PARTICLES AND COSMOLOGY
17th Baksan School
on Astroparticle Physics

Volcanic hazard in Northern Caucasus

(and the underground geophysical observatory)

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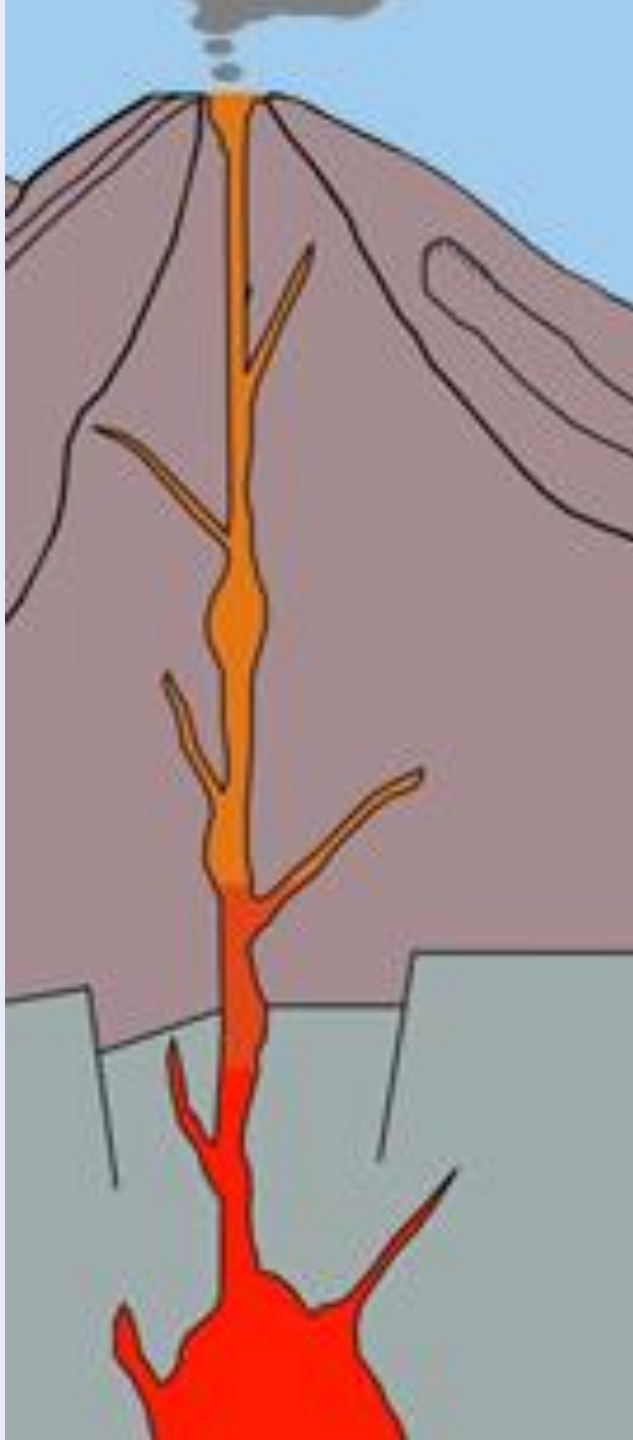
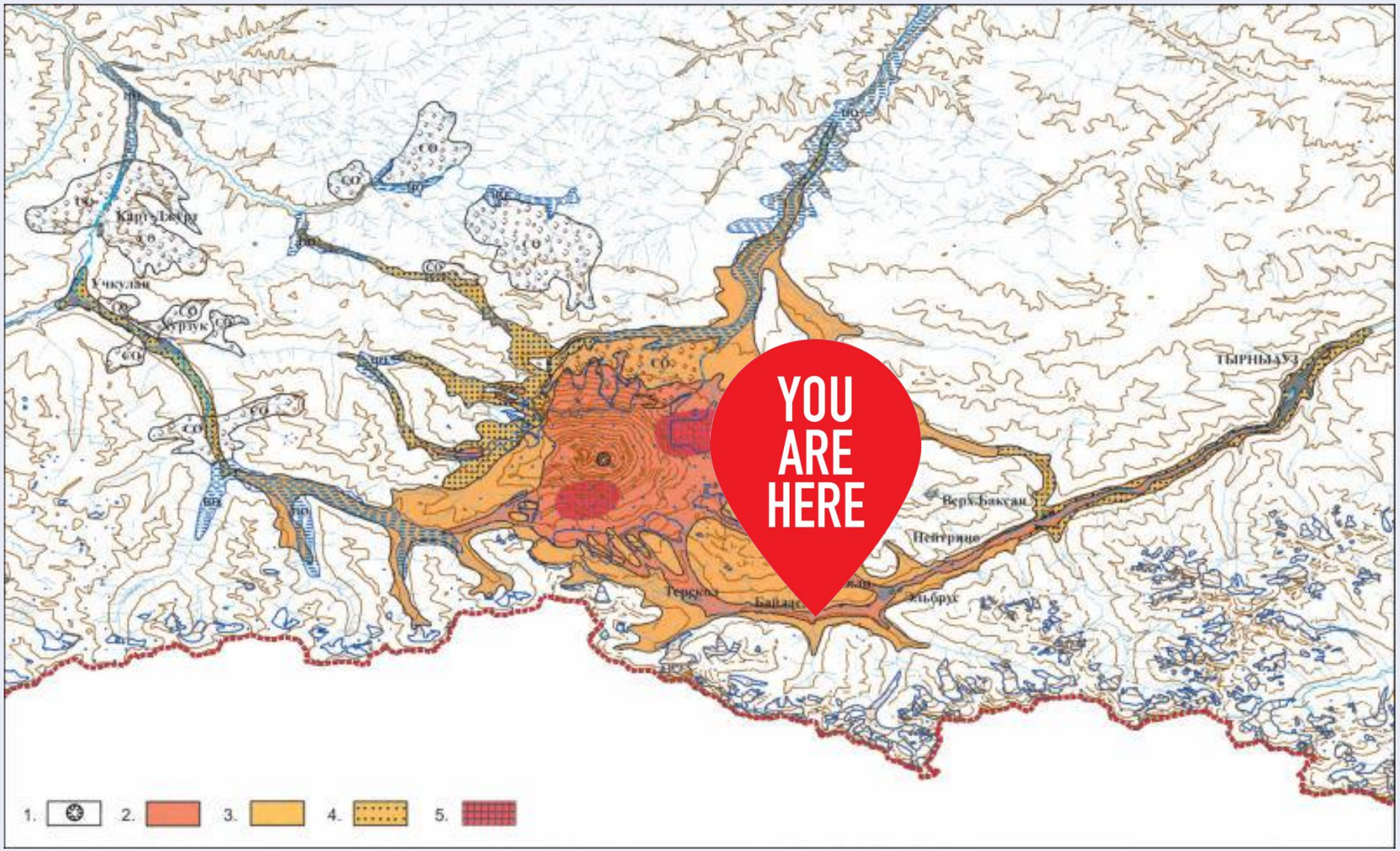
The Schmidt Institute of Physics of the Earth
Russian Academy of Sciences

2025

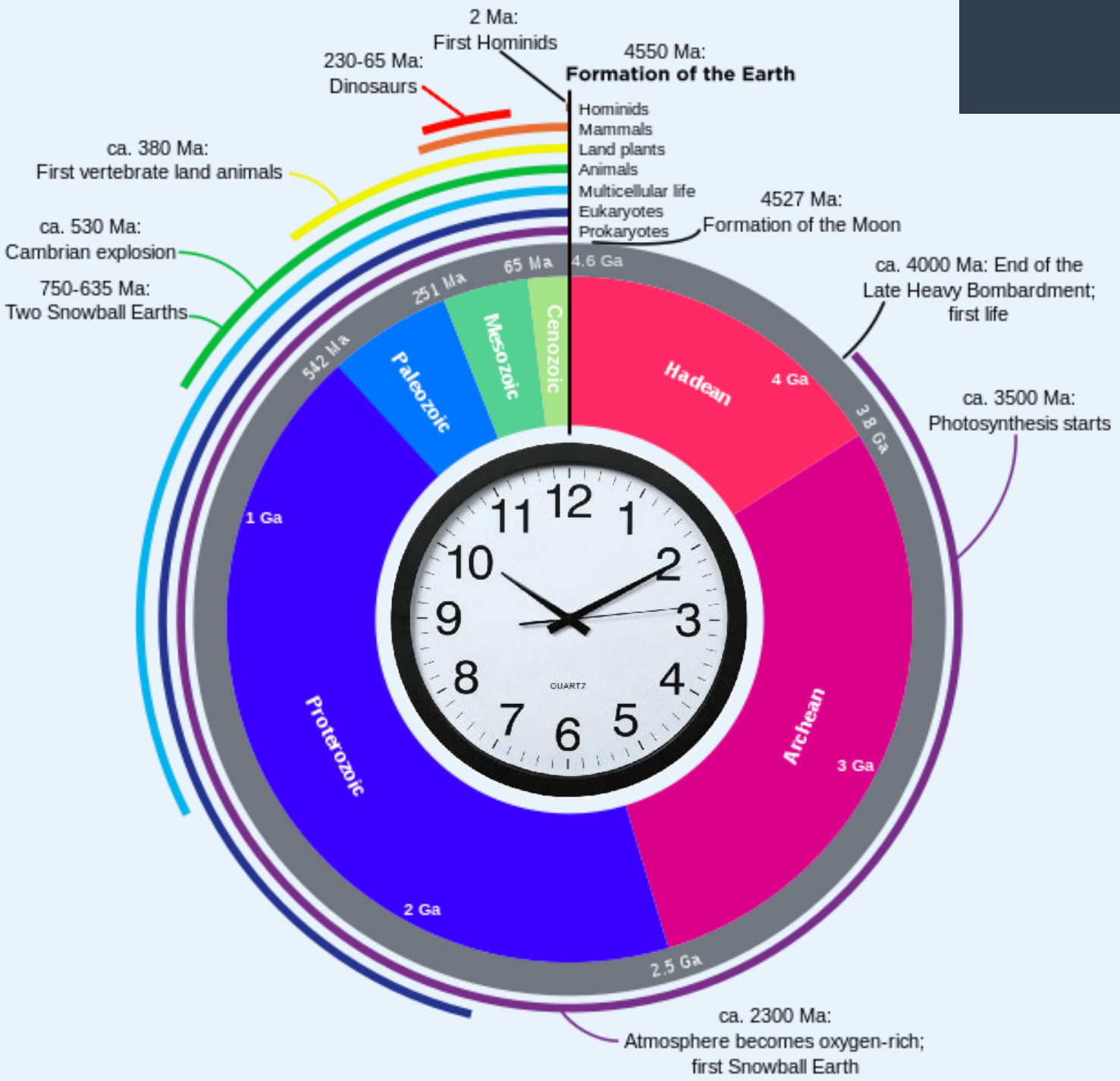




The map of possible catastrophic processes in the Elbrus volcanic center

1 – the eastern crater; 2 – small-scale eruptions; 3 – paroxysmal eruptions;
4 – progress of pyroclastic flows; 5 – most likely sites for magma to emerge.

The geological timing

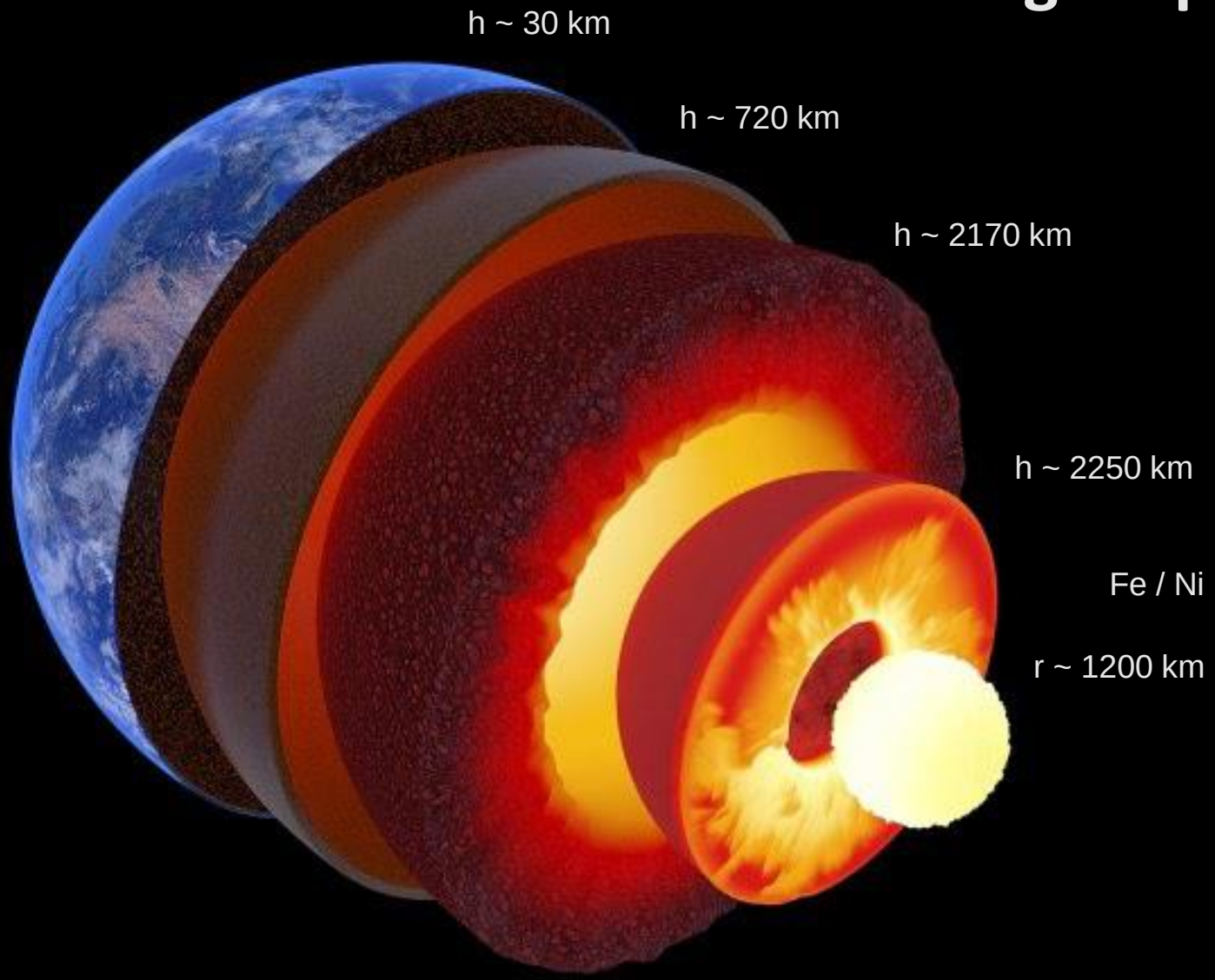


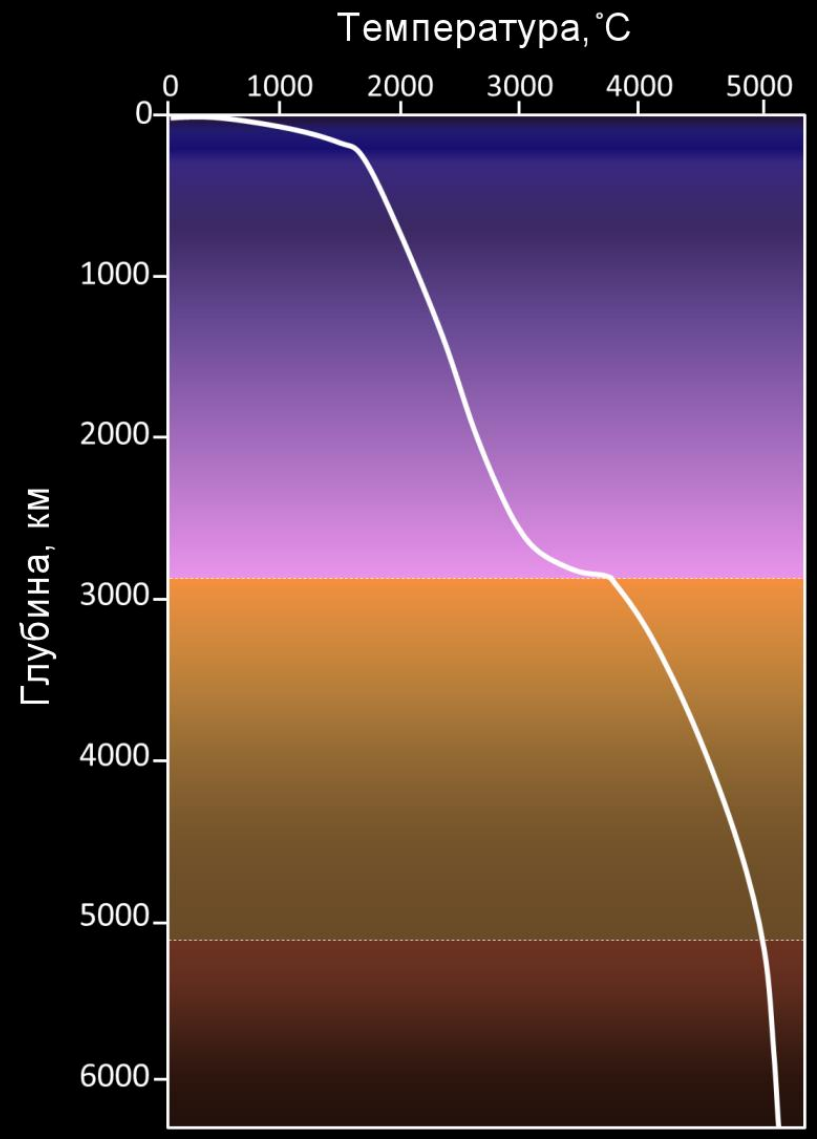
1 second = 100 000 years

Unhappy last hour (6 mass extinctions):

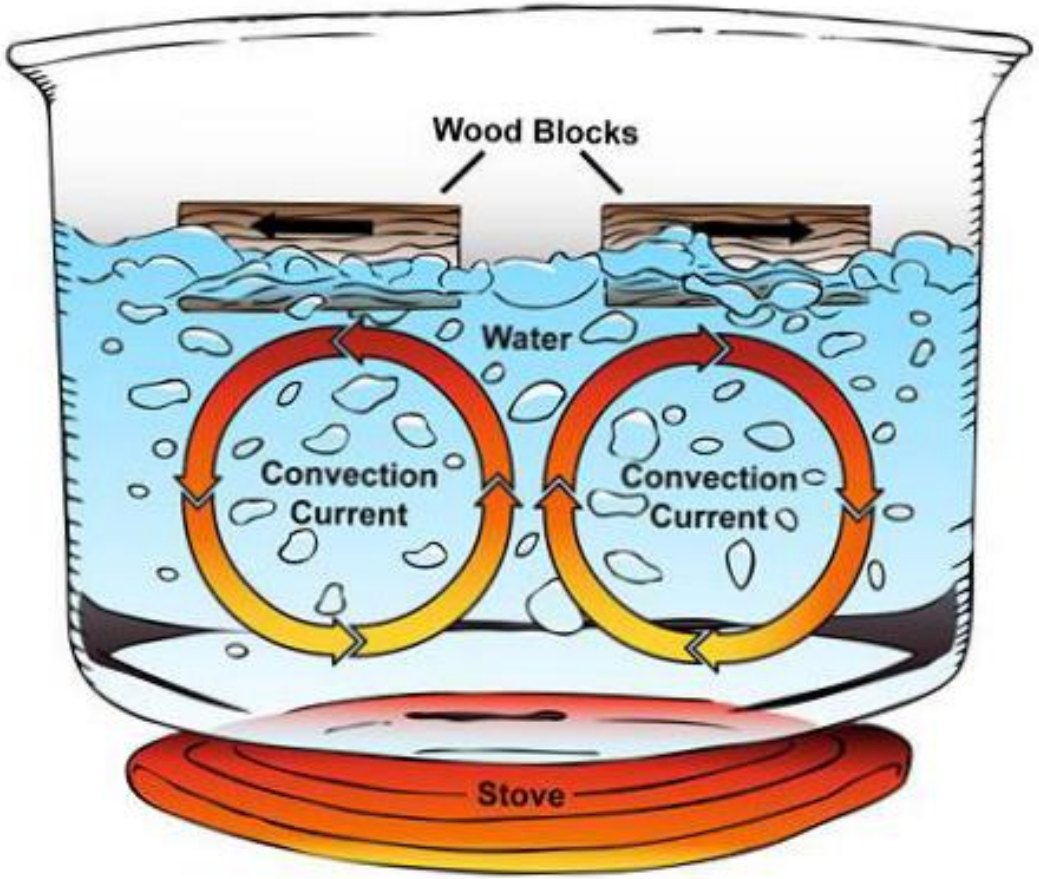
- end of the Ordovician LOME, 445 Ma (85% of all marine species),
- late Devonian (372 Ma),
- Permian-Triassic boundary (252 Ma),
- end of the Triassic (200 Ma),
- Cretaceous-Paleogene boundary (61 Ma).

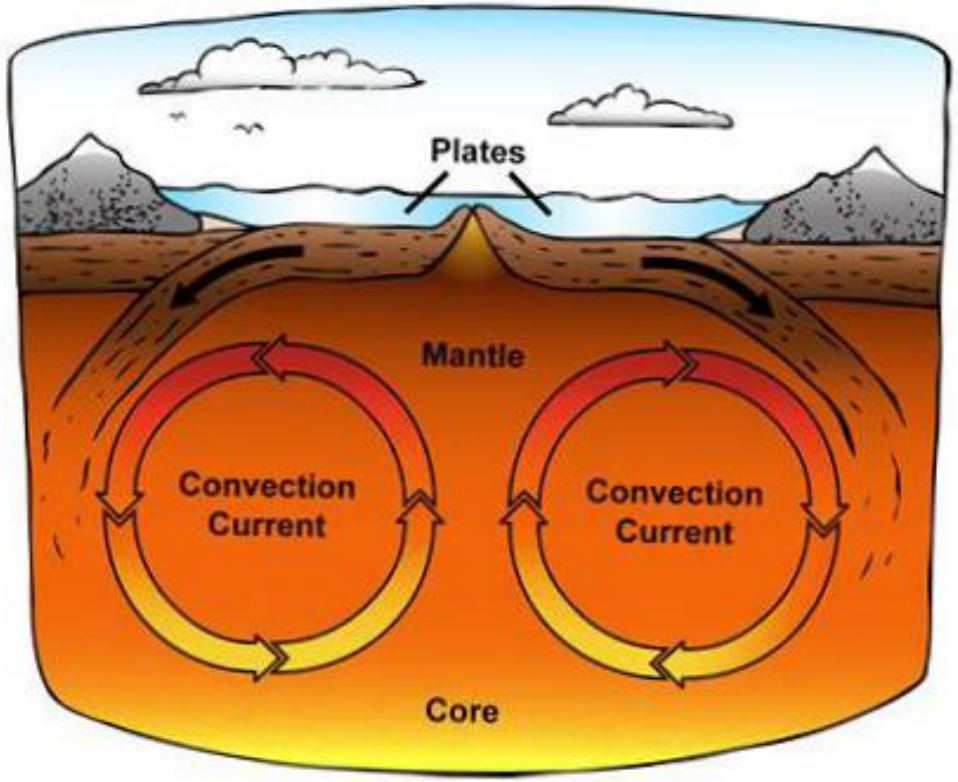
The geospheres and the deep heat

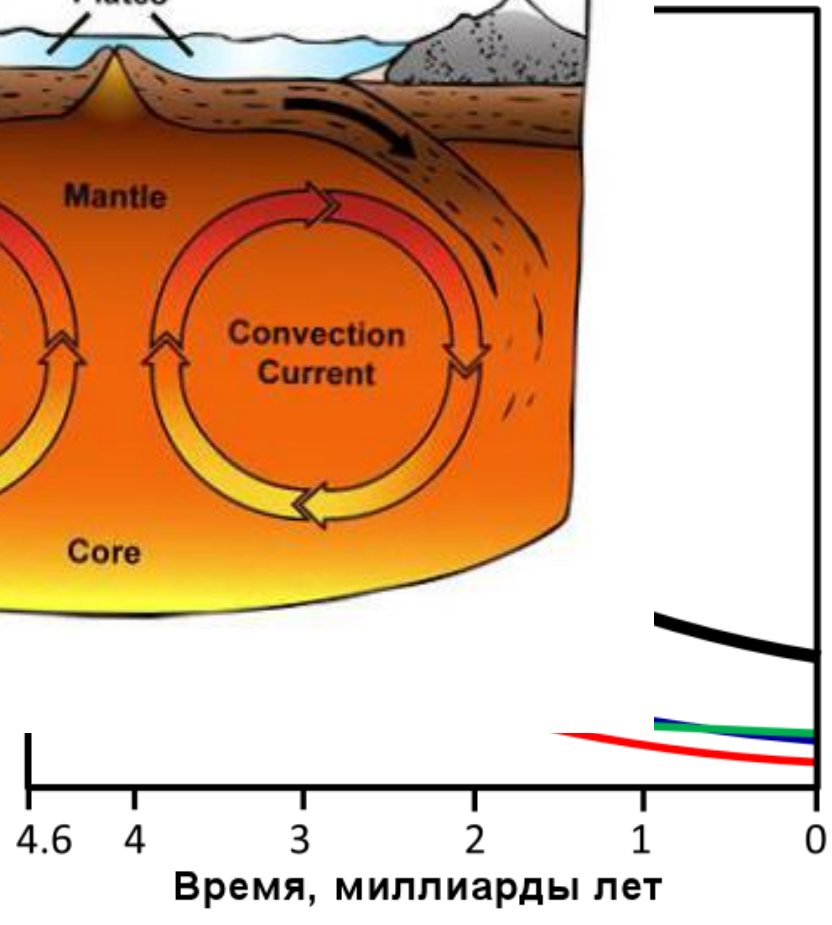




The mantle convection and the plate tectonics





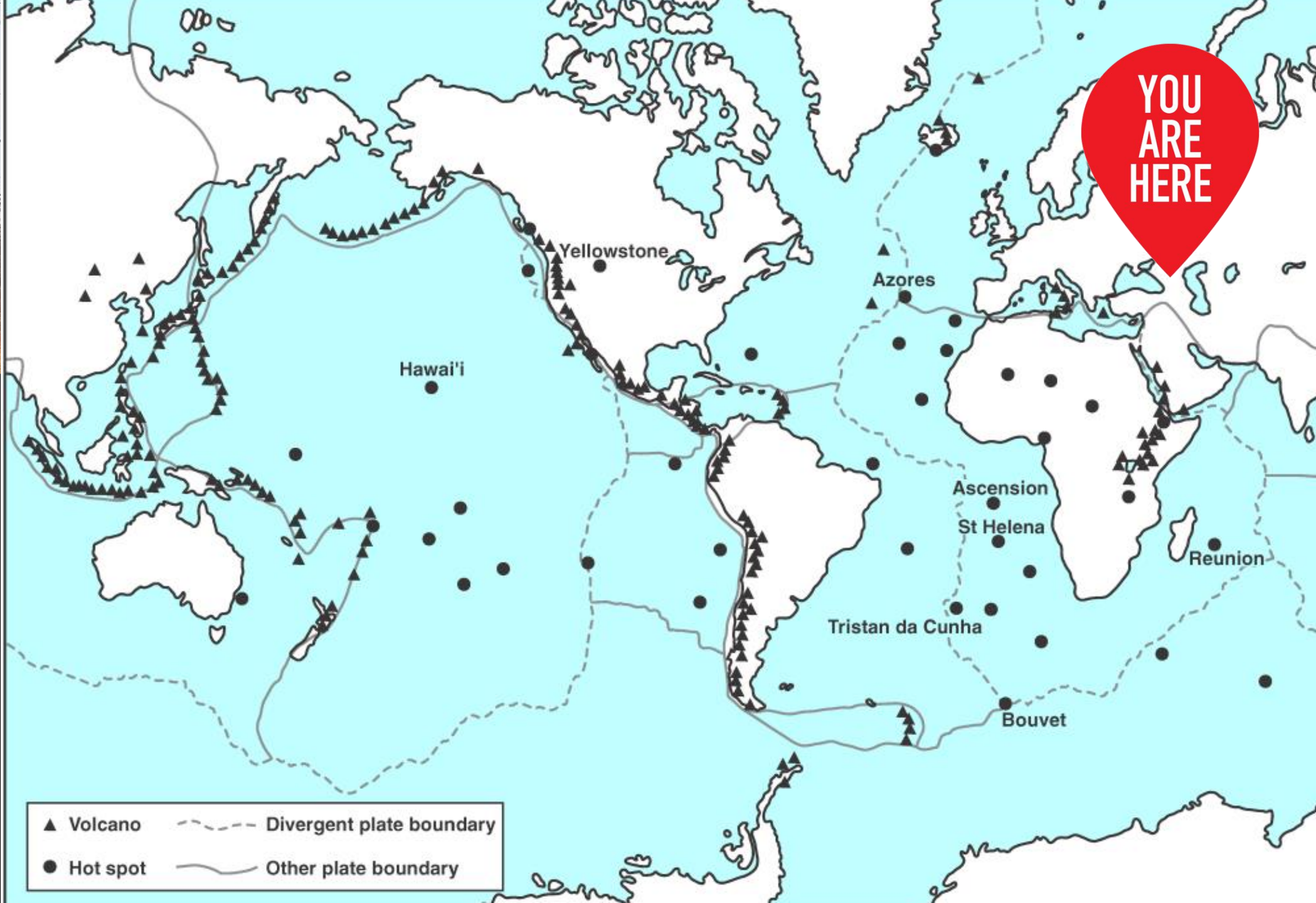


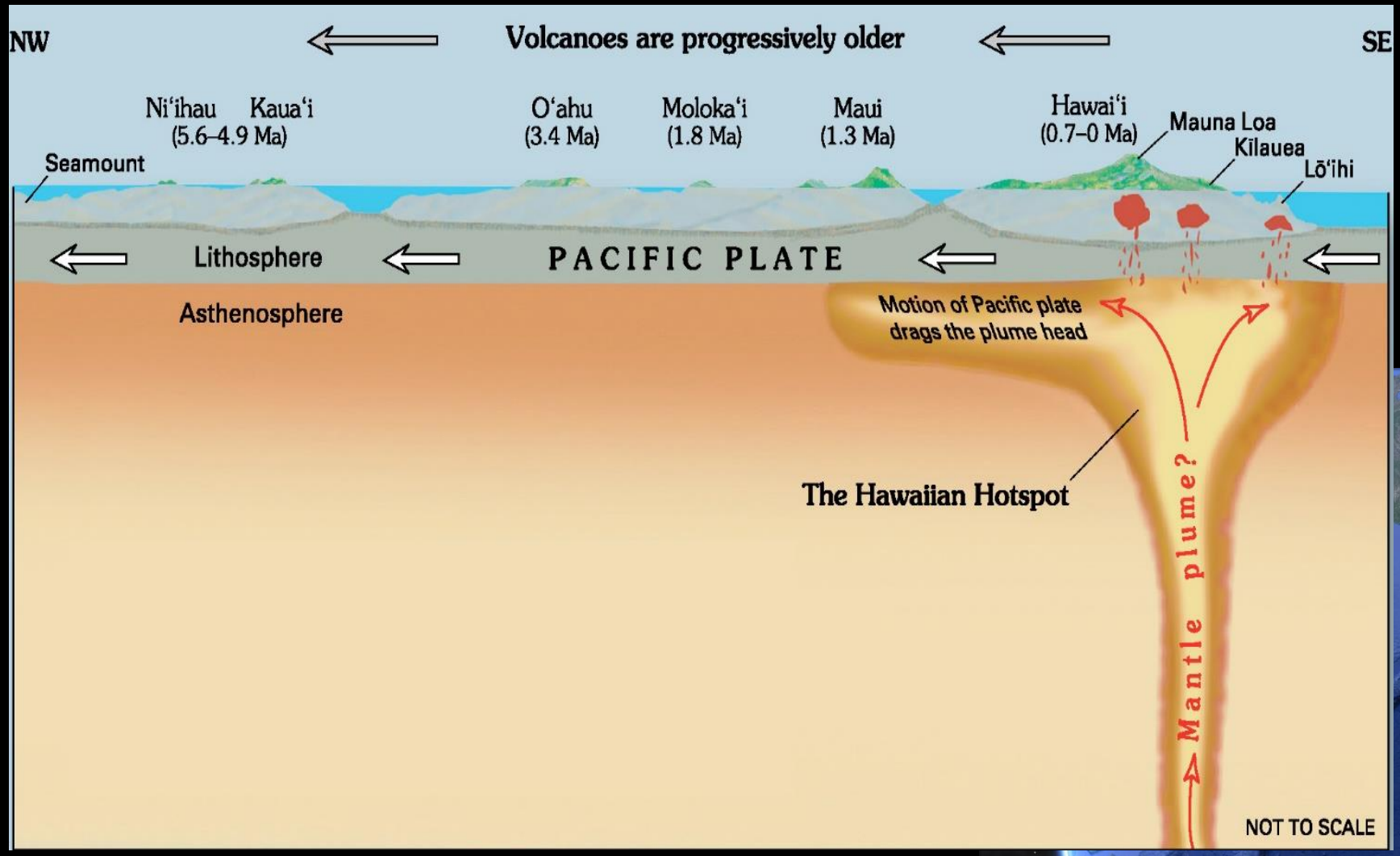
Magma production:

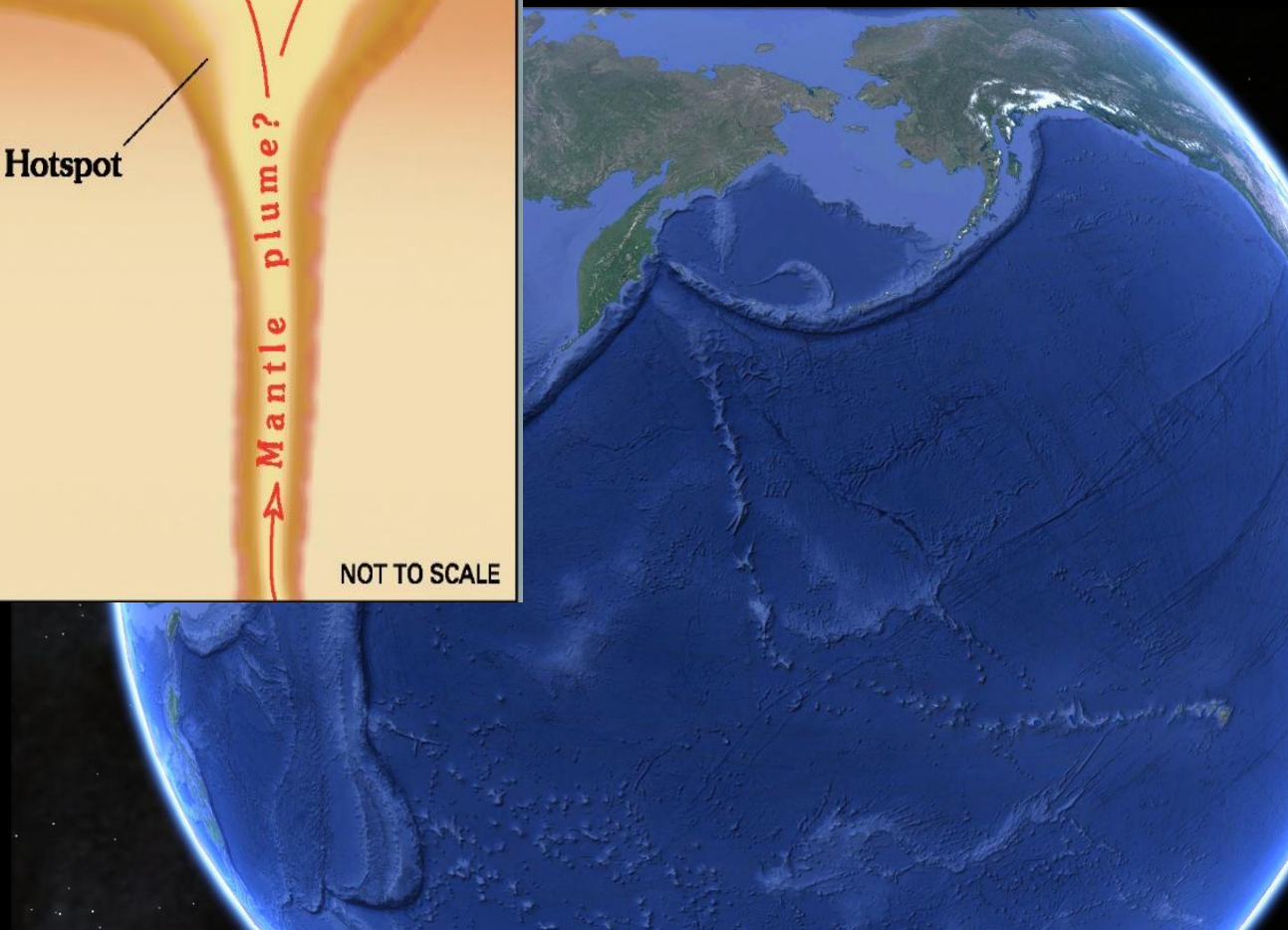
88% – tectonic plate boundaries (62% - MORB, 26% - subduction zones), 12% – «hot spots»/ intraplate volcanism.

Earth's heat losses:

subduction zones + MORB – 60%, «hot spot» volcanism – 40%.

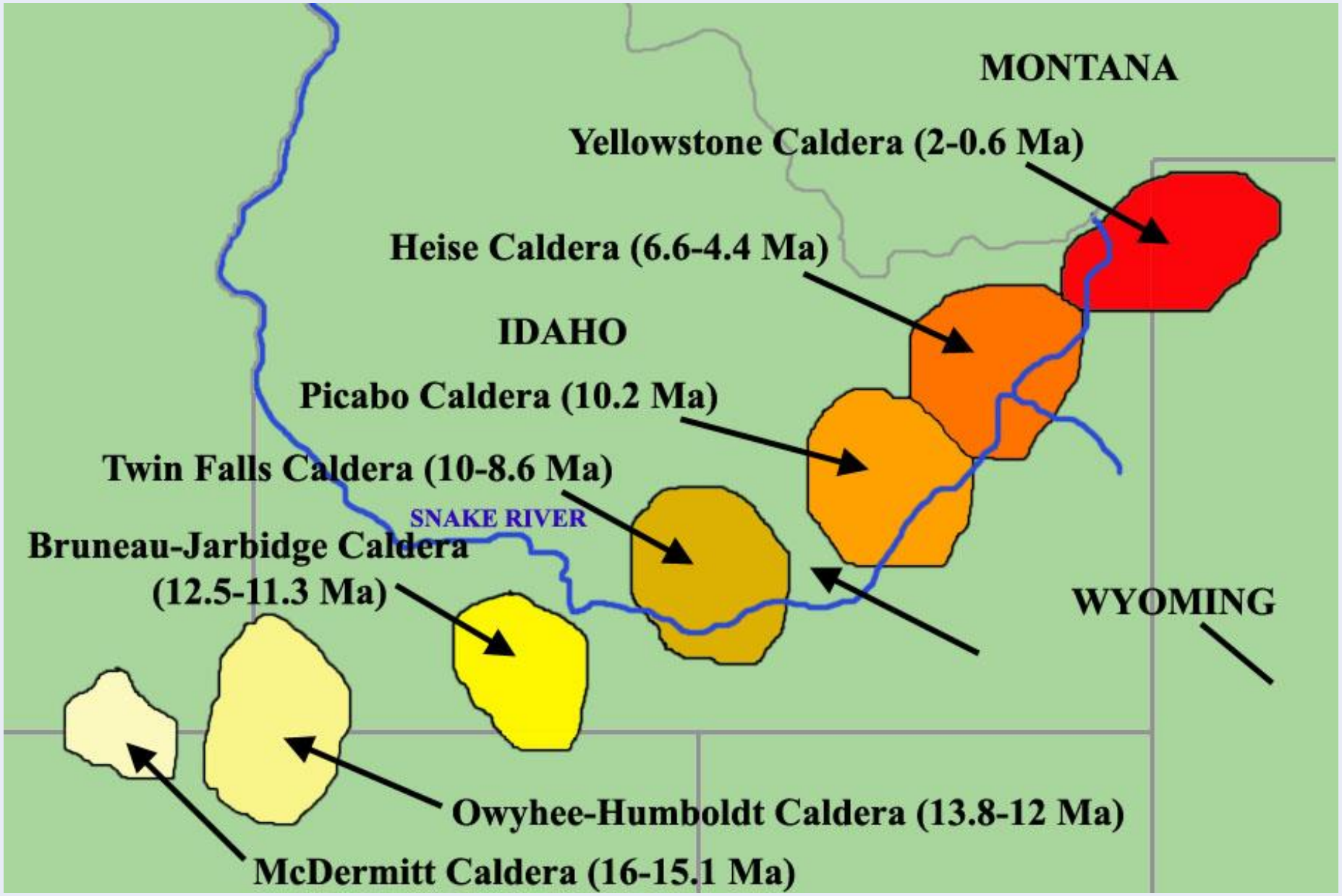


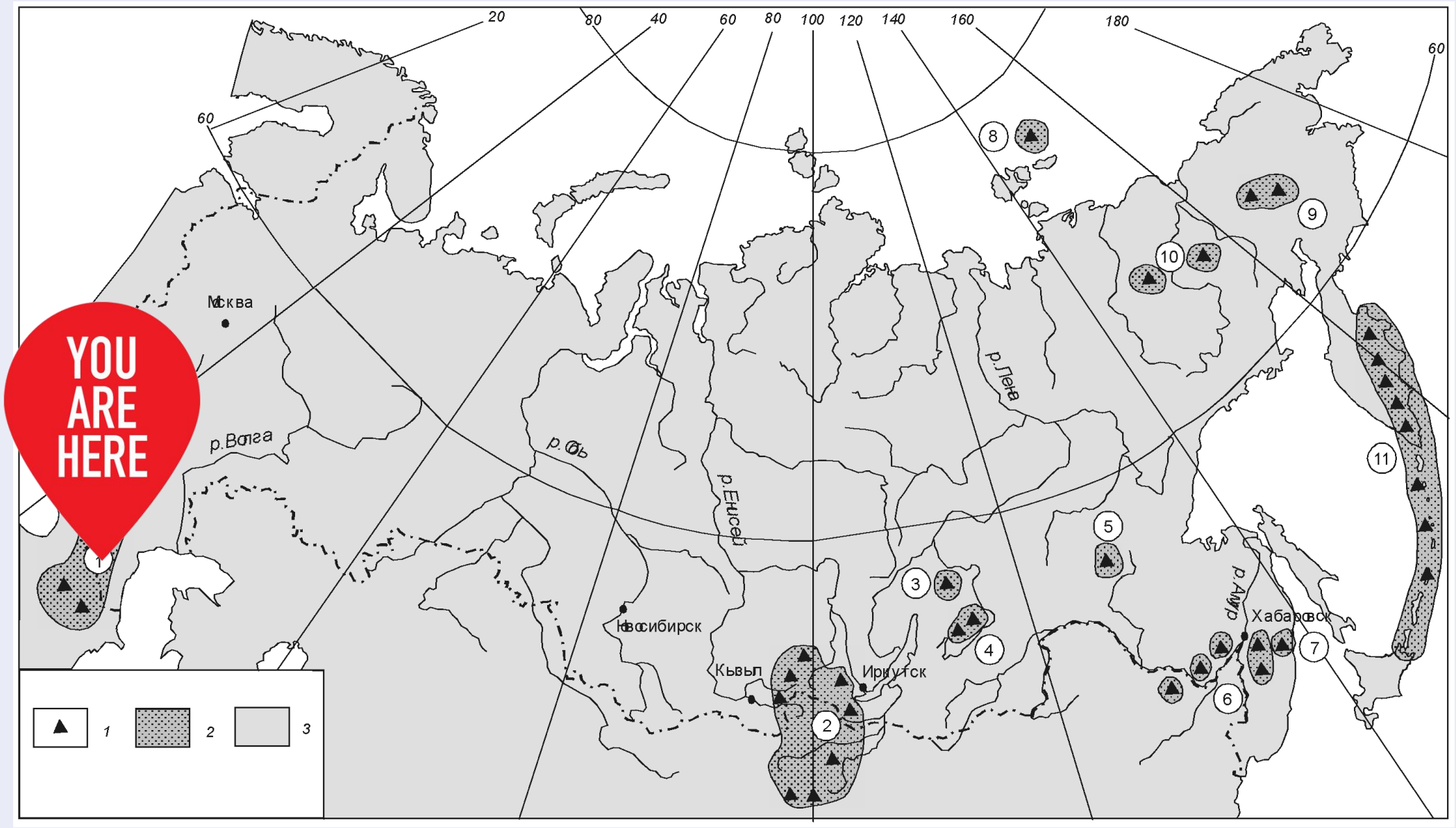




~ 300 000 km^3 of lava over 5,5 Ma.

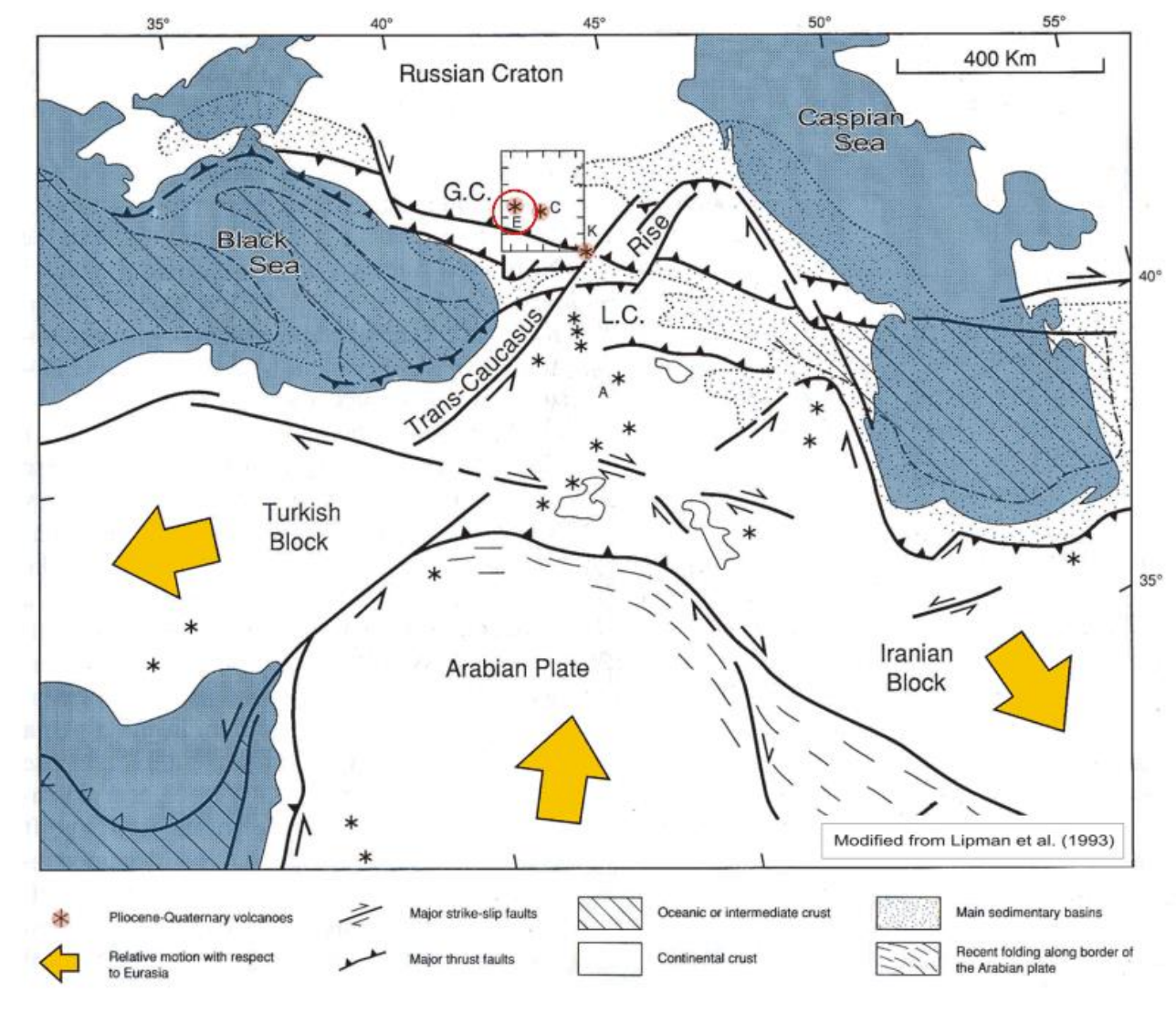
Yellowstone Caldera – yet another “hot spot” (NA tectonic plate, 2.35 cm/yr)



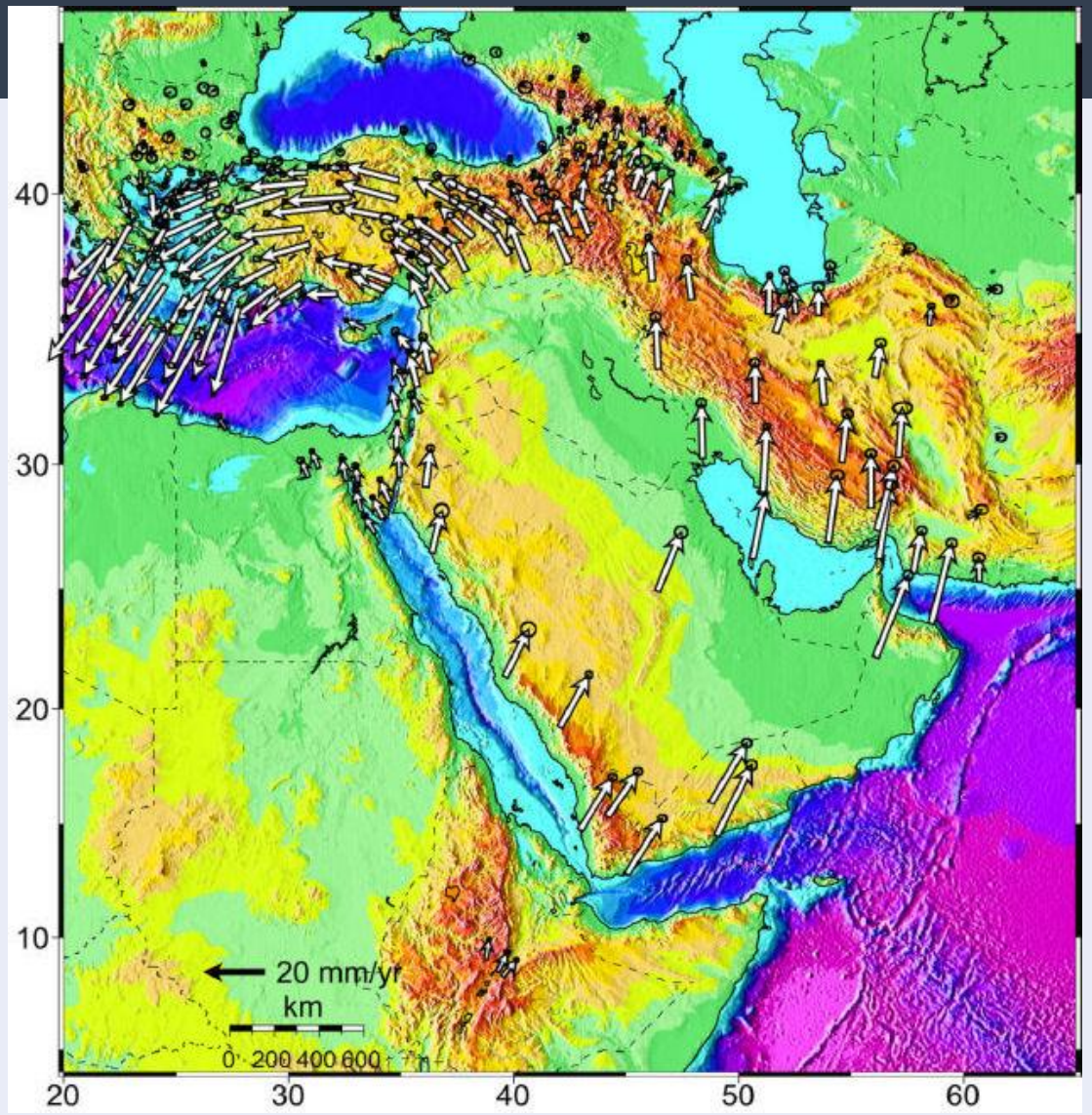


Volcanic regions and areas of the most recent (**1 million years and younger**) volcanism in Russia:
1 – **Caucasian**, 2 – South Baikal, 3 – Udokan, 4 – Vitim, 5 – Tokinsky, 6 – Amur-Ussuri, 7 – Sovgavansky, 8 – De Long Islands, 9 – Anyui-Aluginsky, 10 – Srednekolymsky, 11 – Kuril-Kamchatka area [Laverov et al., 2005].

Continental collision



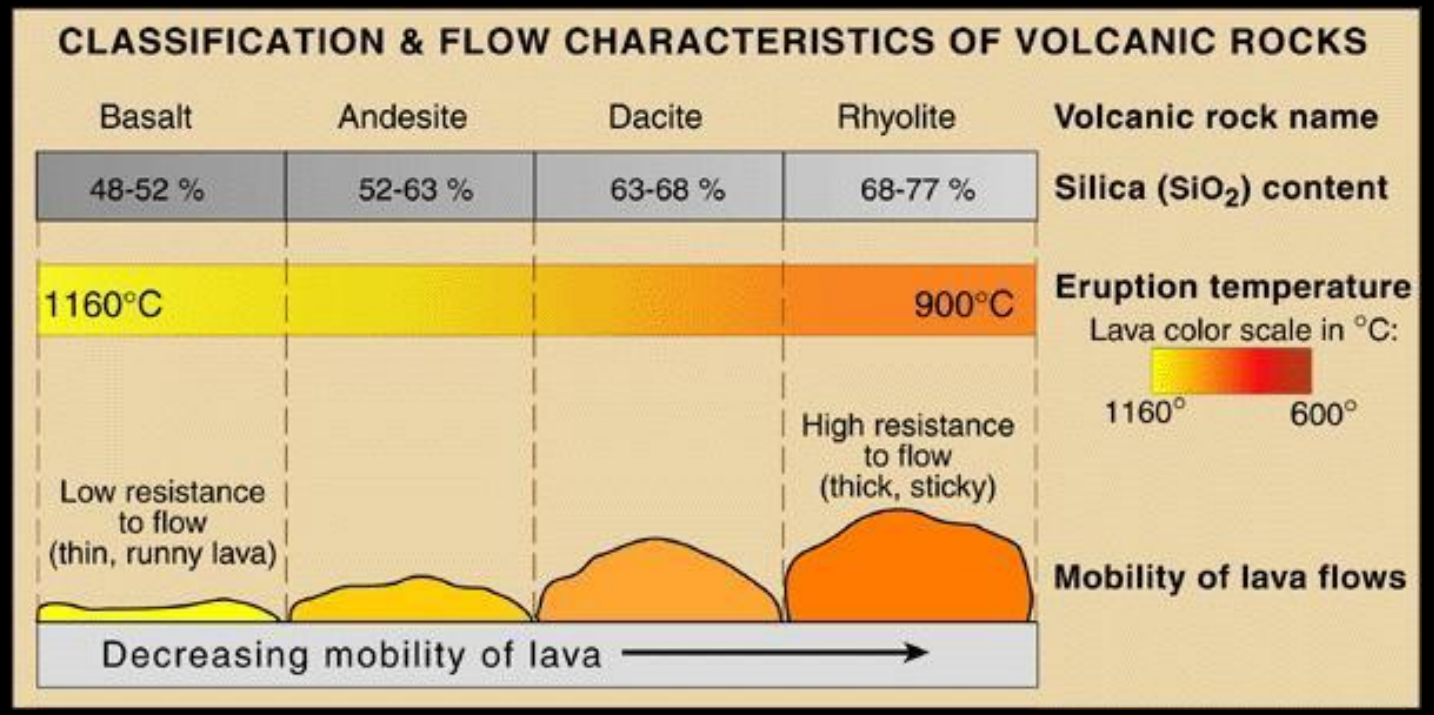
Geodynamic model of the central segment of Alpine-Himalaya mobile folded system and the Greater Caucasus, after [Lipman et al., 1993].



GPS velocity field 1988-2005 for the Eastern Mediterranean with respect to Eurasia showing CCW rotation of a broad region in the Africa-Arabia-Eurasia collision zone [*Reilinger et al.*, 2006],


YOU ARE HERE
Kerch'
Krasnodar
Armavir
Novorossiysk
Maykop
Tuapse
Sochi
ABKHAZIA
Elbrus
Sukhum
Kazbek
SOUTH OSSETIA
BLACK SEA
CASPIAN SEA
Kizlyar
Grozniy
Makhachkala
Derbent
GEORGIA
Tbilisi
Batumi
Gyumri
Aragats
ARMENIA
TURKEY
Gyandzha
AZERBAIJAN
Sumgait
Baku
Lenkoran'
IRAN
Legend
- area of maximal volcanic hazard, past eruptive activity within 50 ka
- area of very high volcanic hazard, late Quaternary activity (500 - 0 ka)
- area of high volcanic hazard, Quaternary activity (2 - 0 Ma)
- area of moderate volcanic hazard, Pliocene-Quaternary activity (5 - 0 Ma)
- area of potential volcanic hazard, late Cenozoic volcanism in Caucasus (15 - 0 Ma)
- area of possible volcanic hazard, Alpine orogeny (the Caucasus)
Scale 1 : 1000000
(C) V.A.Lebedev, IGEM RAS

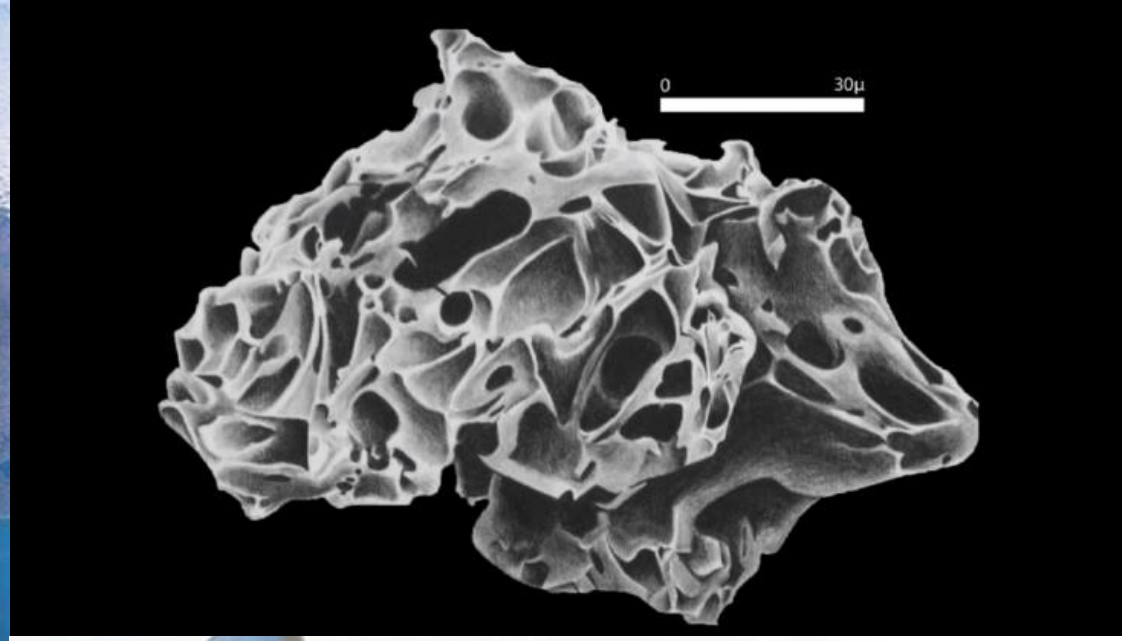
The size and style of eruption is mostly determined by the composition of magma and by the content of volatiles:
H_2O
CO_2,
SO_2, H_2S,
HCl, HF.



Plinian type (v = 100 - 600 m/s). Productivity from 10^6 to 10^9 kg/s.

Strombolian – explosions (1-2 s), mainly basaltic composition of magmas with low viscosity.

Vulcanian – more acidic composition (v = 200 - 400 m/s), eruptive columns, instability, pyroclastic flows.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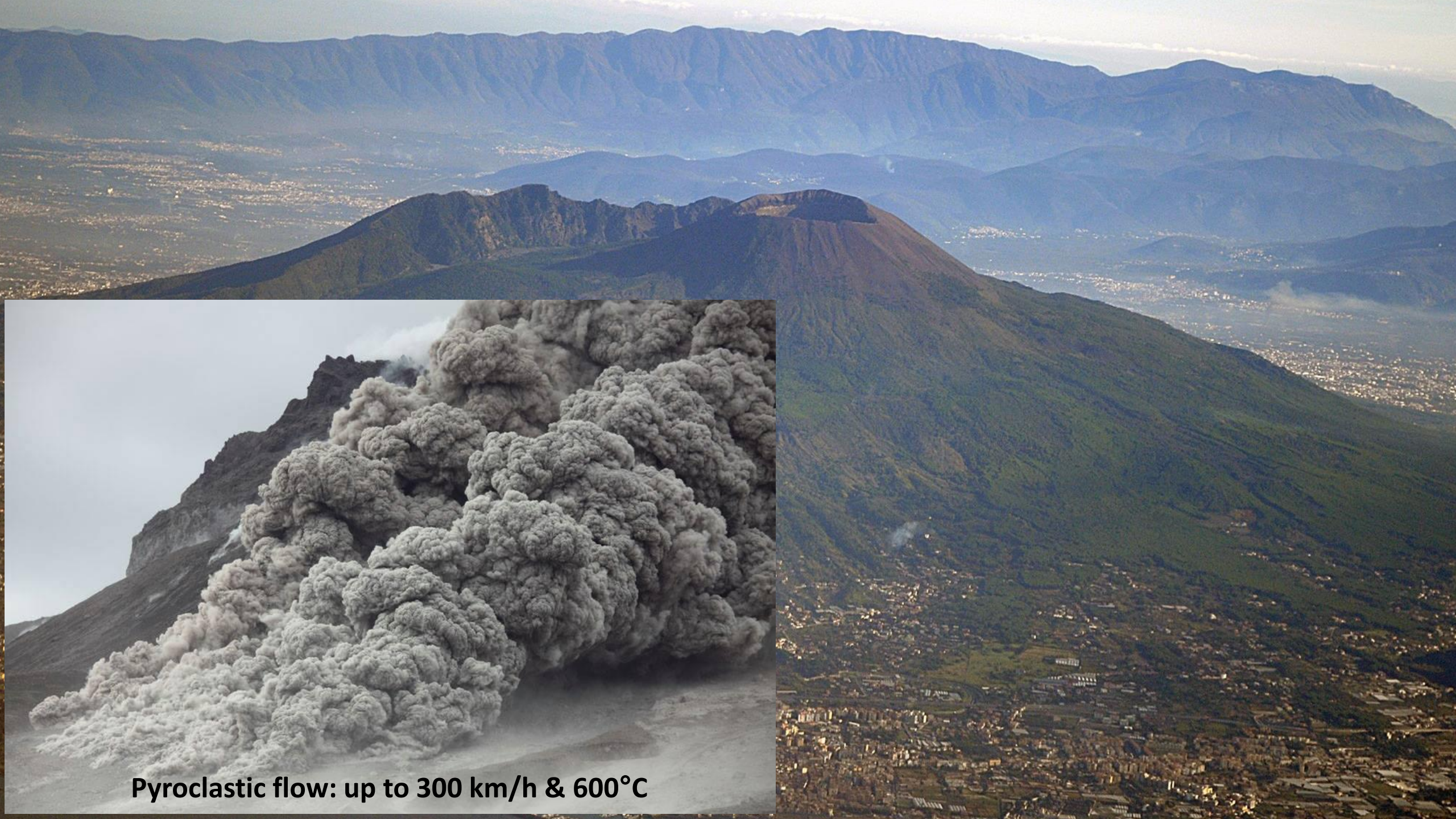
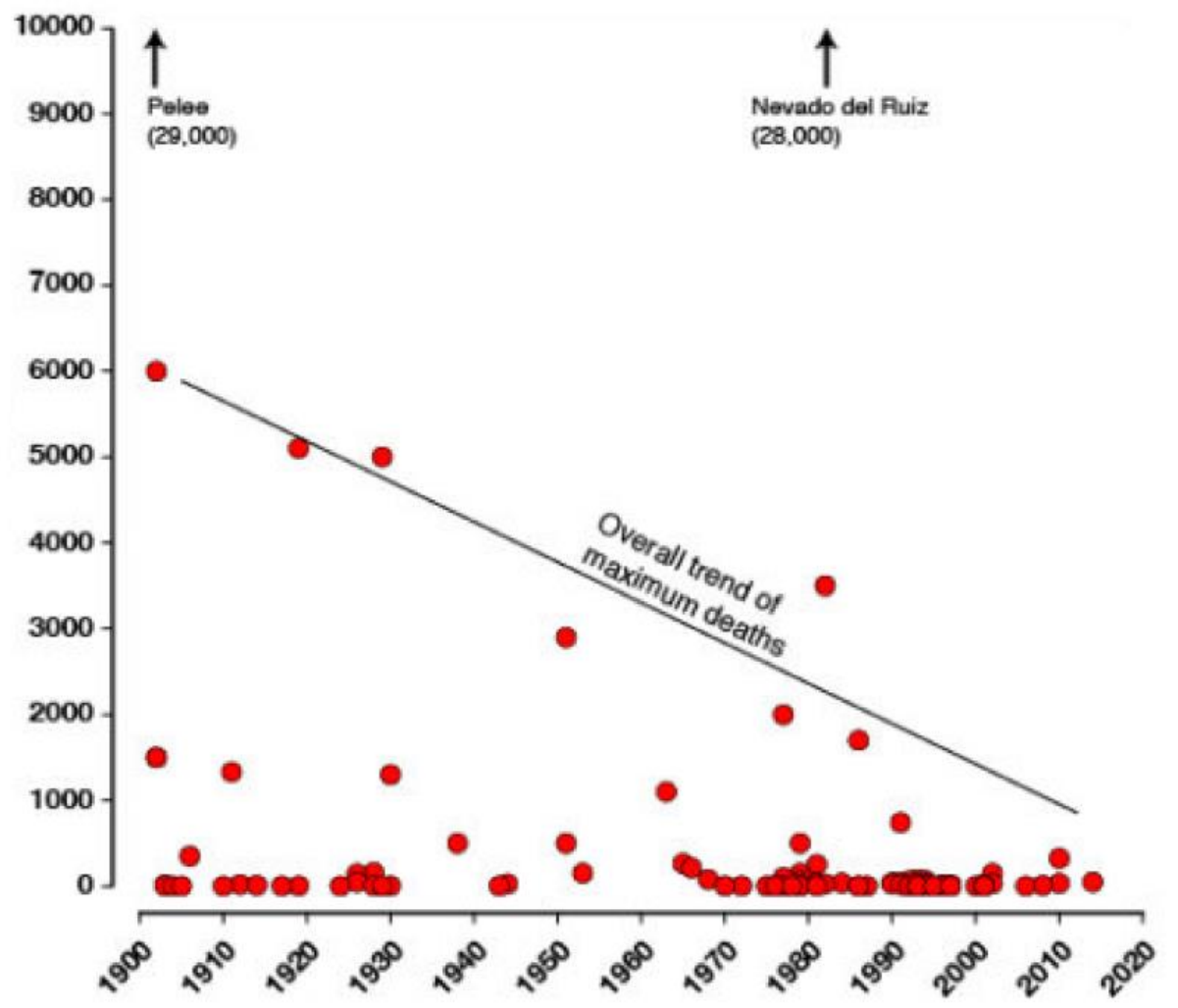
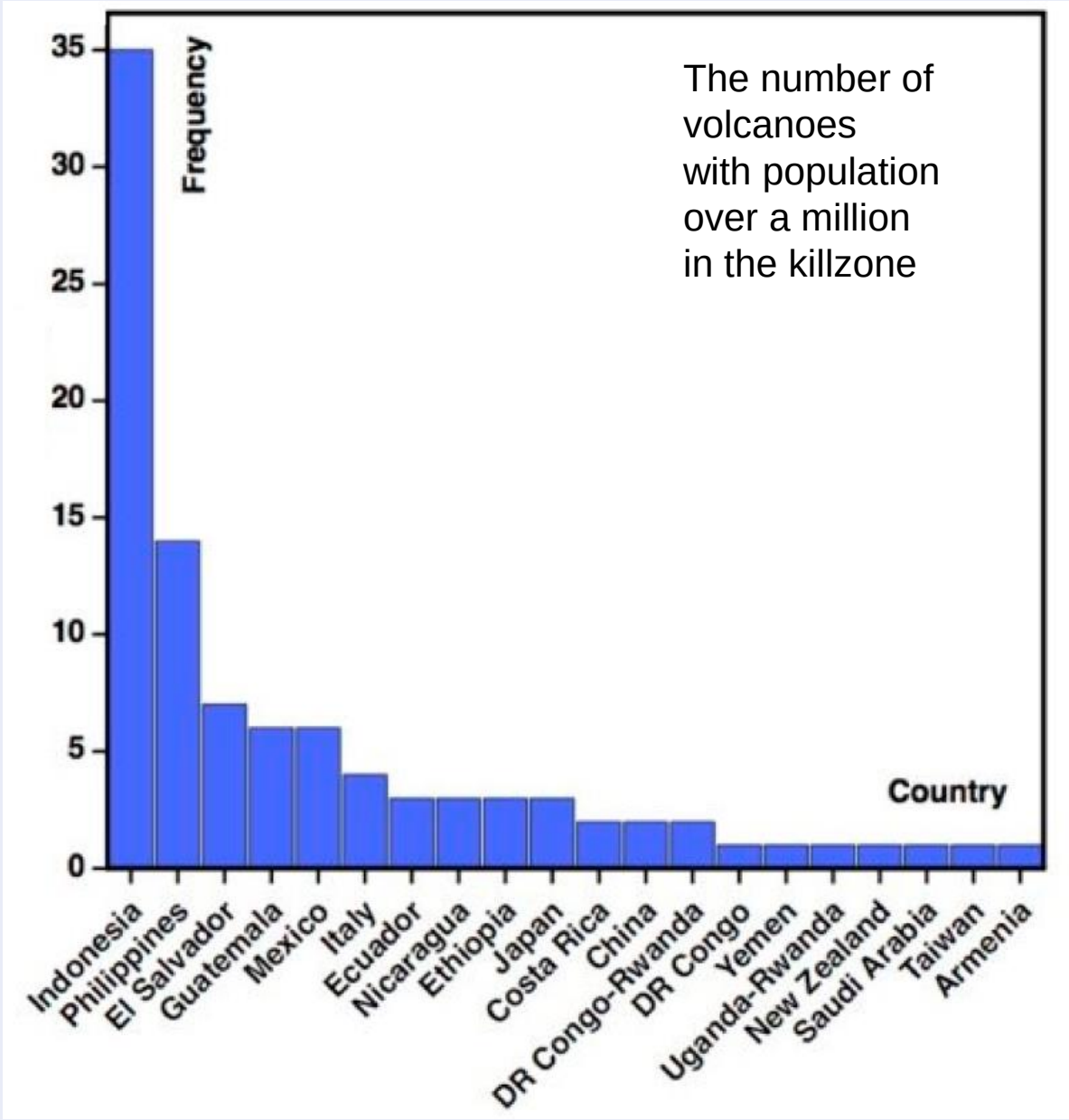
30µ


Pyroclastic flow: up to 300 km/h & 600°C

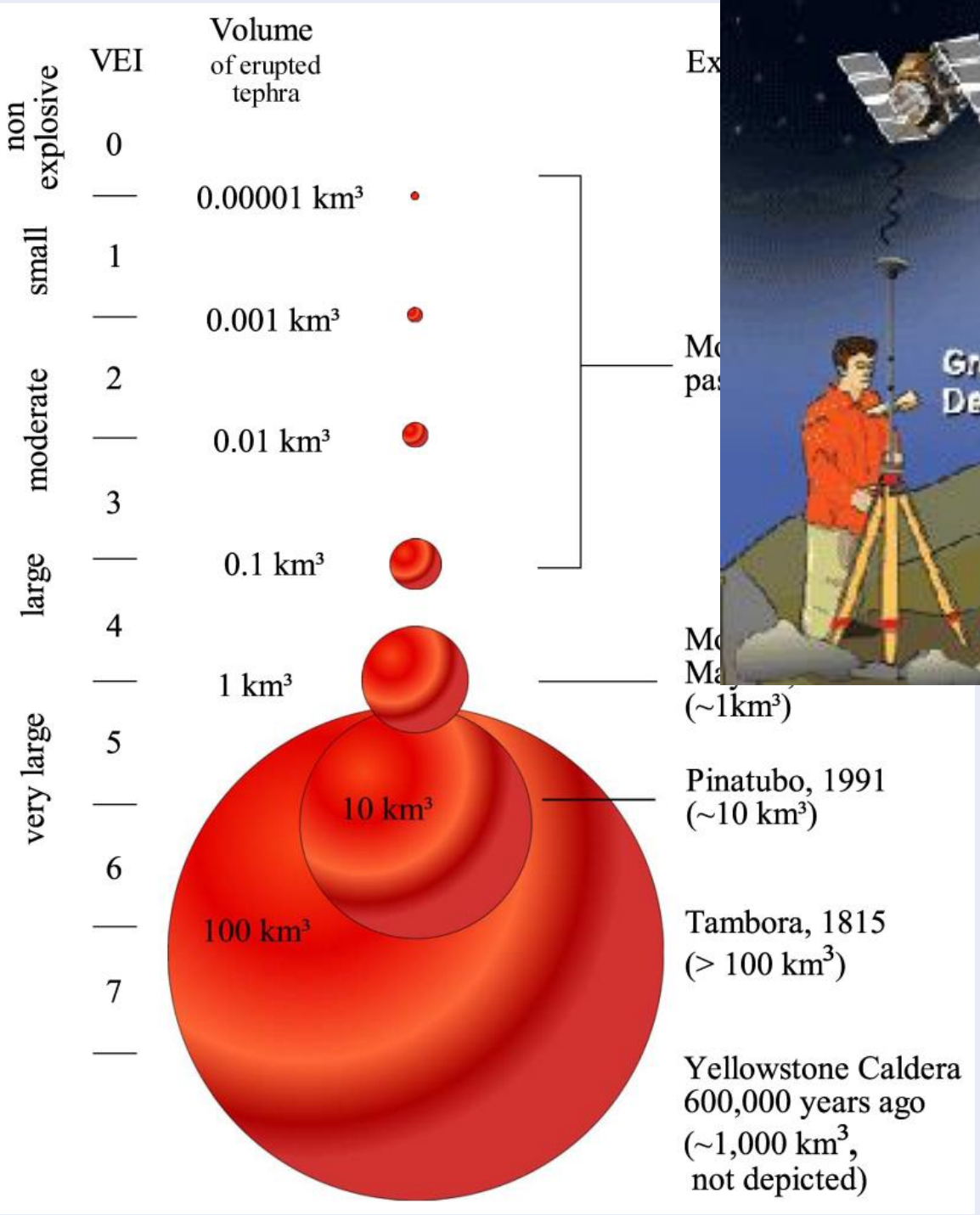
Pyroclastic flow (yes, it's a force majeure event)

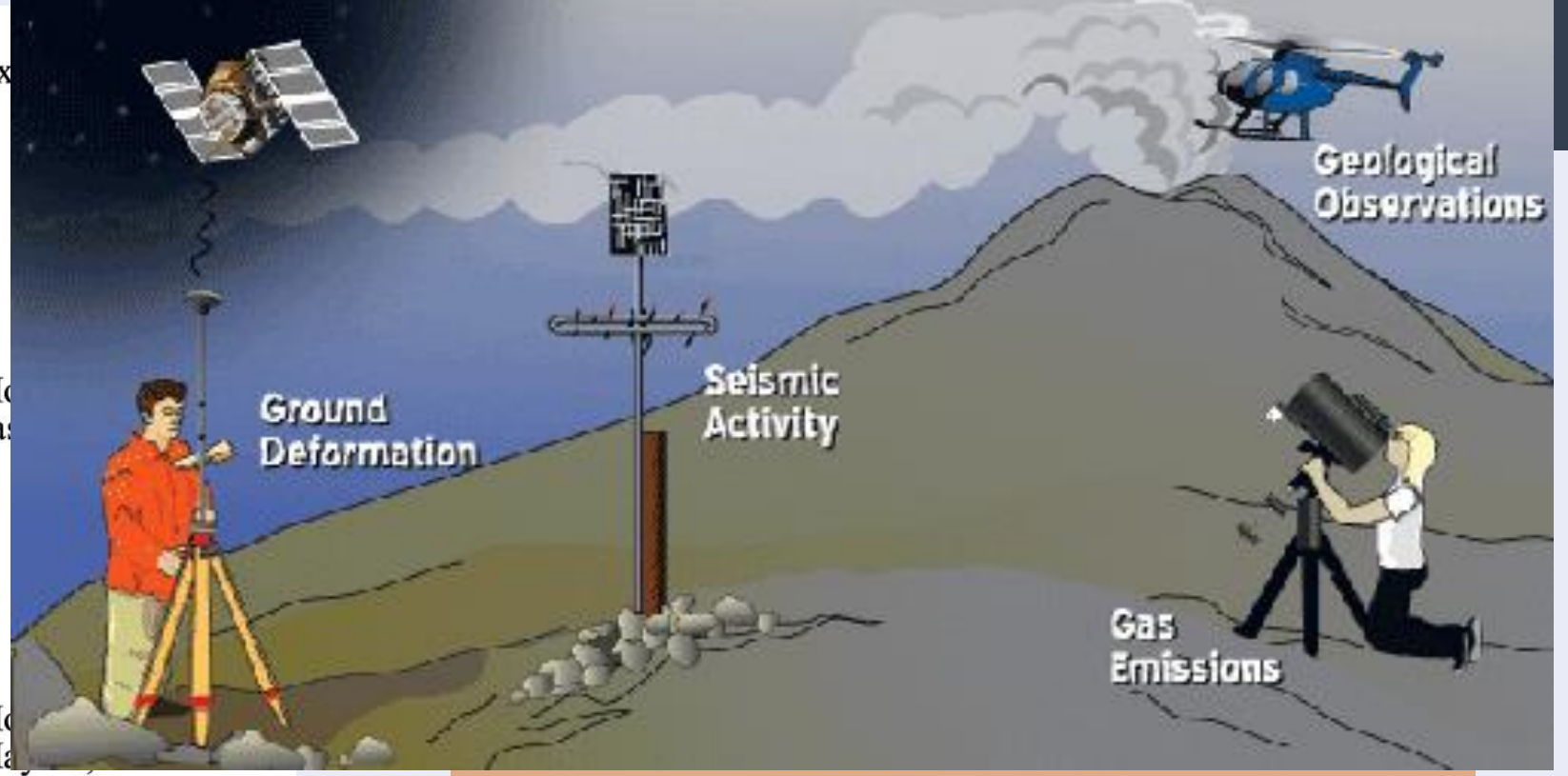


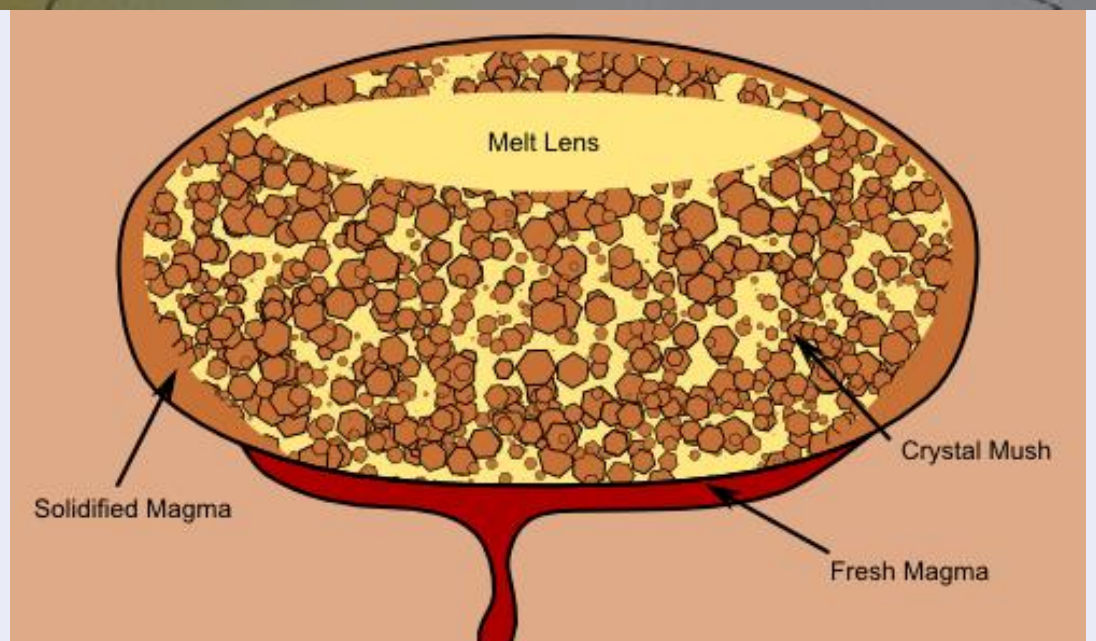
1. History of eruptions.
2. Population density in the affected area.
3. Geophysical observation system.
4. Civil defense preparedness.

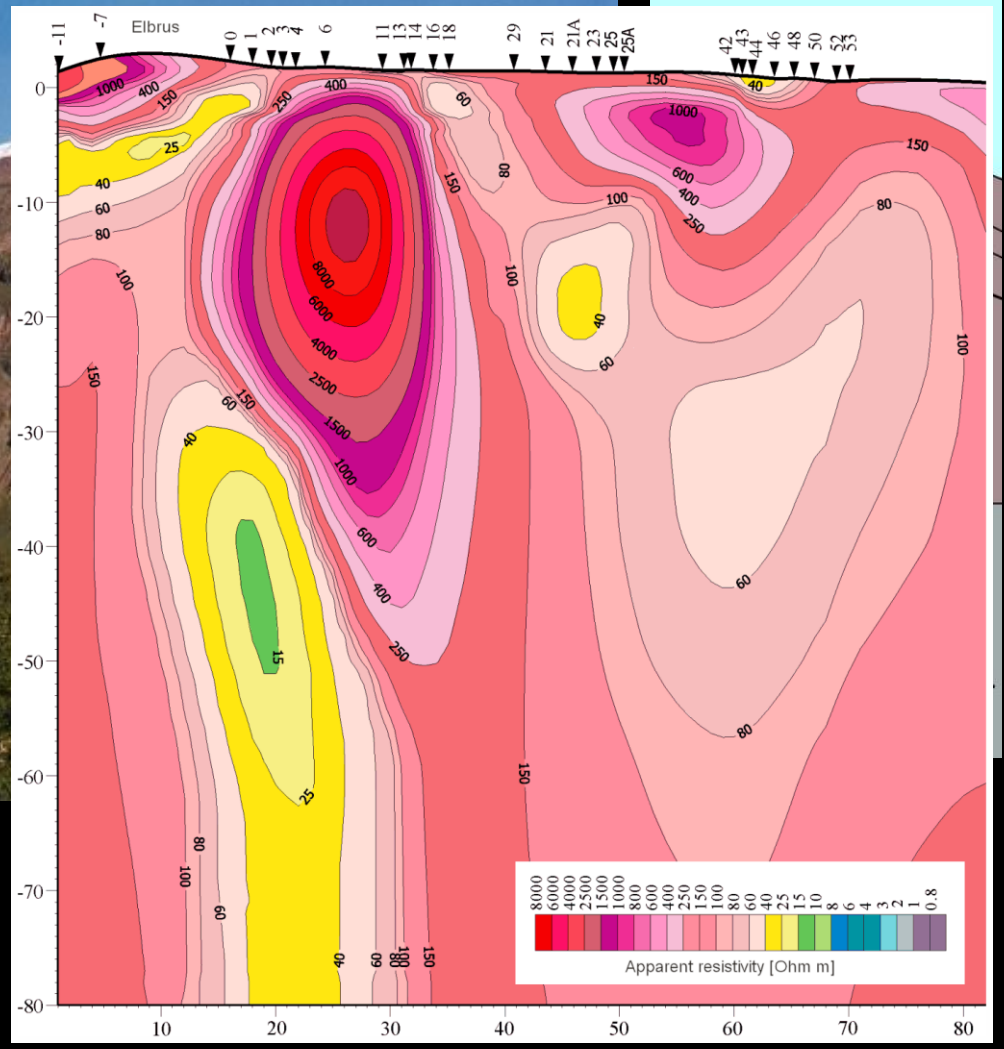


Klemetti E. All the ways to know if that volcano might kill you (2017), https://www.wired.com/2017/04/ways-know-volcano-might-kill/

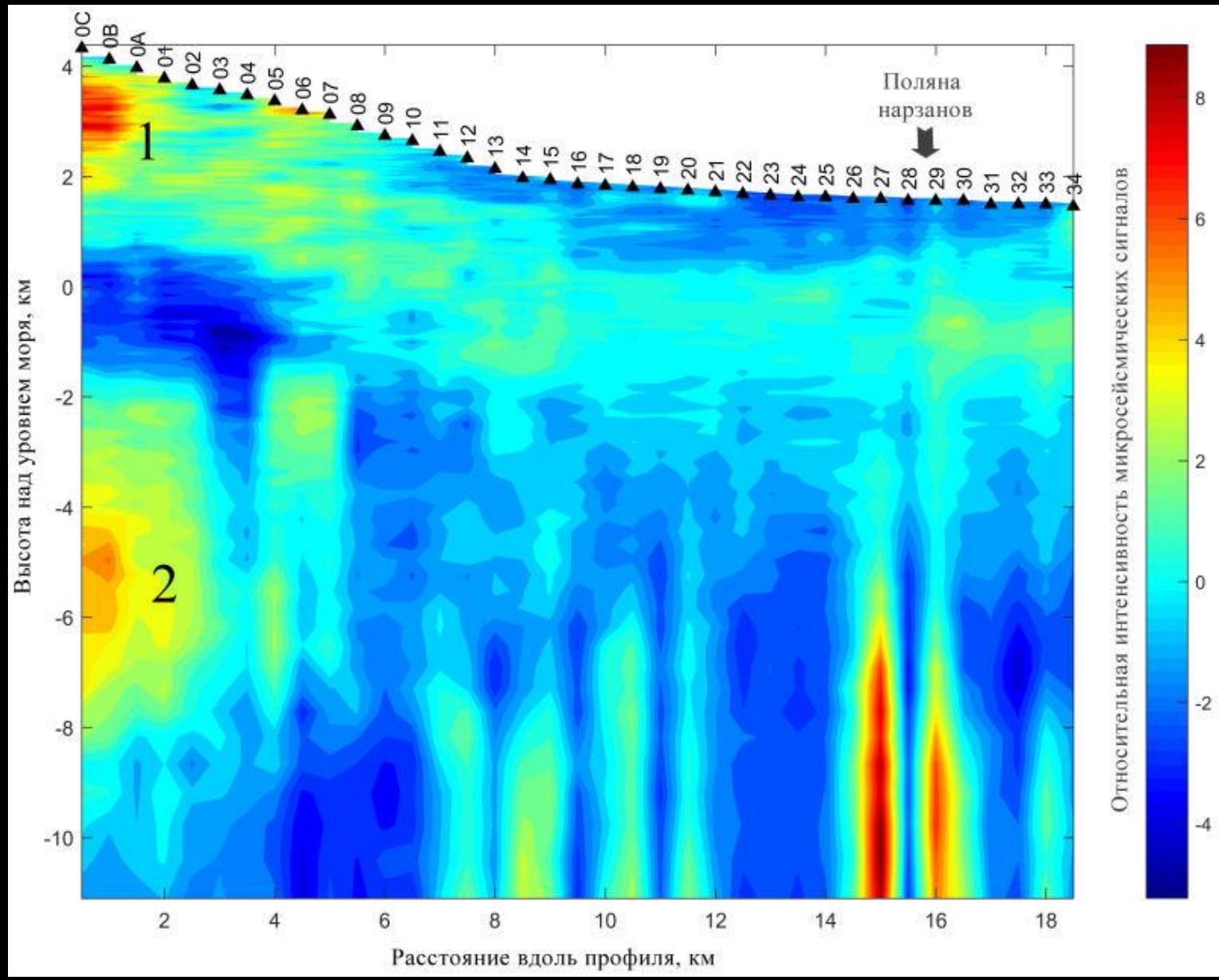

Volume
of erupted
tephra
VEI
non explosive
small
moderate
large
very large
0
1
2
3
4
5
6
7
0.00001 km³
0.001 km³
0.01 km³
0.1 km³
1 km³
10 km³
100 km³
(~1km³)
Pinatubo, 1991
(~10 km³)
Tambora, 1815
(> 100 km³)
Yellowstone Caldera
600,000 years ago
(~1,000 km³,
not depicted)


Geological
Observations
Ground
Deformation
Seismic
Activity
Gas
Emissions

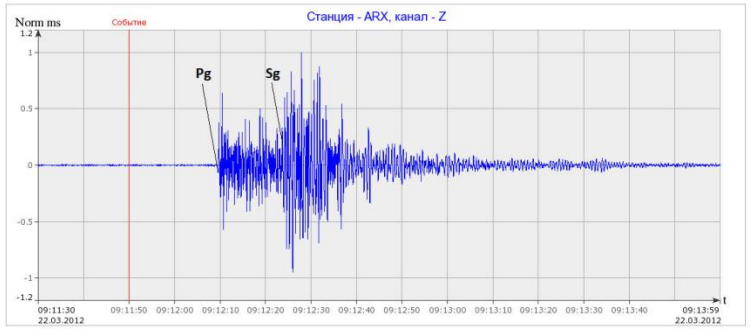

Melt Lens
Crystal Mush
Solidified Magma
Fresh Magma

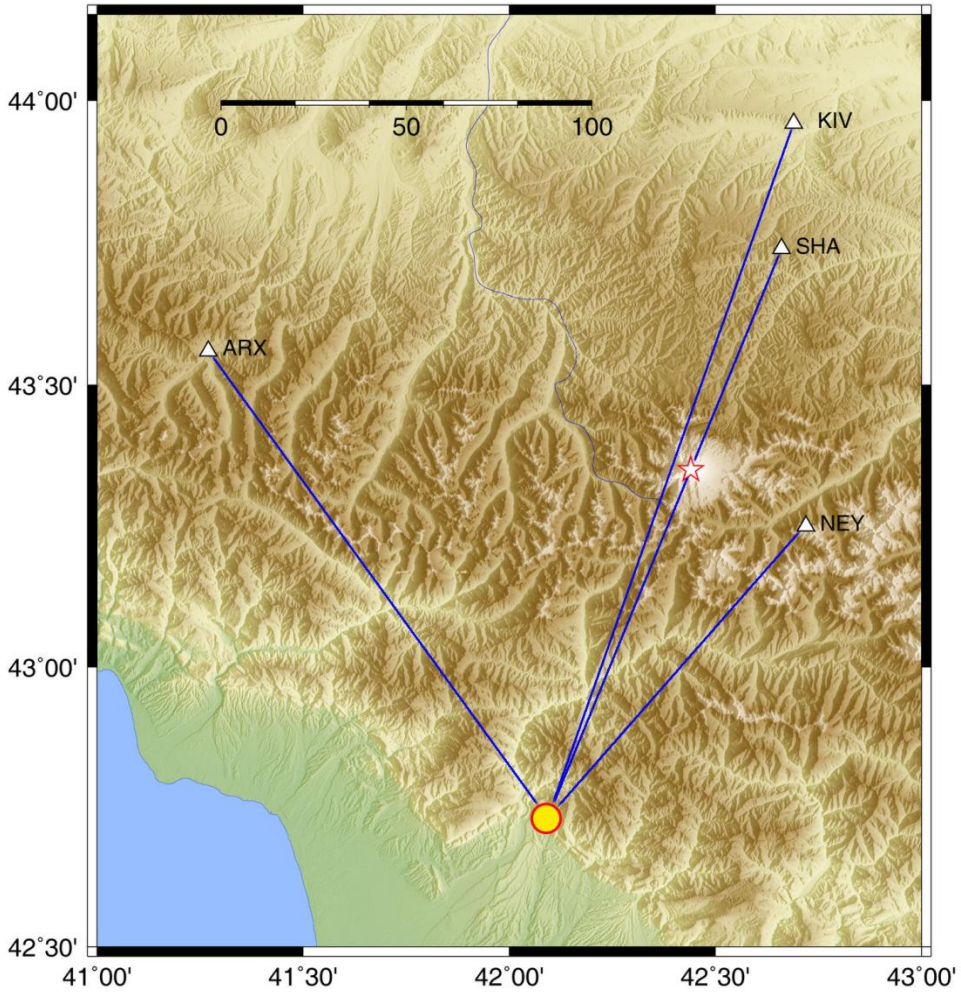


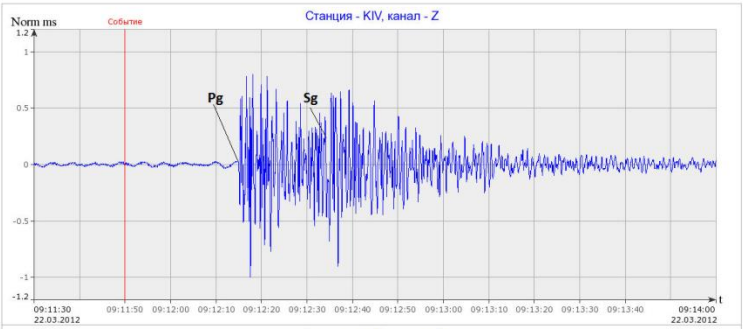
Vertical cross-section according to MT sounding (contours of apparent resistivity) [*Arbuzkin et al., 2002*]. Volcanogenic formations with high resistivity (>1000 Ohm m) on volcano slopes. Decrease of Ro related to higher deep temperatures (up to 400–1000 °C) and may be associated with magmatic structures.

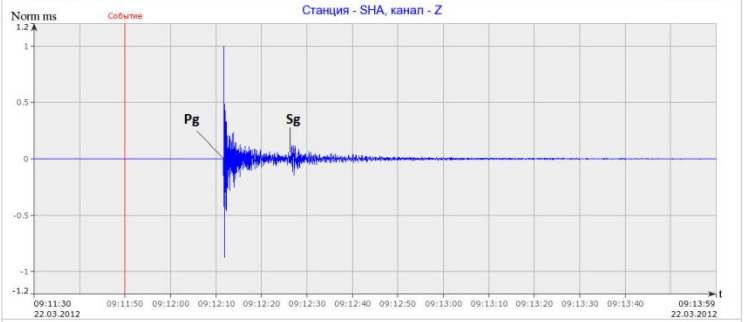


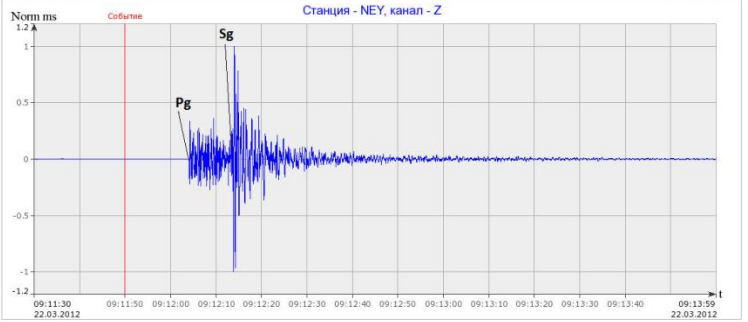
Vertical geophysical cross-section obtained by means of microseismic sounding method. Relatively low-velocity areas (warm colors) spatially coincide with the near-surface elements (1, 2) of the fluid-magmatic feeding system of the Elbrus volcano.





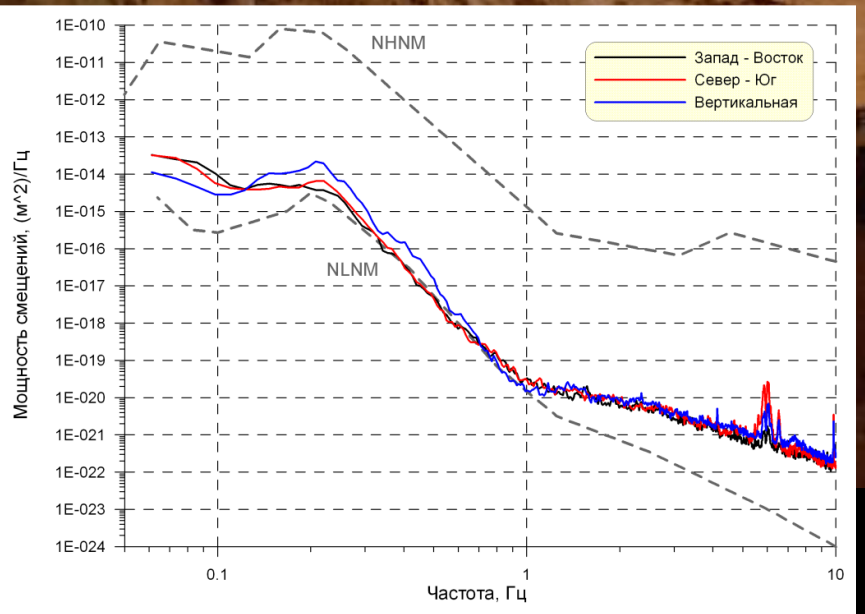




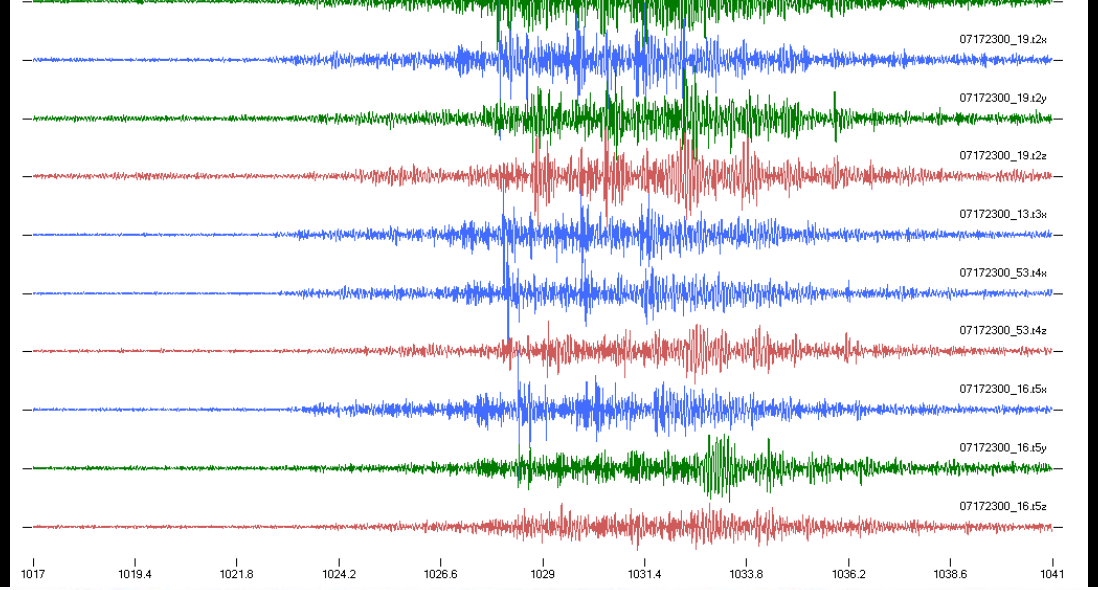


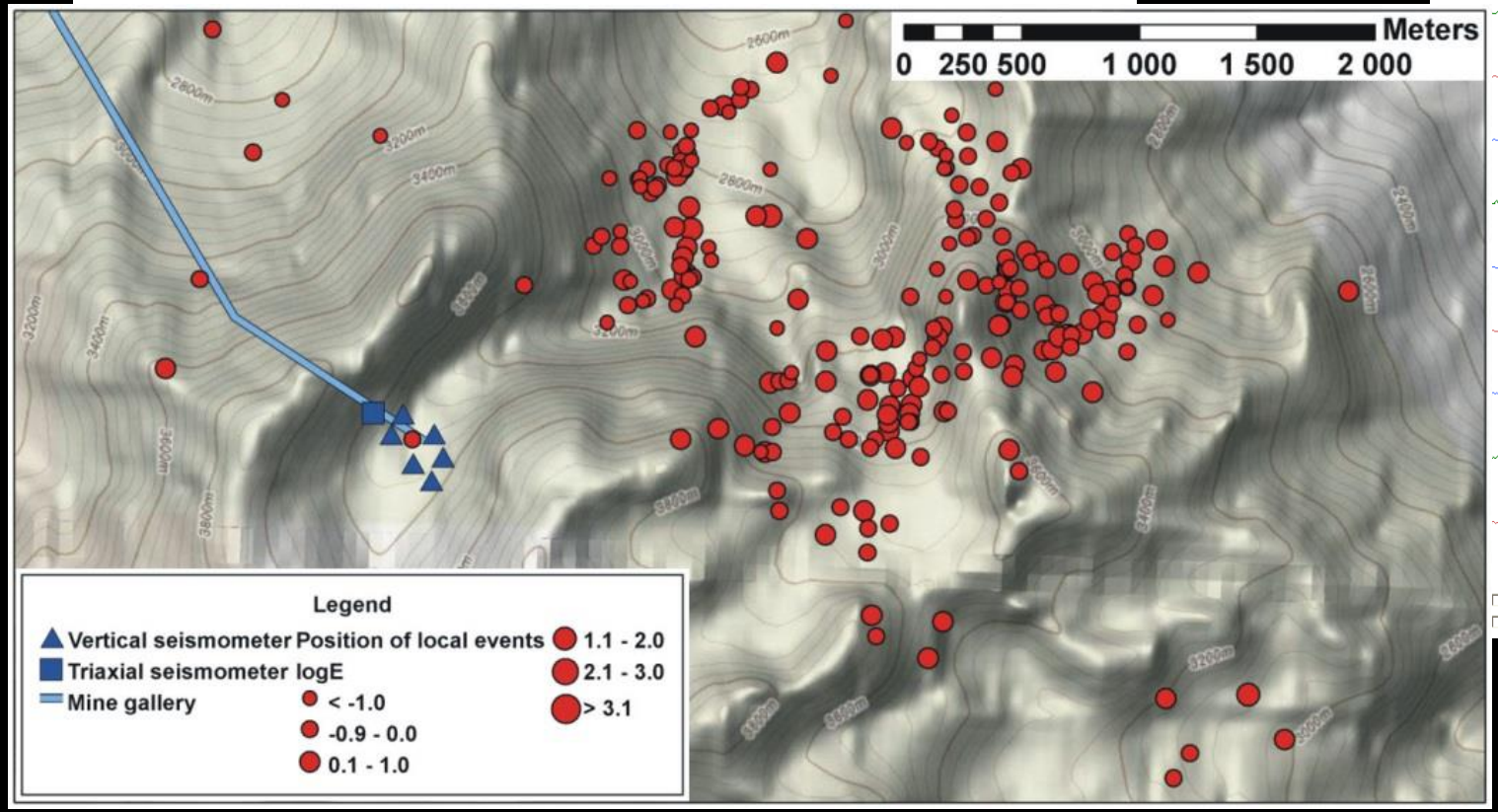
Regional seismic event with visible attenuation effect for short-period shear waves passing through the Elbrus volcanic center.

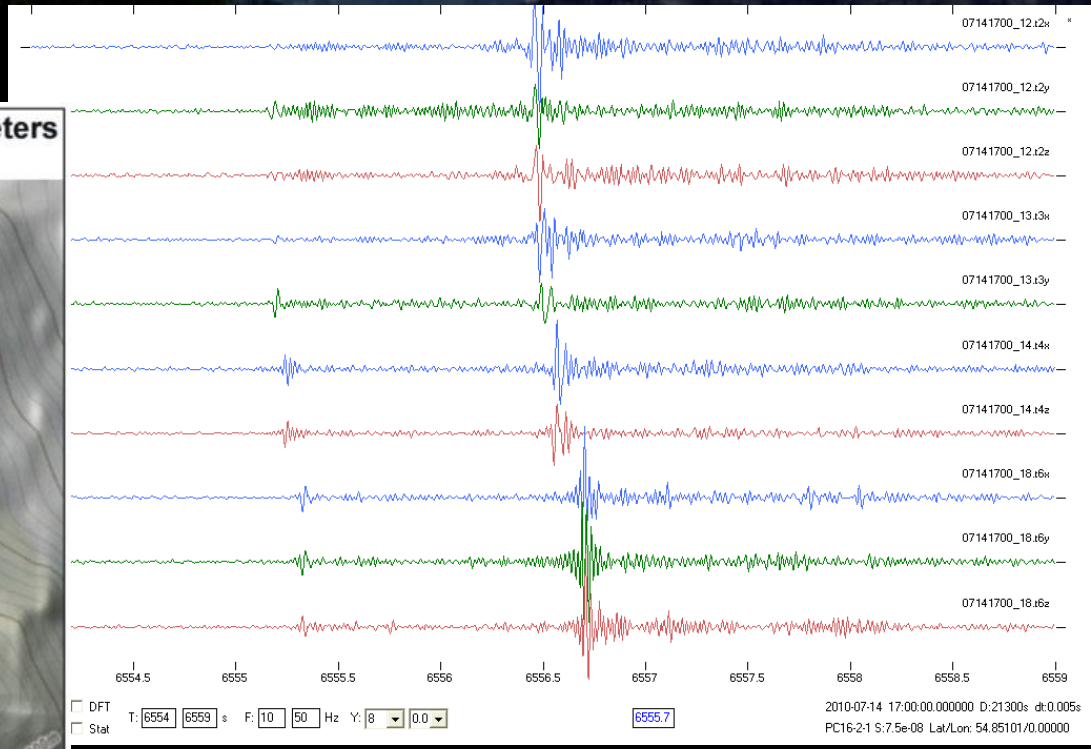
The underground research facility



Geophysical instrumentation in the deep underground laboratory

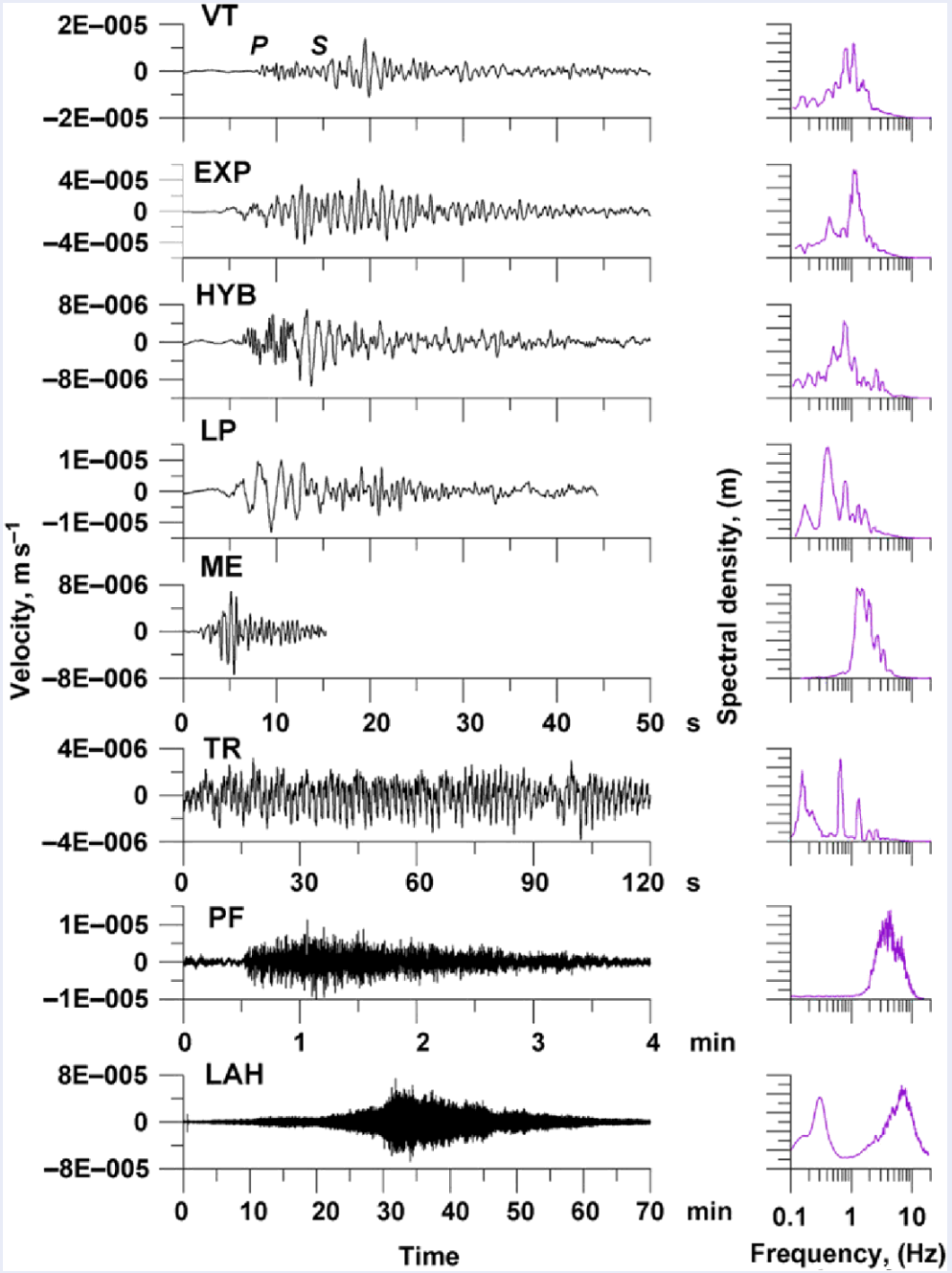






Epicenters of local earthquakes (rock bursts, tectonic events and icequakes) near the tunnel of the Baksan Neutrino Observatory [Verkholantseva et al., 2012].

Seismic signals observed at the Colima volcano [Zobin, 2011].



VT – volcano-tectonic earthquakes,

EXP – crater explosions,

HYB – gas outbursts,

LP – long-period earthquakes,

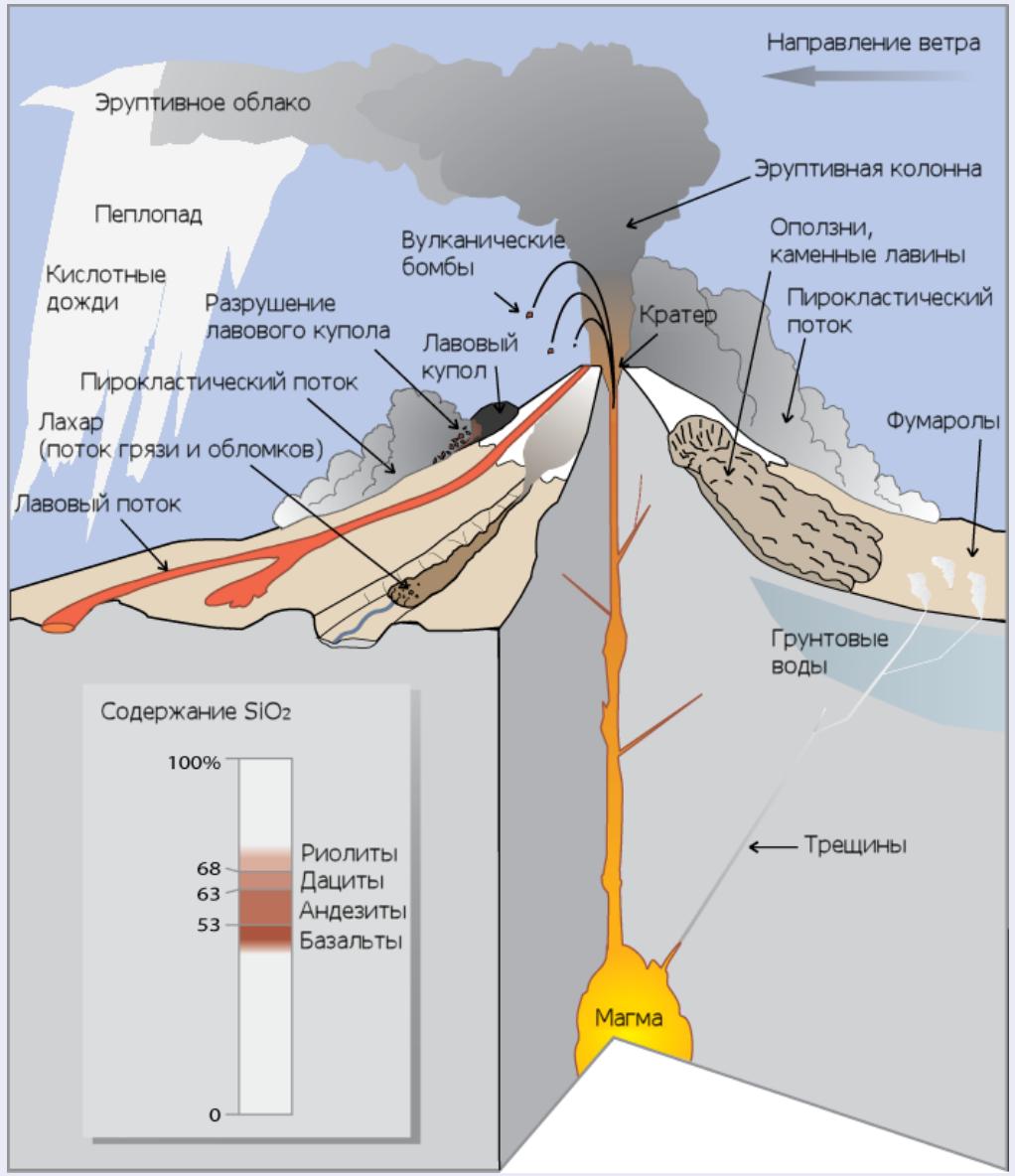
ME – extrusion related,

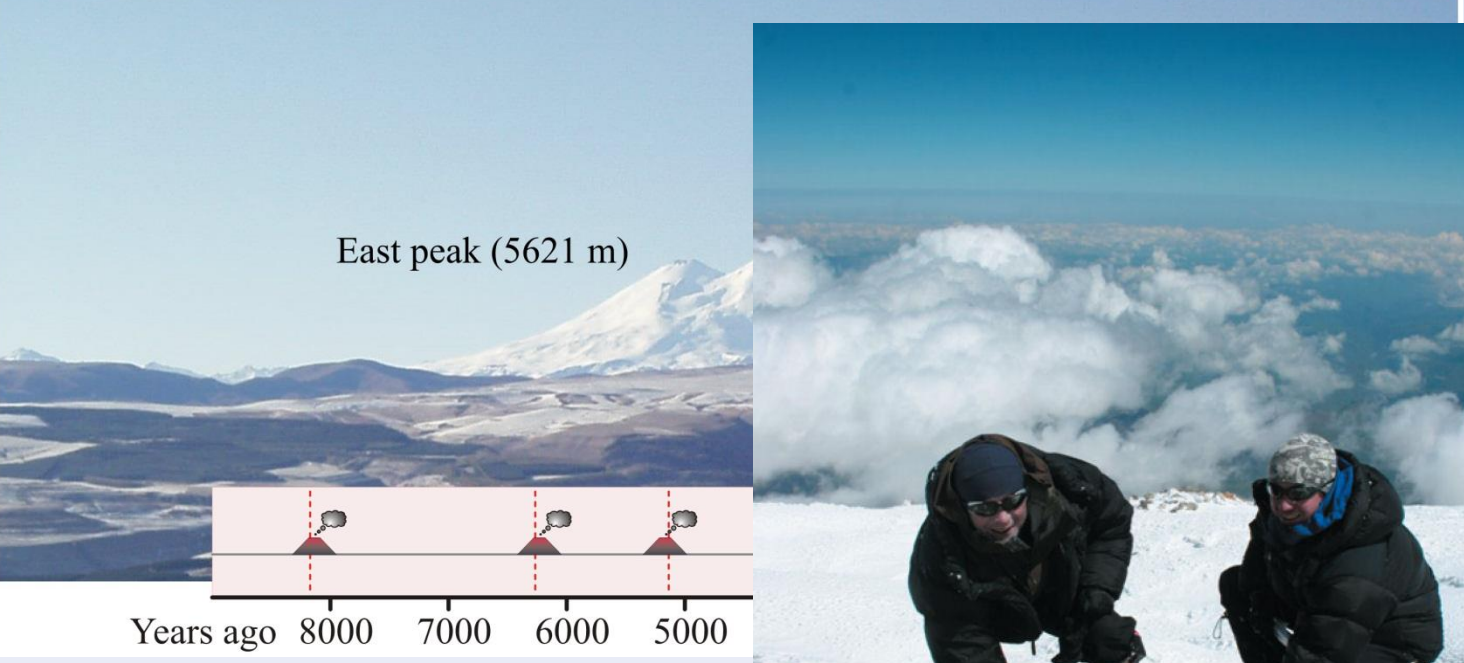
TR – volcanic tremors,

PF – pyroclastic flows,

LAH – lahar flows.

The underground sound

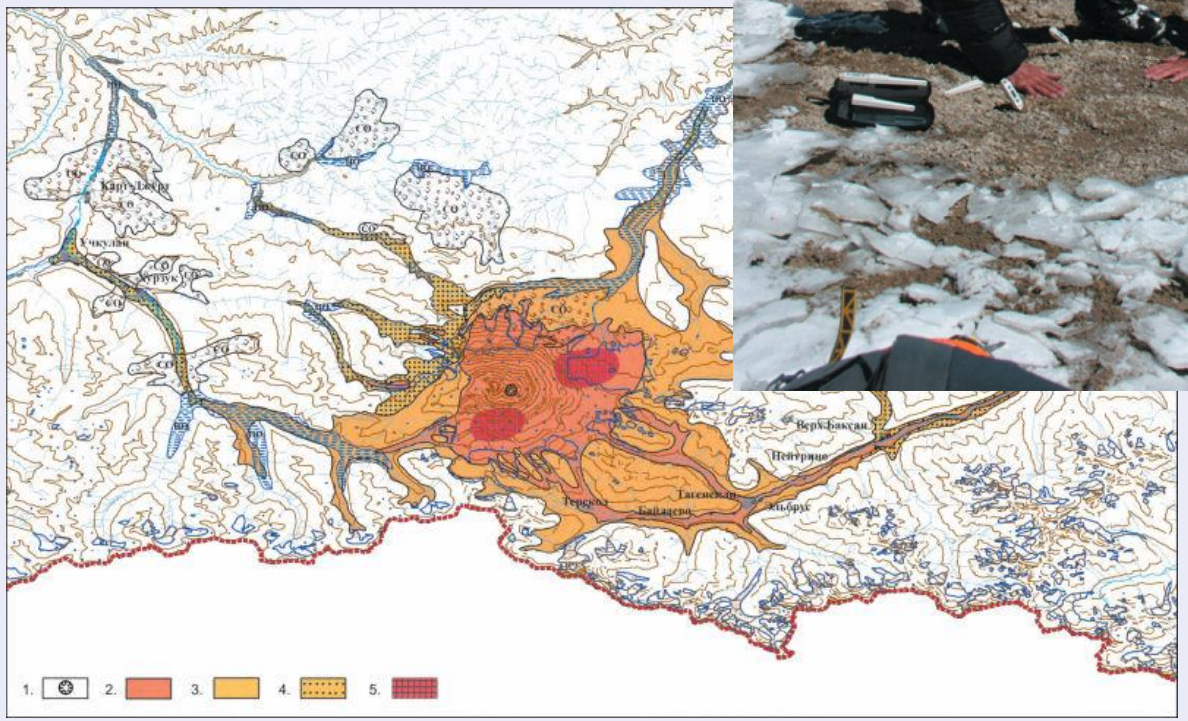




Expedition of the Institute of Geography, Russian Academy of Sciences, mount Elbrus, Eastern peak, 5600 m.

Air temperature – 20°C,
surface temperature + 5°C
~20 cm deeper + 20°C.

Glacier-covered (~140 km^2).

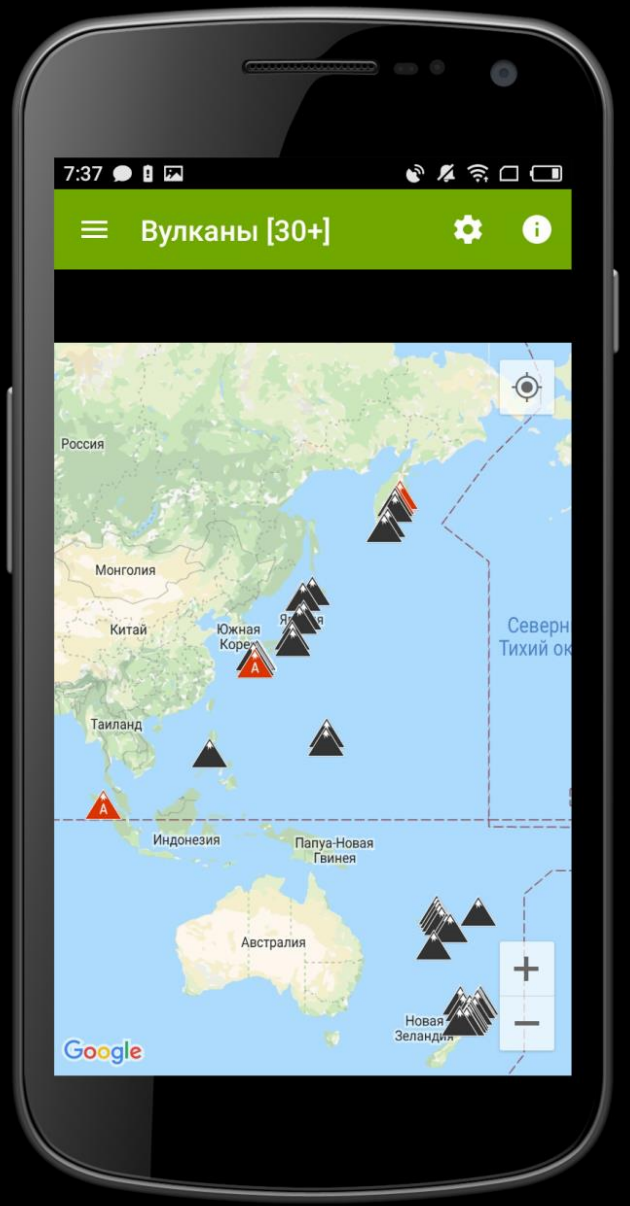


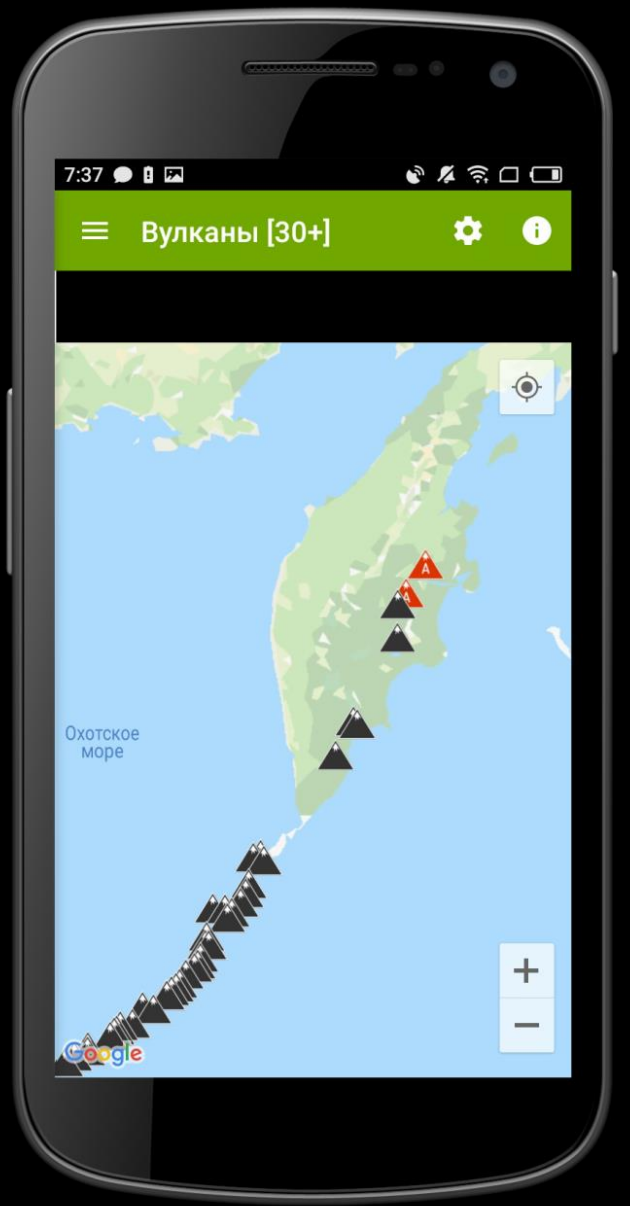
Lahar deposits on the sides of the valleys of the Baksan and Malka rivers, 50 to 72 km from the Elbrus volcano.

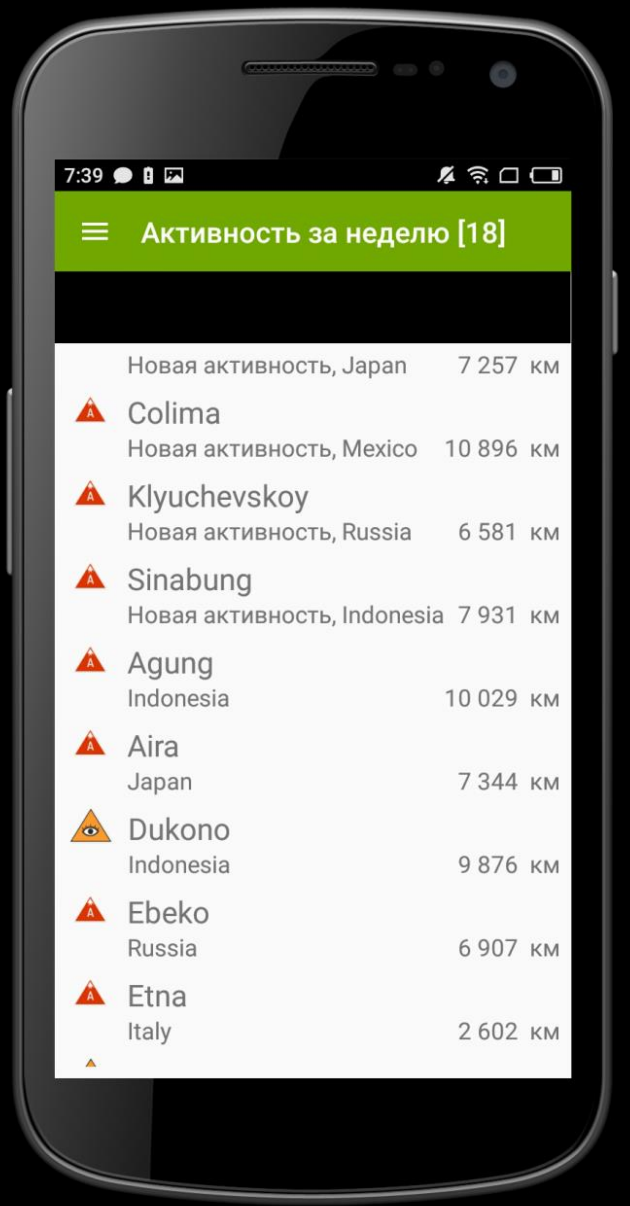
Interactive map of volcanic activity

ANDROID APP ON Google play

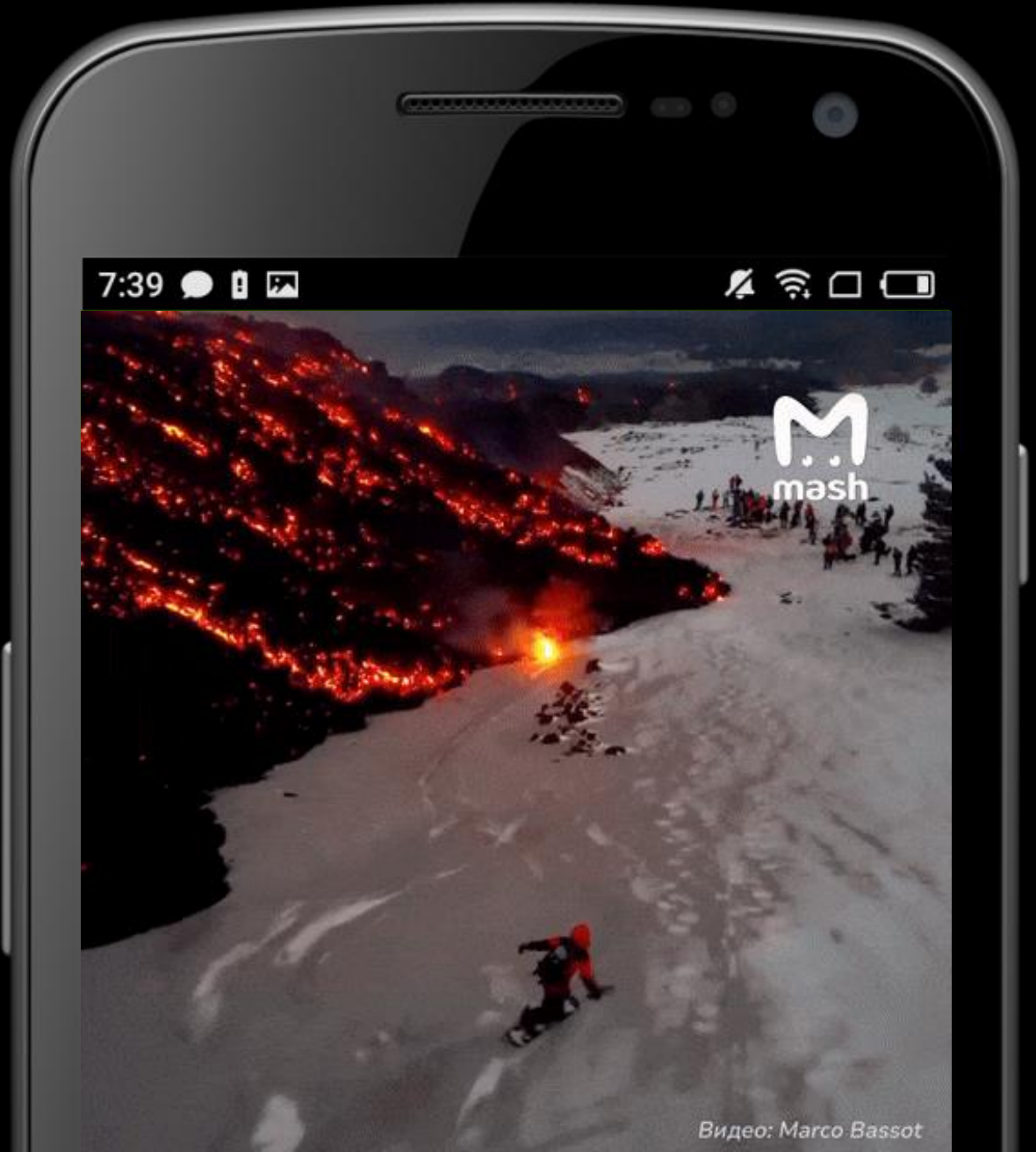
Download on the App Store

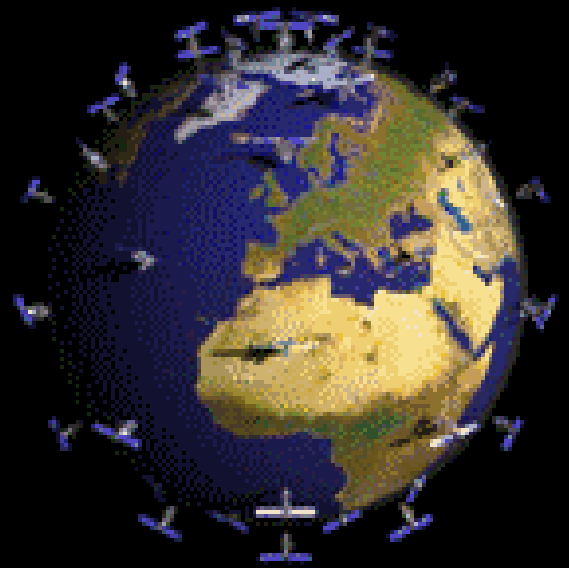

7:37
Вулканы [30+]
Россия
Монголия
Китай
Южная Корея
Таиланд
Индонезия
Папуа-Новая Гвинея
Австралия
Новая Зеландия
Google


7:37
Вулканы [30+]
Охотское море
Google

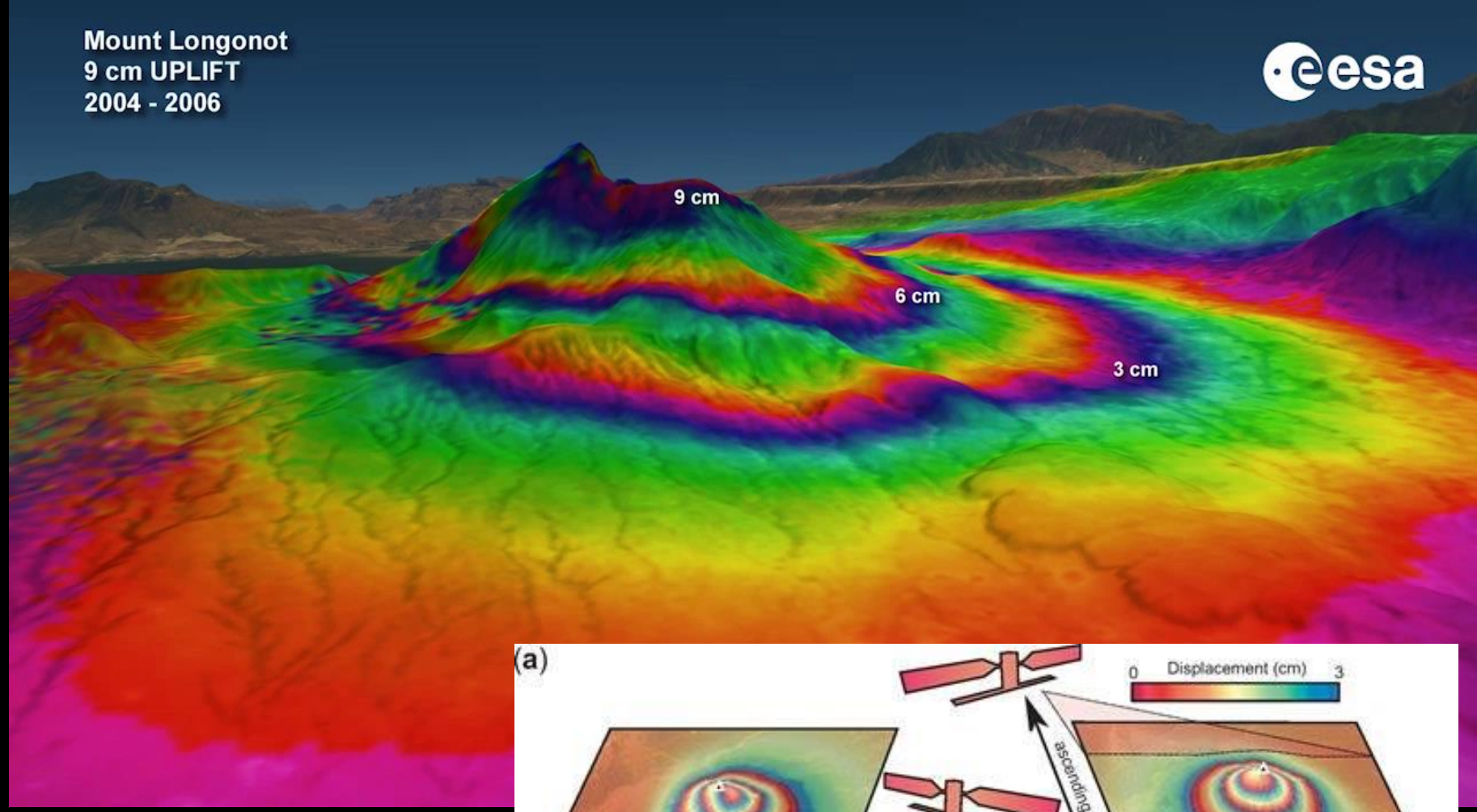

7:39
Активность за неделю [18]
Новая активность, Japan 7 257 км
Colima
Новая активность, Mexico 10 896 км
Klyuchevskoy
Новая активность, Russia 6 581 км
Sinabung
Новая активность, Indonesia 7 931 км
Agung
Indonesia 10 029 км
Aira
Japan 7 344 км
Dukono
Indonesia 9 876 км
Ebeko
Russia 6 907 км
Etna
Italy 2 602 км

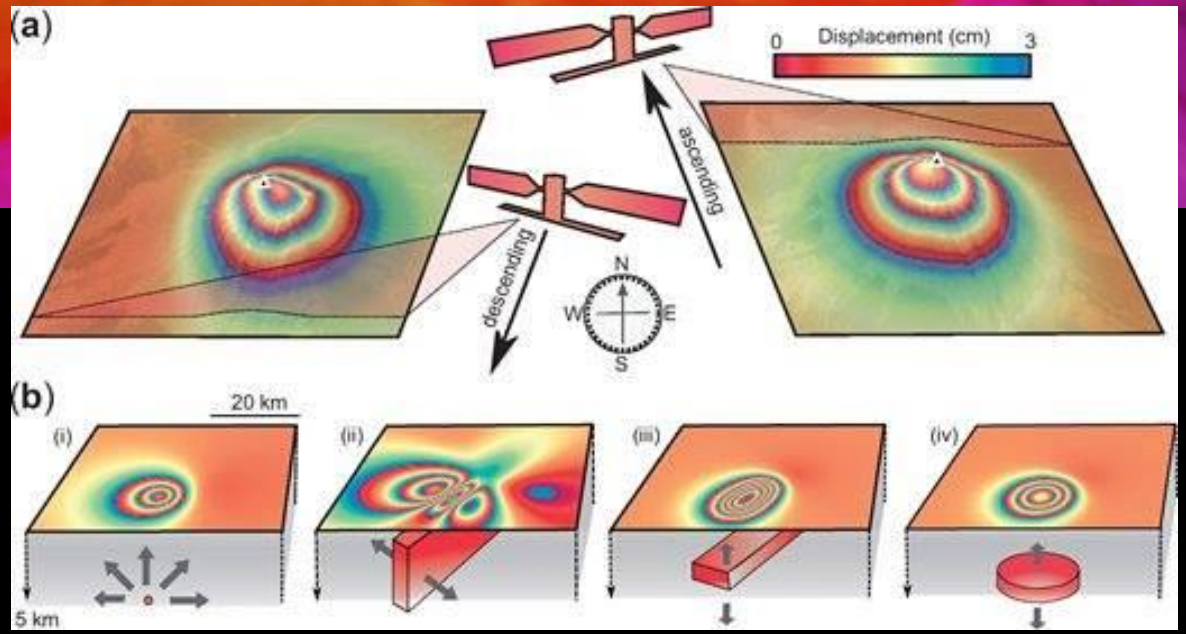
Snowboarding on slopes of the active volcano!





Remote sensing:
InSAR imaging





Vertical uplift detection (phase variations in reflected signals) and modelling [Biggs, Robertson et al., 2013].

China has 10 Holocene volcanoes. Note that as a scientific organization we provide these listings for informational purposes only, with no international legal or policy implications. Volcanoes will be included on this list if they are within the boundaries of a country, on a shared boundary or area, in a remote territory, or within a maritime Exclusive Economic Zone. Bolded volcanoes have erupted within the past 20 years. Suggestions and data updates are always welcome (Contact GVP).

Volcano Name	Last Eruption	Volcanic Region	Primary Landform
Arxan-Chaihe	0 CE	Central East Asia Volcanic Province	Cluster
Ashikule Volcanic Field	1951 CE	Kunlun Fault Volcano Group	Cluster
Changbaishan	1903 CE	Central East Asia Volcanic Province	Composite
Hainan Volcanic Field	1933 CE	Southeast Asia Volcanic Province	Cluster
Honggeertu	Unknown - Evidence Uncertain	Central East Asia Volcanic Province	Cluster
Jingpohu	520 BCE	Central East Asia Volcanic Province	Cluster
Keluo Group	Unknown - Evidence Credible	Central East Asia Volcanic Province	Cluster
Longgang Group	350 CE	Central East Asia Volcanic Province	Cluster
Tengchong	5750 BCE	Southeast Asia Volcanic Province	Cluster
Wudalianchi	1776 CE	Central East Asia Volcanic Province	Cluster

Volcano Observatories
Chinese Earthquake Authority

https://volcano.si.edu/volcanolist_countries.cfm?country=China