



VOLCANIC HAZARDS AND HOW WE MONITOR VOLCANOES

John Eichelberger

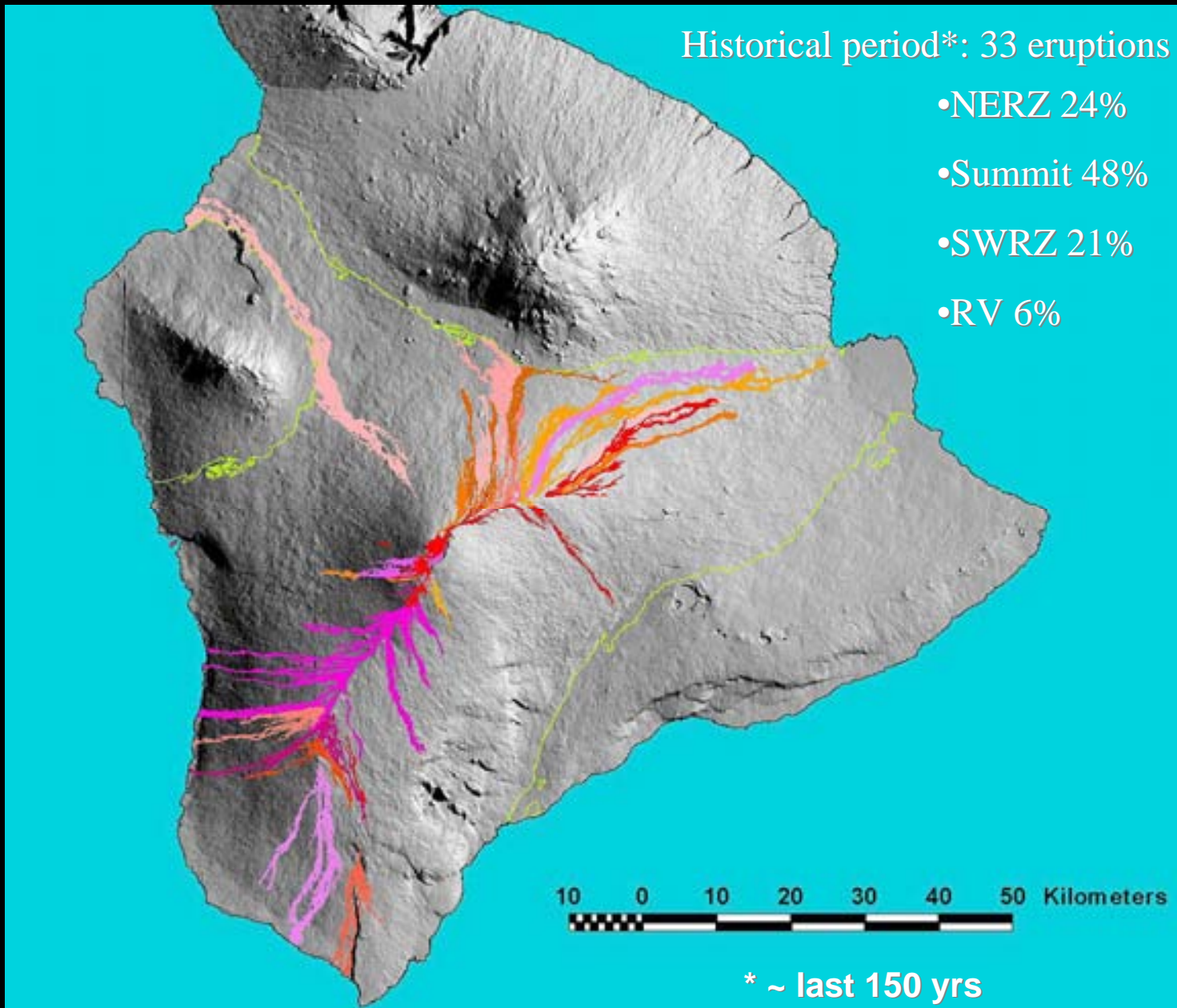
USGS

June 29, 2010

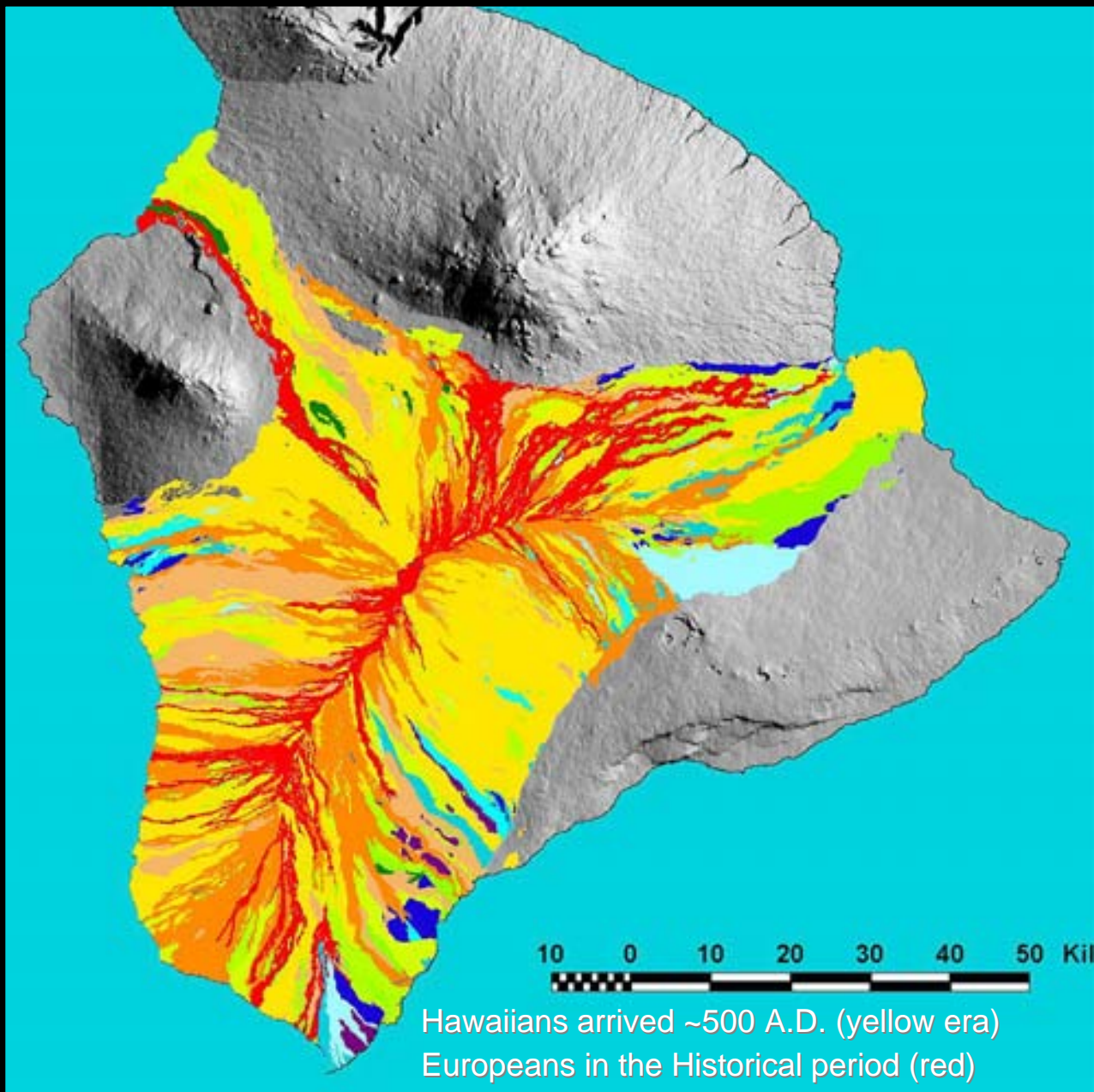
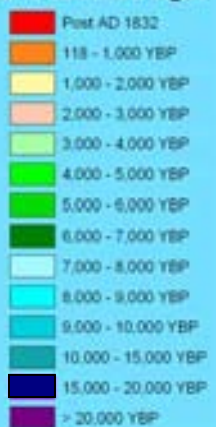
Historical Flows of Mauna Loa

Historical period*: 33 eruptions

- NERZ 24%
- Summit 48%
- SWRZ 21%
- RV 6%

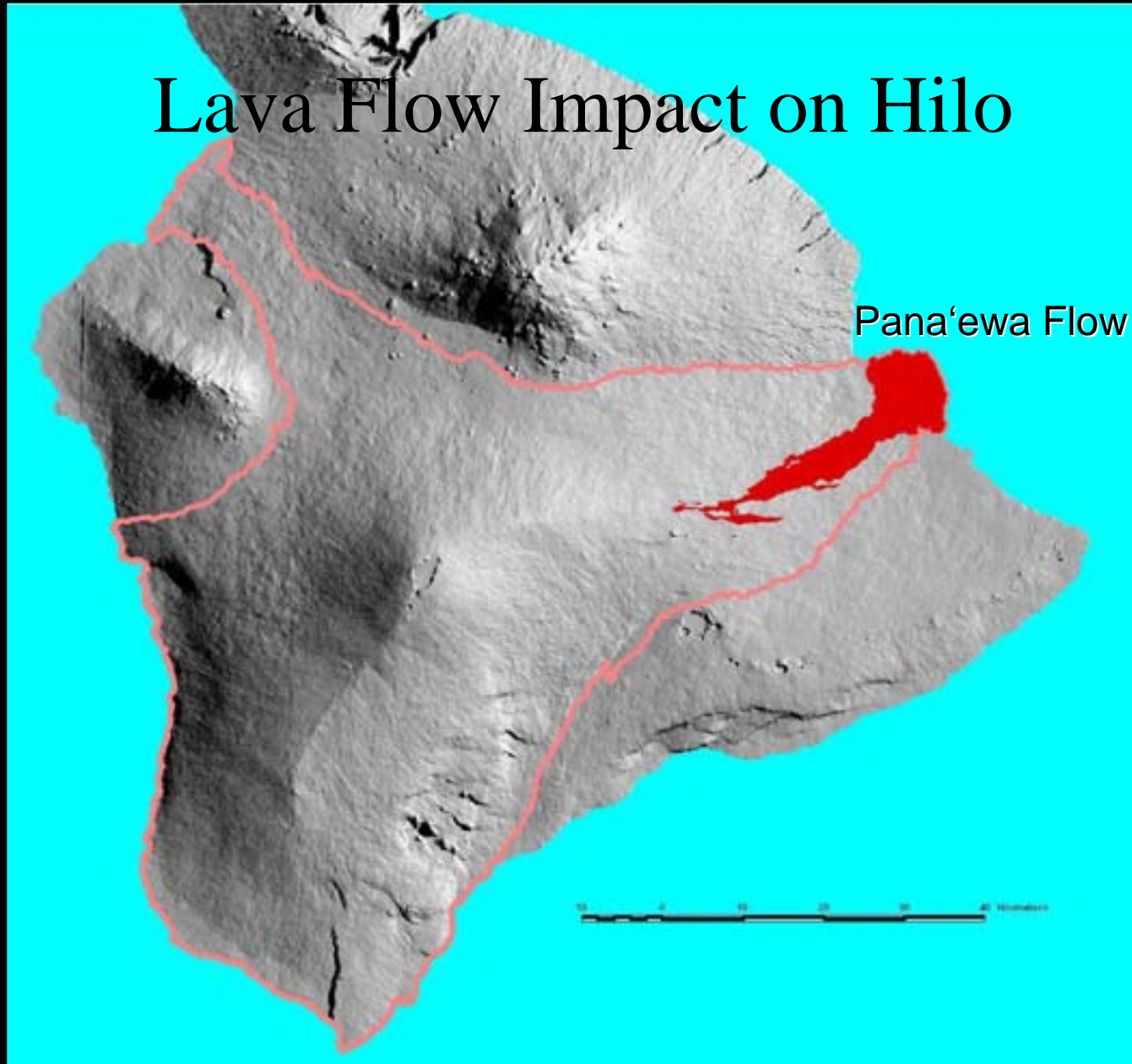


Mauna Loa Flow Ages

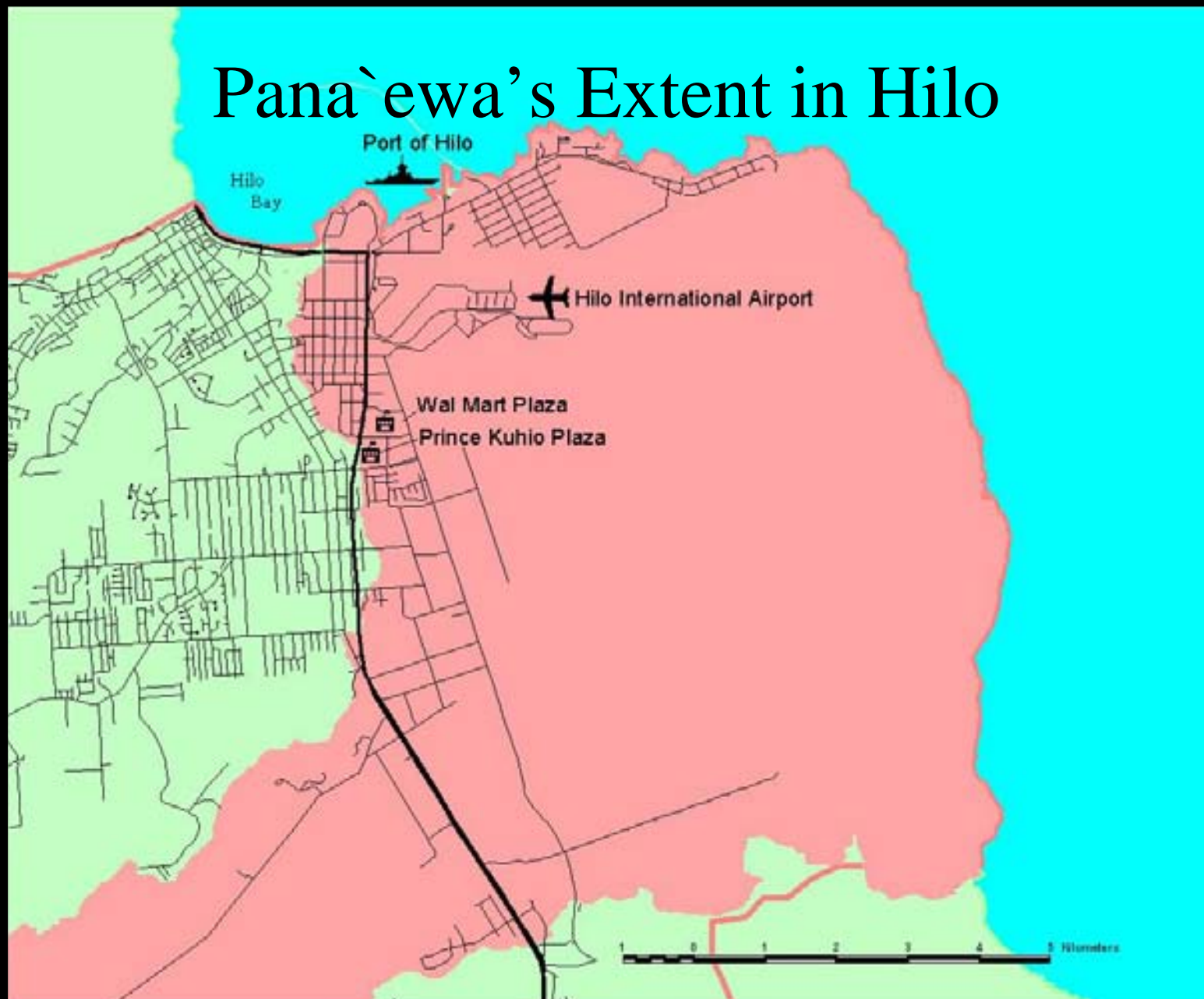


Hawaiians arrived ~500 A.D. (yellow era)
Europeans in the Historical period (red)

Lava Flow Impact on Hilo



Pana`ewa's Extent in Hilo



Modeling Using DEM

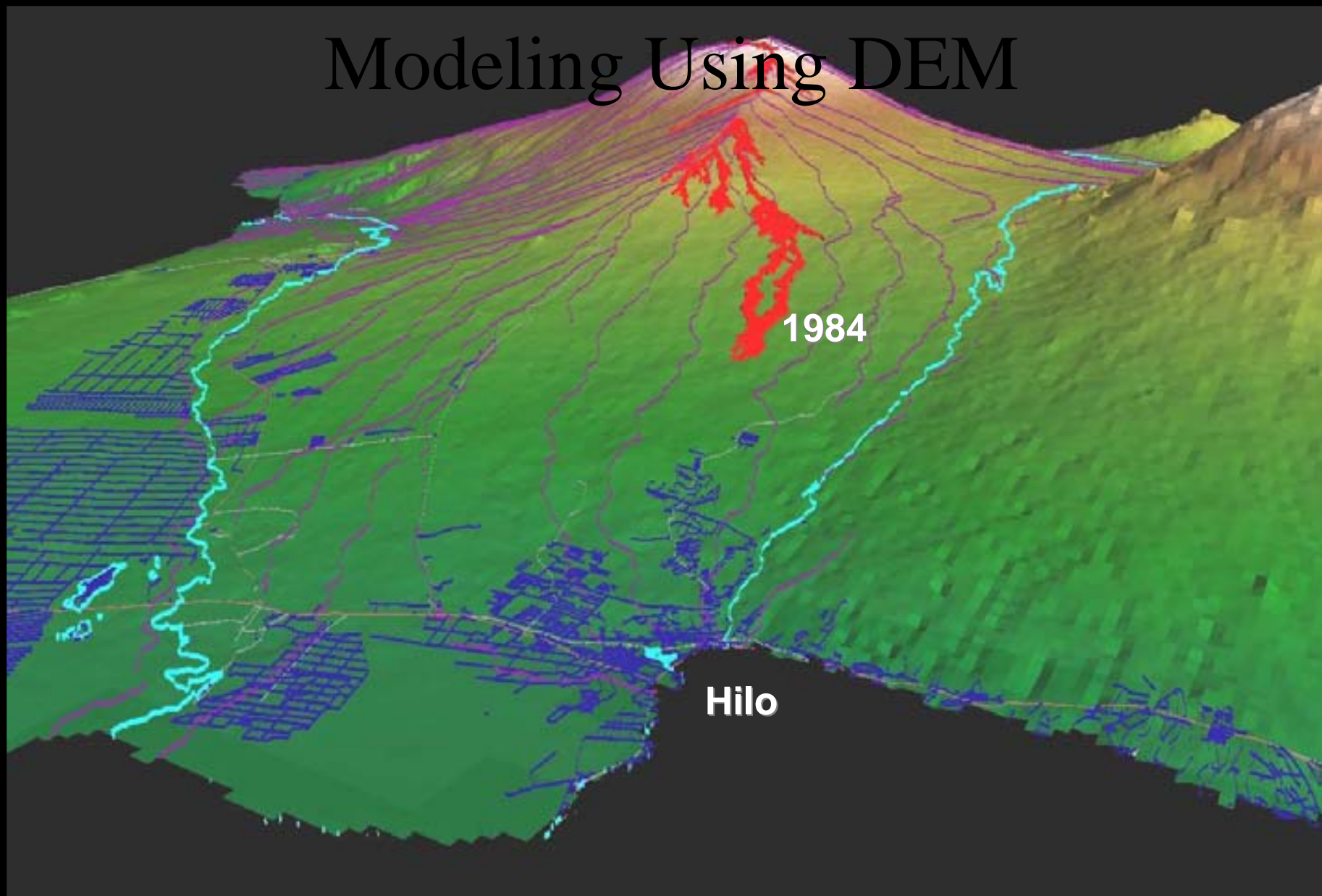




Photo By D. Little



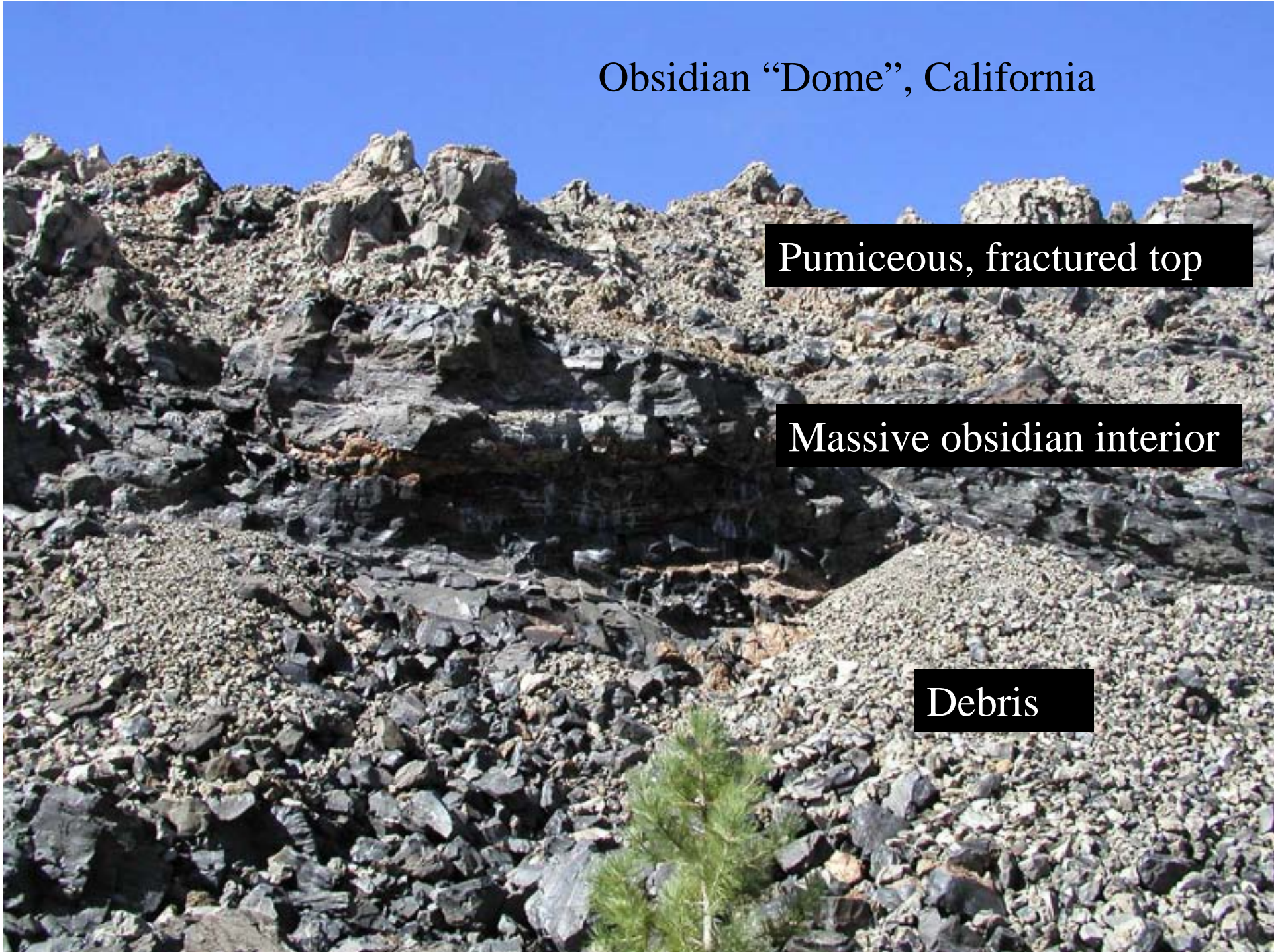


Obsidian “Dome”, California

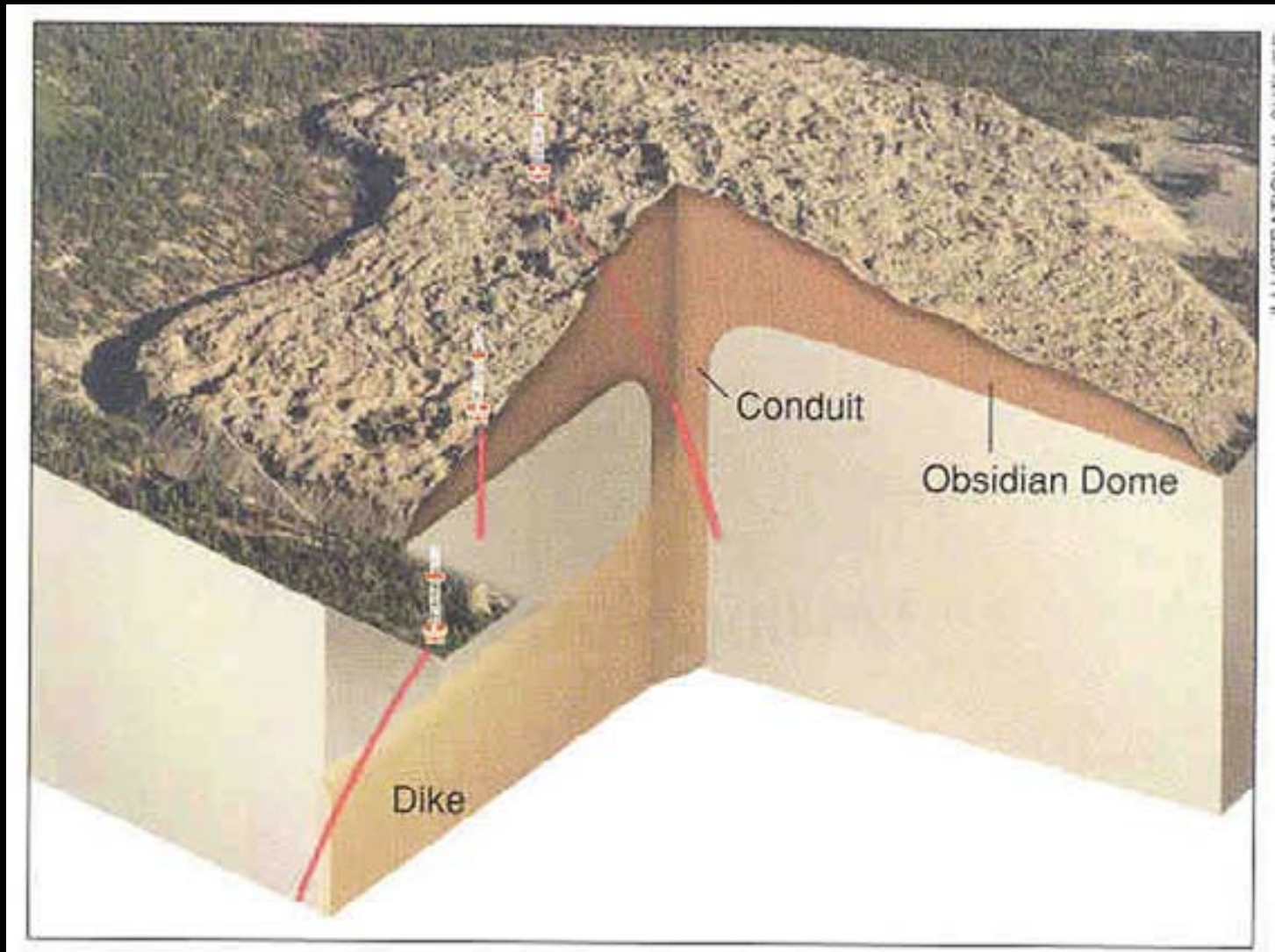
Pumiceous, fractured top

Massive obsidian interior

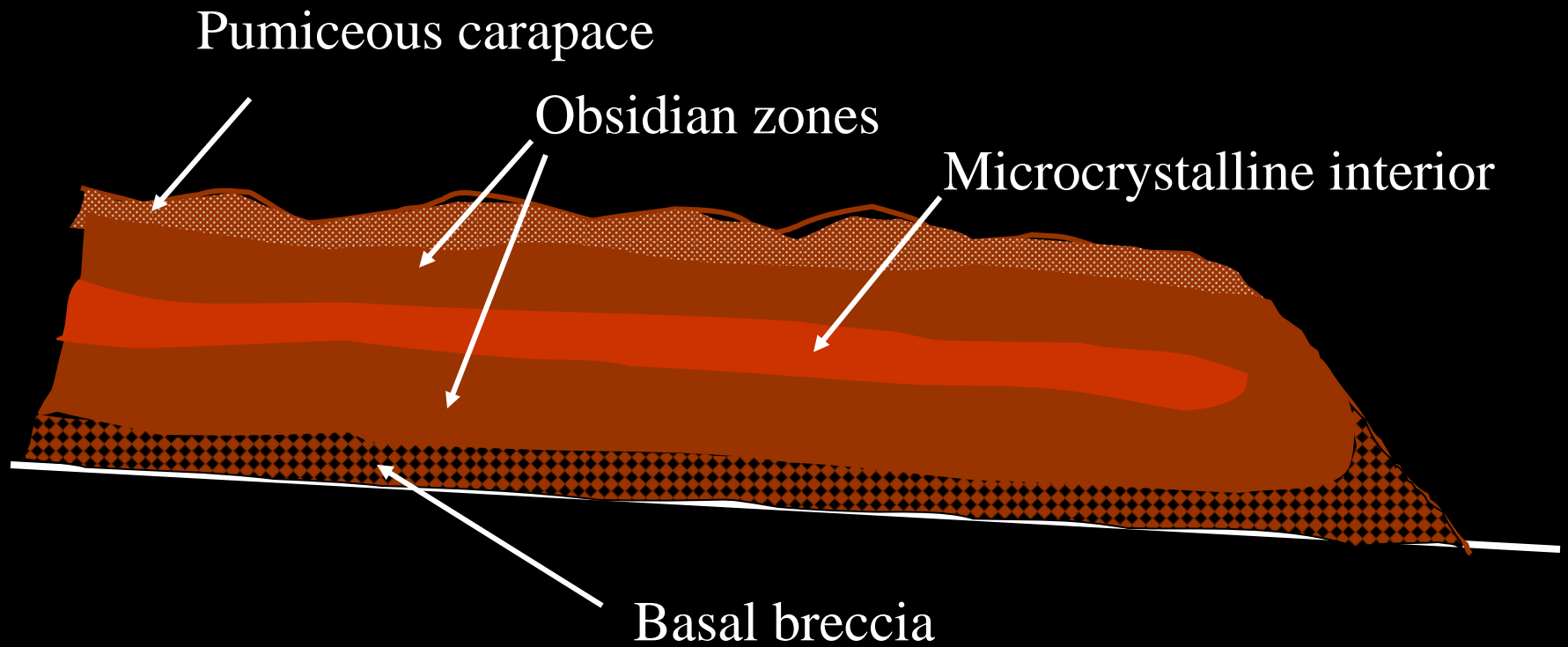
Debris



Obsidian Dome emerged from a pipe extending from the top of a long dike.



Rhyolite lava flow cross section



Lava flows

- Cause complete destruction and render land unusable.
- Slow moving – only rarely kill people.
- Path is generally predictable.
- Commonly a few kilometers in length, but can travel as much as 100 km from volcano.

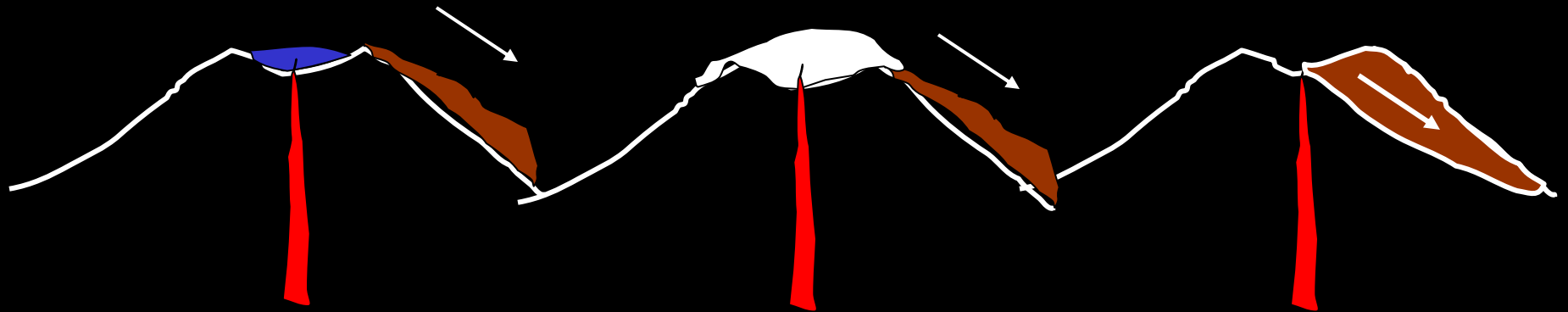
- Lahars (mud flows)

Another eruption product: lahars (mud flows)

Magma interacting
with crater lake

Magma interacting
with ice cap

Magma cause
failure of volcanic
edifice



Pinatubo, 1991

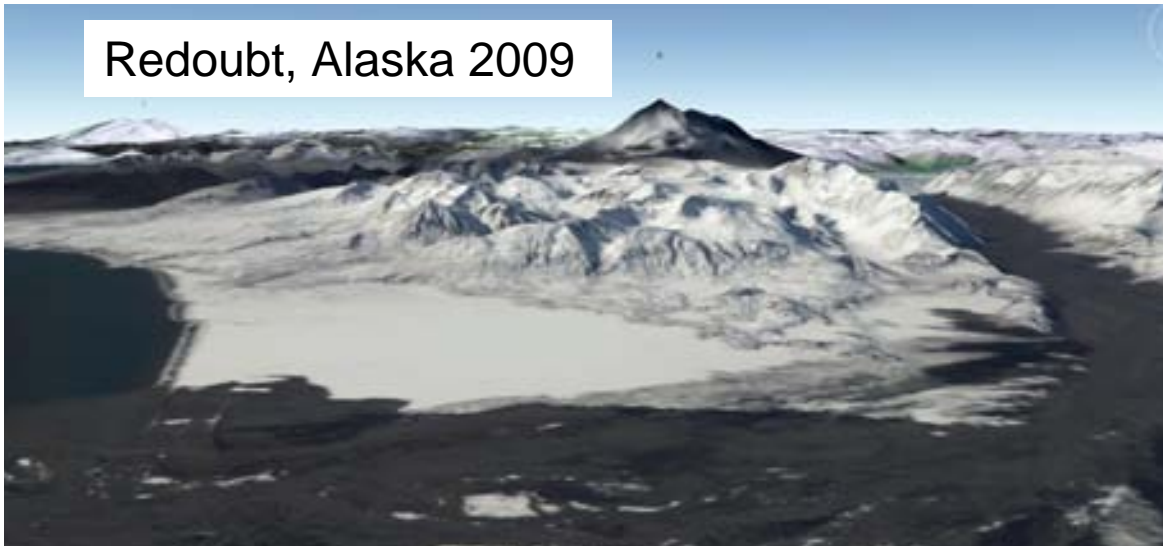


Aramera, 1985

23,000 dead



Redoubt, Alaska 2009

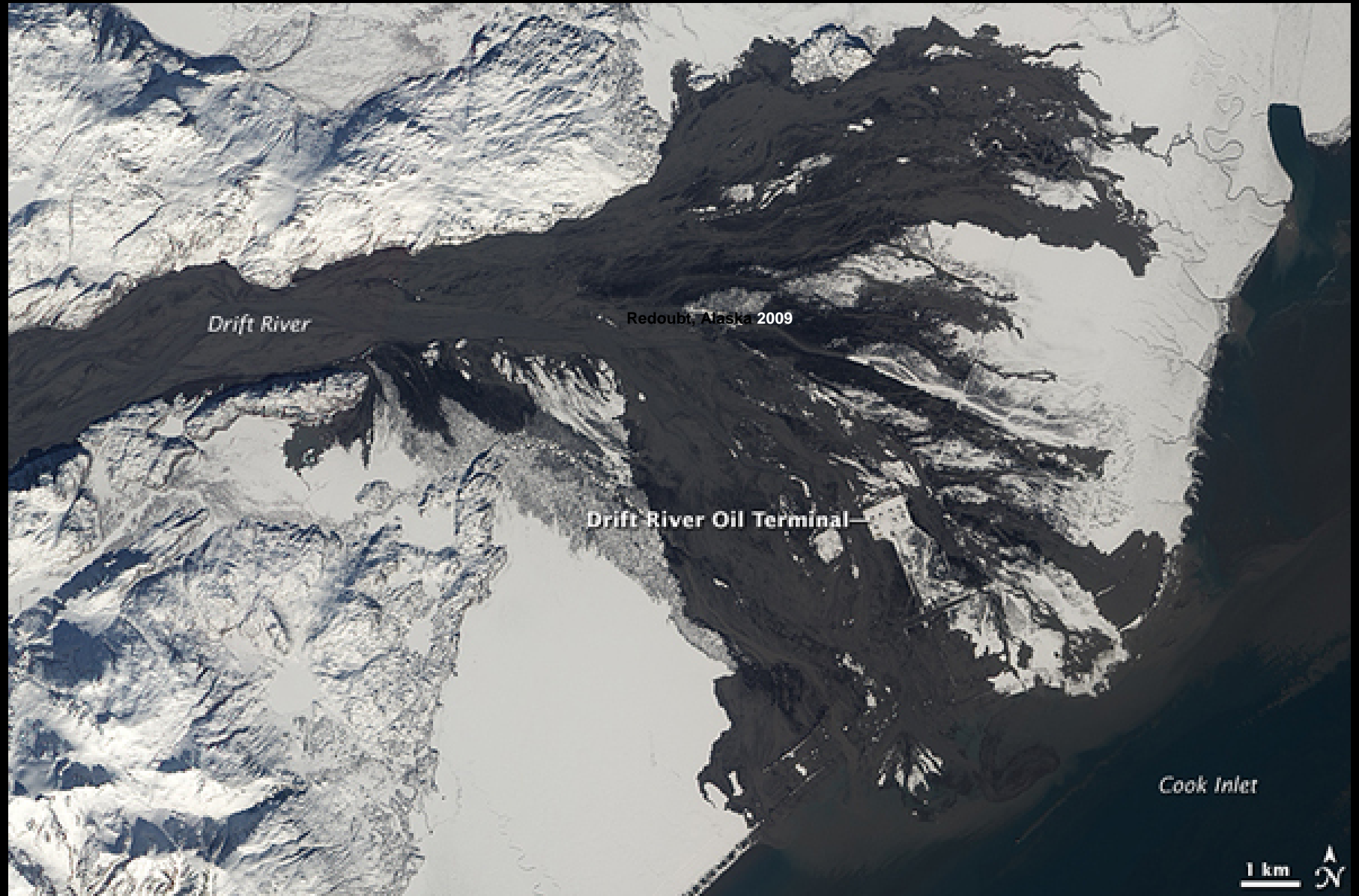


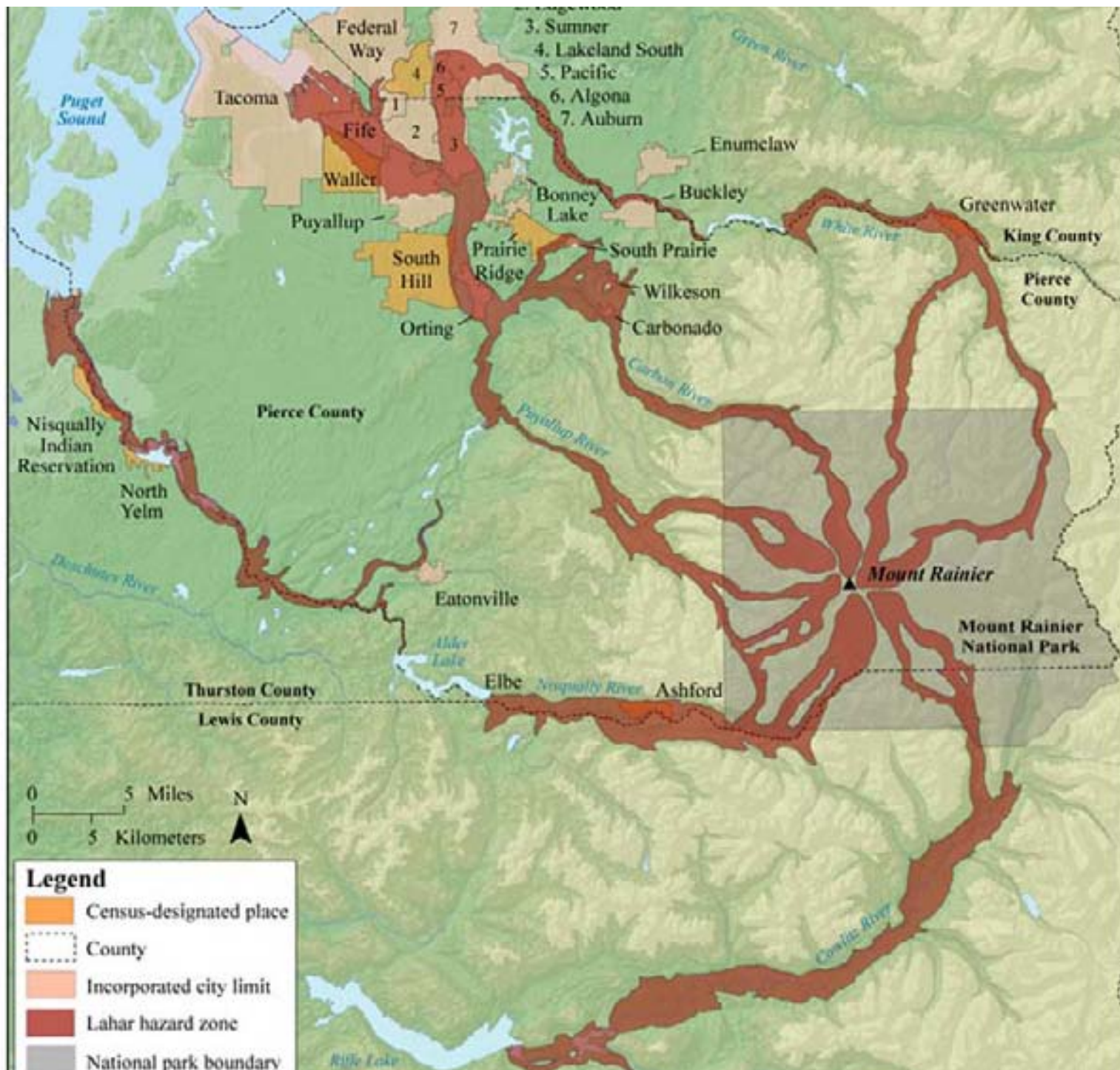
Chaiten, Chile 2008



Savonoski, 1912





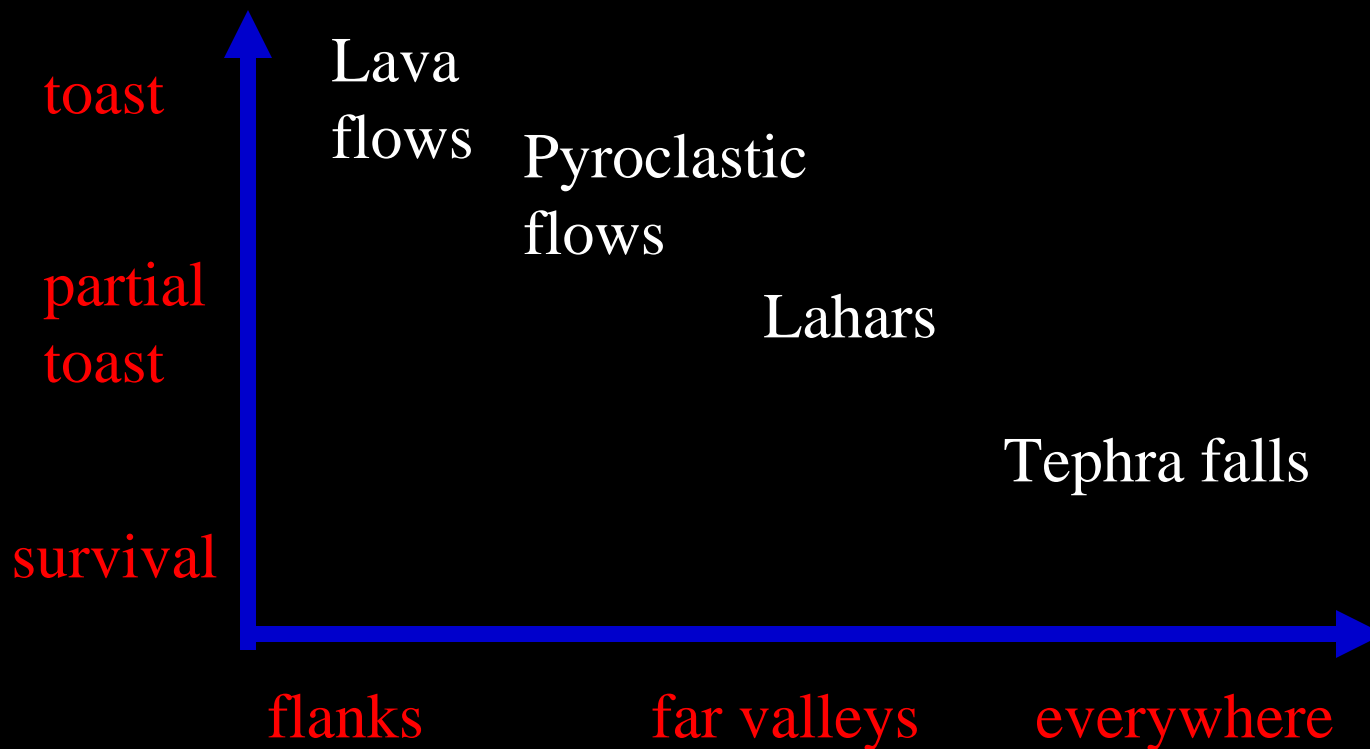


Lahars

- Can travel well over 100 km from volcano
- Confined to valleys, path is predictable
- Near total destruction within path
- Can be stopped (sabo works), but very expensive
- Survivable, if valleys are monitored
- Can continue for years after an eruption

HAZARDS

DESTRUCTIVENESS



EXTENT

Gas



August 1986

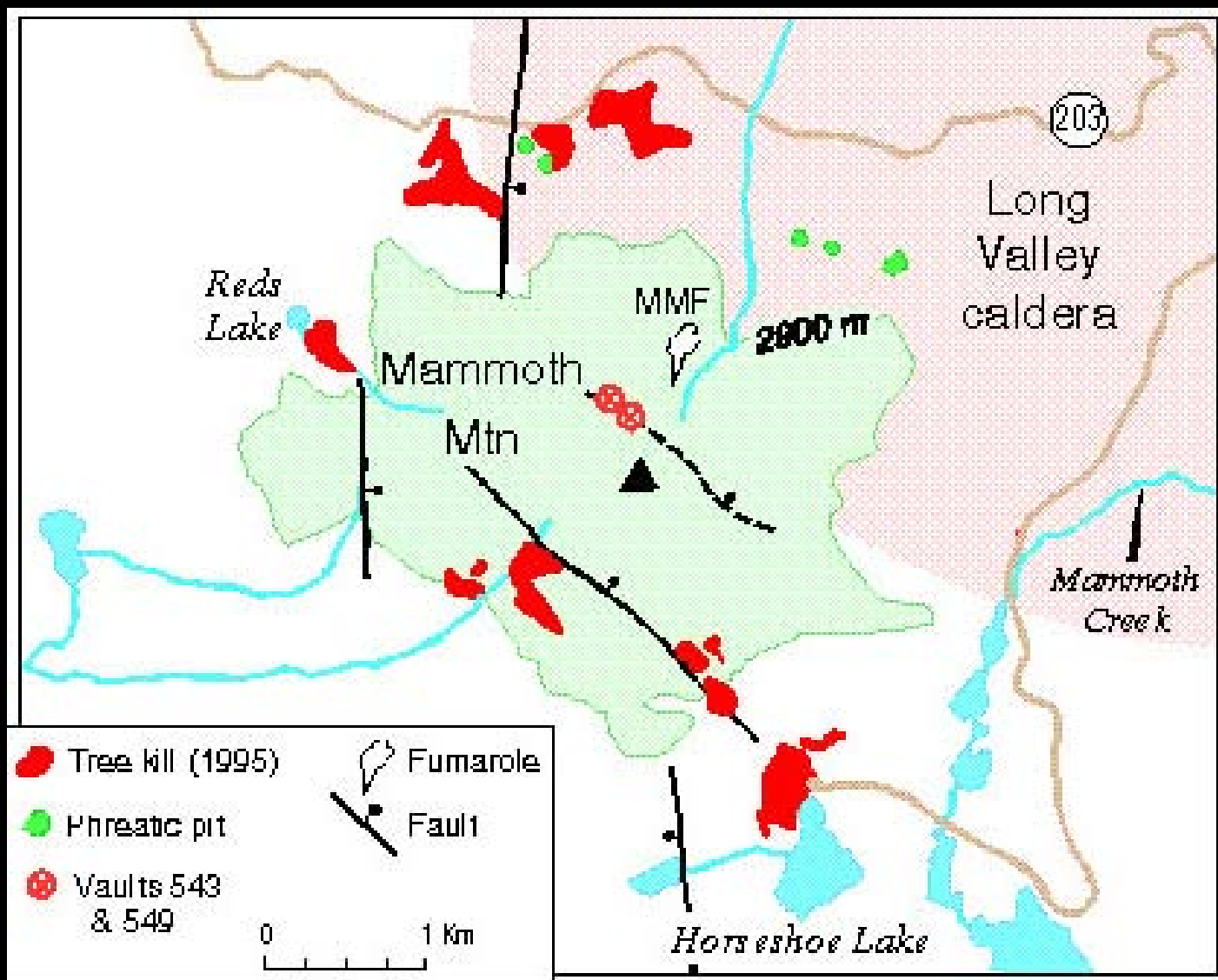
1700 deaths



Mammoth Mountain Accident Results in Three Deaths: Patrollers Fall into Volcanic Vent

April 7, 2006

Three members of the Mammoth Mountain ski patrol were killed when a snow collapse plunged two into a volcanic gas vent on the 11,053-foot peak in the Eastern Sierra and others tried to rescue them, a resort official said. Four of their colleagues who tried to rescue them were hospitalized for exposure to carbon dioxide and were doing well late Thursday, said Rusty Gregory, chief executive officer of Mammoth Mountain Ski Area.

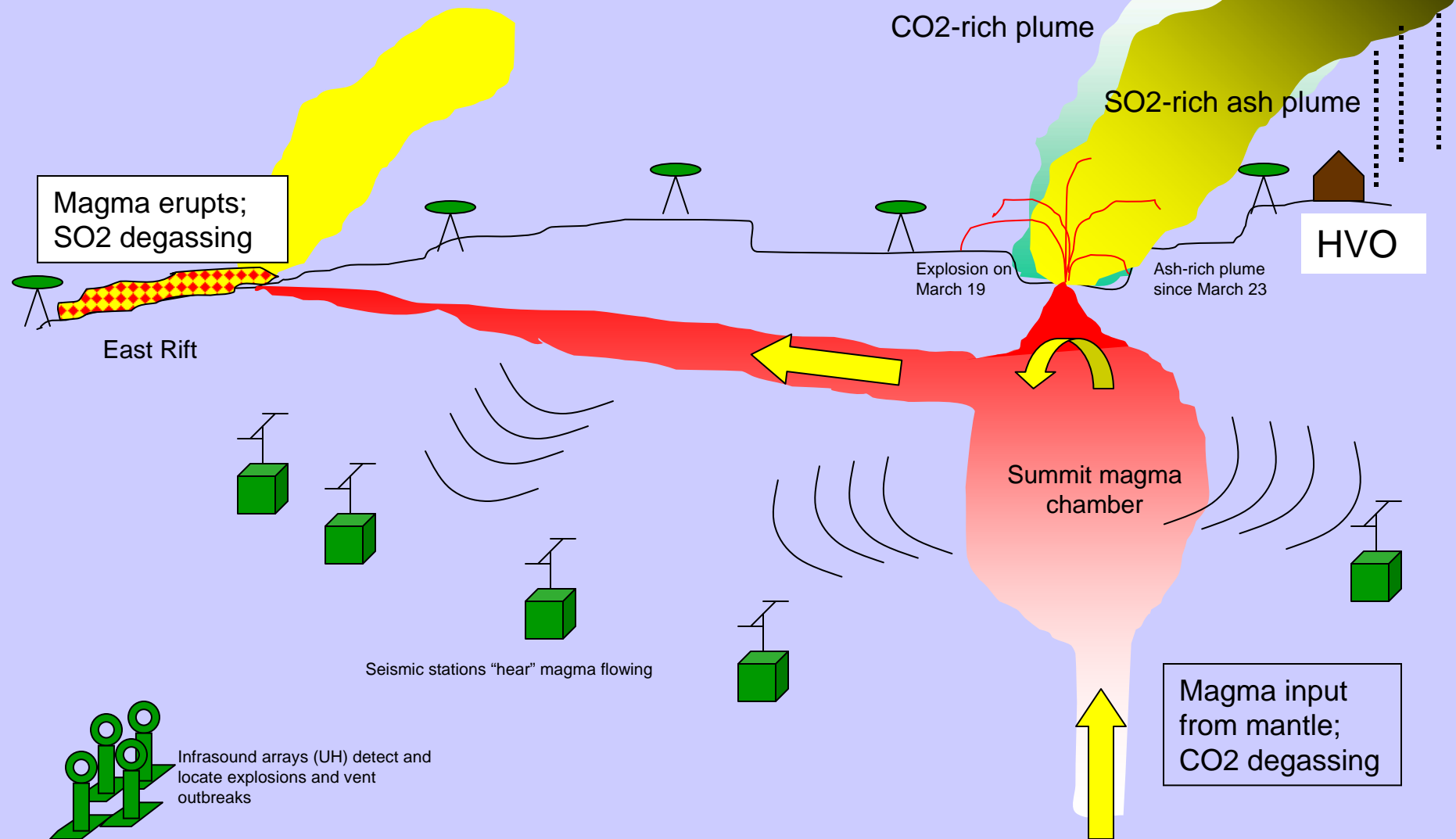


Explosions



How we monitor volcanoes

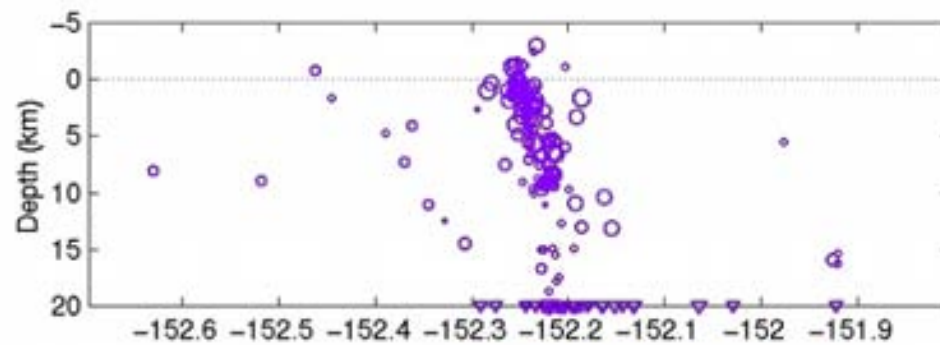
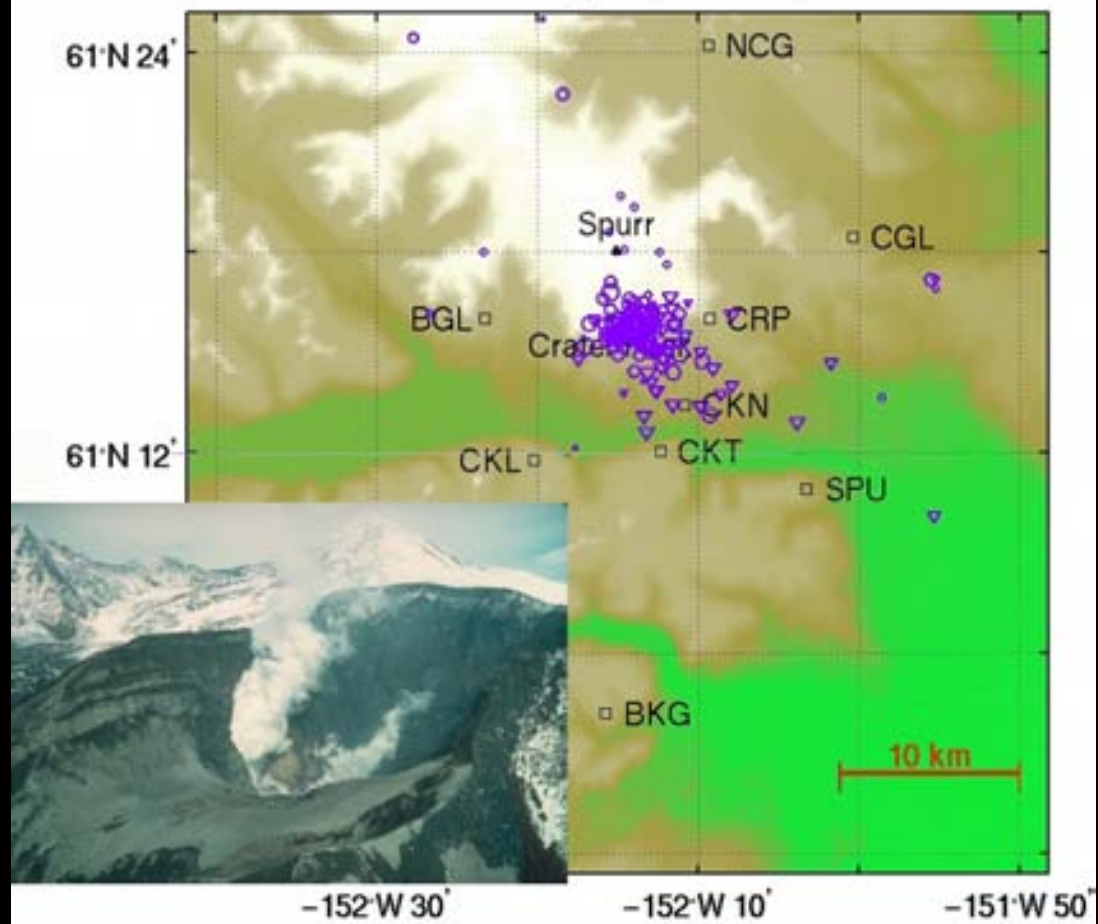
Hawaiian Volcano Observatory (HVO)

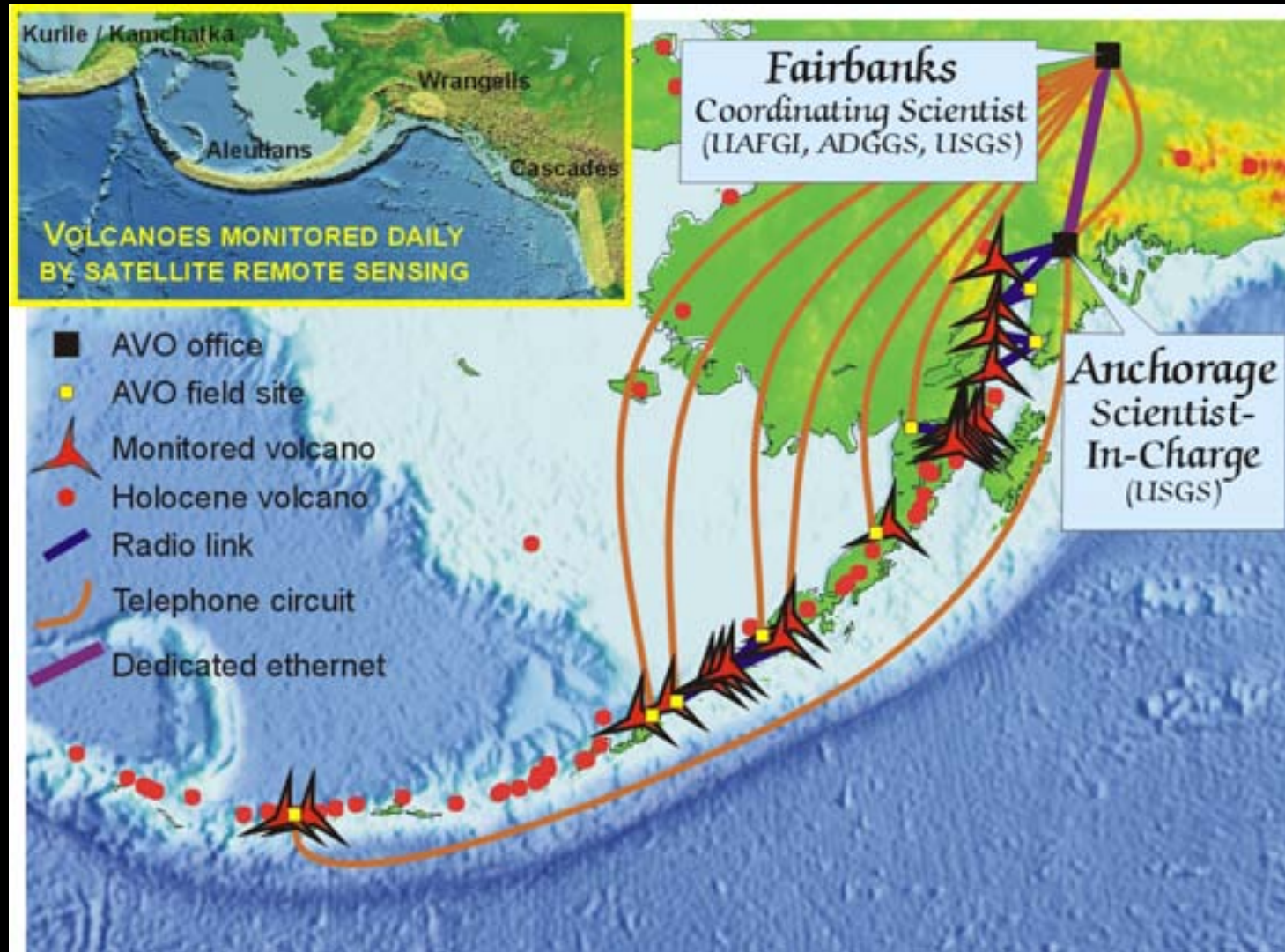


SEISMICITY

- When magma moves, it causes earthquakes.
- High frequency – from brittle failure of wall rock
- Low frequency – vibration of crack through which magma is flowing (tremor if continuous)
- Earthquakes don't occur within magma because magma lacks strength

Mt. Spurr Volcano



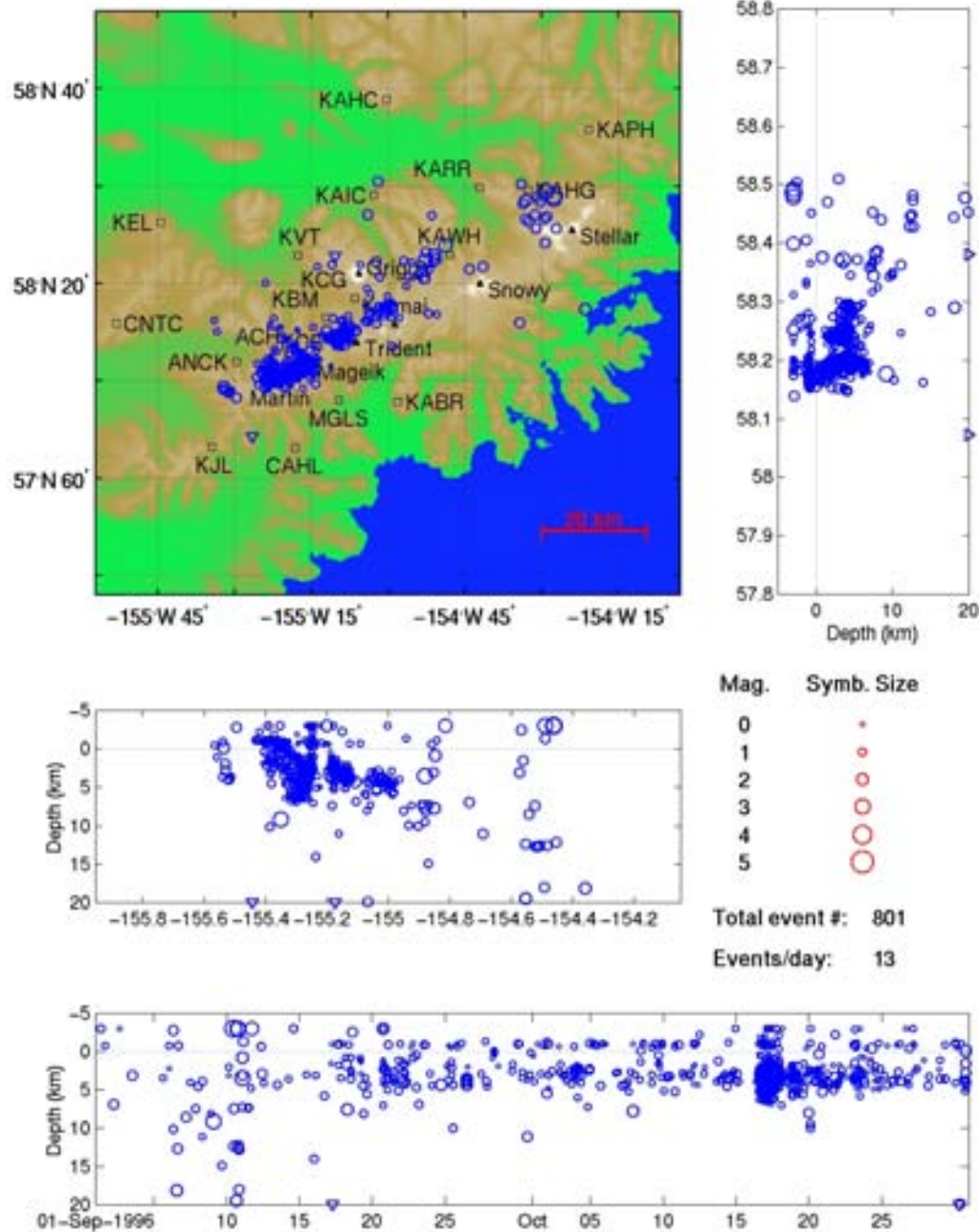


The Alaska Volcano Observatory now monitors about half of the active volcanoes in Alaska

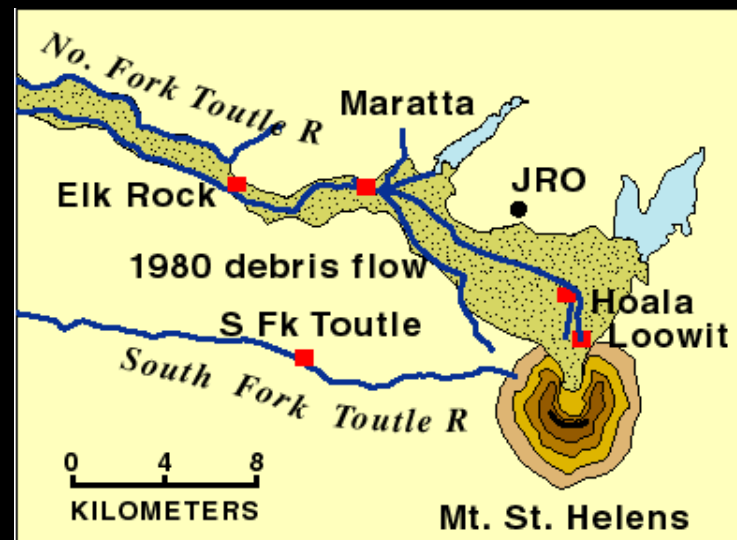
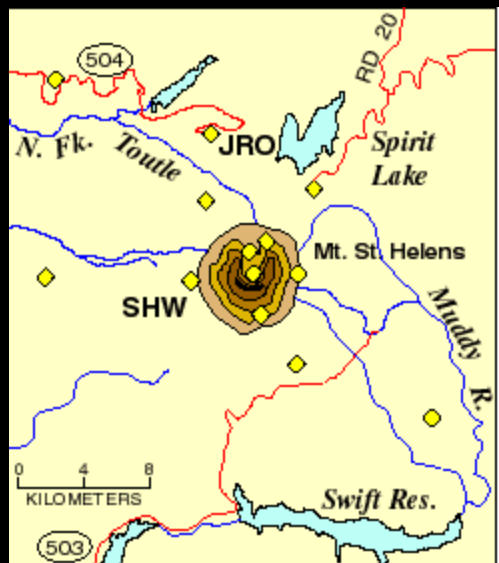


One of many self-contained seismic stations in Katmai National Park

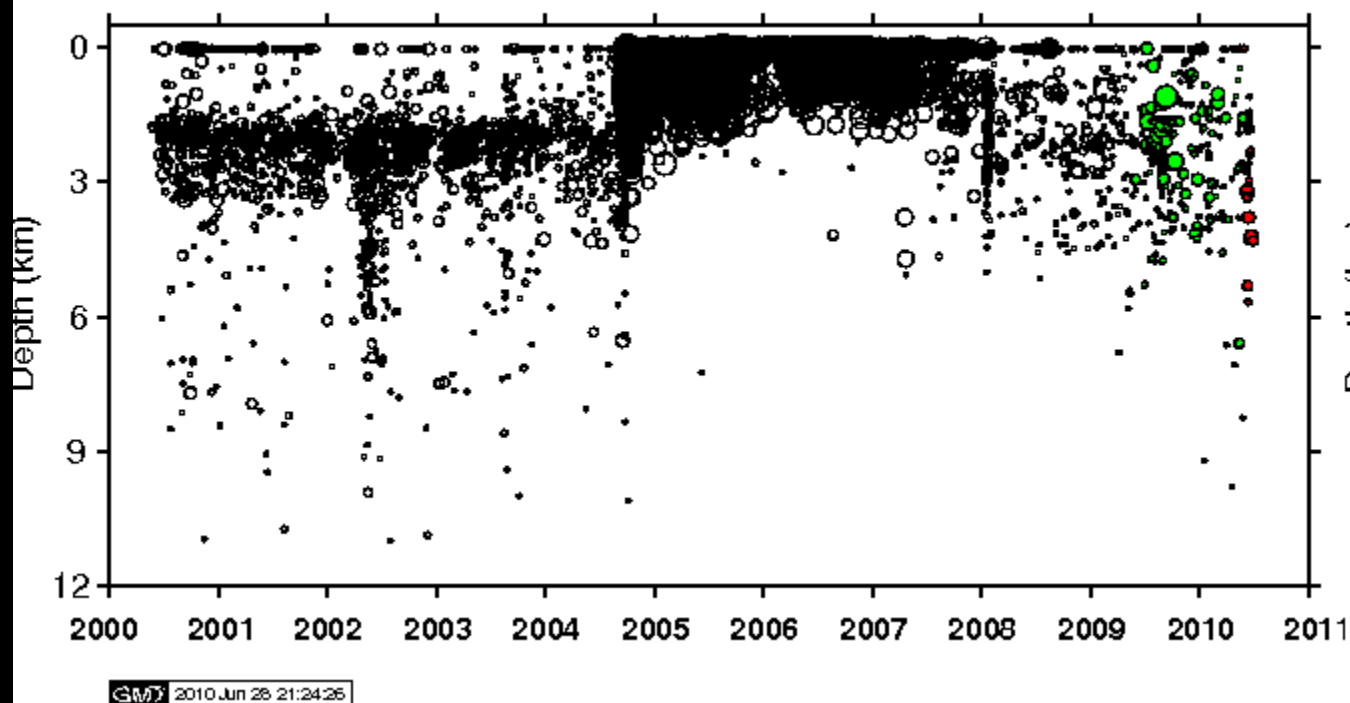
Katmai Group 01-Sep-1996 - 31-Oct-1996

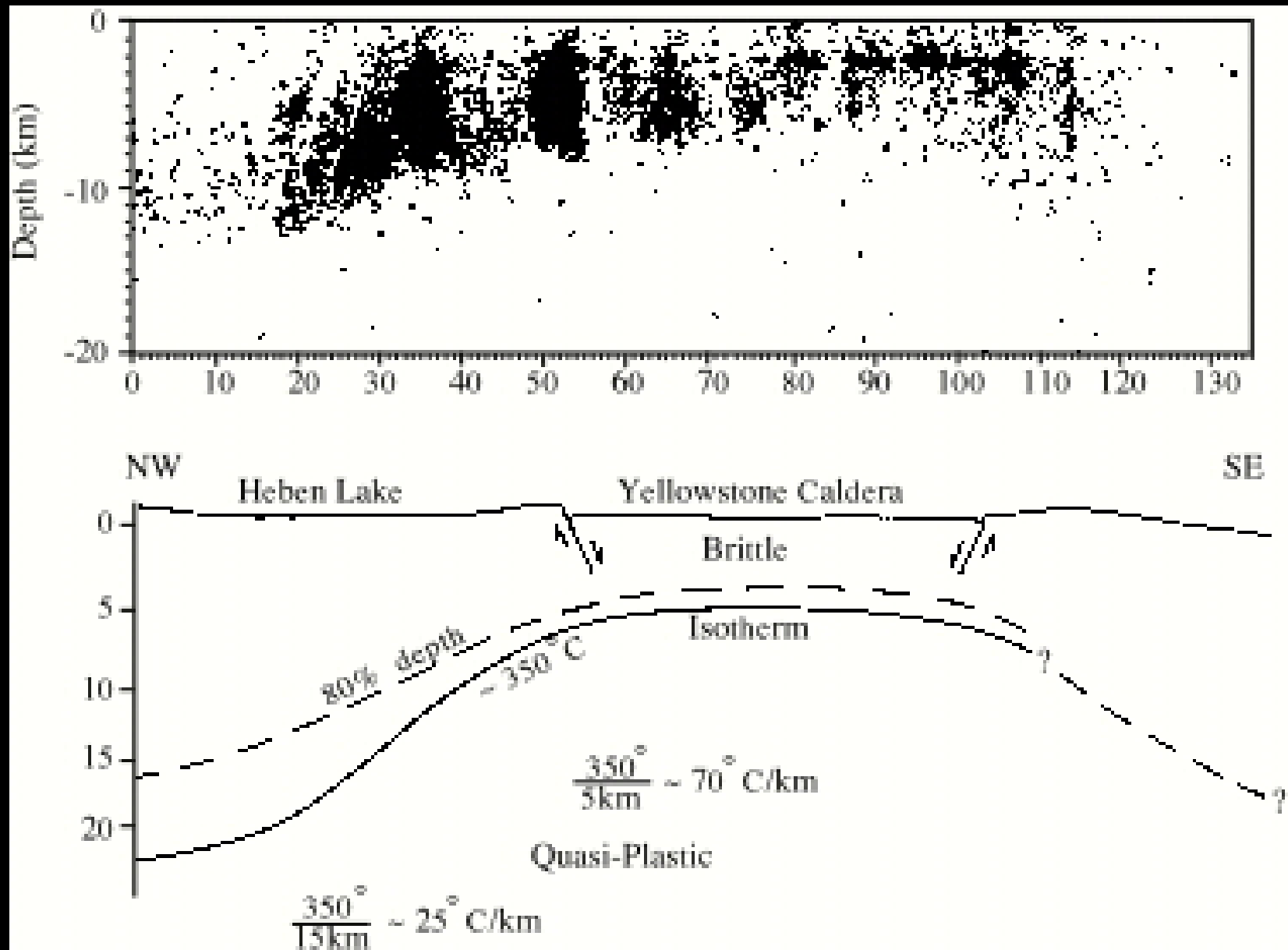


Earthquake
locations at
Katmai from
seismic
monitoring

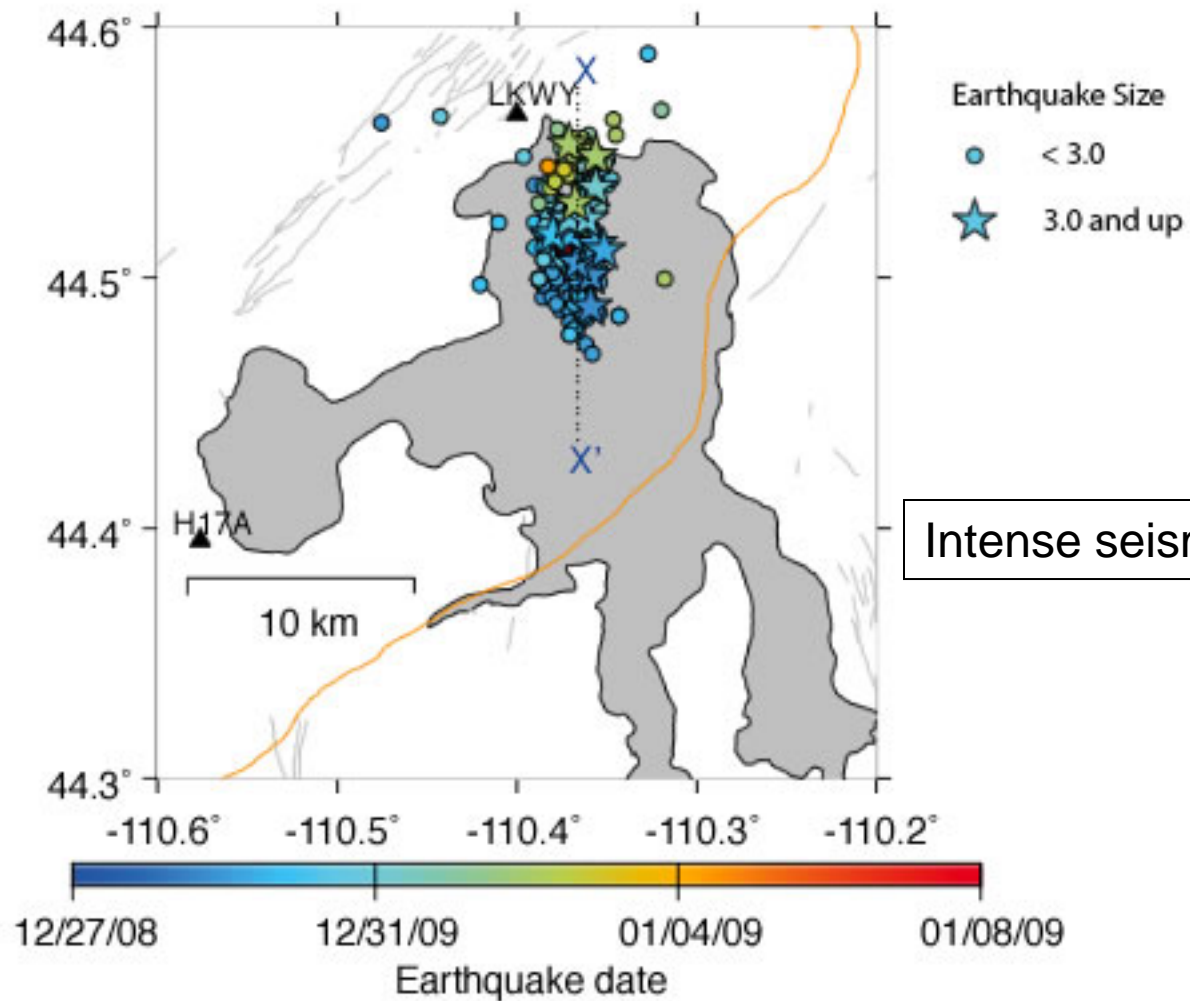


Mt. St. Helens Seismicity, 2000 - Present





Depth view of Yellowstone's earthquakes



Intense seismic swarms

Data From the University of Utah Yellowstone Research Group and Seismograph Stations

http://www.pnsn.org/WEBICORDER/VOLC/MBW_SHZ_UW_--.2010062912.html

Cool web sites (Google them)

- AVO
- HVO
- Institute of Volcanology and Seismology
- OMI SO₂
- MVO

GEODETIC MEASUREMENTS

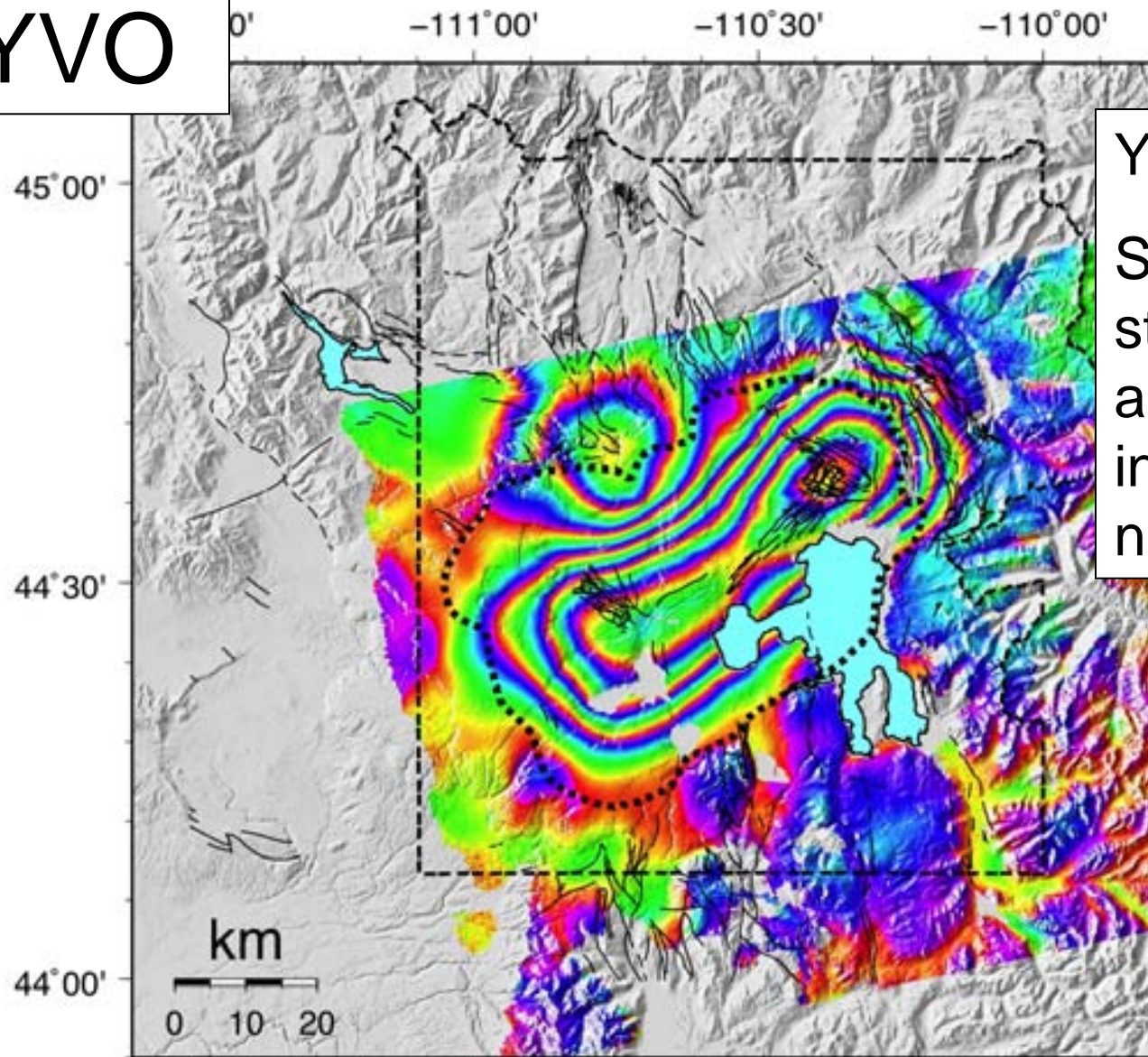
GEODETIC MEASUREMENTS

- Rapidly evolving technology
- Already the best way to “watch” magma move.
- May become a primary means of forecasting

TECHNIQUES

- Leveling (transit and rod)
- Electronic distance measurement (light beam)
- GPS (Global Positioning System)
- InSAR (Interferometric Synthetic Aperture Radar)

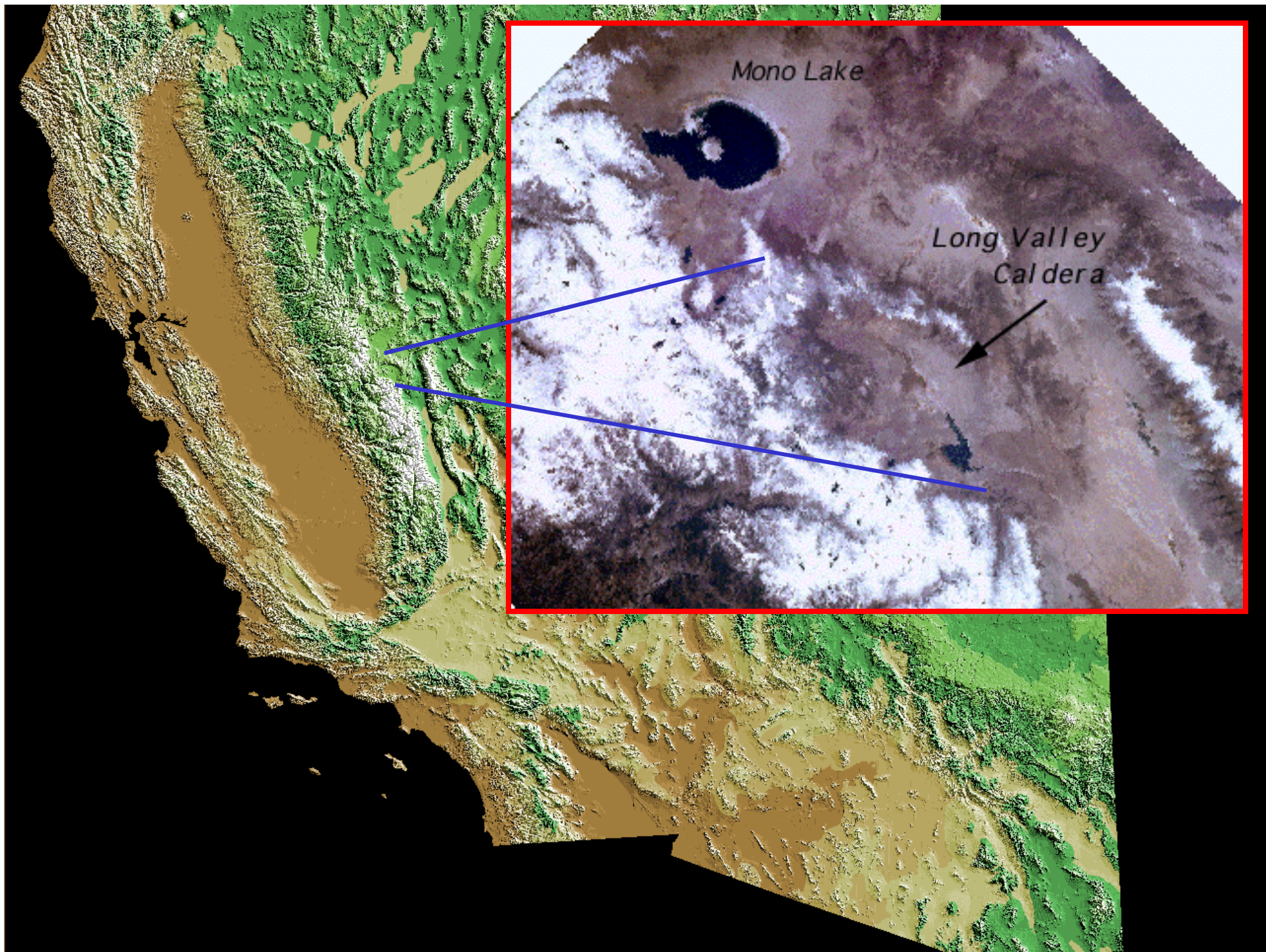
YVO

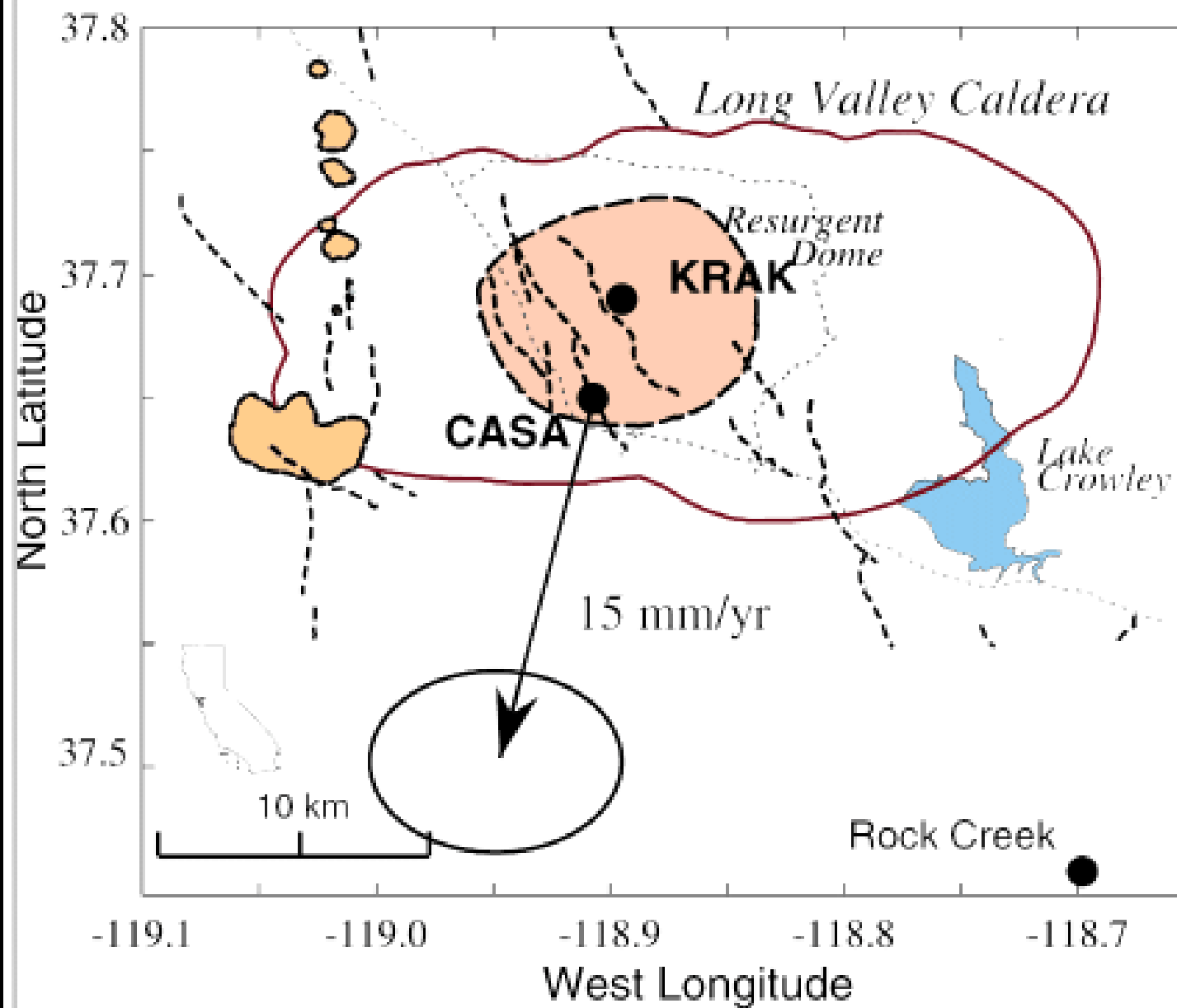


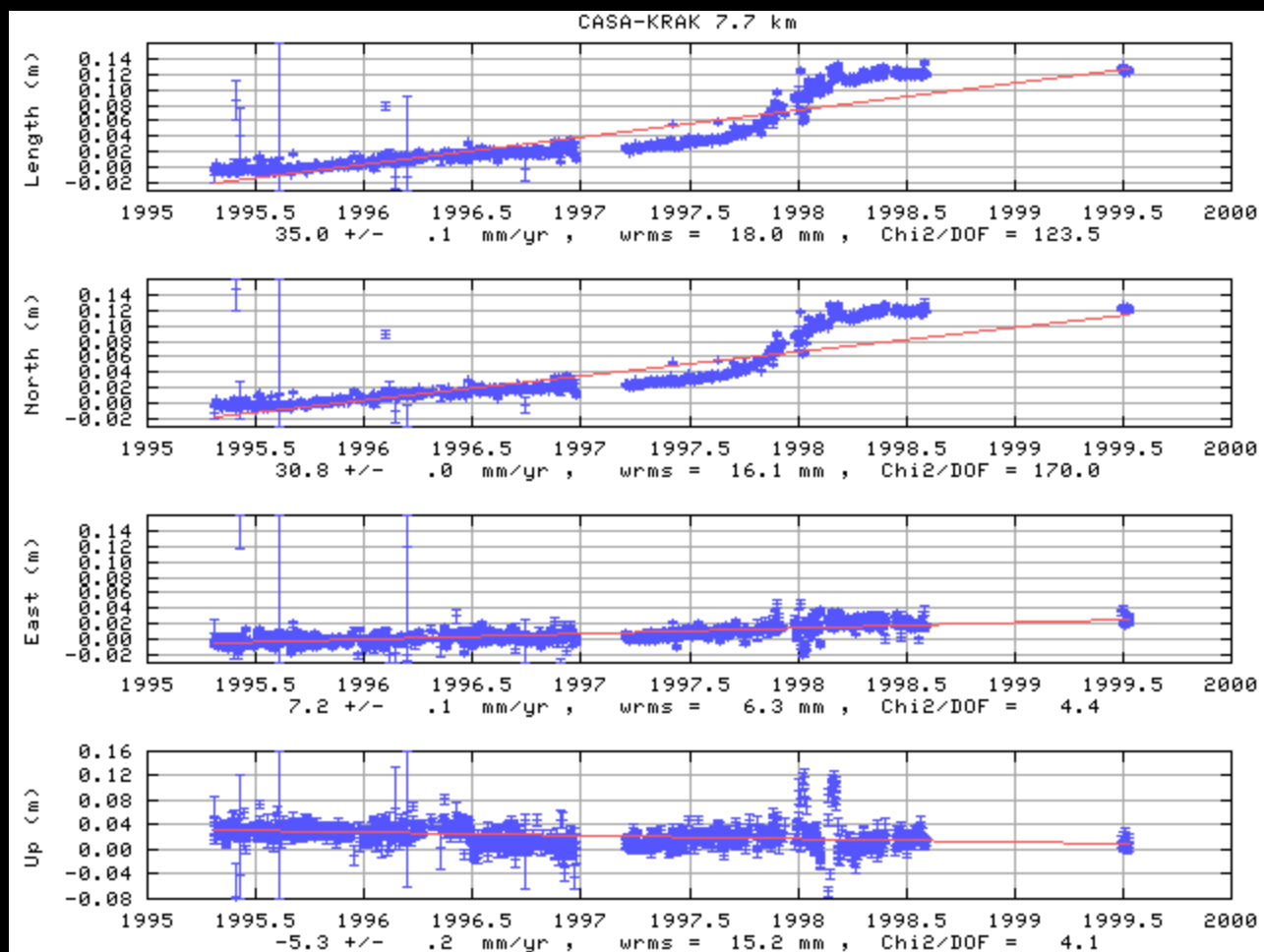
Yellowstone:

Seismic swarms,
steam explosions
and gas hazards
in a popular
national park

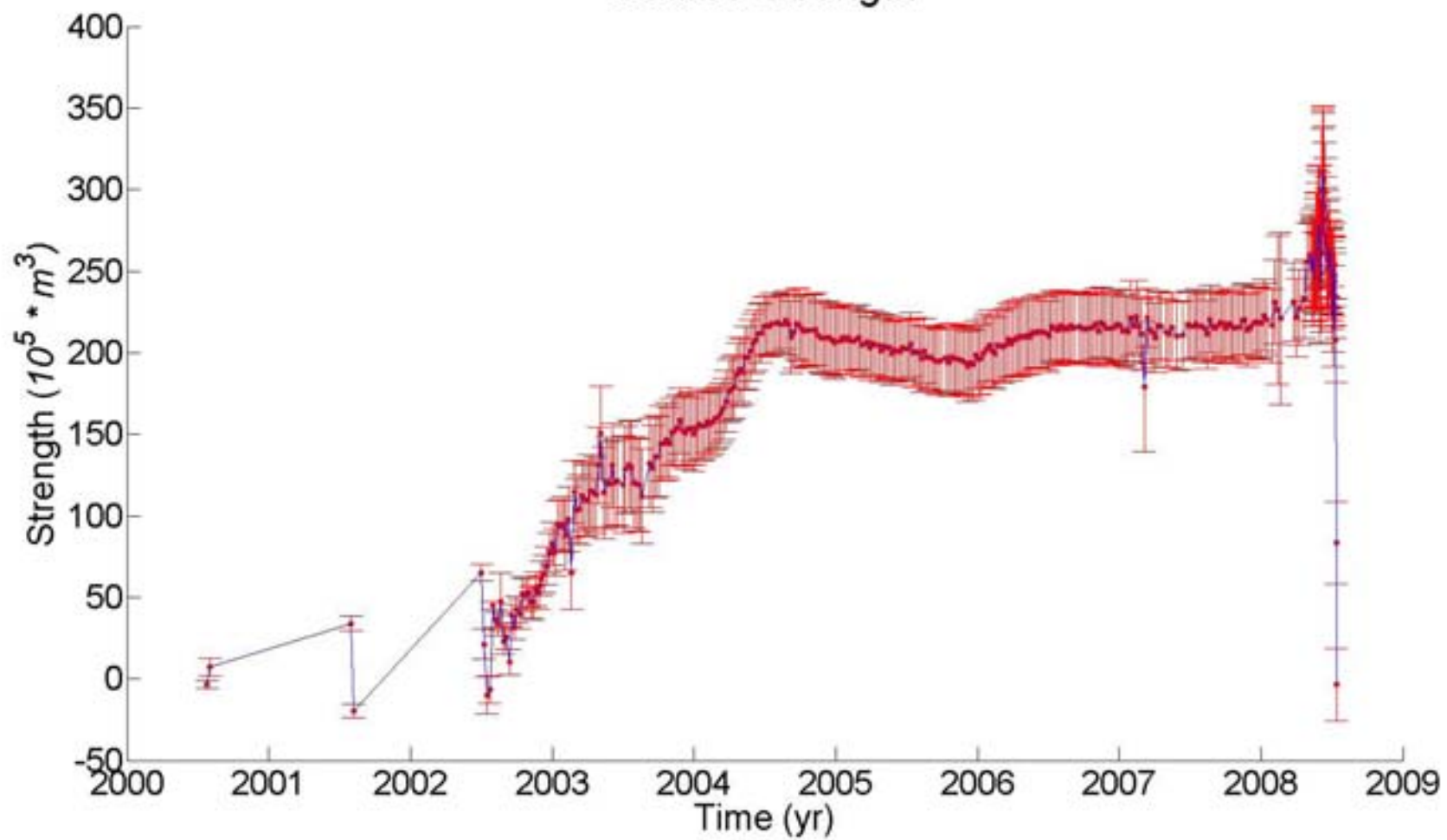
Rapid uplift
(InSAR image)



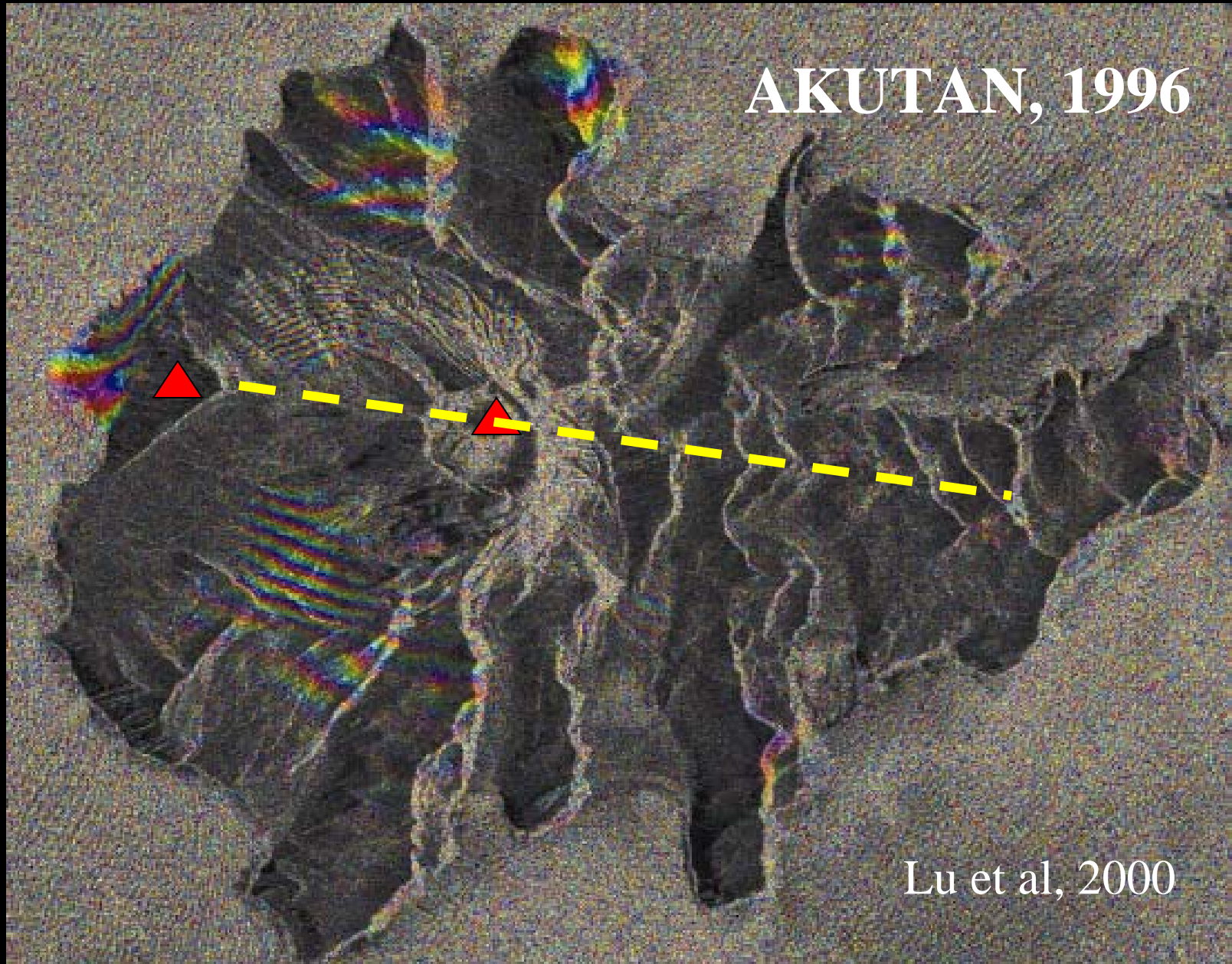




Source Strength



AKUTAN, 1996



Lu et al, 2000

VOLCANIC GASES





H_2O , CO_2 , SO_2

VOLCANIC GASES

in volcano monitoring

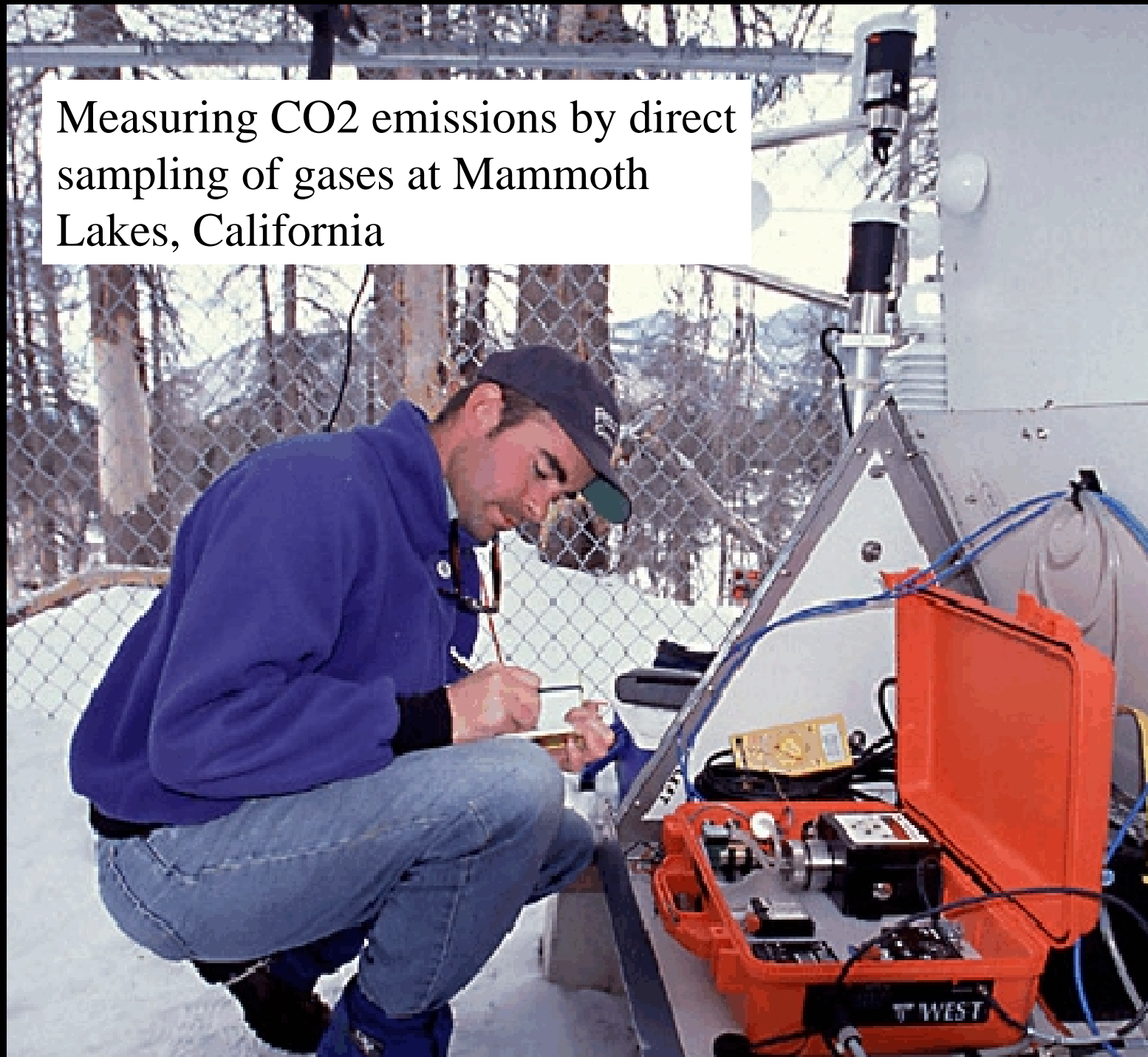
- H₂O: Most abundant in volcanoes, but it's everywhere anyway - hard to tell from "meteoric" water.
- CO₂: Easy to detect, but starts coming out of magma when it's still very deep.
- SO₂: Easy to detect, and only comes out when the magma is almost "in your face", but can be "masked" by groundwater.

Measuring SO₂ at Mount St Helens with a spectrometer



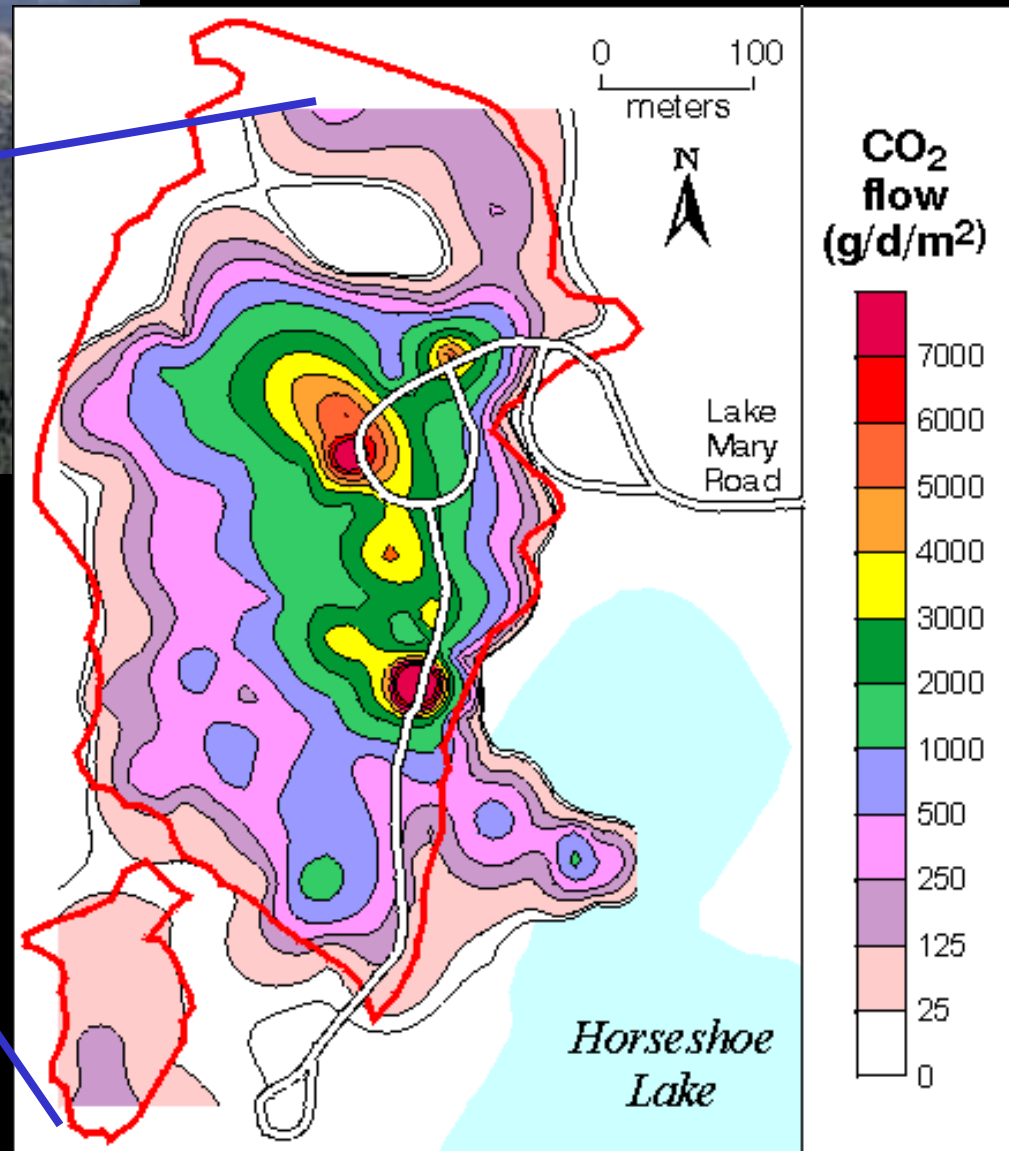
USGS Photo by Lyn Topinka, October 21, 1983

Measuring CO₂ emissions by direct
sampling of gases at Mammoth
Lakes, California





Dead trees from
CO₂ emission at the
base of Mammoth
Mountain volcano



OBSERVATIONS FROM SATELLITES (REMOTE SENSING)

- Ash clouds
- Temperature
- Sulfur dioxide (SO₂)
- Surface deformation

<http://so2.umbc.edu/omi/pix/daily/0610/loopall.php?yr=10&mo=06&dy=14&bn=hawaii>

<http://so2.umbc.edu/omi/pix/daily/0610/loopal1.php?yr=10&mo=06&dy=02&bn=kamchat>



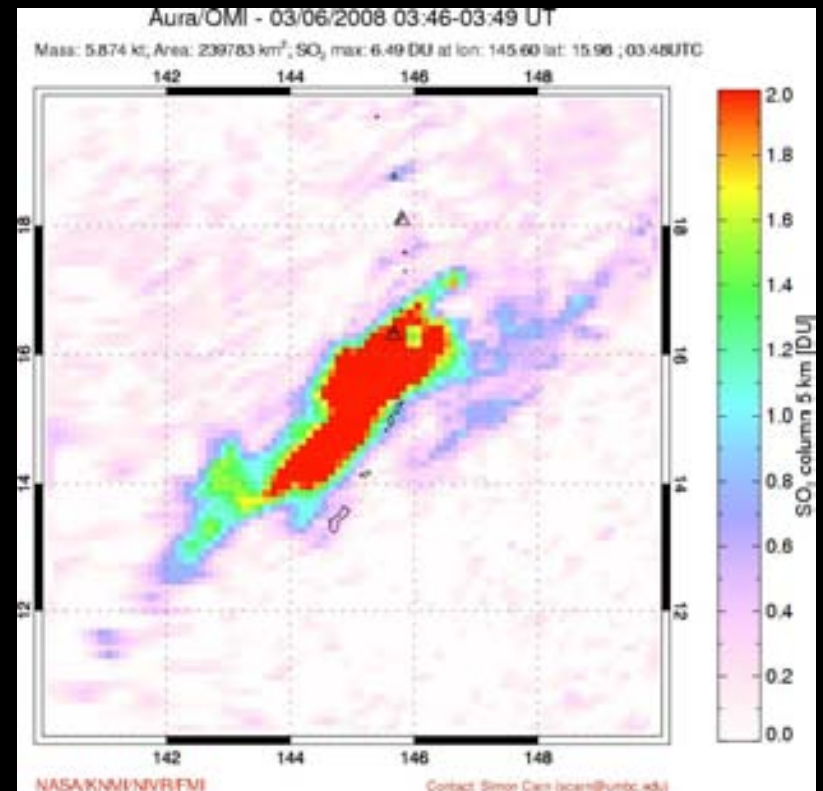
<http://www.kscnet.ru/ivs/eng/index.html>

http://www.kscnet.ru/ivs/volc_activity.shtml

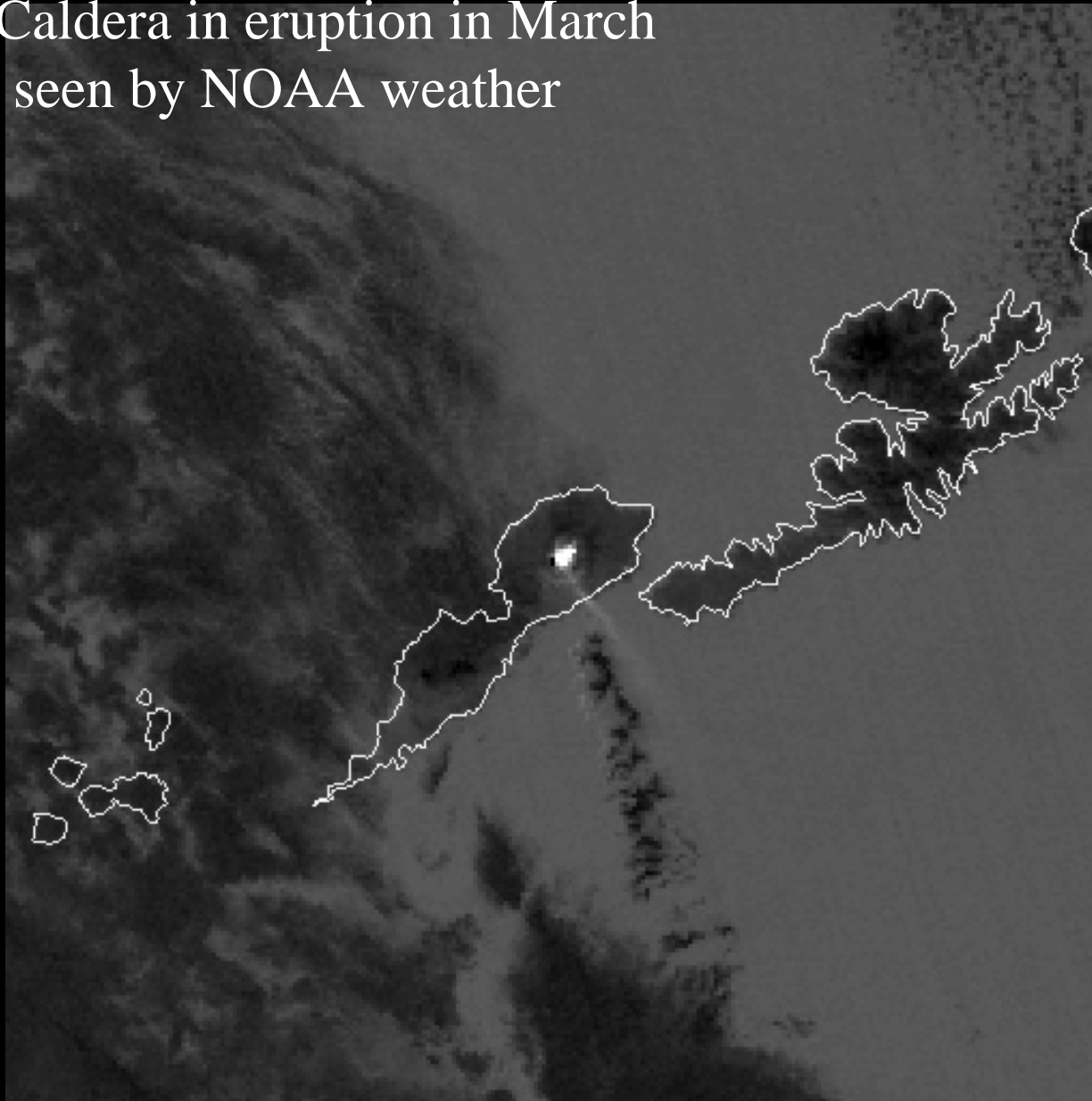
Commonwealth of Northern Mariana Islands



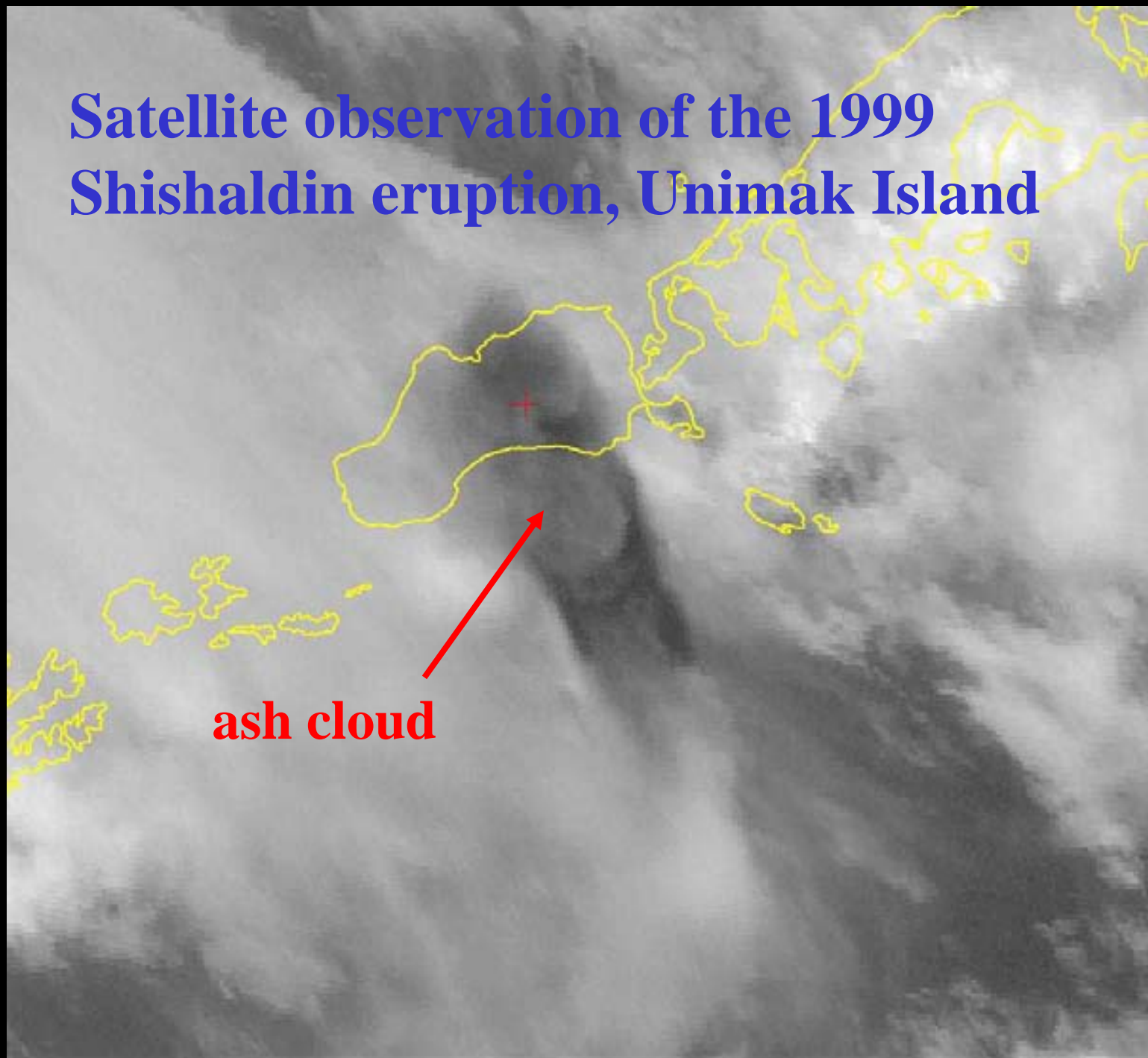
Hazards to aviation and health



Okmok Caldera in eruption in March 1997, as seen by NOAA weather satellite.



**Satellite observation of the 1999
Shishaldin eruption, Unimak Island**



ash cloud

Eruption of Mount Pinatubo, Philippines - 2nd largest of the 20th century



April 4, 2009 ash cloud

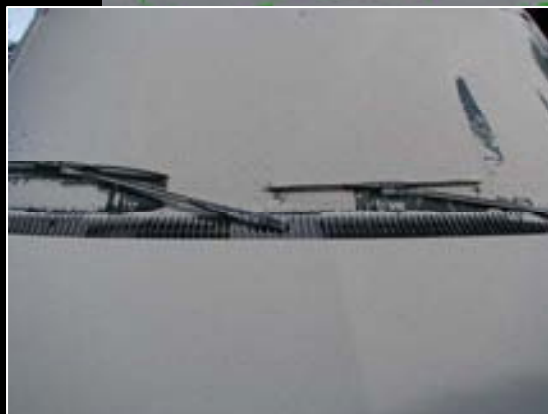
Mt. Redoubt

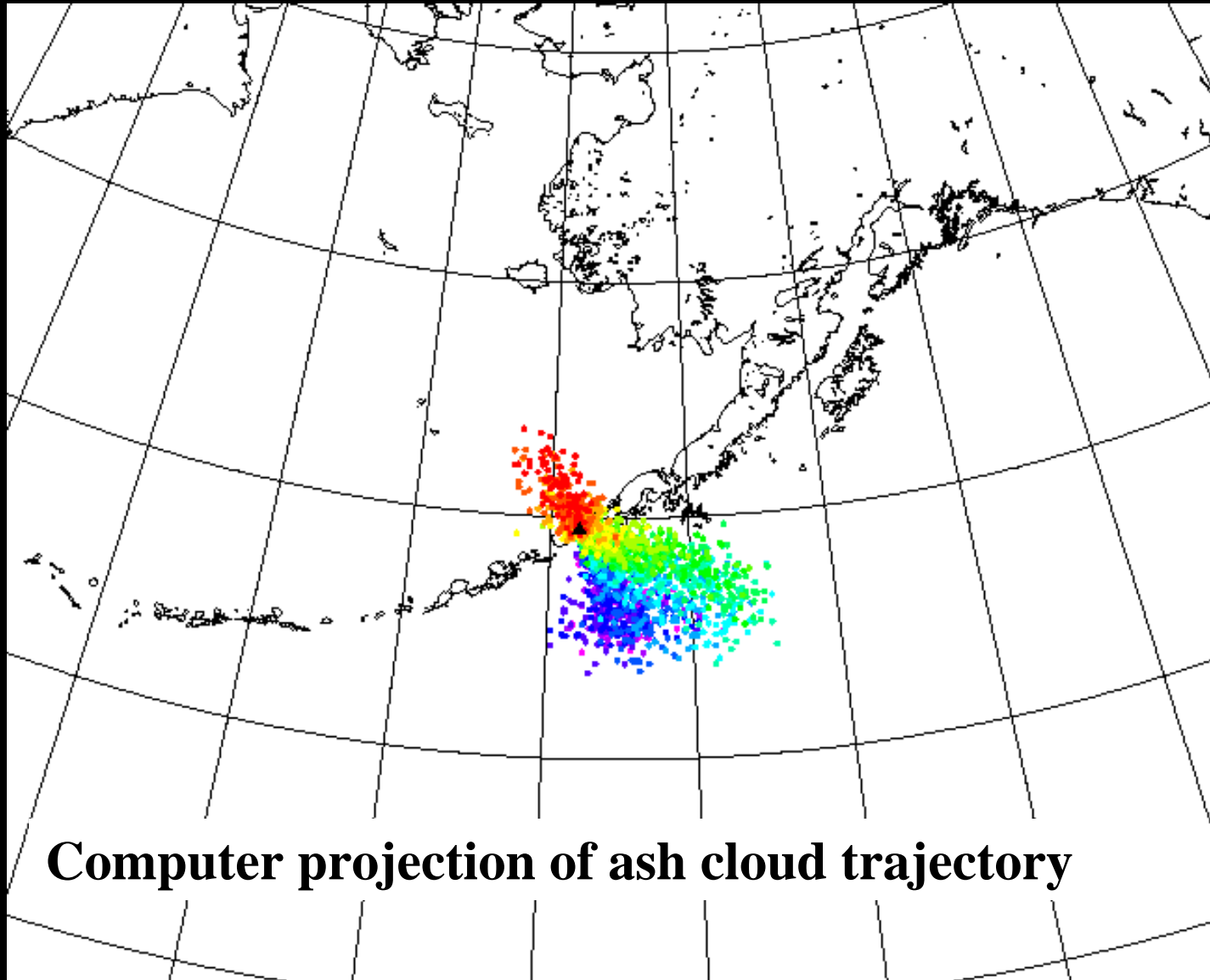
Anchorage

Homer

Temperature (oC)

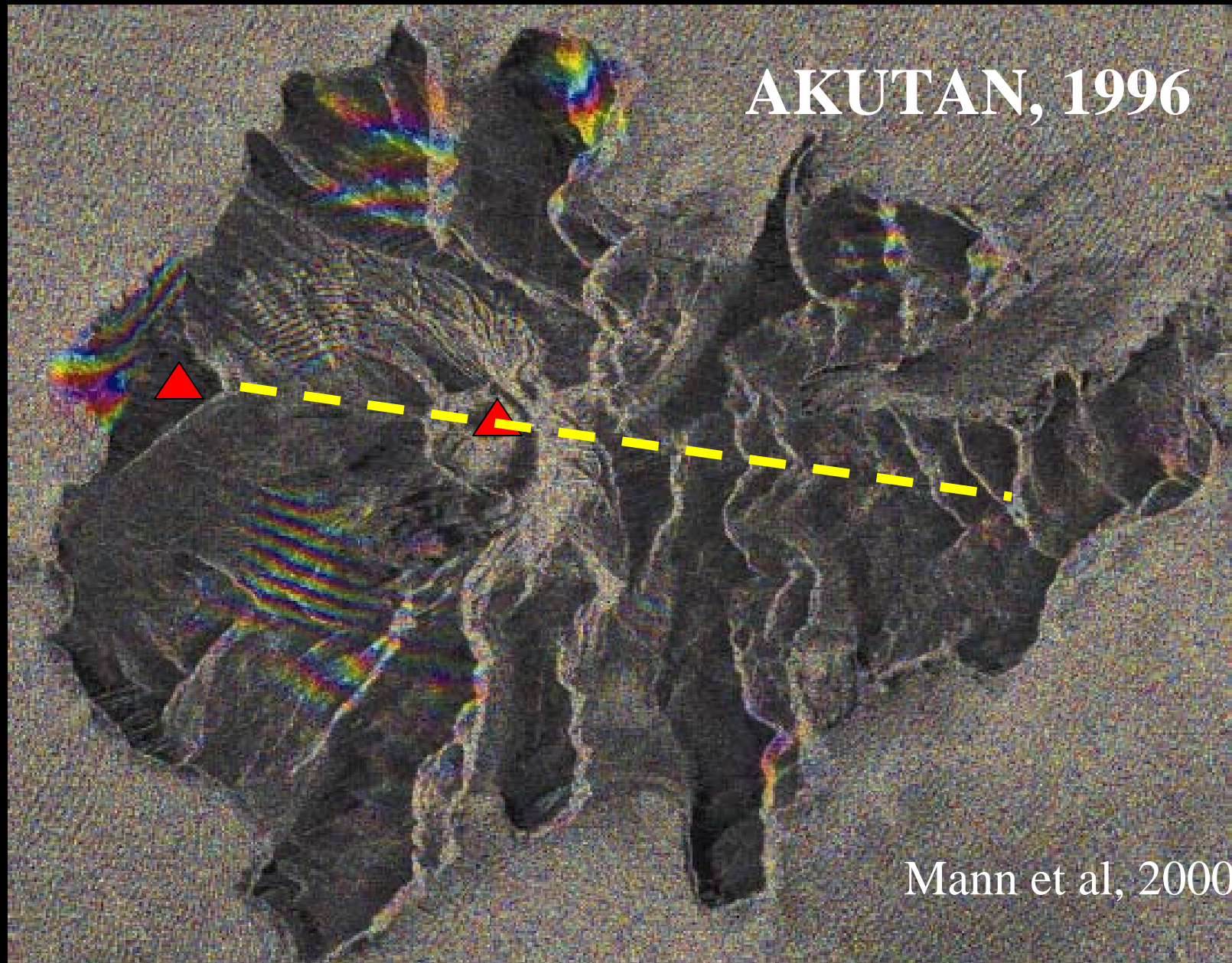
30 11 -8 -17 -46





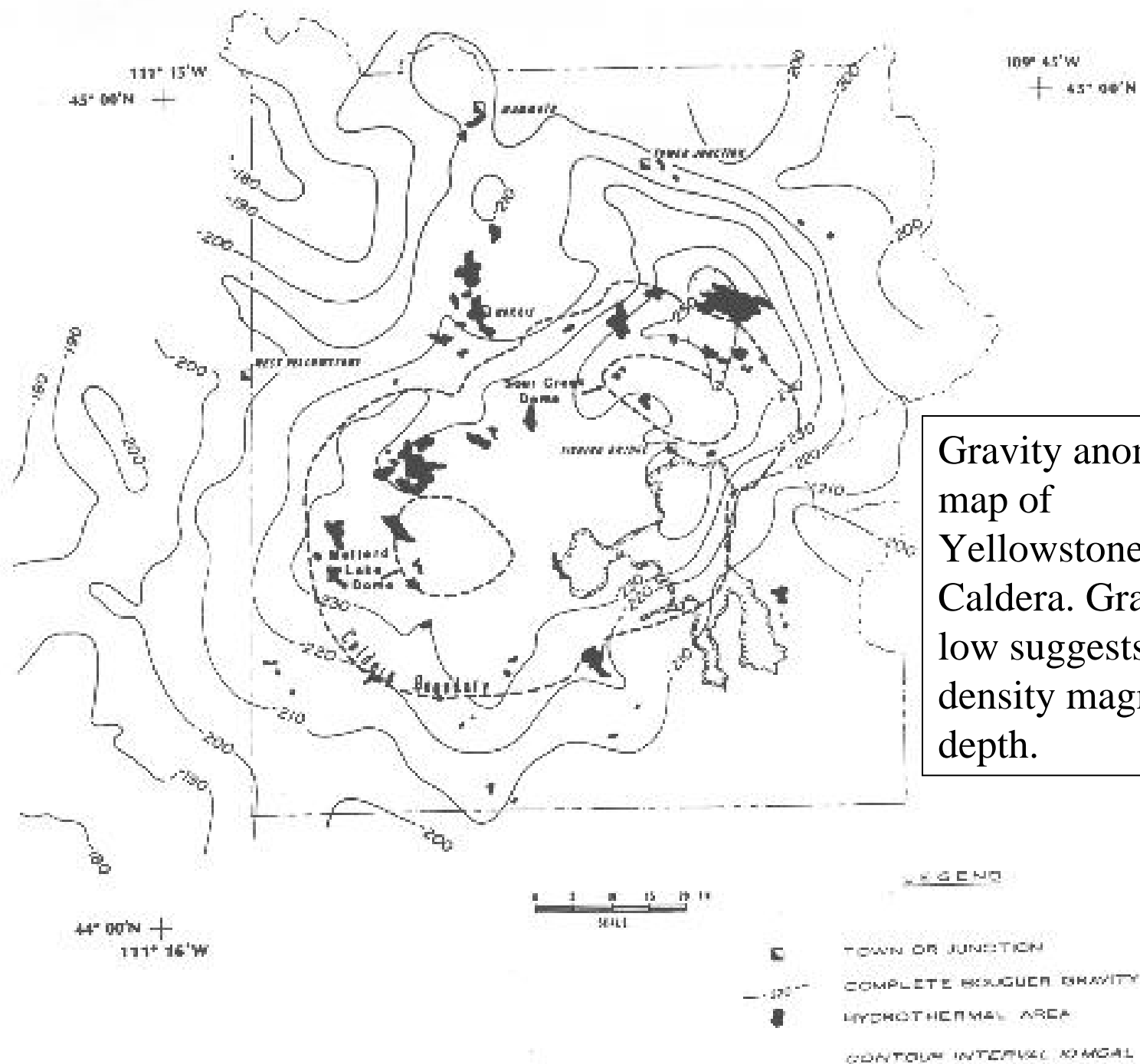
Computer projection of ash cloud trajectory

Dike emplacement at Akutan revealed by InSAR

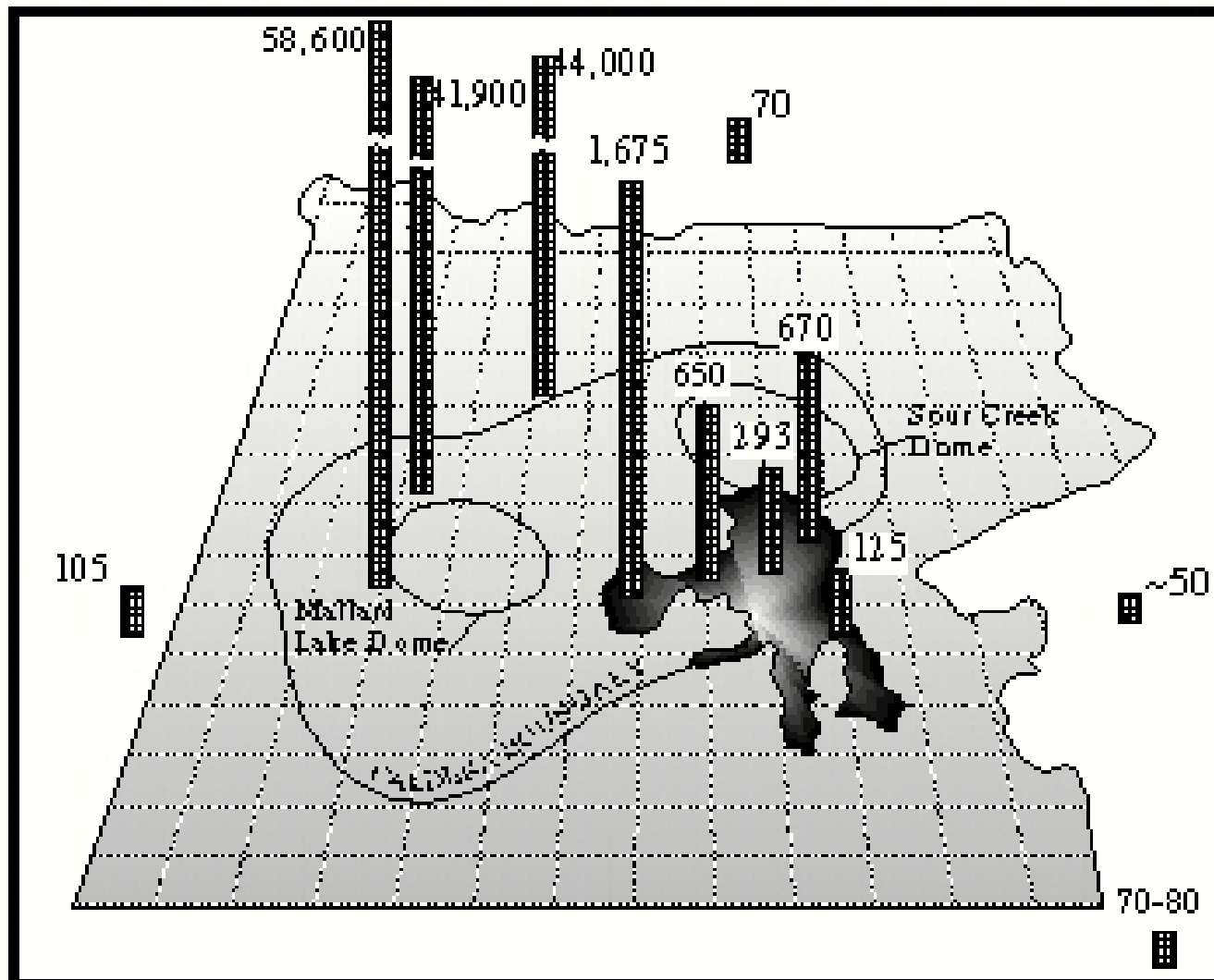


OTHER GEOPHYSICAL OBSERVATIONS

- GRAVITY
- MAGNETIC MEASUREMENTS
- ELECTRICAL MEASUREMENTS
- HEAT FLOW



Gravity anomaly map of Yellowstone Caldera. Gravity low suggests low-density magma at depth.



Heat flow at Yellowstone Caldera. Heat flow is normal outside the caldera.

Pulling it all together



AVO operations room, Anchorage

Background: The United States and its territories contain 169 potentially active volcanoes. Monitoring of the most dangerous volcanoes is conducted by 5 USGS observatories

Eruption in Progress:

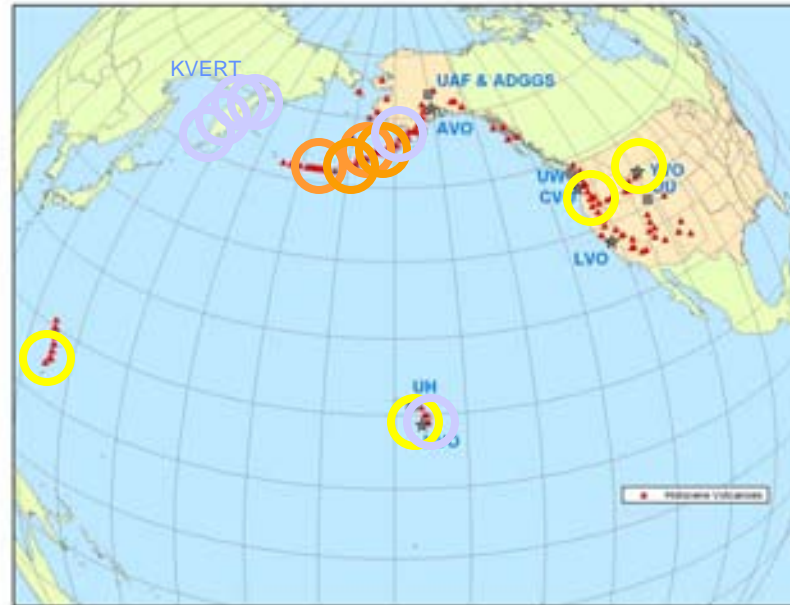
Kilauea
Redoubt

Eruptions in last year:

Kasatochi, Okmok,
Pavlov, Cleveland,
Korovin

Unrest in last year:

Mauna Loa
Three Sisters
Anatahan
Yellowstone



USGS Volcano observatories:

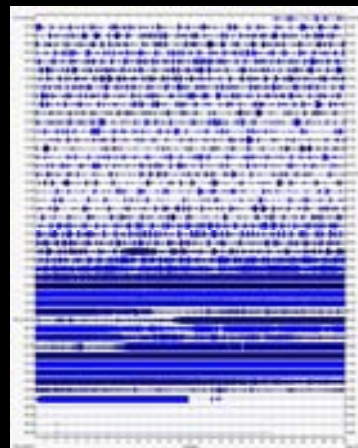
| | |
|-----|---------------------------------|
| HVO | Hawaii Volcano Observatory |
| AVO | Alaska Volcano Observatory |
| CVO | Cascades Volcano Observatory |
| YVO | Yellowstone Volcano Observatory |
| LVO | Long Valley Observatory |

Observatory Partners:

| | |
|-----|--|
| UH | University of Hawaii |
| UAF | Univ. Alaska & Alaska Div. Geol. & Geophys Surveys |
| UW | University of Washington |
| UU | University of Utah |

Communication tools:

1. **Calldown:** To emergency response agencies, FAA, government officials.
2. **Email reports and notifications:** Emergency notifications and daily to weekly status reports to all information users in the public and private sectors.
3. **Web sites:** Observatory web sites provide all warnings and updates together with real-time monitoring data, webcam views, and background information.
4. **Other communication techniques:** Press conferences, town hall meetings, eruption response plans, eruption scenario exercises, workshops, hazard maps, fact sheets.
5. **Scientific output:** About 75 peer-reviewed articles per year in international journals.
6. **International outreach:** VHP's Volcano Disaster Assistance Program (VDAP) responds to countries' requesting help in dealing with volcanic crises, e.g. in South and Central America, the Philippines, and Indonesia. VHP works with Russian volcanologists to mitigate the hazard of ash clouds to trans-Pacific flights.



THE FUTURE?

- New ways to chemically analyze rocks.
- Further improvements in surface seismic, geodetic, and other geophysical measurements.
- New satellite remote sensing techniques.
- Drill and sample magma directly.
- Actual samples and new data from volcanoes on other planets.
- Much more data available to everyone on the Web.