Reconsiderations on 1986-IzuOhshima eruption,Introduction

*Kei Kurita[1], Hidefumi Watanabe[2]

1. Earthquake Research Institute,University of Tokyo, 2. Disaster Prevention Division,Tokyo Metropolitan Goverment

1986 Izu-Ohshima eruption has revealed several significant problems, which disclosed unmatured state of volcanology at that moment. The most significant situation was that the eruption style as well as the eruption site shifted with time during the course of eruption episodes. The volcanologists were faced the social demands for immediate response towards the transient behavior. This eruption may be the first occasion where the volcanologists deeply recognized the importance of real-time monitoring of the eruption activity. Why the eruption sequence changed? How did the observations trace the shift and how was the prediction of the shift possible?, these problems are still unanswered today. In this 100 years izu-Ohshima erupted repeatedly with the interval of 30-40 years.Already 30 years have passed since last eruption so that we could consider the next eruption.
In this session we will focus the following subjects,
1.Reconsideration on the unanswered problems of the eruption
2.Reconsideration on the eruption based on the current knowledge and technique
3.Propositions and proposals about future expected eruption
This presentation will summarize the session and try to show the possible orientation.

Keywords: volcanic eruption, prediction of volcanic eruption, volcanic island

A Comprehensive magma source model to explain all available crustal deformation data for 1986 Izu-Oshima eruption

*Osamu Kamigaichi[1]

1. Japan Meteorological Agency

We present a comprehensive magma source model to explain all available crustal deformation data(1 borehole strainmeter, 3 borehole tiltmeters and leveling surveys on the island, and 3 borehole strainmeters outside of the island) for 1986 Izu-Oshima event, along the context of Linde et.al.(2016)Journal of Volcanology and Geothermal Research vol.311, p.72-78. Borehole strainmeters data used in this study are calibrated by using long period seismic wave response.
Here we discuss the whole event in two phases, phase 1(Nov.15-20, from the start of summit eruption to quiescence just before the start of fissure eruption) and phase 2(Nov.21-30, after the estimated dike intrusion to fissure eruption).
Phase 1
The eruption started from the south wall of the nested caldera at 17:25(JST) on Nov. 15, 1986. Before the eruption, no significant change in seismicity and short-term crustal deformation was observed, indicating no new conduit formation. After the start of the summit eruption, synchronized changes were observed not only by 1 borehole strainmeter and 3 tiltmeters on the island, but also 2 borehole strainmeters on Izu peninsula facing to the island, until they cease at around the midnight on 20th. To explain all these changes, pressure decrease of spheroidal source, centered at NW part inside of the caldera at 4km depth, with 2.25km long major axis dipping 70 degrees in a vertical plane perpendicular to the maximum tension direction due to the bending of Philippine Sea Plate, and aspect ratio of 1:0.3, was estimated as an optimal magma source model. The extension of the major axis intersects the surface close to the eruption point. Pressure increase of the source of this shape can also explain the relative subsidence of the crater relative to the caldera rim revealed by repeatedly conducted short line leveling surveys before the eruption.
In phase 1, erupted magma volume was precisely estimated from the observed magma top level in the crater with known topography. This was a very rare case in which the erupted magma volume to the surface was quantitatively compared with the magma source volume change estimated independently from crustal deformation observation. The former was larger than the latter, and it can be interpreted as a simultaneous recharge of magma to the pressure source probably from a deeper reservoir.
In recent years, long-term island inflation overlaid by short-term relative deflation and inflation has been observed by borehole strainmeter, GNSS and laser ranging on the island. Spherical sources which are located near the above mentioned spheroidal source for respective changes are estimated by Meteorological Research Institute. We expect a progress of their research as for their relation.
Phase 2
After 1.5 days of quiescence at the end of phase 1, eruption resumed with a fissure eruption inside of caldera at 16:15 on Nov. 21, and it extended to a flank fissure eruption in about one hour. About two hours before the first fissure eruption, borehole strainmeter on the island started to show a large change, and significant seismic activity extending NW-SE across the island started. The strain change started with contraction, and turned to expansion in ten minutes. Expansion continued until the end of the day when it turned its polarity again, and the total expansion was over 100 micro strains. Synchronized significant strain changes were also recorded at 3 borehole strainmeters outside of the island. To explain all these crustal deformations, fissure trend on the surface, hypocenters distribution and leveling survey results (including the effect of phase 1) conducted before and just after the eruption, opening of main two dikes

trending NW-SE direction, slightly offset, and pressure decrease of oblate spheroid centered at 10km depth under the caldera was estimated. In this model, the conservation of magma mass is considered.

Keywords: 1986 Izu-Oshima eruption, Crustal Deformation, Magma source model

Two types of volcanic tremor changed with eruption style during 1986 Izu-Oshima eruption

*Aika Kurokawa[1], Minoru Takeo[2], Kei Kurita[2]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Earthquake Research Institute, The University of Tokyo

Izu-Oshima Island is one of the most active volcanoes in Japan. The most recent eruption occurred in 1986, when the most active stage consisted of three eruption episodes at different craters. The eruption initially began at the summit crater in a strombolian style with a continuous lava fountain, which gradually became intermittent explosions accompanied by infrasound and shock waves with a decreasing rate of magma discharge. The summit eruption suddenly ceased four days after the onset. In parallel with the decrease in the summit activity, two subplinian eruptions occurred producing fissures in the caldera floor and in the flank of the outer rim. So far, the only reported precursor phenomenon to the fissure eruptions was an increase in seismicity in shallowparts of the caldera just 2 h before the first fissure eruption (Yamaoka et al., 1988). The shifts in eruption style and eruption site during the course of eruption are not so peculiar phenomena but commonly observed at other volcanoes. How to monitor and predict these shifts is one of the imminent tasks assigned for volcanology. 1986 Izu-Oshima eruption should be an indispensable test case to check this even now.
In order to explore possible prospects for the eruption sequence, we have analyzed volcanic tremors occurred during 1986 Izu-Oshima eruption using recently digitized data. This study demonstrates that eruption style, waveform characteristic, and source location of volcanic tremor are consistently related in the most active stage of the 1986 Izu-Oshima eruption. During the summit eruption, the tremor is continuous and the source is located around the summit while the correlation between the magnitude of amplitude and the effusive rate disappears with change in the eruption style from strombolian to vulcanian. Then tremors become episodic occurring along the fissures during the stage of the subplinian fissure eruptions. Based on the finding about the relation, it was revealed by extracting episodic tremors superimposed on the continuous tremor during the summit eruption that precursory migration of tremor sources along fissures occurred 5 days prior to the fissure eruptions. On the other hand, Linde et al., (2016) insist that the precursory changes in seismic activity starting 2 h before the first fissure eruption is consistent with the ground deformation and explained by propagation from a deep (10 km) reservoir to a long sub-surface dike. However, the precursory activity of the tremors, which suggests injection of magma below fissures cannot be explained by the scenario because it preceded the seismic activities. The fact demonstrates the importance of tracking temporal changes in volcanic tremor on a priority basis. Since Izu-Oshima has approximately 30-year eruption cycle in recent history and 30 years have passed since the last eruption, the implications of this study should be incorporated into adaptive monitoring in anticipation of the next eruption.

Keywords: Izu-Oshima, volcanic tremor

“Sub-plinian” column of Izu-Oshima 1986B Eruption

*Kazutaka Mannen[1]

1. Hot Springs Research Institute of Kanagawa Prefecture

The 1986B eruption, which is the climatic phase of the 1986 Izu-Oshima eruption is a sub-plinian eruption observed remotely by satellite and radar echo along with media footage on a large scale and conventional terrestrial observation for the first time in the history. Although large number of papers from a variety of perspective have been published, some details of the eruption remain still unknown. The column height, which is one of the most important parameter to describe an eruption is among them.
The column height of the 1986B eruption have been reported as 16.5 km in 17:00-17:20 (Hayakawa, 1987), 12 km in 17:02 (Hirata, 1989) and 7 km in 16:30 (Sawada, 1998) based on terrestrial observations. On the other hand, GMS, which is a meteorological satellite captured infrared images during the eruption and temperature of the coldest portion of the eruption cloud marked -33ºC. If the temperature of the eruption cloud is same as ambient, the cloud height is assumed to be from 7 to 9 km high (Sawada, 1998). Also, advection rate inferred from the image sequence (approximately 200 km/h) is same as wind velocity of approximately 8 km high.
Mannen (2006) assumed vertical eruption column, which is not affected by wind, and calculated eruption column of 13.8 km high based on column model and decay rate of tephra mass loading as a function of distance from the eruption centre. This study assumed all particles on the ground originated from umbrella region; however, Mannen (2014) showed that most of the particles on the ground originated from the eruption column lower than 8 km high.
Woodhouse et al. (2013) established a new model of eruption columns that bend with wind. Based on the model and the aerological observation of Hachijyojima island near Izu-Oshima, mass flux rates are calculated as 1×10^7 kg/s for 8 km high and 1×10^8 kg/s for 12 km high. Since the total erupted mass of the eruption is calculated to be 1.4×10^{10}kg (Mannen and Ito, 2007), duration of the eruption column is calculated to be 20 minutes for an 8 km high column and 2 minutes for a 12 km high column.
The 1986B eruption started 16:15 then reached to the climax at around 17:00 then waned until 22:00 and thus the duration is about 6 hours. Therefore, column height of 12 km is unlikely. Even if the column height marked 8 km, duration of such climax is assumed to be less than 20 minutes, and phases, column heights of which are lower than 5 km (1×10^6 kg/s) or 4 km (1×10^5 kg/s) could fill a large part of the duration of the 1986B eruption.

Keywords: sub-plinian eruption, eruption column, wind

Present weak precursor of the next eruption at Izu Oshima volcano based on the precursory phenomena observed in the 1986 eruption.

*Yuichi Morita[1]

1. Earthquake Research Institute, University of Tokyo

1. Introduction
It has passed 30 years since the latest eruption occurred in 1986-87 at Izu-Oshima volcano. Ground inflation, that is generated by magma storage at reservoir at the depth of approximately 5km, started in the middle of 1990’s and it continues from the long-term point of view with short-term fluctuation: inflations and deflations every 1 -3 years. From this observation, we can present indefinitely that the volcano will erupt in future. Long-term prediction of eruption as mentioned above is not so difficult in general. And we may be able to forecast easily the eruption just before a few hours in the case of appearing large amplitude volcanic tremors and ground deformations like the Nov.21, 1986 flank eruption. However, middle term prediction, that is much effect to mitigate volcanic disaster, is not so easy. It is normally conducted based on the previous observation facts prior to the eruption. If the process prior to the eruption progress in the same manner, it may be not so difficult. But it may be very difficult in the case that the process and type of eruption are not same as the previous one. We should look back the observation facts at the previous eruption, and realize the condition inside of the volcano, try to imagine the condition inside of the volcano, look for new insight of observations.
2. Visiting old: geophysical observation facts in the previous eruption
Many observations are reported for the latest eruption at Izu-Oshima. Among them, I would like to focus on the followings: Magnetic field at the south of the crater decreased 4 years before the eruption and it was accelerated approximately one year before, simultaneously electro-conductivities changed suddenly. Area of anomalous high temperature inside of crater was enlarged before a few months of the eruption. Volcanic tremor appeared 4 months before the eruption and its amplitudes increased gradually until the beginning of the eruption. All of them shows the geothermal anomaly occurred in the shallow part (near ground water level) prior to uprising magma. The heat might be carried by high temperature volatile component: volcanic gasses emitted from magma reservoir. It is common that the volatile component migrates upward from magma reservoir and steam from crater becomes strong prior to the eruption. If we can detect the upward migration of volatile in the other method, we can predict the eruption more precisely and earlier. Behavior of the volatile component is important to know the condition inside of the volcano and eruption type of the future eruption.
3. Learn new: new insight based on the previous observations
Direct observation of volcanic gas flux is one of most effective method to know the behavior of volatile component. However, the measures strongly depend on the place and gloss features cannot be revealed without systematic and wide-area measurements. On the other hand, new method to know the volatile condition deeper than ground water level was proposed using volcano-tectonic seismicity. I have studies volcano-tectonic seismicity whose hypocenters are located beneath caldera and just above magma reservoir, and found out that seismicity is well correlate with stress changes at hypocenter zone (Refer my presentation in the session of S-VC47 in detail). From this analysis, effective normal stress acting on fault surface decreased after 2011-2013, and kept low level at the present. The effective stress is affected by pore pressure acting on the fault plane, and low effective normal stress is equivalent to high pore pressure. One of the most feasible processes of the facts is increasing volatile component emitted from the magma reservoir. This observation is probably the earliest evidence of upward migration of volatile component prior to the next eruption. We should concentrate to watch the seismicity and find out the

relation of the other phenomena until next eruption to develop the method on prediction of volcanic eruption.

Keywords: volvano-tectonic earthquakes, seismicity, precursor to volcanic eruptions, Izu Oshima volcano

On the significance of the monitoring of volcanic islands activity from the neighboring sea surface

*Yozo Hamano[1], Hiroko Sugioka[3], Mie Ichihara[2]

1. Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology, 2. Earthquake Research Institute, University of Tokyo, 3. Department of Planetology, Kobe University

We have developed a remote island volcano monitoring system using the Wave Glider (WG) manufactured by Liquid Robotics Inc. The WG sails sea surface for long time using sea waves and solar energy without any fuel, and is equipped with a satellite communication modem to transmit data message to the land station. The system observes 1) volcanic eruptions with infrasound signals, 2) deep volcanic activity by seismic signals with the underwater hydrophone, 3) eruptive activity by photographs, and 4) waves by wave gauge while autonomously navigating around the remote island far from the land, and transmit the information to the land station via satellite communication. This sea going monitoring system of the volcanic activities is useful not only for inhabited small volcanic islands but also the big islands such as Izu-Oshima island. Especially, the hydrophone measurements from the sea extend the seismic network confined within the island and enable the highly sensitive seismic observation on the seismic activity in the deeper part of the island.

Keywords: Volcano, Izu-Oshima, Volcanic activity monitoring