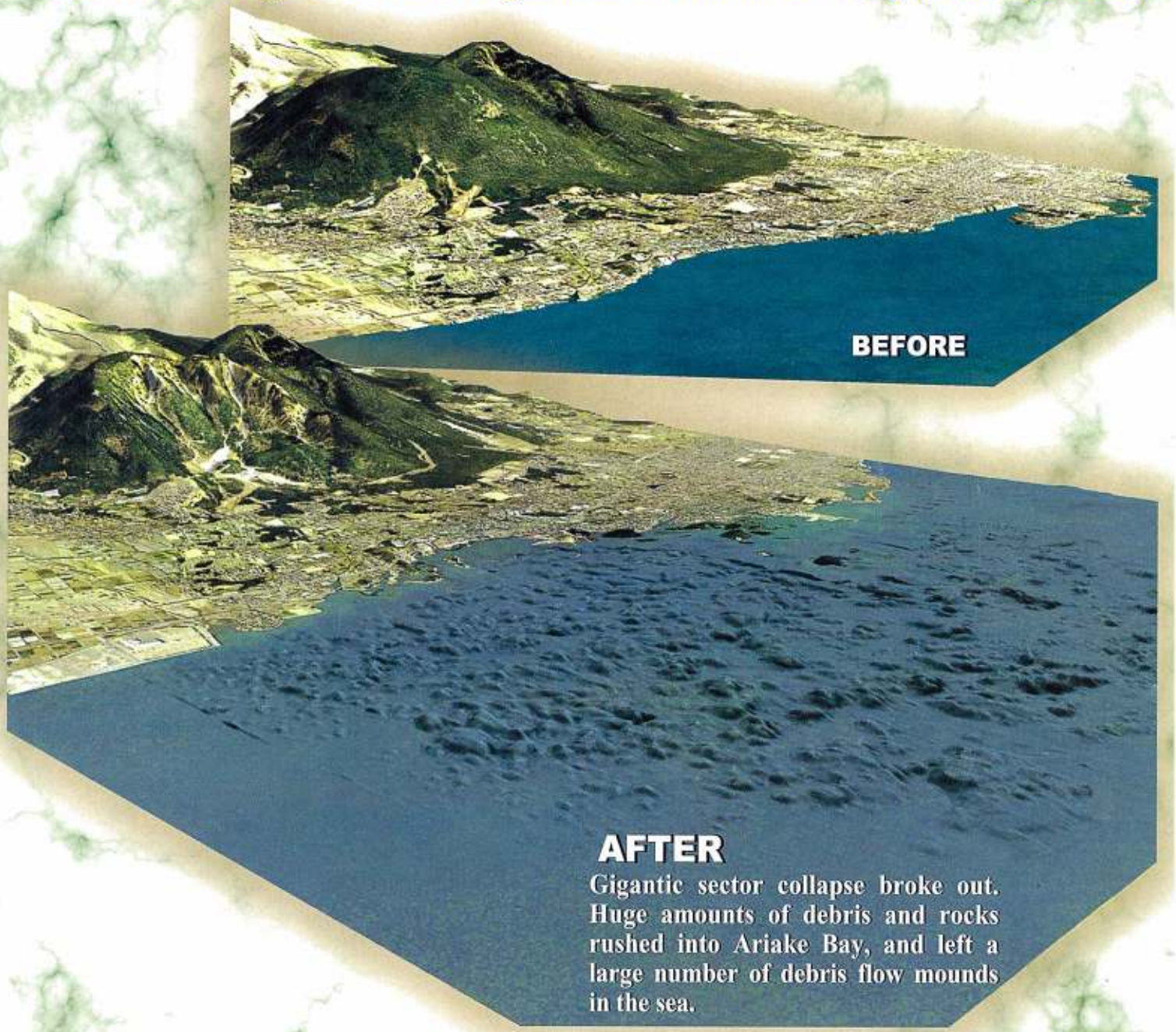
THE WORST DISASTER IN JAPAN

島原大変

The Catastrophe in Shimabara

The 1791-92 eruption of Unzen-Fugendake and the sector collapse of Mayu-Yama



Unzen Restoration Office

Ministry of Land, Infrastructure and Transport of Japan

Introduction

May 21, 1792, a gigantic sector collapse broke out on the eastern slope of Mayu-Yama in Shimabara Peninsula, Nagasaki Prefecture, Kyushu. The sector collapse was induced by earthquakes which occurred under Shimabara, a castle town, in the last stage of eruptive activities of Unzen-Fugendake(Mt. Fugen). The eruptive activity began in November, 1791 and ceased in July, 1792. Huge amounts of debris rushed into Ariake Bay generating a big tsunami. The tsunami hit both sides of the inland sea, and killed about 15,000 persons. And then, the hazard was called the catastrophe in Shimabara.

November 17, 1990, Unzen-Fugendake began its eruption after 198 years of dormancy. May 20 of the following year, the first lava lobe was effused, and totally 13 lobes of lava dome were formed one after another by July 1994. June 3, 1991, large-scale pyroclastic flows rushed down along the Mizunashi River, killing 43 people. The pyroclastic flows and consequential debris flows brought about damages to building, farmfield and forest over a vast area on the slopes around the mountain.

In 1993, a large portion of pyroclatic flow deposits were flushed out many times as debris flows by many heavy rains of long duration, and Shimabara city was temporary isolated by the severe inundation of large debris flows. The Unzen Restoration Office was established against the repetition of significant disasters. Since then, the office has been implementing two types of projects: sabo project and road construction project. The office is undertaking these projects to help the devastated area recover fastly by improving the infrastructure for the land.

The catastrophe on 210 years ago and recent hazards brought big damage to the people who lived at the foot of Unzen-Fugendake. We must learn what kind of thing those hazards were. Furthermore, how damage expanded. This pamphlet was made by our office so that everyone could learn past hazards well.

October, 2002 Shozo Koga
Director of Unzen Restoration Office
Ministry of Land, Infrastructure and Transport of Japan

Table.1 Comparison of Volcanic Hazards

Volcano	Unzen 1791-92	Unzen 1990-95	St.Helens	Pinatubo
Active period	Nov.1791-Jul.1992	Nov.1990-May 1995	Mar.1980-Dec.1980	Mar.1991-Oct.1992
Total Volume of magma	$2.0\times10^7m^3$	$2.0\times10^8m^3$	$1.3\times10^9m^3$	$8.4\text{-}10.4\times10^9m^3$
Volume of pyroclastic fall deposits	—	—	$1.1\times10^9m^3$	$3.4\text{-}4.4\times10^9m^3$
Volume of pyroclastic and debris flow deposits	—	$1.6\times10^8m^3$	$2.5\text{-}3.0\times10^9m^3$	$5.0\text{-}6.0\times10^9m^3$
Volume of sector collapse	$3.4\sim4.4\times10^8m^3$	—	$2.3\text{-}3.0\times10^9m^3$	—
Date of sector collapse	May 21,1792	—	May 18,1980	—
Dead (person)	15,000	44	60	more than 250
References	Japan Meteorological Agency(1996): National catalogue of the active volcanoes in Japan (second edition)	Data of Public Works Research Institute and Geographical Survey Institute	United States Geological Survey(1981): The1980 Eruptions of Mount St.Helens	Newhall & Punongbayan (1996): FIRE and MUD, PHIVOLCS

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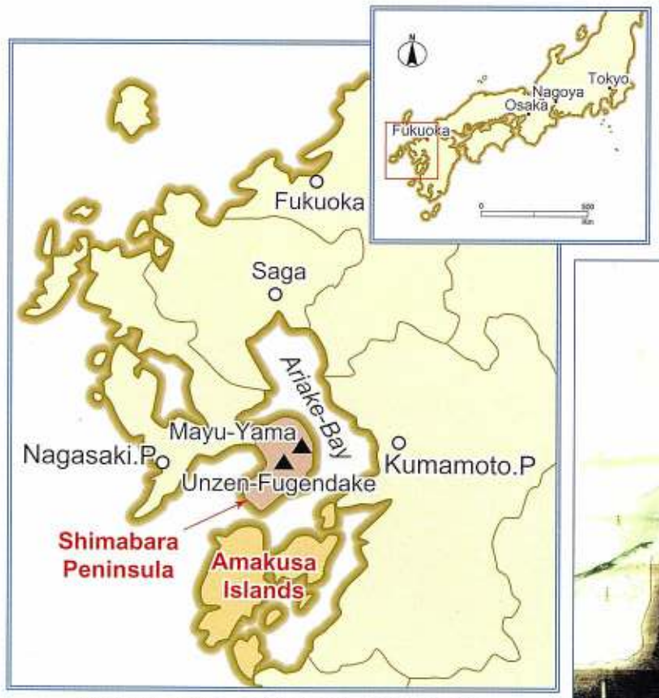


Fig.1 Map showing of Shimabara and Kumamoto

Fig.2 寛政四年大震図（本光寺蔵） Kansei yonen daishinzu
Before the sector collapse in April, 1792

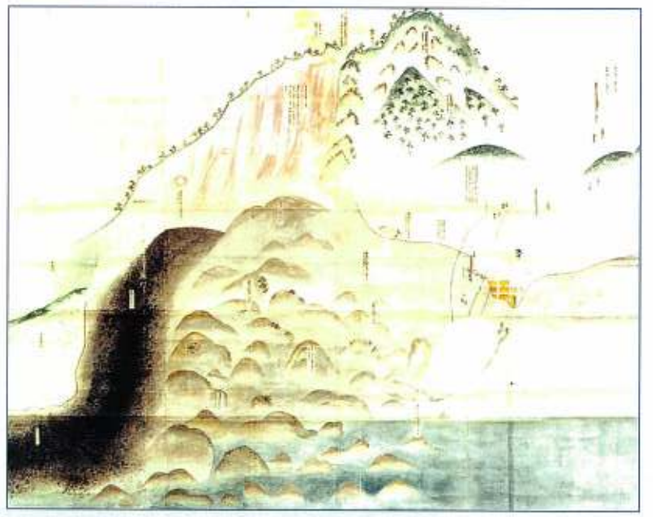


Fig.3 島原大変大地図（島原市図書館蔵） Shimabara taihen ohchizu
After the sector collapse in May, 1792

※ The bird's eye view of the cover was made by using the following materials.
The topographic data of the land was made by Hokkaido Chizu Co. Ltd., on the basis of 1/ 25,000 map of the Geographical Survey Institute.
The topographic data of the seabed was prepared by the Geographical survey Institute with narrow multi beam sounding system (Niwa, 1998).
The aerial photograph was taken by the the Unzen Restoration Office.

Chapter I The 1791-92 eruption of Unzen-Fugendake and the catastrophe in Shimabara

1 The eruption of Unzen-Fugendake and the catastrophe in Shimabara

Mayu-Yama, one of Unzen compound volcanoes, situated in the eastern part of Shimabara Peninsula, Nagasaki Prefecture, is a lava dome composed of dacite. It consists of two peaks, the Shichimenzan and Tenguyama. The sector collapse scattered debris deposits over about 10 km² bringing about a gentle slope, and debris materials reached to Shimabara Bay, 5 km away from the top of the mountain. A record at that time reports 15,000 persons were killed by the primary sector collaspe and secondary hazards of tsunami.

February 10, 1792, phreatic eruption initiated at the Jigokuato crater near the summit of Fugendake. March 1, lava effused and it continued for two months, the lava flow was 220~360 m wide and 2.7 km long, and volume of the lava was 20 million m³. May 21, a large portion of Mayu-Yama collapsed induced by a strong earthquake, and volume of about 340 million m³ of debris which is equivalent to 1/6 of the whole mountain body rushed into Ariake Bay, resulting in tsunami (Ohta, 1969).

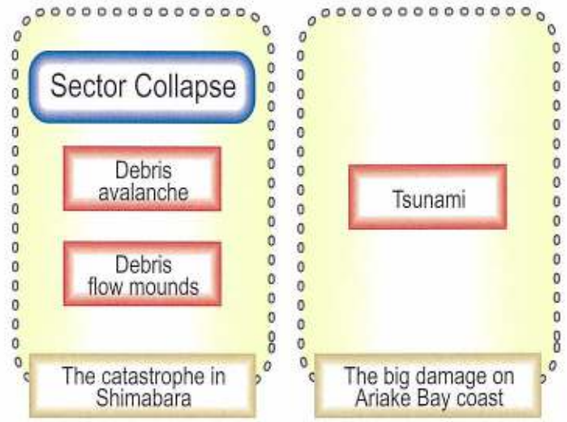


Fig.4 Outline of the 1792 event

Table.2 A number of damage for the 1792 hazard (Modified after Katayama,1974)

	SHIMABARA	AMAKUSA	KUMAMOTO	TOTAL
Dead (person)	9,532	343	4,653	14,528
Injured (person)	707	–	811	1,518
Livestock (no.)	496	109	151	756
House (no.)	3,347	373	2,252	5,972
Devastated fields (ha)	378	65	2,639	3,082

Unzen volcano is a generic term of many mountains centering around Unzen-Fugendake in eastern part of Shimabara Peninsula. Unzen Volcanoes are situated in volcanotectonic depression area of Unzen graben. This graben continues extending the distance in the north-south direction. The graven forms many faults in the east-west direction, inducing earthquakes.

Unzen volcano can be divided into two ages : Older and Younger Unzen Volcanoes. The Older Unzen Volcanoes, shown blue triangle in Fig.5, are dated at 200-500 thousand years and exceed 36 km³ in volume. The Younger Unzen Volcanoes, shown red triangle, are dated younger than 100 thousand years with the total volume of 8 km³.

The volcanic products of Unzen volcano composed mainly lava and pyroclastic deposits of highly viscous andesite to dacite composition. The type of lava tends to form lava dome. The pyroclastic flow and lahar formed alluvial fan around lava dome. A sector collapse of lava dome usually deposited a huge amount of debris forming many debris flow mounds on the mountain slopes and on the shallow sea floor. According to the photo interpretation by Geographical Survey Institute(1995) and Inoue(1999), the area covered by debris materials is clearly recognized topographically marking the remains of debris flow mound.

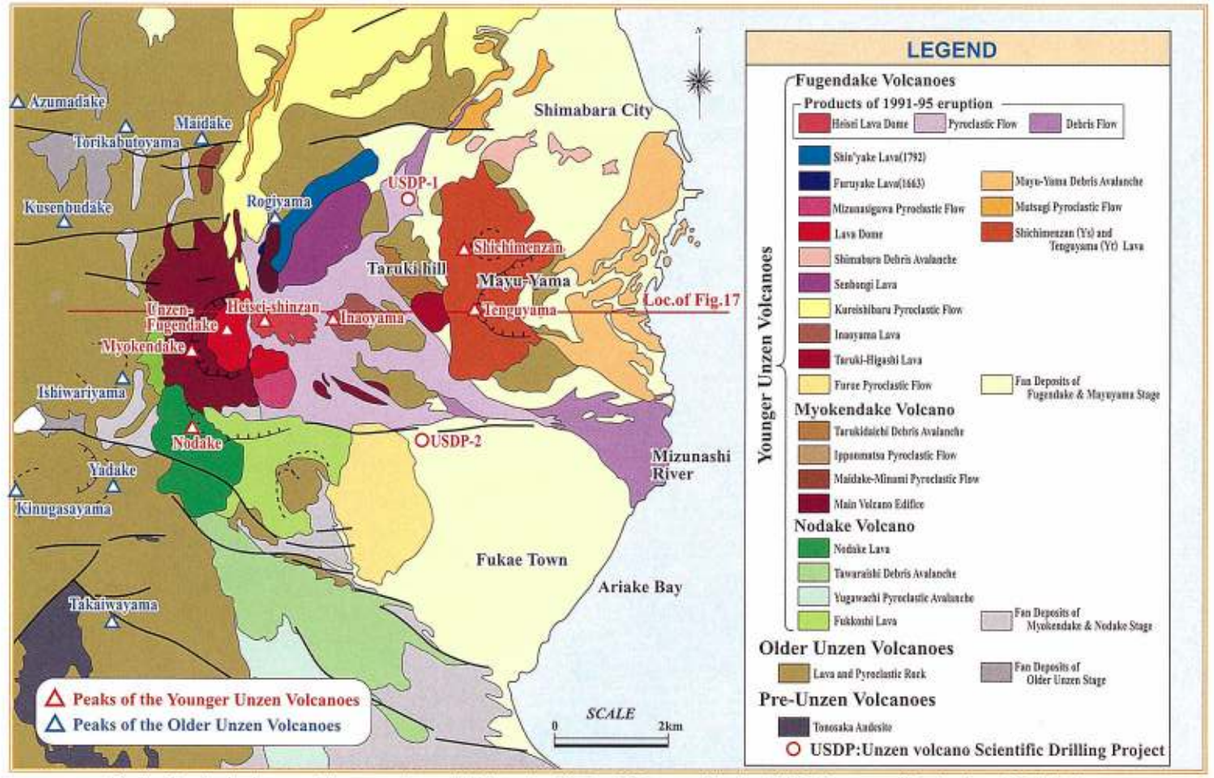
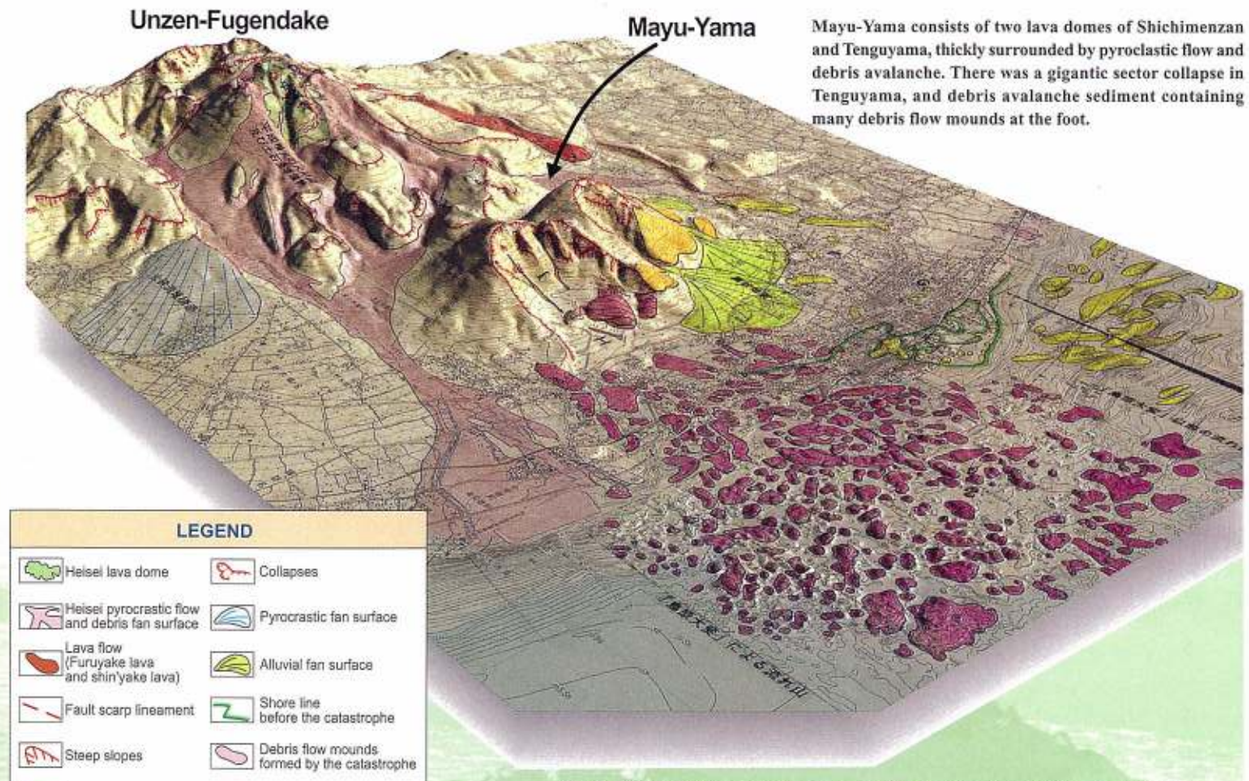


Fig.5 Geological map of Unzen volcano (National Institute of Advanced Industrial Science and Technology Website)



Mayu-Yama consists of two lava domes of Shichimenzan and Tenguyama, thickly surrounded by pyroclastic flow and debris avalanche. There was a gigantic sector collapse in Tenguyama, and debris avalanche sediment containing many debris flow mounds at the foot.

Fig.6 Bird's eye view which based on the geomorphological map by photo interpretation around Unzen-Fugendake and Mayu-Yama (Modified after Inoue, 1999)

2 The geomorphic history of Mayu-Yama

There are several explanations on the occurrence of the sector collapse as shown in Table.3. The explanaton on combination of earthquake and hydrothermal become leading opinion.

Conseptive pictures of the history of volcanic activity and topography formation around Mayu-Yama is shown in Fig.7.

Table.3 Proposed explanations about the cause of the sector collapse (Modified after Ohta,1987)

Explanations	Basis and Assertion	Adovocate
Eruption	The horseshoe shape disintegration and debris flow mounds are characteristic phenomenon of the volcanic eruption. There is old record of the fire, smoke, and weak earthquakes.	Sato,D. (1925)
	After frequent local earthquakes, there was an explosion with incidental ground water changes.	Komada,I. (1913)
	The horseshoe shape disintegration and debris flow mounds are formed.	Furuya,T. (1978)
Earthquake	It contradicts in the pattern of the weak earthquake → small eruption → explosion → lava flow. There is no old record written about many explosion.	Ohmori,H. (1908)
	Fragmentation by earthquake → debris flow → induced tsnami	Ohta,K. (1969)
Hydrothermal	Landslide was induced by the increment of hydrothermal pressure. Tsunami was caused by an abrupt lift of the sea floor due to a slump motion along a slip surface along a circular arc.	Katayama,N. (1974)
Combination of earthquake and hydrothermal	Fragmentation by earthquake under the condition of the increment of hydrothermal pressure.	Ohta,K. (1987)

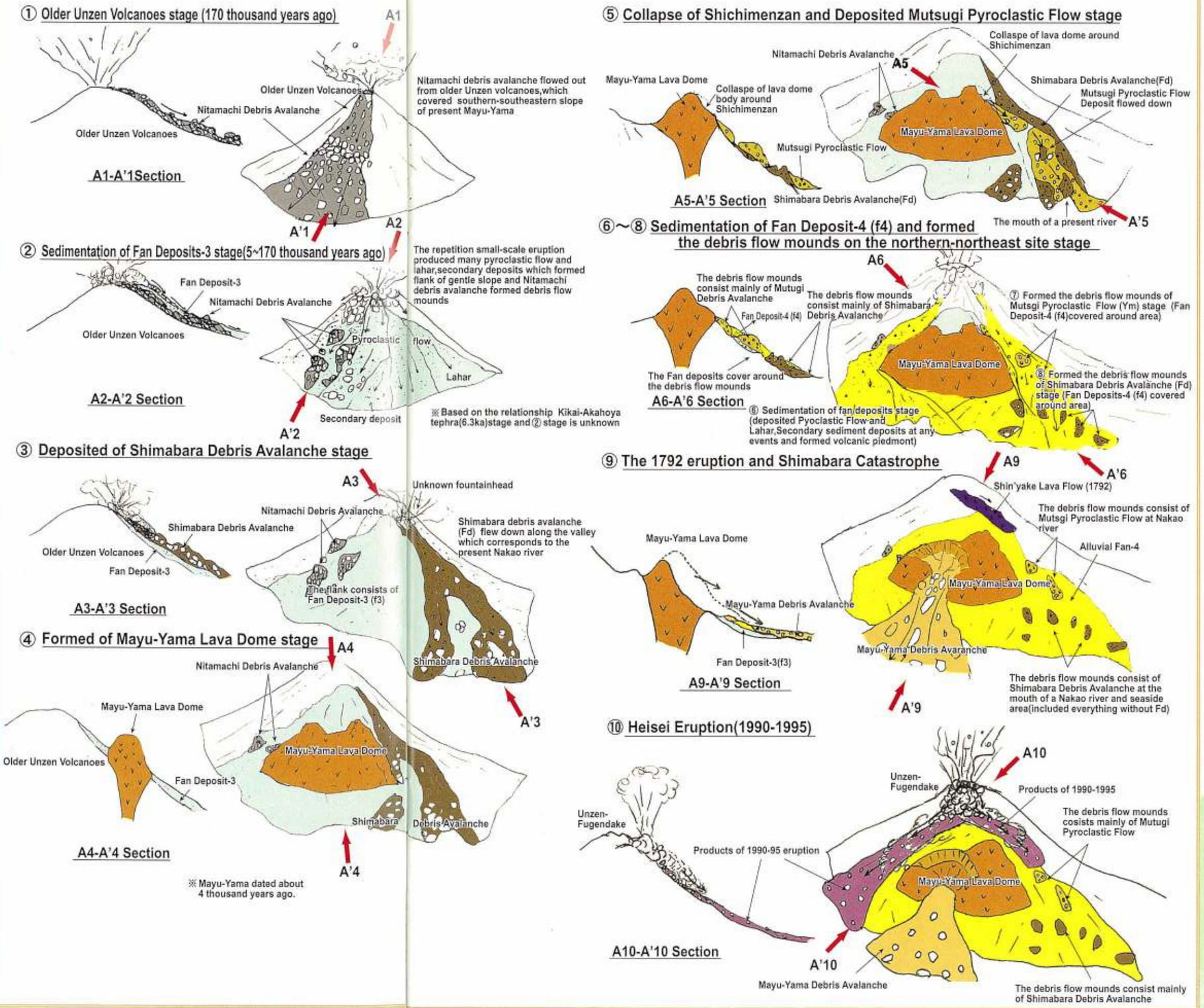


Fig.7 Conceptive pictures of the history of volcanic activity and topography formation around the Mayu-Yama

3 The sequence of the 1791 - 92 eruption

The sequence of 1791-92 eruption is shown in this section. These were put in order as follow through interpretations of many historical documents.

Topographic changes before and after the catastorophe in Shimabara is divided into 4 stages. (Katayama, 1974, Inoue, 1999)

Stage1: As the preceding phenomena, earthquakes continued almost every day since November 3, 1791. Earthquake at Obama area on the west side of Shimabara Peninsula recorded the strongest seismic intensity reaching V - VI on the Japanese standard of Meteorological Agency.

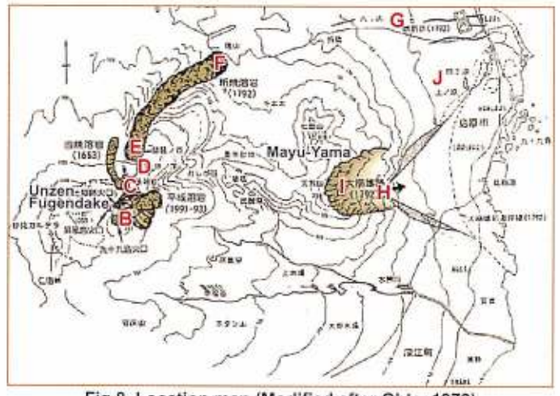


Fig.8 Location map (Modified after Ohta, 1973)

Fig.9 Unzen volcanic graben

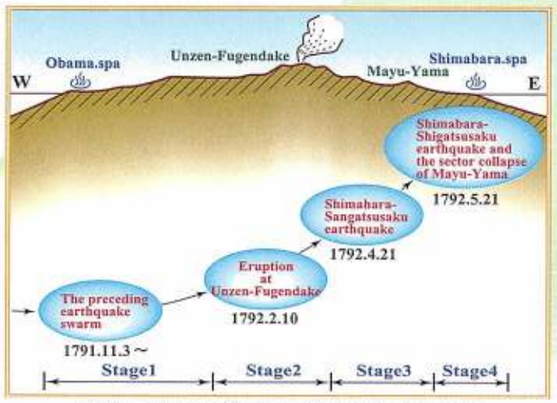


Fig.10 Profile section from Obama to Shimabara (Itoh,1977. Modified after Katayama,1974)

Stage2: Shin'yake lava effused. The preceding earthquakes almost ended, and rumbling of the mountain began in January 1792. A big earthquake and rumbling happened on February 10, then eruption began. The earthquake and rumbling were the strongest in the southeastern foot of Unzen-Fugendake, and Shin'yake lava flow filled up the valley Anasako-Tani for 2 km long from February 27 through April 20.

Stage3: The Shimabara-Sangatsusaku earthquake occurred on April 21, that epicenter located at Mayu-Yama and Shimabara area.The earthquake swarm continued until May 14. The seismic intensity reached V - VI on the Japanese standard of Meteorological Agency at Shimabara castle. The tremor of Mayu-Yama (Tenguyama) was especially strong, and the mountain disappeared by the dust cloud of disintegration of the mountain. Two or three large fissures extended east to west in Shimabara castle town, and the discharge from springs in the town were drastically changed its volume. April 29, a significant landslide occurred at the slope of Kusunoki-Daira which is in front of Mayu-Yama (Tenguyama) . The landslide was (N-S) 720 m long, (E-W) 1080 m long and landslide cliff 90 m high. In Kusunoki-Daira, a few people noticed an unusual rise in the groundwater stage, and escaped to survive.

Stage4: Sector collapse of Mayu-Yama occurred at about 8 p.m. on May 21. The collapse accompanied two strong earthquakes and loud noises. A huge amount of debris and rocks rushed into Ariake Bay, and generated a big tsunami.

Table.4 The sequence of the eruption in 1792 and topographic changes before and after the catastrophe in Shimabara (Modified after Katayama,1974 and Inoue,1999)

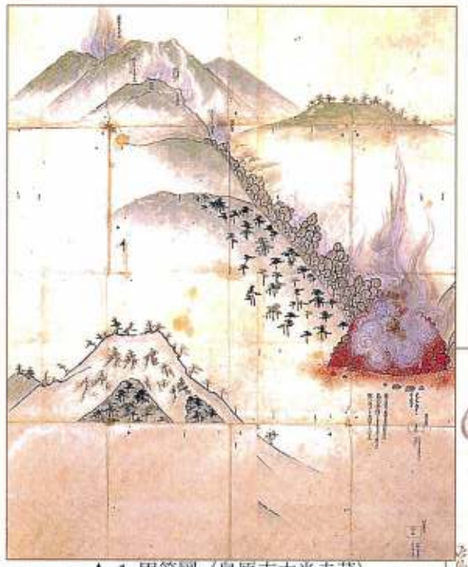
	Location in Fig.8	Name of the Eruption and earthquake	A.D.	Topographic Changes
Stage 1		The preceding earthquake swarm	1791.11.3～12.5	The volcanic activity started with preceding earthquake swarm benearth Tachibana Bay at the western foot of Unzen volcano on November 3, 1791(Seismic intensity V～VI on the Japanese standard of Meterological Agency, at Obama, the western foot of Unzen volcano).
Stage 2	B	Eruption at the Fugenshi-Mae	1792.2.10～7.19	Big earthquakes occurred on February 10, 1792 and the eruption started with ash cloud emission from Fugenshi-Mae, Jigokuato crater opened at the Fugendake cone.
	C	Eruption at the Anasako-Tani	1792.2.27～3.1	The Shin'yake lava flow effused from the top of Anasako-Tani valley on February 27, and lava flew down slowly.
	D	Eruption at the Hachinokubo	1792.3.21～4.20	A new lava flow effused from Hatinokubo on March 21. The lava flew down slowly and jointed with Shin'yake lava flow.
	E	Eruption at the Furuyake-Kashira	1792.3.24	Phreatic eruption at the Furuyake-Kashira occurred 3 days after the eruption from the Hachinokubo without extruding of lava flow.
	F	Flow down at the Shin'yake lava flow	1792.3.25～4.21	The Shin'yake lava flow flew down slowly between March 25～27 and the front of the lava flow reached at the point of 0.5 km to houses. The average velocity was 30～50 m/day and the lava volume was about 20 million m^3.
		Various phenomena which accompanies eruption	1792.3.19～	Carbonated spring begins to breed at Kureisibaru in Mie-villege.
				There was a new smoke from Oshiga-Tani.
			1792.4.9	There were new cracks from Hachino-Kubo to Furuyake-Kashira.
Stage 3	G	Shimabara-Sangatsusaku earthquake	1792.4.21～4.22	The evening on April 21 (March 1, the lunar calender of Japan), strong earthquakes occurred several times (Seismic intensity V～VI) and two or three large fissures were formed in the Shimabara castle town.
	H	Landslide in the Kusunoki-Daira	1792.4.29～5.21	Kusunoki-Daira was a small hill located between Mayu-Yama and Ariake Bay. Large scale landslide occurred on April 29 without strong earthquake and without heavy rain fall. Groundwater level rose up abnormally at Imamura, the eastern foot of Kusunoki-Daira.
Stage 4	I	Shimabara-Shigatsusaku earthquake and the sector collapse of Mayu-Yama	1792.5.21	Very strong earthquake (M6.4, Magunitude in the Richter scale, Usami,1996) occurred on May 21 (April 1, the lunar calender of Japan), and seismic intensity was VI～VII in Shimabara area. The gigantic sector collapse was induced by the earthquke on the eastern slope of Mayu-Yama lava dome of Unzen volcanic area. Huge amounts of debris and rocks rushed down into Ariake Bay generating a big tsunami. The tsunami hit both sides of the bay, and approximately 15,000 people were killed.
	J	Topographic changes after the catastorophe in Shimabara	1792.5.22～	After the catastrophe, the frequency of earthquakes and volcanic activities decreased gradually. A fountain broke out on Uenohara and Shirachi-Ike (pond, bigger than the present one, J point) was formed. The cliff which formed by the sector collapse in Mayu-Yama (I point), collapsed several times due to strong earthquakes and heavy rain.

4 Many documents and pictures about the catastrophe in Shimabara

The old documents and pictures are left showing the catastrophe by the 1791-92 eruption and the sector collapse of Mayu-Yama in minutely. Because of 15,000 persons were dead or missing, the catastrophe was reported by many people, and left many old documents and pictures. When we quote them, we should be careful to verify the contents and meaning of the pictures in order to avoid the acceptance of exaggeration, misunderstanding, and so on by the reporters.

Some of the old pictures are shown below.

A. Pictures describing the eruption of Unzen-Fugendake

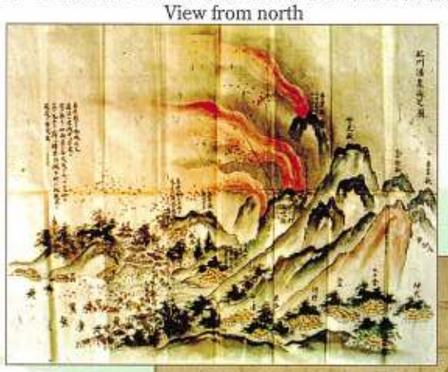


A-1 甲第図（島原市本光寺蔵）
Shin'yake lava flow

A-2 寛政四子年肥前嶋原山々焼崩城下町々村々破損之図（東京大学地震研究所）
Blaze of Shin'yake lava flow and the sector collapse

A-3 穴迫谷噴出図（長野・真田宝物館蔵）
The front of Shin'yake lava flow

A-4 肥州温泉山之図（安芸市立歴史民俗資料館蔵）
View from north

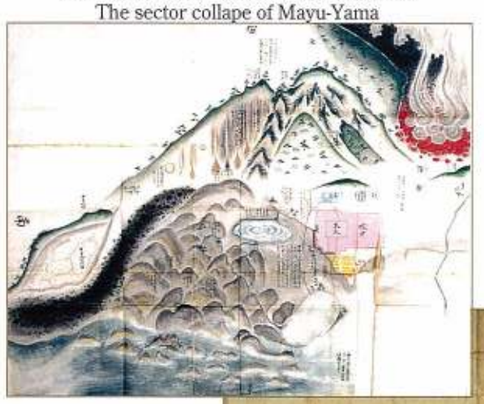


A-5 肥前国嶋原津波之絵図（大変前）（熊本大学永青文庫蔵）
Before the sector collapse

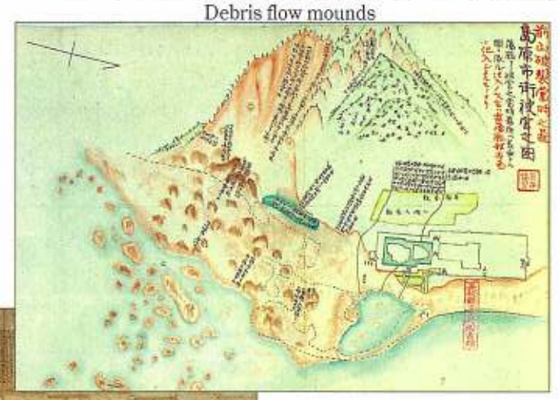
A-6 視聴草所収肥州島原焼崩図（国立公文書館蔵）
Severe eruptions

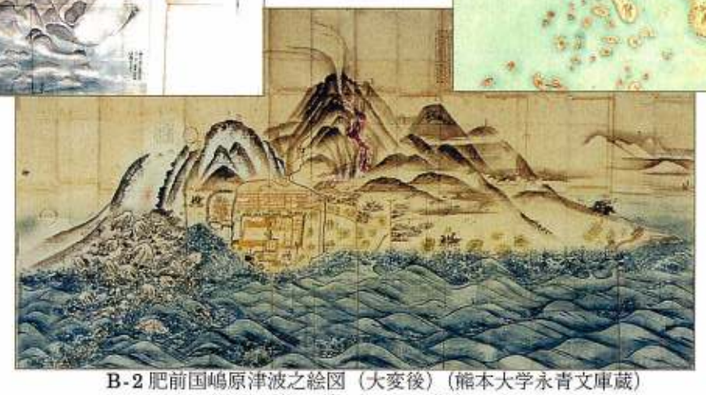
B. Pictures describing the sector collapse of Mayu-Yama

B-1 島原大変図（長野・真田宝物館蔵）
The sector collapse of Mayu-Yama



B-3 島原地変記所収前山破裂当時之図（長崎県立長崎図書館蔵）
Debris flow mounds

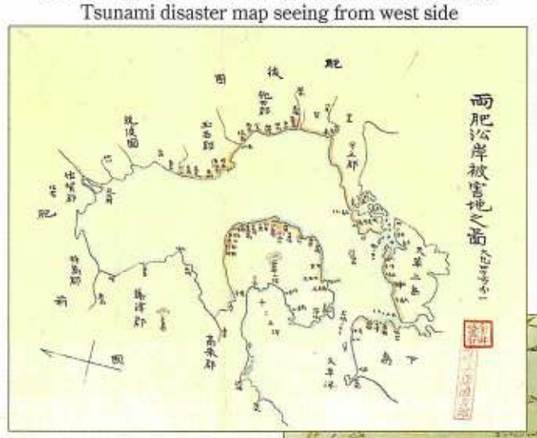




B-2 肥前国嶋原津波之絵図（大変後）（熊本大学永青文庫蔵）
After the sector collapse

C. Pictures describing Tsunami

C-1 両肥沿岸被害地之図（長崎県立長崎図書館蔵）
Tsunami disaster map seeing from west side



C-2 島原湾図（安芸市立歴史民俗資料館蔵）
Tsunami disaster map seeing from east side

C-3 島原山崩高潮大変図（長崎県立長崎図書館蔵）
Whole view of tsunami disaster

5 Topographic changes for the sector collapse of Mayu-Yama

It is supposed that two old pictures (Fig.11 and 13) were drawn exactlly from the same place at Shimabara Castle. Photo.1 is taken from the same place. Fig.14 is bird's eye view on the basis of Digital National Land Information 1996. Comparing Fig.13, Fig.14 and Photo.1, it is assumed that those are showing almost the same landscape. Therefore, based on two old pictures which are considered to give a realistic description, Inoue (1999) reconstructed pre-disaster bird's eye view of Mayu-Yama with trial-and-error method, as show in Fig.12.

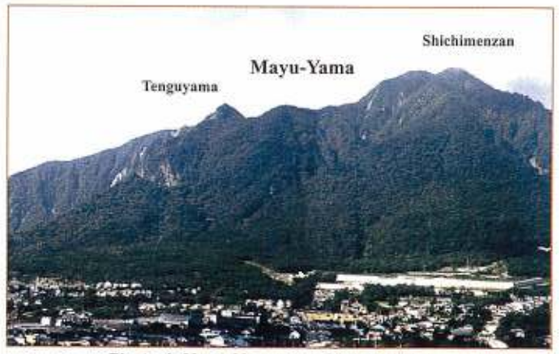


Photo.1 Mayu-Yama, south-west view from Shimabara Castle tower

Fig.11 A piece of "Kansei yonen daishinzu" showing before the sector collapse (Refer to Fig.2)

Fig.13 A piece of "Shimabara taihen ohchizu" showing after the sector collapse (Refer to Fig.3)

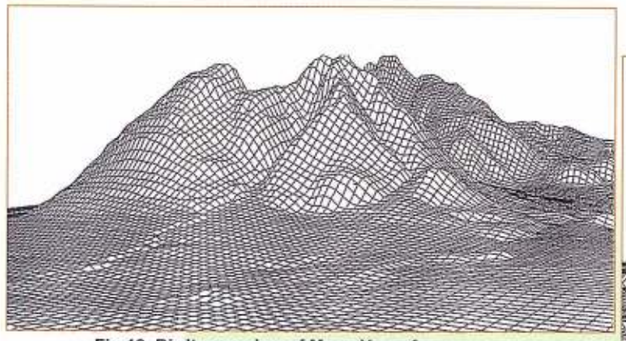


Fig.12 Bird's eye view of Mayu-Yama from the Shimabara Castle (before)(Inoue, 1999)

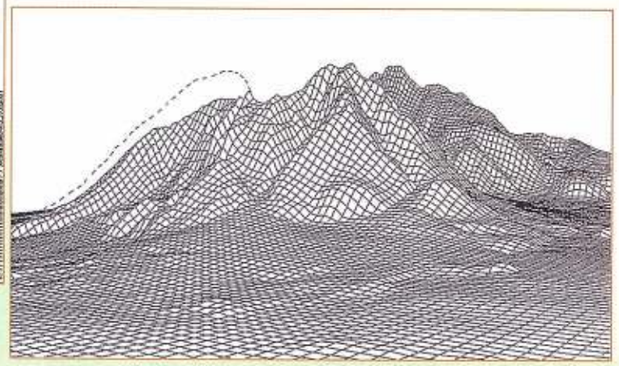


Fig.14 Bird's eye view of Mayu-Yama from the Shimabara Castle (after)(Inoue, 1999)

According to the detail examination by Kobayashi.et,al.(1986), Miyachi.et,al.(1987) and Miyachi(1992), two old pictures are justified the historical accuracy among 27 pictures depicting the catastrophe.

One is a pre-disaster condition titled as "Kansei yonen daishinzu", as shown in Fig.11. And the other is a post-disaster condition titled as "Shimabara taihen ohchizu", as shown in Fig.13. Kobayashi.et,al.(1986) clarified that both pictures had important historical value, because they were submitted to the Tokugawa Shogun in 1792 as the official documents of the catastrophe in Shimabara.

Two contour maps (Fig.15,16) show the doramatic changes of the land and the bottom of the sea. The total volume of the debris was calculated to be 4.4×10^8 m^3. (Inoue,1999)

Fig.17 is a geological cross-section of the Mayu-Yama. The Mayu-Yama was lava dome of 760 m high, and the height became 690 m after the catastorophe.

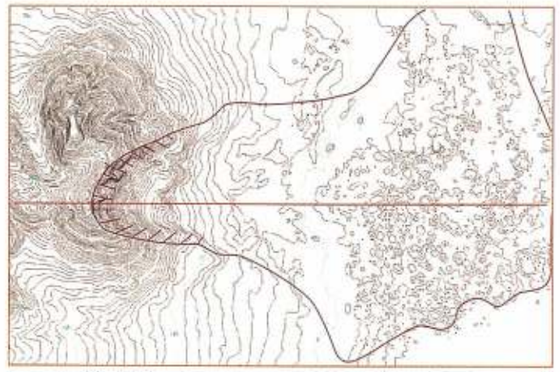


Fig.15 Contour map around Mayu-Yama (after)

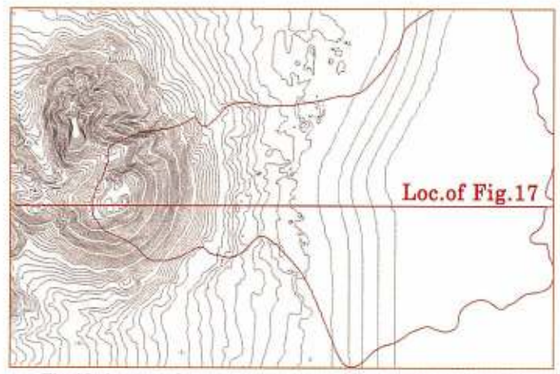


Fig.16 Assumed contour map around Mayu-Yama (before)

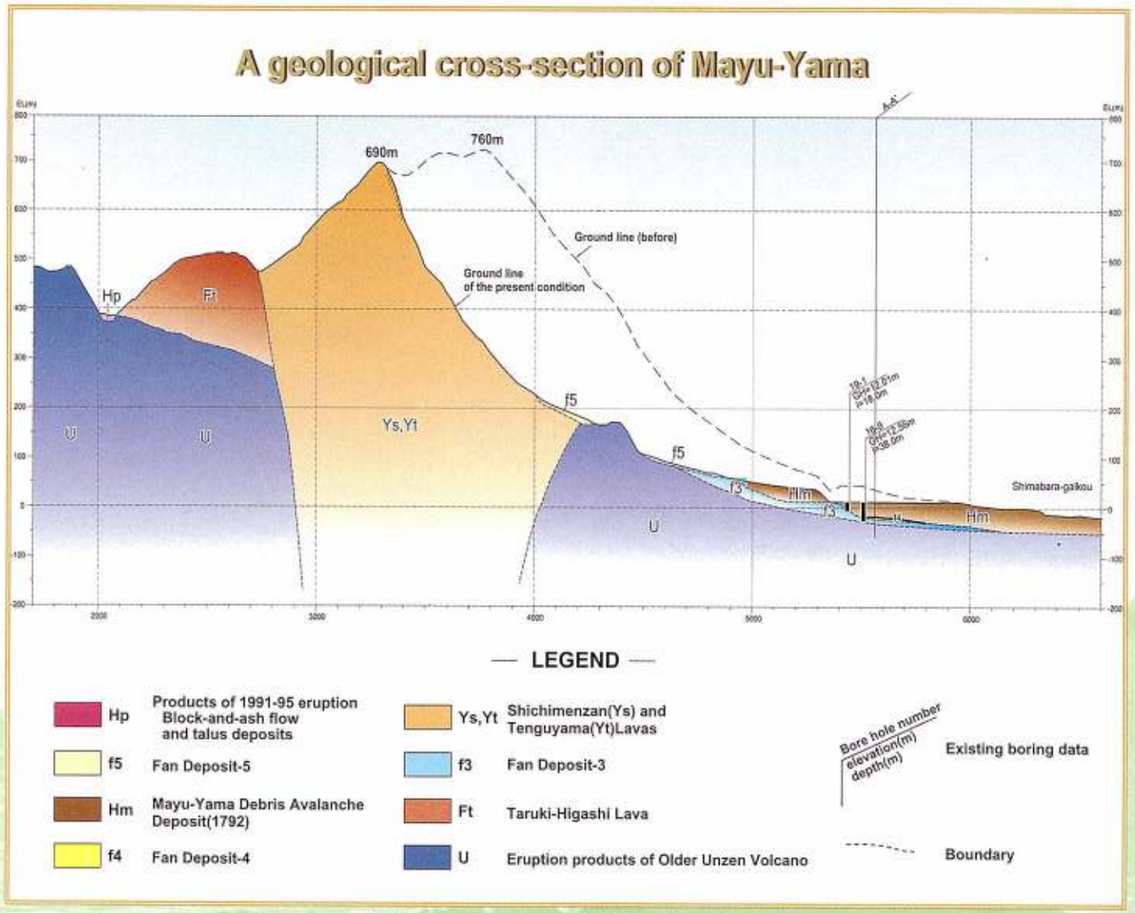


Fig.17 A geological cross-sections of Mayu-Yama

6 Many debris flow mounds in Shimabara city

According to a drawing before the 1792 eruption, many old debris flow mounds are shown in the northern area of debris flow mounds. Furuya (1974) and Miyachi et, al. (1987) proposed those old debris flow mounds had formed before the catastrophe, and the collapse point had been Shichimenzan. Though, the collapse point and the formed period has not been specified yet.

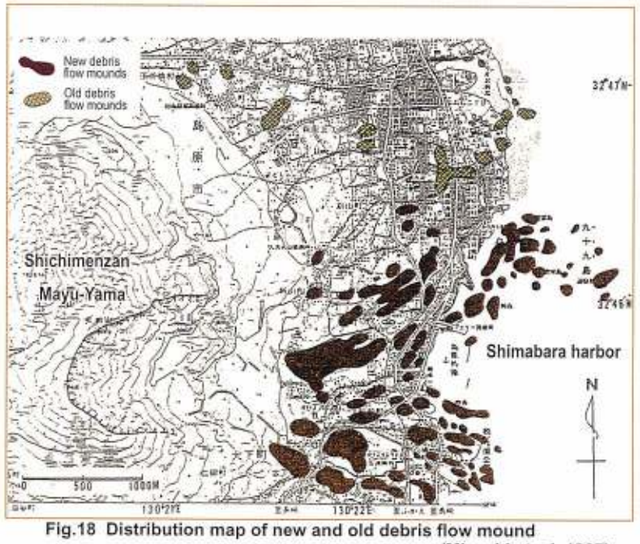


Fig.18 Distribution map of new and old debris flow mound (Miyachi et, al.,1987)

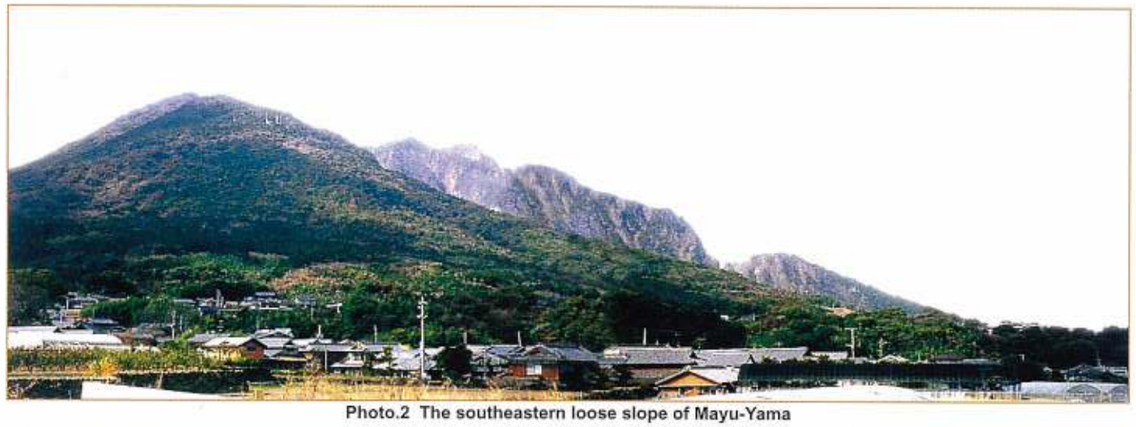


Photo.2 The southeastern loose slope of Mayu-Yama

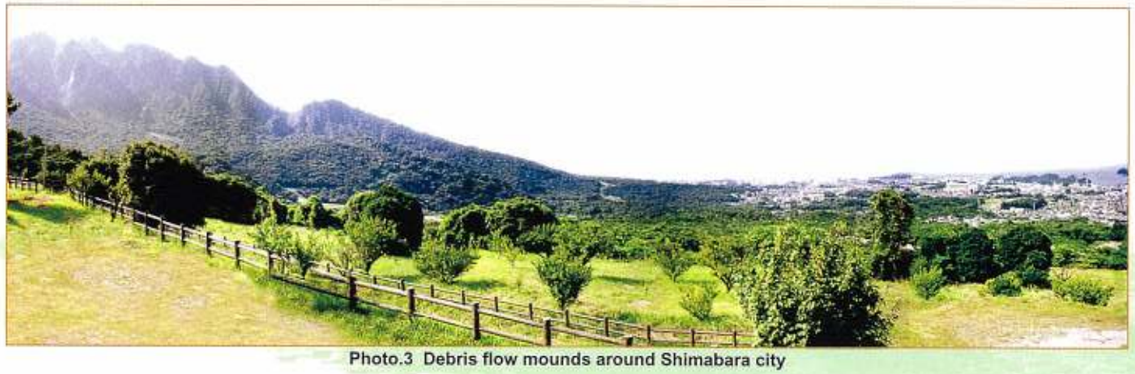


Photo.3 Debris flow mounds around Shimabara city

Inoue(1999) indicated that these old flow mounds were yielded from upstream of Nakao River, not from Shichimenzan. Once, there was a depression called "Biwanobachi" in the upstream of Nakao River, but the depression cannot be recognized because Shin'yake lava flow covered it. Inoue(1999) assumed that a lava dome near Biwanobachi collapsed. The deposites flowed down Nakao River, and formed many flow mounds in Shimabara city and Ariake Bay.

Tadataka Inou surveyed Shimabara

Column

A part of the survey map which Tadataka Inou museum owns.

Tadataka Inou (1745-1818) , who surveyed all Japan at first, surveyed Shimabara geographical features in 1812, 20-years after the catastrophe. The feature of reconstruction of Shimabara castle town and the distribution of debris flow mounds were surveyed minutely. The debris flow mounds were recorded as islands, though some of the mounds were lost now.

In the surveying note, 45 islands and 4 shallows were recorded on the basis of landing survey. Matsuo (1998) counted 22 mounds, and indicated the rest were lost on reclaimed to the land.

The detailed surveying notes and sketches are housed in Tadataka Inou Museam in Sawara-City, Chiba Pref.

This figure transferred the result of the geographical features measurement 20 years after the catastorophe in Shimabara by Tadataka Inou in the 1/ 10,000 topographical map of Shimabara city.

7 The big tsunami that hit Ariake Bay coast

Huge amounts of debris and rocks from the sector collapse rushed into Ariake Bay, and generated big tsunami. Tsunami hit not only Shimabara Peninsula, but also coastal area of Kumamoto and Amakusa Islands. About 15,000 lives were claimed by the collapse and the tsunami, and one-third among of 15,000 were lost by the tsunami at Kumamoto and Amakusa. Now there are many tombs reminding the victims. "Tsunami-dome-ishi" is the monument indicating the tsunami inundation reached.

The number of dead persons for every village is understood. The damage by tsunami around the Ariake sea is very big, although most of damage under Shimabara castle town is 5,251 people dead by the collapse of Mayu-Yama and tsunami. In and around Shimabara castle town, so many peoples were tolled the death mainly because the collapse occurred at 8 p.m. in the moonless dark night, then they could not grasp the situation. And also, they had returned from their evacuation places due to lull of seismic activities. In the southern part of Shimabara Peninsula, the number of dead persons of every village isn't clear because of no records. As a result of subtracting the number (6,066 people) which was clear until now from the number (9,534 people) of the dead person in the whole of the Shimabara Peninsula, about 3,500 people suffered damage in this area.

As for the submerged area of tsunami, Kumamoto side reffered the result of Tsuji・Hino(1993), for the Shimabara Peninsula side reffered Akagi (1986,2001).

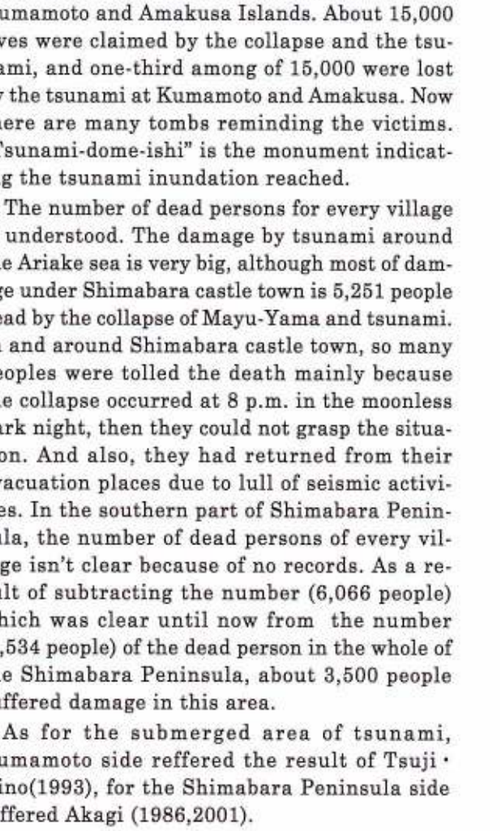


Fig.19 大変後島原絵図（本光寺蔵）
Taihengo Shimabaraezu
Showing the hazards around Shimabara Peninsula

Fig.20 Distribution of the hazard victim around Ariake Bay

Fig.21 寛政津波被害之図（崇城大学蔵）
Kansei Tsunami Higainozu
Disaster map of east side of Ariake Bay in Kumamoto

Chapter II The 1990-95 eruption of Unzen-Fugendake

1 The eruptive activity after 198 years of dormancy,1990-95

November 17, 1990, 198 years after the eruption of 1792, Unzen-Fugendake resumed eruption. The pyroclastic flows were followed by debris flows under the condition of heavy rainfall, which brought about damages to building, farmfield and forest over a vast area on the slopes around the mountain. Total volume of magma 2.0×10^8 m³ for five years.

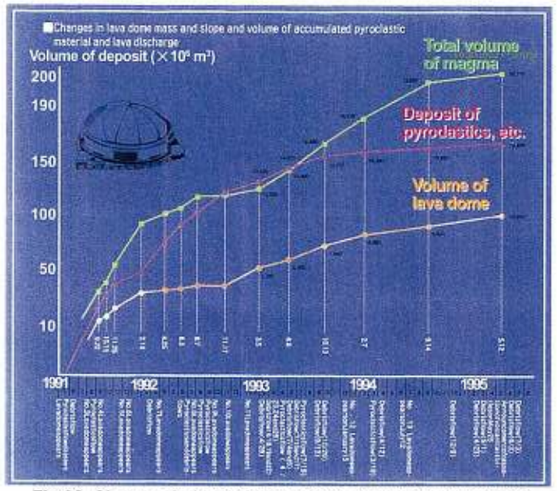


Fig.22 Changes in lava dome volume, talus and pyroclastic deposit volume, and lava discharge (Data of Public Works Research Institute and Geographical Survey Institute)

Photo.4 A still-growing lava dome
(on Unzen-Fugendake photographed on October 1,1993)

Photo.5 Ohno-Koba elementary school damaged by pyroclastic flows occurred on September 15,1991

Photo.6 Pyroclastic flow occurred in Senbongi Plateau on June 24,1993

Photo.7 Aftermath of debris flows (Photographed on May 2,1993)

Photo.8 Debris flows occurred in Nakao River on July 4,1993

The volcanic activities started with an earthquake swarm beneath Tachibana Bay at the western foot of Unzen Volcano in November, 1990.

From March 29, 1991 until the beginning of May, intermittent eruptions continued simultaneously from three craters, Kujukushima, Jigokuato and Byobuiwa, emitting a large amount of ash cloud.

May 15 and 19, debris flows were caused in spite of light rain falls, and ran through the Mizunashi River into the sea.

A lava dome emerged in the Jigokuato crater on May 20. The dome continued to grow, and then filled up the crater.

May 24, the lava started overflowing and falling down as blocks onto the eastern slope resulting in the successive formation of pyroclastic flows.

One person working in the upper stream of Mizunashi River got burnt due to a pyroclastic flow. Then, Shimabara Municipality recommended residents to evacuate. Nevertheless, some of the press and so on continued their activities in the evacuate advice area.

June 3, the biggest pyroclastic flow occurred. And 43 peoples were killed and 179 houses were burnt. The accumulation of this pyroclastic flow is measured with 2.5×10^6 m³ (Nagaoka,1993).

June 8, another big pyroclastic flow occurred. The flow burnt 207 houses.

June 30, a large-scale debris flow flowed down to the sea through the southern part of the city overtopping from the midstream of Mizunashi River. This debris flow destroyed 137 houses along the new flow line.

September 15 lava dome collapsed again, the large-scale pyroclastic flow occurred. It hit Taruki Hill, and changed the direction to Oshigatani. The main flow dashed along Mizunashi River. Ash cloud surge ran straight to Ohno-Koba hill. This surge burnt 218 houses including Ohno-Koba elementary school.

Though growing rate of lava and pyroclastic decreased at the end of 1992, it changed to increase in 1993, and the direction of pyroclastic flow changed to north-east.

After eruption activities subside, pryoclastic flow deposits at the foot of the mountain flow down as debris flow by rainfall again and again.

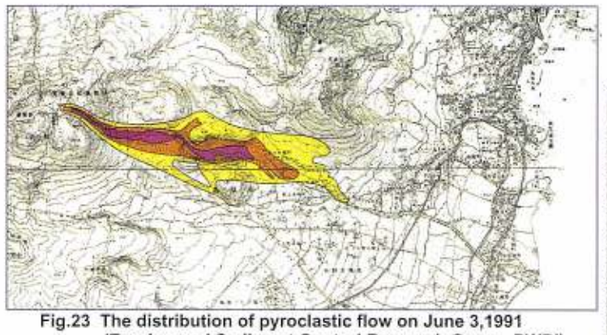


Fig.23 The distribution of pyroclastic flow on June 3,1991
(Erosion and Sediment Control Research Group, PWRI)

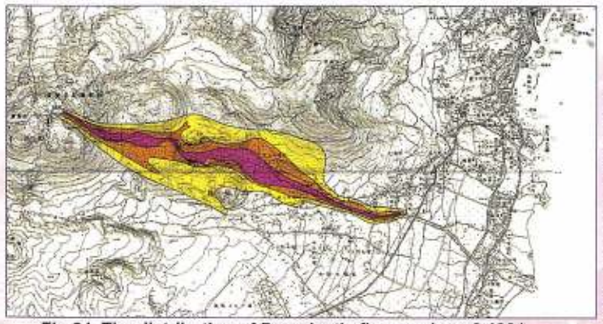
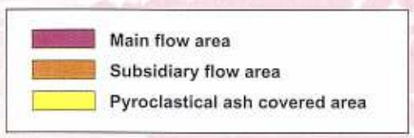


Fig.24 The distribution of Pyroclastic flow on June 8,1991
(Erosion and Sediment Control Research Group, PWRI)



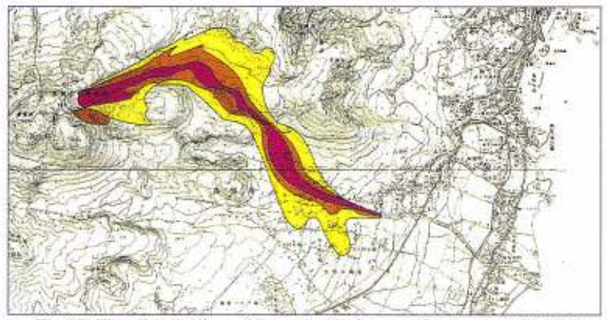


Fig.25 The distribution of Pyroclastic flow on September 15,1991
(Erosion and Sediment Control Research Group, PWRI)

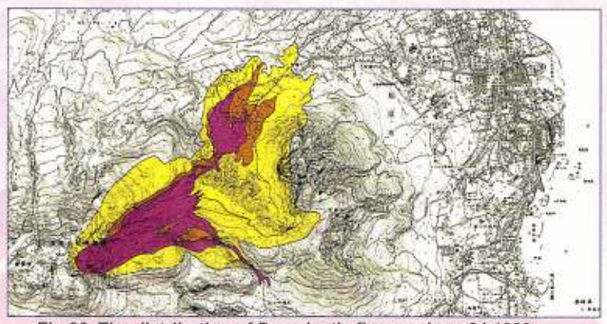


Fig.26 The distribution of Pyroclastic flow on June 24,1993
(Erosion and Sediment Control Research Group, PWRI)

2 Comparison of the 1791-92 eruption with the 1990-95 eruption

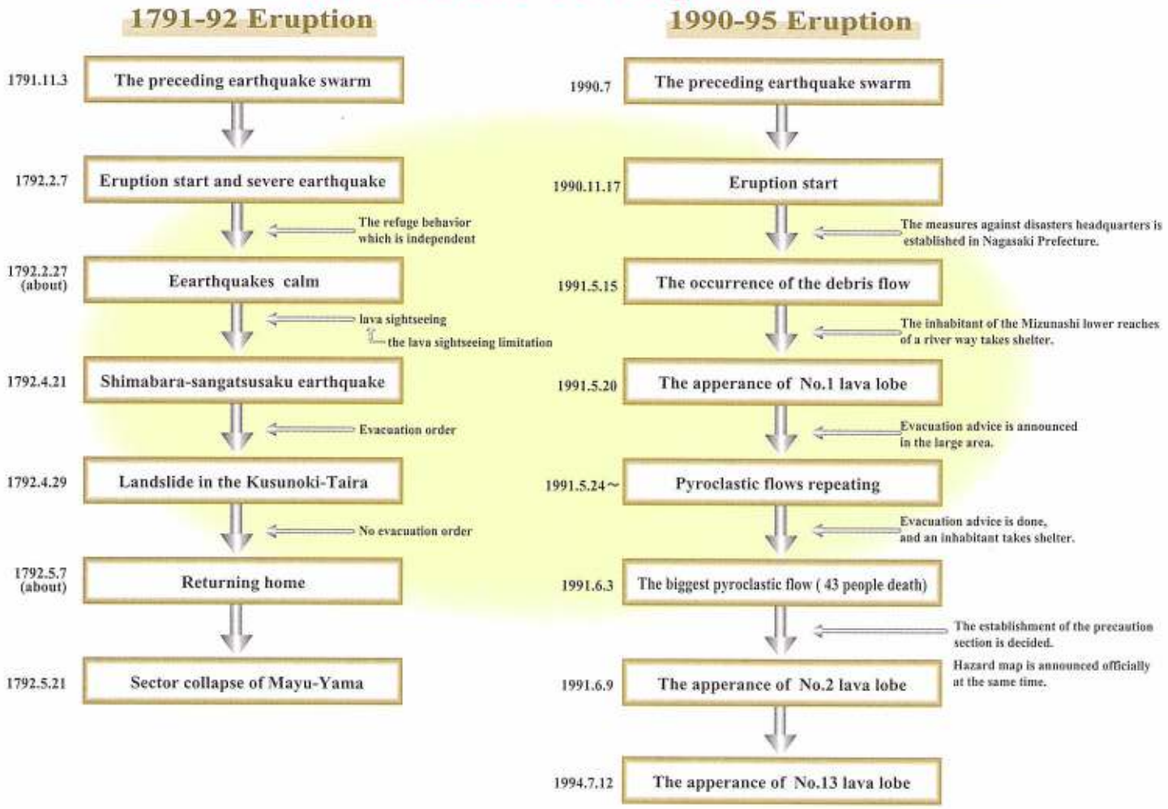


Fig.27 The comparison about volcanic activities and warning/evacuation arrangements

Volcanic activities and warning/evacuation arrangements were compared with the eruption in 1791-92 and 1990-95.

The arrangement in 1791-92 was quoted from "Ohdake Jigoku Monogatari" of the ancient documents.

That in 1990-95 was quoted from the documents recorded by Shimabara high school and the materials for Unzen Restoration Office.

Photo.9 Pyroclastic flow in Night
(Photogaraphed on August 11, 1991)

Photo.10 Pyroclastic flow (Photographed on May 30, 1991)

Many inhabitants were saved because evacuation advice was announced a little earlier than the eruption in 1991. In spite of the advice, some peoples stayed in the danger area, and tragically tolled death by large-scale pyroclastic flow.

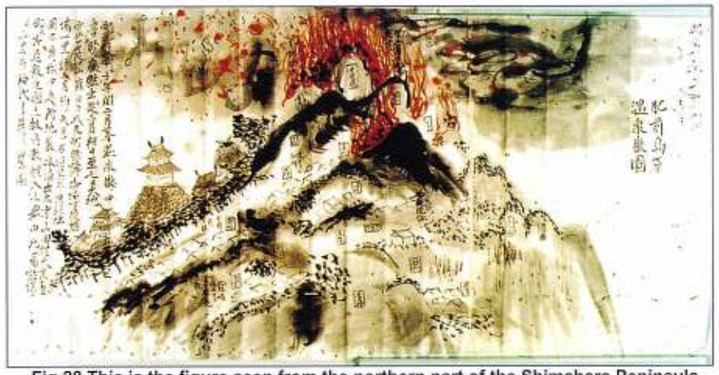


Fig.28 This is the figure seen from the northern part of the Shimabara Peninsula. Yojibei took record with looking at such a scene. (Museum of history and forklore in Aki-city, Kouch prefecture)

In 1792, many peoples visited to see Shin'yake lava without aware of danger. An evacuation order was declared after the Sangatsu-saku earthquake. Nevertheless, Kusunoki-Daira landslide happened during the swarm earthquakes, none thought the possibility of sector collapse of Mayu-Yama. On the contrary, inhabitants came back home from their evacuated places, because earthquakes were calmed down. Many inhabitants were inevitably tolled death at home by the collapse of Mayu-Yama.

In order to restrain the damage to minimum, the 1792 hazard on 210 years ago induces that following two points are necessary. First, the precise information should be transmitted rapidly to the proper authorities for warning/evacuation. Second, inhabitants should evacuate actively.

"Ohdake Jigoku Monogatari" written by Yojibei

Column

"Ohdake Jigoku Monogatari" is the diary which was written by that the farmer of Yojibei of Saga clan Kojiro experienced it in detail. A Natural phenomena and restoration progresses for 8 years have been written in this diary since 1791 of the year that disaster started.

Information was collected from the peoples who passed by Yojibei's house. He revealed a sense of duty, and said "I must record and report this catastorophe to future generations".

This historical materials which Yojibei's descendent owned were presented to the Board of Education in Kunimi-cho. Therefore, all seven rolls were published by the Kojiro ancient documents study meeting.

大岳地獄物語
Ohdake Jigoku Monogatari

神 代
Location of Kojiro

3 Information about Unzen Restoration Office

Sabo Projects

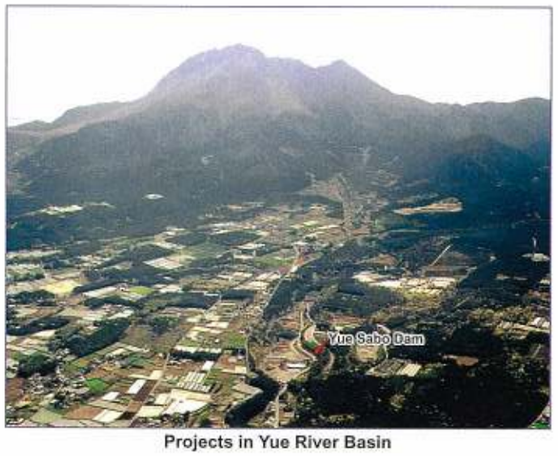
The basic plan of sabo works was provided in the Unzen-Fugendake so as to establish the security against debris flow disaster and to gain the regional restoration.

In the basic plan, sabo dams were planned for capturing a debris flows above the sabo control points .

For countermeasures before sabo dams completion, training dikes and channel works were planned in order to control the direction of a debris flow and to prevent erosion and flooding between the sabo control points and estuary along Mizunashi River and Nakao River.

Projects in Mizunashi River Basin

Projects in Nakao River Basin



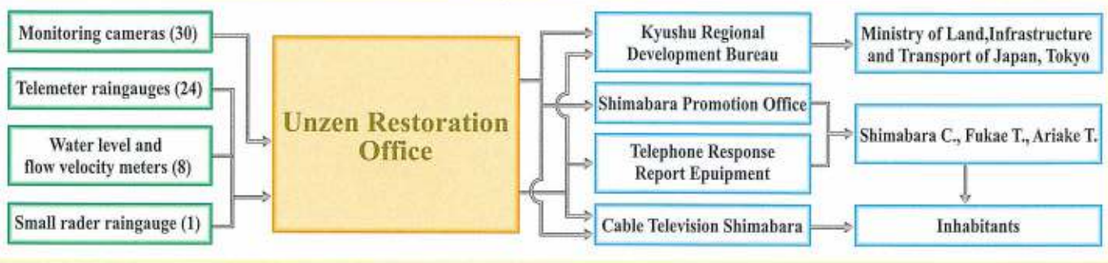
Projects in Yue River Basin

Monitoring system for disaster prevention

The disaster prevention monitoring system which consists of ITV cameras, raingauges, and so on are prepared to secure the safety of the construction site and the area from the collapse of the lava dome and the debris flow. Disaster prevention information is transmitted to the construction site that people concerned through the watch point, and transmitted to the inhabitant through the related organization and Cable Television Shimabara.


The disaster prevention information system : control room

● Diagram of monitoring system for disaster prevention



Sending the Information

The Unzen Restoration Office publishes a bulletin Unzen Fukko Dayori ("Unzen Restoration News") every three months to inform the local residents of the progress of the activities and facilities being constructed, and to request local understanding and cooperation. And, learning of the eruption disaster is done in Ohno-koba Information center. The sabo works are introduced through the homepage of Unzen Restoration Office.

The Present Condition of the Restoration

The sediment remained sabo construction, was utilized the ground raising of Annaka delta in 6 m height for more safety.

Besides this, various activities are conducting with the aim of the rich town-making under the theme "The everyone is the leader for restoration".

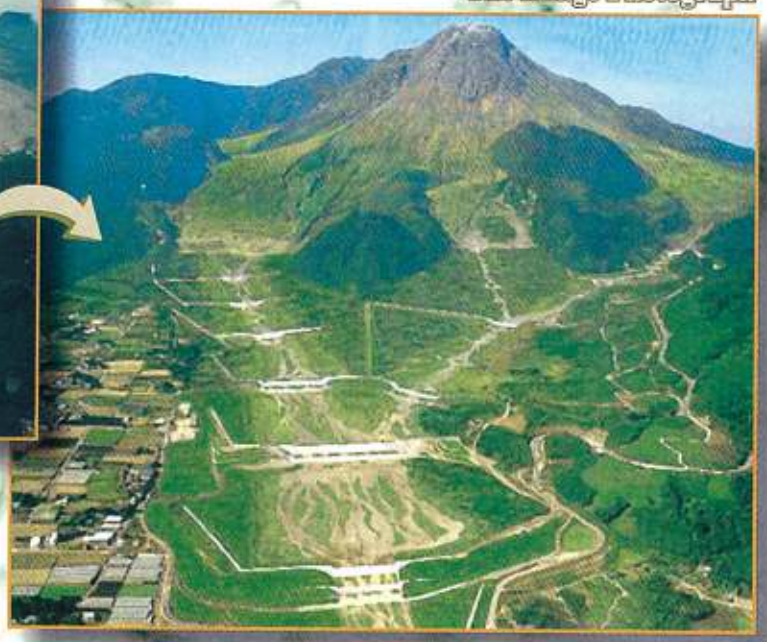
A new Sabo Plan for Volcanic area

It still exists unstable sediment of 1.7 $\times 10^8 m^3$, at the foot of Unzen-Fugendake. But, compared with an eruption activities term, the occurrence number of the debris flow becomes less gradually, and the amount of overflow sediment decrease, too. The new sabo plan of reconsidering the amount of applicable sediment and the arrangement of sabo facility has been started based on such present condition.

Three themes of "Securing of the safety", "The green restoration", "The support to the regional restoration" are decided, and it has been executing under the relation with the inhabitant and related organizations.

The Present Condition

The Image Photograph



Sabo works include constructing structures to prevent surface collapses, and planting trees or seeding to prevent surface erosion. These measures reduce the quantify of instable sediment produced on the slope.
The right photograph is the image of sabo facility plan in the Mizunashi River.

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(*in English, **in Japanese with English abstract, ***in Japanese)

Unzen Restoration Office,Ministry of Land, Infrastructure and Transport of Japan

7-4, Minami-shimokawajiri-cho Shimabara-shi, Nagasaki 855-0866, Japan
TEL: 0957-64-4171 Research Division: Ext. 351 FAX: 0957-64-4127
http://www.qsr.mlit.go.jp /unzen/ E-mail: unzen@qsr.mlit.go.jp

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