

Eruption of Redoubt Volcano March 22 - ?, 2009

Report to Subcommittee on Disaster Reduction
May 7, 2009



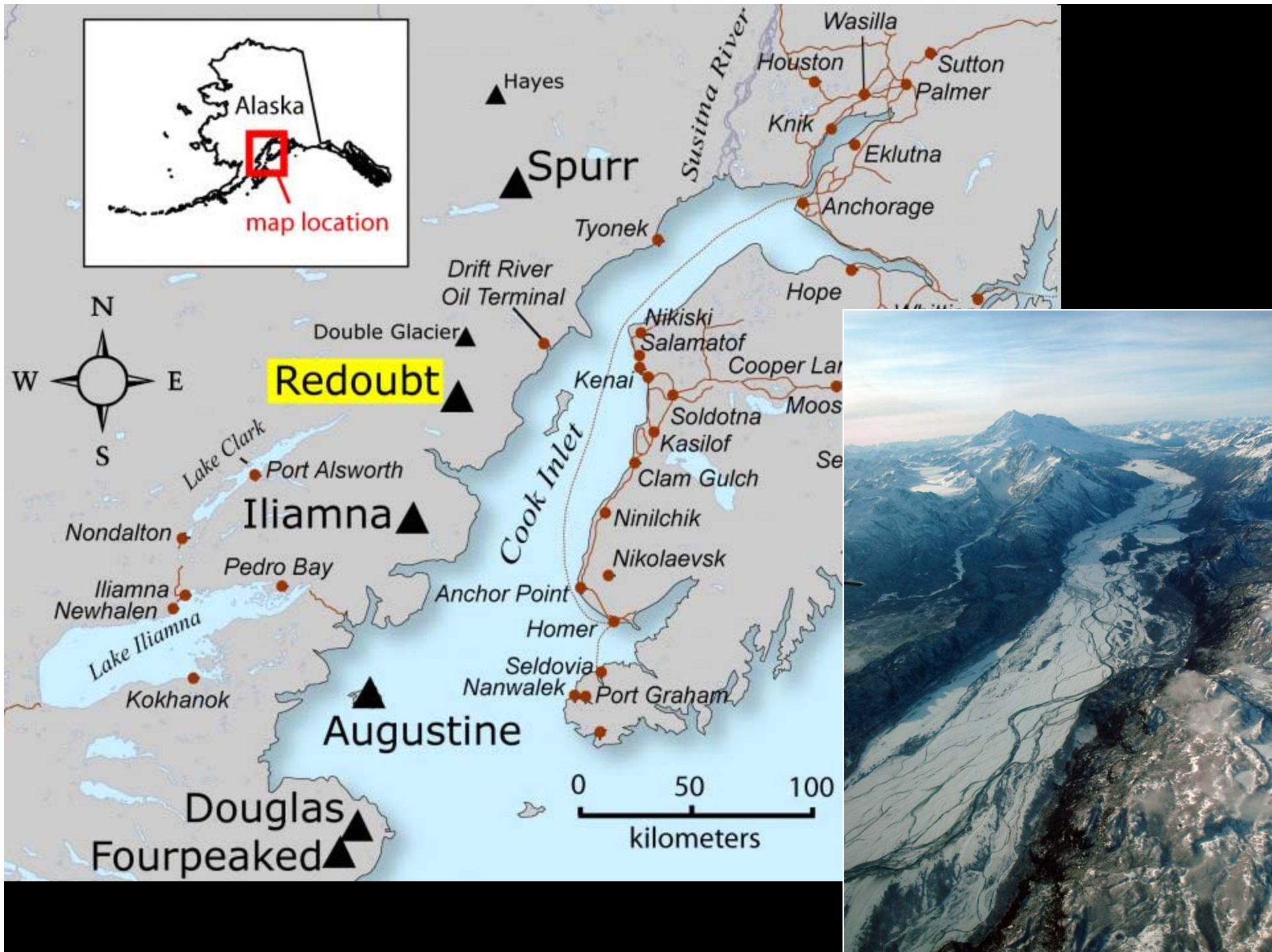
John Eichelberger, Program Coordinator
Volcano Hazards Program, USGS

Photo: TM Grice, 4/11/09

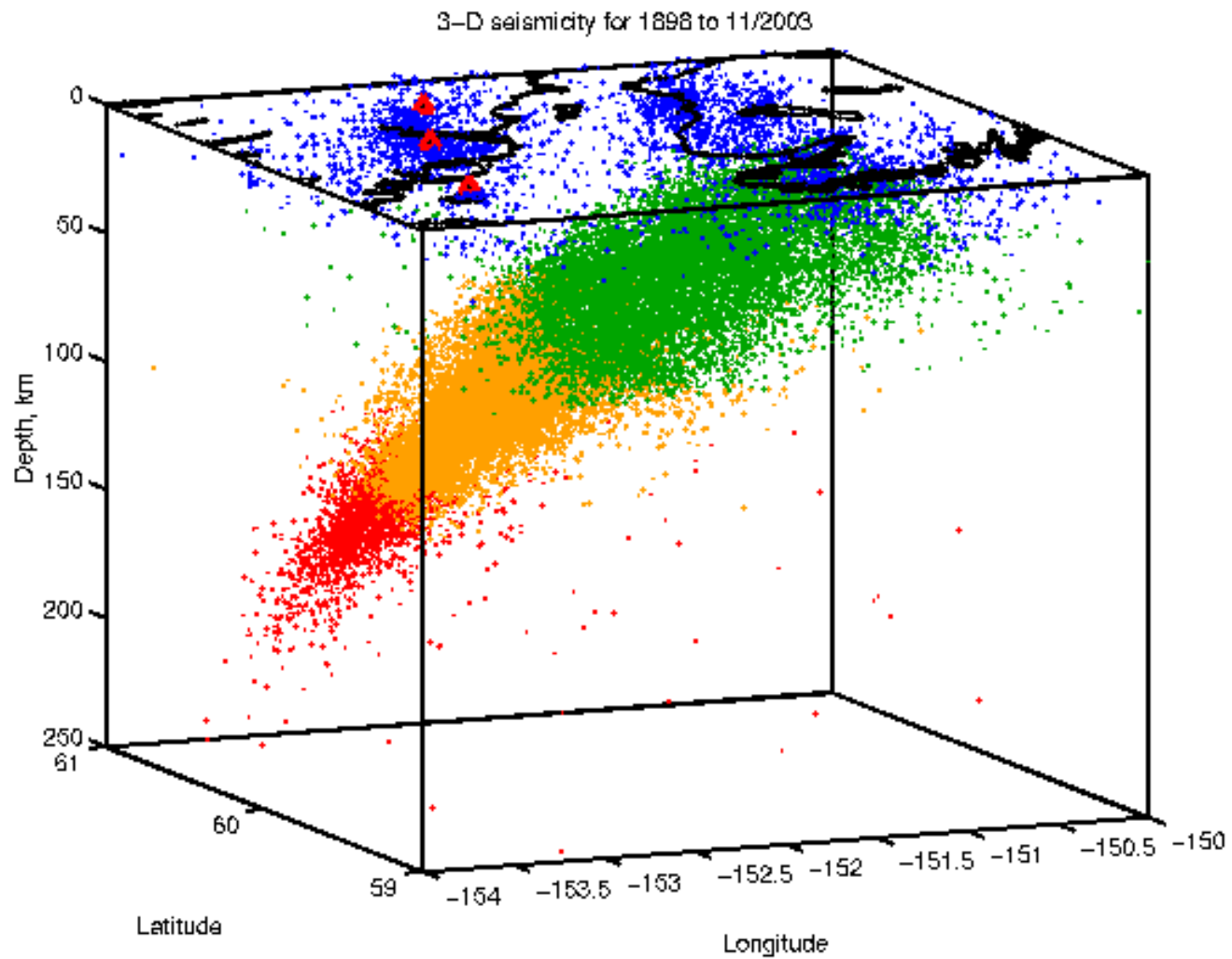
Outline

A photograph of a snow-capped volcano erupting, with a large plume of ash and smoke rising into a blue sky. The volcano is the central focus, with its peaks covered in snow and a thick, dark plume of ash and smoke rising from its summit. The sky is a clear, pale blue, and the overall scene is captured from a distance, showing the surrounding landscape.

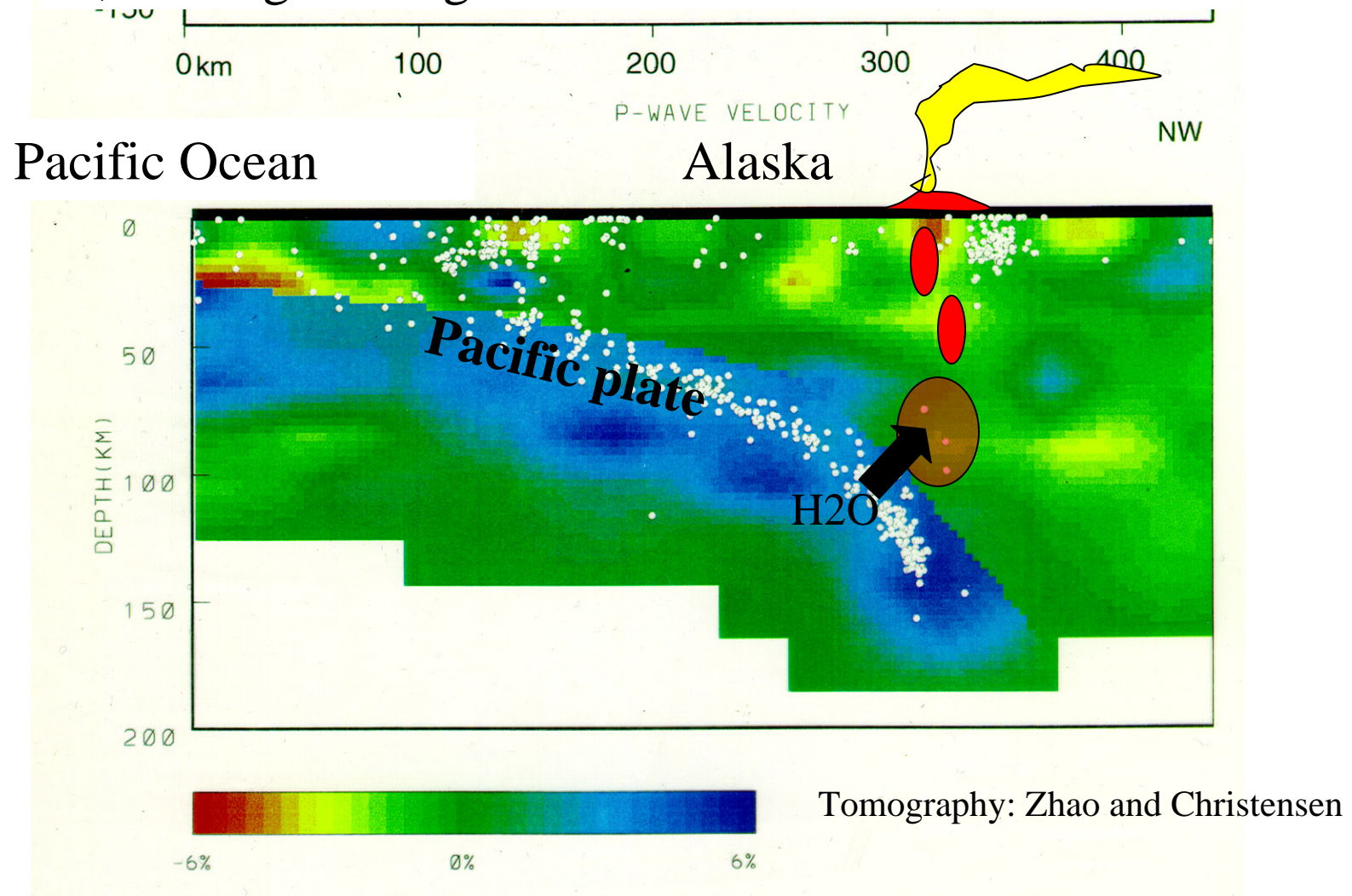
- Intro: Volcanology 101
- How we monitor volcanoes
- Eruption chronology
- What's next?



Pacific slab underthrusting Cook Inlet (AEIC)



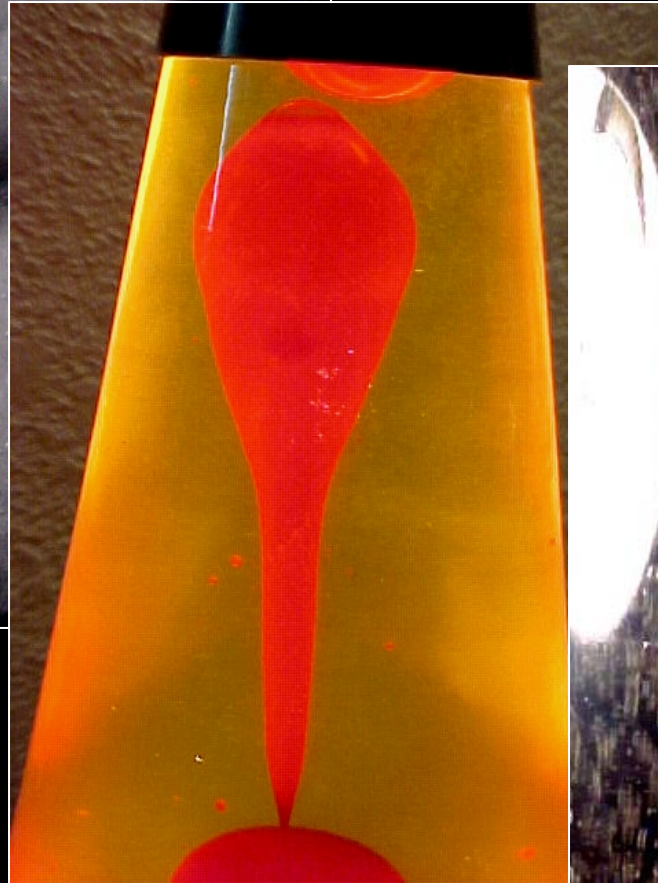
Seismic cross section: Colors roughly correspond to temperature, white dots are earthquakes. Underthrusting (subduction) of Pacific plate introduces water to mantle under Alaska, causing melting.



How do volcanoes work?



melting

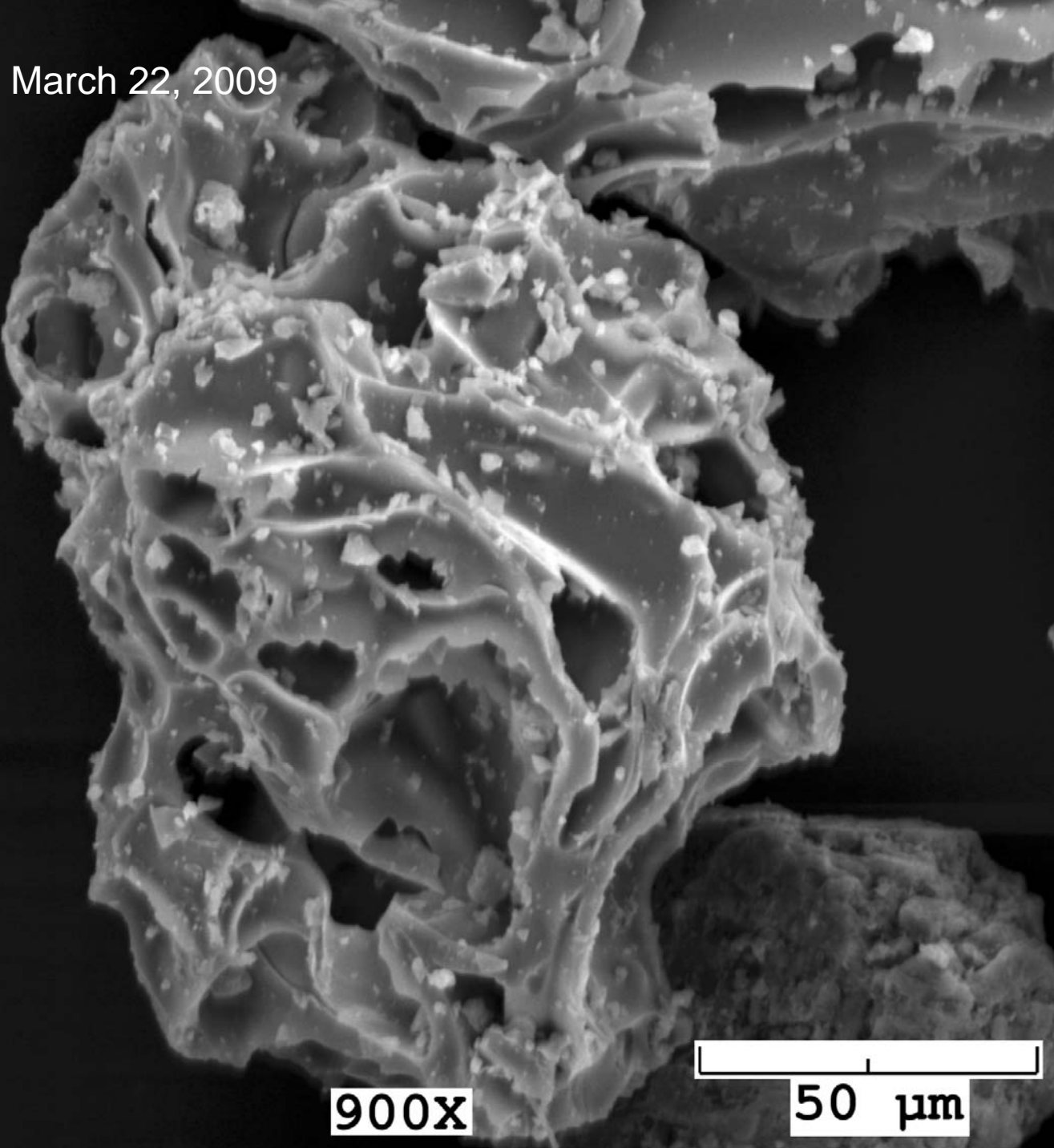


buoyant rise



Bubble growth (boiling)

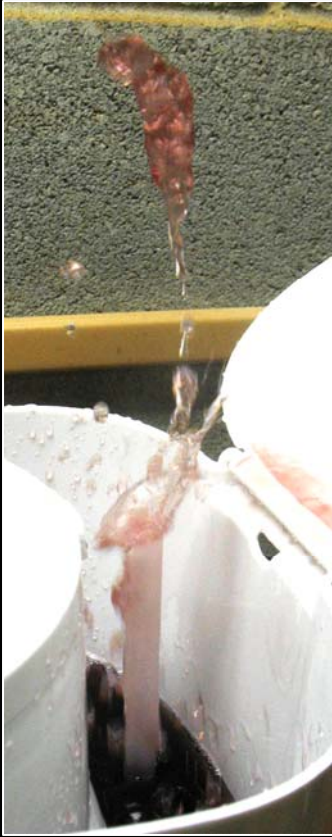
Redoubt ash March 22, 2009



900X

50 μm

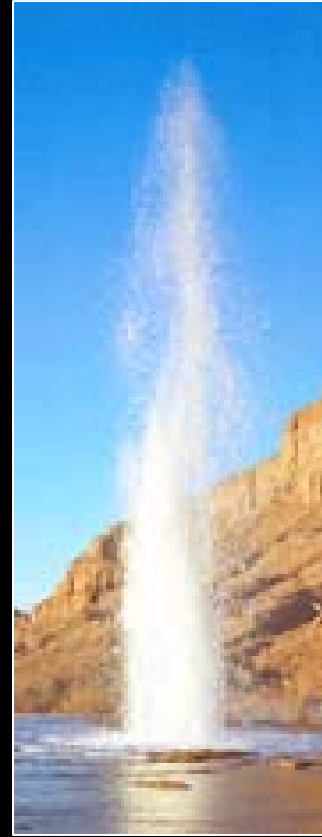
BOILING IN A TUBE CONNECTED TO A RESERVOIR



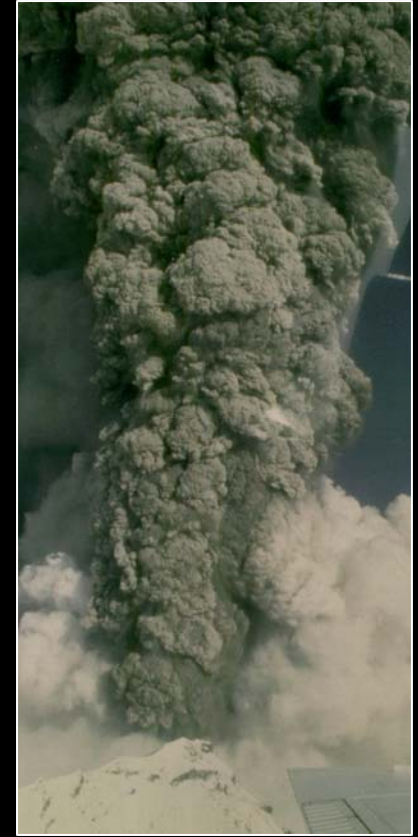
Boiling water



Boiling water



Water + CO₂

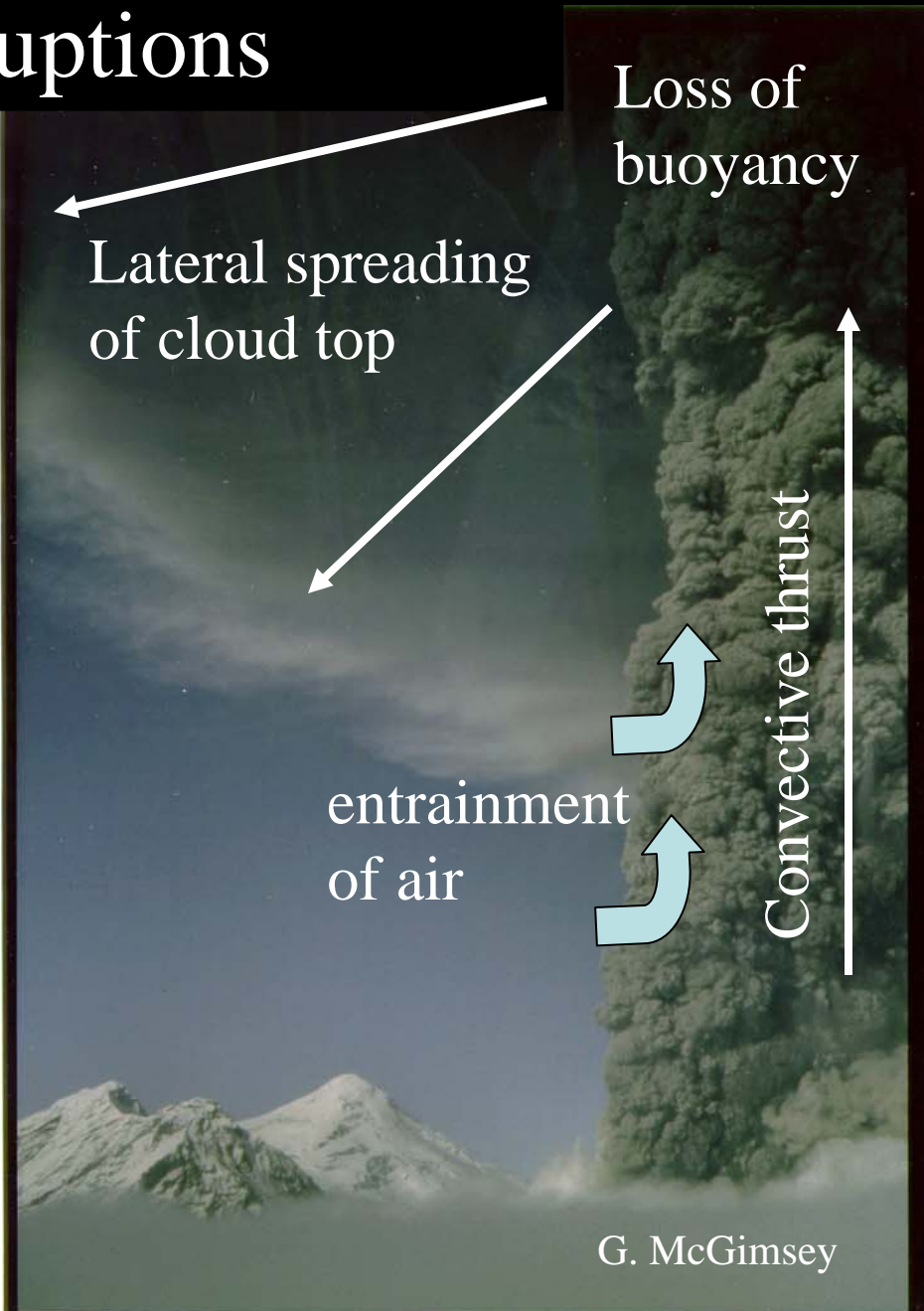


Molten rock + water



Self pumping

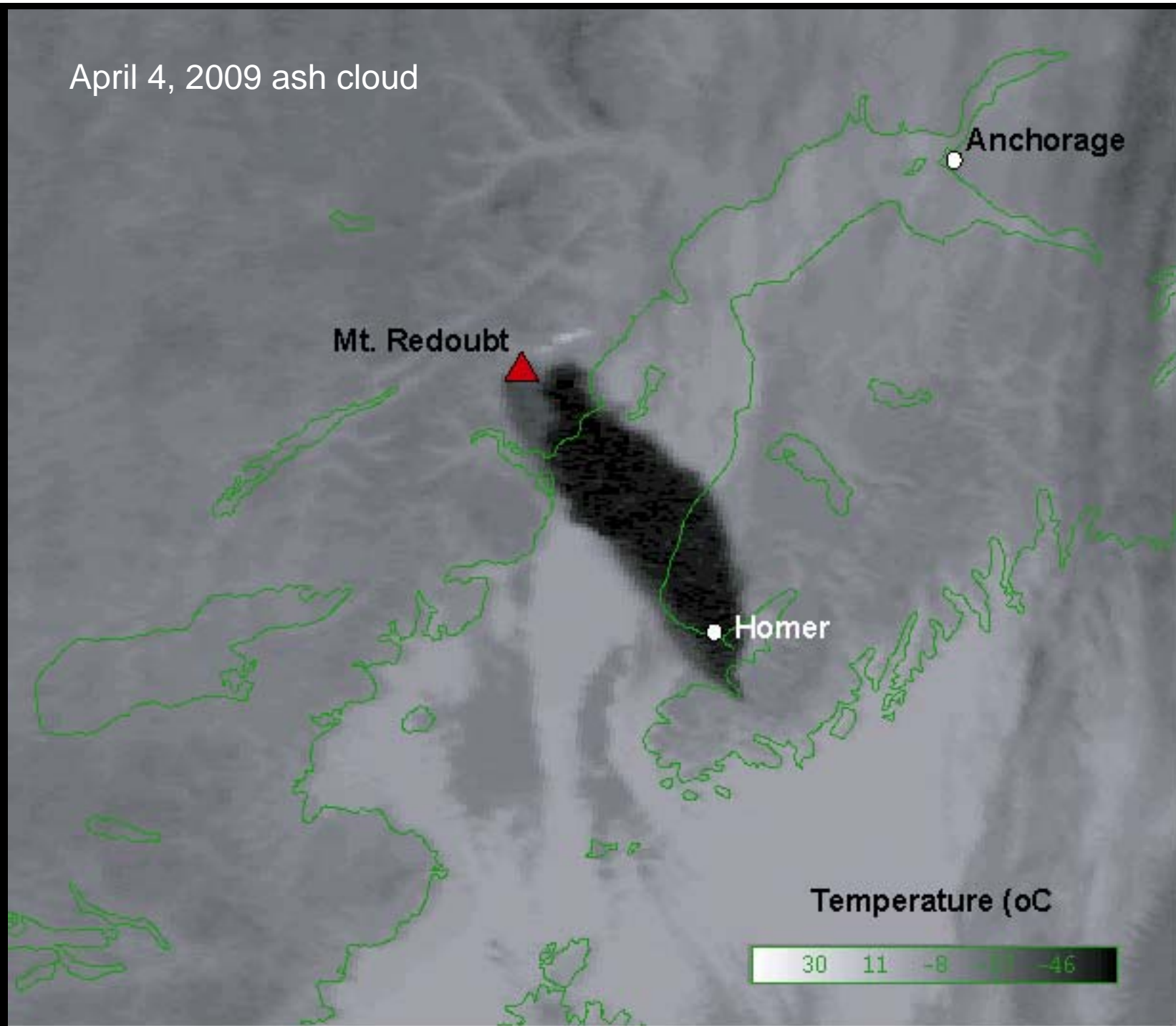
Ash eruptions



April 4, 2009

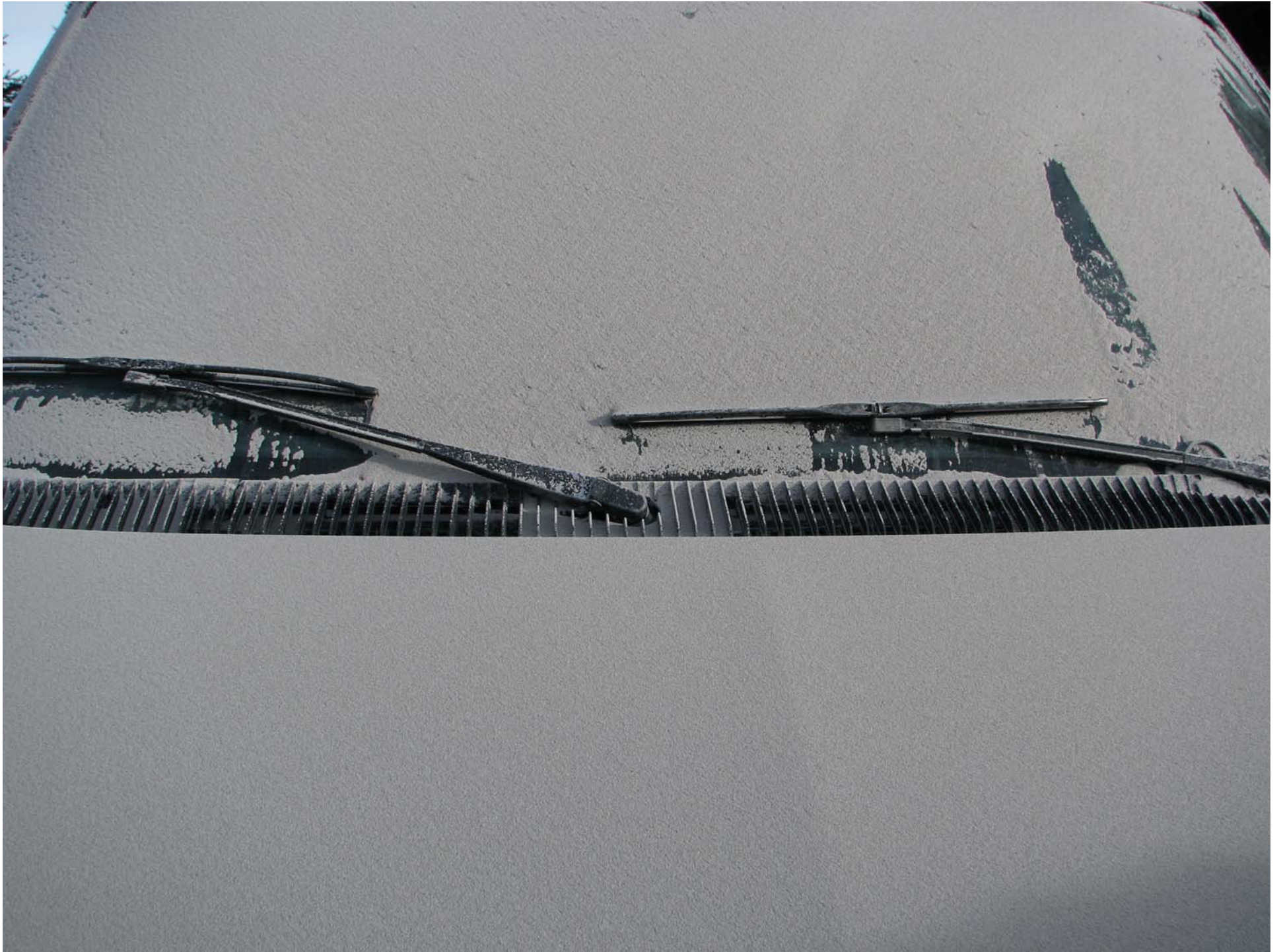


April 4, 2009 ash cloud

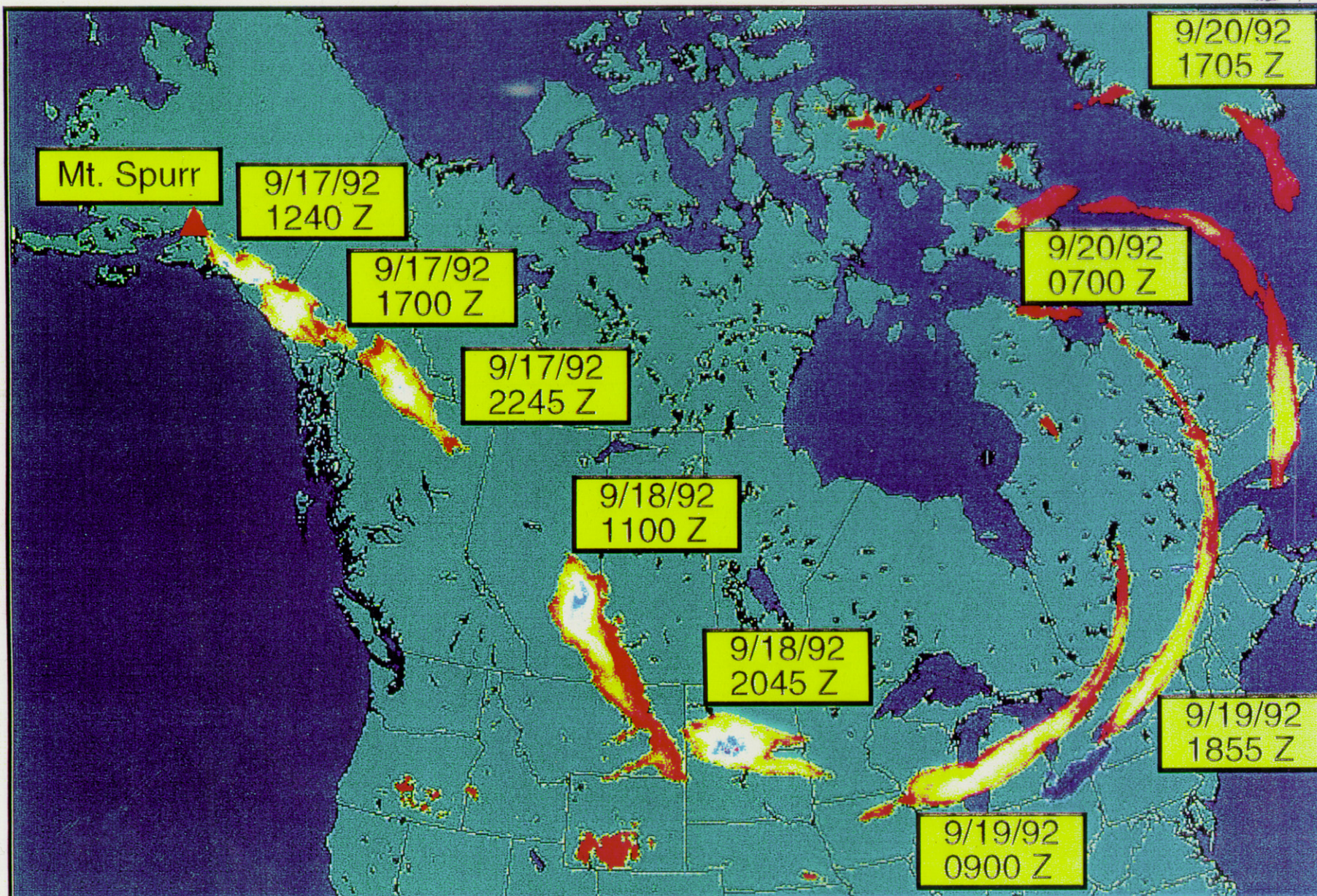


April 4, 2009 Homer, AK





Satellite Tracking of Mt. Spurr Volcanic Ash Cloud





15 DEC 1989
12:46:10pm



15 December 1989:

A KLM 747 encounters the Redoubt eruption cloud north of Anchorage, loses power in all 4 engines and “glides” to within a minute of impact.

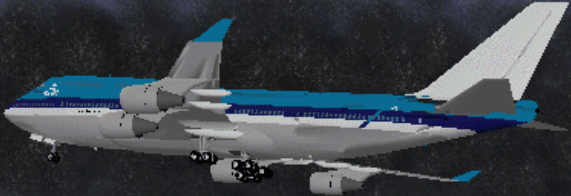


Image © 2008 DigitalGlobe
Image NASA
Image © 2008 TerraMetrics
Streaming 100%

© 2007 Google™
Eye alt: 22.98 km

Pilot: "KLM 867 heavy is reaching {flight} level 250 heading 140."

Anchorage Center: "Do you have good sight of the ash plume?"

P: "Its just cloudy it could be ashes. Its just a little browner than a normal cloud."

"We have to go left now... it's smoky in the cockpit at the moment sir."

AC: "KLM 867 heavy, roger, left at your discretion."

P: Climbing to level 390, we're in the black cloud, heading 130."

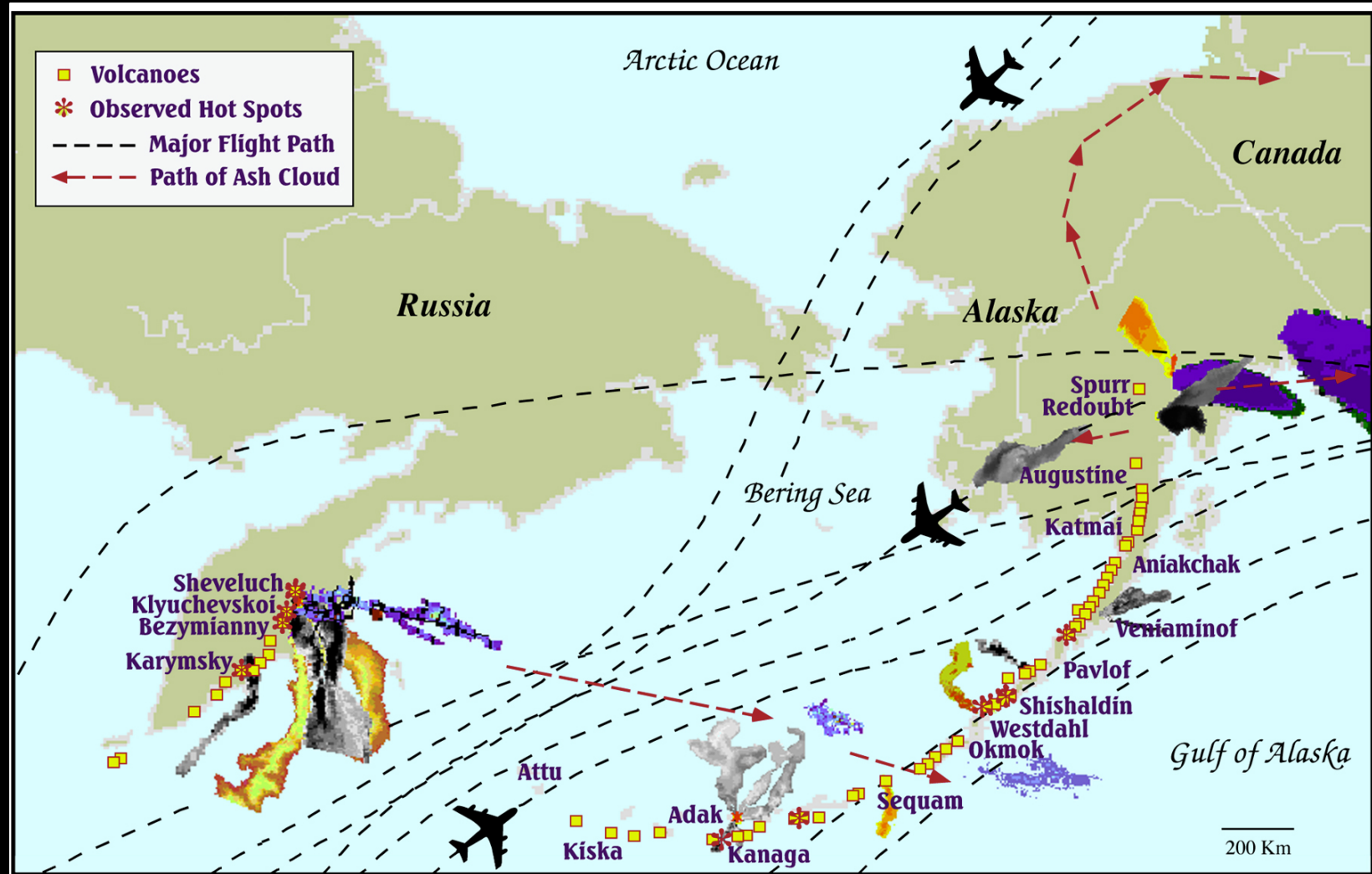
"KLM 867 we have Flame out all engines and we are descending now."

"KLM 867 heavy we are now descending now...."

We are in a fall!!"



The northern Pacific is one of the busiest international air routes in the world.



Some ash clouds of the 90s

Clearing ash at Ted Stevens International Airport, Anchorage

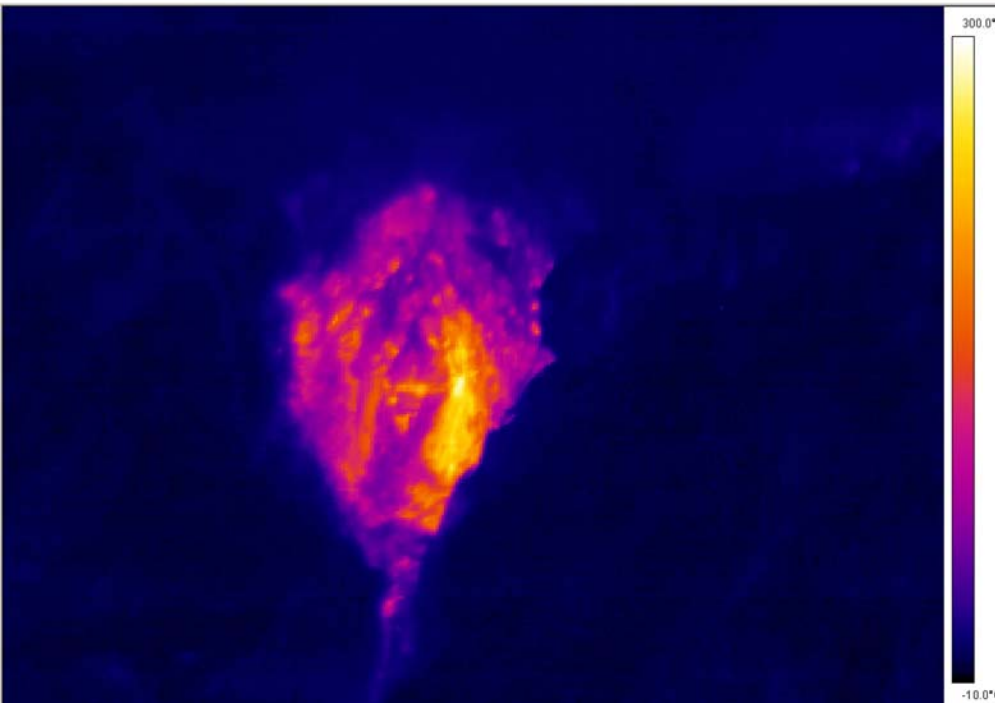


Redoubt Dome from North - 4/16/2009, 12:48:50 AKDT
420C max temp



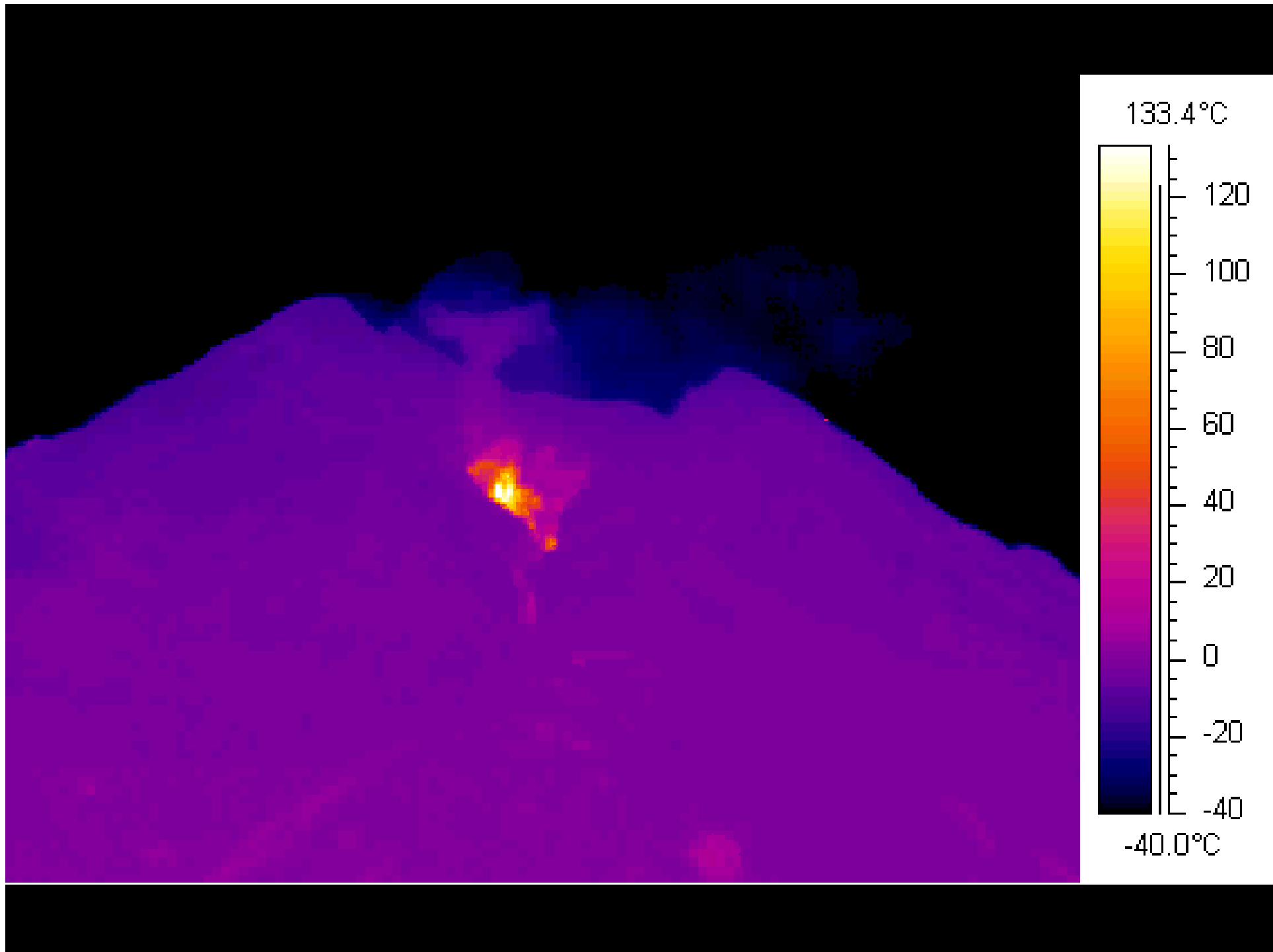
Lava dome:

Sometimes gas is able to escape from ascending magma, so that the magma does not fragment during decompression. Magma then emerges as lava, forming a dome or flow.



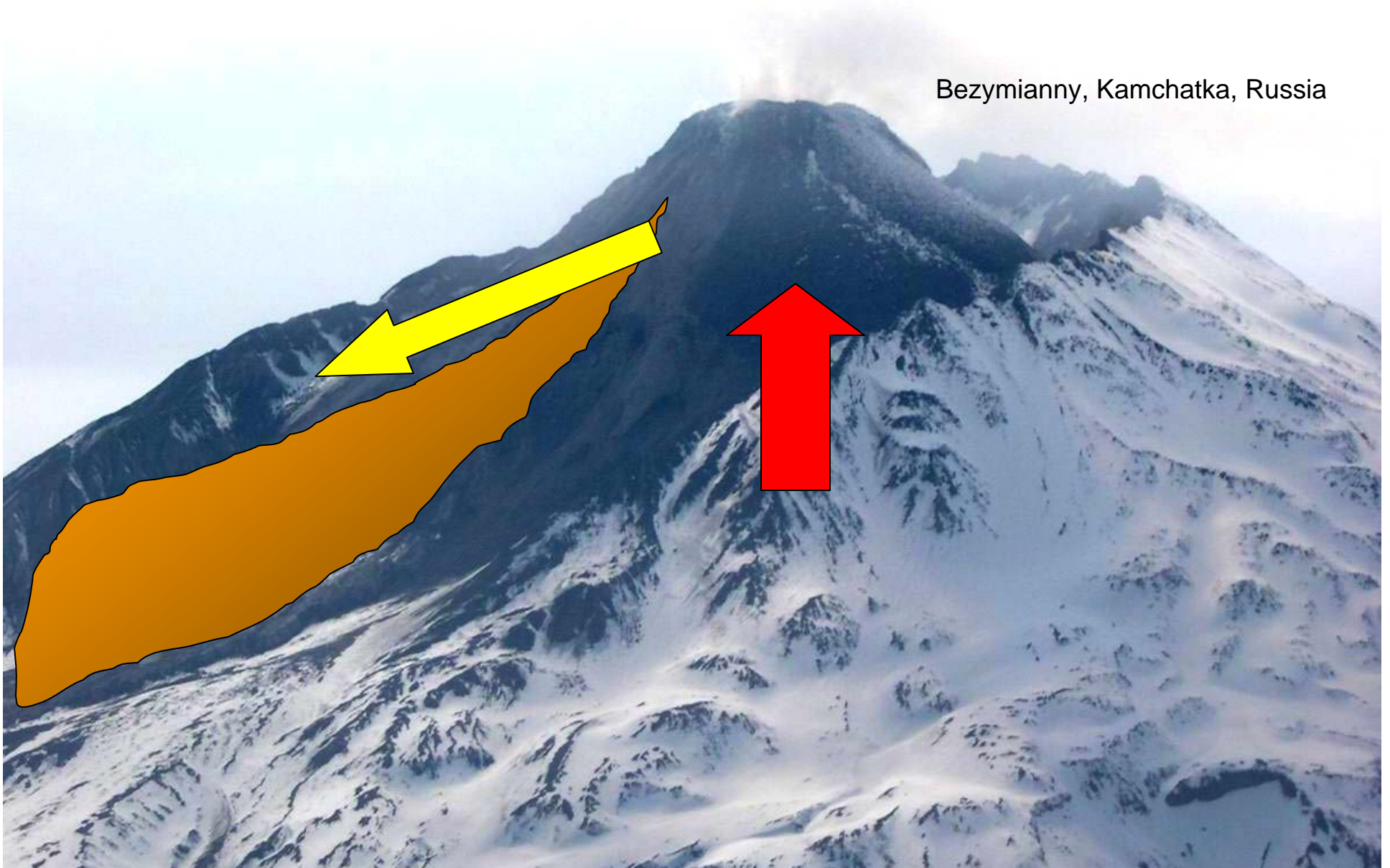


April 28



Pyroclastic flows from dome collapse

Bezymianny, Kamchatka, Russia

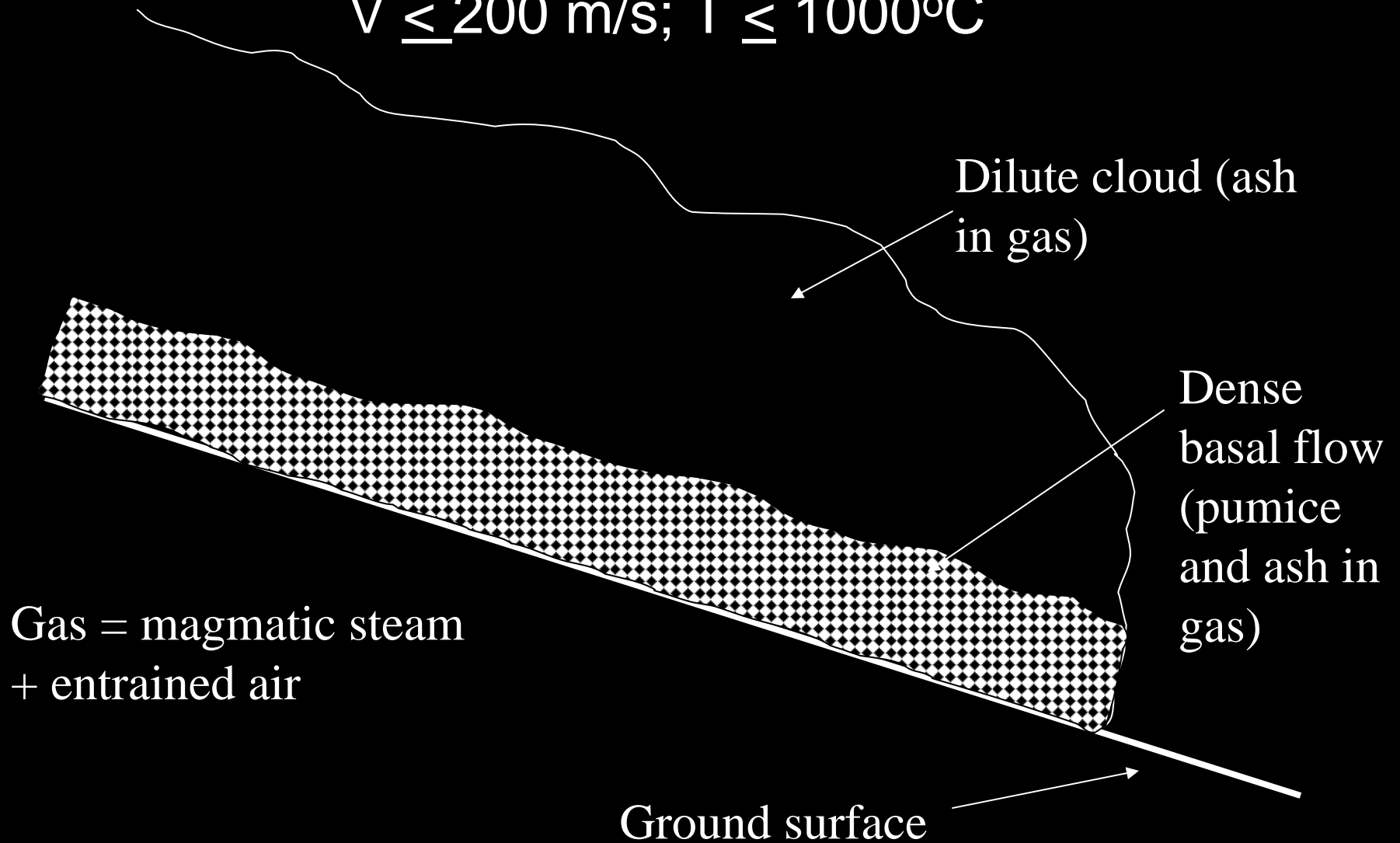




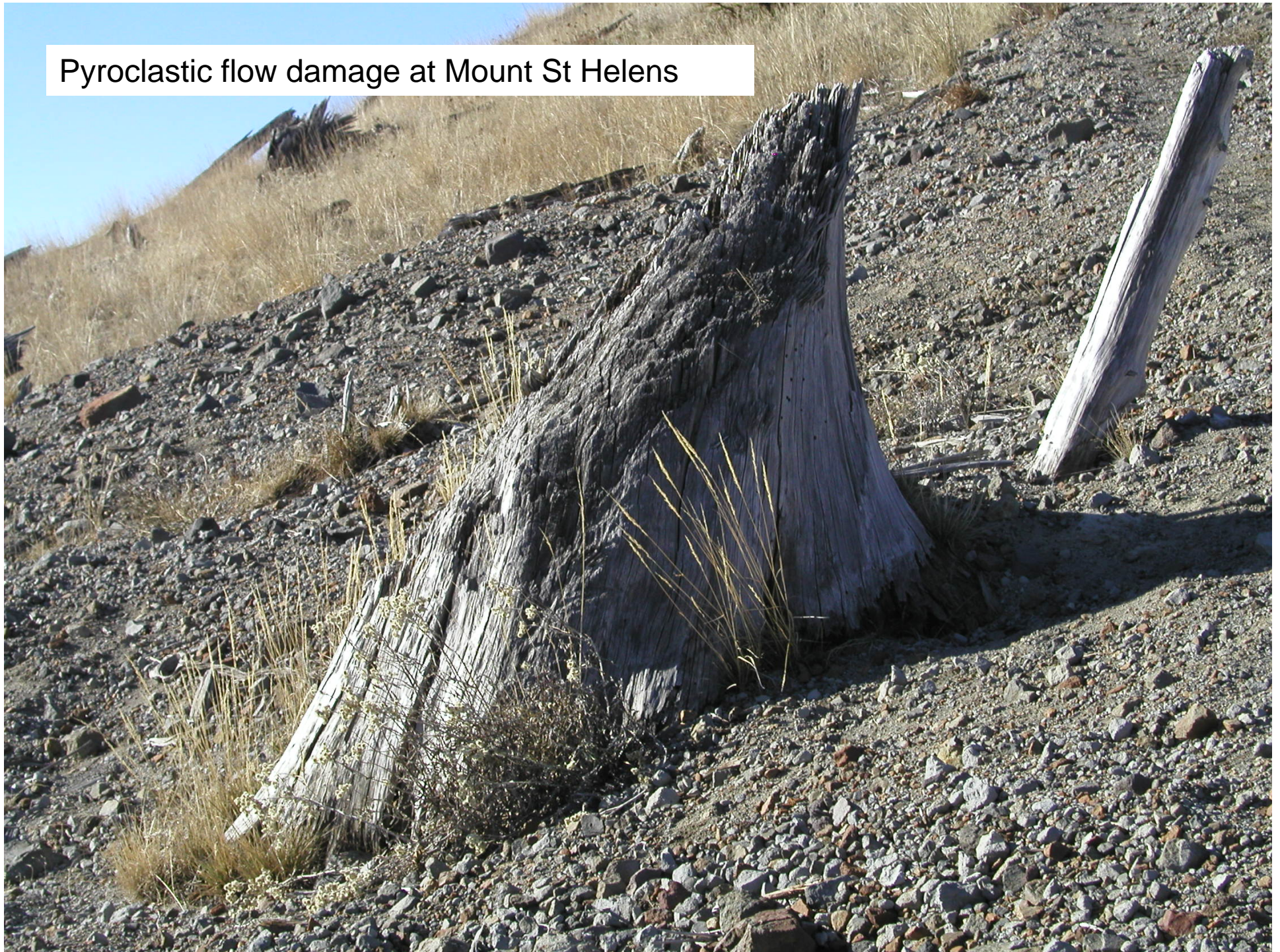
Pyroclastic flow, Unzen Volcano, Kyushu, Japan

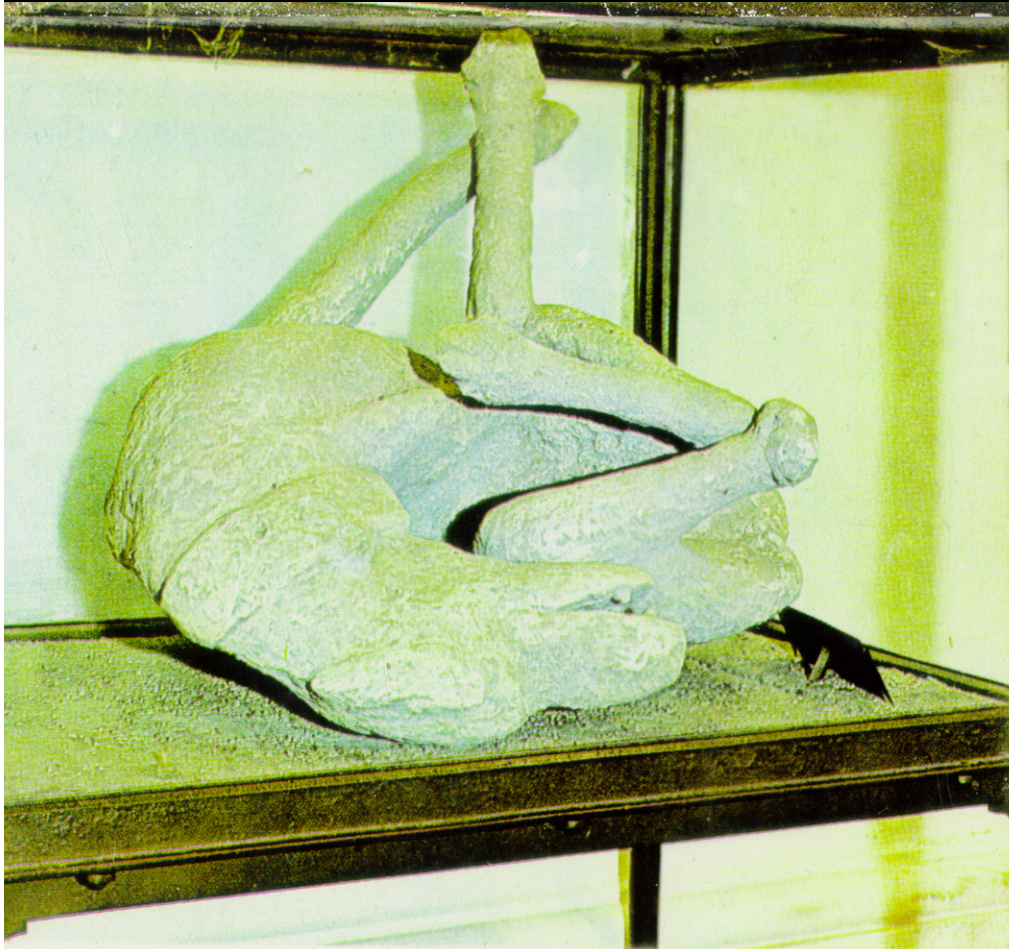
Pyroclastic flows:

$V \leq 200$ m/s; $T \leq 1000^\circ\text{C}$



Pyroclastic flow damage at Mount St Helens





Antiquarium - Cast of a watchdog from the House of Orpheus.

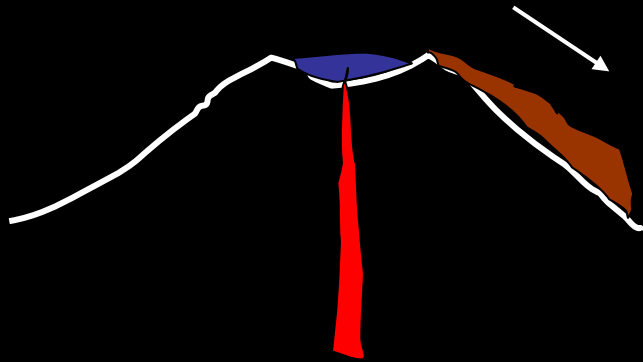


Antiquarium - Cast of a mule-driver.

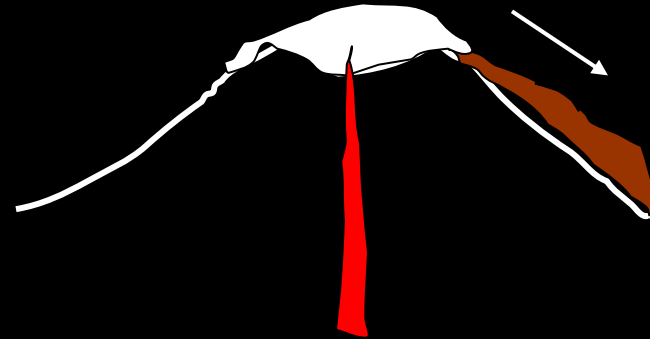
from pyroclastic flows that buried Pompeii

lahars (mud flows)

Magma interacting
with crater lake



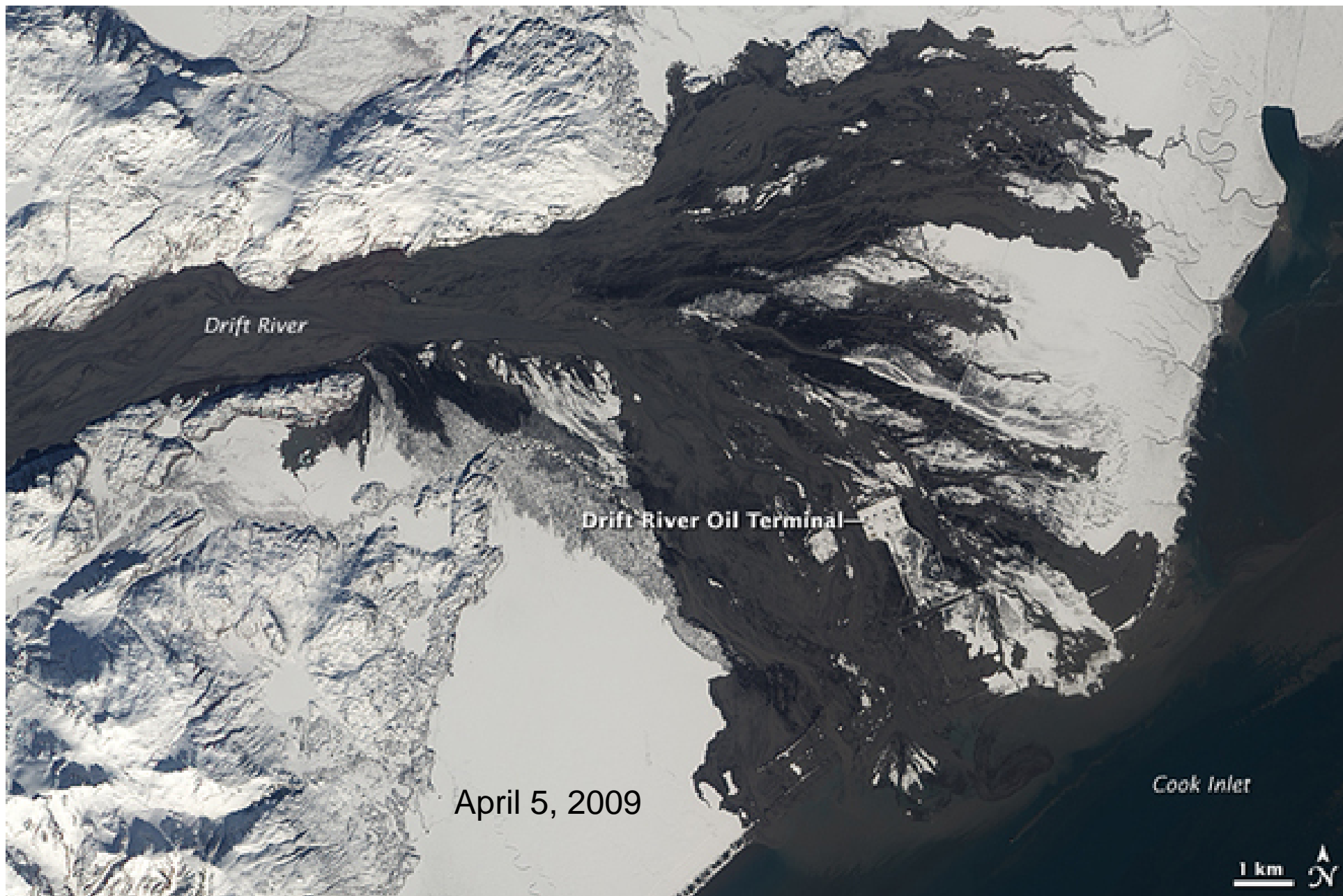
Magma interacting
with ice

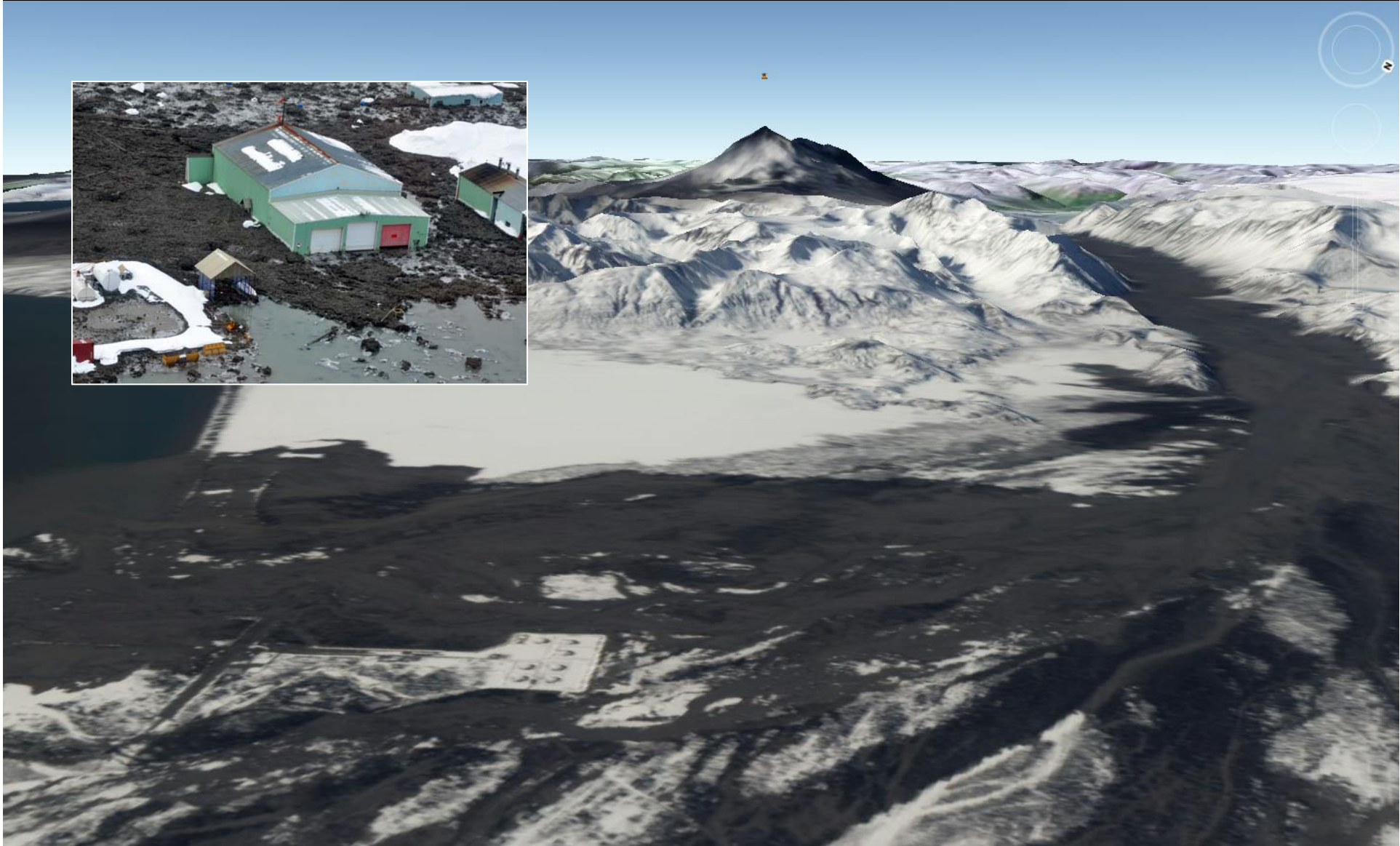




April 4 lahar, Drift River





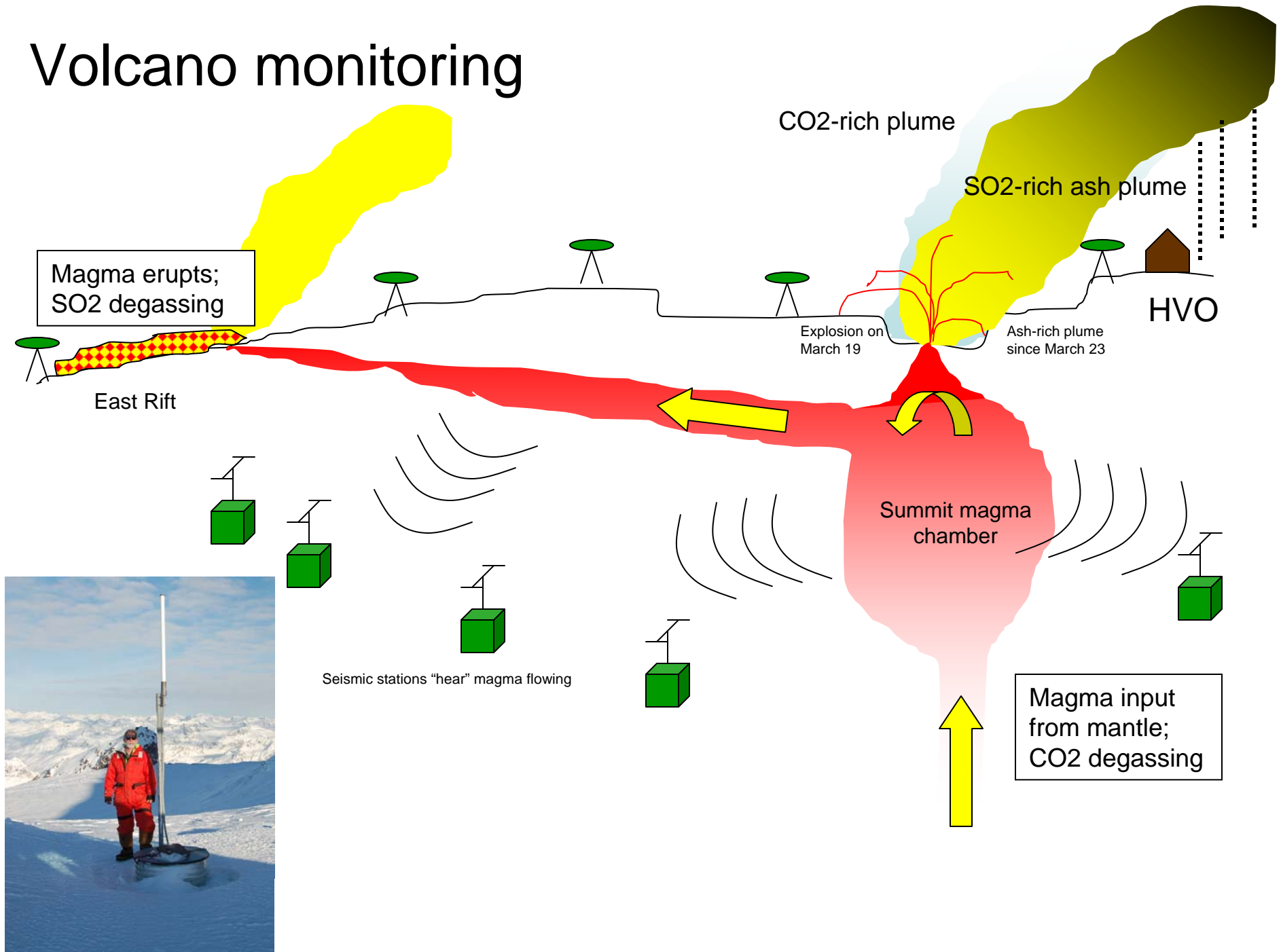


1293 m
60°35'35.75" N 152°14'45.11" W

Image © 2009 GeoEye
© 2009 Europa Technologies
© 2009 Tele Atlas
Image © 2009 TerraMetrics
elev 19 m

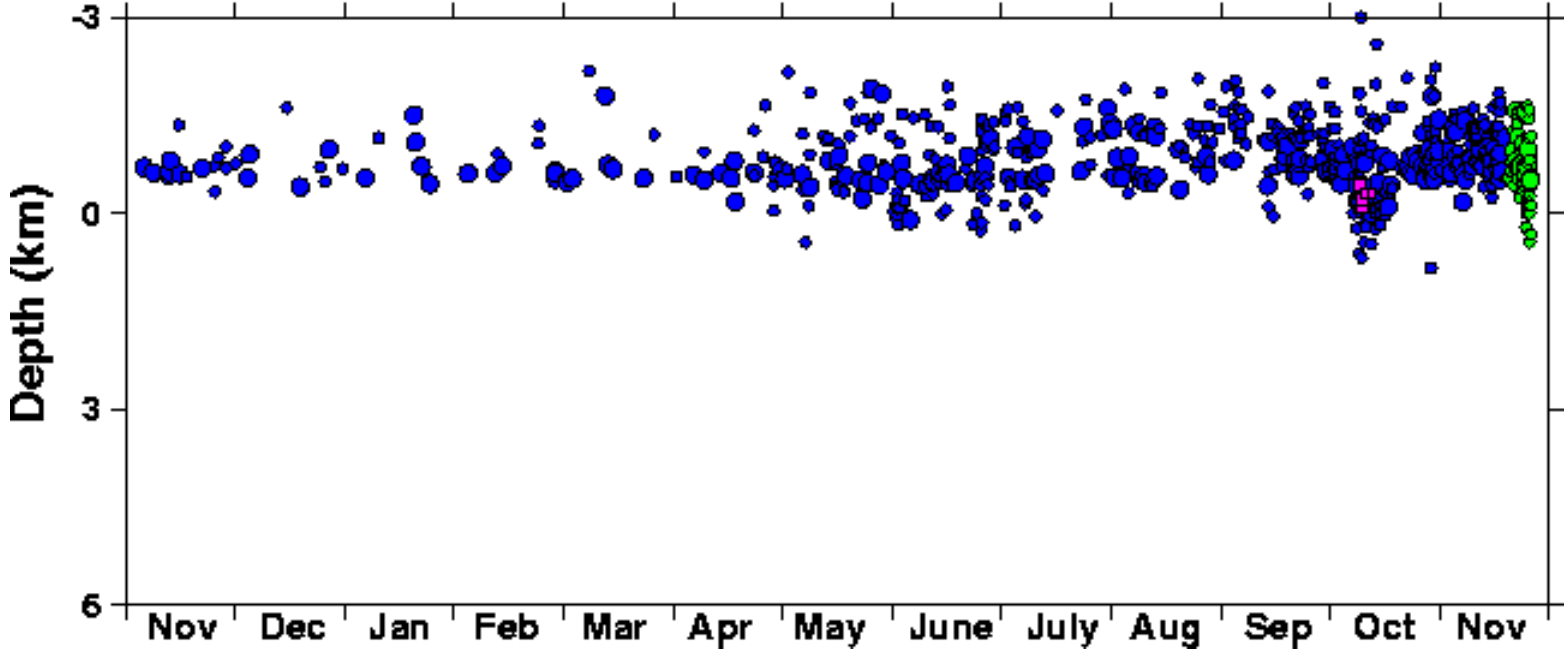
©2008 Google
Eye alt 2.77 km

Volcano monitoring

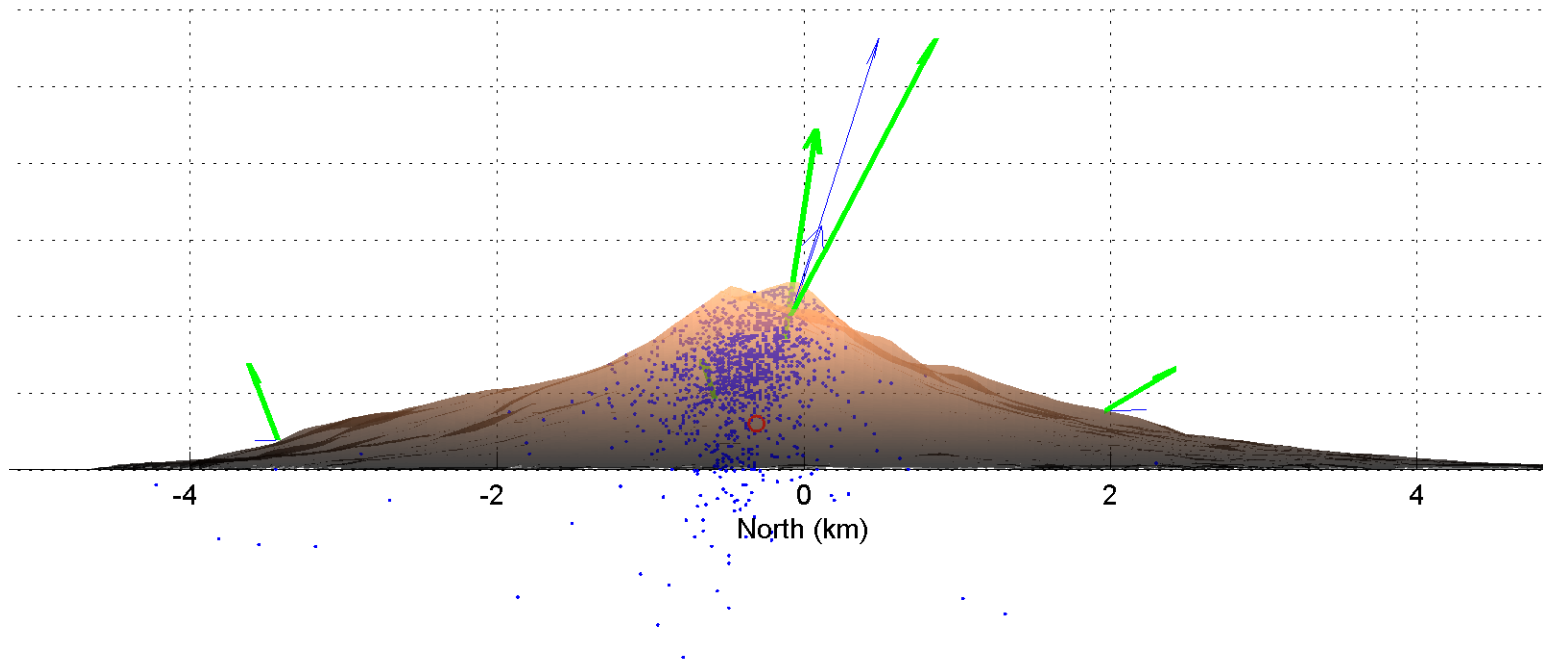


Seismology: First line of defense

Augustine Seismicity, 11/2004 - 11/2005



Geodesy: Constrains volume and depth of magma



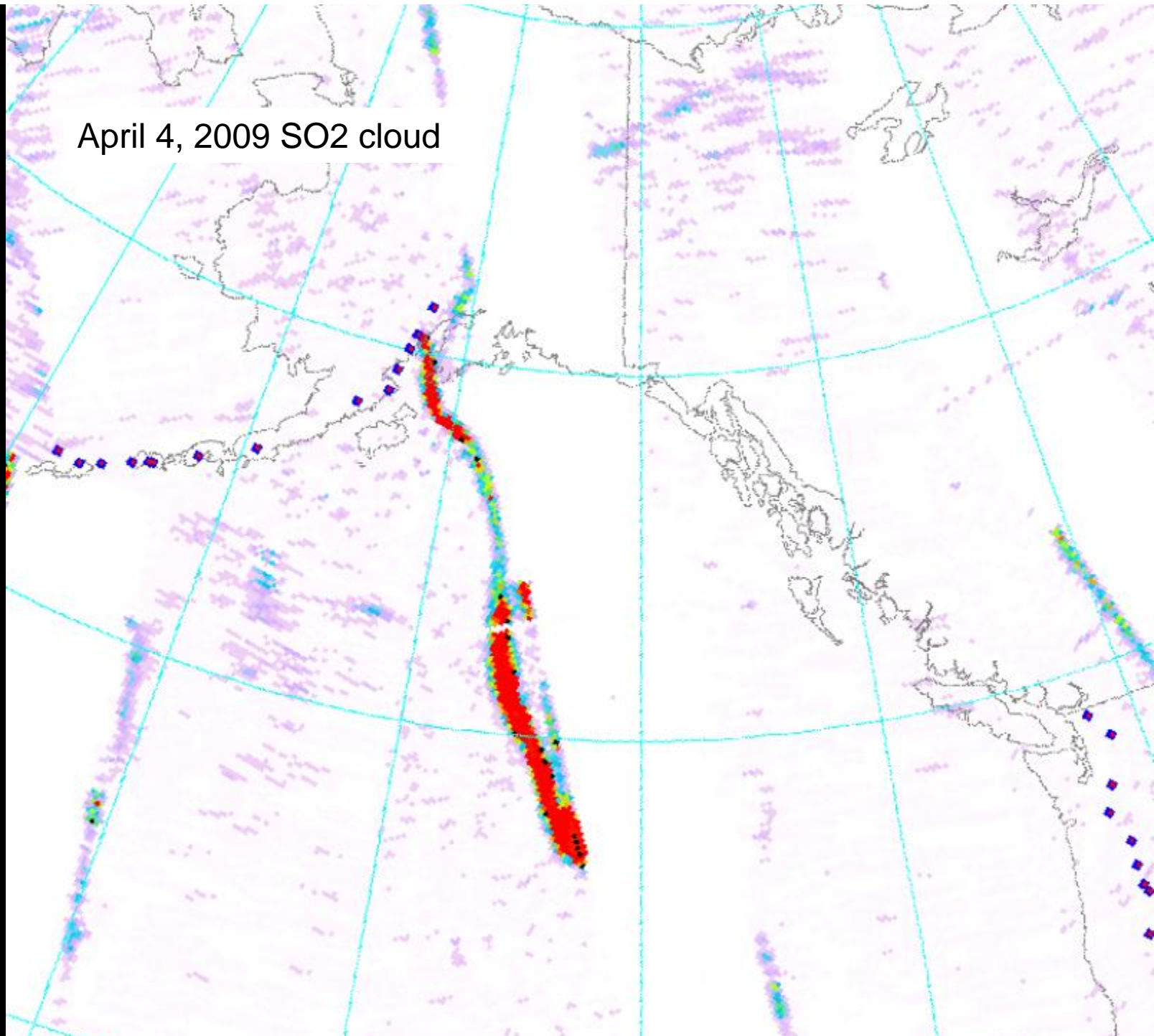
Example: January 2006 eruption of Augustine

Arrows show deformation; blue dots show earthquakes; red circle is interpreted magma location.

Magmatic gas: SO₂ and CO₂ measurements



April 4, 2009 SO₂ cloud

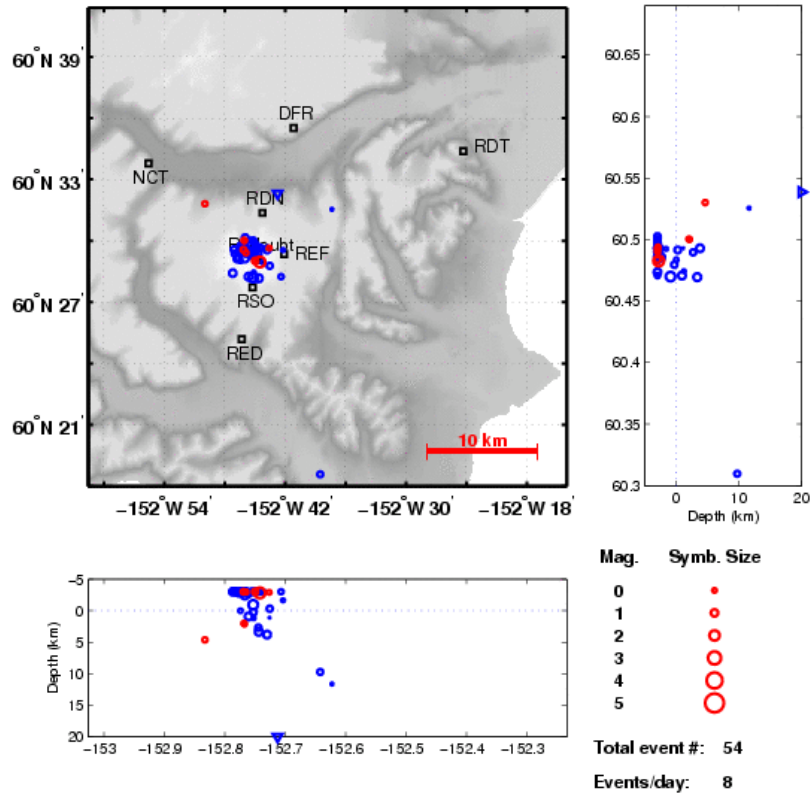




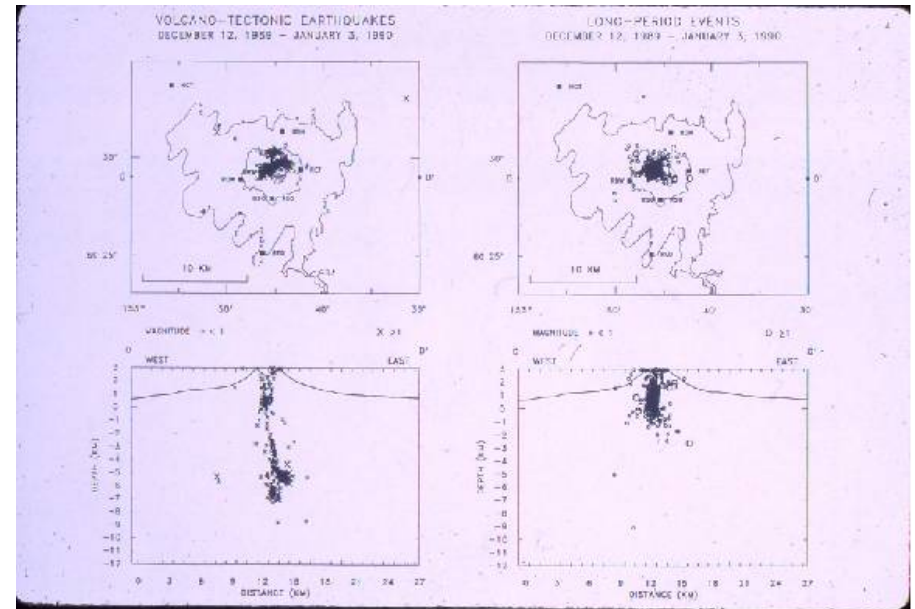
AVO operations room, Anchorage

January: Seismicity intensifies

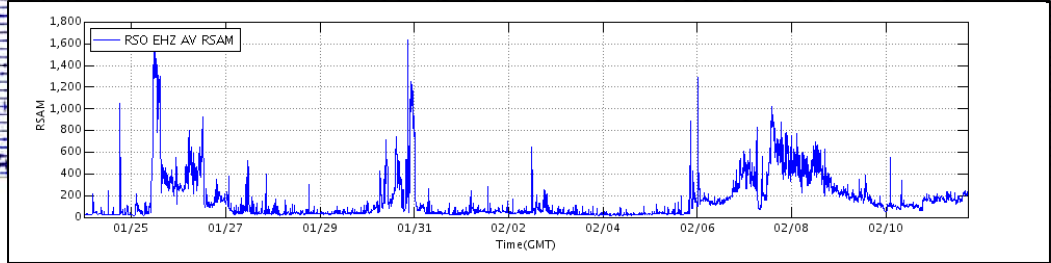
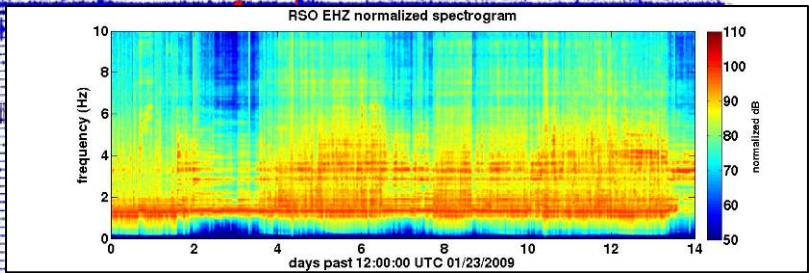
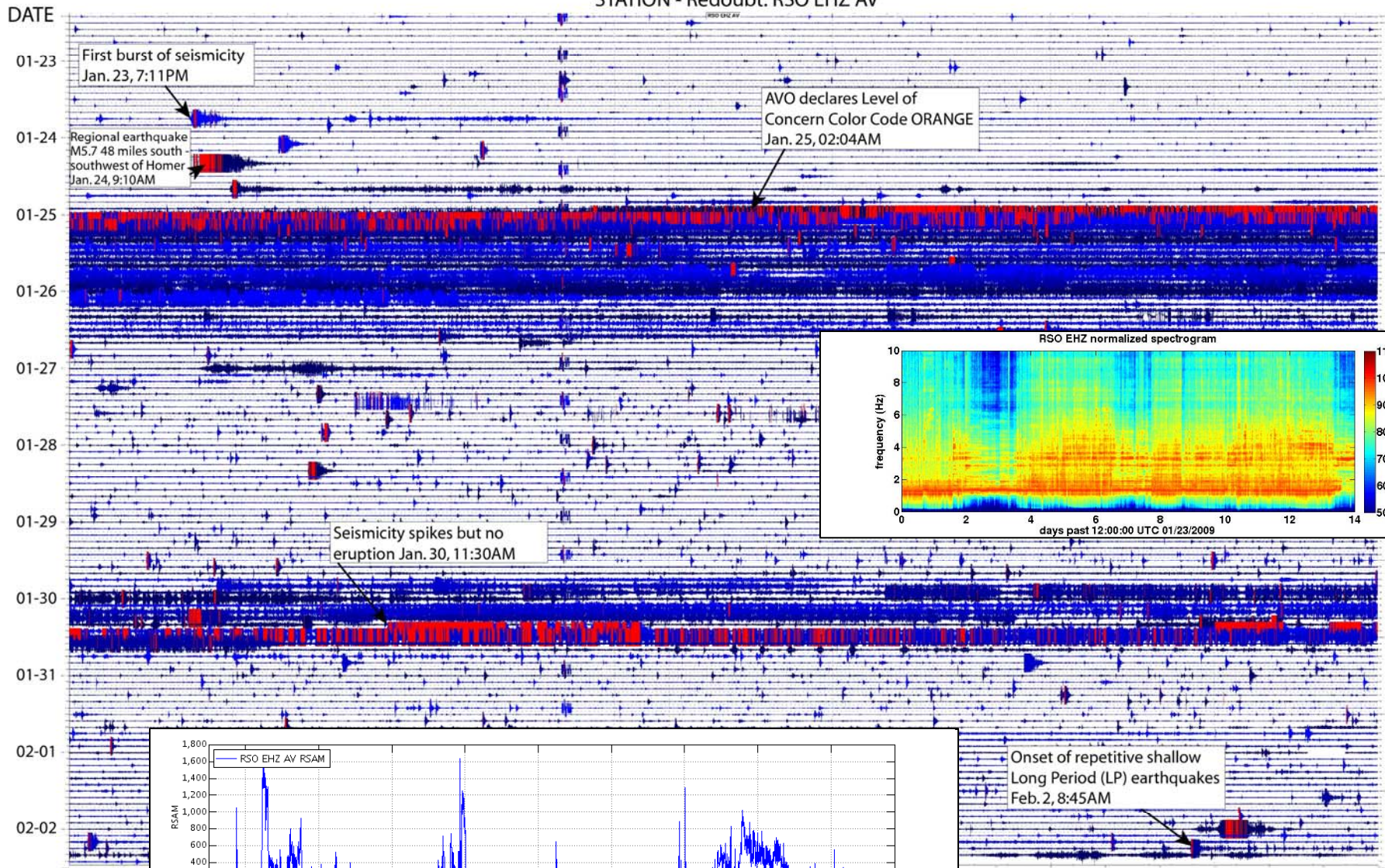
Redoubt Volcano Seismicity 20-Jan-2009 17:57:14 - 27-Jan-2009 17:57:14



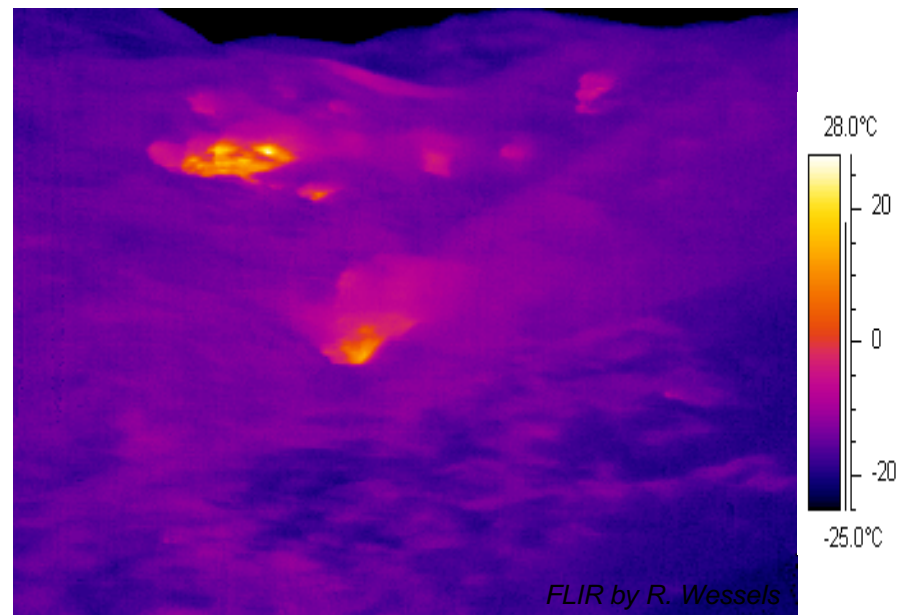
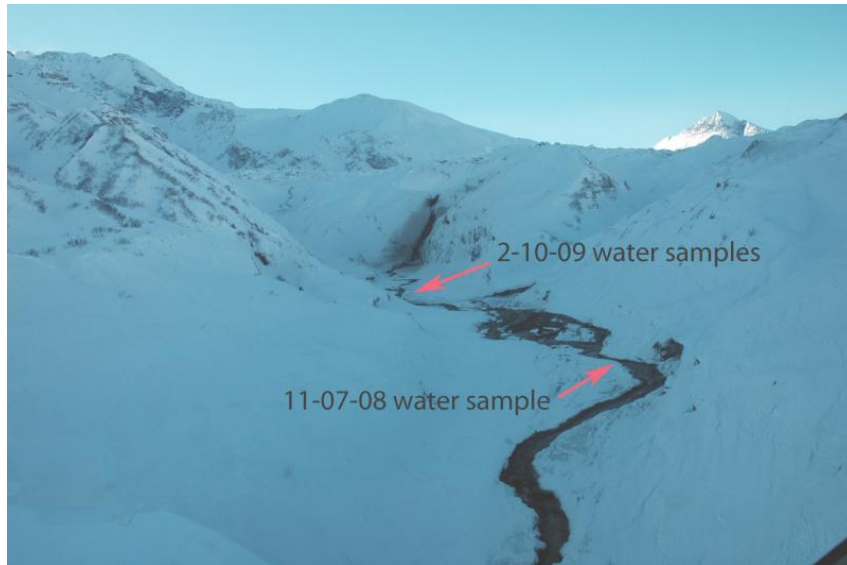
December 12, 1989 – January 3, 1990



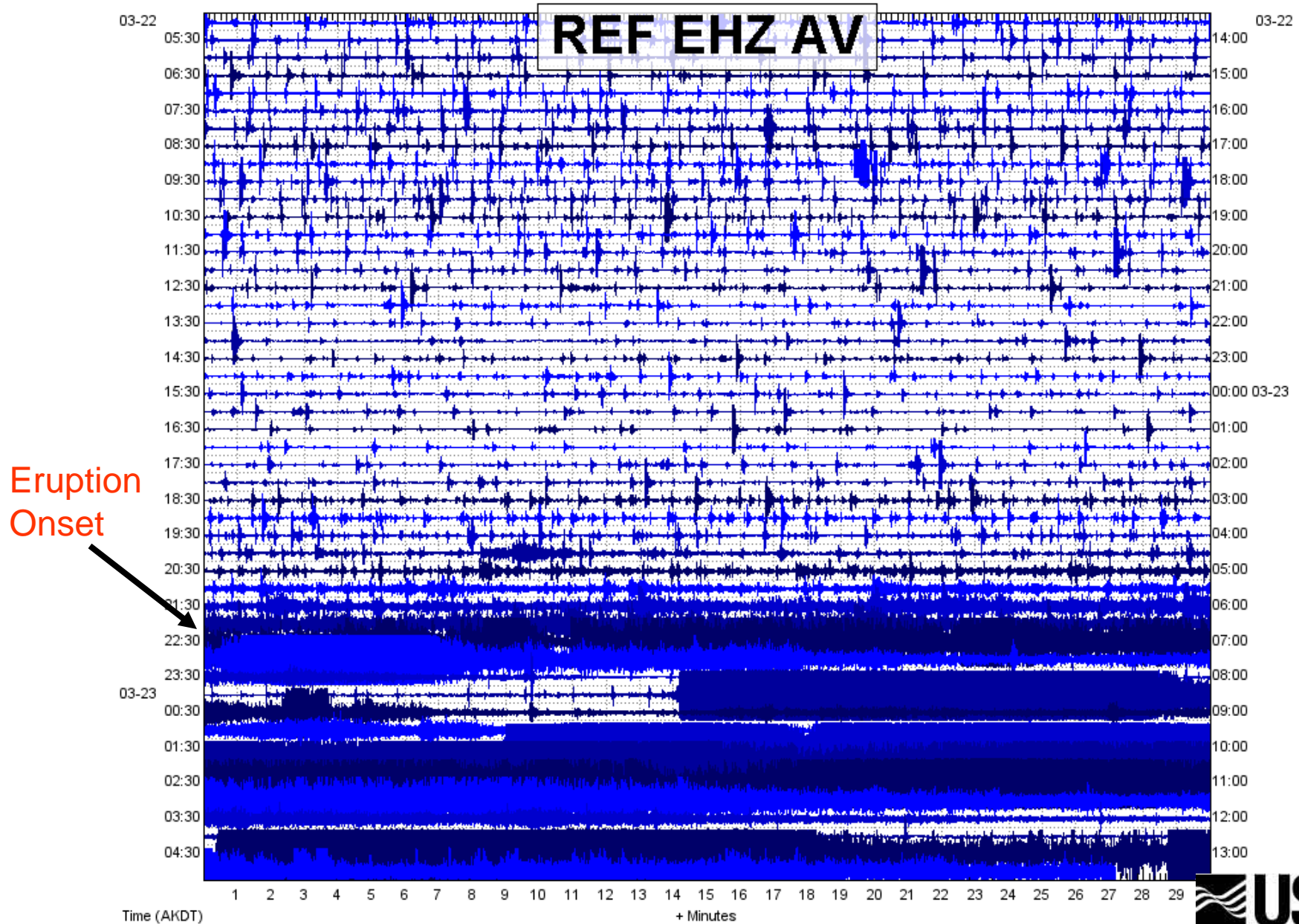
STATION - Redoubt: RSO EHZ AV

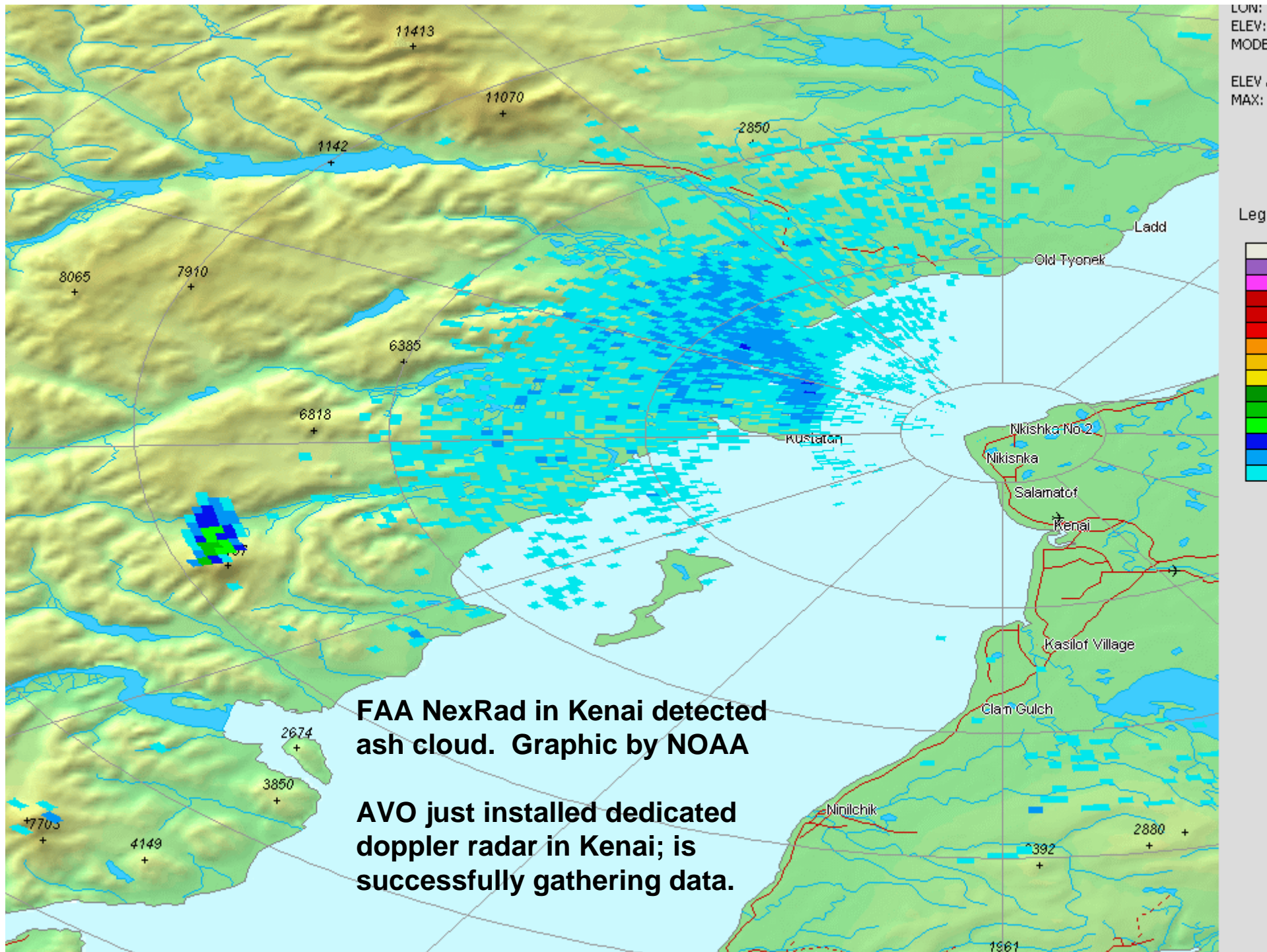


February: Heating and melting

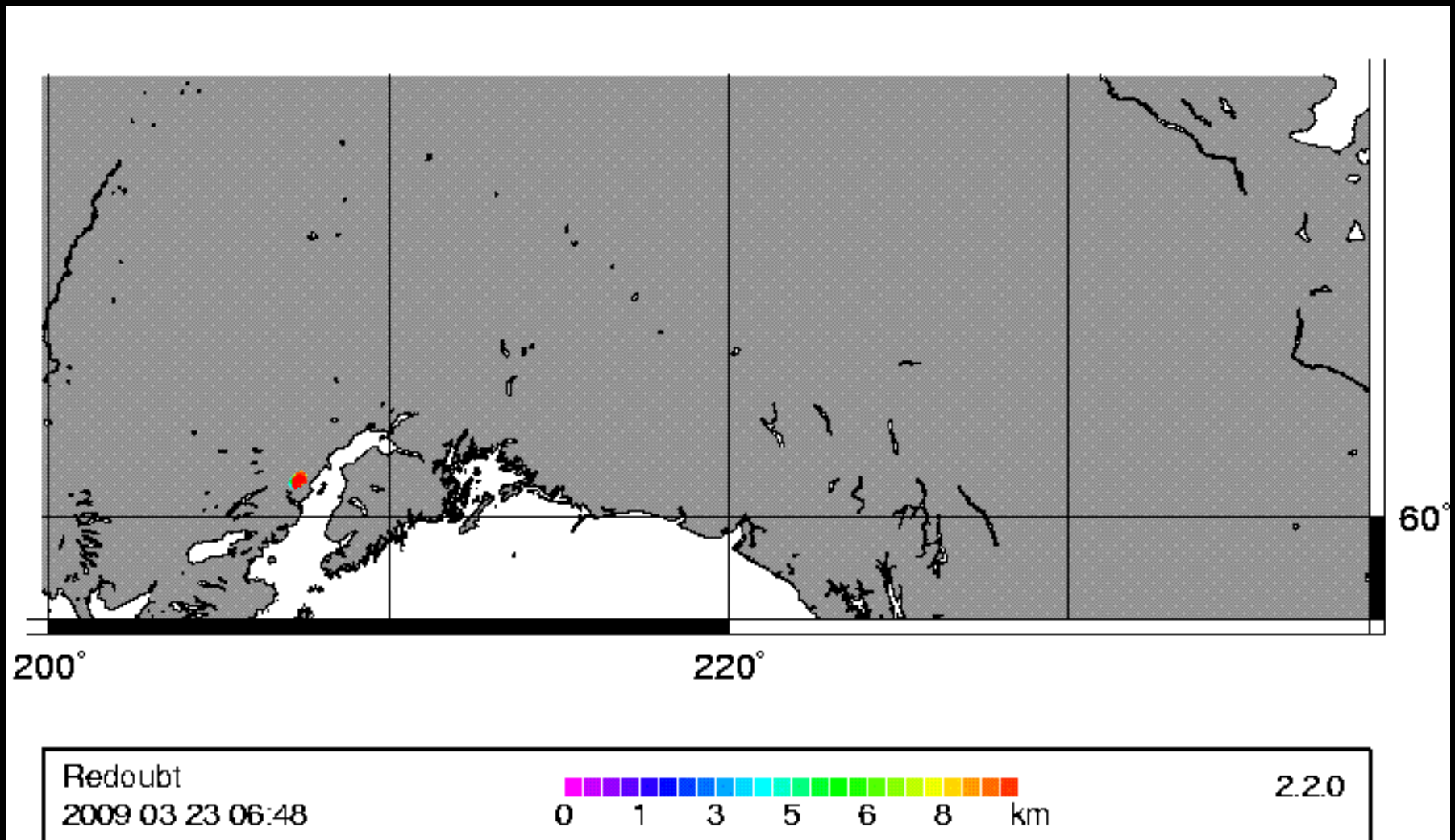


March 22: Eruption





Computer projection of ash dispersion



Communication tools:

1. **Calldown:** Emergency response agencies are notified of unrest by telephone and electronically to mitigate hazards to communities at risk.
2. **Email reports and notifications:** Emergency notifications and daily to weekly status reports and activity updates are provided to all information users who wish this information in the public and private sectors.
3. **Web sites:** Each observatory, and the overall program, has a web site. Observatory web sites provide all warnings and updates together with real-time monitoring data, webcam views, and background information.
4. **Other communication techniques:** Eruption response plans, eruption scenario exercises, workshops, hazard maps, fact sheets.
5. **Scientific output:** To advance the field of volcanology and provide discourse with the broader scientific community, the program publishes about 75 peer-reviewed articles per year in internationally available journals.
6. **International outreach:** The program's Volcano Disaster Assistance Program (VDAP) responds to countries requesting help in dealing with volcanic crises. Notable responses have been undertaken in South and Central America, the Philippines, and Indonesia. AVO collaborates closely with volcanologists in the Russian Far East to mitigate the hazard of ash clouds to trans-Pacific flights.

Redoubt Activity - Color Code **ORANGE**: Alert Level WATCH

Local time: May 06, 2009 07:45 AKDT (May 06, 2009 15:45 UTC)

Redoubt Links

- Description
 - Images
 - Maps
 - Bibliography
 - Reported Activity
 - Current Activity
- Other Links**
- ASH FALL ALERTS
 - Puff ash cloud predictions
 - Ted Stevens Airport Flight Status (Anchorage)
 - Ashfall collection instructions
 - USGS Ashfall Preparedness website
 - Report ashfall to AVO
 - Send us an email

Code Definitions

ORANGE Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, limited uncertainty, OR eruption is underway or likely to occur. Minor volcanic ash emissions (ash plumes) are expected, if needed.

WATCH Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, limited uncertainty, OR eruption is underway but poses limited hazards.

More information on color/alert definitions

Maps



Location of Redoubt volcano and other Cook Inlet volcanoes with respect to nearby cities and towns...click to view larger image. Seismic station locations at Redoubt volcano...click to view larger image.

Selected Images



Images of the 1989-1990 Redoubt eruption. Images of current activity at Redoubt. Images associated with the Redoubt Hazard Report.

Redoubt FAQ

Redoubt Activity Notice: May 5, 2009

Previous observations and background

Links

Ashfall & Preparedness Information

- NOAA/NWS ash advisory webpage
- Ash fall camera, how to find ash plumes
- USGS Ashfall Preparedness website
- Kenai Peninsula Borough Office of Emergency Management
- Municipality of Anchorage, Office of Emergency Management Volcanic Ash Information
- Mat-su Borough Office of Emergency Management
- State of AK Dept. of Homeland Security and Emergency Management Volcano Mitigation
- AK Department of Environmental Conservation - Division of Air Quality
- State of AK Dept. of Public Health
- Anderson.org, General Volcano Information
- Red Cross

Before an eruption

Read the national report for Redoubt: (2 MB PDF)
Read the USGS Ashfall Preparedness "Before an eruption" website

Useful Links

- Interactive simulations by Redoubt volcano
- National Weather Service - Redoubt Coordination Page
- Ted Stevens Airport Flight Status (Anchorage)
- Fairbanks Airport Flight Status
- HMA Fact Sheet: Volcanoes
- IRMA volcanoes: Alaska ready
- Alaska Division of Homeland Security and Emergency Management
- Send us an email

How to collect an ash sample for AVO

Report ashfall to AVO

Please report ashfall to us by email or phone (756-7497). We'd like to know your location, time of the fall, height of plume, and the current weather. It would help us if you collect a sample for us. Here are instructions.

Redoubt Volcano Latest Observations

2009-04-30 00:26:59
Seismic activity remains elevated and largely unchanged over the last 2 hours. It is possible that an explosive event could occur at any time with little warning. The volcano is visible in this morning's infrared images. There are a couple secondary steam plumes visible in the drainage immediately below the dome. These likely result from hot dome fragments interacting with glacial ice.

2009-05-06 04:23:52
2009-05-06 02:15:59
2009-05-06 02:08:21
2009-05-05 22:31:11

More ...

Follow these updates on Twitter: http://twitter.com/alaska_avo

Redoubt Volcano Activity Notifications

- 2009-05-05 12:59:26 - Status Report
 - 2009-05-05 06:59:43 - VA/VQVA
 - 2009-05-04 15:09:34 - Status Report
 - 2009-05-03 11:13:06 - Status Report
 - 2009-05-02 12:41:21 - Status Report
 - 2009-05-02 09:29:22 - Information Statement
 - 2009-05-01 14:50:15 - Weekly Update
 - 2009-04-30 13:18:03 - Status Report
- More ...

Color Code and Alert Level Definitions

Webcams



Webcams

Redoubt - REF Redoubt - CI Redoubt - OFR

Click to view larger images.

Webcams

Station available:

- REF_INZ_AV
- REF_OUT_AV
- REF_INZ_AV
- NCT_INZ_AV

Webcams

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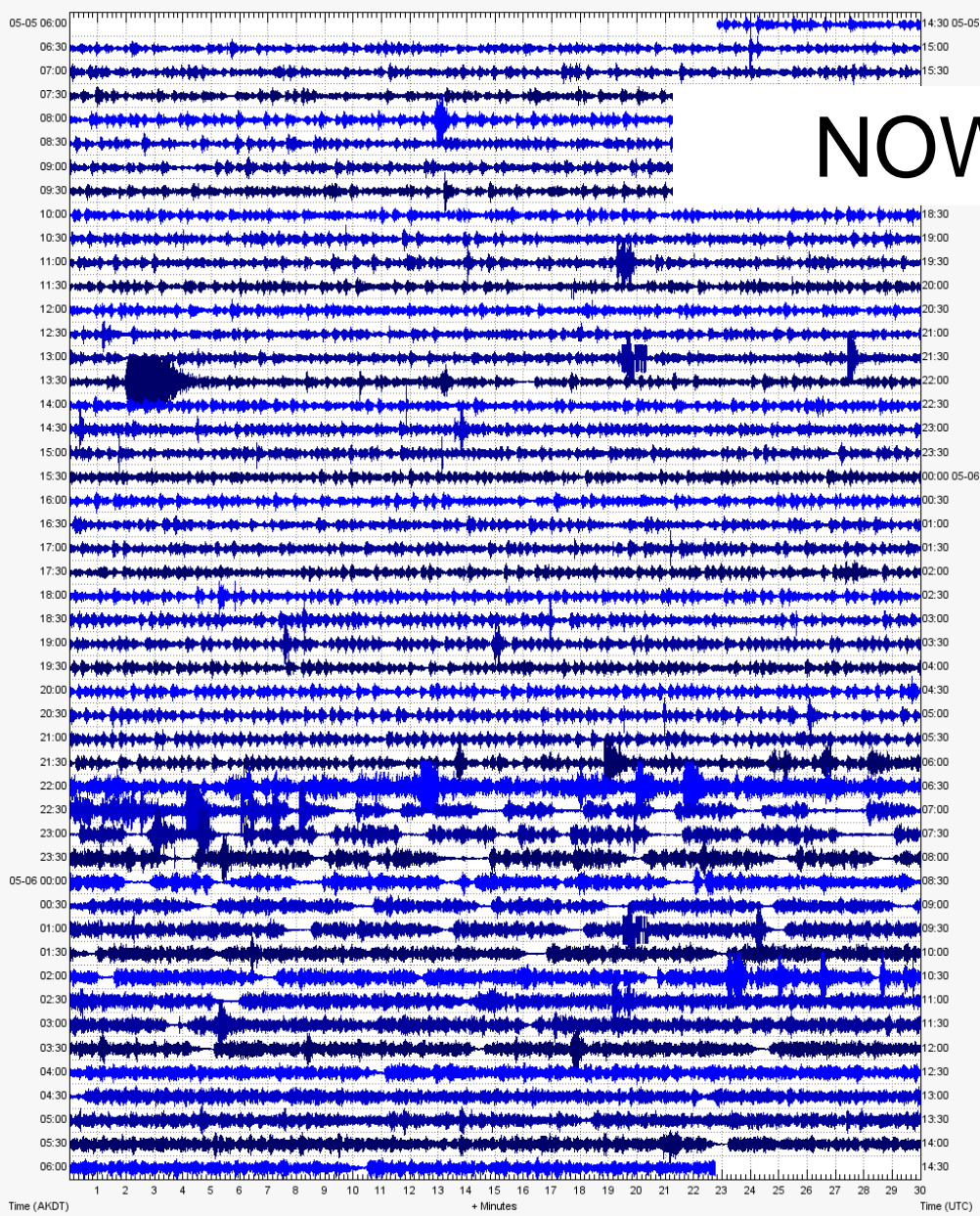
Webcams

Webcams

What's next?

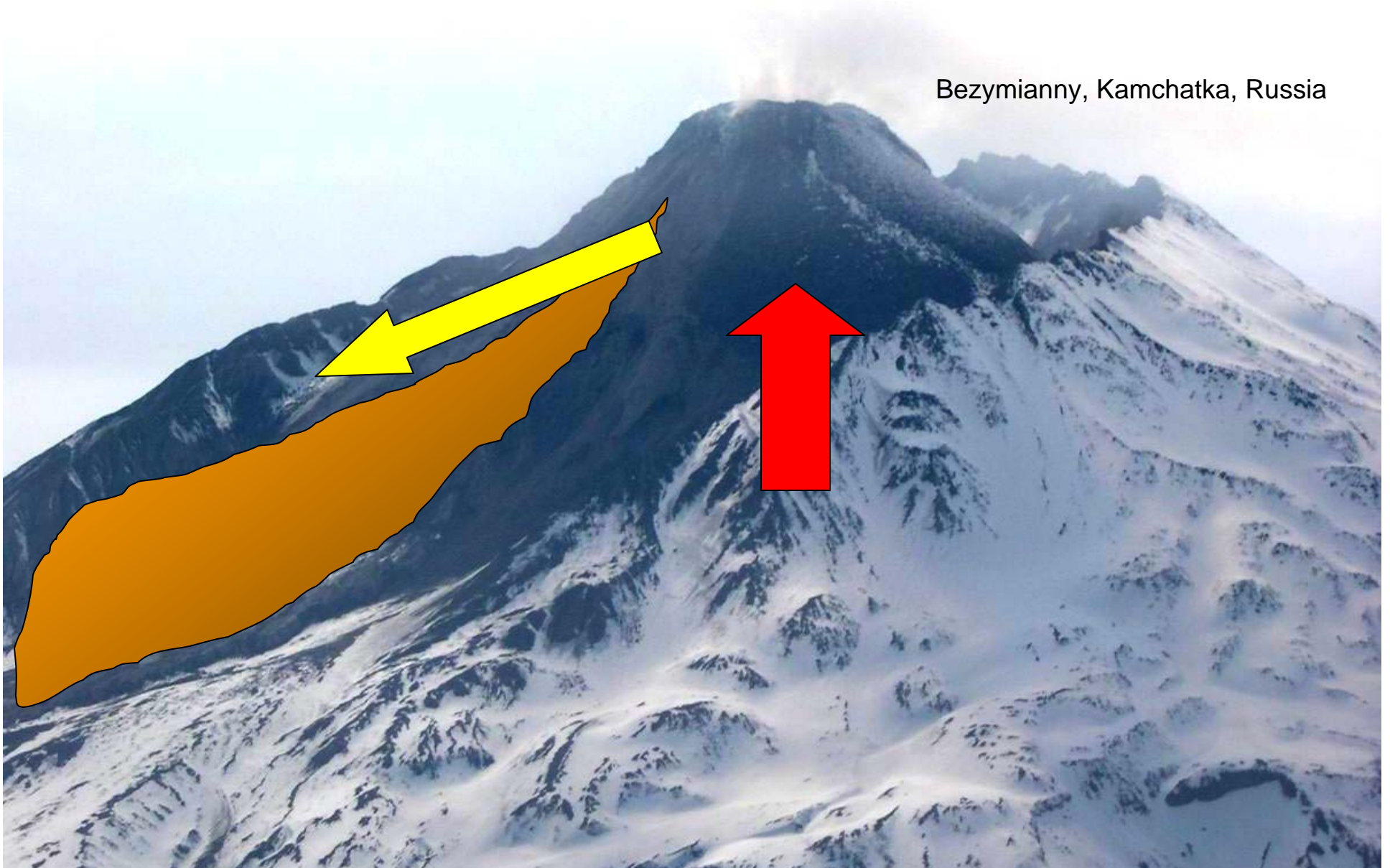
Product: HUP_104_May_05_005605_2009
Exposure: 1.00

NOW



Pyroclastic flows from dome collapse

Bezymianny, Kamchatka, Russia





R Clucas



April 21, 1990

Summary

- Unrest detected early; eruption warning issued 2 months prior to first event.
- Eruption onset was detected immediately.
- Anticipated scenario and impacts were correct.
- No encounters with ash clouds by aircraft.
- Several hundred flights cancelled or diverted.
- No oil spillage- tanks intact but dikes at design limit.
- Reduction in oil production in Cook Inlet; layoffs probable.
- Reduction in cargo flights; layoffs by air cargo industry; revenue loss to airport.