

Strombolian dynamics from thermal (FLIR) video imagery

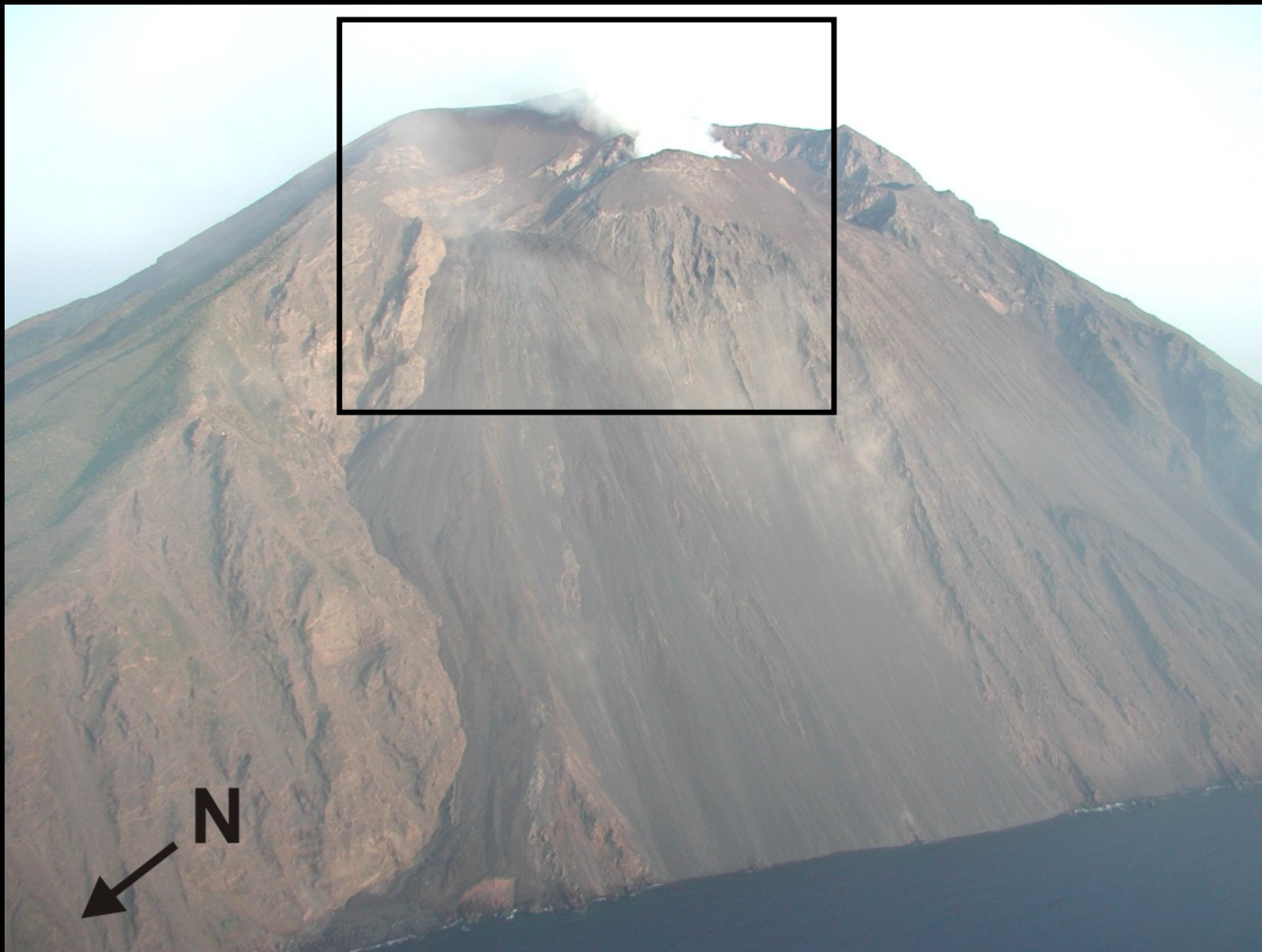
Matthew Patrick



Shortcomings of previous imaging studies of strombolian eruptions

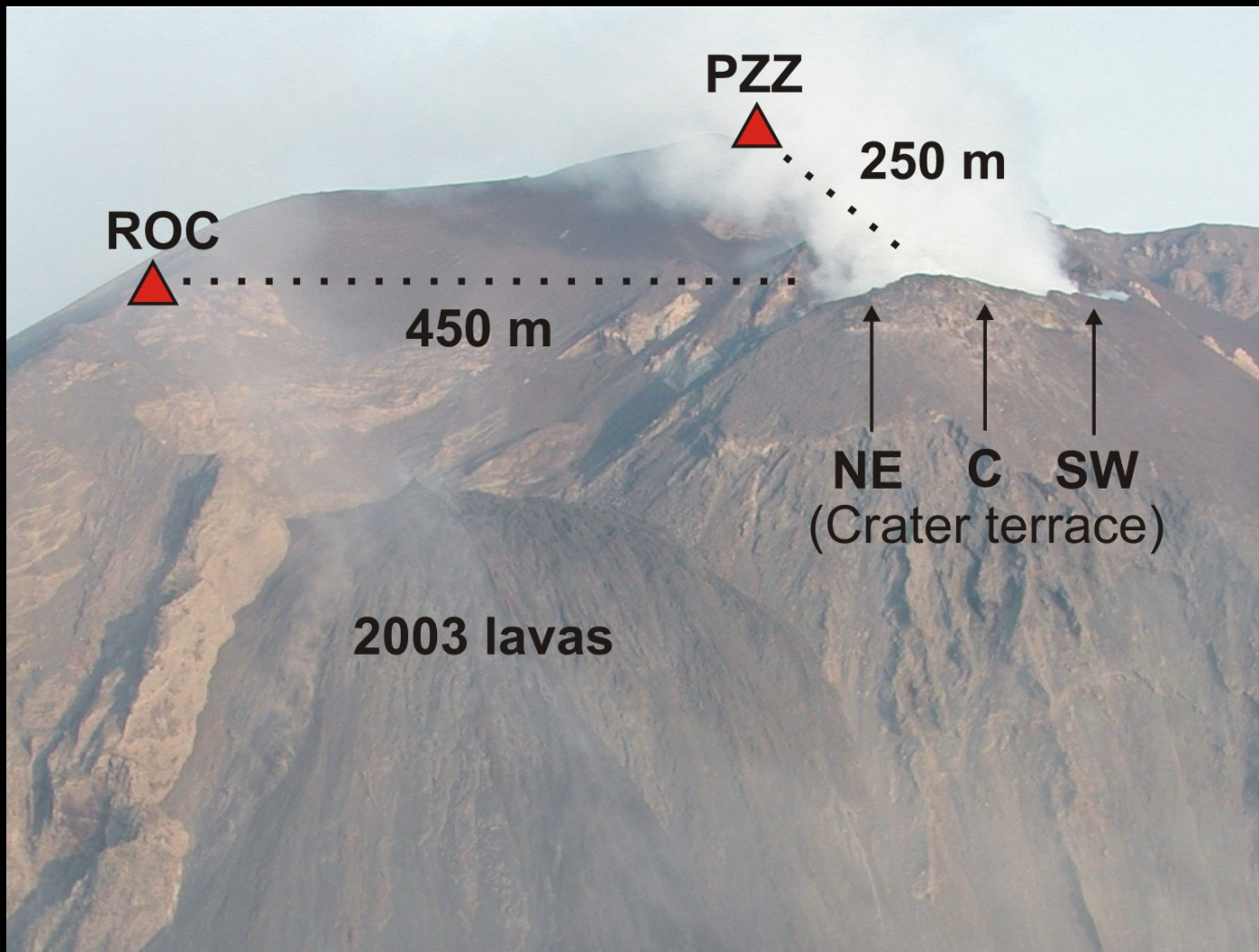
- Small datasets:
 - Chouet et al., 1974: 2 eruptions
 - Blackburn et al., 1976: 16 eruptions
 - Ripepe et al., 1993: 10 eruptions
- Short observation periods (e.g. single day): no data on temporal evolution
- Visible or near-infrared imagery: limits observation of different ejecta types (ballistic particles, ash) for a given eruption
- Lack of scope: literature provides no unified context for strombolian activity

University of Hawaii / Open University FLIR campaign, summer 2004



Pizzo sopra la Fossa

Rocette



Setup at Rocette station June 2004



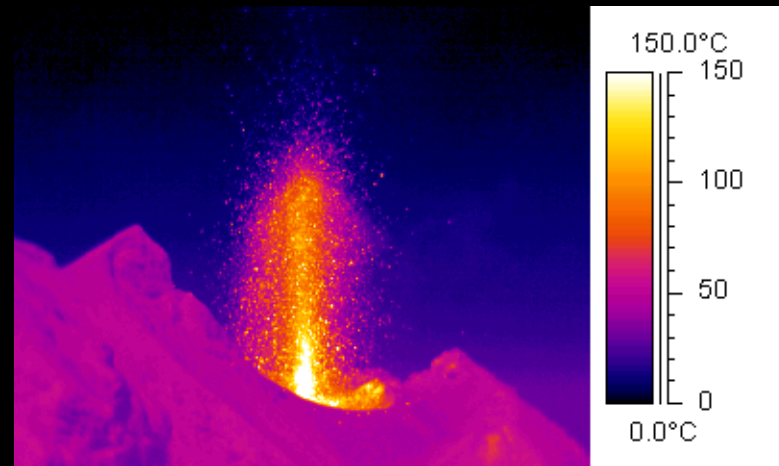
FLIR specs:

- FLIR ThermaCAM S40 (320 x 240 pixels, 8-14 micron)
- Base 24 dg lens
- 0-550 Celsius temperature range
- 30 fps acquisition via laptop computer (firewire connection)

Observed Strombolian eruption styles

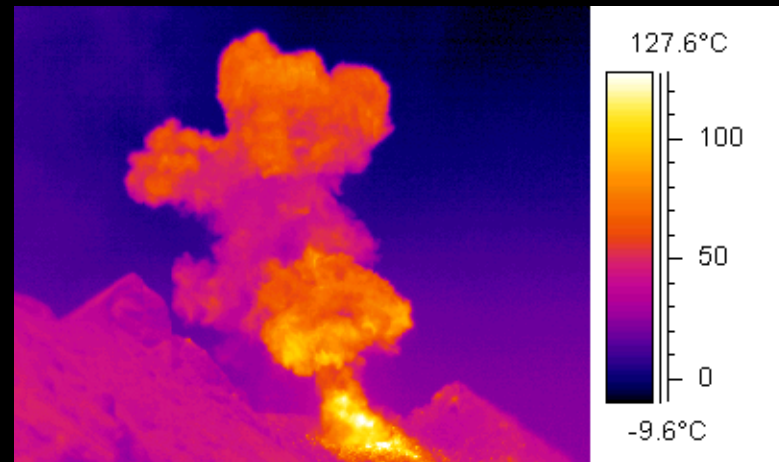
Type 1 (36%)

- Ash-poor plume
- Ballistic-dominated

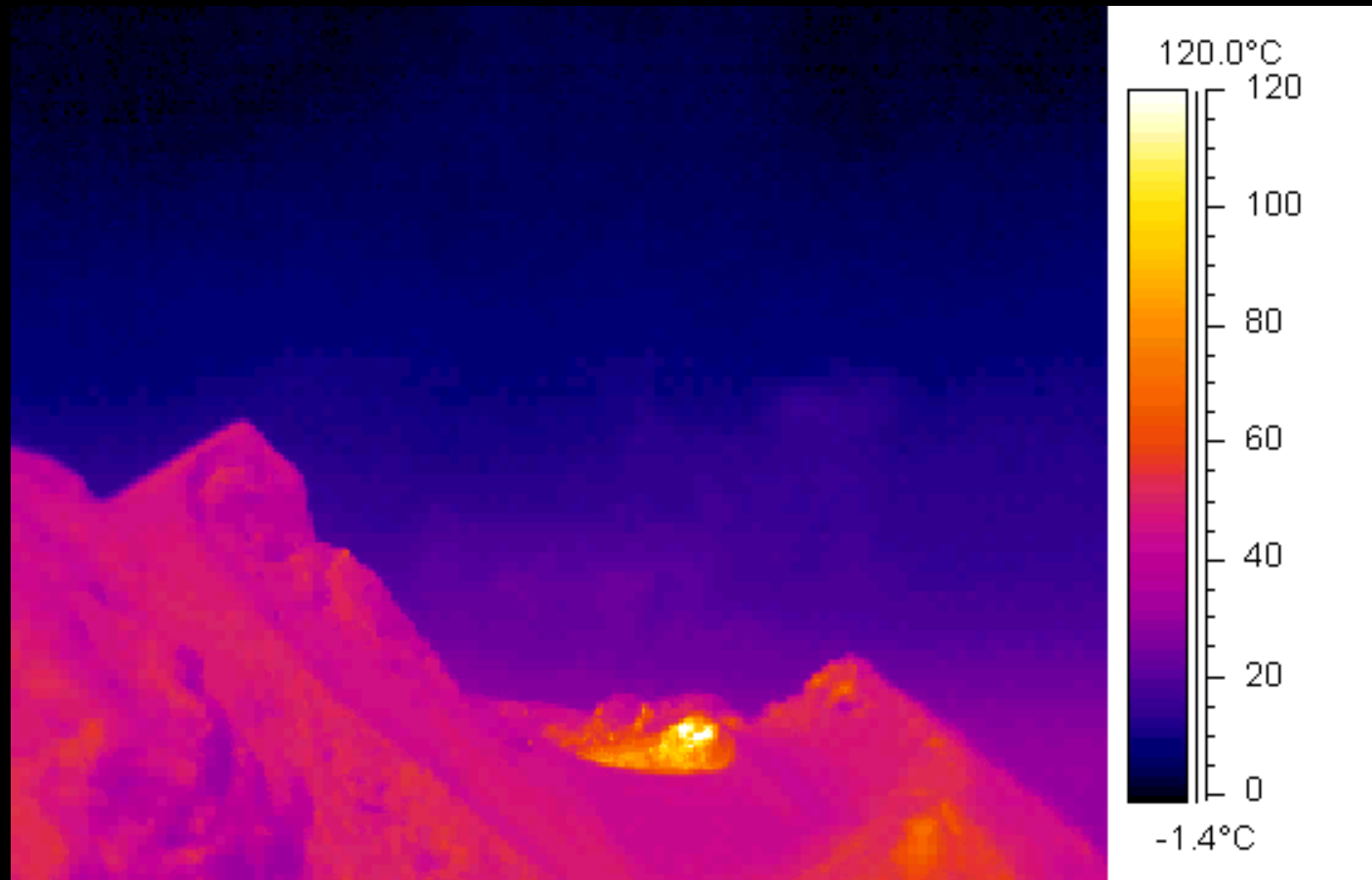


Type 2 (64%)

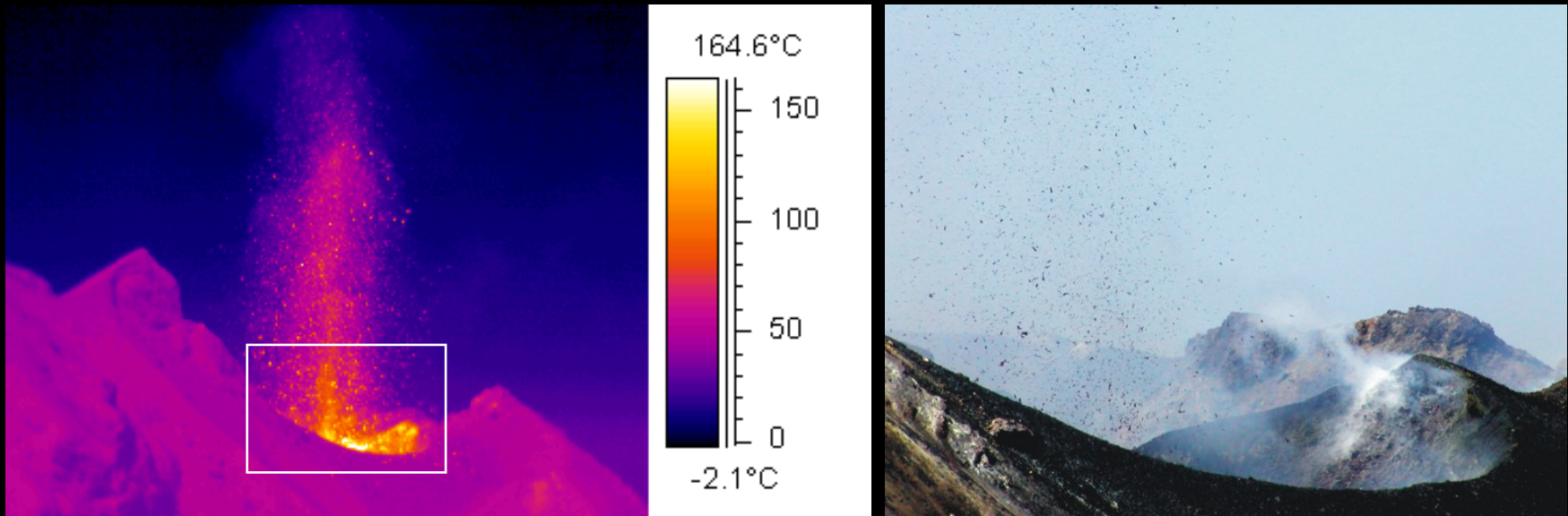
- Ash-rich plume
- With or without significant ballistic particles



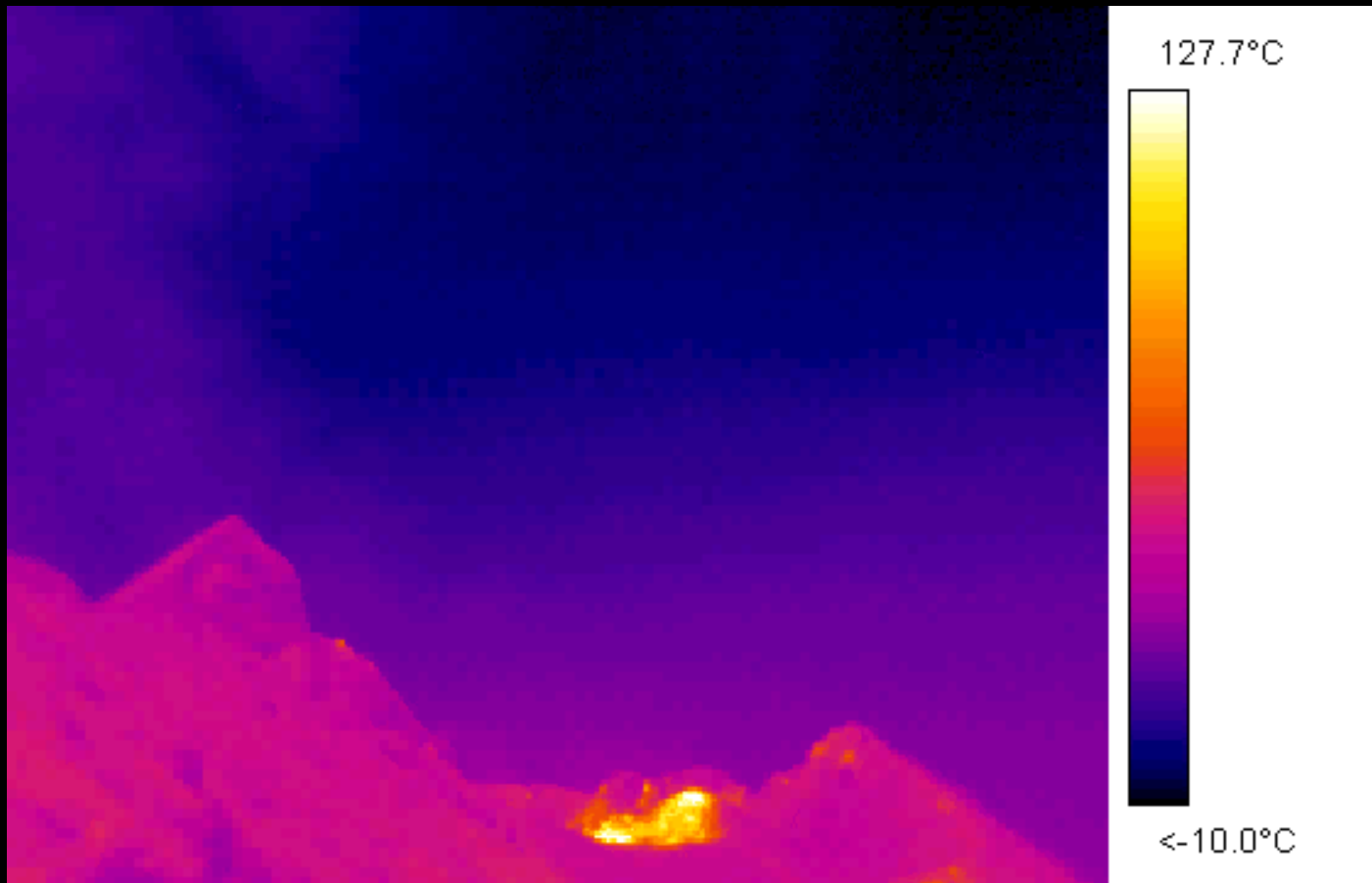
Type 1: Ash-poor plume, ballistic dominated



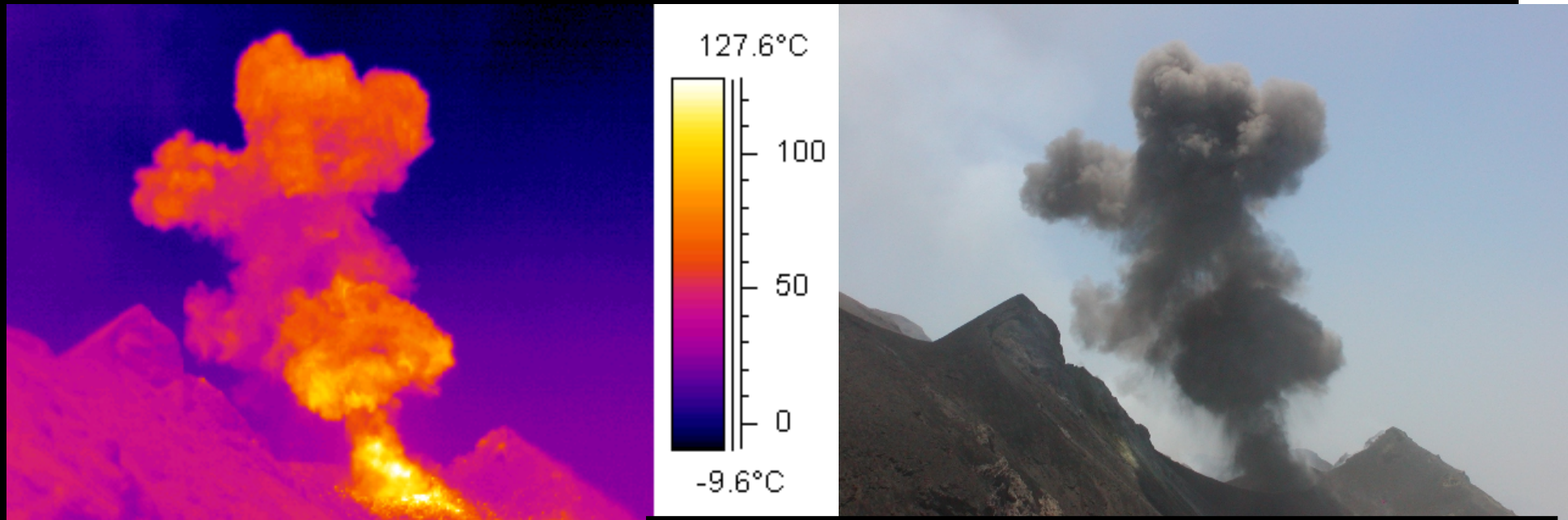
Type 1: Ash-poor plume, ballistic dominated



Type 2: Ash-rich plume



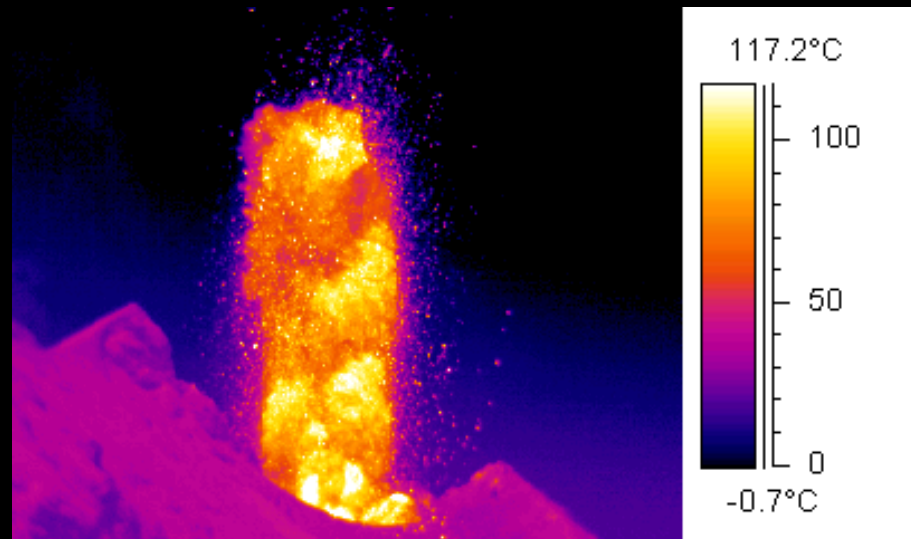
Type 2: Ash-rich plume



Type 2 subgroups

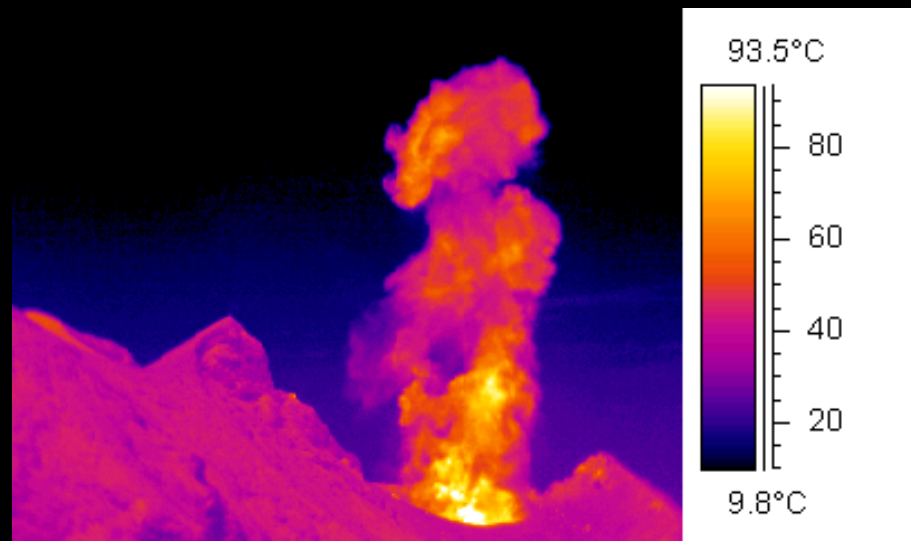
Type 2a

- Gas-thrust phase
- Many ballistic particles

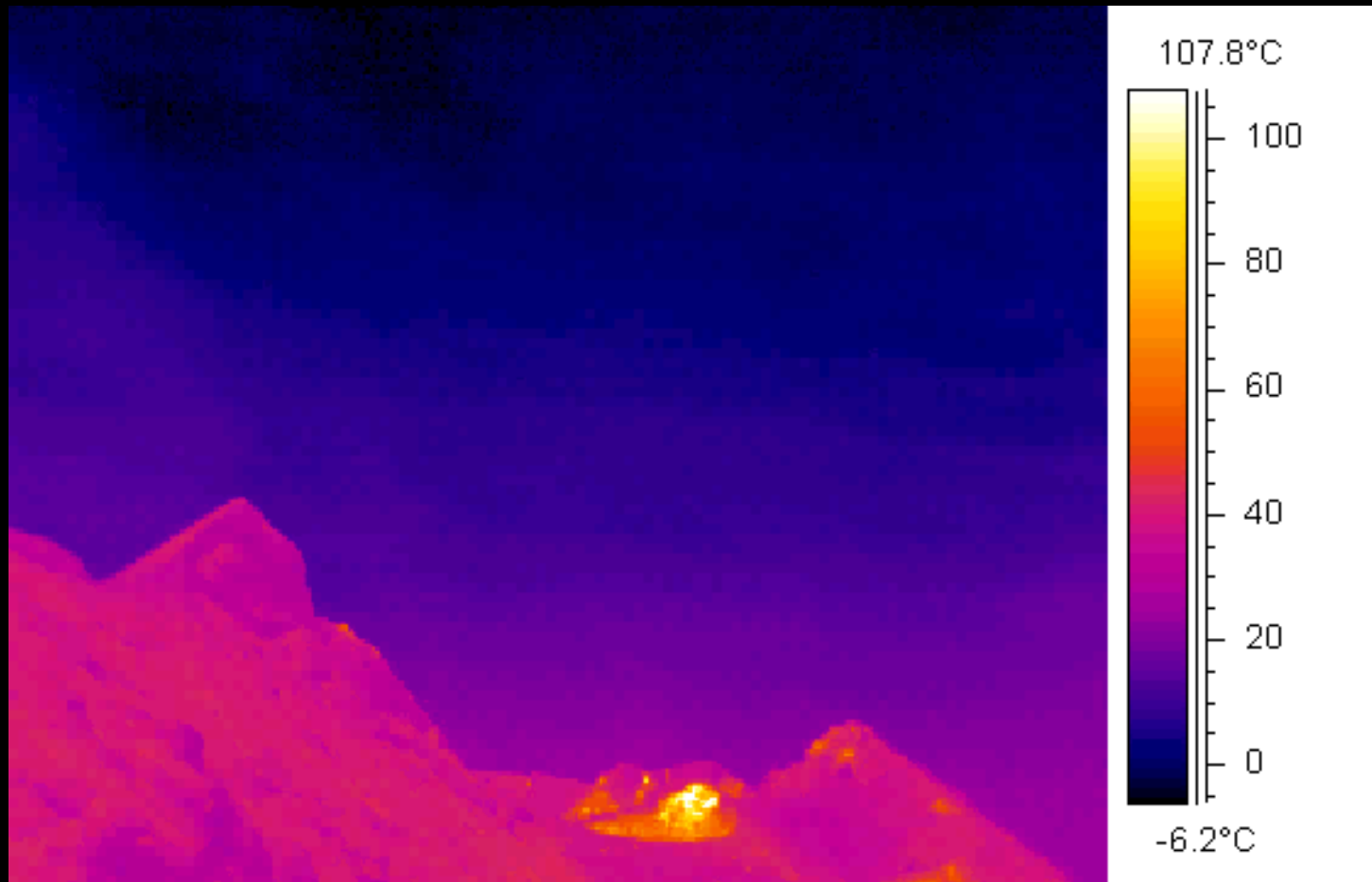


Type 2b

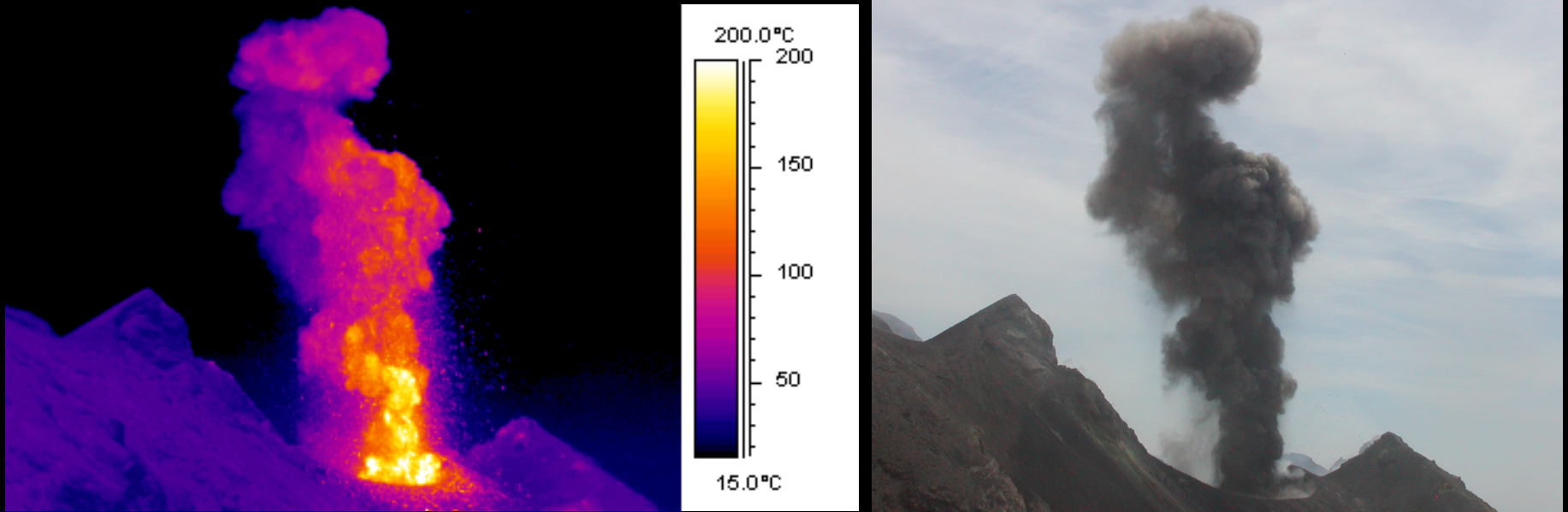
- No gas-thrust phase
- Few ballistic particles



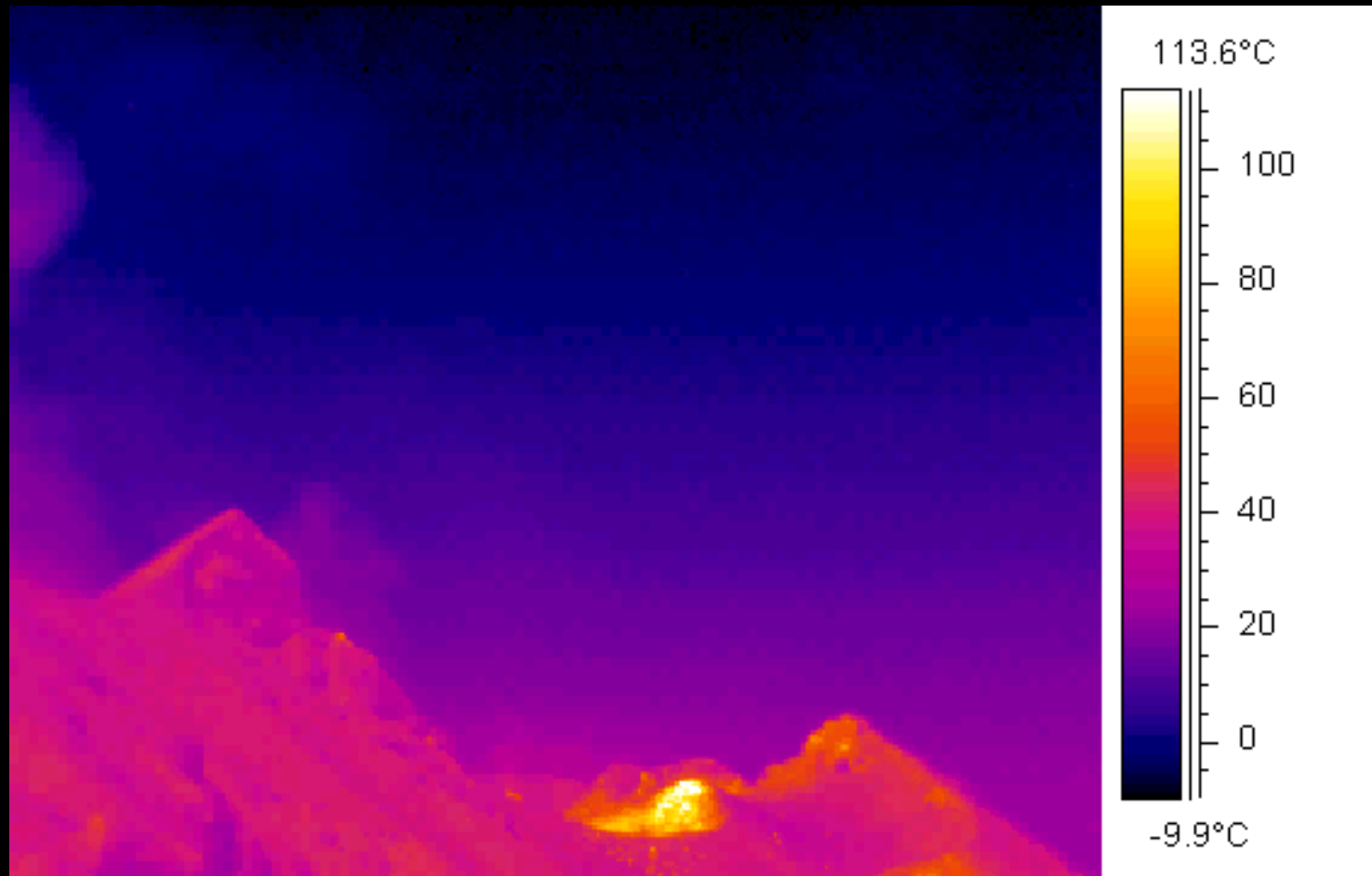
Type 2a: Ash-rich plume, gas-thrust phase, significant ballistics



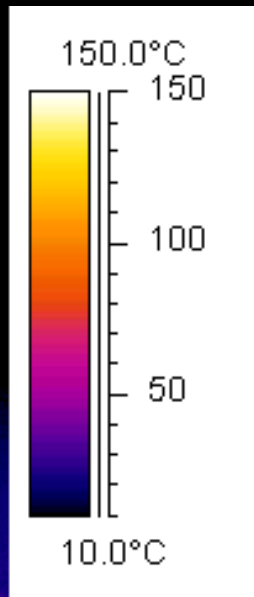
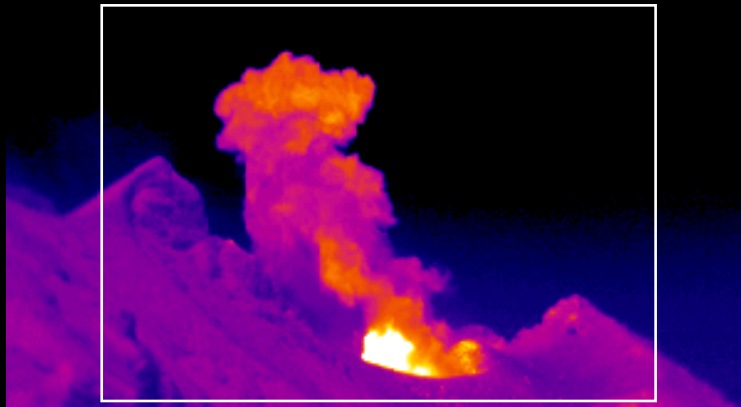
Type 2a: Ash-rich plume, gas-thrust phase, significant ballistics



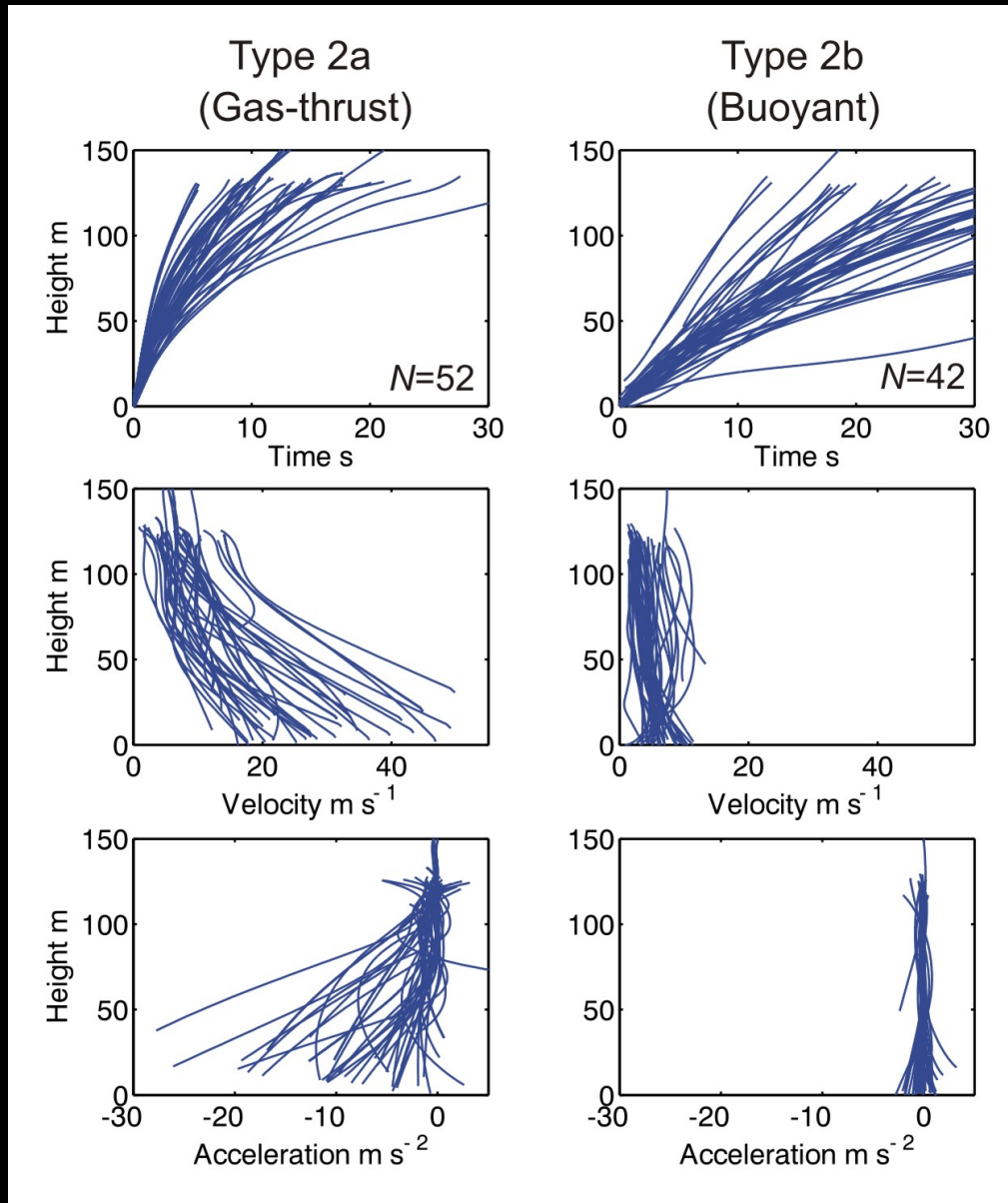
Type 2b: Ash-rich plume, no gas-thrust, no significant ballistics



Type 2b: Ash-rich plume, no gas-thrust, no significant ballistics

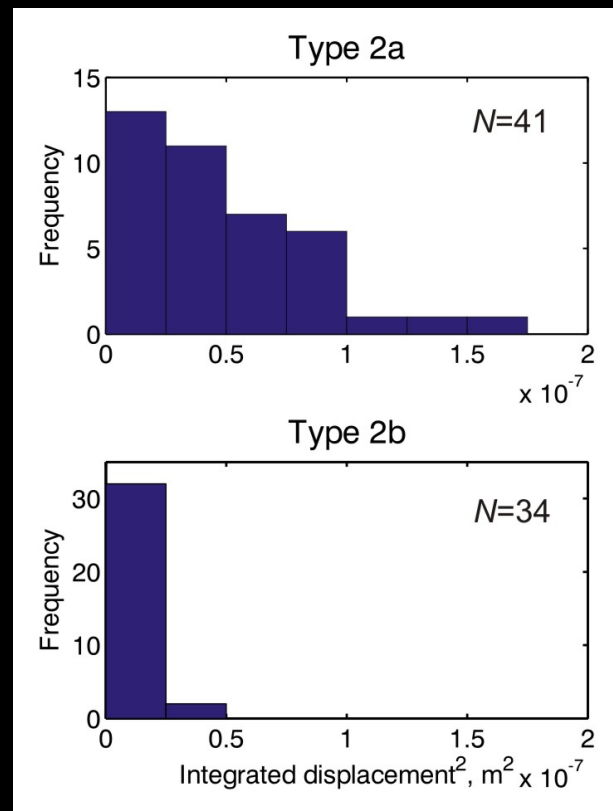


Positions of the plume front

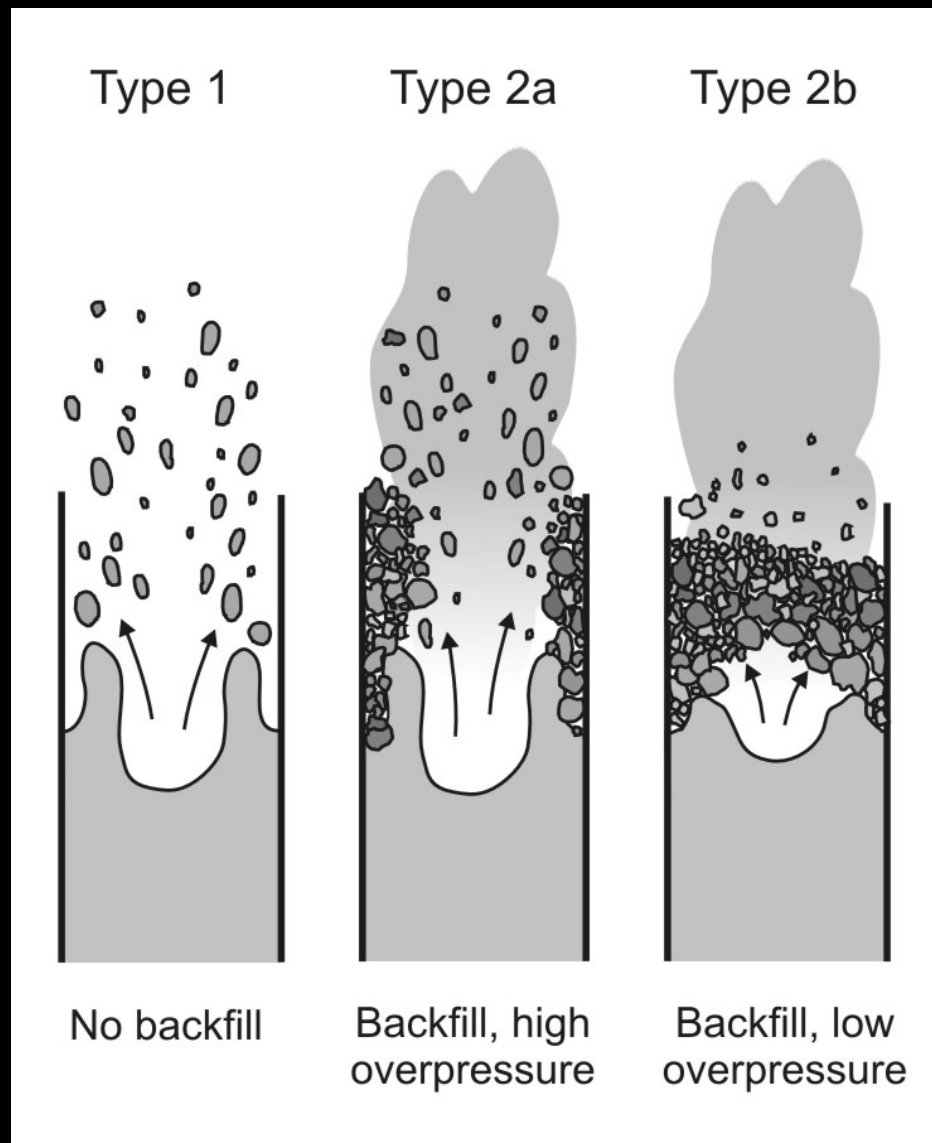


Type 2a vs. 2b a function of source conditions (i.e. overpressure), not observational differences

Type 2 seismic energy



One model for strombolian eruption styles



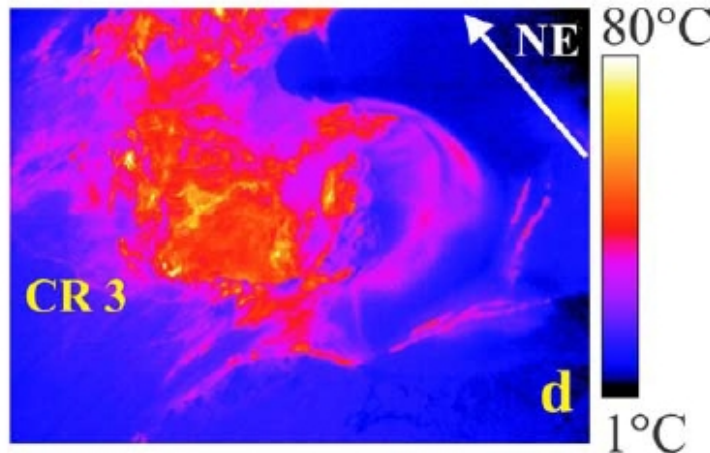
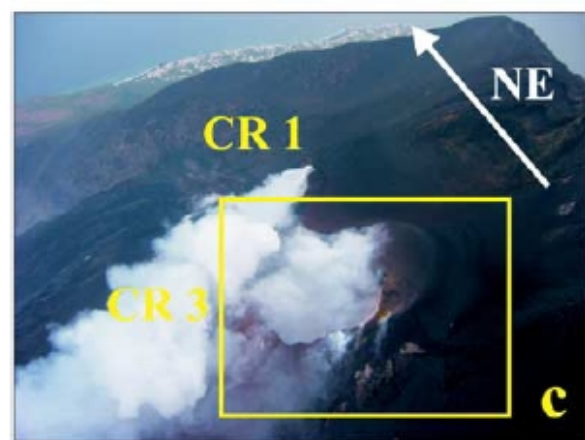
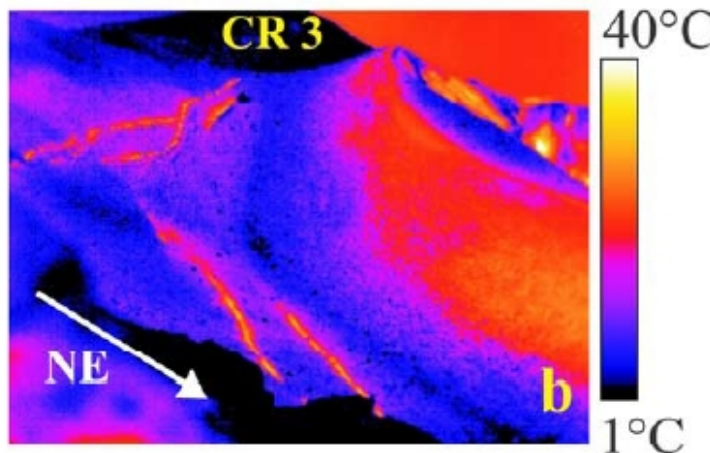
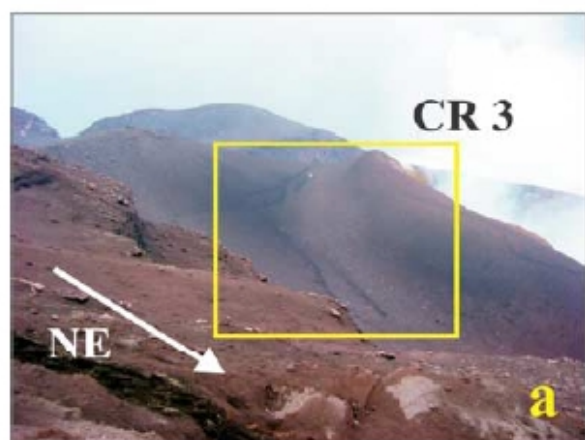
Styles are a function of:

- 1) *Backfill* (Type 1 vs. 2) – which is maintained on scales of days-weeks
- 2) *Bubble overpressure* (Type 2a vs. 2b) – which can be variable on a scale of minutes to hours

Chronology and complex volcanic processes during the 2002–2003 flank eruption at Stromboli volcano (Italy) reconstructed from direct observations and surveys with a handheld thermal camera

Sonia Calvari,¹ Letizia Spampinato,¹ Luigi Lodato,¹ Andrew J. L. Harris,² Matthew R. Patrick,² Jonathan Dehn,³ Michael R. Burton,¹ and Daniele Andronico¹

2002-2003 eruption at Stromboli



Monitoring edifice stability through eruption

Tracking changes in vent configuration through eruption (ability to see through fume)

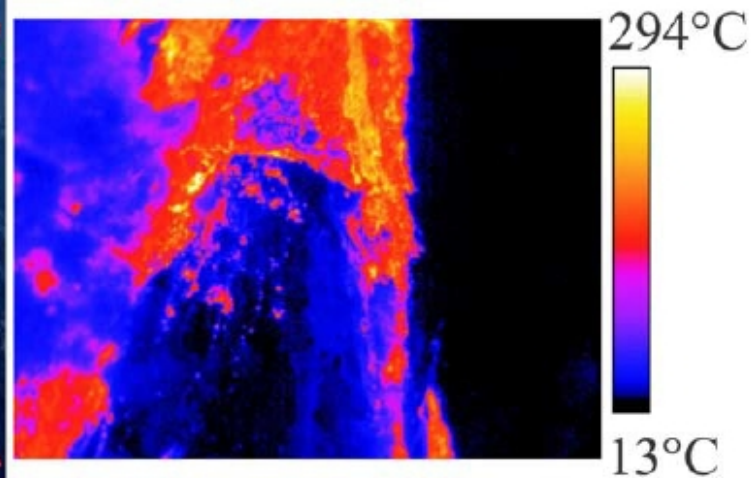
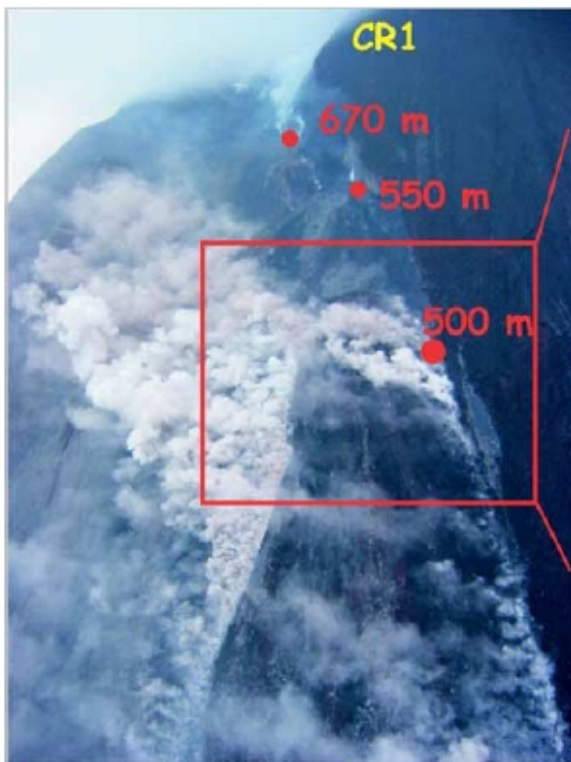
INGV: hot cracks opened one hour before landslide, tsunami in late 2002

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 110, B02201, doi:10.1029/2004JB003129, 2005

Correction published 7 April 2005

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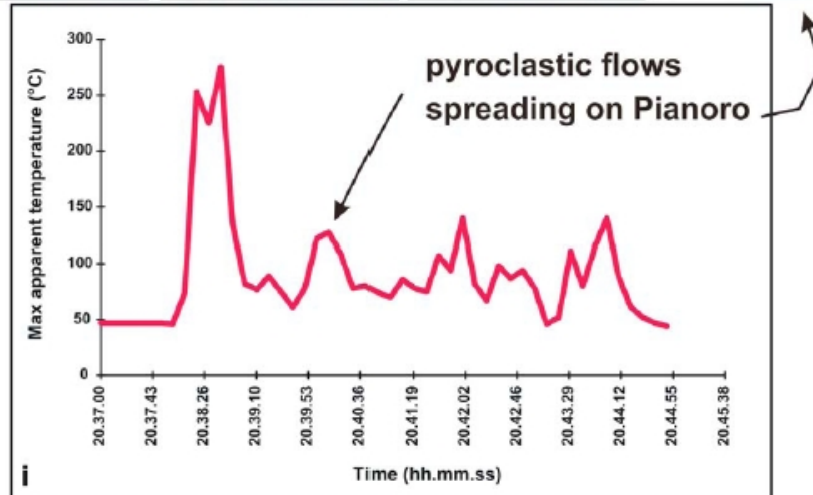
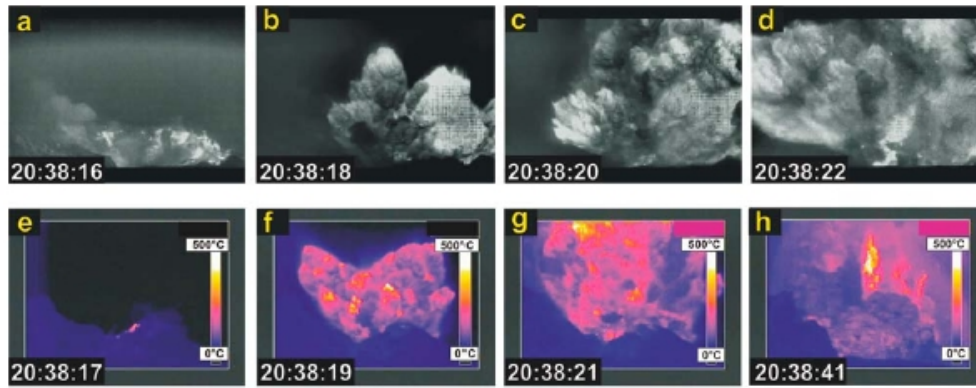
Current work by INGV and Univ. Firenze uses fixed thermal cameras



JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 115, B04201, doi:10.1029/2009JB006478, 2010

The 2007 Stromboli eruption: Event chronology and effusion rates using thermal infrared data

S. Calvari,¹ L. Lodato,¹ A. Steffke,² A. Cristaldi,¹ A. J. L. Harris,³ L. Spampinato,¹ and E. Boschi¹



Plot of apparent temperature through time for 2007 paroxysm provides proxy for explosion intensity

Advantages of thermal camera at Stromboli

- Explosion style (ash or spatter rich) is better observed with thermal cameras: Can observe ash plumes and ballistic ejecta simultaneously
- Can see through a minor amount of cloudy weather
- Ability to monitor edifice stability – detection of hot cracks
- Ability to monitor vent configuration (seeing through fume)
- Fixed cameras can count explosive events, track explosion velocities (roughly)