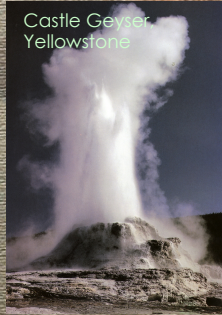


## Topic 10: EQs and Volcanoes in Western North America

Castle Geyser  
Yellowstone



<https://geowiki.ucsd.edu/sio15>

Canvas test 3 (Monday): **includes HW1!**

San Francisco EQ, 1906



Mt. St. Helens (May 18, 1980)

## in-person Beachwalk

<https://geowiki.ucsd.edu/sio15>

sign-up for in-person beachwalk **group 1**  
**closes at 5 pm today**

### Beachwalks

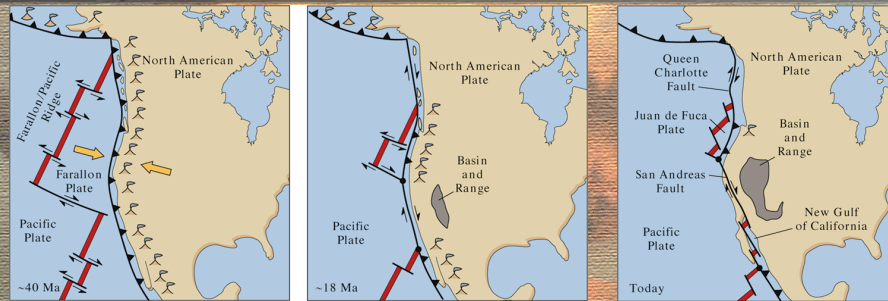
- Sat 10/19 1:00 pm
- Sat 10/19 1:30 pm
- Sun 10/20 2:00 pm
- Sun 10/20 2:30 pm

**please watch beachwalk prep video!**

**bring writing utensils, hat, water!!**



## History of the North America Plate Boundary



> 30 M yrs: subduction of Farallon plate  
 ~ 30 M yrs: ridge reached continent; SAF  
 < 30 M yrs: subduction of Juan de Fuca;  
 plate shear → Basin & Range  
 ~ 17 M yrs: opening of Gulf of California

S.D. on N. America p.

“  
 “

S.D. on Pacific plate  
 moves north resp. N.A.

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## The North America – Pacific Plate Boundary



North:

- Subduction along Cascade Trench (Cascadia)
- tsunami quakes
- Juan de Fuca Plate subducting
- Mendocino Triple Junction

middle: SAF

- transform boundary
- right-lateral strike-slip EQs
- SAF Big Bend/oblique stress
- reverse (and even thrust) EQs

South:

- Gulf of California
- ocean spreading

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## Cascadia

- some history of local seismicity in Seattle/Tacoma area
- no recorded history of megathrust EQ
- 1700 orphan tsunami in Japan has no corresponding local EQ
- Native American lore ?
- 1990s exploration of "Cascadia ghost forest"



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## Cascadia

- some history of local seismicity in Seattle/Tacoma area
- no recorded history of megathrust EQ
- 1700 orphan tsunami in Japan has no corresponding local EQ ->  $M_w=9.0$  in Cascadia
- complex aseismic slip and episodic tremors (GPS and seismometers)

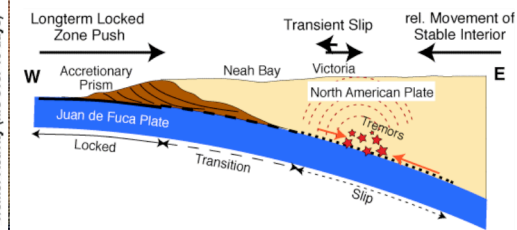
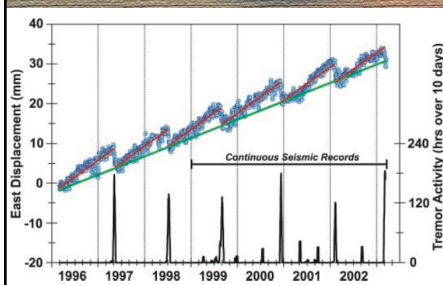


Fig. 5.21

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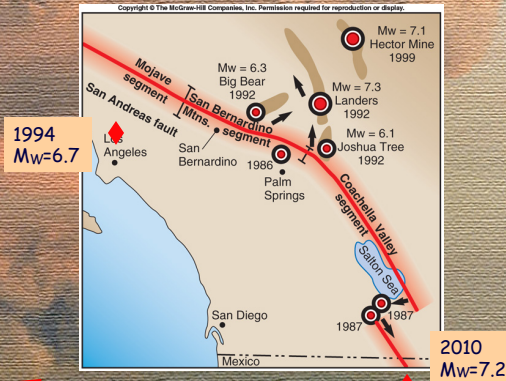
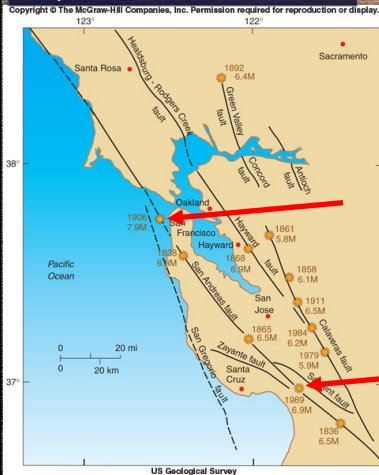


# The SAF and its Neighbors

EQs not only on SAF

north:  
Hayward, Calaveras, etc

south: Johnson Valley (92 Landers),  
Pico thrust (94 Northridge), etc



middle:  
2003 San Simeon EQ  
2004 Parkfield

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# The SAF and its Neighbors

last major EQ on SAF:  
Loma Prieta 1989

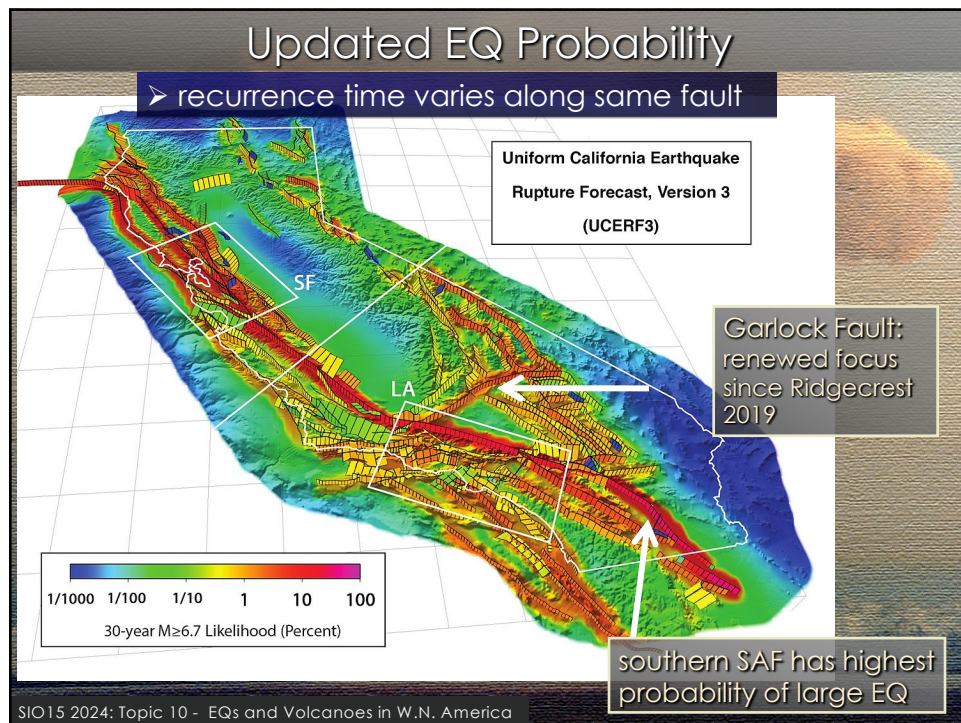
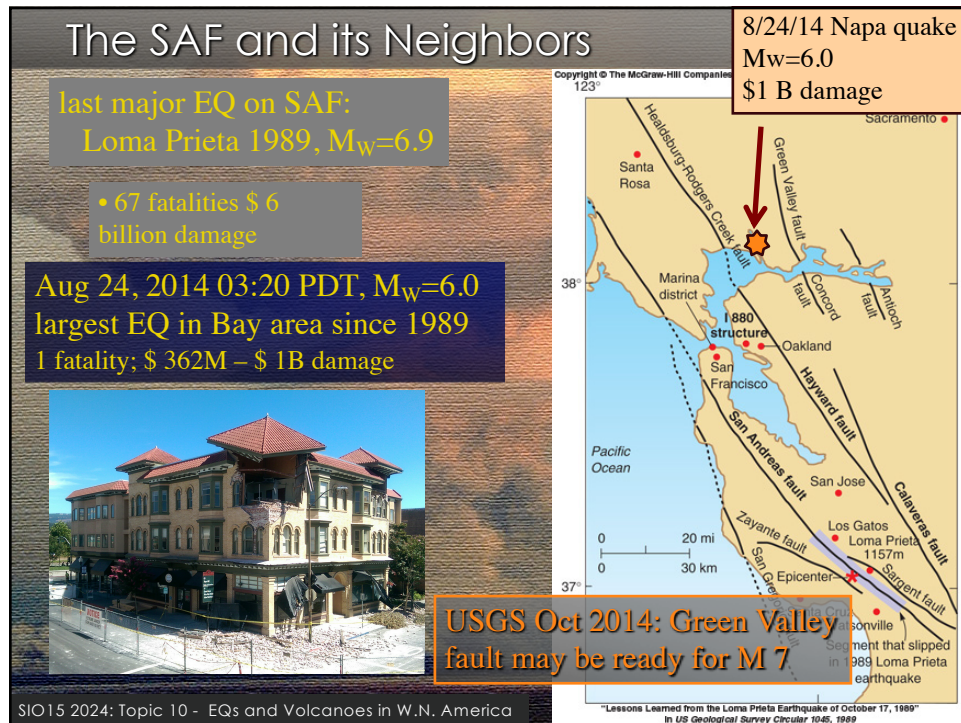
liquefaction!

- $M_W=6.9$
  - ~ 70km south of S.F.
  - 42km long rupture
  - southern segment of 1906
  - located in seismic gap (other sections crept)
- 
- 67 fatalities
  - 3757 injured
  - 12,000 homeless
  - landslides
  - \$ 6 billion damage
  - first EQ broadcast live !!



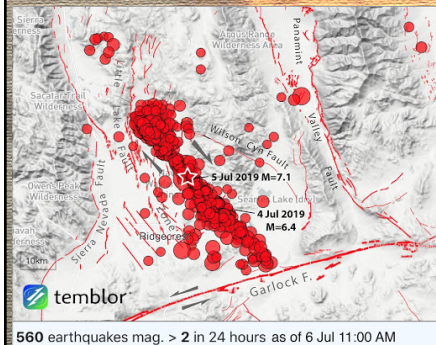
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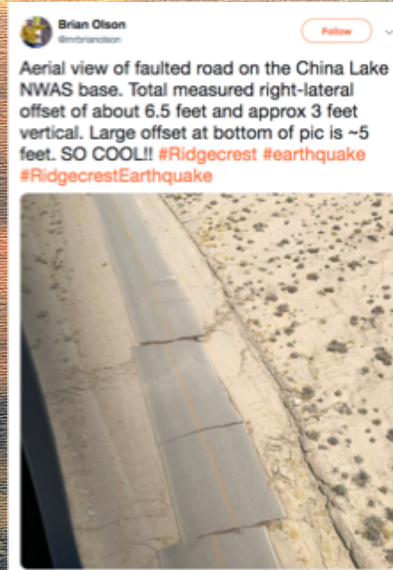


## Ridgecrest July 4,5<sup>th</sup> 2019



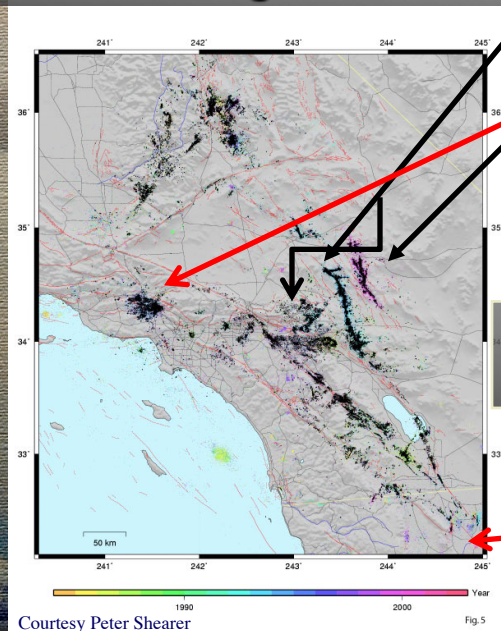
7/4 M=6.4  
aftershocks in the south  
7/5 M=7.1 in the north

InSAR/GPS: creep on the Garlock  
far field vs on the fault  
what does this mean for LA?



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## Zooming in on SoCal and San Diego



- Landers/Big Bear 1992 (Mw=7.3/6.5)
- Northridge 1994 (Mw=6.7)
- Hector Mine 1999 (Mw=7.1)

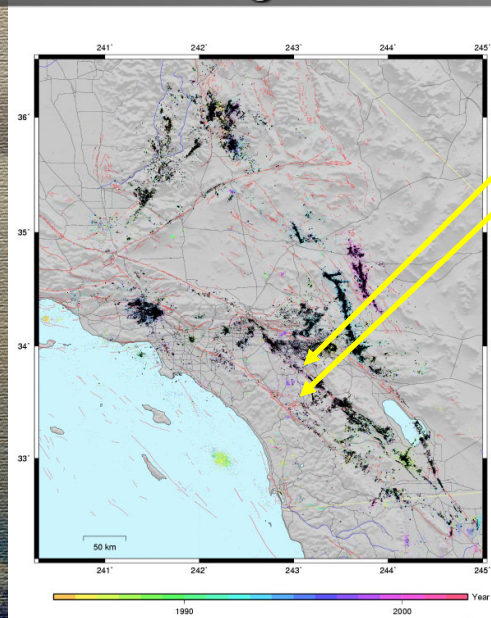
- quiescent SAF east of Salton Sea
- seismicity picks up farther south
- INSAR suggests: SAF ready!

Laguna Salada  
map pre-dates  
2010 Easter M=7.2 Easter EQ

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## Zooming in on SoCal and San Diego



Courtesy Peter Shearer

Fig. 5

### SAN DIEGO COUNTY

- San Jacinto Fault
- Elsinore Fault

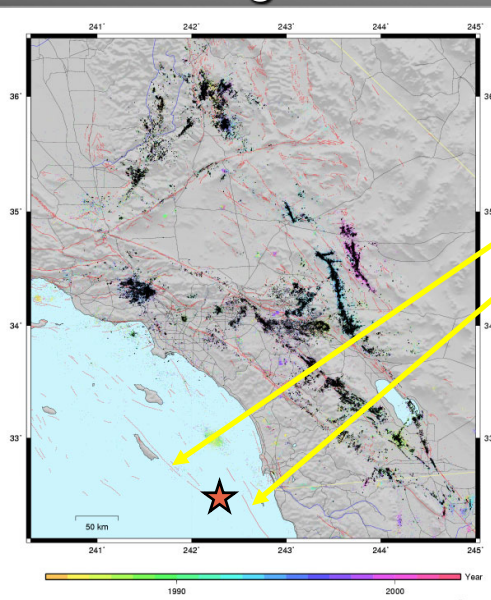
### SAN JACINTO:

- most active fault in county
- M 6 recurrence time: 8-12 yrs
- last EQ: 1987 – 31 years ago!

### SJF:

- 1/12/22 M3.9 south
- 1/17/22 M3.5 north

## Zooming in on SoCal and San Diego



Courtesy Peter Shearer

Fig. 5

### SAN DIEGO:

- sparse seismicity
- but active faults exist!

### off-shore faults:

- San Clemente Fault
- San Diego Trough Fault
- Coronado Bank Fault

### SAN CLEMENTE:

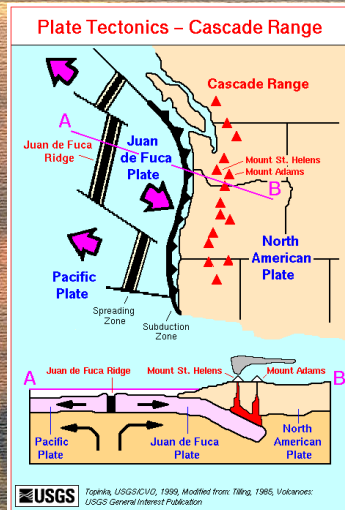
- M 6.5 in 1800?
- M 5.9 in 1951
- M 5.2 on 15 June 2004
- intensity V shaking in S.D.

RCF/Newport Inglewood?  
M7?? -> Beachwalk!

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## The Hazardous Cascade Volcanoes

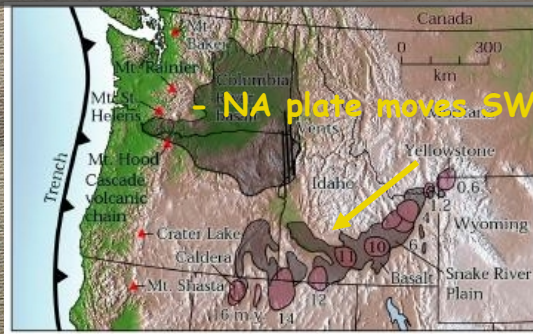


✧ some are active  
✧ some are dormant

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<http://vulcan.wr.usgs.gov>

## Columbia River - Yellowstone

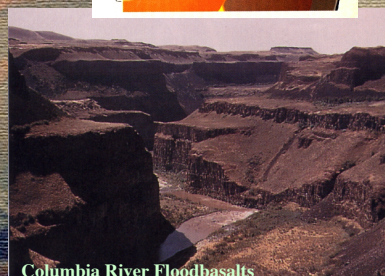
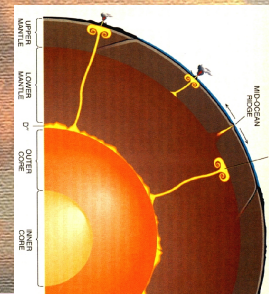


- Yellowstone started ~ 16 M yrs ago
- hotspot track on Snake River Plain
- last caldera 630,000 yrs ago

### Flood Basalts/Large Igneous Provinces

- when hotspots have a lot of melt (10%)
- associated with rifting?

### Hotspots/Mantle Plumes





## Supervolcano Yellowstone -2024

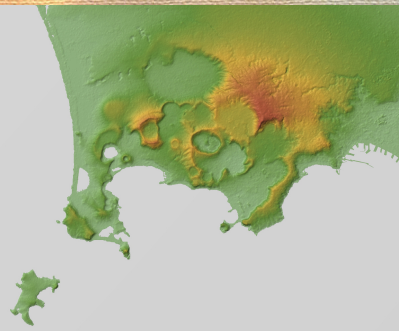
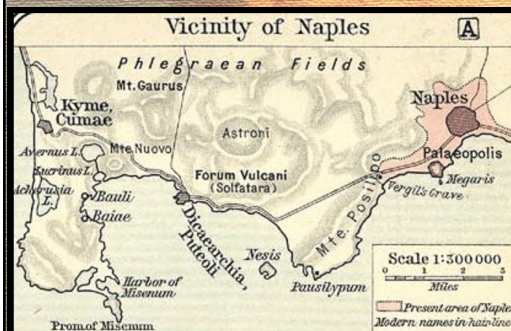
7/23/24 Biscuit Basin eruption  
hydrothermal, not volcanic explosion  
grapefruit-sized rocks  
closed for remainder of year



source: NPS.gov

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## Supervolcano Phlegraean Fields, Italy – HW3



'acting up since 2023'

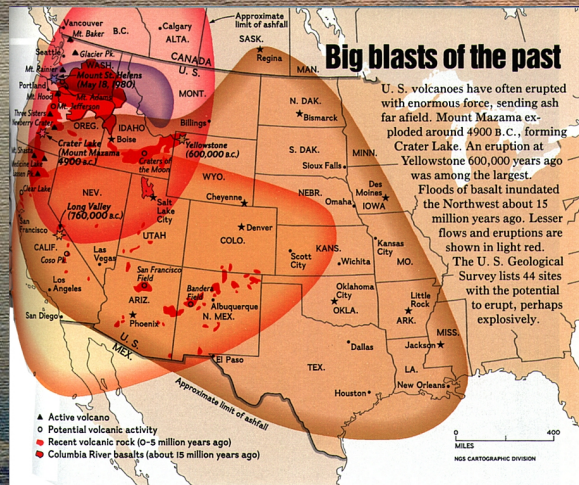
recurring episodes of tremors & EQs  
resurging caldera  
NAPLES (1M people)  
last eruption: 1538

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## The Last Yellowstone Eruption

Yellowstone 630,000 yrs ago  
VEI 8



Mt. St. Helens 1980  
VEI 5

Mt. Mazama 4900 B.C.  
VEI 7

Long Valley 760,000 B.C.  
VEI 7

compare: Tambora 1815  
“year without summer”  
VEI 7 (Lecture 8)

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## The Hazardous Cascade Volcanoes

### Potentially Active Volcanoes of Western United States



Mt. Rainier (4,400 m):  
✧ tallest Cascade volcano  
✧ ice cap → lahars  
✧ had traveled 120 km in past (now home to 100,000)  
✧ last eruption: 1894  
✧ now a “decade volcano”

Mt. Rainier

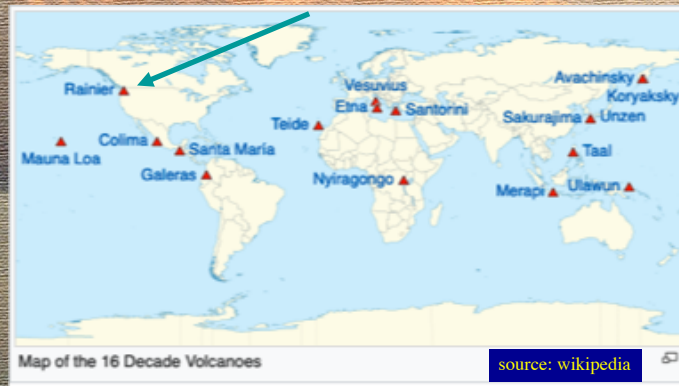


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<http://vulcan.wr.usgs.gov>



## The 16 Decade Volcanoes



IAVCEI:  
International Association  
of Volcanology and  
Chemistry  
of the Earth's Interior

**Decade Volcano**  
-worthy of particular study  
-history of large eruptions  
-proximity to populated areas

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## The Hazardous Cascade Volcanoes



**Mt. Shasta:**  
✧second tallest Cascade volcano  
✧most voluminous  
✧“currently not active”  
✧11 eruptions in last 3400 yrs  
✧lahars threaten 3 towns

Mt. Shasta



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<http://vulcan.wr.usgs.gov>



## The Hazardous Cascade Volcanoes



Mt. St. Helens:

- ✧ most active Cascade volcano
- ✧ can be dormant for 1000s of yrs
- ✧ not active since 1857



Mt. St. Helens, 1980

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<http://vulcan.wr.usgs.gov>

## Mt. St. Helens 1980/Watching a Disaster Unfold



- a “small” EQ 20 Mar 1980 (M 4.2)
- seismicity was then monitored
- 27 Mar: steam (phreatic), volcanic ash, explosions
- roadblock
- seismicity died out by early April

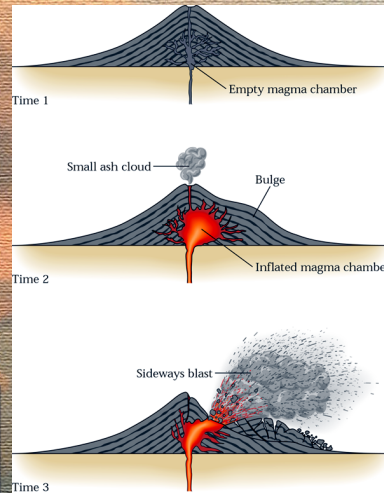
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## Mt. St. Helens 1980/Watching a Disaster Unfold

- bulge on N flank by mid-April
- continuous geodetic survey
- check ground water chemistry/fumaroles
- 10 May: scientists concerned
- ...roadblocks ... residents allowed in ...

- May 18, 8:30am complex earthquake (M=5.1)
- possibly triggering landslide
- VEI 5



1883 Krakatau may also have erupted like this (VEI 6)

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## Mt. St. Helens 1980/Watching a Disaster Unfold



before



after

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## Mt. St. Helens 1980/The Consequences

- ash fall into Montana
- small lava flow
- pyroclastic flow (directed blast)
- lahars (clogged Columbia River)
- 57 people died



Harry Truman



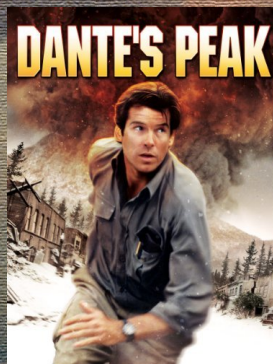
David Johnston



2 more people  
on geowiki

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available on Youtube (from 1997)  
...close your eyes and you see  
Mt. St. Helens!  
(producer was a geologist)



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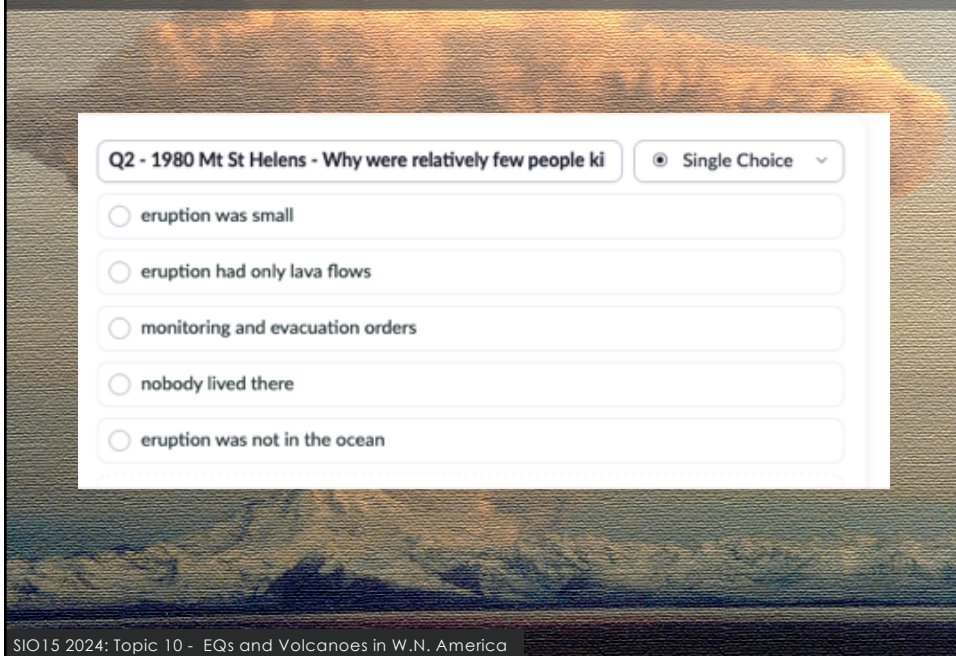


## Poll



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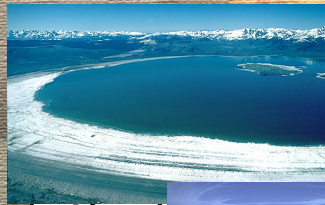
## Poll



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## Mammoth, the USGS and Politics



### Long Valley Caldera

- 760,000 yrs ago
- activity intermittent (< 1000 yrs)
- Mono Lake 150-250 yrs ago
- geothermal activity

### 25/26 May 1980:

- increase seismicity (four M 6)
- damage in Mammoth
- caldera floor uplift 10 in

### 1982:

- new seismicity, fumaroles
- 27 May: USGS considers "Notice of Potential Volc. Hazard"
- press leak
- real estate fell 40% overnight
- tourism dropped

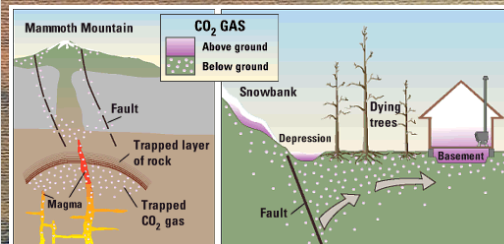
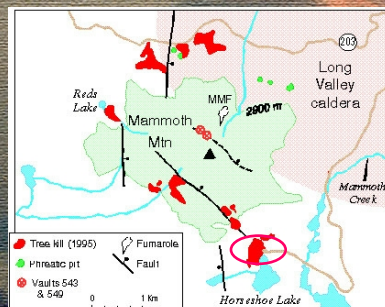


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## Mammoth and Monitoring Volcanism



- tremors and seismicity
- geodetic survey (tilt, GPS, laser)
- chemical analysis of ground water
- fumarole activity/chemistry
- above/below ground CO<sub>2</sub> emission (basements/tree kill)
- remote sensing/satellites/INSAR



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