Vulcano's Fumaroles and Geochemical Monitoring of Volcanoes

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1. What Are Fumaroles?

- holes in the ground where hot gas comes out
- gas comes out of the magma chamber (where differentiation occurs)
- fumarole + groundwater
 = geyser



2.1 Gas Composition

- composition:
 - H₂O (35%-90%)
 - CO₂ (5%-50%)
 - SO₂ (2%-30%)
 - HCI
 - $-H_2S$
- the atmosphere and hydrosphere are of volcanic origin

2.2 Influences on Solubility

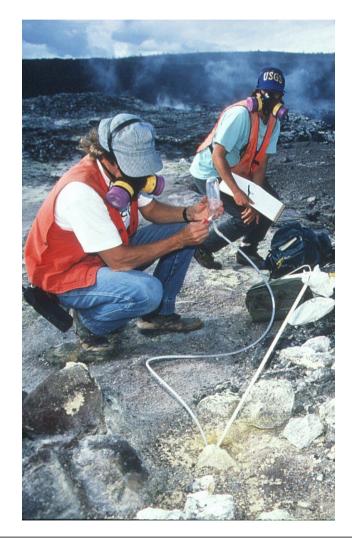
- solubility in the magma depends on:
 - pressure
 - temperature
 - viscosity
 - chemical structure
- saturated magma \Rightarrow gas is released
- release order: CO₂, S, CI, H₂O, F

3.1 Monitoring: Why?

- to understand what happens in the magma chamber
- eruption warnings
 - geophysical methods are more common
 - several methods are combined
- volcanic gas itself can be a danger
 - Lake Nyos (Cameroun, 1986, CO₂), 1700 fatalities (suffocation)
 - Dieng Plateau (Java, CO₂)
 - Laki (Iceland, 1783, HF), >10000 fatalities (famine)

3.2 Monitoring: How?

- Continuous Monitoring:
 - only few types of gas
 - shortage of energy (clouds!)
 - maintenance required
 - measuring interval must be short
- Laboratory Analysis:
 - more exact
 - not realtime
 - not regularly
 - somewhat dangerous



3.3 Measuring Methods

- gas chromatography, ion chromatography
- mass spectrometer
- chemically selective sensors
- optical methods:
 - COSPEC (COrrelation SPECtroscopy): SO₂ measurement by UV absorption
 - FTIR (Fourier Transform InfraRed spectroscopy): CO₂ measurement with an interferometer
 - LIDAR (light detection and ranging): measurement of light scattering with different wavelengths (DIAL, DIfferential Absorption Lidar)

3.4 Patterns for Volcanic Activity

- appearance of fumaroles in general
- rising gas temperature
- shift of the chemical equilibrium:
 - rise of the ratio F/CI and NH_4/B (= higher pressure)
 - decrease of CI/S
 - more CO_2
 - more HCI
- other atypical things like oscillation of concentration

3.5 Examples for Monitoring

- Colombia: Galeras
- Indonesia: Merapi (Java)
- France: Soufrière (Guadeloupe), Pelée (Martinique), Piton de la Fournaise (Réunion)
- USA: Kilauea (Hawaii)
- Japan: Mt Mihara
 - increase of F, CI, S between 17th and 30th of July 1957, eruption on 5th and 6th of August
 - ditto in the beginning of October 1957, eruption on October 13th

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4. Fumaroles on Vulcano





References

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