Rootless phreatomagmatic explosions with generation of pyroclastic flows: result of interaction of lava flows and ice or ice/fluid-saturated rocks

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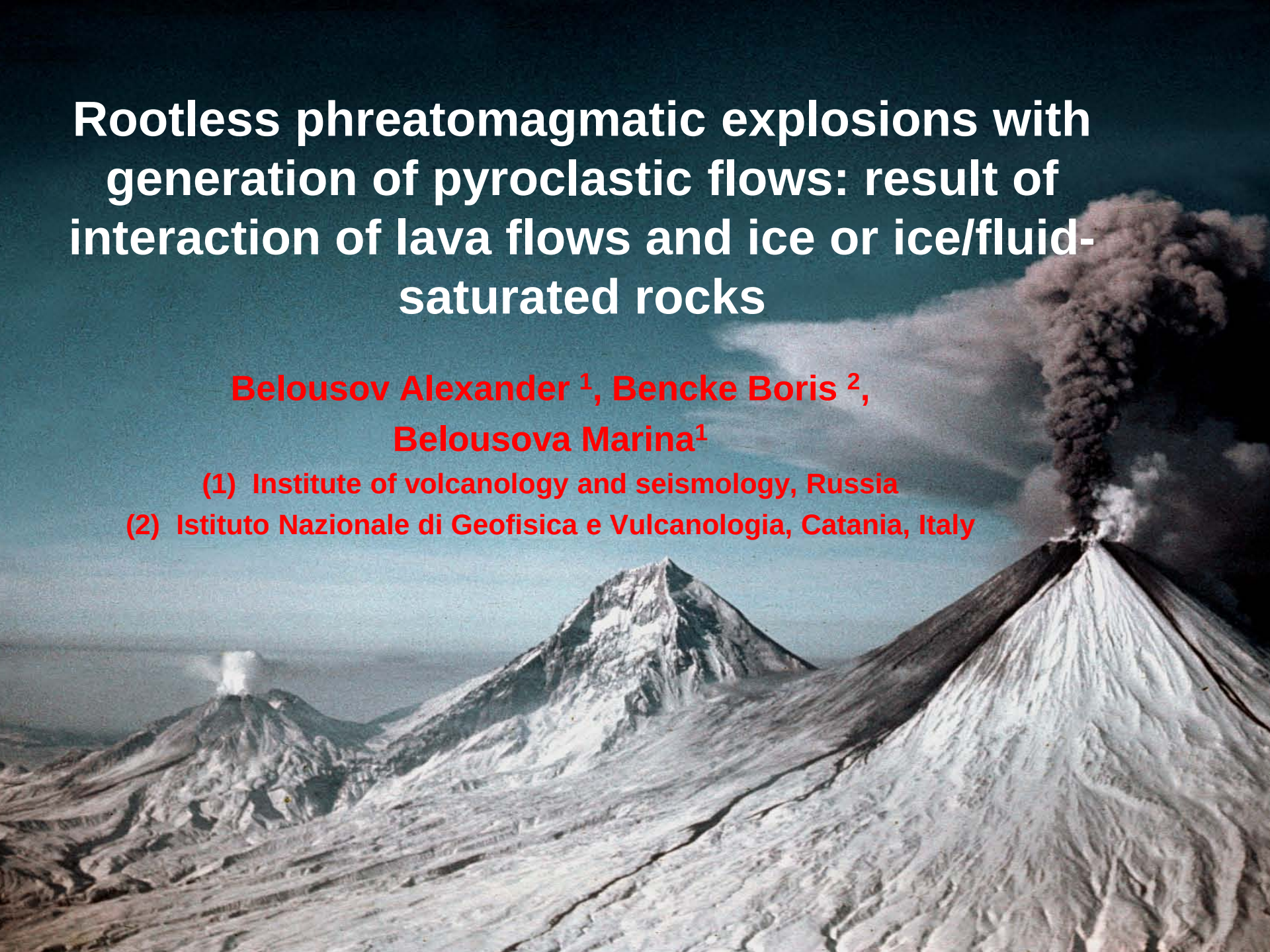
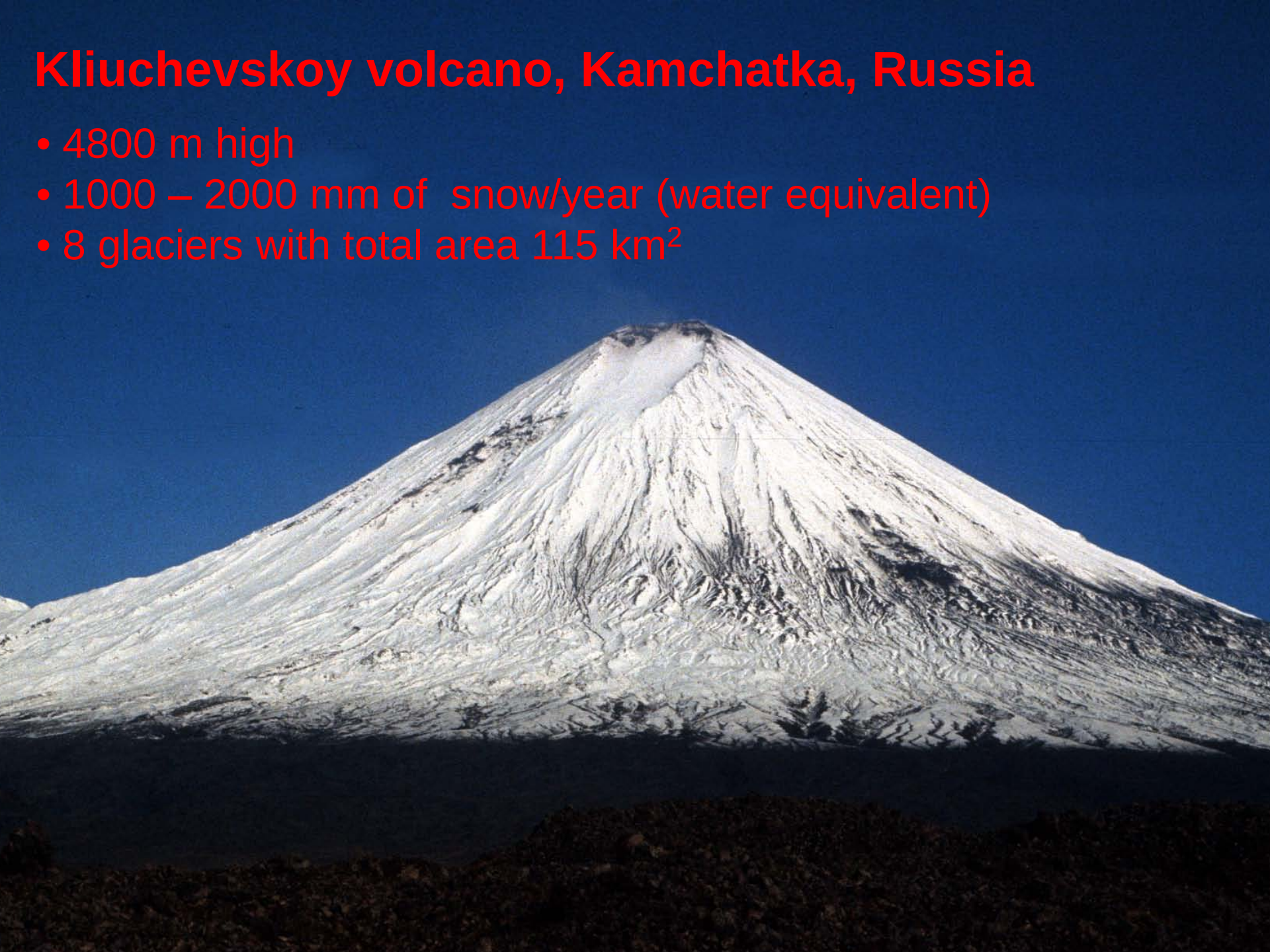


Kliuchevskoy volcano, Kamchatka, Russia

- 4800 m high
- 1000 – 2000 mm of snow/year (water equivalent)
- 8 glaciers with total area 115 km^2



Kliuchevskoy volcano

- 80 historical eruptions (since 1697)
- average discharge of magma 6×10^7 ton/year
- basalt – basaltic andesite with temperatures up to 1100^{o} C


1985


1993


1994


2007
Yu. Demianchuk

Kliuchevskoy, January 1, 1945.
Drawing by B.I.Piip

Deposits of the 1945
“hot avalanche”


Kliuchevskoy, October 1, 1994

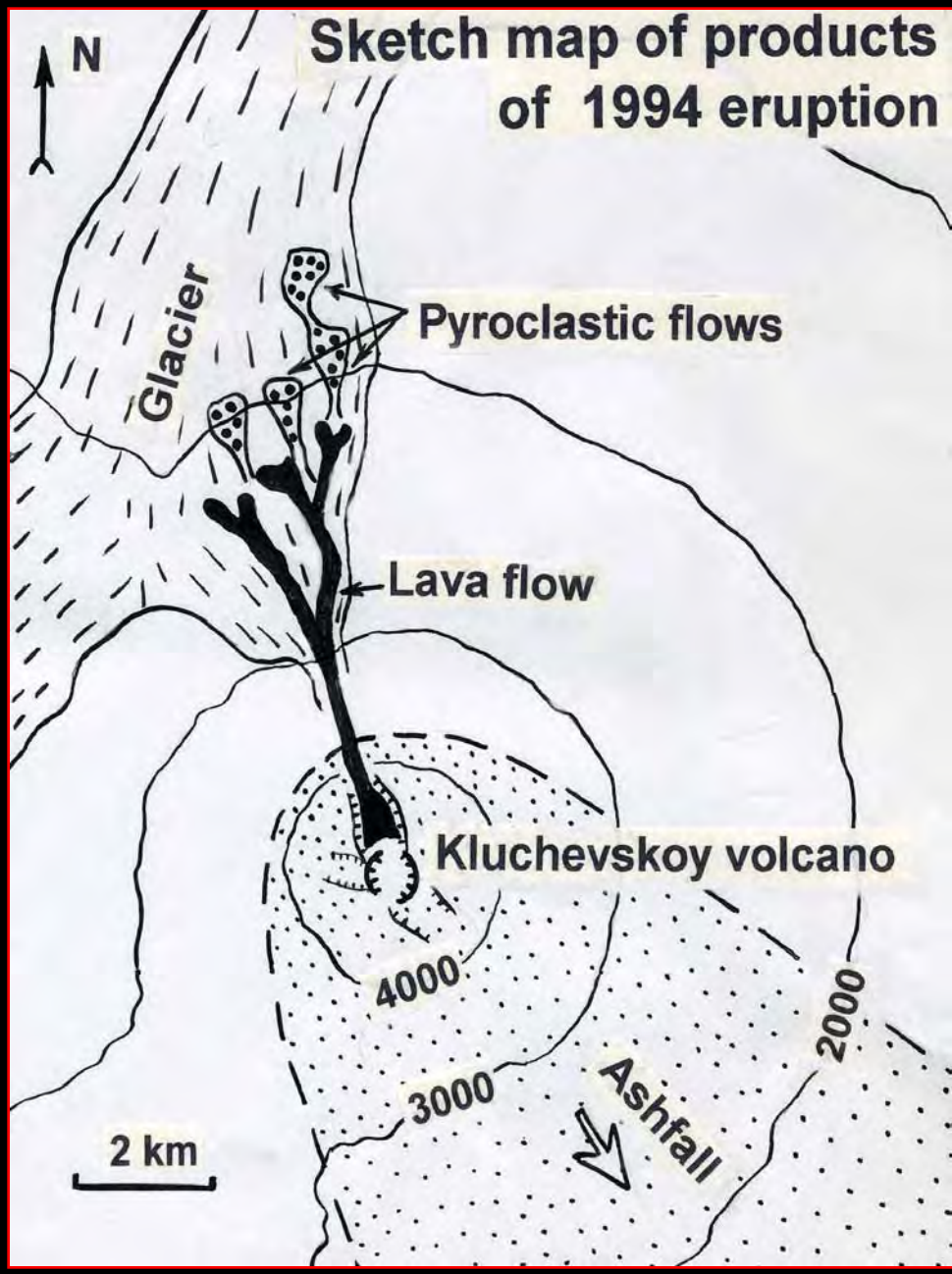

Kliuchevskoy, October 1, 1994.

Kliuchevskoy, October 1, 1994.

The 1994 pyroclastic flows

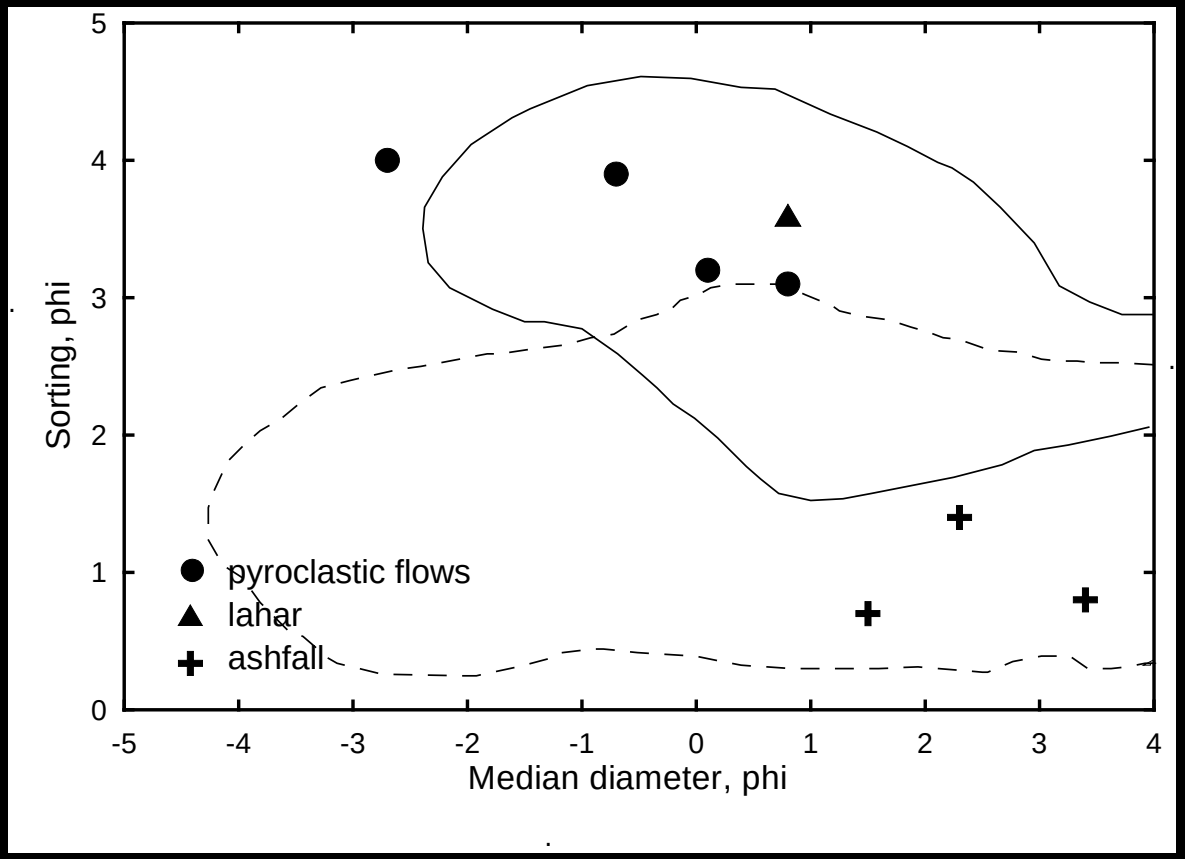
Pyroclastic flow deposits:

Multiple intercalated flow lobes 0.5 – 1 m thick, 10 – 20 m wide formed several extensive fan-shaped compound fields (hundreds m across) at elevations 2100 - 2300 m.
Thickness >10 m.
Volume 1-5 million cub. m.).

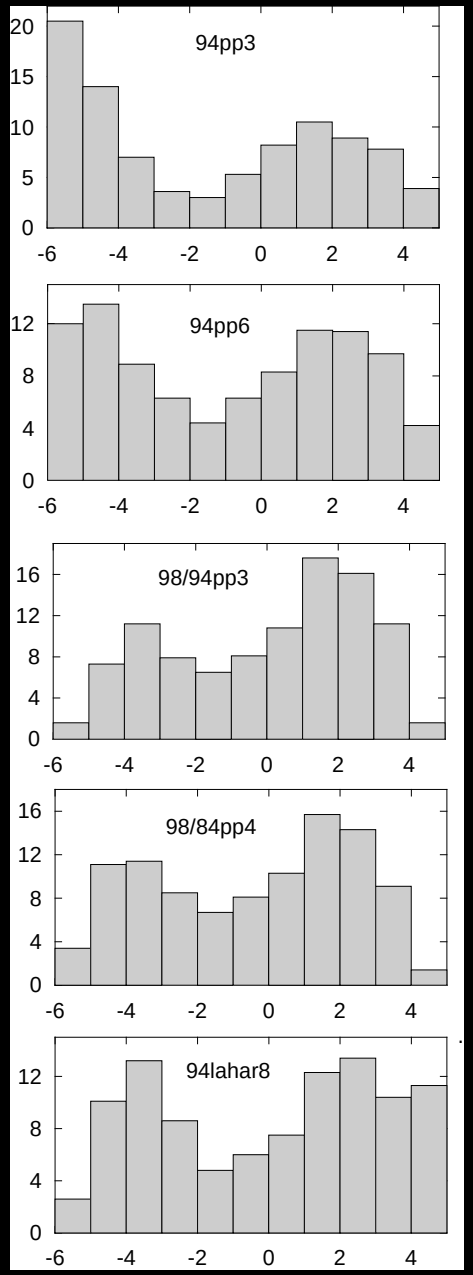


Surface morphology of the products of the 1994 eruption of Kliuchevskoy volcano

Grain-size characteristics of the products of the 1994 eruption of Kliuchevskoy volcano

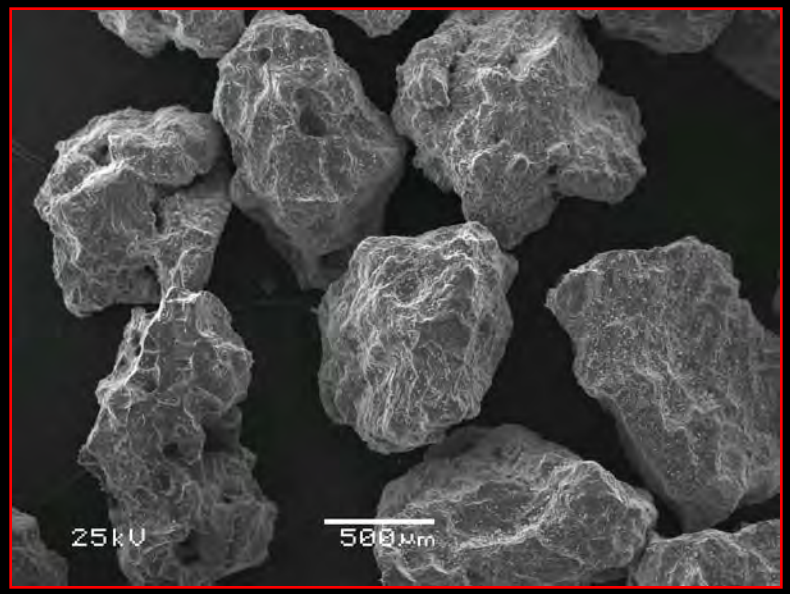


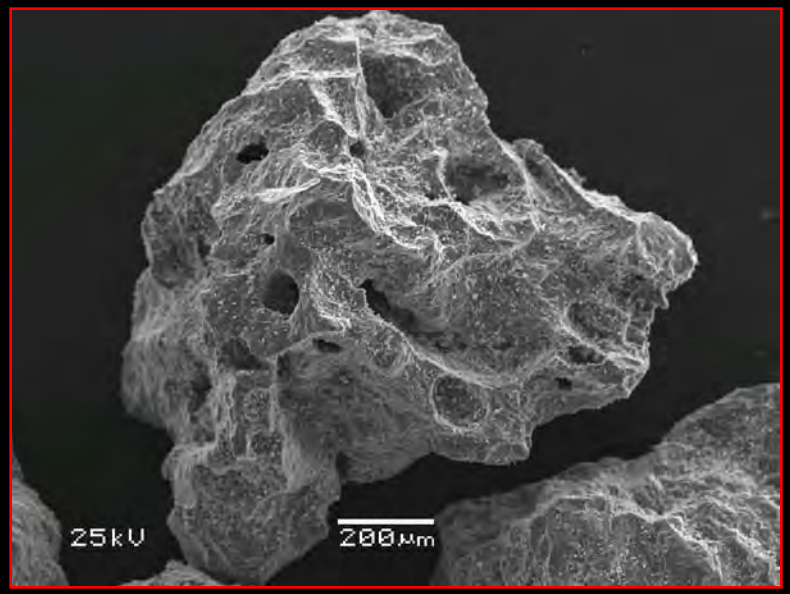
Percentage

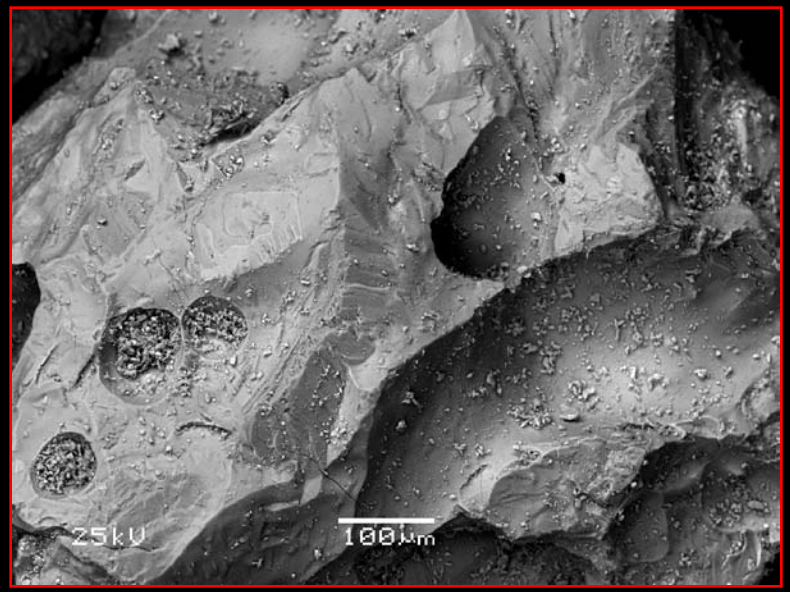


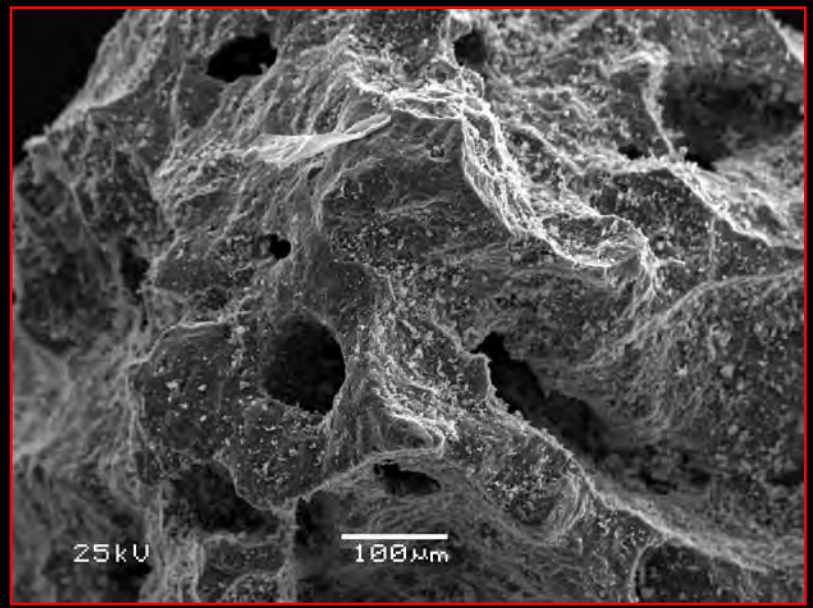
Grain size, phi units

The 1994 pyroclastic flow
SEM

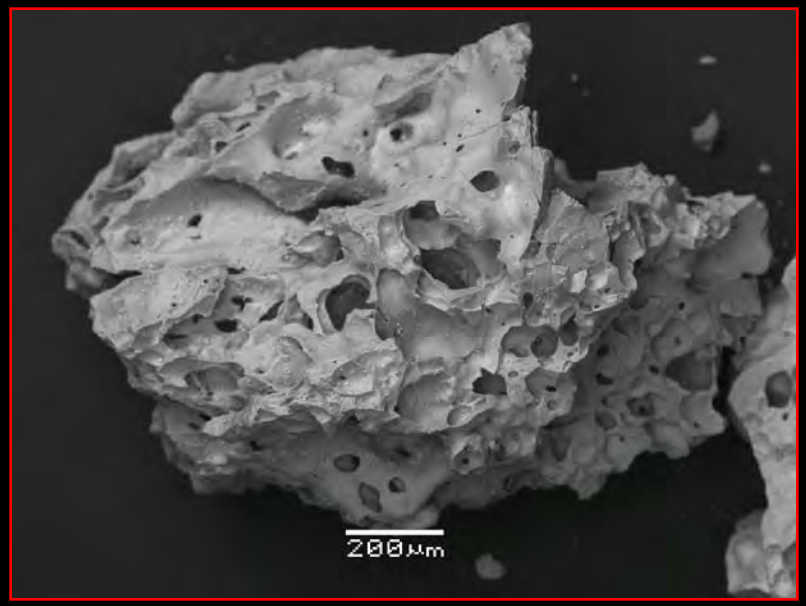


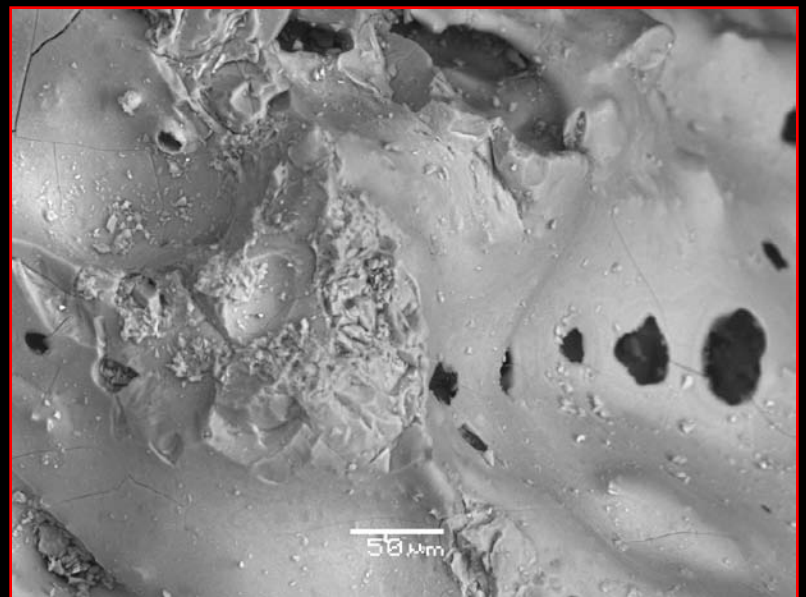


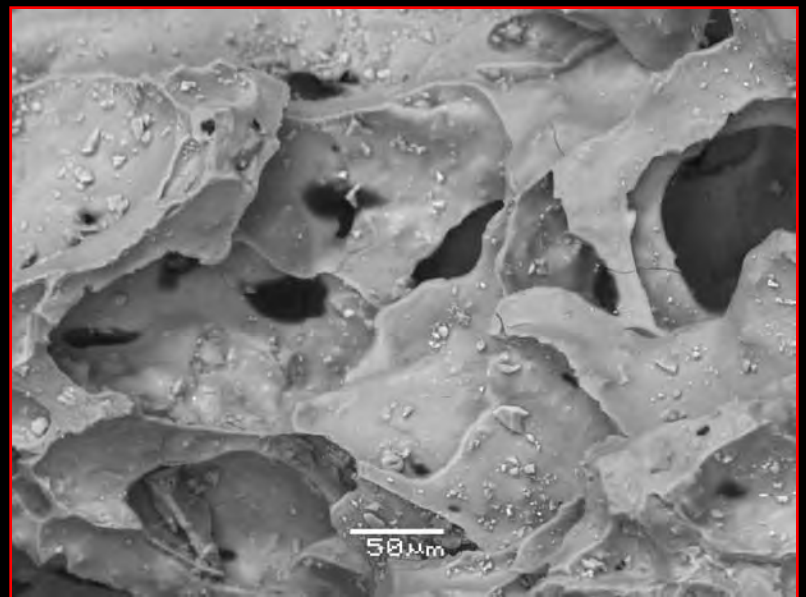




The 1994 fallout deposits
SEM







Mount Etna

Mount Etna, November 16, 2006

M. La Rosa

Abundant cauliflower bombs,
but no evidence for heat…

Mount Etna. Deposits of November 16, 2006 eruption.
Thick (2 m), valley-filling heterolithologic deposit

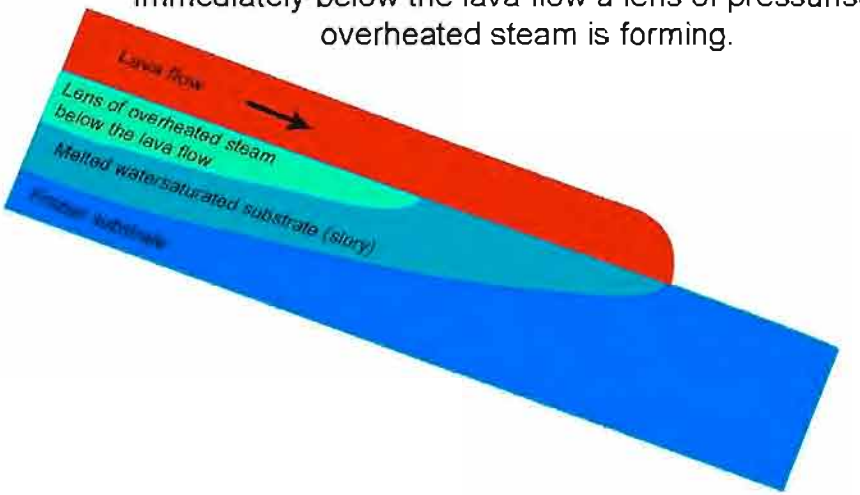
Mount Etna. Deposits of November 16, 2006 eruption.

Thin, topography-mantling lithic deposit

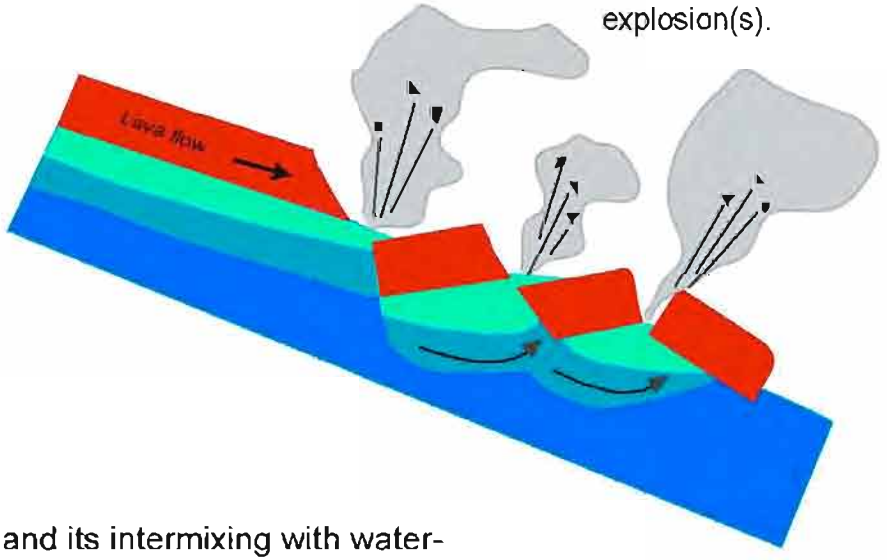
Photo H. Pinkerton


Llaima volcano, Chile 2008

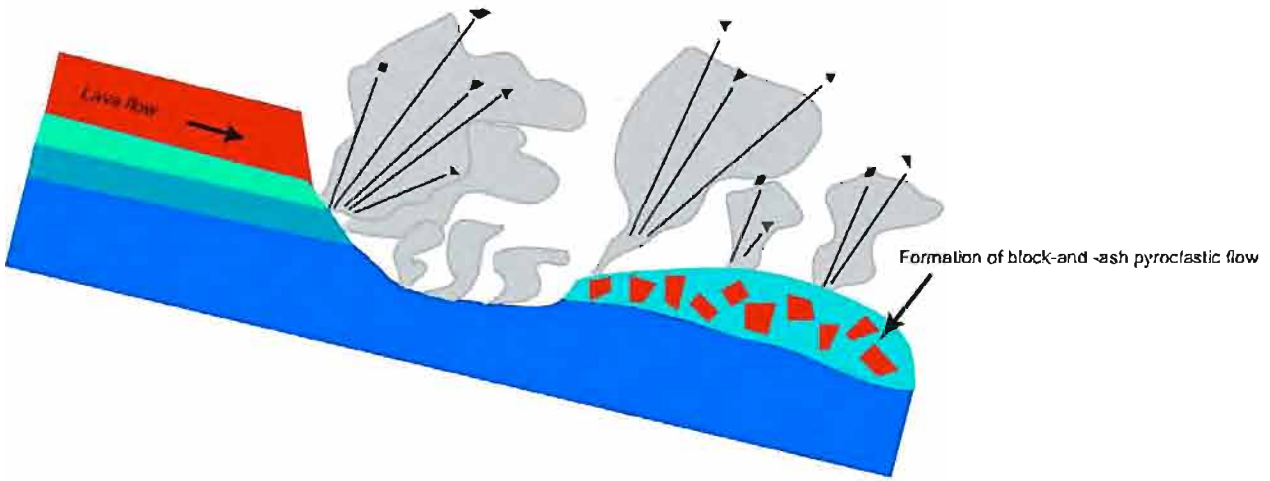
1. Advancing lava flow; gradual melting of substrate. Immediately below the lava flow a lens of pressurised overheated steam is forming.



2. Gravitational failure of lava flow and melted substrate. Initial "pressurised bowl" type explosion(s).



3. Disintegration of sliding lava and its intermixing with water-saturated substrate. Explosion due to lava/wet rock interaction.



Conclisions

- Interaction of lava flows of basic composition with ice, frozen or wet rocks can be highly explosive with generation of block-and-ash pyroclastic flows.
- The described secondary rootless phreatomagmatic explosions commonly occur at steep slopes. The key elements of the mechanism are gravitational failure of lava moving over wet substrate and their explosive interaction (“fuel-coolant” type).
- The described type of explosions appears to be common at snow- or ice-clad basaltic stratovolcanoes but can also occur at water-saturated volcanic slopes (including those affected by hydrothermal alteration), and thus the related hazard is present in many volcanic areas.


May 27, 2007
Photo of Yury Demyanchuk

Mount Etna