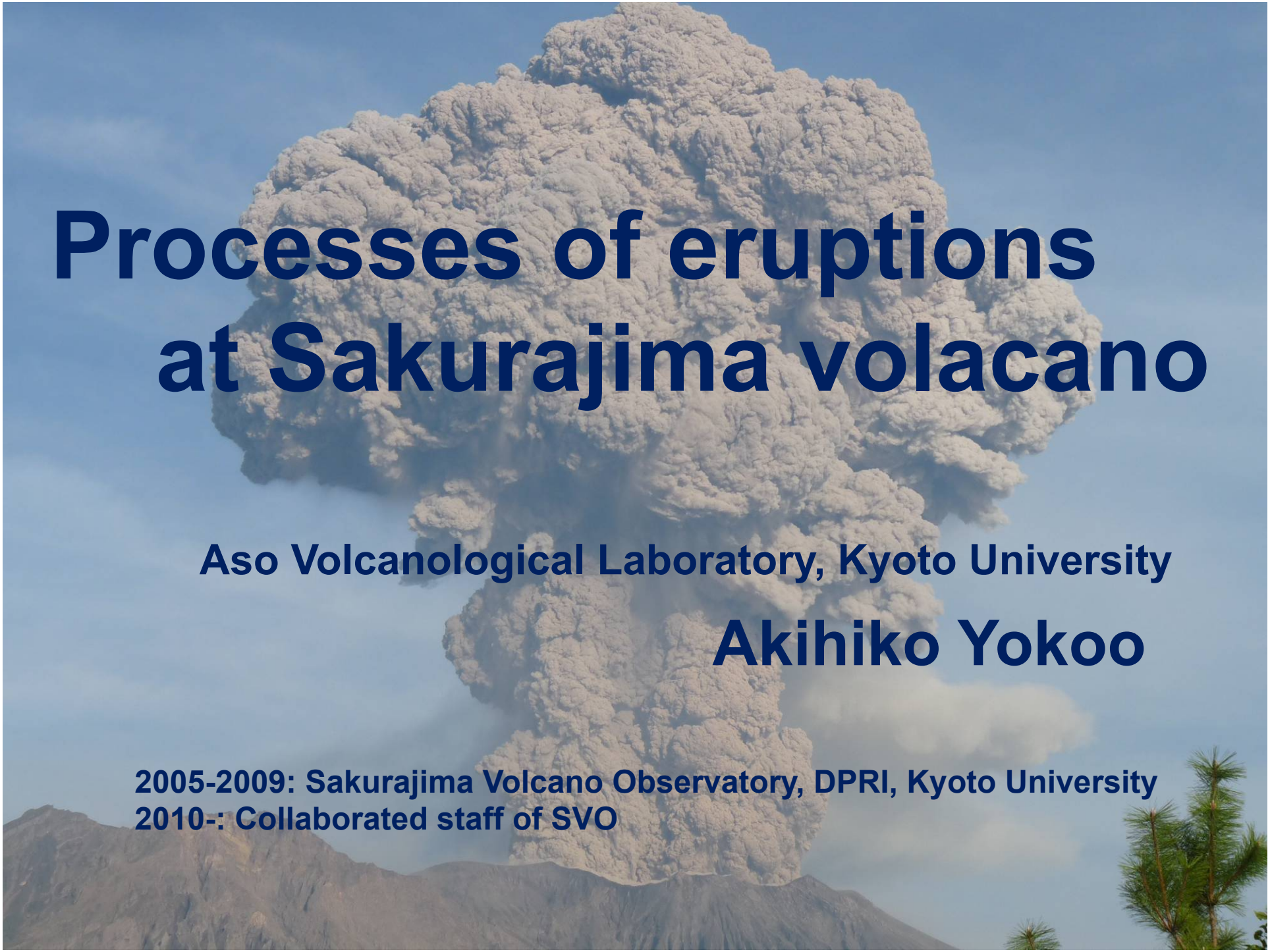

Processes of eruptions at Sakurajima volacano

Aso Volcanological Laboratory, Kyoto University

Akihiko Yokoo

2005-2009: Sakurajima Volcano Observatory, DPRI, Kyoto University
2010-: Collaborated staff of SVO

Article

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Processes Prior to Outbursts of Vulcanian Eruption at Showa Crater of Sakurajima Volcano

Akihiko Yokoo[*,**], Masato Iguchi[**], Takeshi Tameguri[**] and Keigo Yamamoto[**]

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Showa crater of Sakurajima volcano became active in June 2006 after 58 years of quiescence. From multi-parametric geophysical observations, we have identified the processes that typically occur prior to an explosive eruption at the crater. A few hours prior to the onset of an eruption, magma starts to migrate and accumulates at a depth of about 1 km. This accumulation of magma can be clearly observed in strain change records as an inflation process. Several tens of minutes prior to an eruption, the SO_2 gas emission rate gradually decreases, indicating that a sealing process is taking place in the crater bottom as the eruption nears. During the same time period, the volcano's inflation rate starts to accelerate due to the formation of a plug above the conduit that prevents the gas from escaping, with the result that a gas pocket forms beneath the crater. In nighttime events, a volcanic glow is also seen, which weakens and then disappears. A few minutes prior to an eruption, a small tremor starts to occur. Its amplitude grows as the strain changes from inflation to deflation as the stored gas is released through new fractures within the plug that had been confining the gas pocket, leading to a minor depressurization in the conduit. Then, an expansion process starts, that could explain seismically the first motion of an explosion earthquake. This is probably when the effect of depressurization downward from the crater bottom reaches the magma head and a sudden magma expansion with degassing starts. After a short period (about half a second), this expanding magma rises and pushes the gas pocket upward, leading to a swelling of the crater ground along with the radiation of the preceding phase of infrasound waves, and then a breakup occurs. After the plug fails due to deformation, the accumulated gasses and expanding magma are ejected together from the crater as the surface eruption phenomena starts.

Key words: Vulcanian eruption, eruption process, Sakurajima volcano, Showa crater

1. Introduction

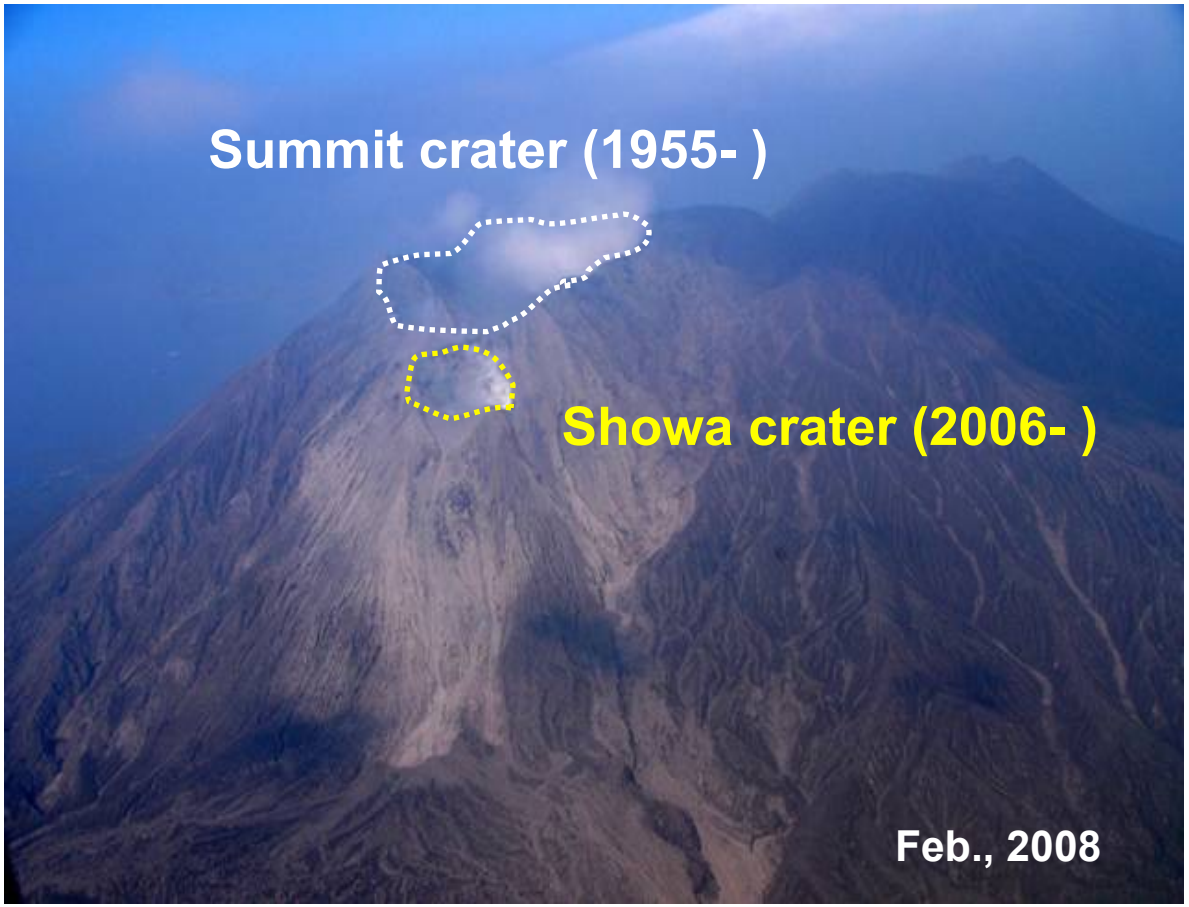
Recent interdisciplinary and multi-parametric observations are attempting to elicit in detail the volcanic eruption processes at several active volcanoes including Stromboli, Italy (Calvari *et al.*, 2008) and Soufrière Hills, Montserrat (Voight and Sparks, 2010).

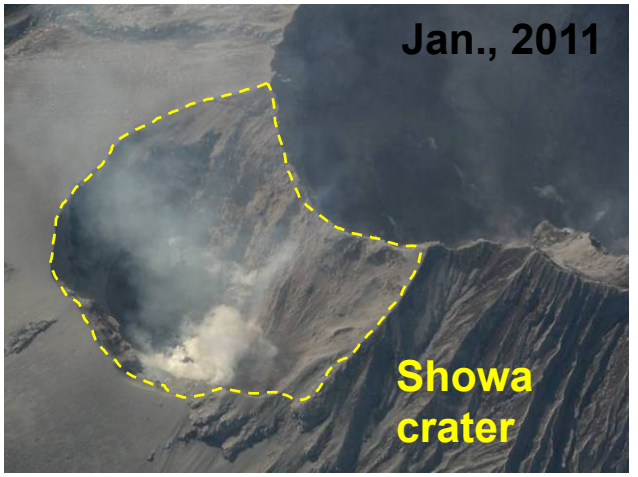
mentioned as occurring at the Soufrière Hills volcano (Burgisser *et al.*, 2011). This zone is covered by a dense and strongly degassed plug a few tens of meters thick.

When the accumulated pressure inside the gas pocket exceeds the strength of the plug as gas accumulates, a failure of a tiny part of the plug, such as a fracture within


Aira-Caldera
20 km diameter
29,000 yrs BP
5,000 people
Kagoshima City
600,000 people
Sakurajima
EW12 km - NS10 km
4,000 yrs BP

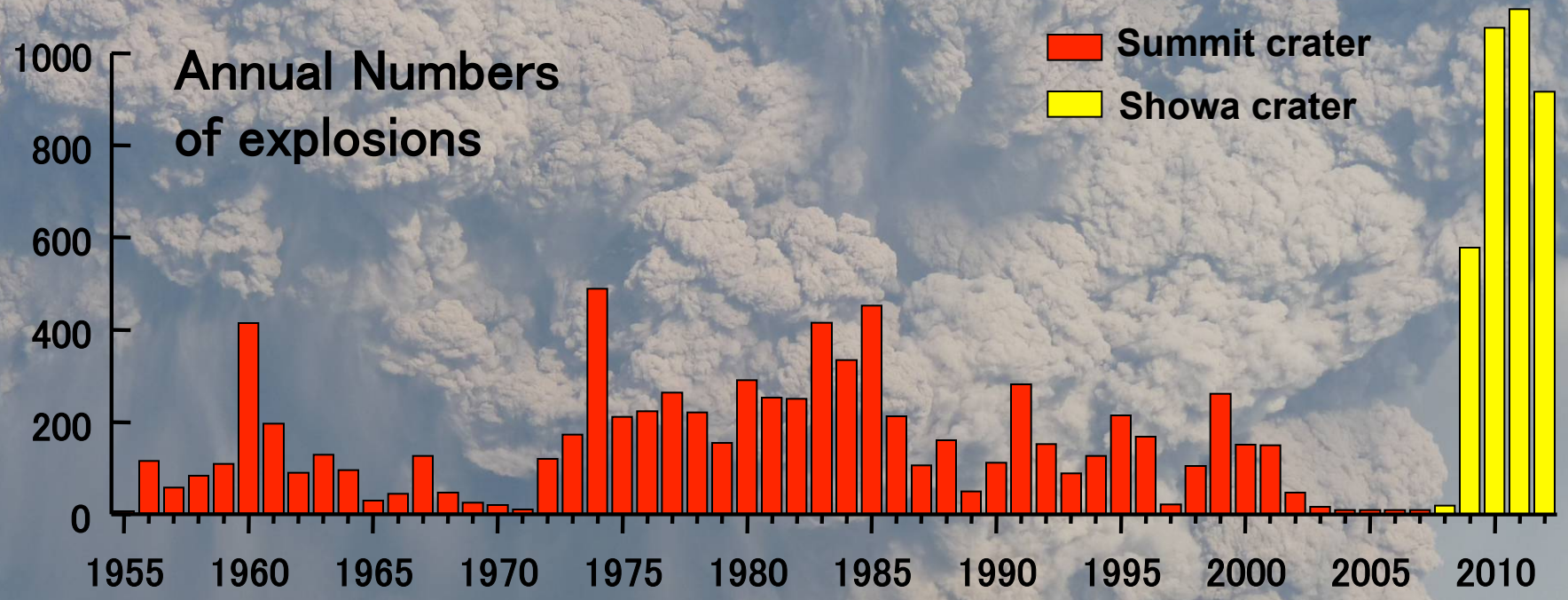
Two craters of Sakurajima





Summit crater: 800 m×600 m×500 m
Showa crater: 360 m×280 m×150 m

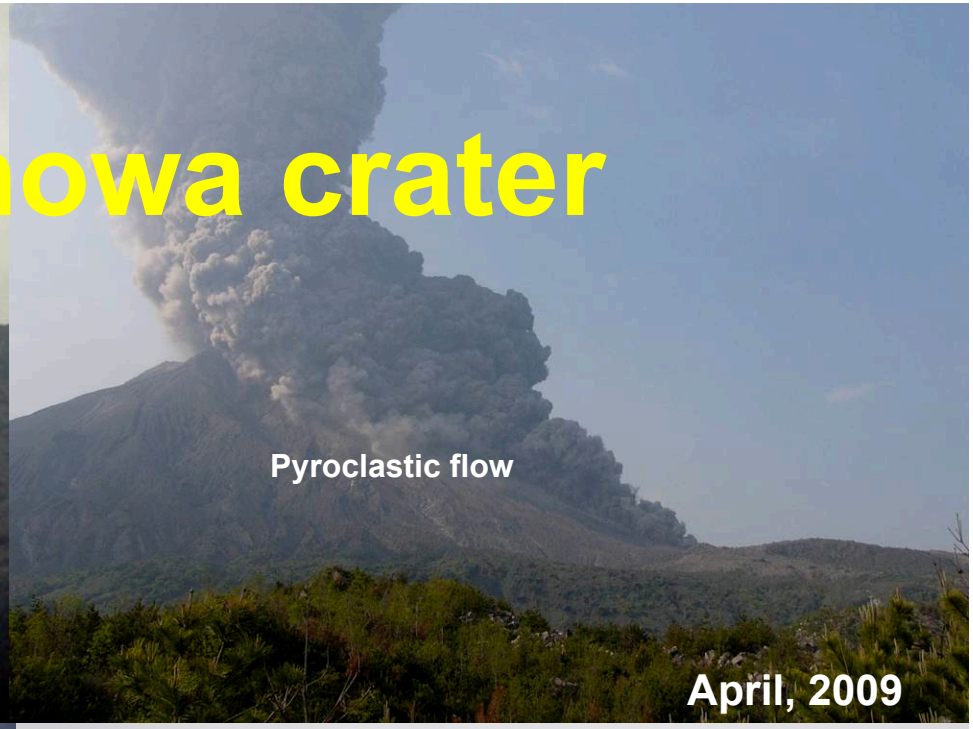
Eruption activity of Sakurajima volcano



Cyclic Vulcanian eruptions at the summit crater suddenly started on Oct 13, 1955. After decreasing activity of the summit crater, On June 4, 2006, Showa crater has reactivated after 60 yrs dormancy and explosivity has been increasing since 2009.

Eruptions at Showa crater

June, 2006



Pyroclastic flow

April, 2009

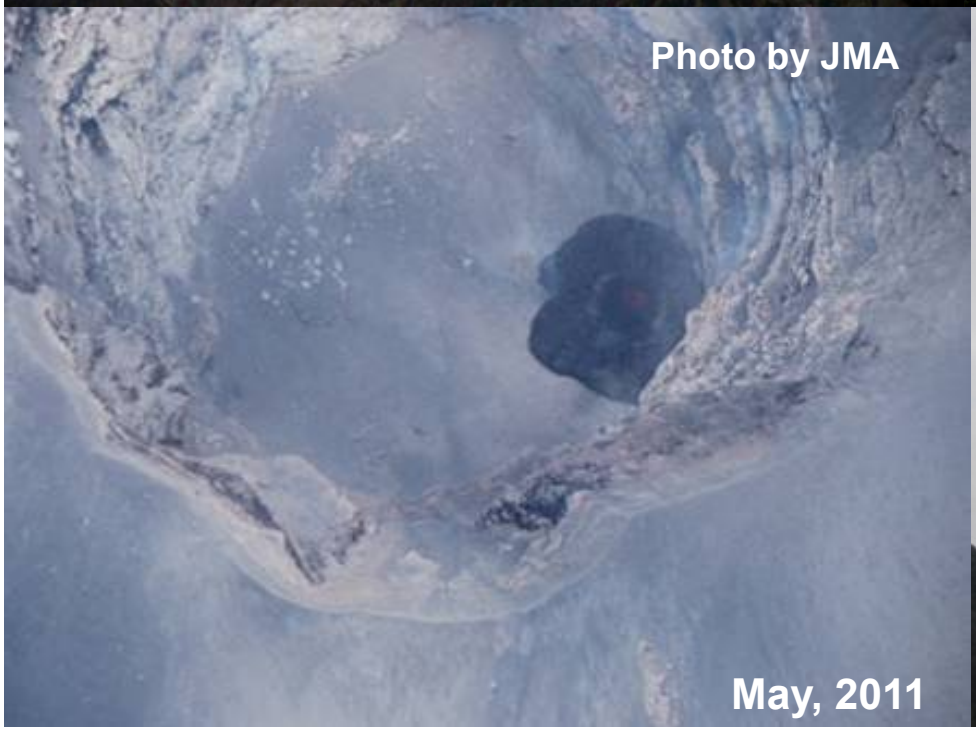


Photo by JMA

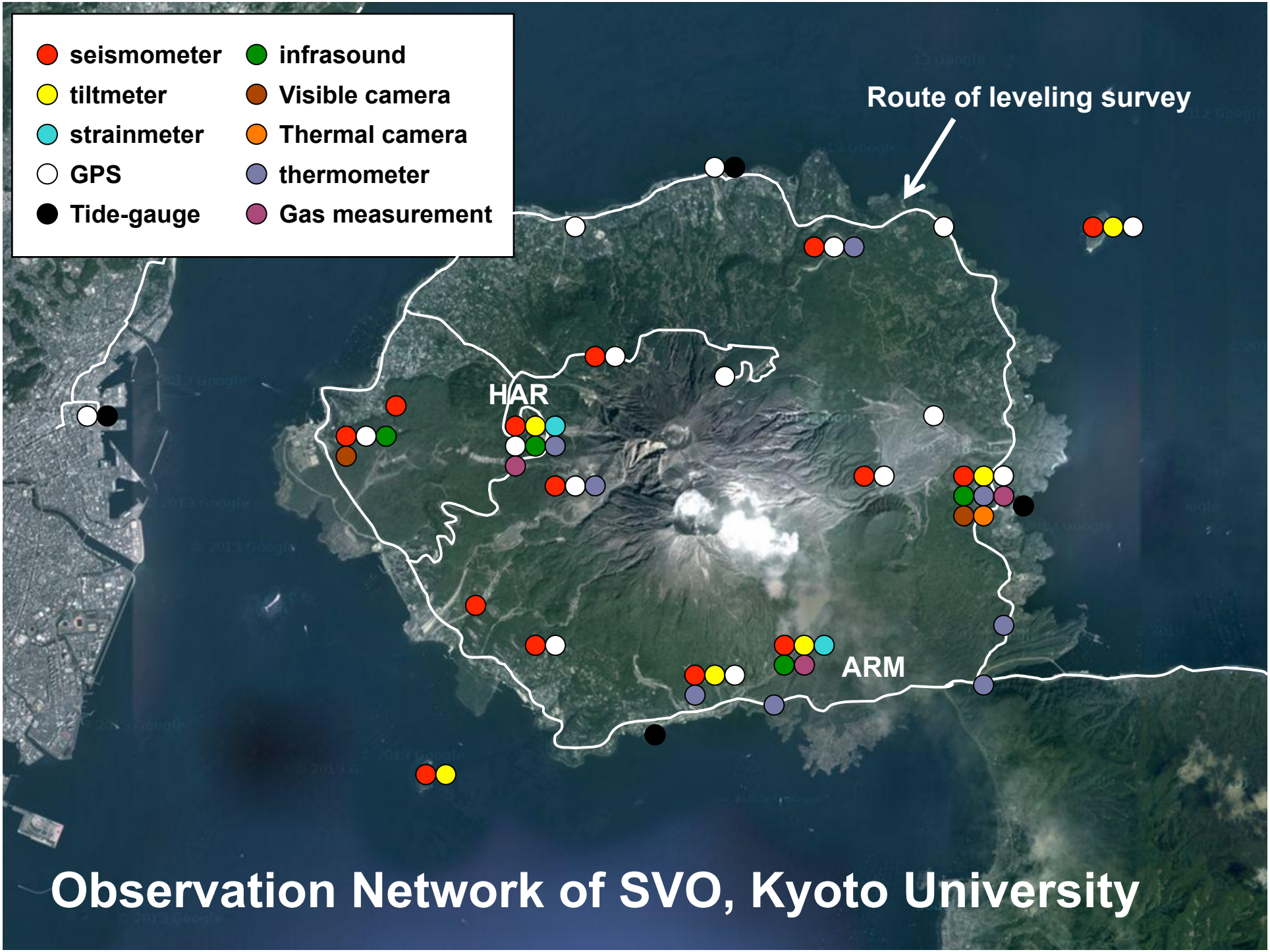
May, 2011

Photo by T. Sonoda

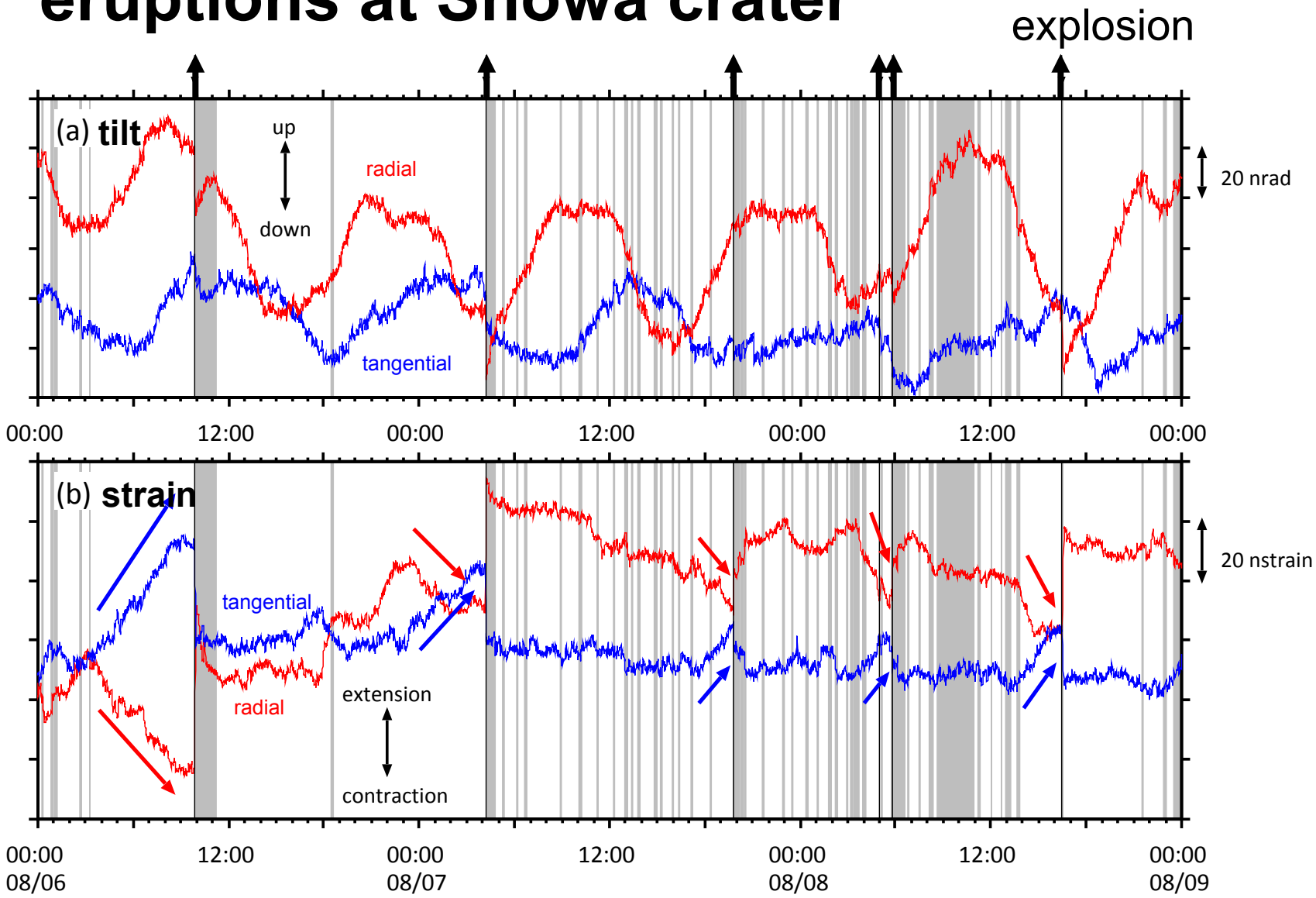
March, 2010

Vulcanian explosion at Showa crater (11:25, Feb. 6, 2008)

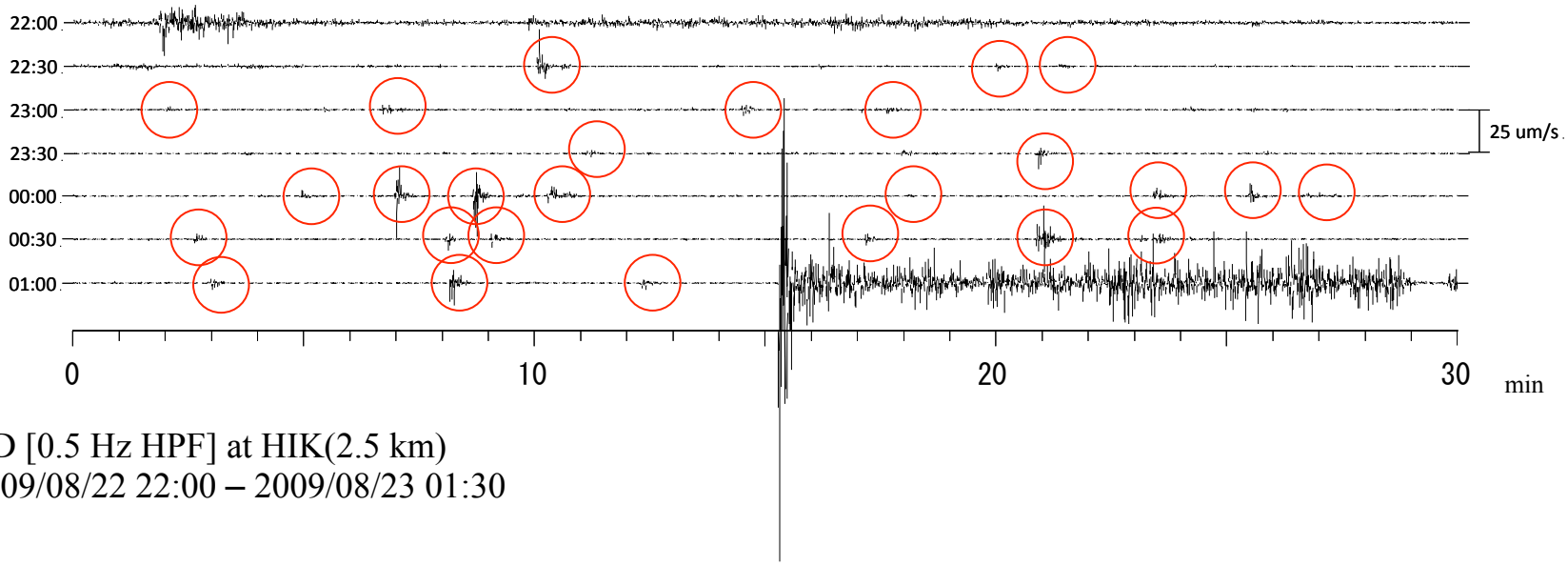
From a site 3 km away from the crater (JMA)


seismometer
tiltmeter
strainmeter
GPS
Tide-gauge
infrasound
Visible camera
Thermal camera
thermometer
Gas measurement
Route of leveling survey
HAR
ARM
Observation Network of SVO, Kyoto University

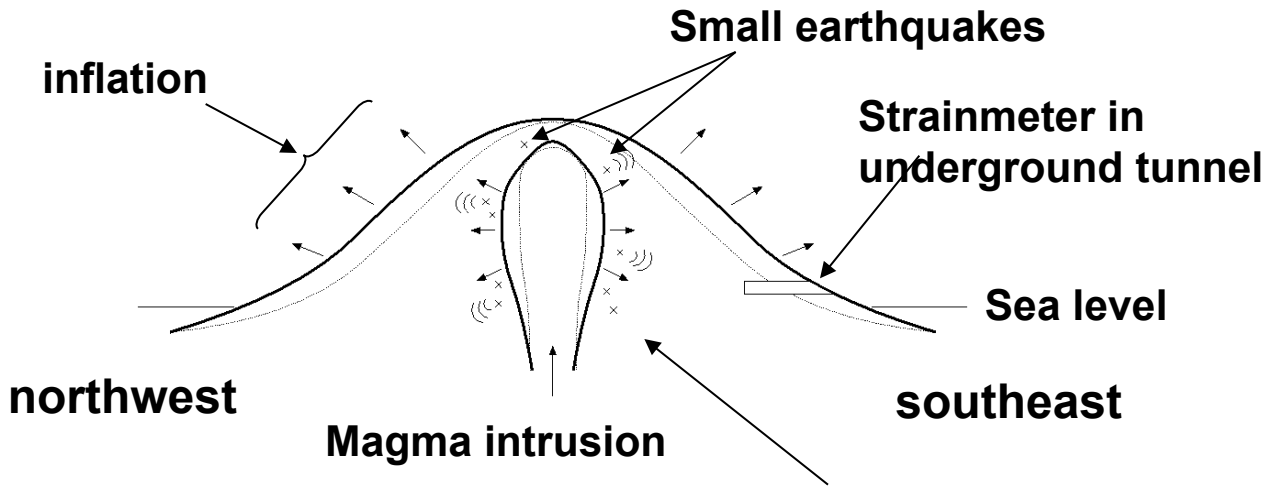
Tilt and Strain record associated with eruptions at Showa crater



small-earthquakes during inflation stage

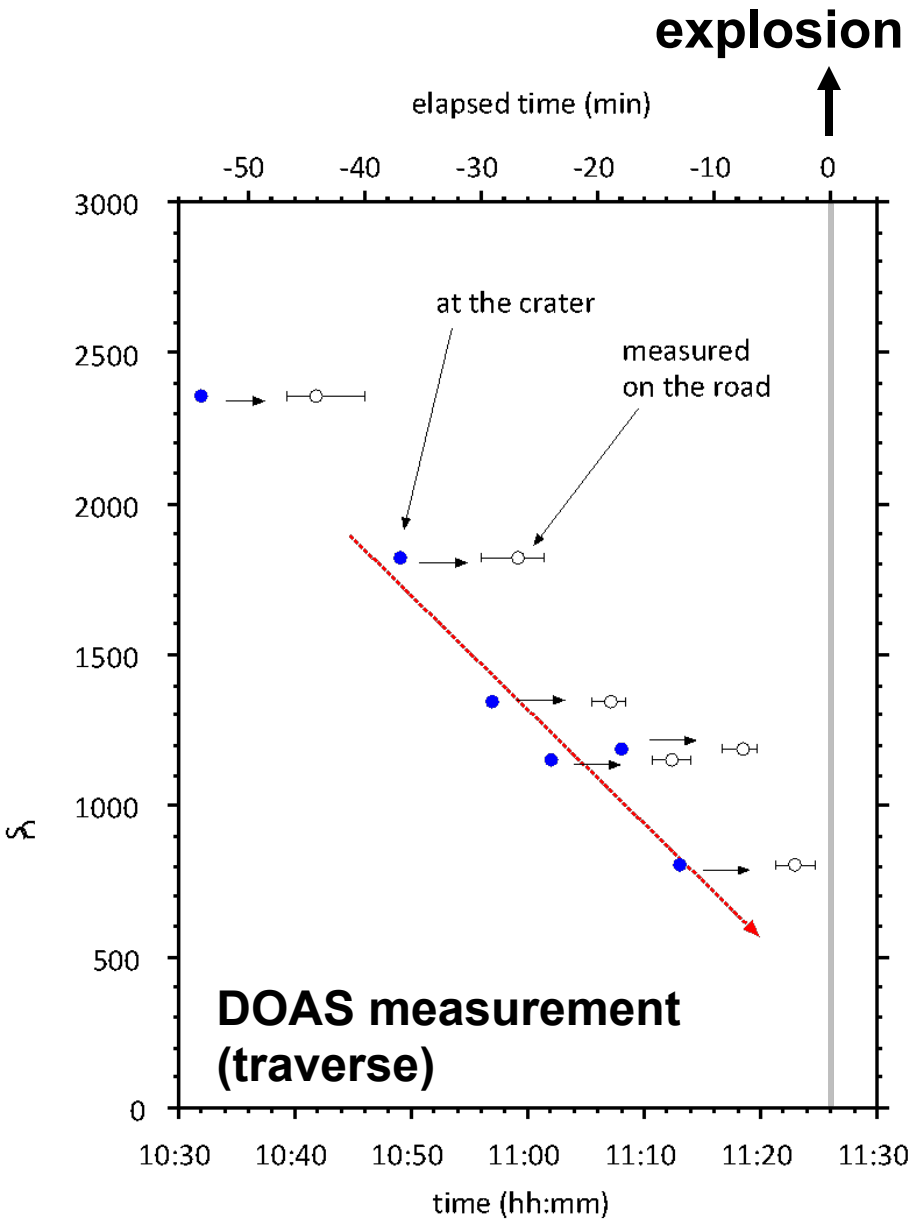


UD [0.5 Hz HPF] at HIK(2.5 km)
2009/08/22 22:00 – 2009/08/23 01:30

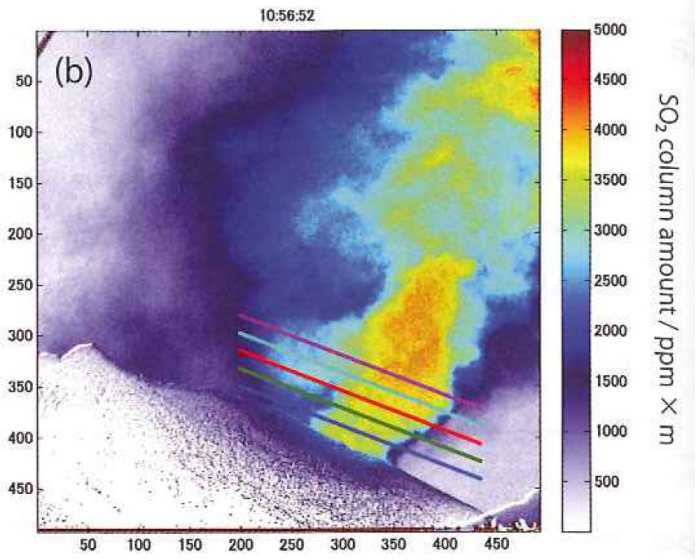


(a) A few hrs

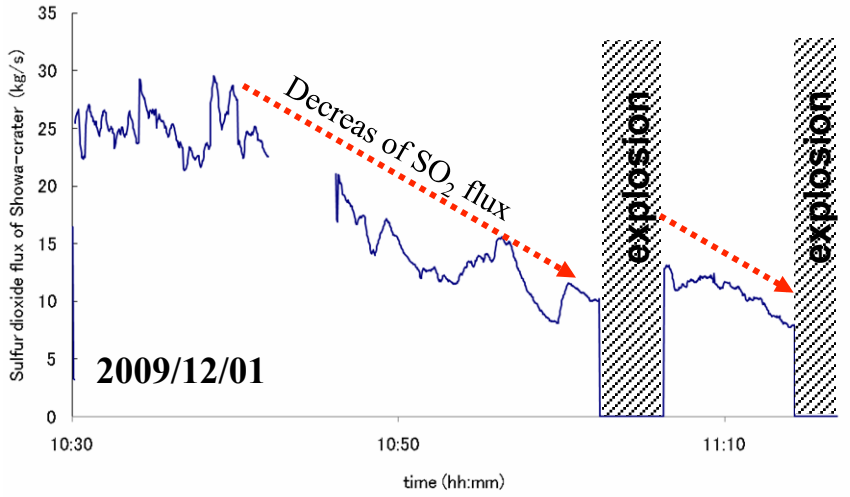
Decrease of gas emission



SO_2 imaging by UV camera



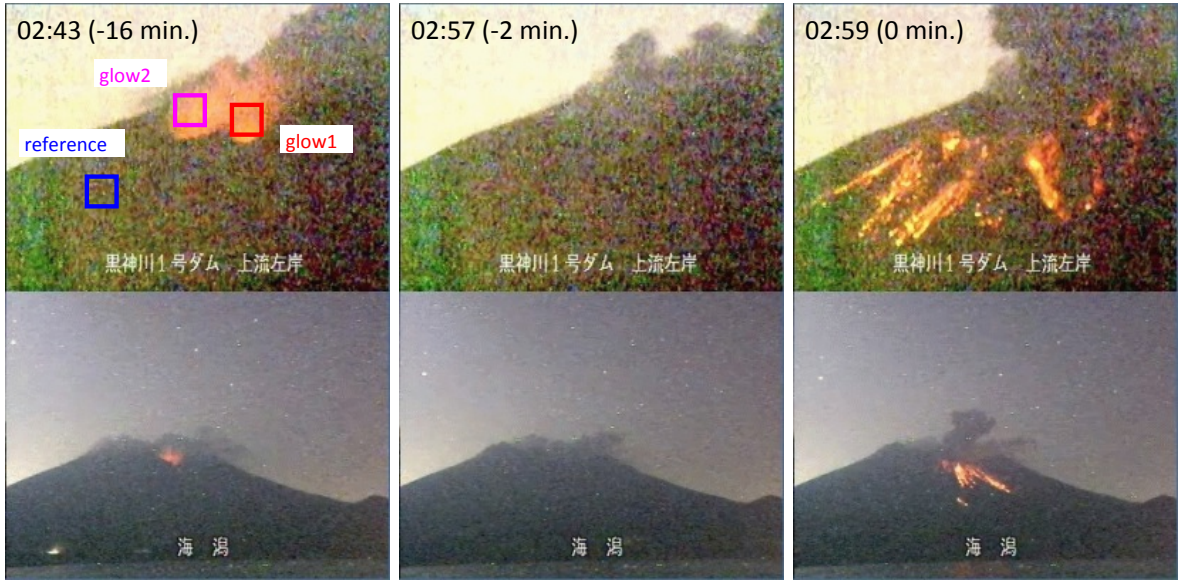
Kazahaya et al. (2013)

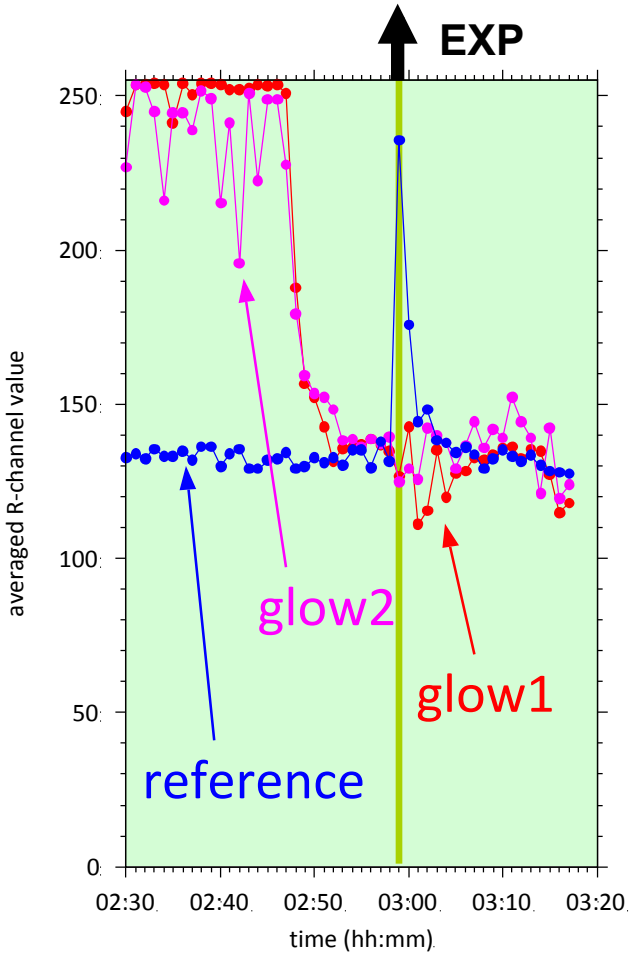


Kazahaya et al. (2010)

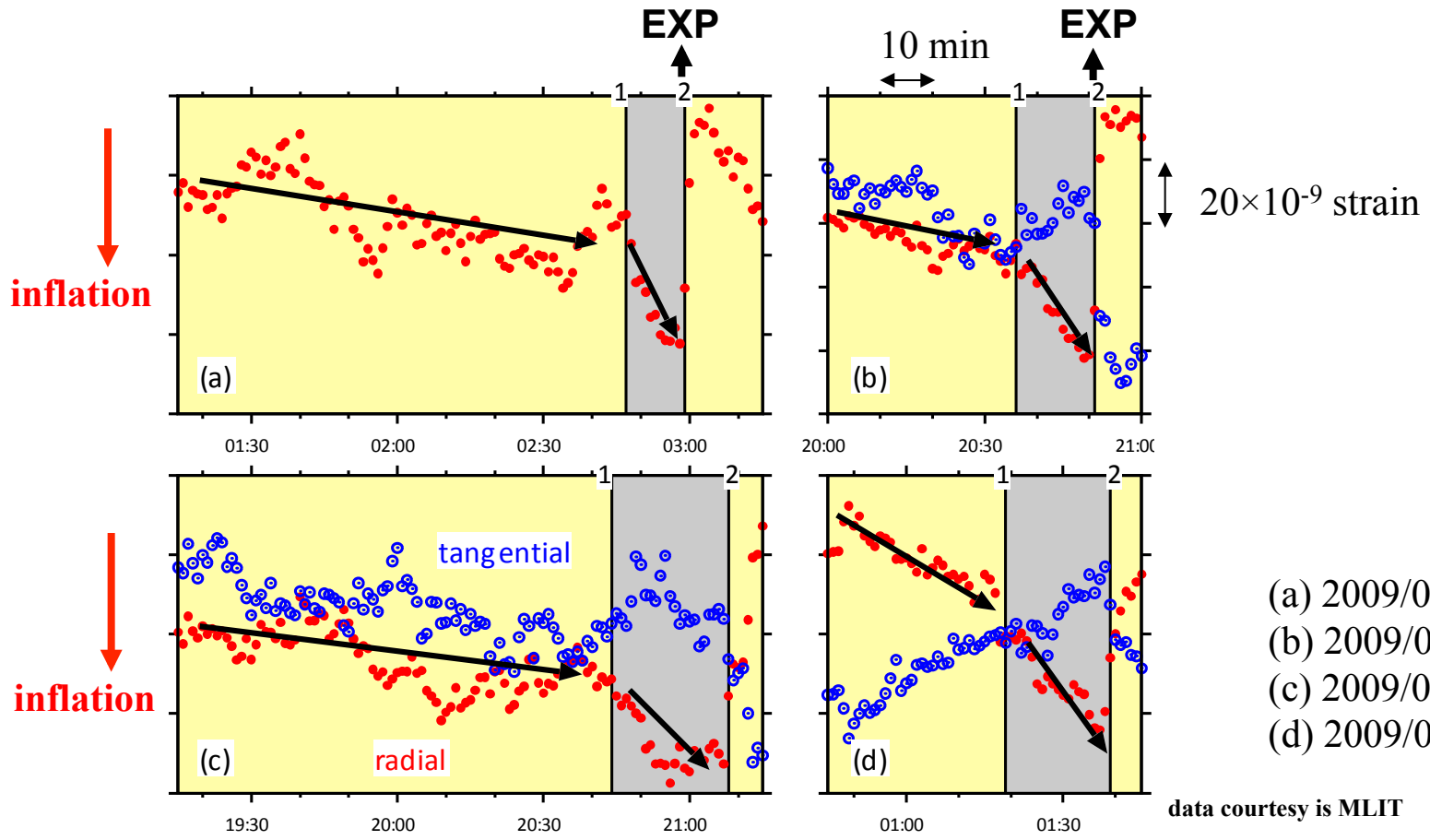
2009/08/27 02:30-03:30

Weakening and disappearance of volcanic glow



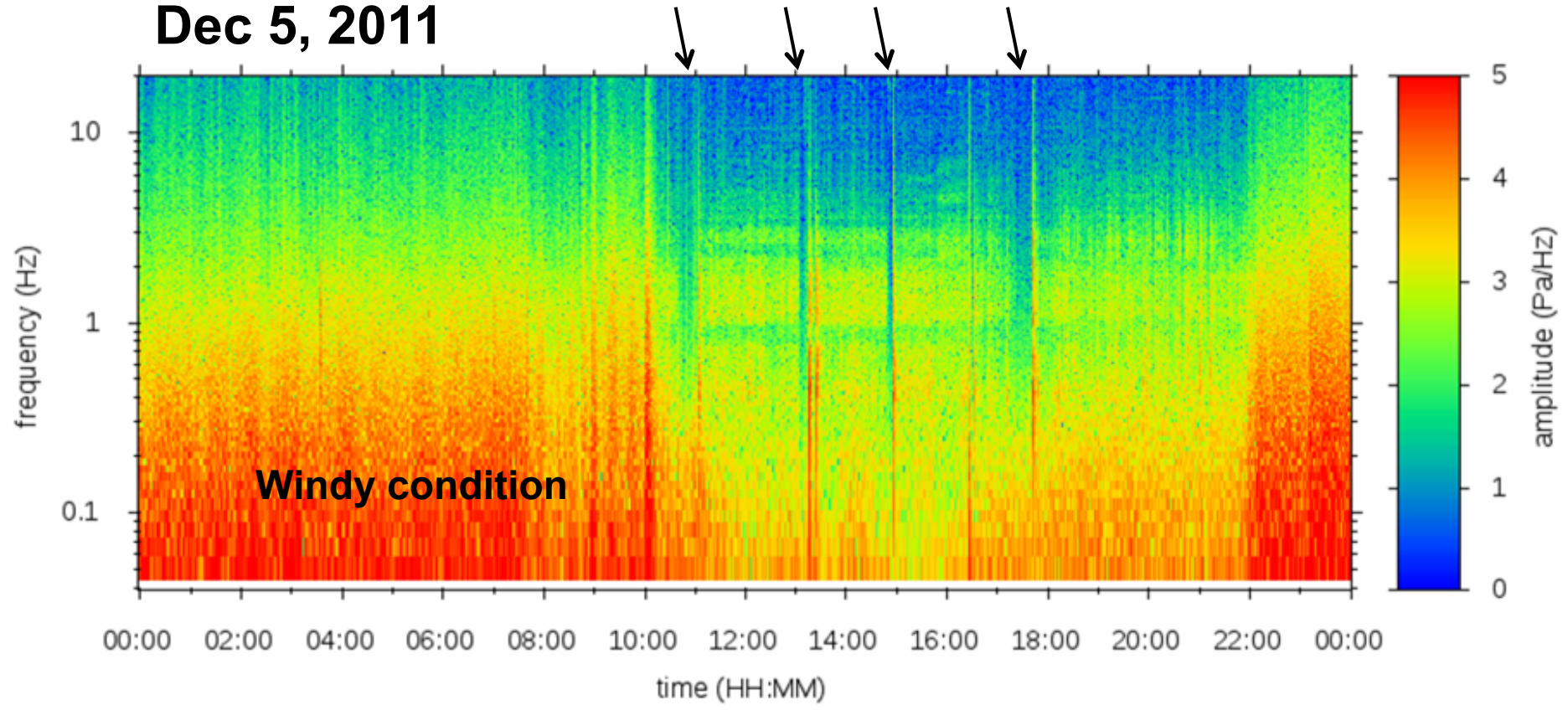


Acceleration of volcano inflation



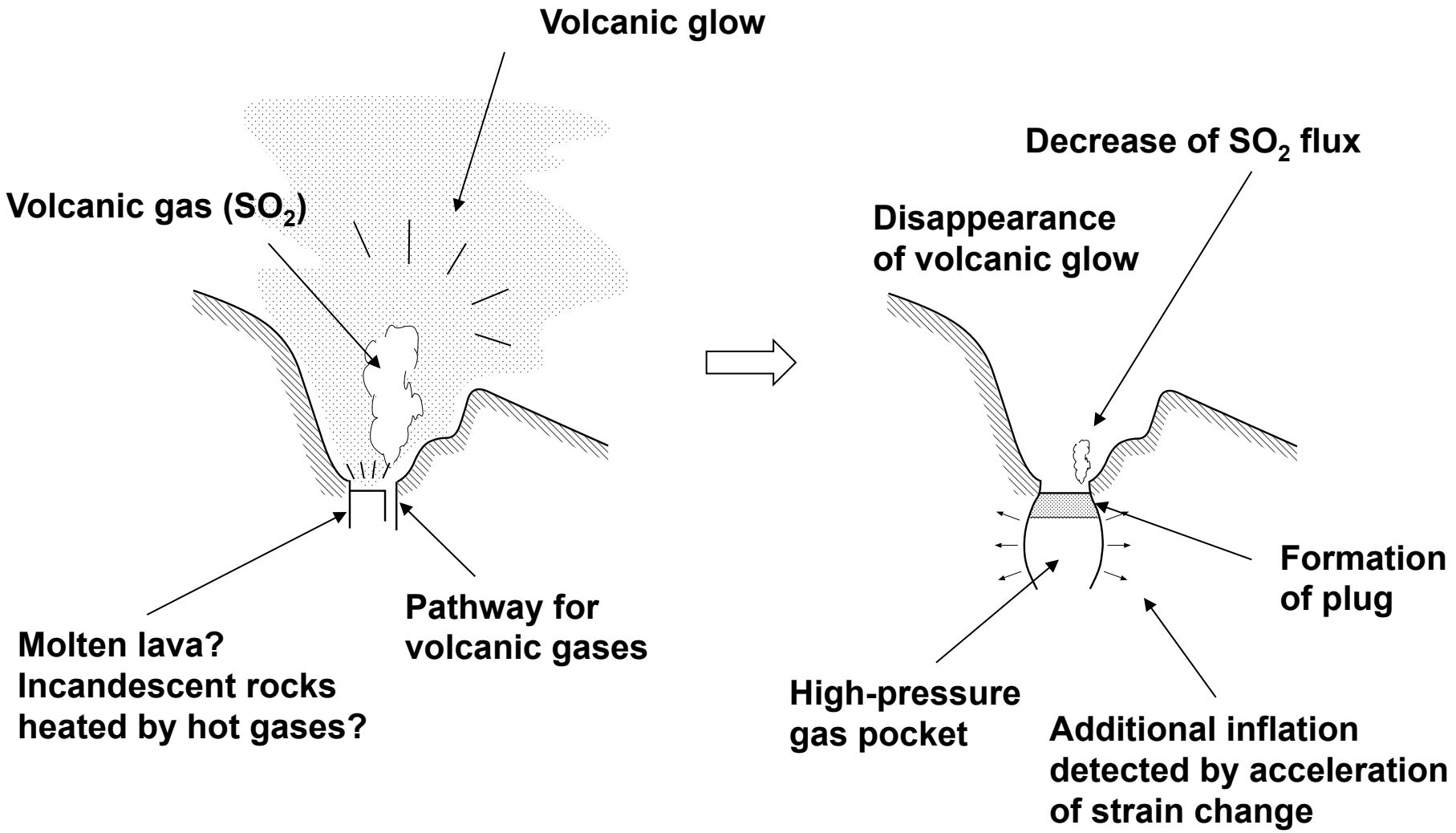
Strain change increases around a time that volcanic glow starts to disappear!

Spectrogram of infrasound record

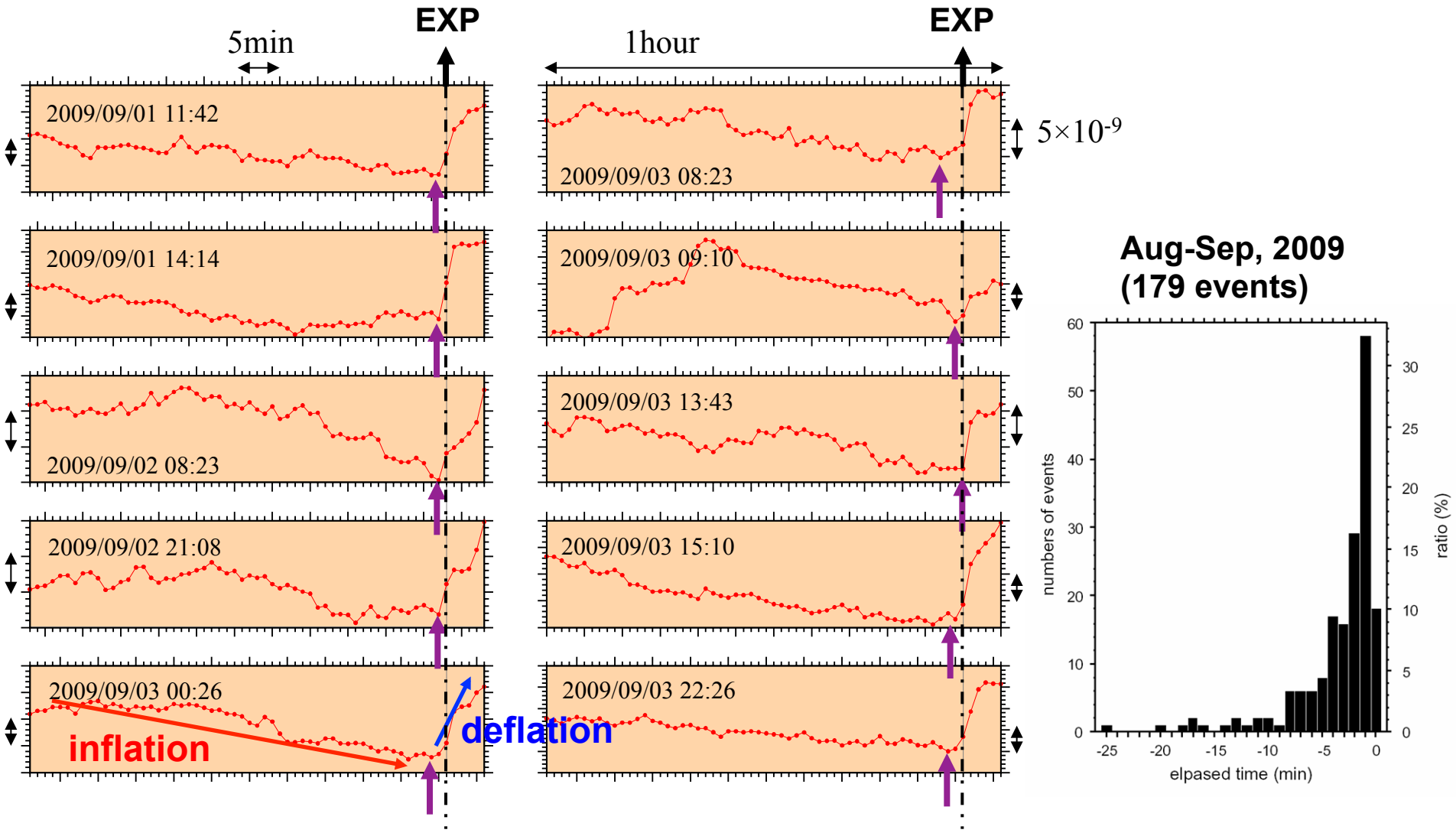


We can also see this phenomenon from perfectly disappearances of infrasound noise

(b) A few tens of minutes prior to eruption

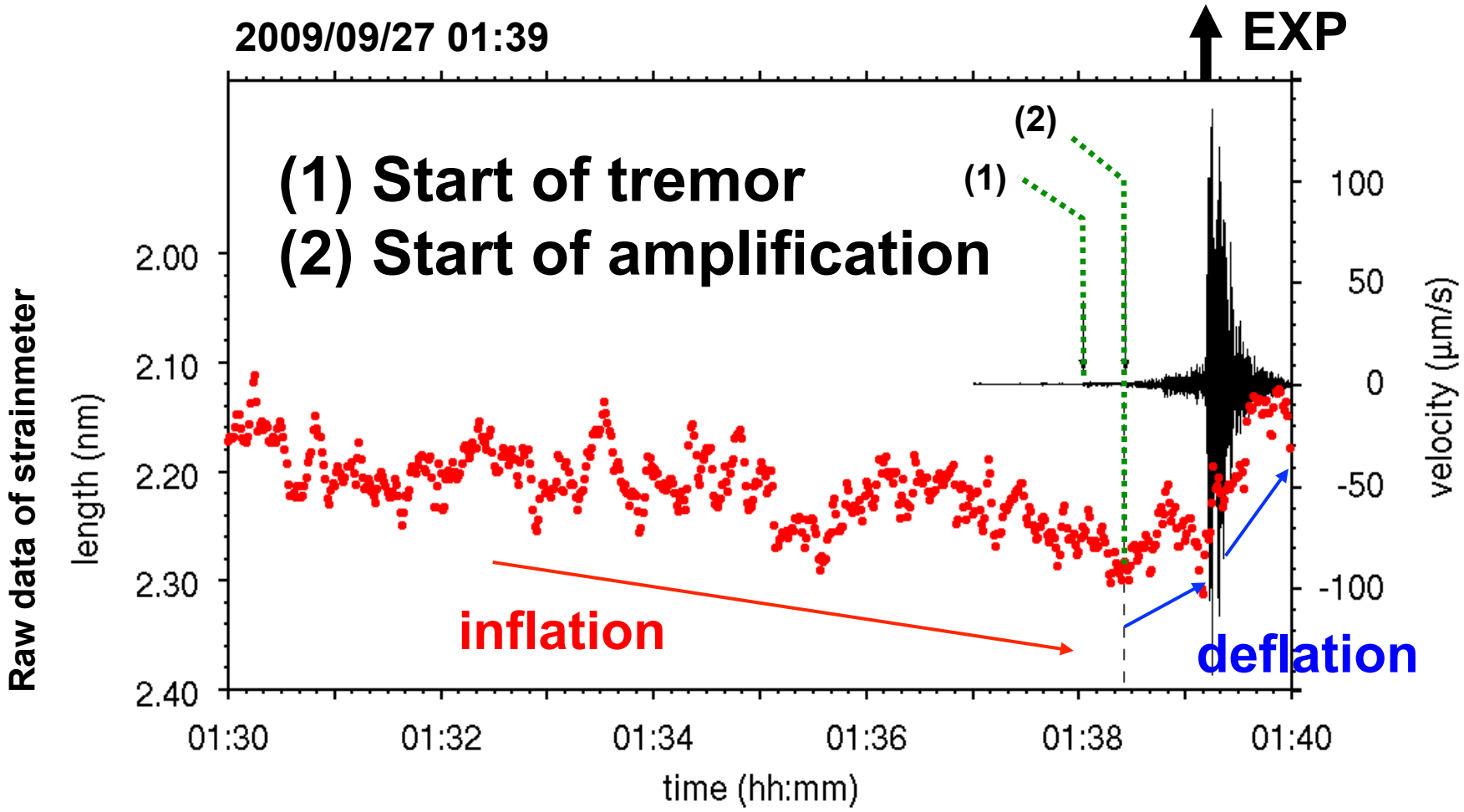


Inverting of strain change



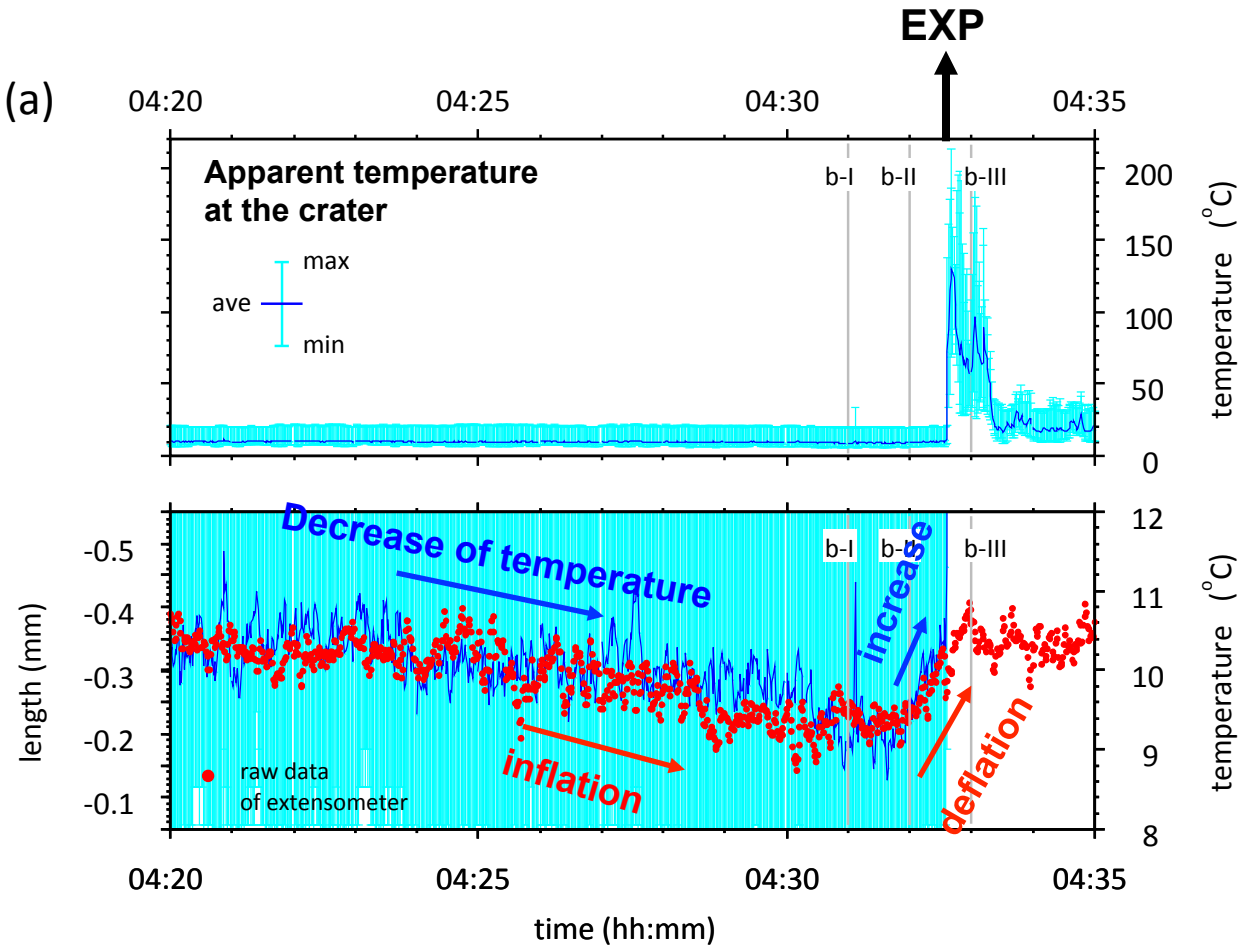
Deflation is already started before eruption onset

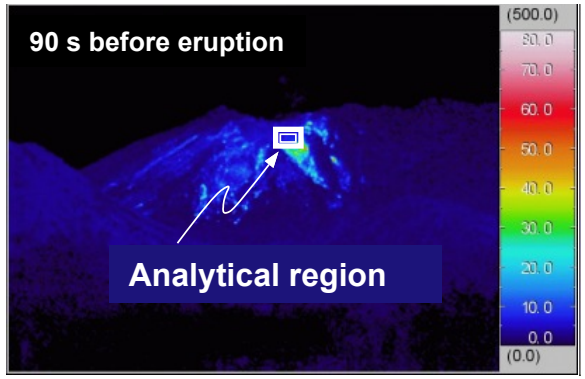
Increase of tremor amplitude

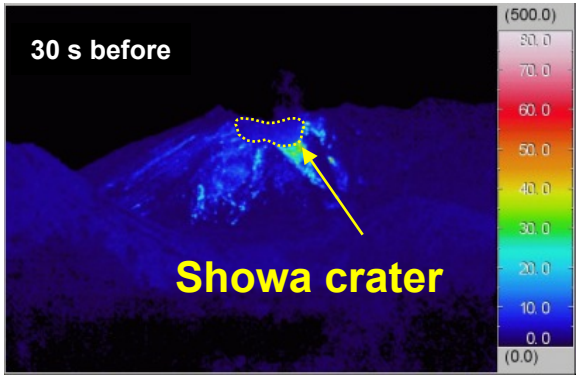


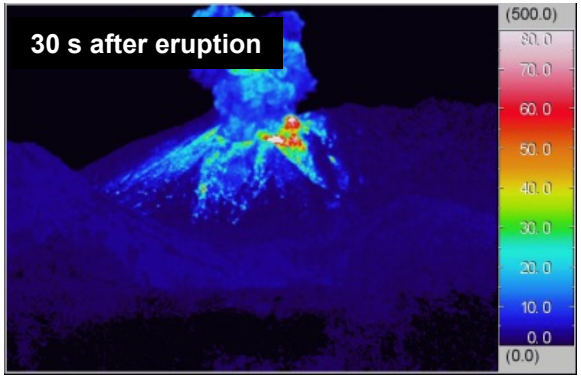
Start time of deflation is corresponding to the time that increasing of tremor amplitude starts

Gas leakage?





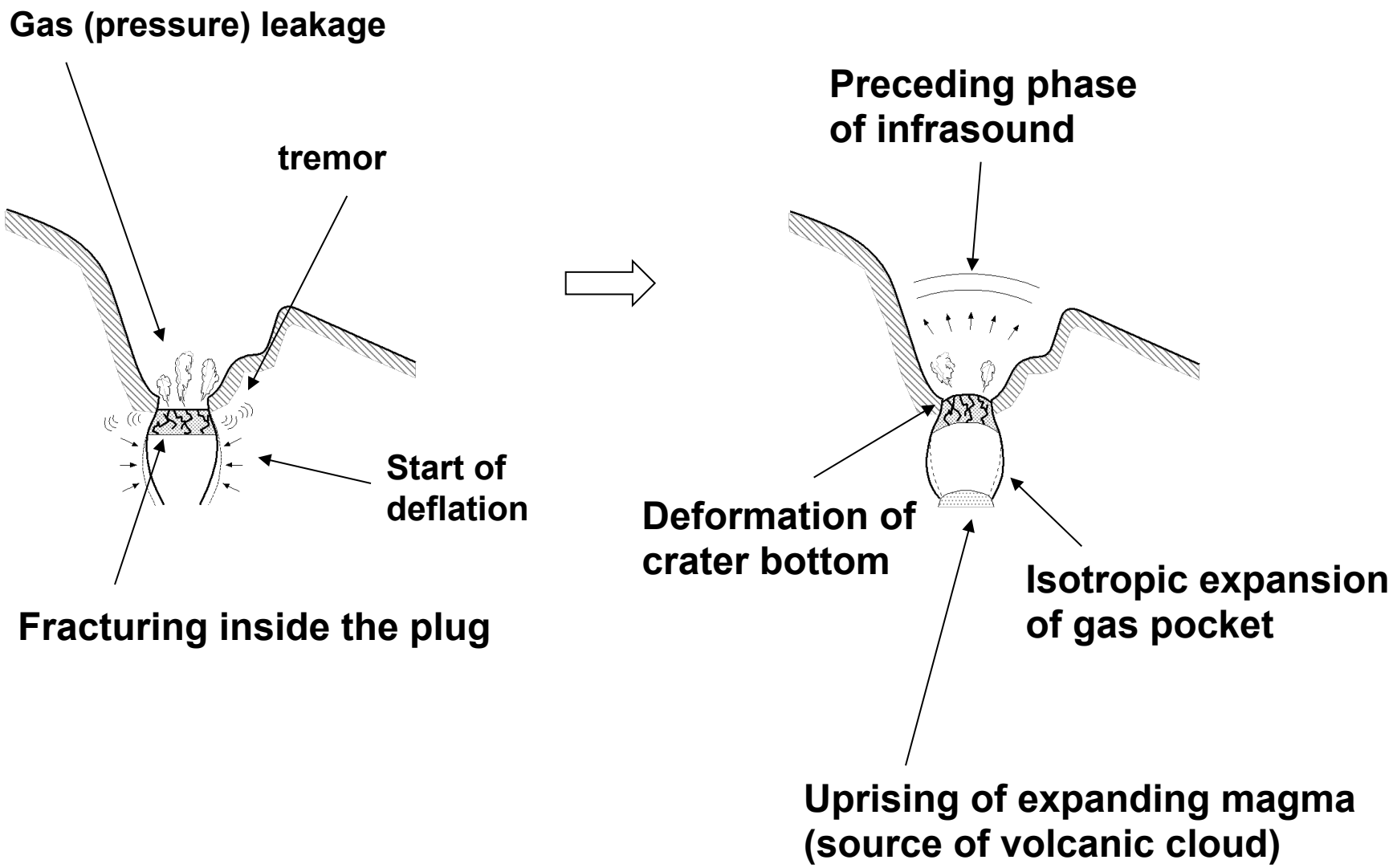




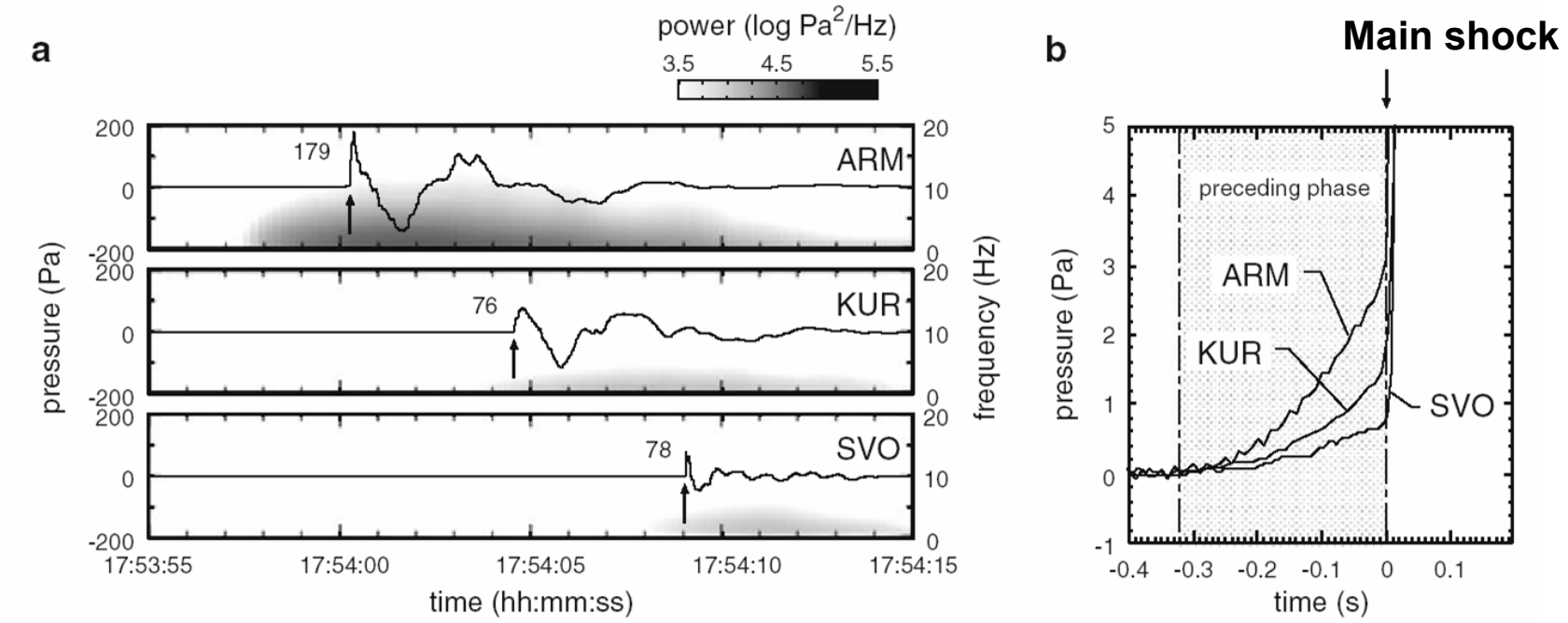
At a time of inverting strain change, change of temperature at the crater is also recorded: from decrease to increase.

(c) A few minutes

(d) 0.5-1 seconds



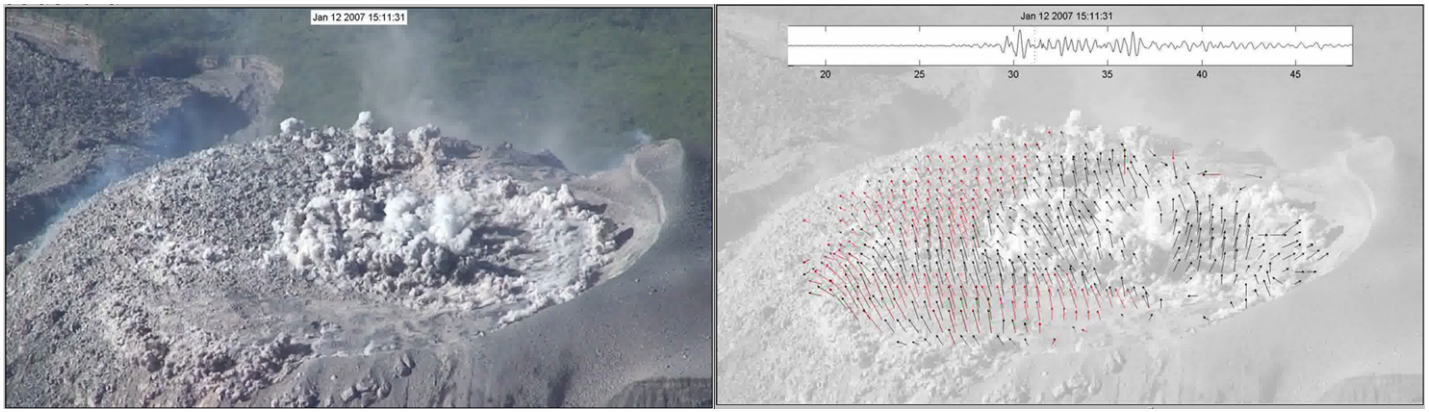
preceding phase of infrasound wave



Yokoo et al. (2009)

Weak infrasound signal (a few Pa) is recorded ahead of the main impulsive phase of infrasound wave

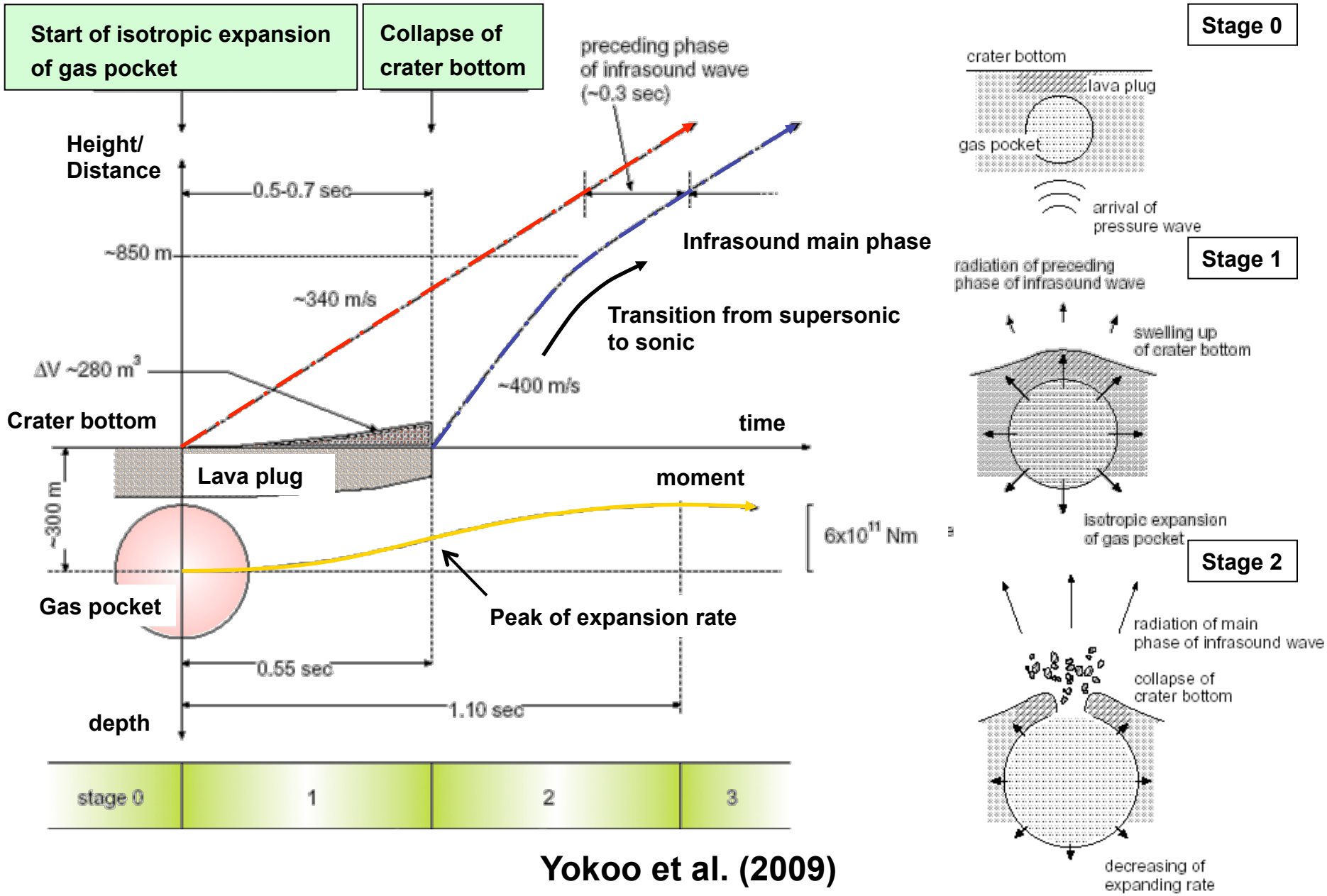
Upheaval and collapse of the crater ground



Johnson et al. (2008)

Etna volcano, Italy

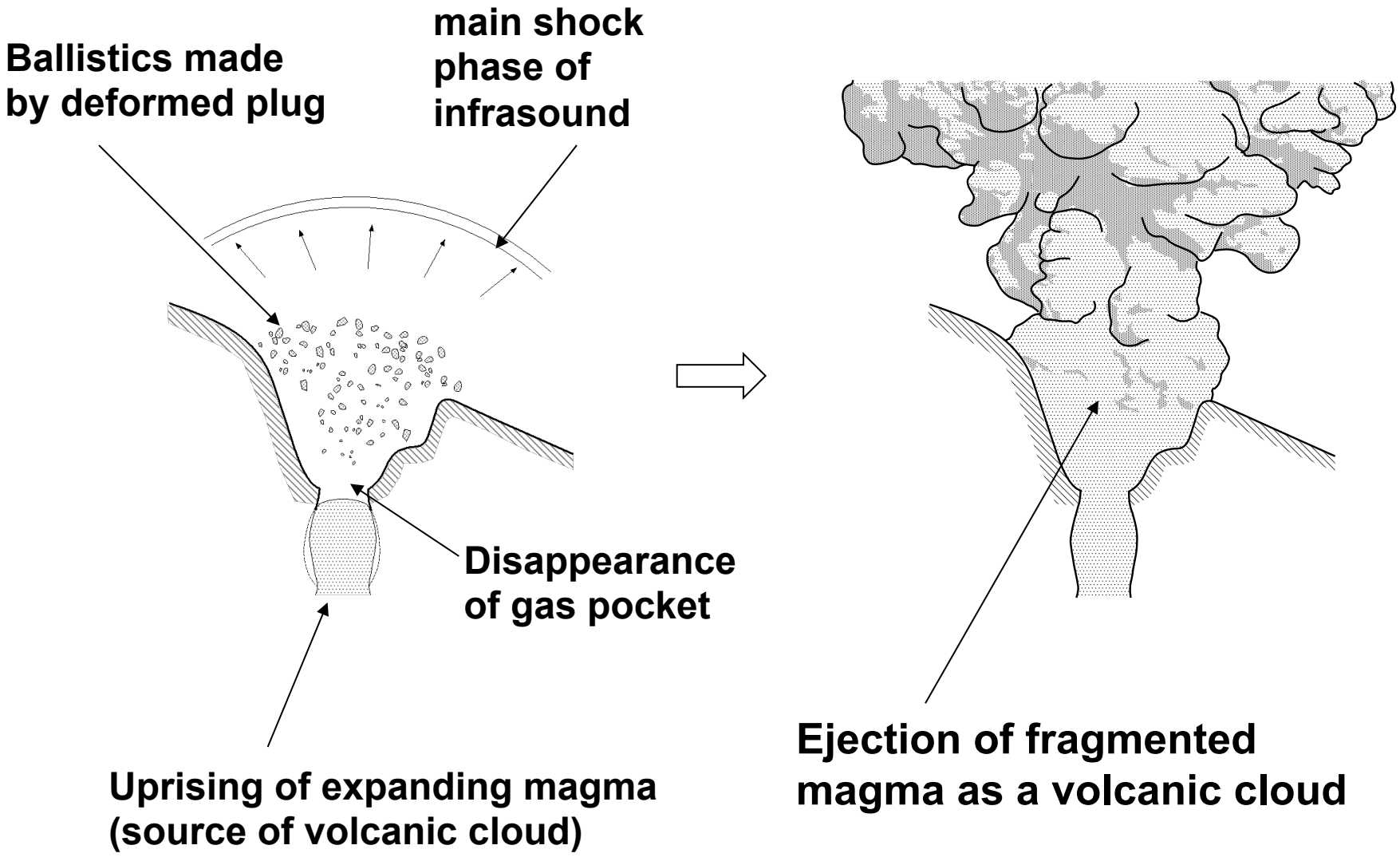
Schematic diagram of infrasound radiation

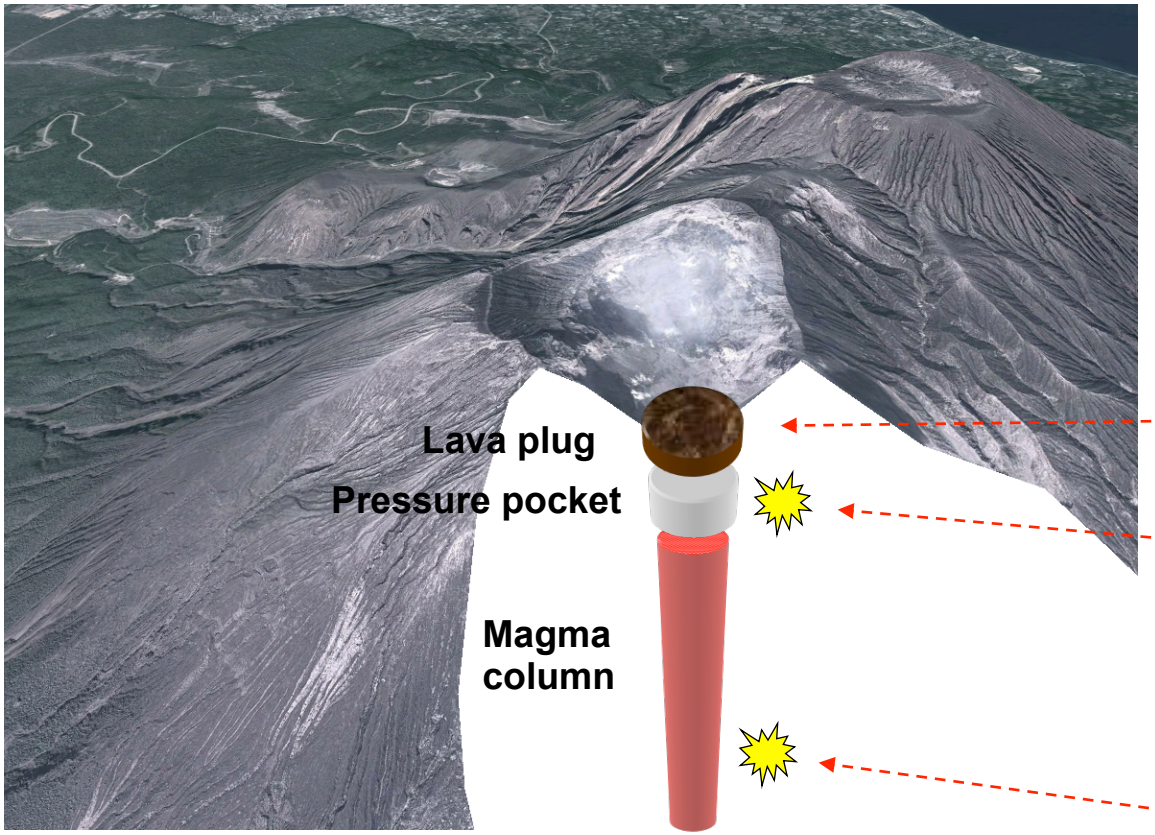


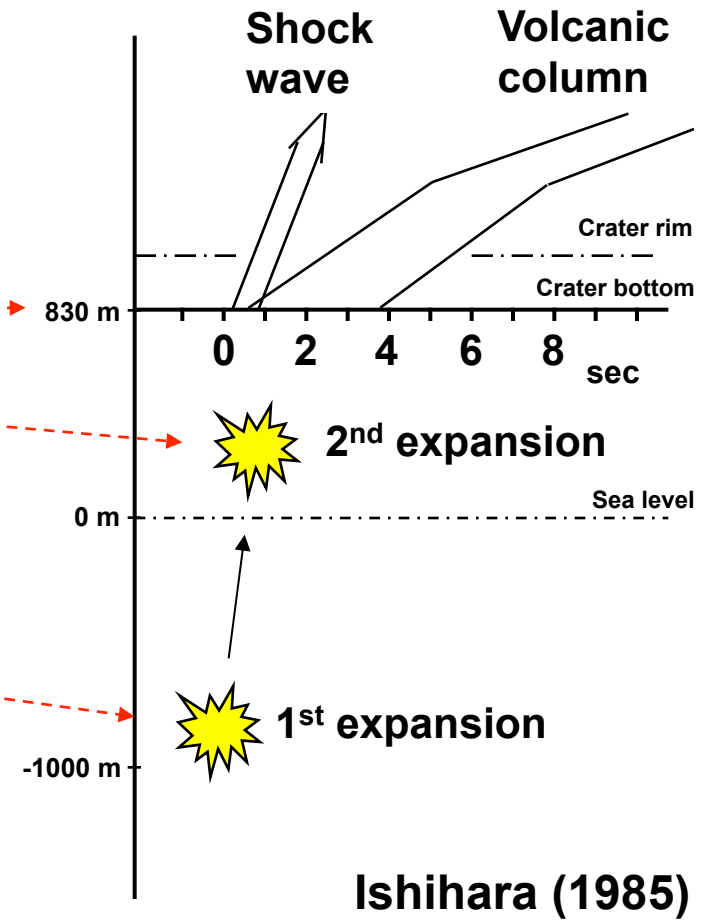
Yokoo et al. (2009)

(e) 0 sec

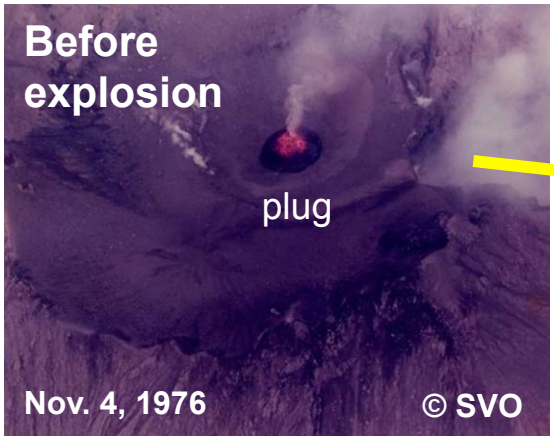
(f) After start of eruption



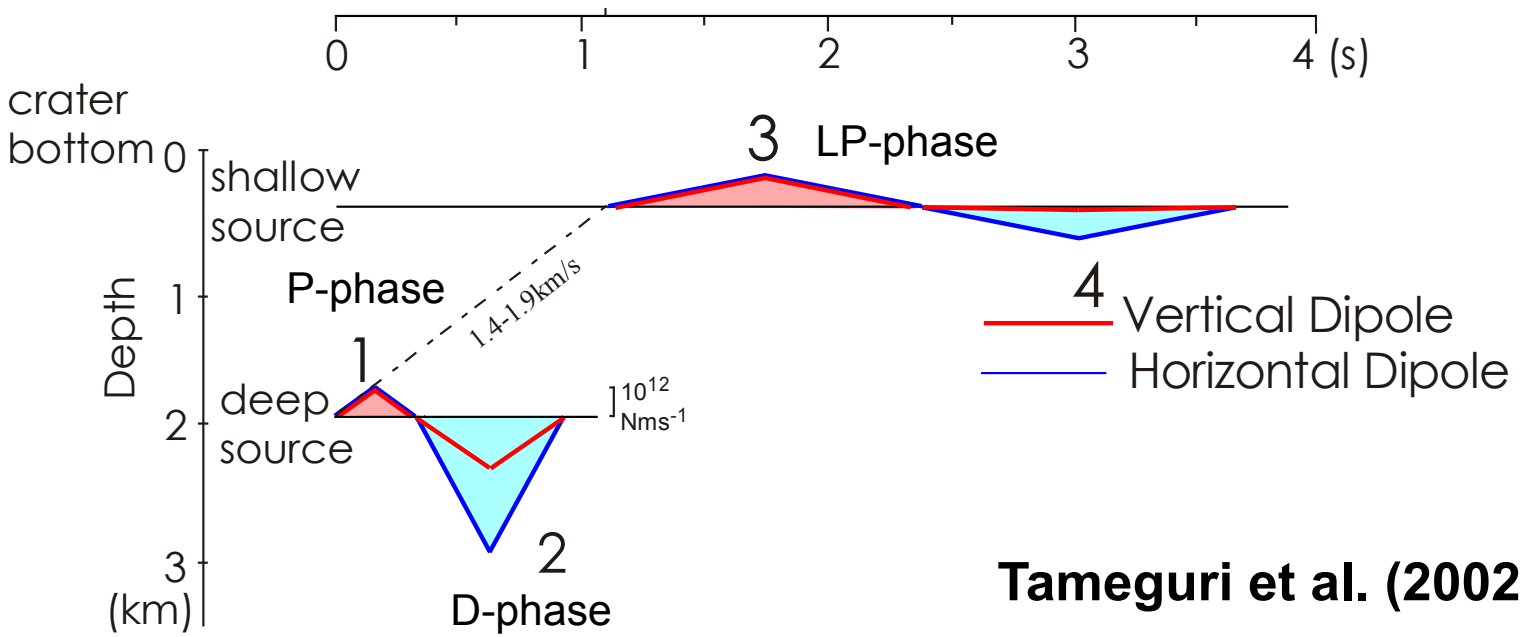




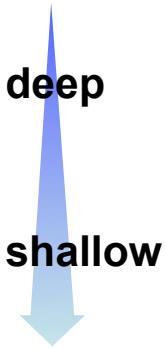
Ishihara (1985)



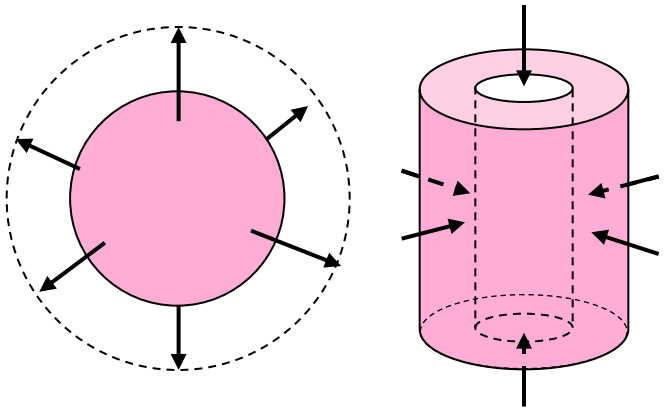
Result of moment tensor analysis



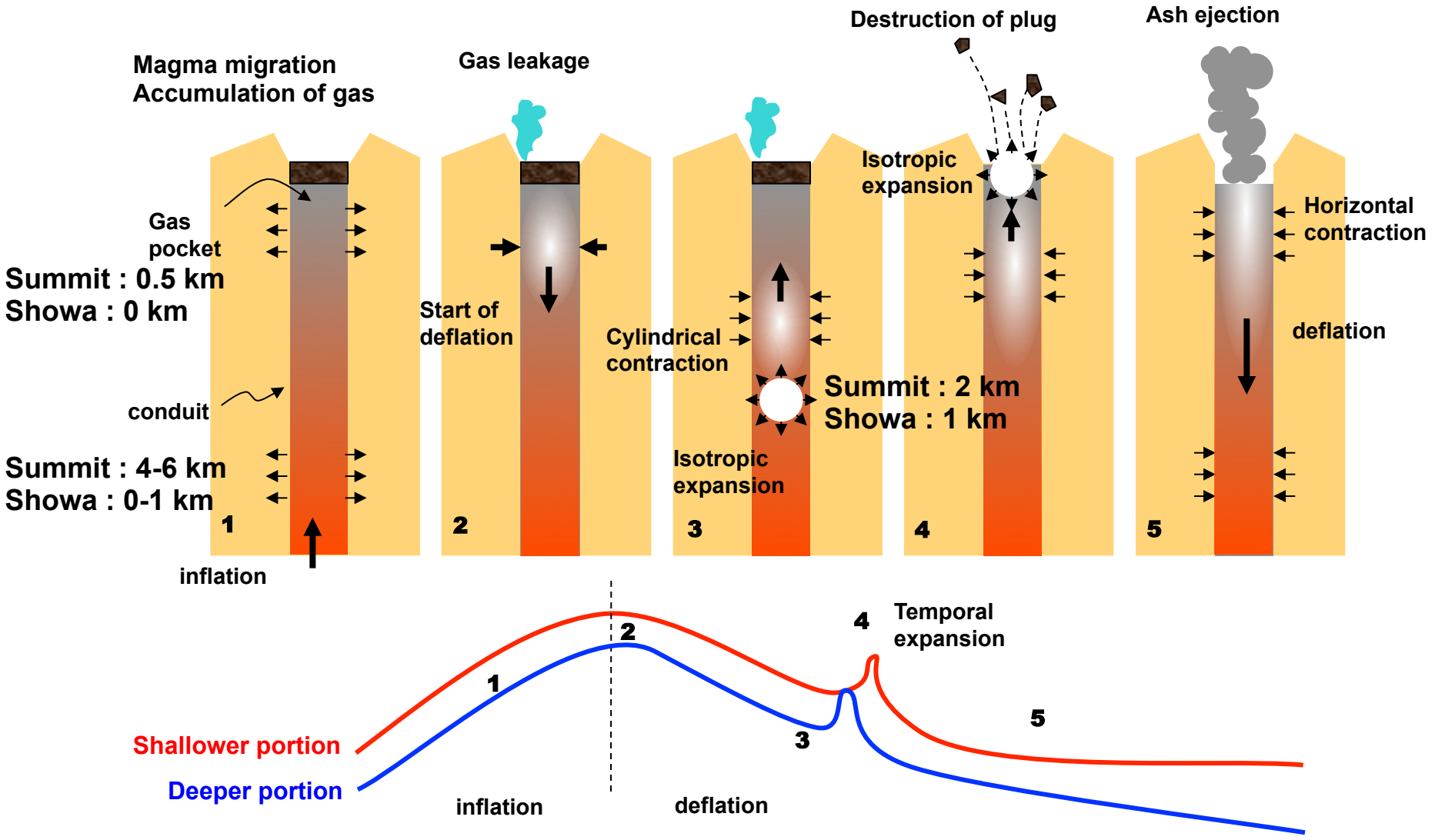
Tameguri et al. (2002)



1. **Isotropic expansion**
2. **Cylindrical contraction**
3. **Isotropic expansion**
4. **Horizontal contraction**

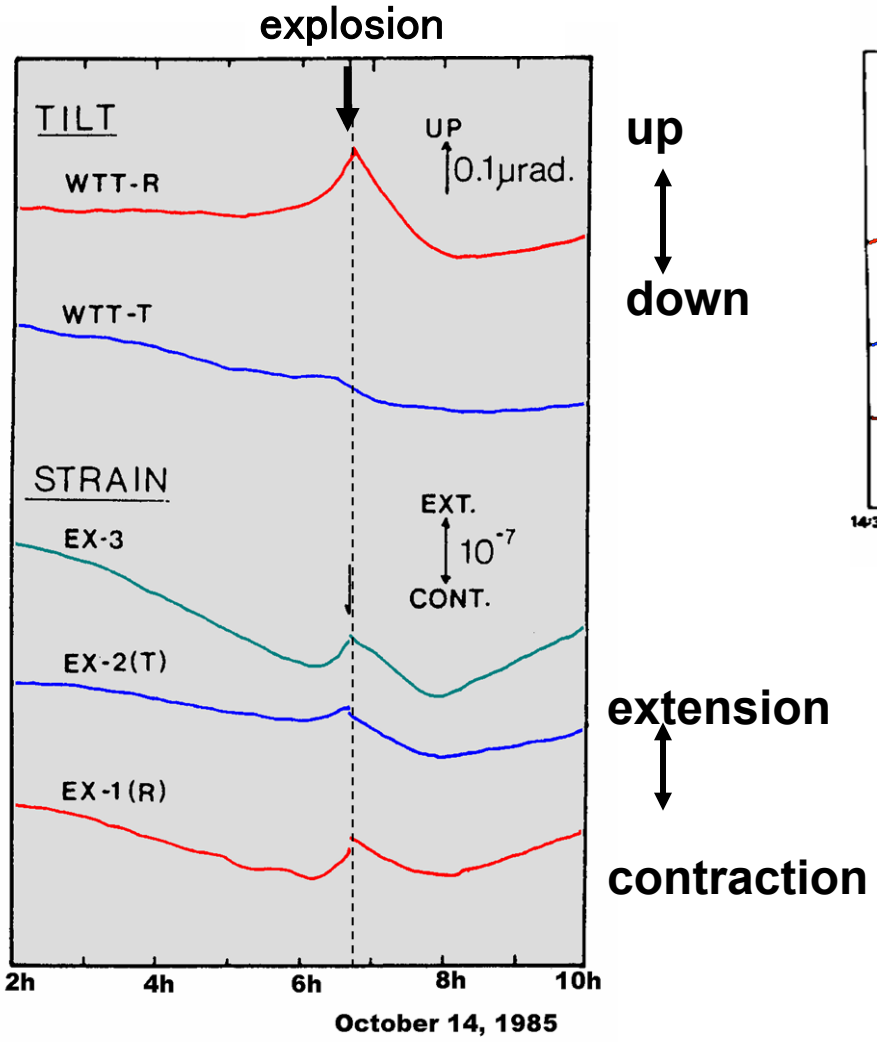


Eruption processes at Sakurajima

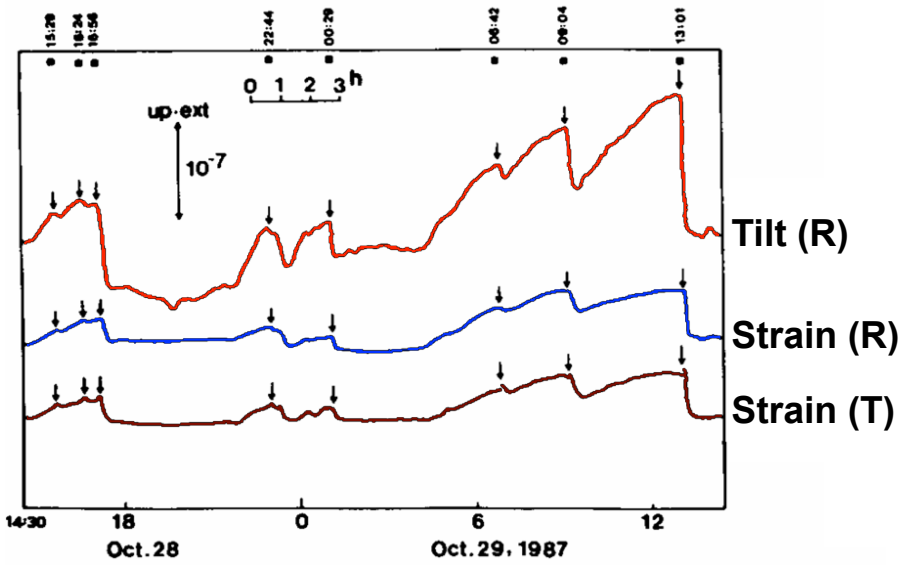


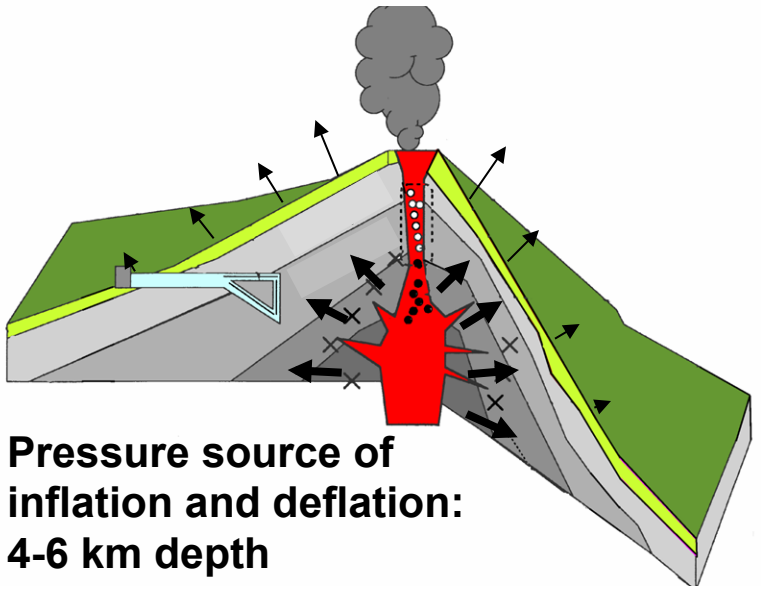
After Iguchi et al. (2008)

Inflation-deflation processes associated with the summit crater eruptions



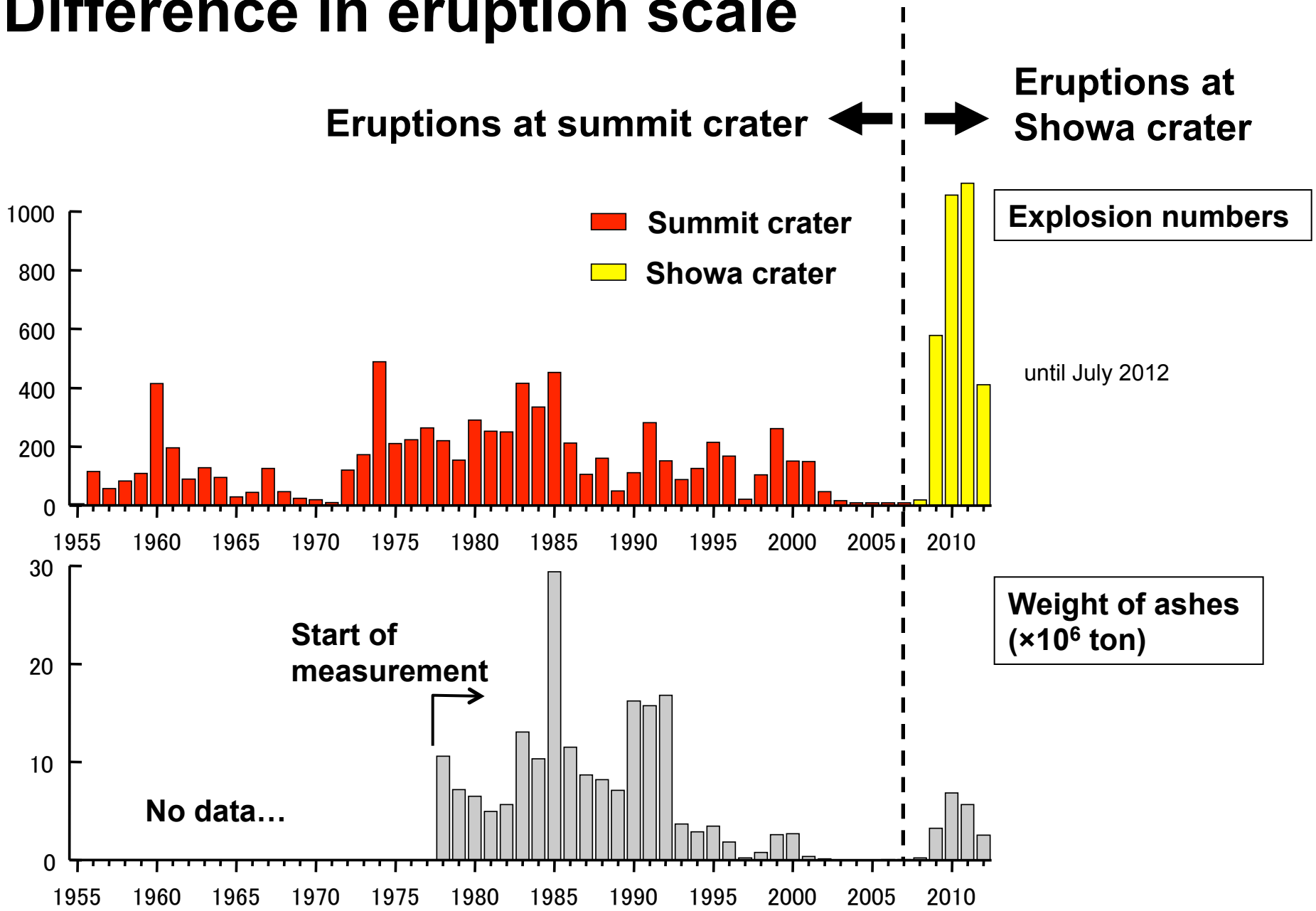
Ishihara (1990)



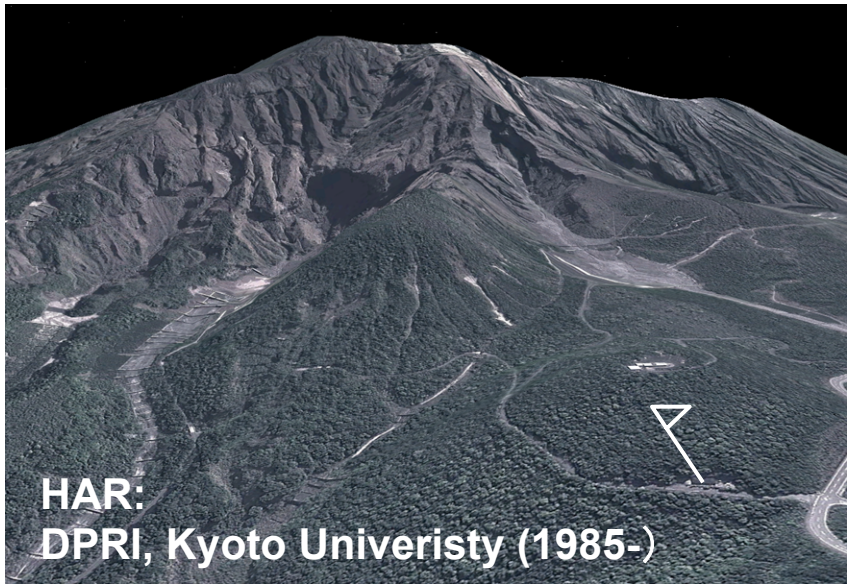


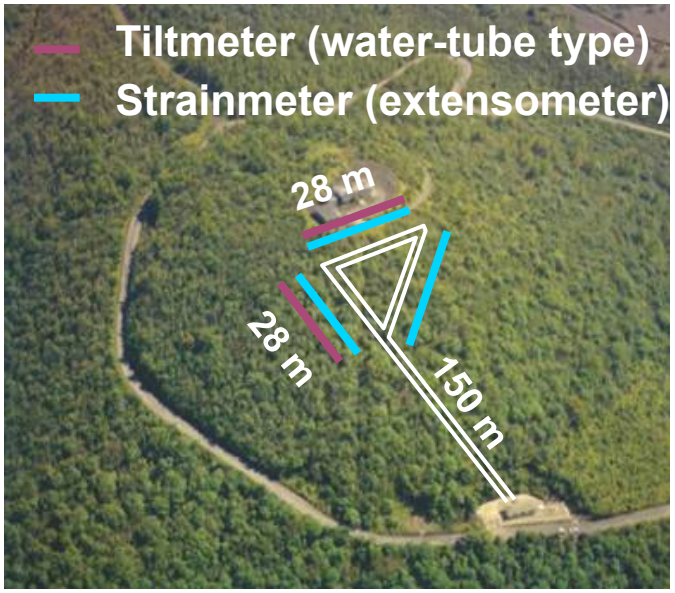
Pressure source of inflation and deflation: 4-6 km depth

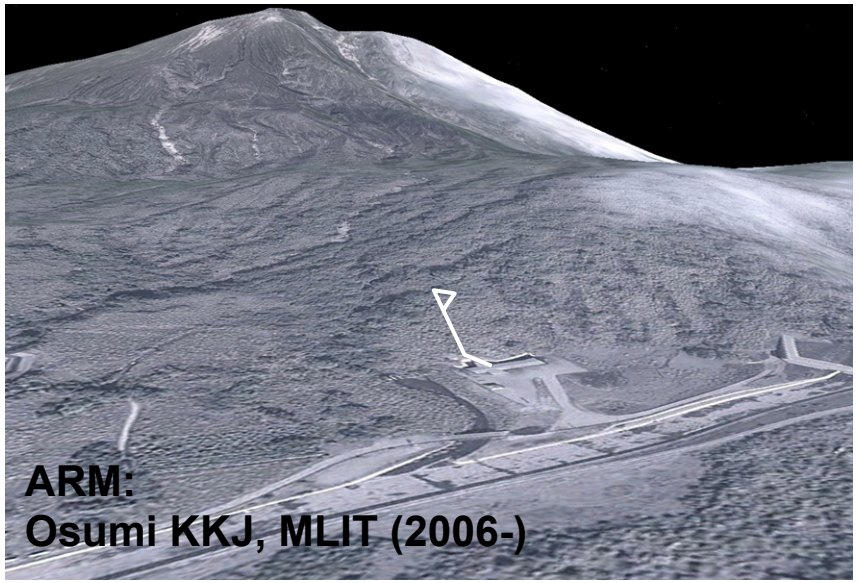
Difference in eruption scale

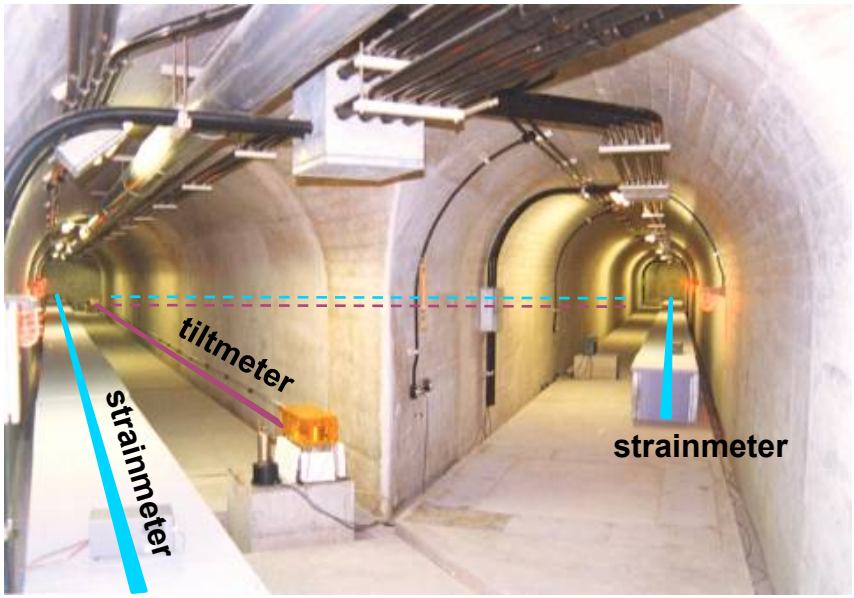


Observation of ground deformation in underground tunnels

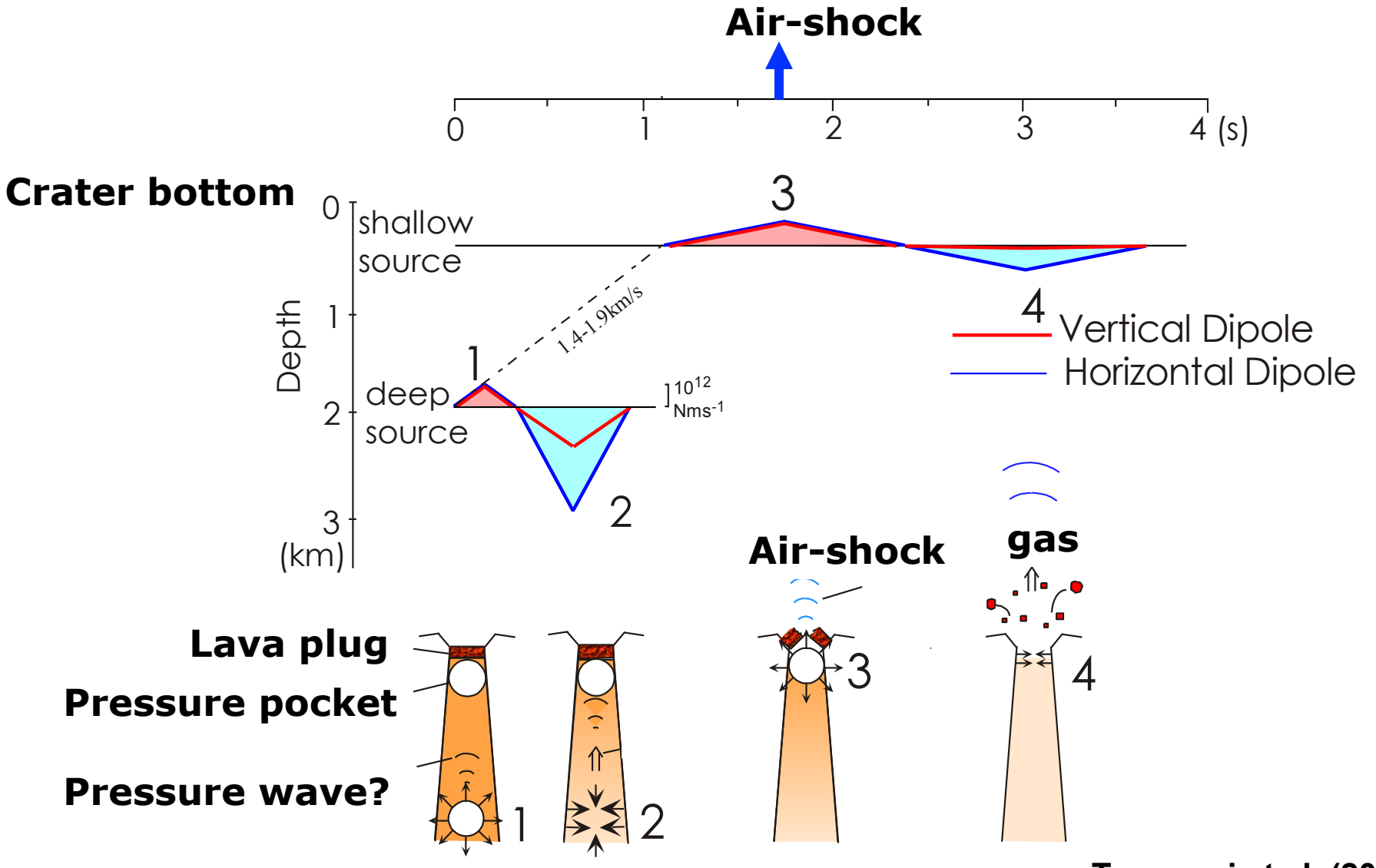




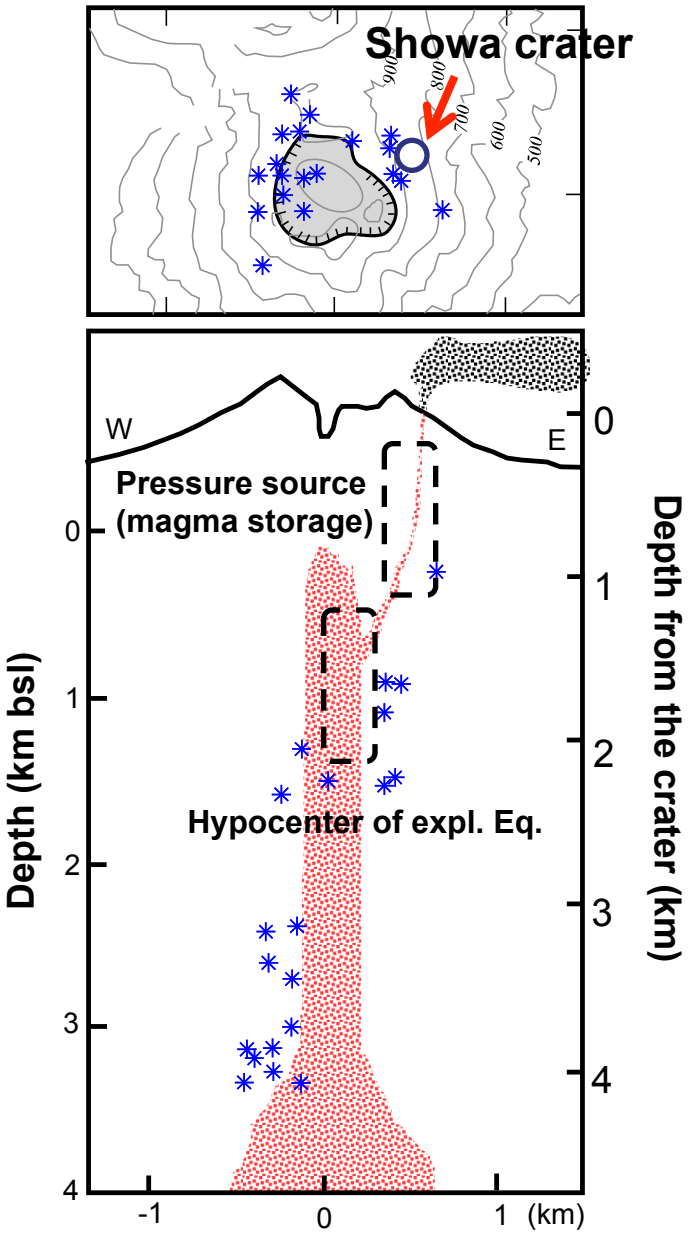




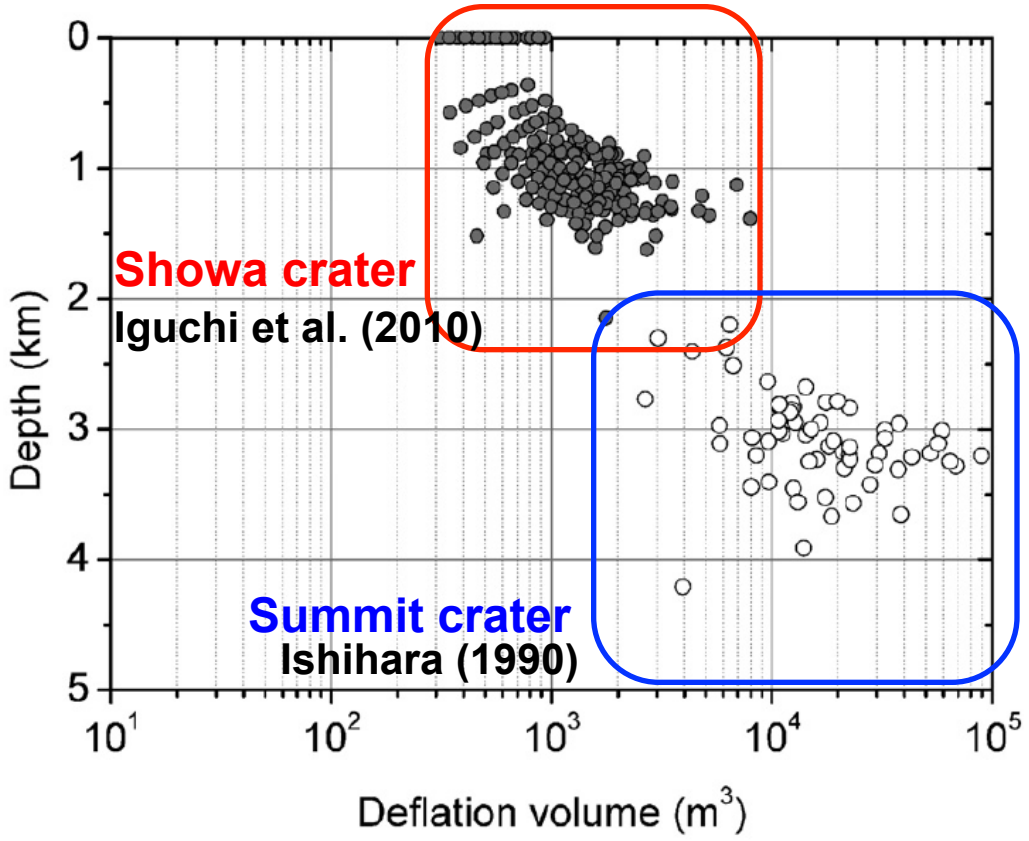
Model of eruption mechanism for the summit crater eruption



Tameguri et al. (2002)



Iguchi et al. (2013)



Deflation source during an eruption at Showa crater is smaller and shallower than the case for an eruption of the summit crater