Muon radiography to investigate and to understand the shallow volcanic processes

Jean-François LÉNAT
on behalf of the TOMUVOL Collaboration
http://www.tomuvol.fr/

Laboratoire Magmas et Volcans, Laboratoire de Physique Corpusculaire, Clermont-Ferrand, France
Institut de Physique Nucléaire de Lyon, France

Volcanic unrest

Magma and/or heat and fluids upward migration

➔ generates

- Seismic activity
- Deformation
- Hydrothermal activity
- Density changes
- Electrical resistivity changes
- Electric and EM fields changes
- …

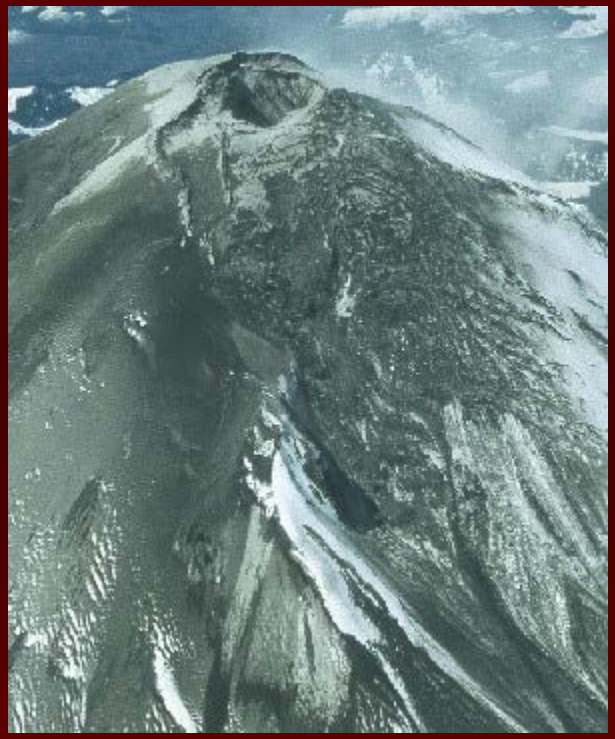
Can muons monitoring help to track these internal processes ?

The example of the 1980 crisis at Mount ST Helens (USA)

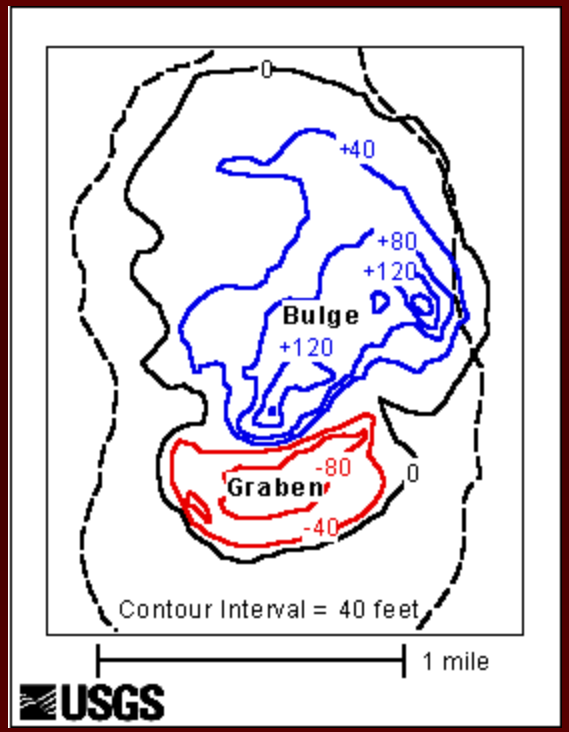
- The first sign of activity on March 16 1980 (a series of small earthquakes).

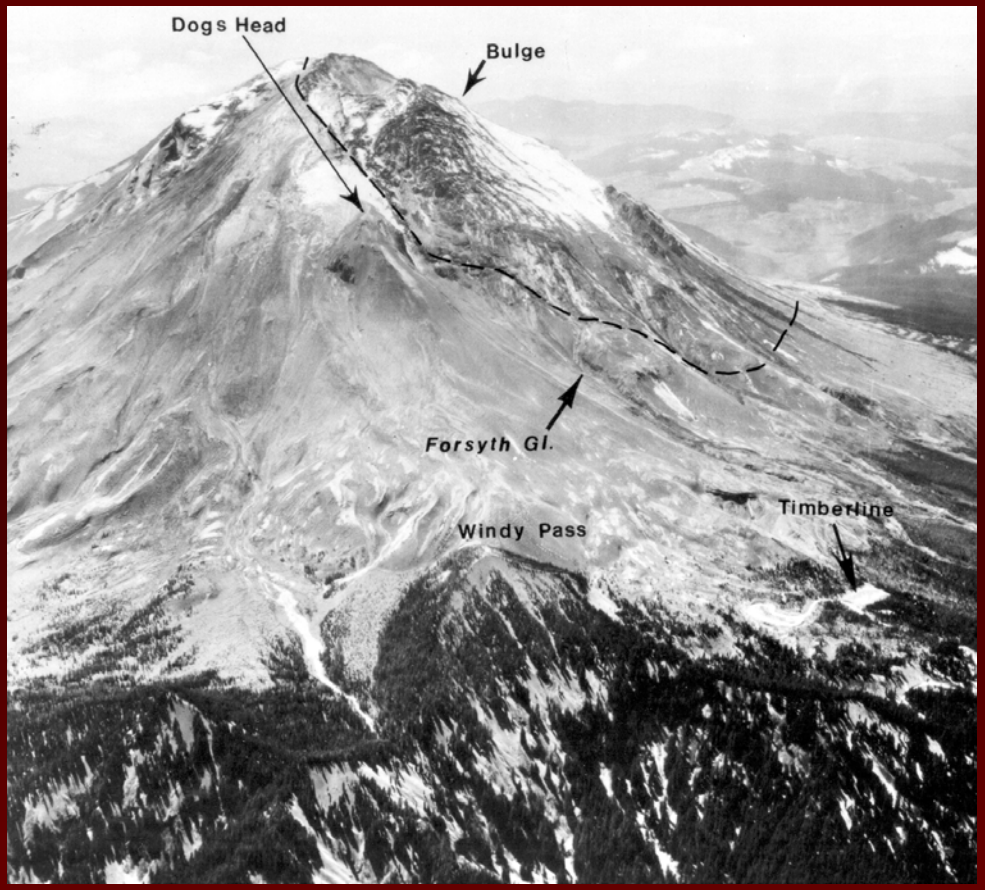
- Steam explosions on March 27 blasted a crater

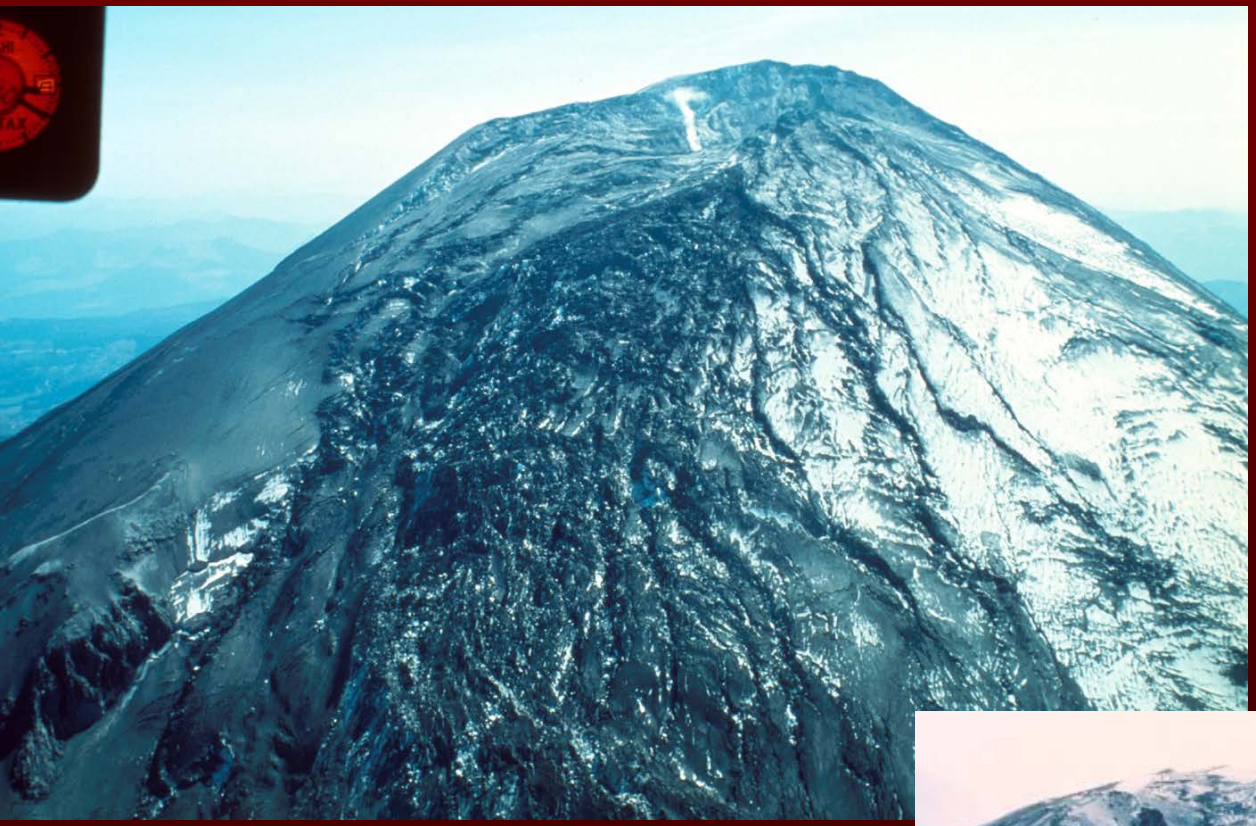
Within a week the crater had grown to about 400 m in diameter and two giant crack systems crossed the entire summit area.



The north flank grown outward at least 135 m to form a noticeable bulge



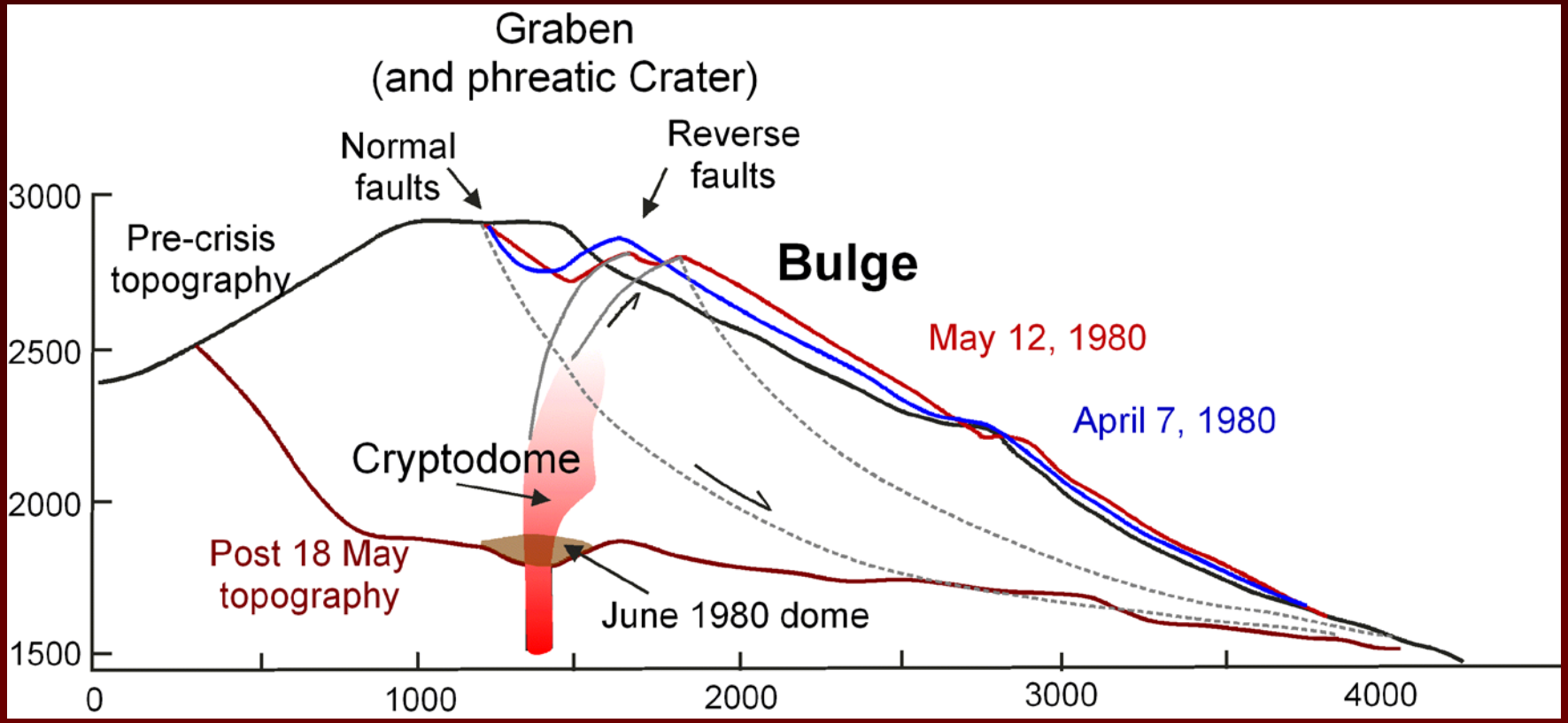





USGS

Cataclysmic eruption on May 18, 1980

The dramatic deformation of the volcano was strong evidence that molten rock (magma) had risen high into the volcano



What muon imagery would detect in a similar crisis ?

- A cone of this dimension is well suited for muon monitoring

- Because of the evident risks to work in the field during this type of crisis, remote sensing methods are very appropriated

- **Different sources for dynamic density changes can be anticipated :**

(1) Emplacement of a magma intrusion **denser** than the mostly pyroclastite material that built the cone

(2) Modification or creation of a shallow hydrothermal system (more liquid → d ↗; more gases → d ↘)

(3) Faulting and deformation of the bulge → probably d ↘

(4) Changes in the topography (crater, collapse, …)