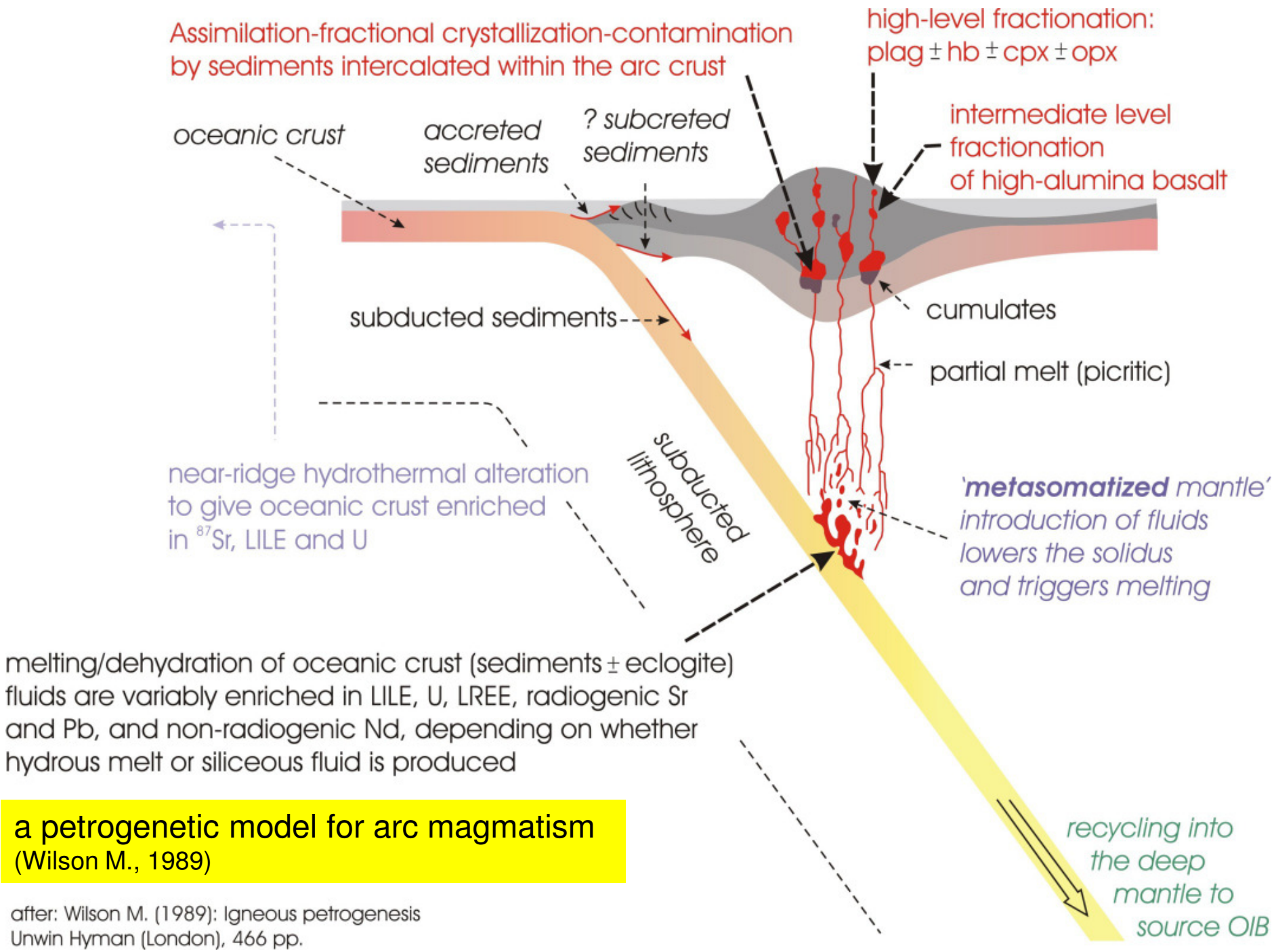
Internal structures tell a lot about the complexity of arc magmatism…




Sierra Nevada Batholith (late Cretaceous arc)
Image: B. Stöckhert


Sierra Nevada Batholith (late Cretaceous arc)
2
1
3
Image: B. Stöckhert

igneous petrogenesis in magmatic arcs is highly complex



a petrogenetic model for arc magmatism
(Wilson M., 1989)

after: Wilson M. (1989): Igneous petrogenesis
Unwin Hyman (London), 466 pp.

A model for **arc magmatism** must take into account the following processes and properties:

- composition of subducted oceanic crust

- fluid release and metasomatism in source region (supercritical fluids vs. melts)

- degree of partial melting in mantle wedge

- assimilation / fractional crystallization / contamination (AFC) in arc crust

- fractionation in intermediate and shallow magma chambers