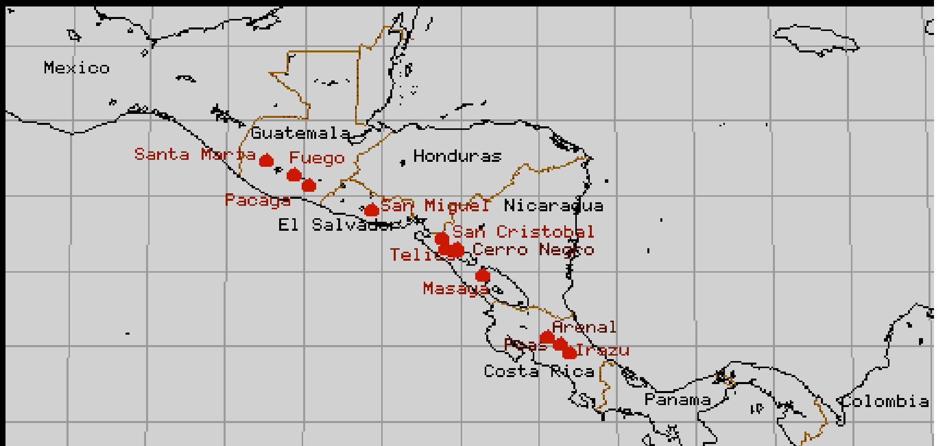
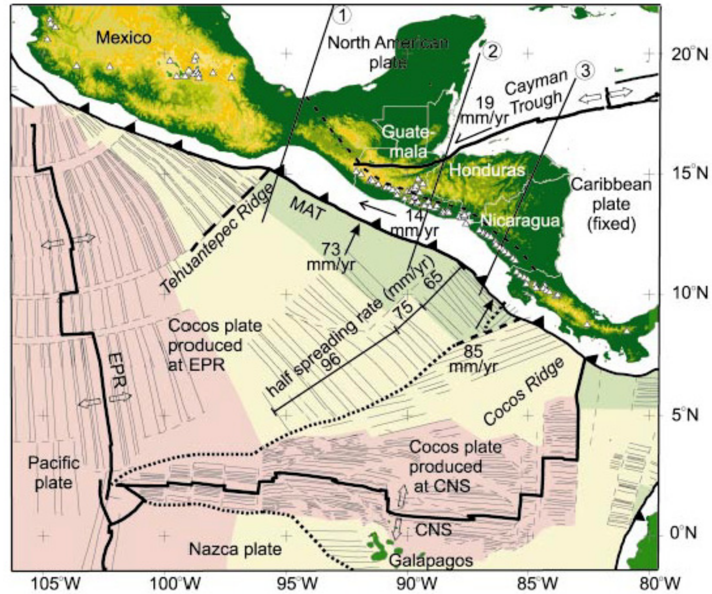
Central America’s most active volcanoes

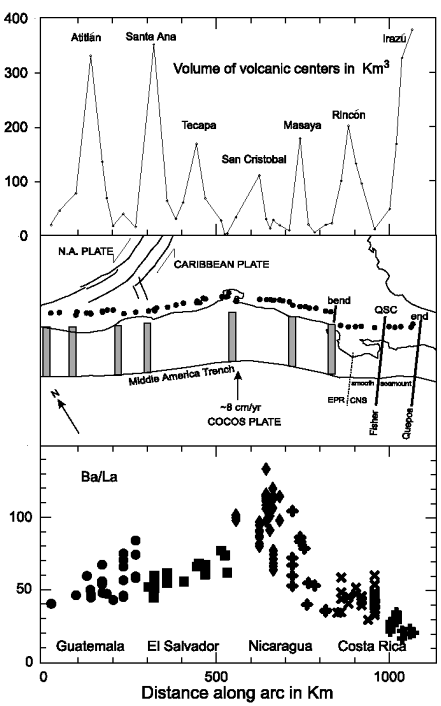


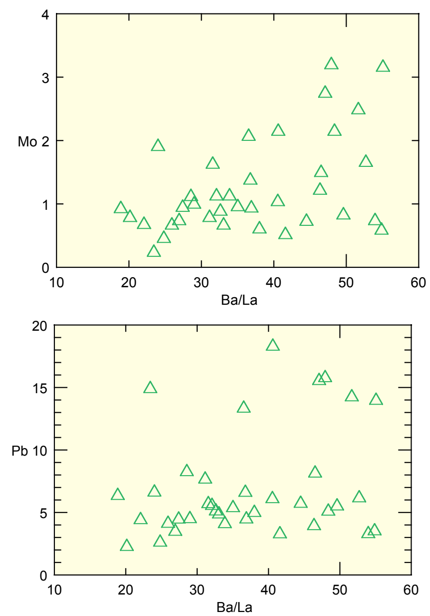


Rogers, Karason & van der Hilst, 2002, Geology 30: 1031-1034.

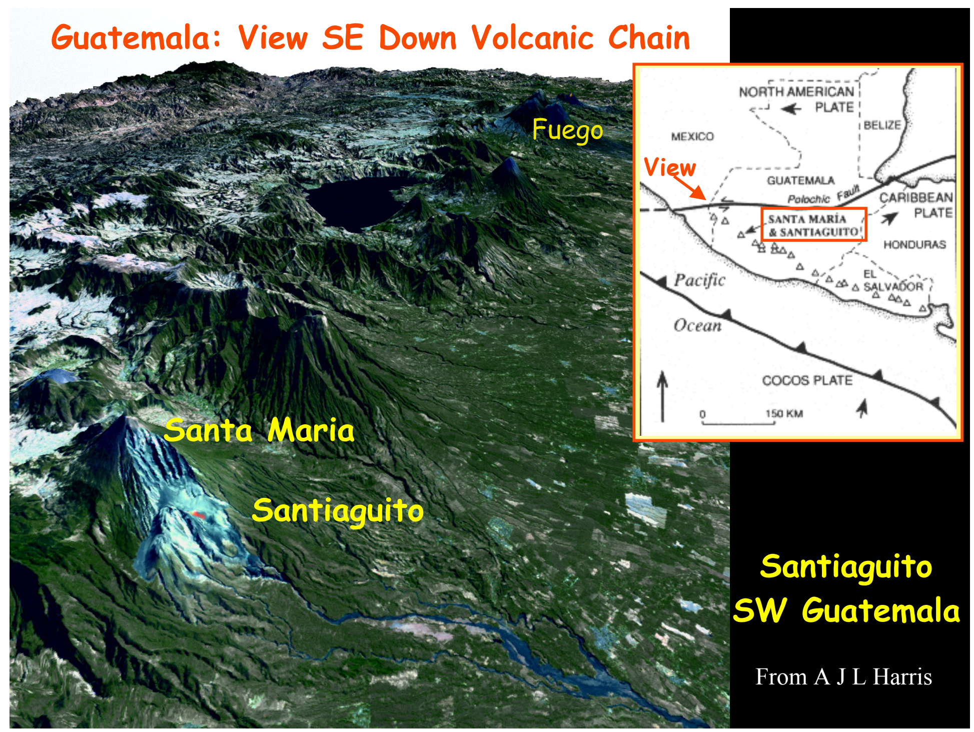
How does the slab variability influence trace elements?

There are probably sedimentary and igneous components to this influence

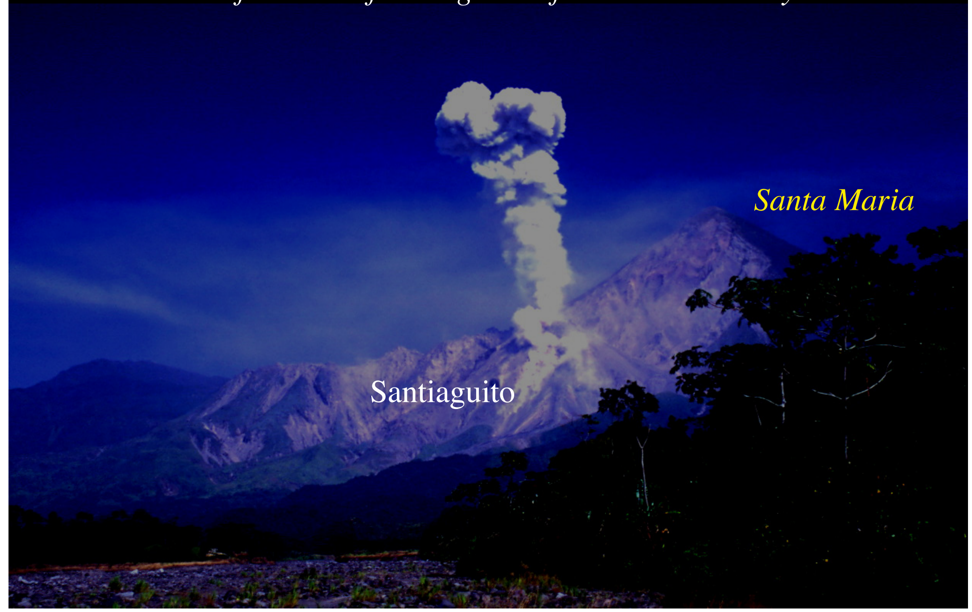




Walker, Patino, Cameron & Carr, 2000, J Geophys Res 105: 18949-18963

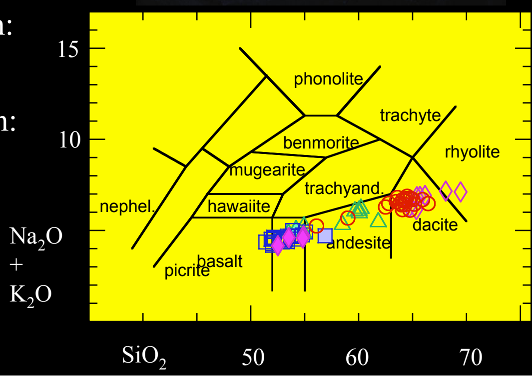


A "child" of Santa Maria, Santiaguito is an active dacite dome, which has erupted every day since 1922. It has killed hundreds of people and causes millions of dollars of damage to infrastructure each year



Santa Maria/Santiaguito, 20 km^3, 40 ka

- Growth of basaltic-andesitic composite cone: 75-34 ka
- Repose (with rare andesitic lava eruptions?) : 34 ka-1902
- Dacite explosive eruption: 1902
- Continual dome extrusion: 1922-2001



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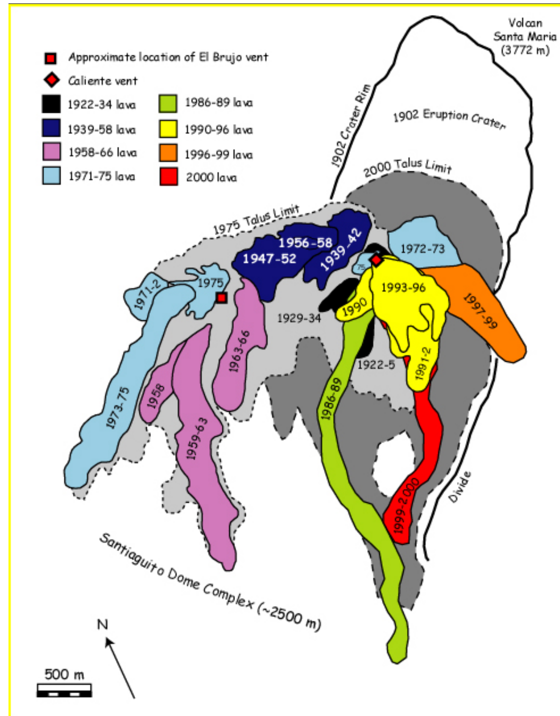
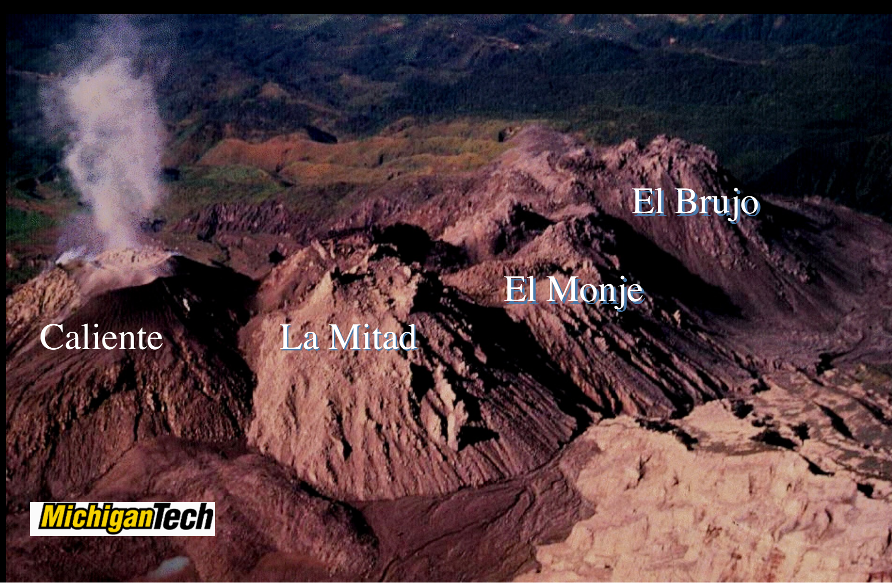
October 1902 eruption

- 1902 crater of Santa Maria exposes a remarkable composite sequence of andesitic flows that were erupted during ~34-75 ka and which record a paleomagnetic and geochemical variation.

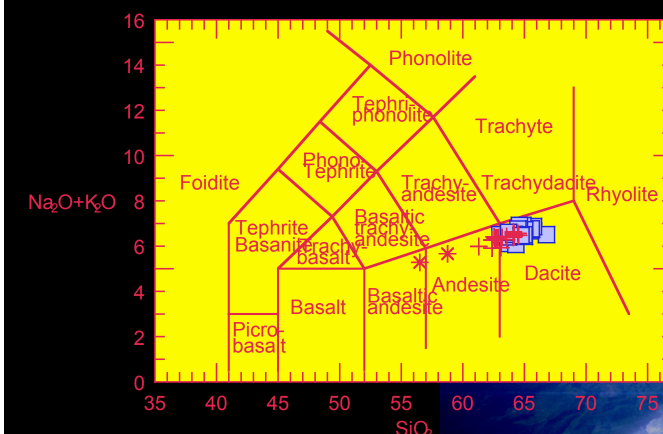


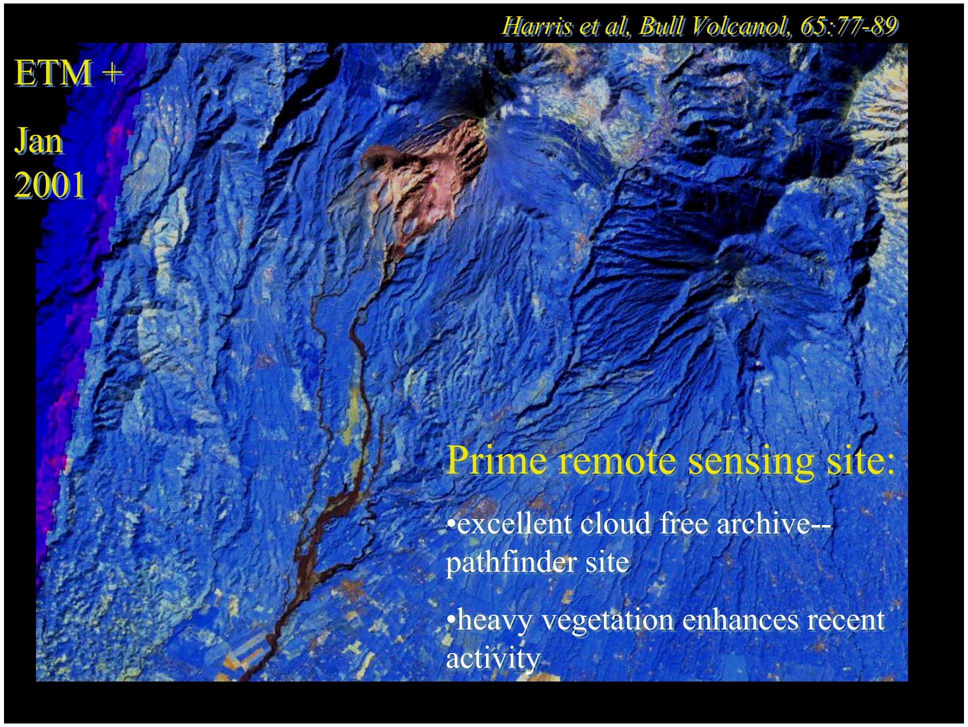
Santiaguito is a long-lived continuously active, volcanic dome complex, which has been growing since 1922. It has a total volume of about 1.1 km3 and is the residual of a much larger (>10 km3) magma chamber that formed within Santa Maria during several millenia and erupted in 1902.

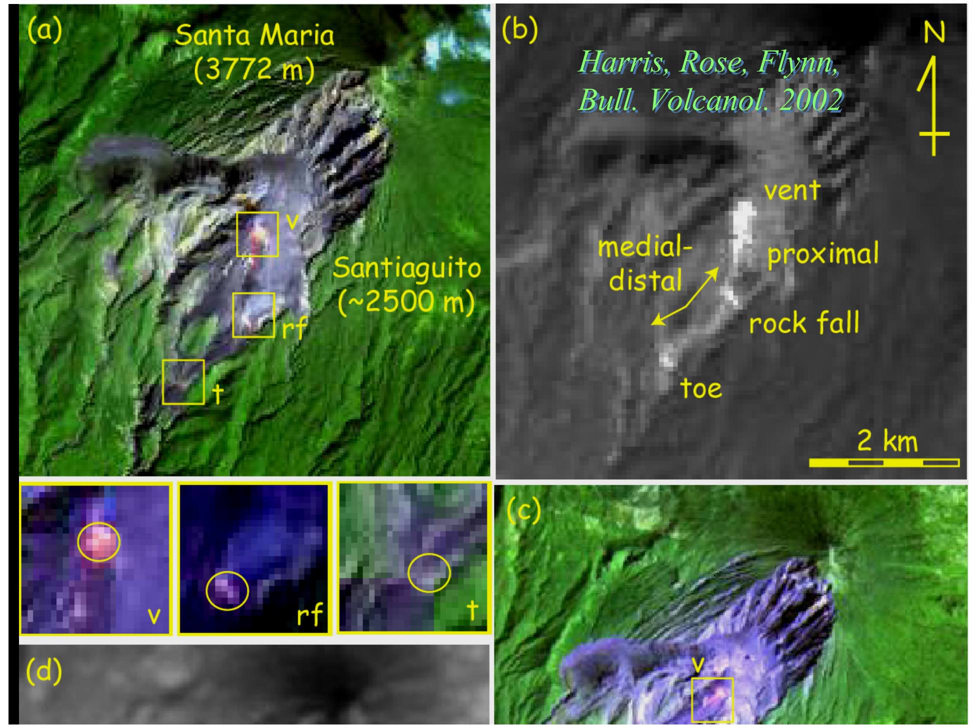
Santiaguito has grown in spurts of extrusion, which has created several dome units that abut each other.

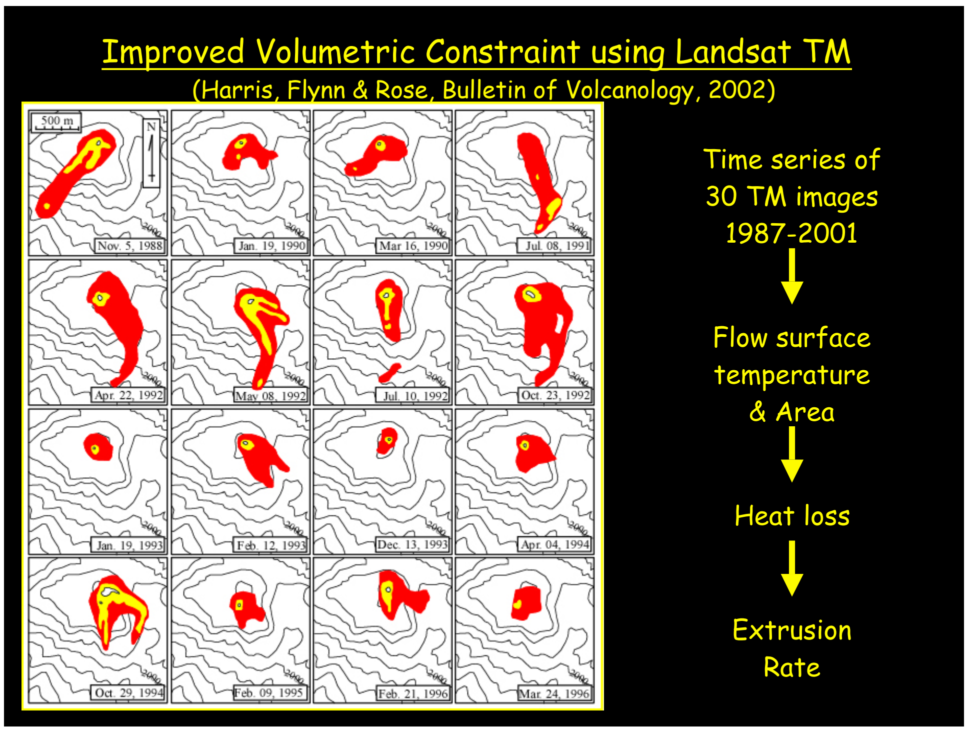


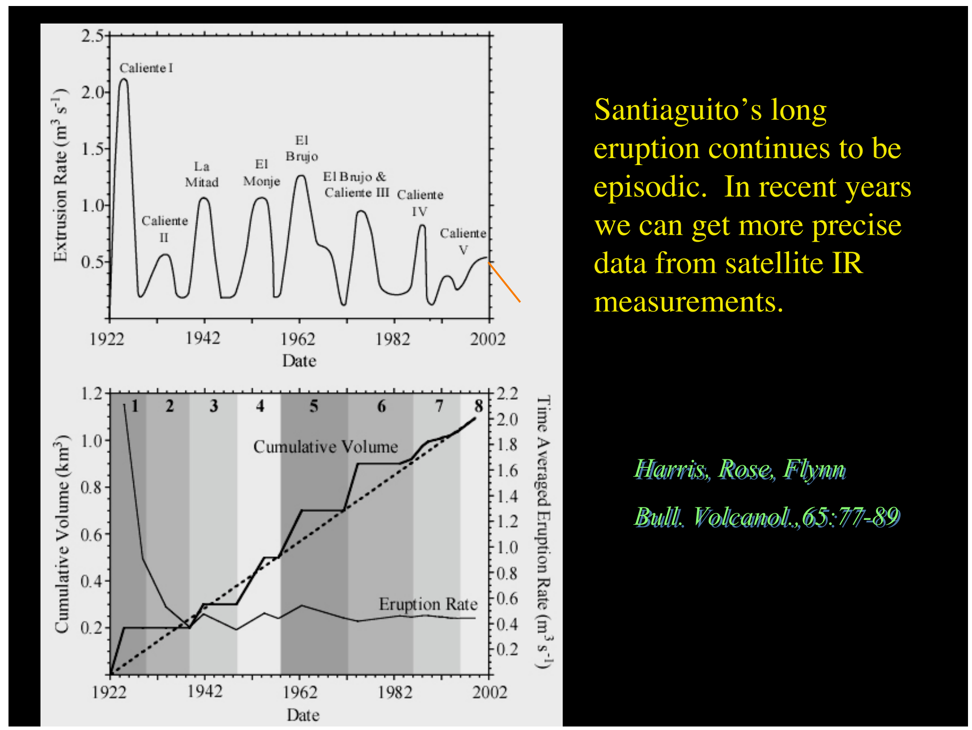
Santiaguito Volcanic Dome, Guatemala 1922-2006

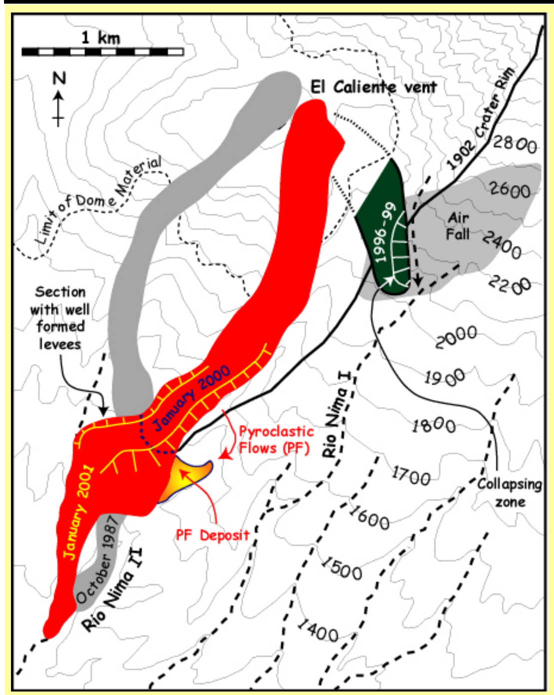



Harris et al, Bull Volcanol, 65:77-89
ETM +
Jan
2001
Prime remote sensing site:
•excellent cloud free archive--pathfinder site
•heavy vegetation enhances recent activity

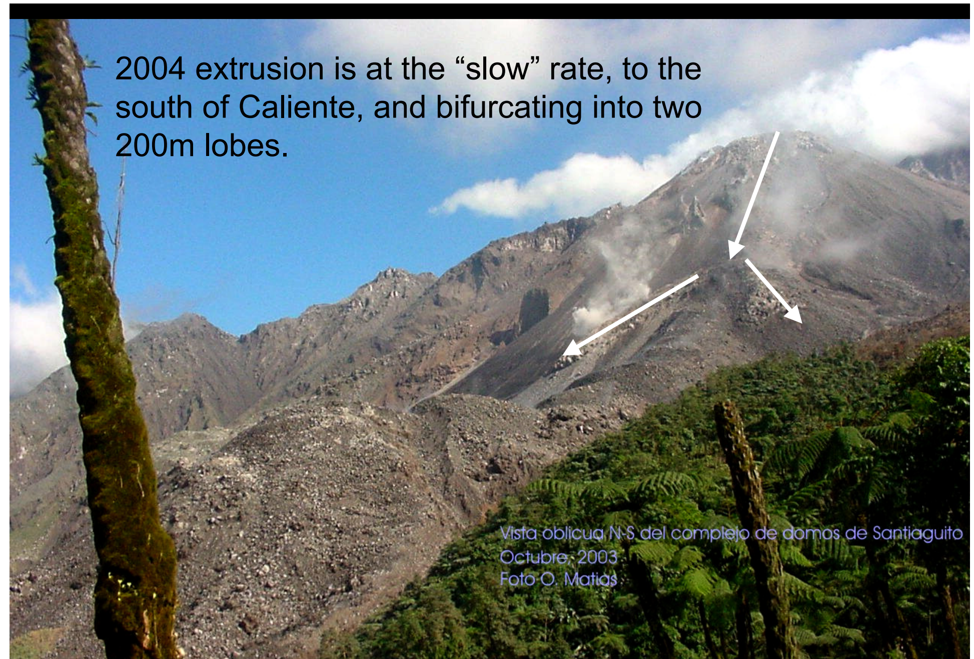

(a)
Santa Maria
(3772 m)
v
Santiaguito
(~2500 m)
rf
t
(b)
Harris, Rose, Flynn,
Bull. Volcanol. 2002
N
vent
medial-
distal
proximal
rock fall
toe
2 km
v
rf
t
(c)
v
(d)


Improved Volumetric Constraint using Landsat TM
(Harris, Flynn & Rose, Bulletin of Volcanology, 2002)
500 m
N
Nov. 5, 1988
Jan. 19, 1990
Mar 16, 1990
Jul. 08, 1991
Apr. 22, 1992
May 08, 1992
Jul. 10, 1992
Oct. 23, 1992
Jan. 19, 1993
Feb. 12, 1993
Dec. 13, 1993
Apr. 04, 1994
Oct. 29, 1994
Feb. 09, 1995
Feb. 21, 1996
Mar 24, 1996
Time series of
30 TM images
1987-2001
Flow surface
temperature
& Area
Heat loss
Extrusion
Rate

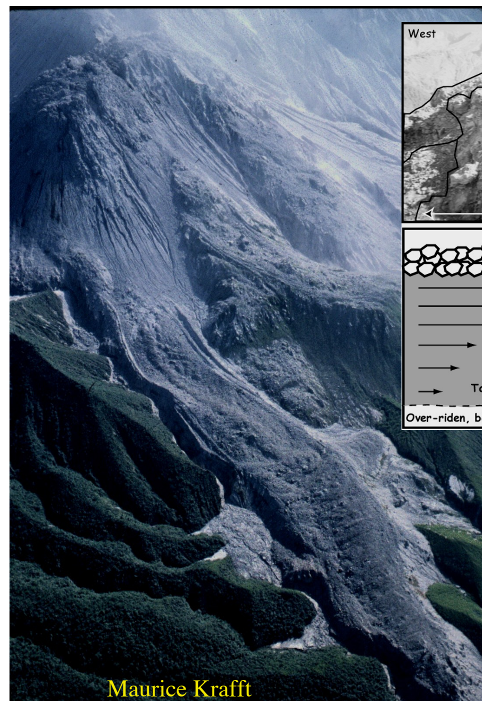

Extrusion Rate (m³ s⁻¹)
Caliente I
Caliente II
La Mitad
El Monje
El Brujo
El Brujo & Caliente III
Caliente IV
Caliente V
1922
1942
1962
1982
2002
Date
Cumulative Volume (km³)
Cumulative Volume
Eruption Rate
Time Averaged Eruption Rate (m³ s⁻¹)
1
2
3
4
5
6
7
8
Santiaguito's long eruption continues to be episodic. In recent years we can get more precise data from satellite IR measurements.
Harris, Rose, Flynn
Bull. Volcanol.,65:77-89

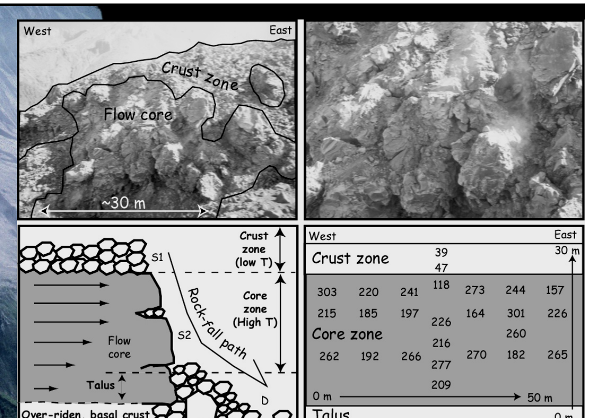


Current (Jan 2002) activity consists of a long merapi-type lava flow with prominent Levees which terminates in the valley of the Rio Nima II.
Erosion of a new canyon east of the 1996-9 flow and breaching the 1902 crater rim is dumping lots of sediment into Rio Nima I



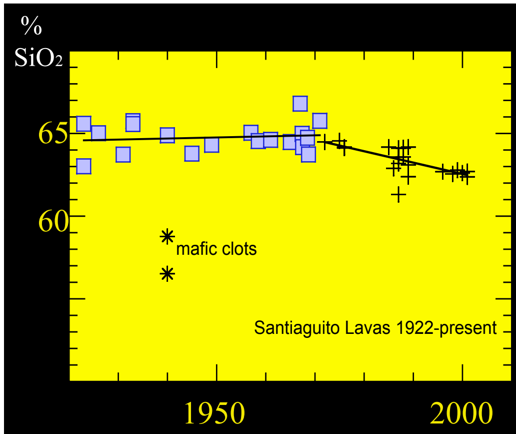
O Matias, INSIVUMEH October 2003





Direct observations of active block lava extrusions and associated phenomena.

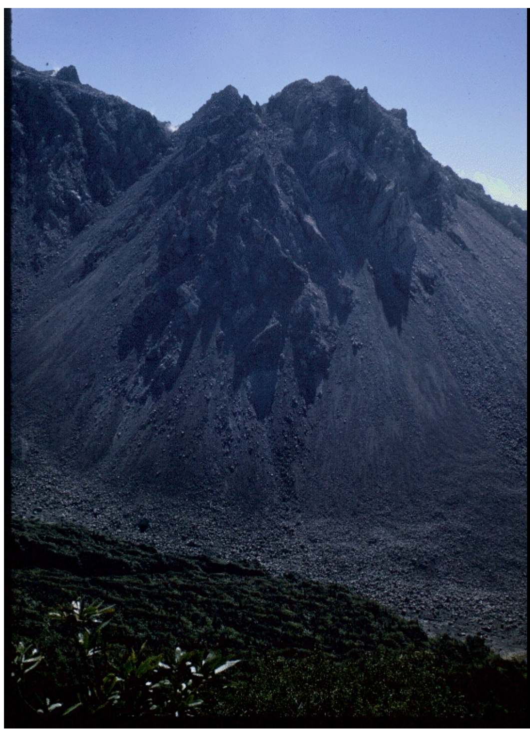
Harris et al, 2002, Bull GSA 114: 533-546



Maurice Krafft

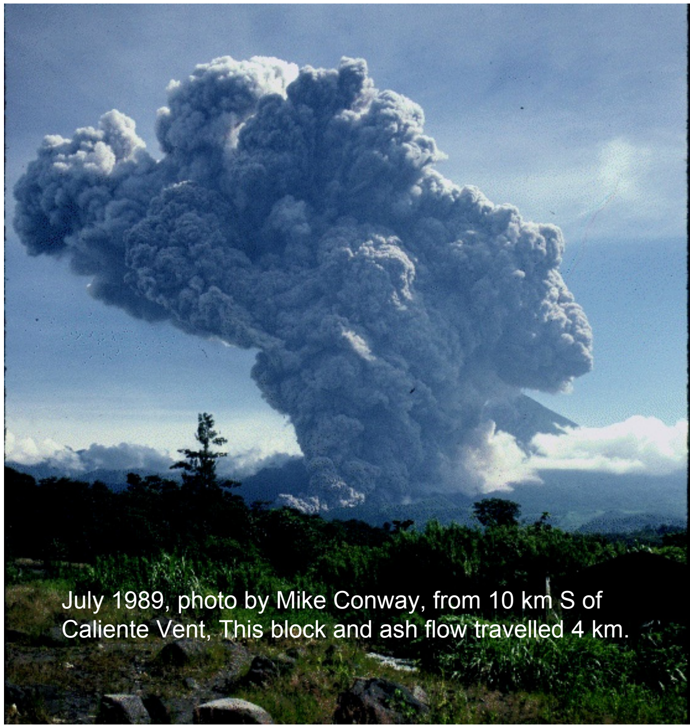
Dacite lava extrusion for 45 years, now becoming more mafic, and more exogenous.

MichiganTech

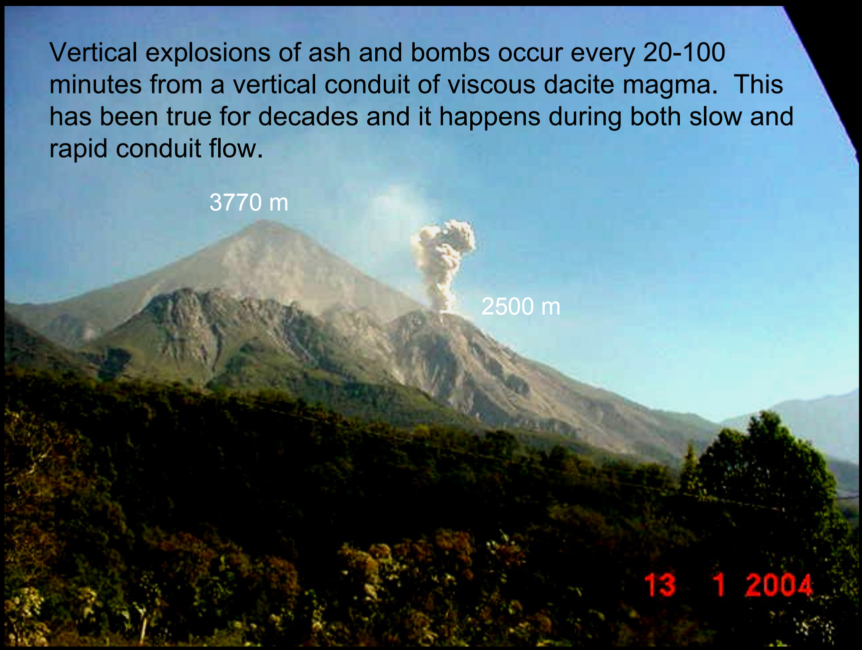


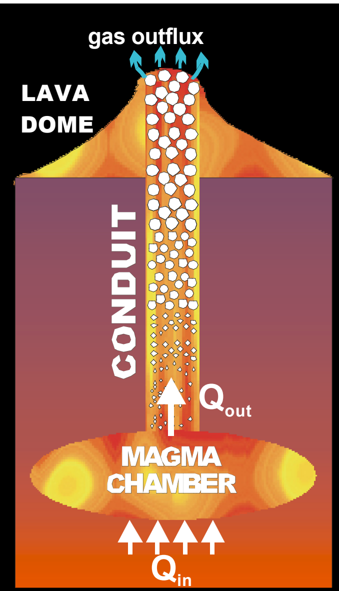
Dacite magma of Santiaguito has 64 % SiO2 and about 35% phenocrysts and makes a highly viscous morphology.

Large volumes of hot viscous magma are found at substantial elevations, representing substantial hazards to nearby populations

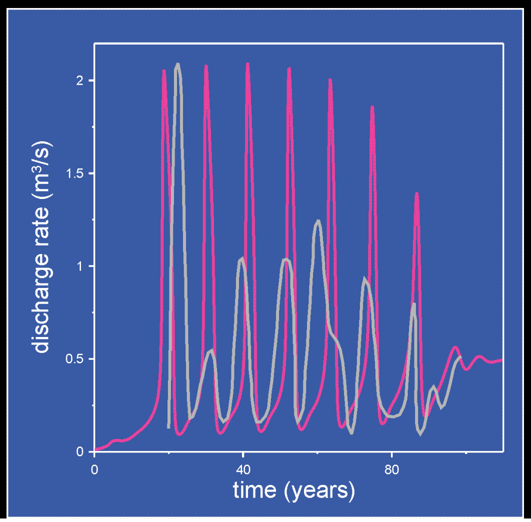


Dome or flow front collapses with block and ash flows occur about once a year





Magma chamber depth	5 km
Magma chamber volume	50 km^3
Conduit diameter	60 m
Melt water content	5 wt%
Magma temperature	830 ºC
Magma crystal content	0.3
Max. crystal growth rate	4×10^{-12} m s^{-1}
Max. nucleation rate	5.7×10^{9} m^{-3} s^{-1}
Max. growth undercooling	200 ºC
Max. nucleation undercooling	250 ºC



Conduit Flow Modeling

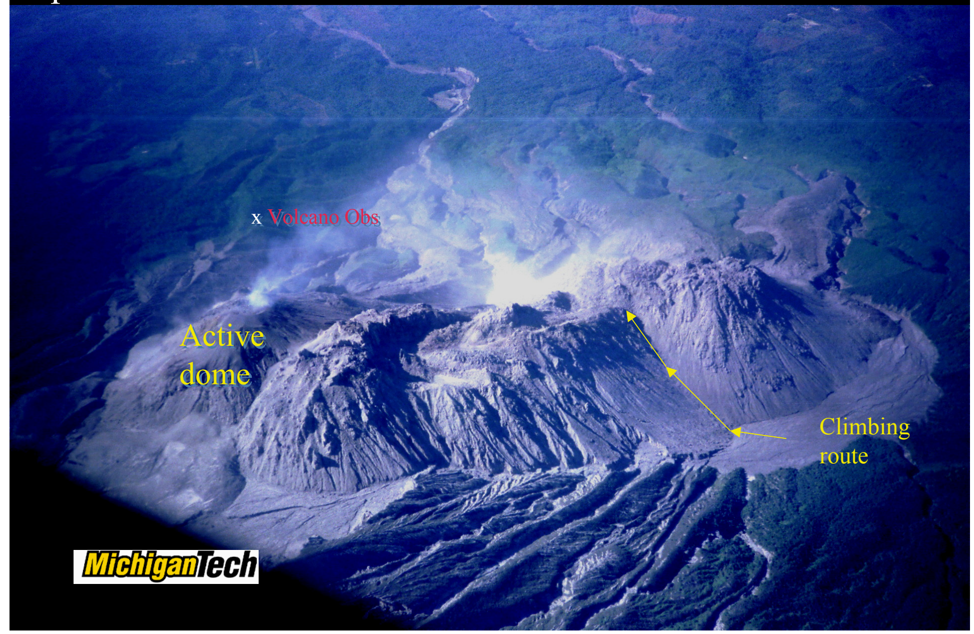
Melnik et al, in prep

•Accessibility to prime observation points,

•Dependable weather in dry season mornings,

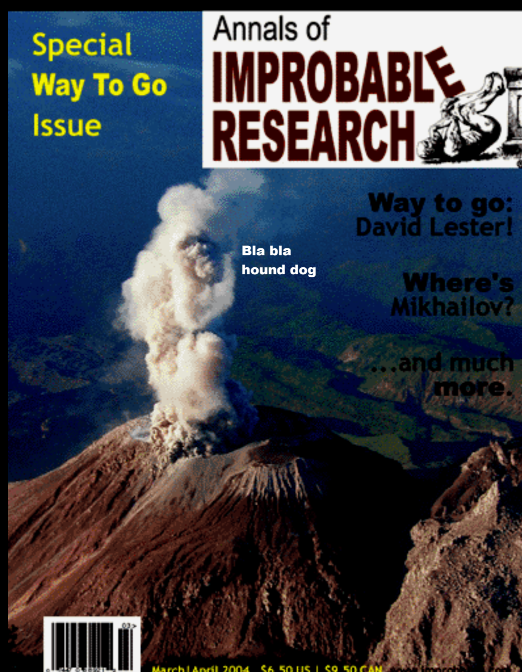
•Daily diverse activity

Access to Study areas at Santiaguito is good--access to prime observational areas is “safe”



Summit vantage for eruption observations

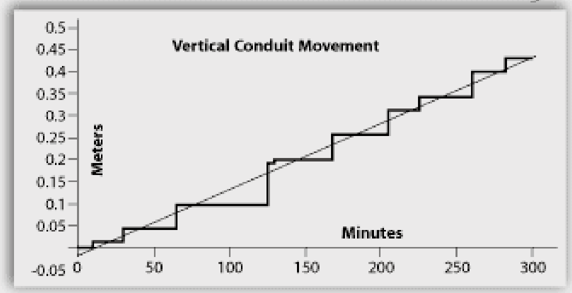
Some have reported visual and auditory hallucinations

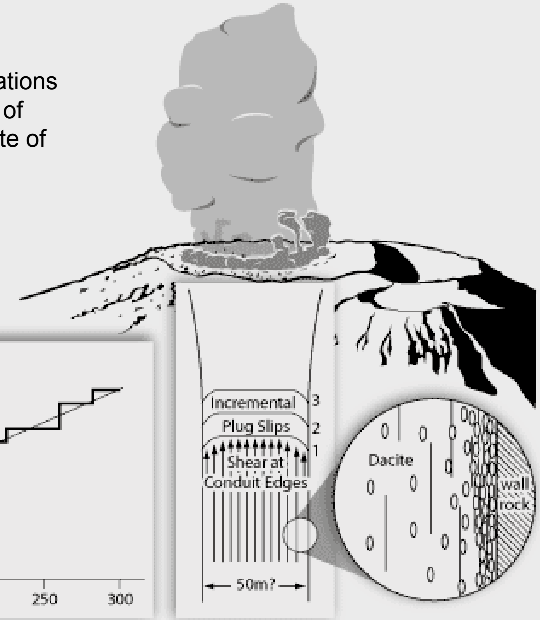


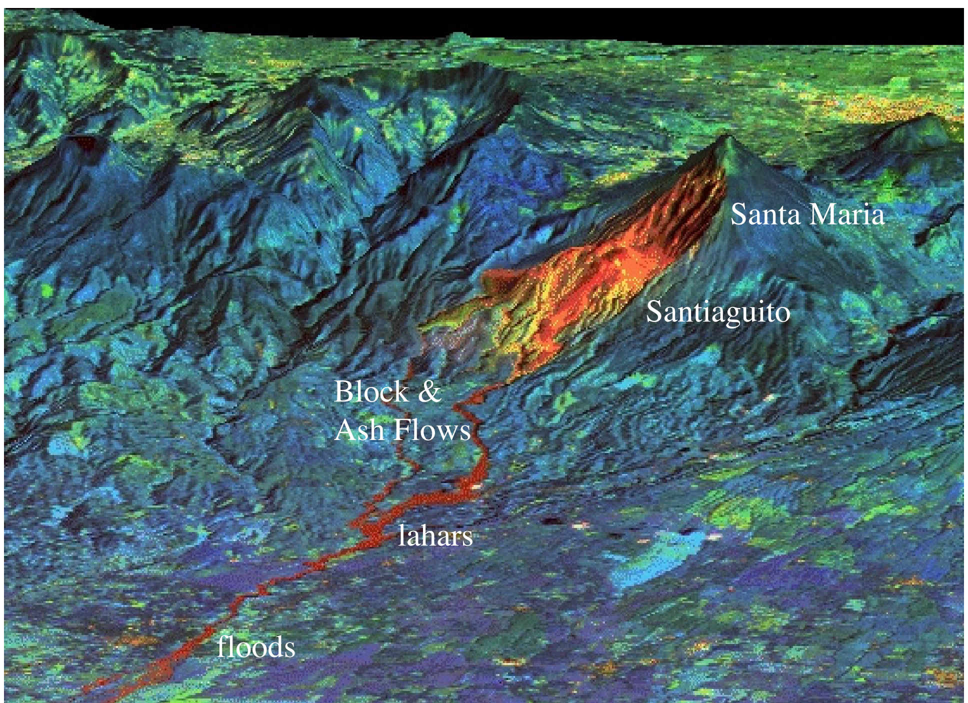
Santiaguito eruption, 1/11/02 6:59:44

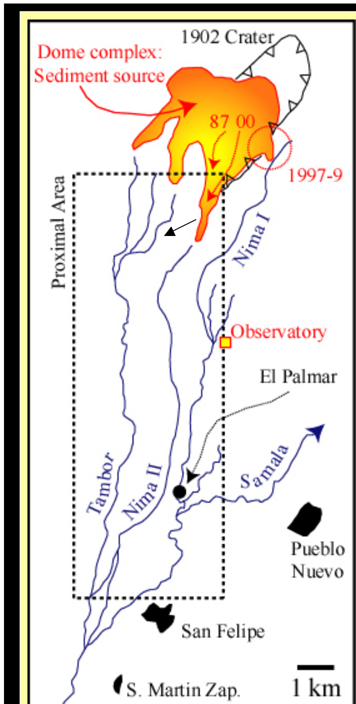
Santiaguito eruption, 1/11/02 8:11:02

Schematic view of Santiaguito's conduit, as inferred from observations of activity. Incremental plug flow of conduit occurs with an overall rate of about 0.2 m^3/s, generating ash eruptions from sheared margins









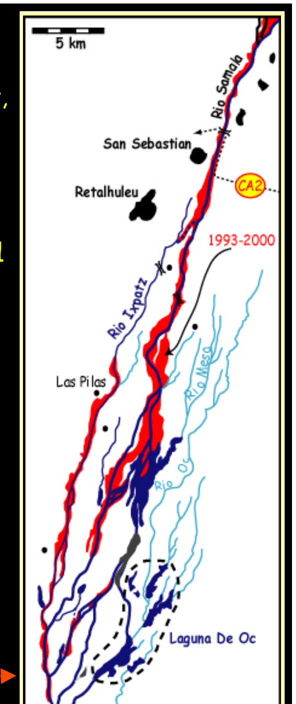
Analysis

(Harris, Vallance, Kimberly, Rose, Matias, Flynn & Garbeil, Bulletin of Volcanology, 2003)

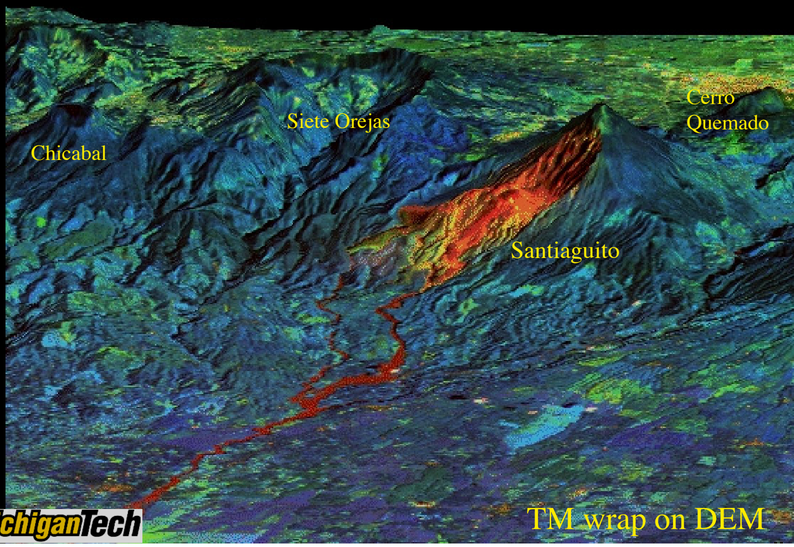
Change analysis using 21 Landsat TM images and ground measurements

Proximal drainage zone

Medial drainage zone



Current generation of volcanic centers in Guatemala and El Salvador are <200ka and their morphology is strikingly more constructional than older erosional features.



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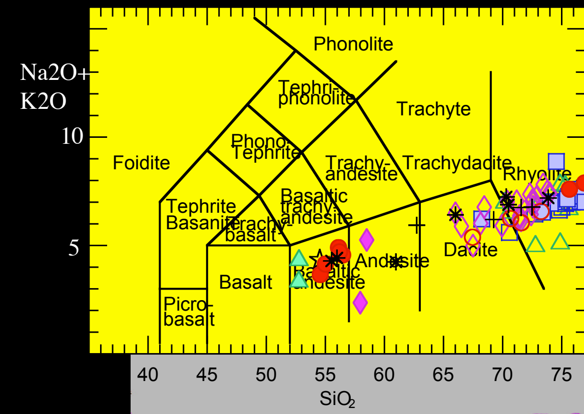
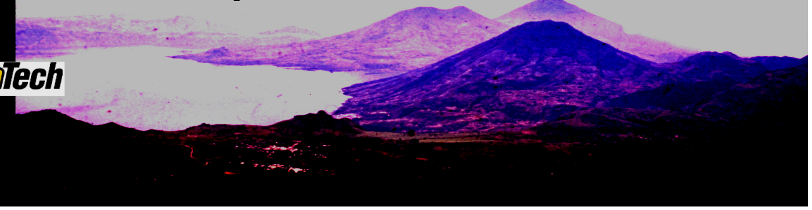
Atitlán Caldera, Guatemala, 250 km^3, 158 ka



Voluminous brief eruptive events, long reposes, substantial hydrothermal systems



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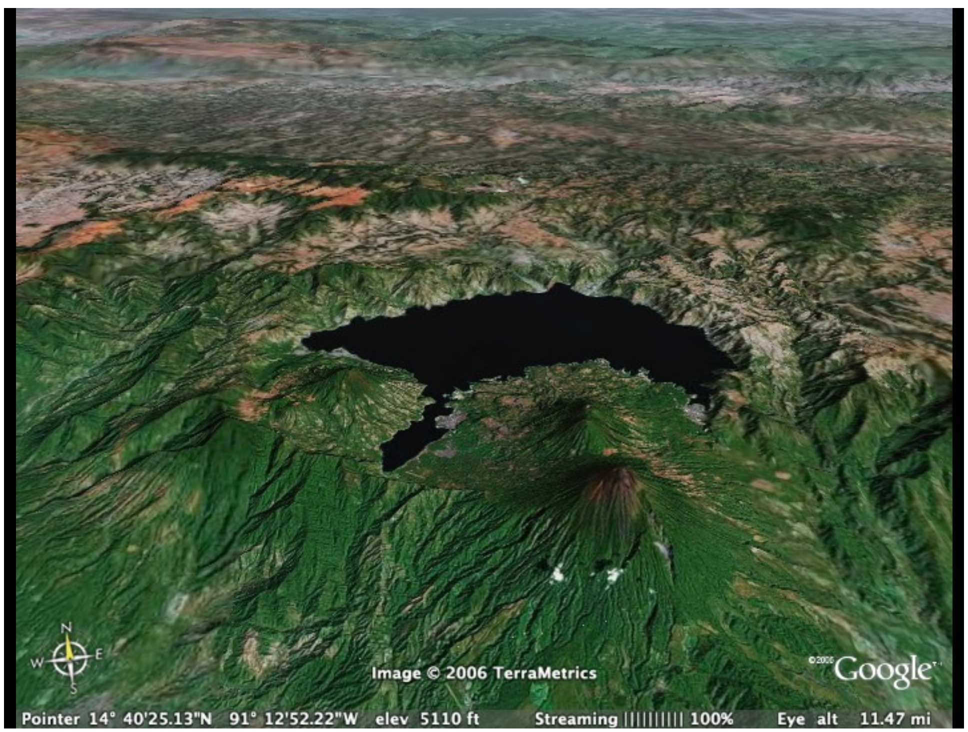
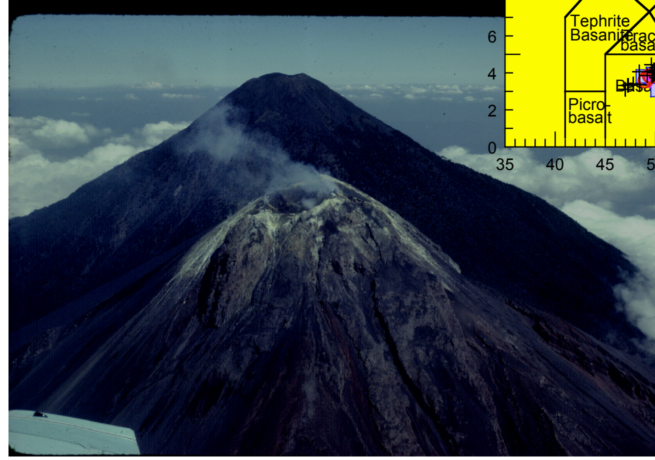
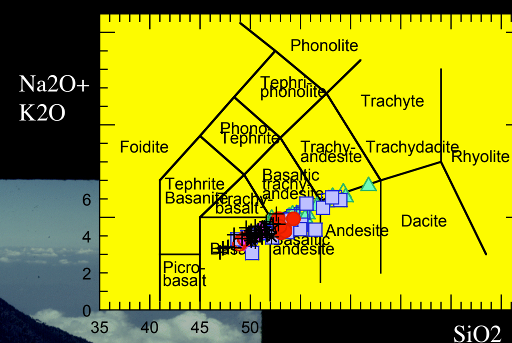


Fuego, Guatemala--180 samples, 17 ka, 135 km^3

- Bellweather volcano-->60 explosive historic eruptions
- Excess gas releases





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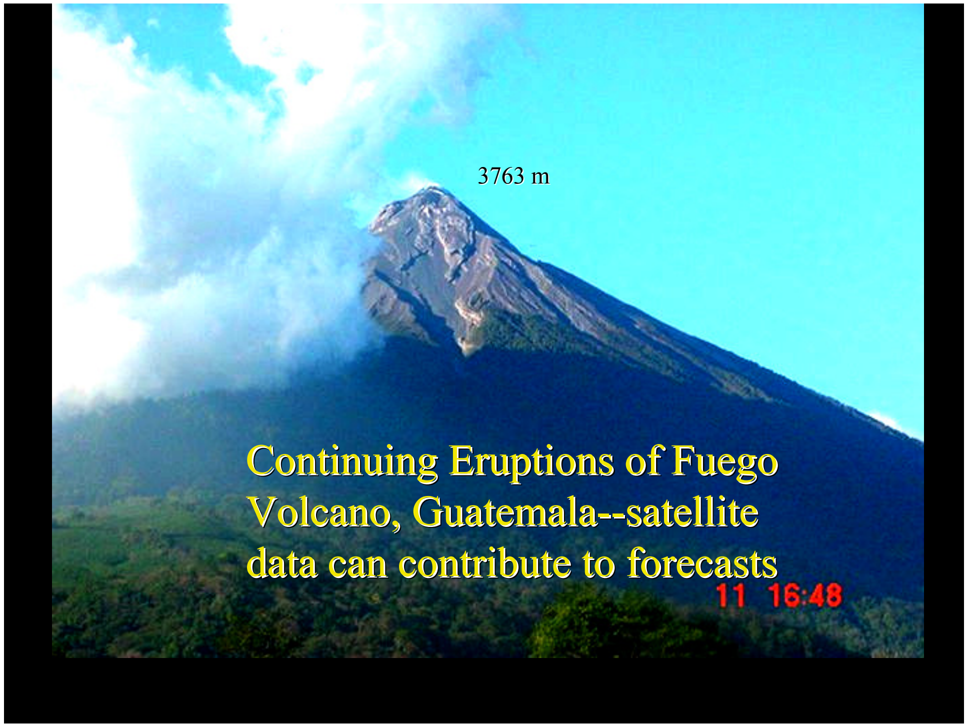
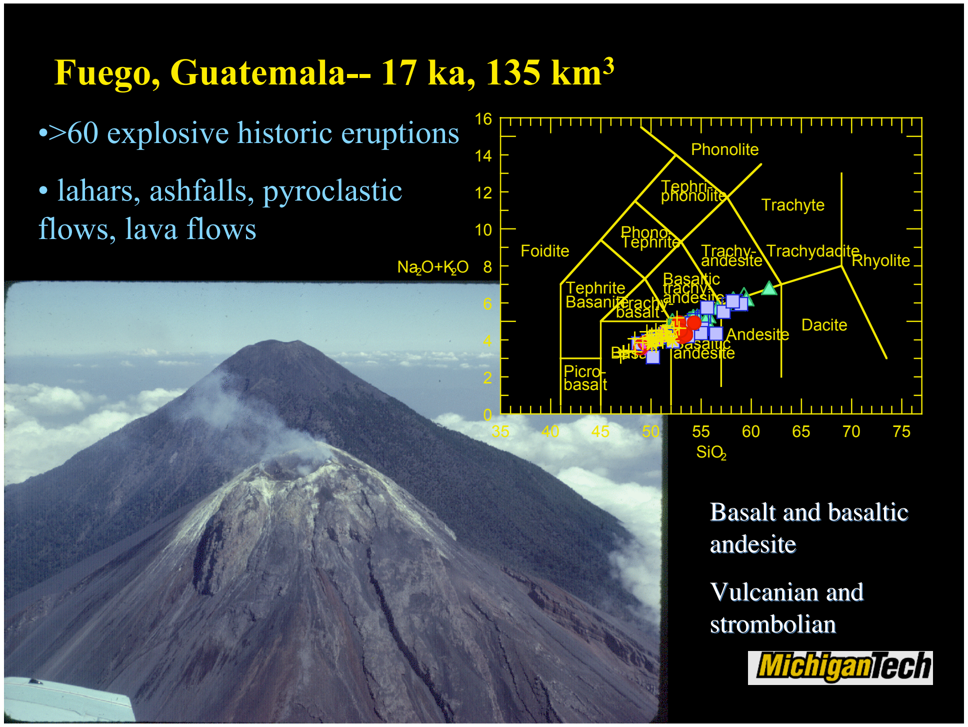
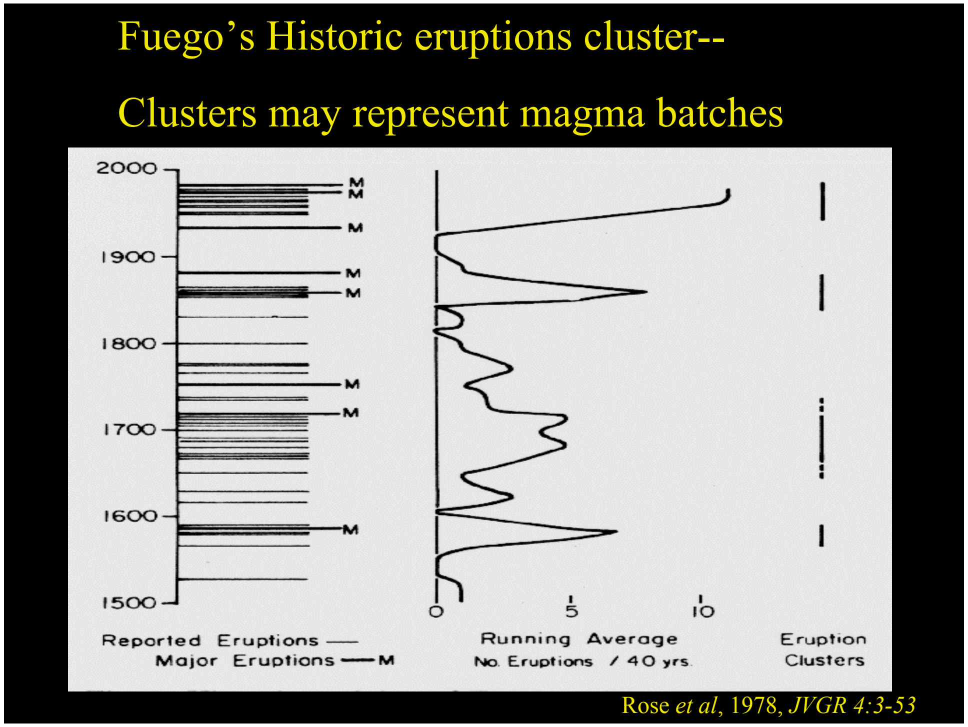

3763 m
Continuing Eruptions of Fuego Volcano, Guatemala--satellite data can contribute to forecasts
11 16:48


Fuego, Guatemala-- 17 ka, 135 km^3
•>60 explosive historic eruptions
• lahars, ashfalls, pyroclastic flows, lava flows
Na_2O+K_2O
SiO_2
Phonolite
Tephri-phonolite
Trachyte
Foidite
Phono-tephrite
Trachy-andesite
Trachydacite
Rhyolite
Tephrite Basanite
Basaltic trachy-andesite
Trachy-basalt
Andesite
Dacite
Basaltic andesite
Picro-basalt
Basalt and basaltic andesite
Vulcanian and strombolian
MichiganTech


Fuego's Historic eruptions cluster--
Clusters may represent magma batches
2000
1900
1800
1700
1600
1500
M
Reported Eruptions —
Major Eruptions —M
0
5
10
Running Average
No. Eruptions / 40 yrs.
Eruption Clusters
Rose *et al*, 1978, *JVGR 4:3-53*

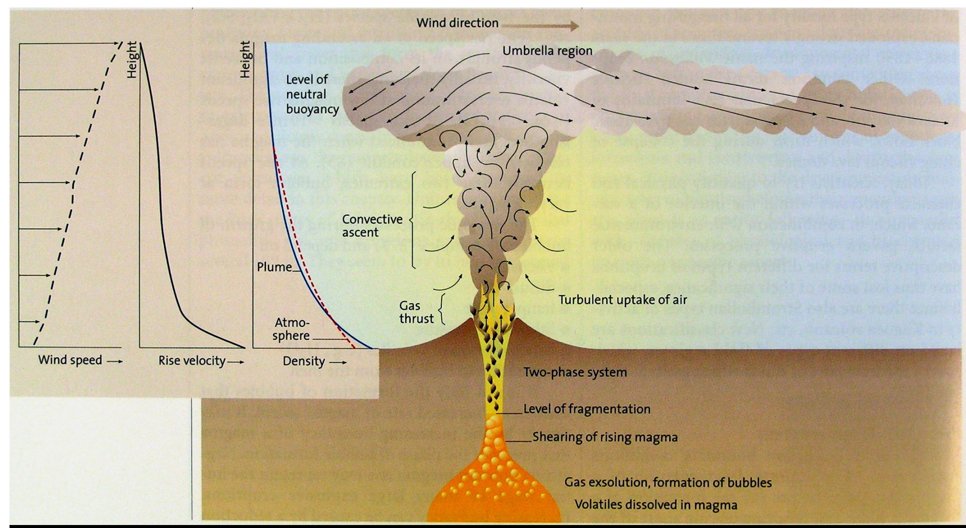

Fuego Volcano, a high basaltic cone; often in "open vent" condition
Average SO2 emission rate, 1975-2000: ~150 tonnes/day
MichiganTech

Volcanic Processes at Fuego

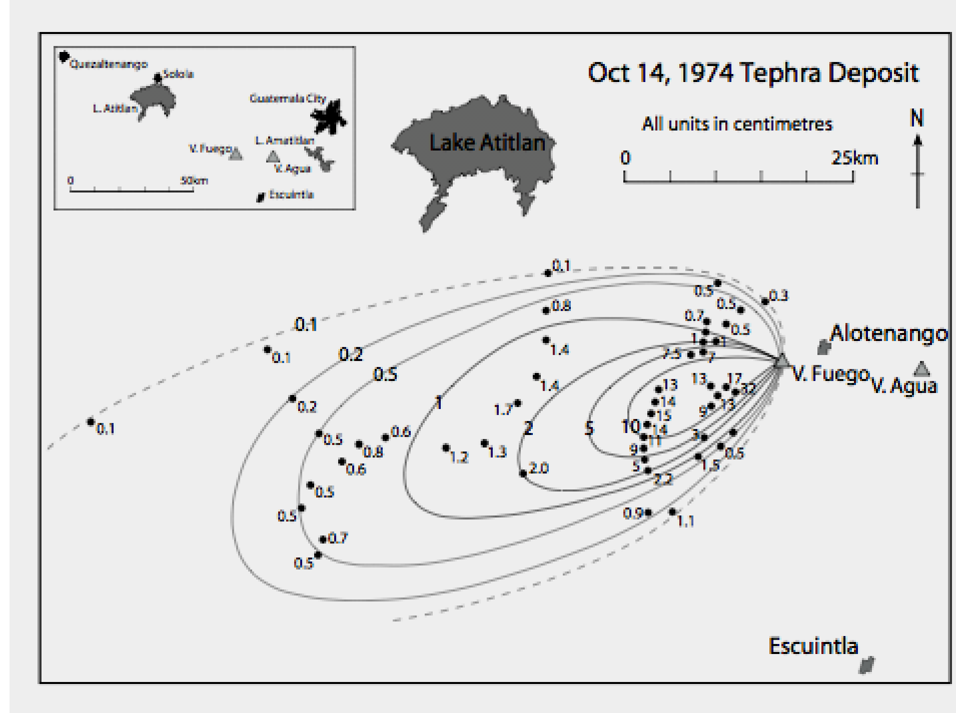
- Vertical ash/bomb explosions
- Ashfalls
- Spatter ramparts
- Lava flows
- Block & ash flows
- Lahars

Low level activity

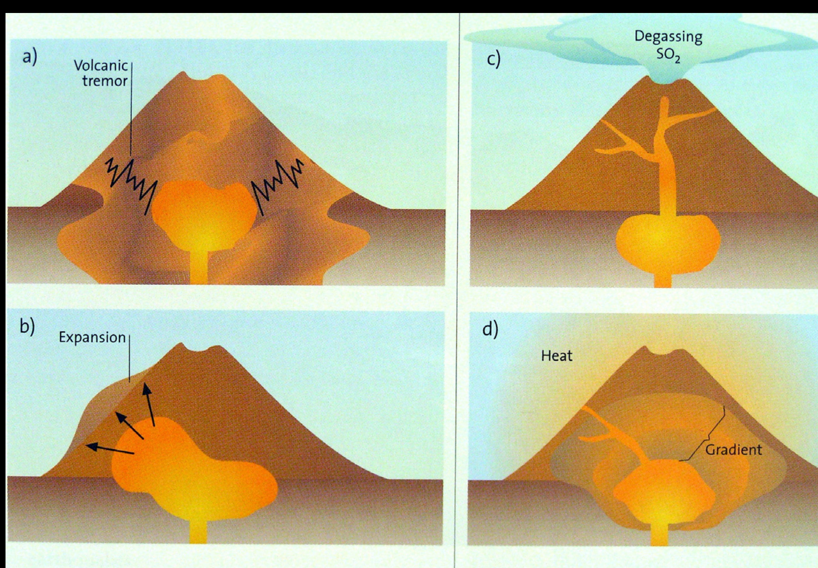
On steep slopes

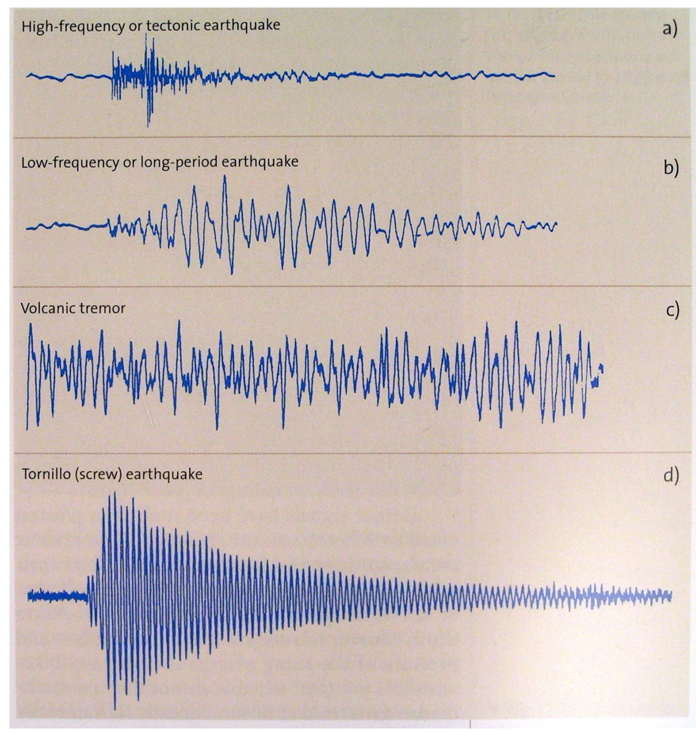


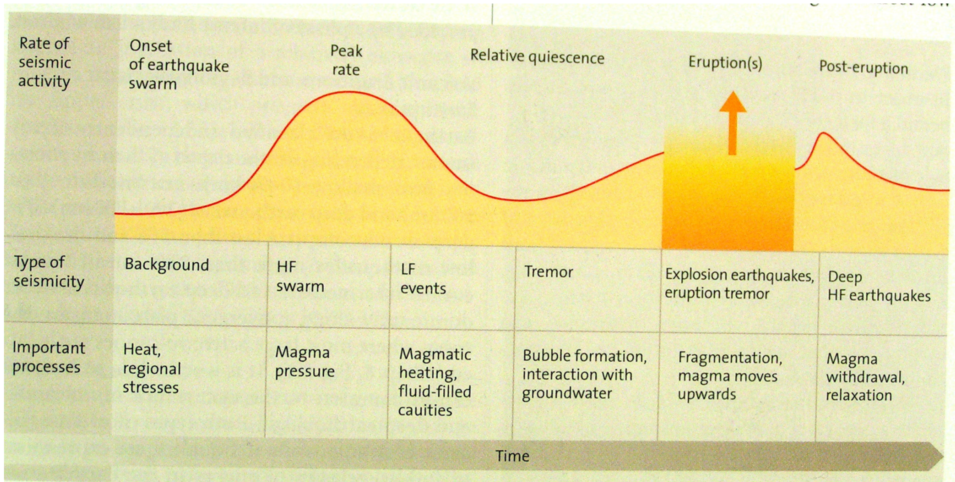
Plinian column and block and ash flows, Fuego 14 October 1974

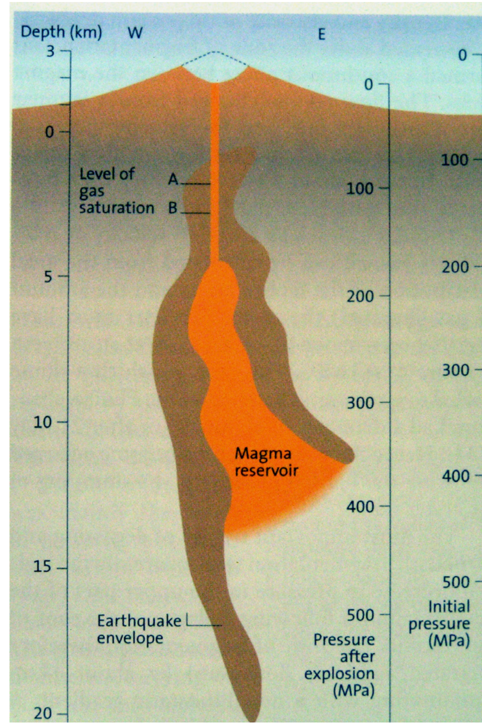


Monitoring Volcanoes





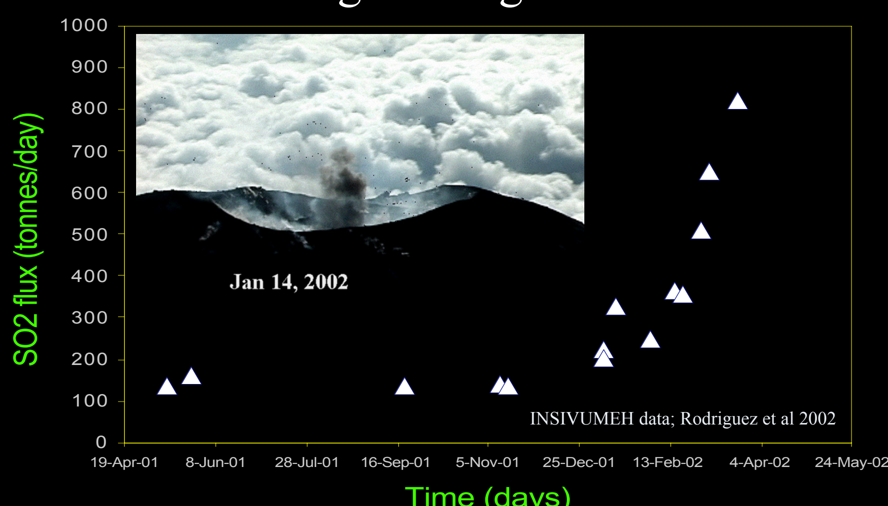


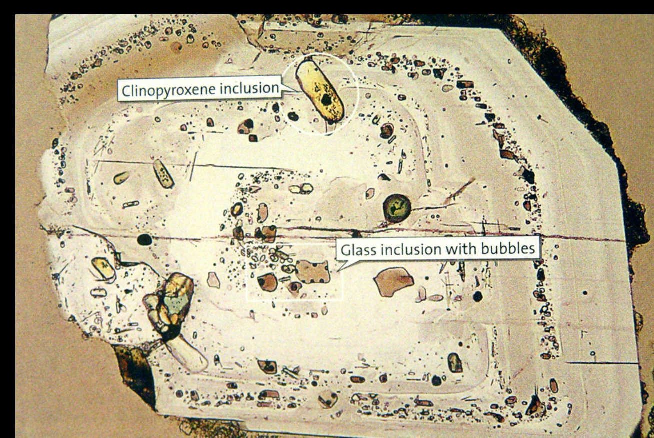


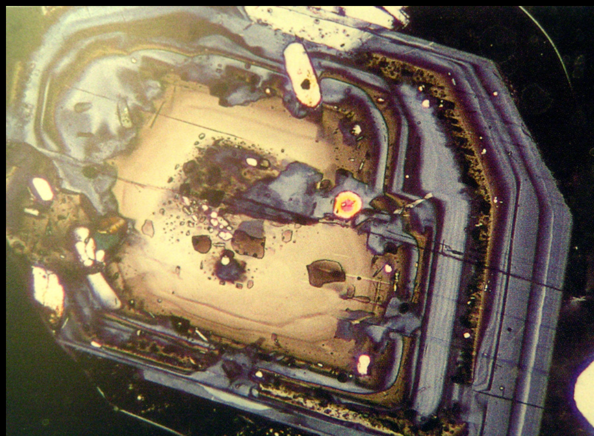
Visualizing the subsurface

Open vent gas emission variations:

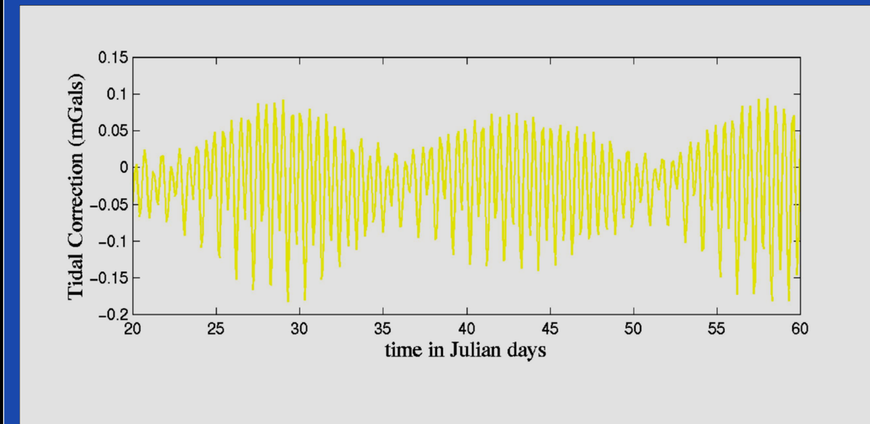
Fuego during 04/01-04/02



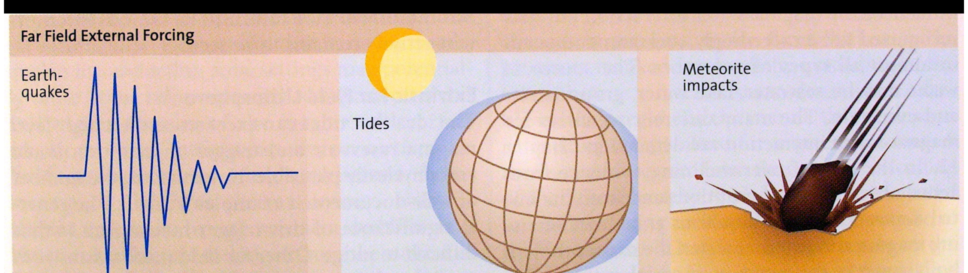


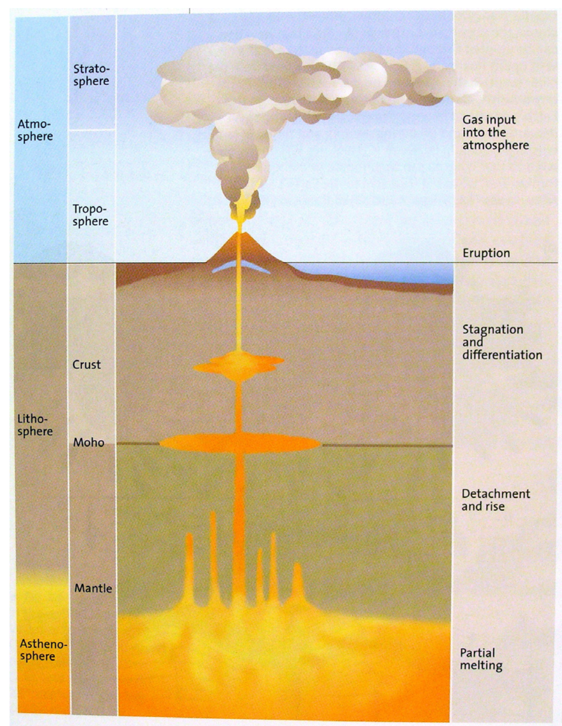


Fuego and Earth Tides



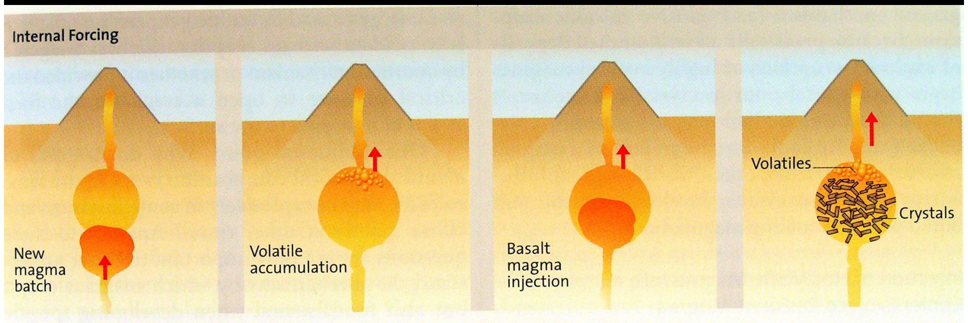
Fuego is known to respond to earth tidal variations during its open vent conditions.



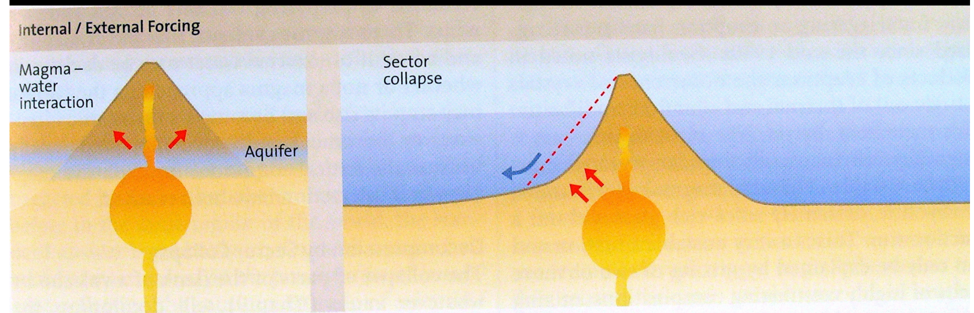


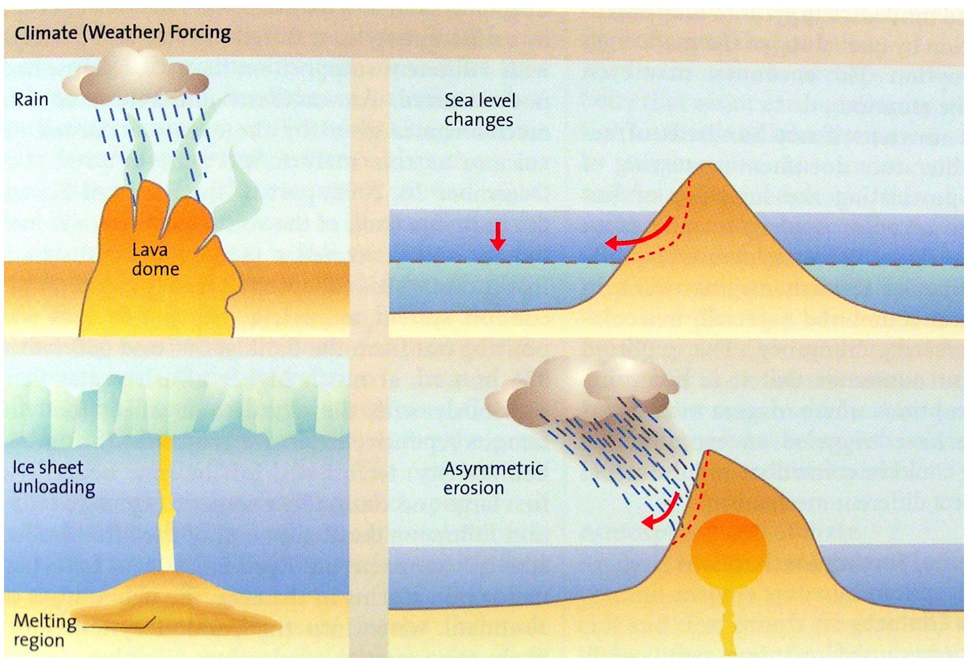
Visualizing the subsurface of volcanoes

Triggers from internal forcing



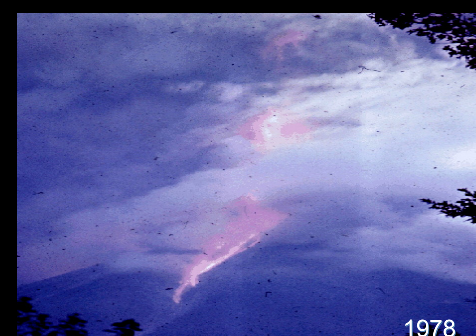
Triggers from external/internal forcing





Fuego's open vent activity may change from "vulcanian" to "strombolian"

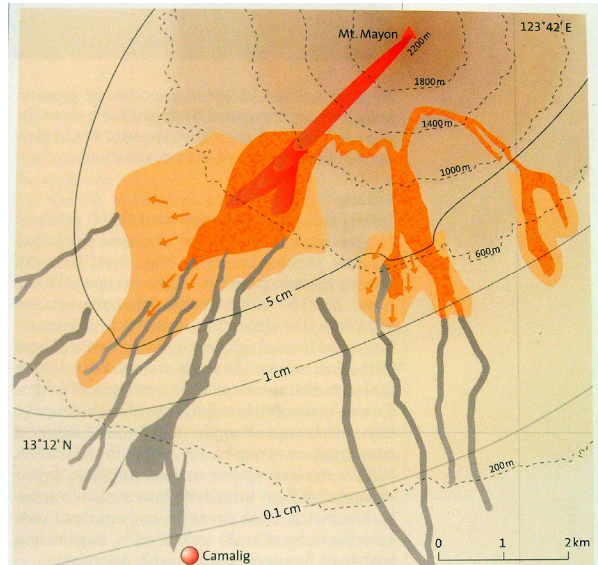
Jan 2003



8 Jan 2004

A strombolian eruption generated a 5 km long spatter fed lava flow

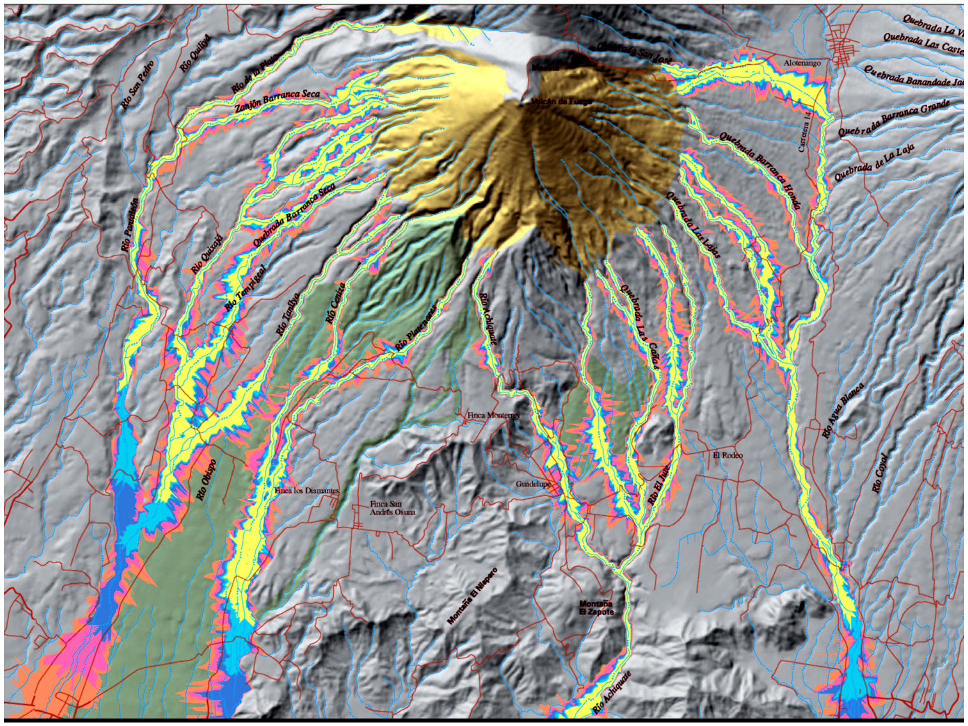
This change could reflect a widening vent, which affects the eruptive style

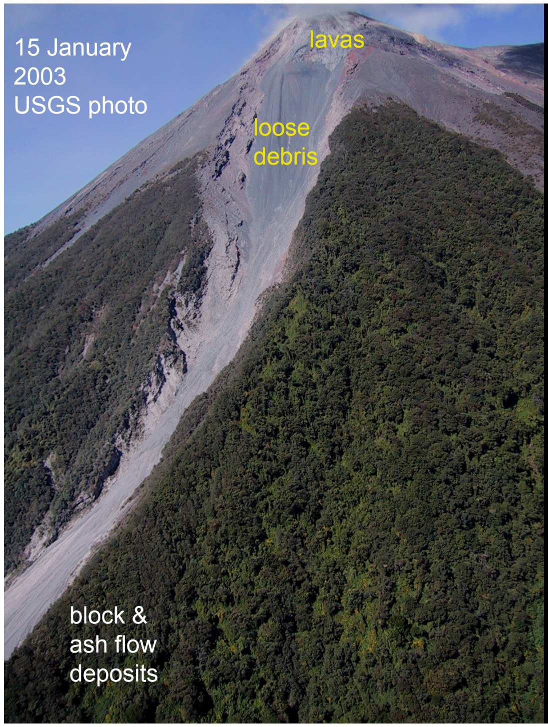


▲ Fig. 13.4. Typical areal distribution of four different types of products of a major explosive volcanic eruption: (a) Lava flows restricted to the upper part of a volcanic cone; (b) pyroclastic flows extending to the foot of a volcano; (c) lahars continuing into the foreland (d) more widely distributed fallout tephra. Eruption of Mount Mayon (Philippines) in 1968 (232)

Accumulation of pyroclastic flow deposits on steep upper flanks of Fuego threatens the barrancas downslope because mudflows will be triggered by heavy rains when the rainy season comes

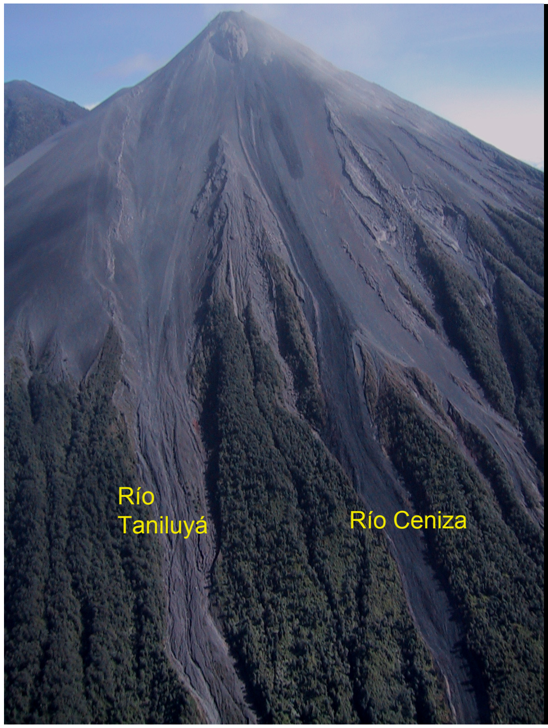
15 January 2003
USGS photo





Recurrent issue, related to seasonal rains

Lahars expected from Fuego beginning late April, when rains begin

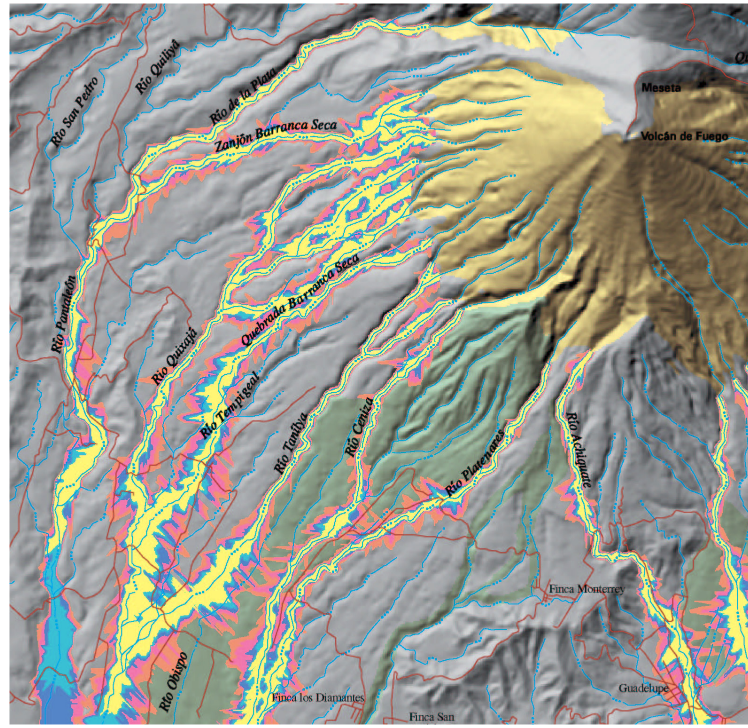


Substantial masses of loose materials lie on the steep the SW and W slopes of Fuego also.

15 January 2003
USGS photo

Accumulation of fragmental materials is more abundant in Las Lajas and El Jute than in Barranca Honda

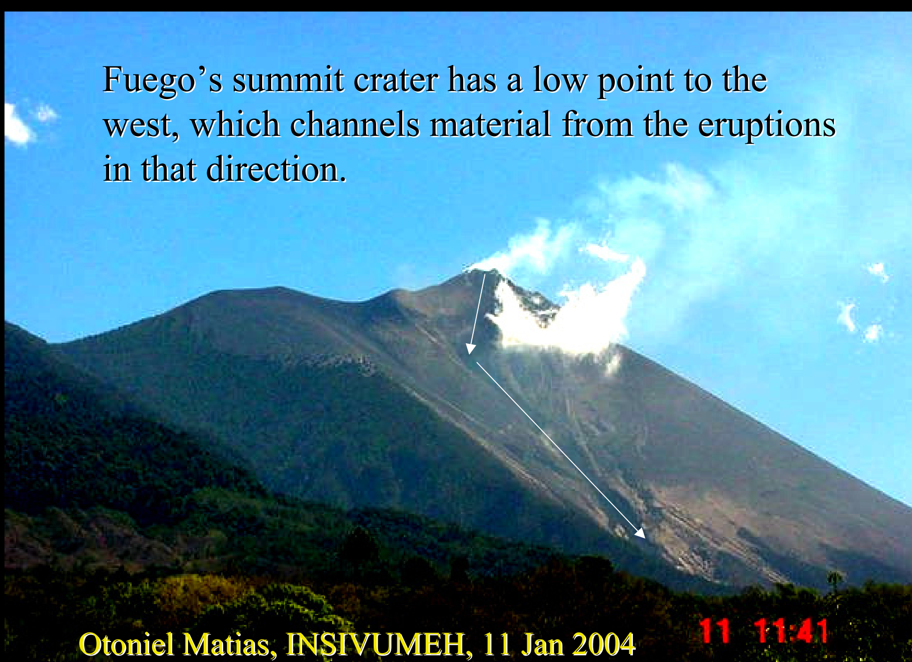
15 January 2003
USGS photo



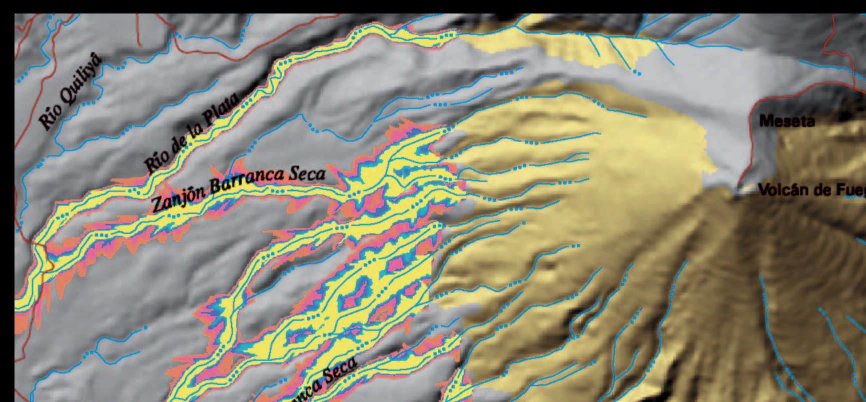
Lahar hazards of Fuego Volcano

USGS Open File Report 01-431

Vallance, Schilling, Matias, Rose & Howell, 2001



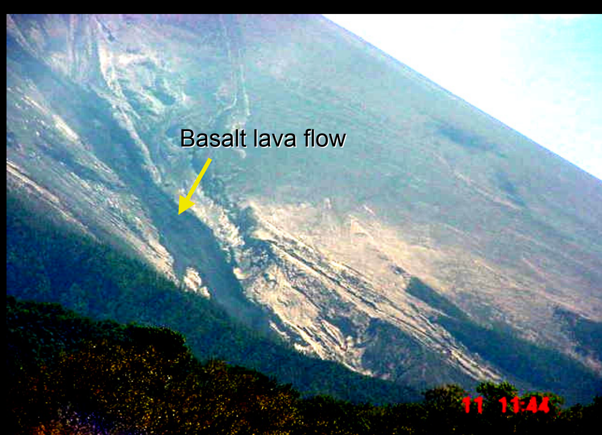
Current focus on Zanjon Barranca Seca, west flank of Fuego



Pyroclastic flows filled barrancas west of Fuego, July 2003

Heavy rain on block & ash flow leads to "Lahar" = volcanic mudflow

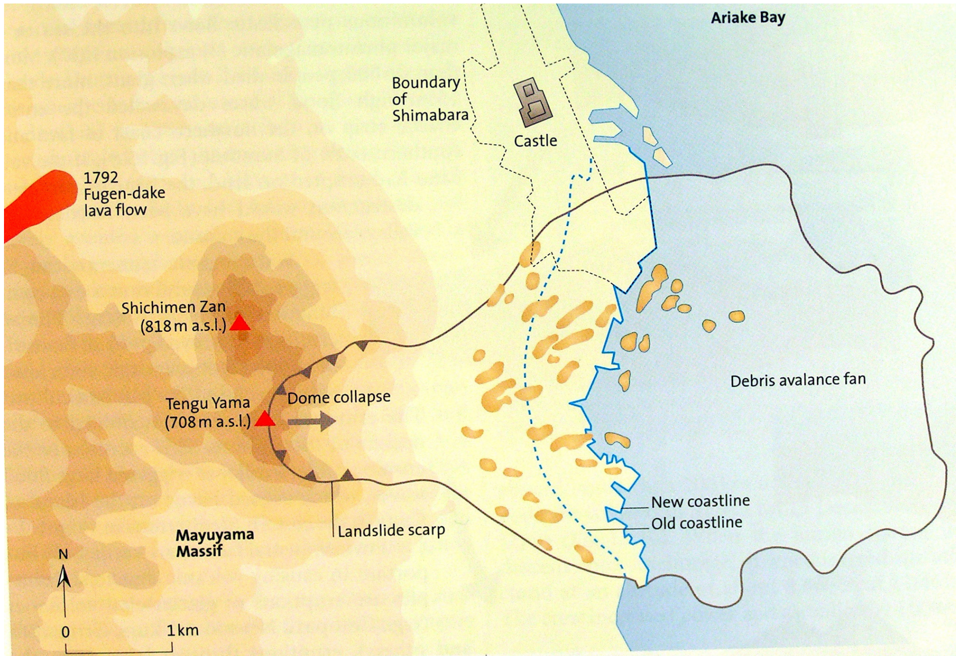
Channels on west slope of Fuego filled with lava flow 5 km long, Jan 2004

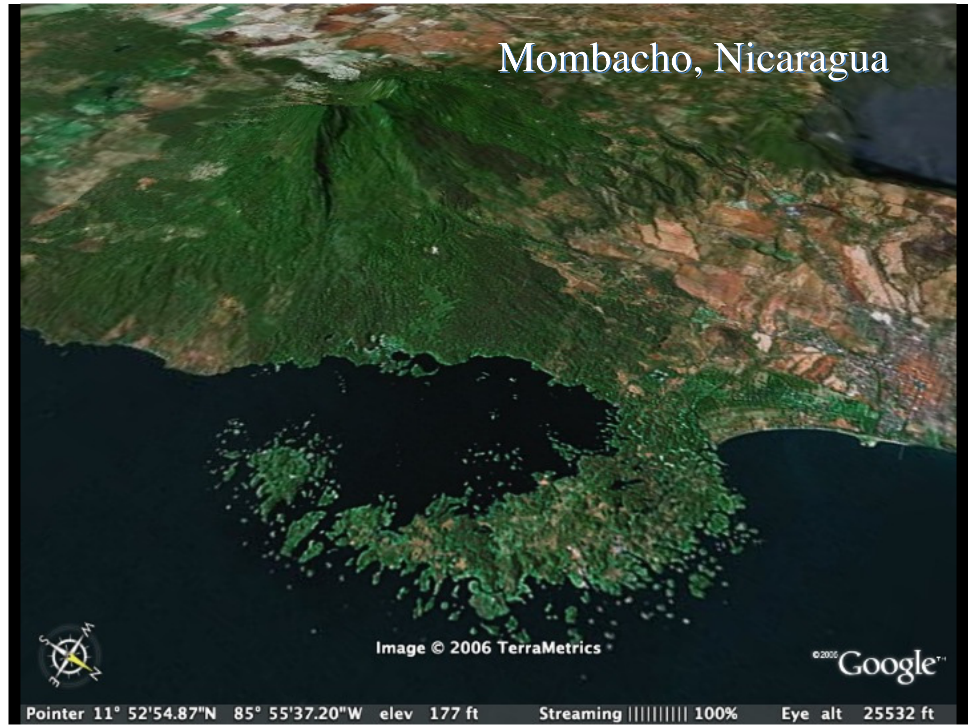


Otoniel Matias, INSIVUMEH, 11 Jan 2004

Fuego future

- ash eruptions and associated ashfalls
- Spatter fed lava flows
- Block & ash flows from ash events and from lava flows on steep slopes
- accumulations of fragmental materials will lead to destructive lahars
- activity is most likely to be at a low level
- regular observations and measurements to detect changes are very important





Guatemalan volcanoes include 3 continuously active centers, Santa María (Santiaguito), Fuego and Pacaya. But that is NOT all!

These volcanoes are important foci for study of volatile emissions, but we must face issues of how to obtain data on inactive vents…

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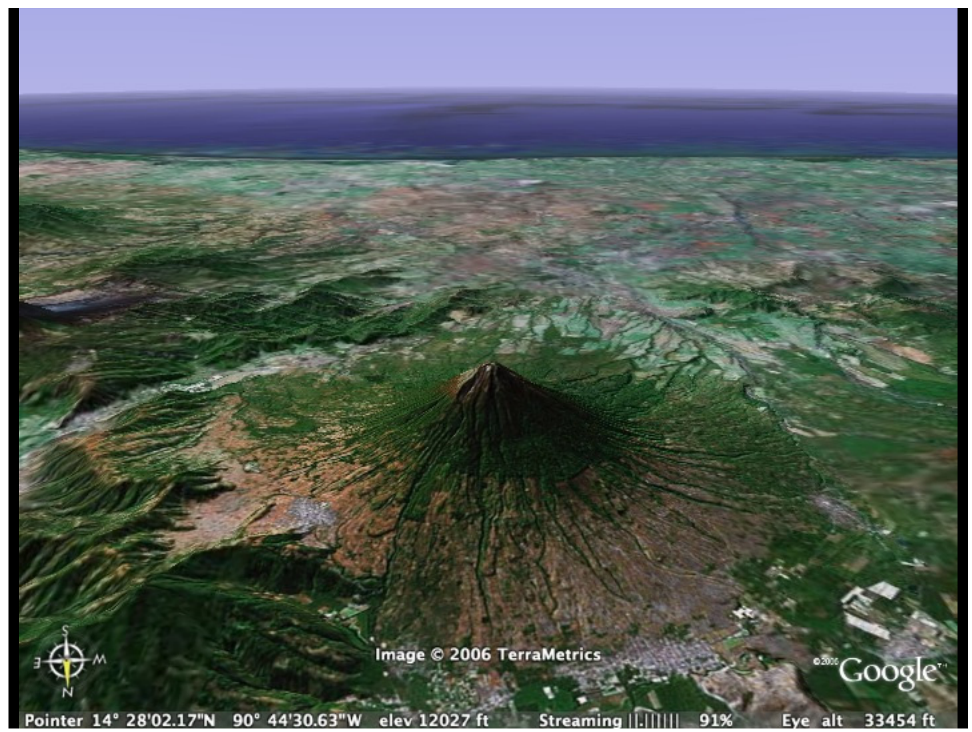

Pacaya, Guatemala

- Continuously active since 1965
- Porphyritic Hi Al Basalt, variable MgO
- Highly variable degassing
- Large gravity anomalies
- Collapse features
- Hazards need attention

Summary of 1965-2006 activity underway to encourage visiting scientists to study this dynamic volcano

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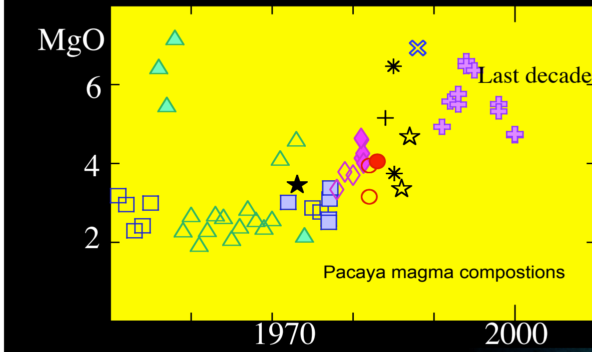

Pacaya basaltic fountaining, flows: 1965-2001

Magma body near surface, open vent

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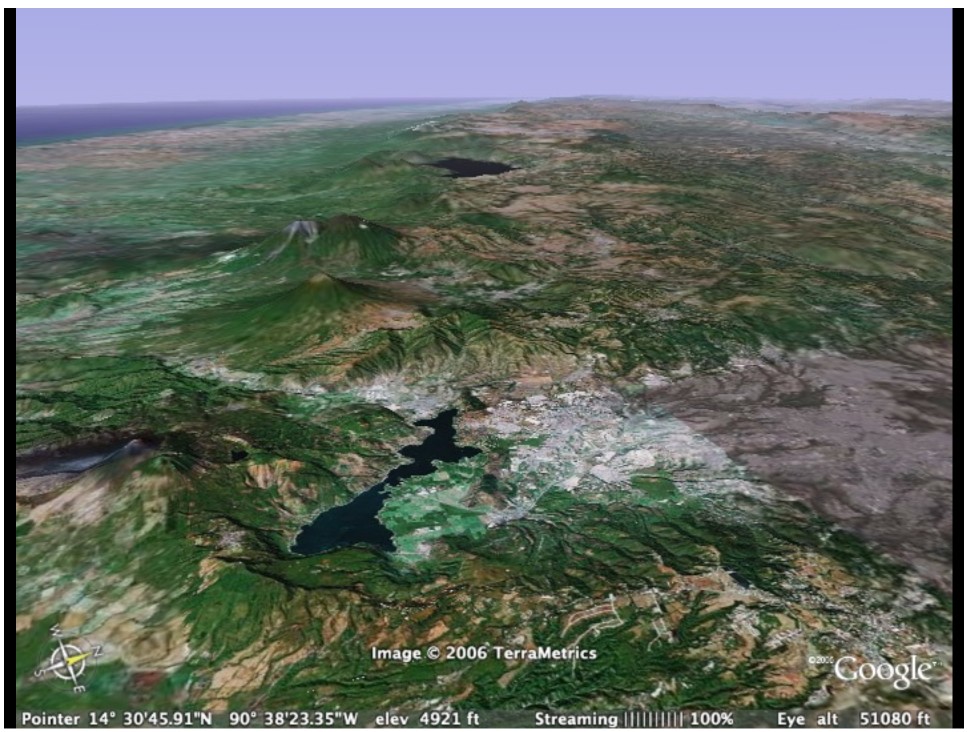

El Salvador has many accessible volcanoes, but a paucity of real volcanic activity in the last century or more. A sleeper for volcanic hazards, there is a dense population, living in remarkably hazardous locations. How can we devise a strategy for measuring volatile flux?

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