# DEBRIS FLOWS AND FLOOD-INDUCED DISASTERS CAUSED BY THE ERUPTION OF ASAMA VOLCANO IN 1783 AND RESTRATION PROJECTS THEREAFTER

Kimio Inoue (Sabo Frontier Foundation)

**ABSTRACT**

Asama Volcano is one of the most active volcanoes in Japan. The eruption in 1783 issued a large amount of pyroclastic fall, lava flow, pyroclastic flow, debris avalanche and lahar (mud flow). Since this disaster had a serious impact on the society that time, various historical documents and images recorded the events. Kambara debris avalanche cascaded down the northern flank of the volcano and rushed into the Agatsuma River to induce Tenmei mud flow. This mud flow ran down more than 200 km in distance and caused the casualties of more than 1,500 people. In these affected areas, a large number of victims, horses and crushed houses were washed away and scattered. Inhabitants of downstream areas gathered bodies of these victims and gave them proper burials. 25 people were rescued alive after being washed away by the mud flow as far as 4-40 km downstream.

This study analyzed debris flows and flood-induced disasters caused by the eruption of Asama Volcano in 1783 using many historical documents and images. Some of the restoration projects and stone monuments are also presented based on the analysis of field research and photographic records collected therein.

**Key Words:** Asama Volcano, 1783 eruption, Kambara debris avalanche, Tenmei mud flow, historical documents, restoration projects

## INTRODUCTION

Asama Volcano (2,568m in elevation), which is located in the center of the Japanese archipelago, is one of the most active volcanoes in Japan. In particular, the eruption in 1783 issued a large amount of pyroclastic fall deposits in the eastern area from the volcano, where as lava flow, pyroclastic flow and debris avalanche deposits in the northern flank of Asama Volcano. Since this disaster had a serious impact on the society at that time, various historical documents and images recorded the events, which provided data with a large

------------------------------------

Chief Engineer, Sabo Frontier Foundation, SABO-Kaikan Annex 6F 2-7-4 Hirakawacho, Chiyoda-ku, TOKYO 102-0093, Japan (Tel.:+81-3-5216-5872; Fax:+81-3-3262-2202; Email: k-i_sanyo@sff.or.jp )

number of studies (Aramaki, 1963, 1993; Hayakawa, 1995, 2007; Tamura and Hayakawa, 1995).

A pioneering geological study of this eruption (Aramaki, 1956, 1957) revealed that most of the eruptive products were generated in the climactic phase of the three months of activity, and eruptive styles changed with time from pumice falls successively pyroclastic flows to lava flows. This scenario of temporal variation in eruptive style was largely based on the simple model of Verhoogen (1951) that eruptive evolution is attributable to a vertical gradient in volatile contents of the pre-eruptive magma column. On the other hand, recent studies which originated from the compilation of the old documents (Yasui et al., 1997; Yasui and Koyaguchi, 1998, 2004) and the detailed field observations (Inoue M., 1998, 2002) have enabled to reconstruct the sequence of the eruption in 1783 with a time resolution of several hours or less.

## TENMEI ERUPTION OF ASAMA VOLCANO IN 1783

Fig.1 shows the disaster map of Asama Volcano eruption in 1783 (Inoue et al., 1994, Inoue, 1995, 2009). The Tenmei eruption occurred in 1783, which was a disastrous eruption of Asama Volcano. Since this disaster had a serious impact on the society of that time, various

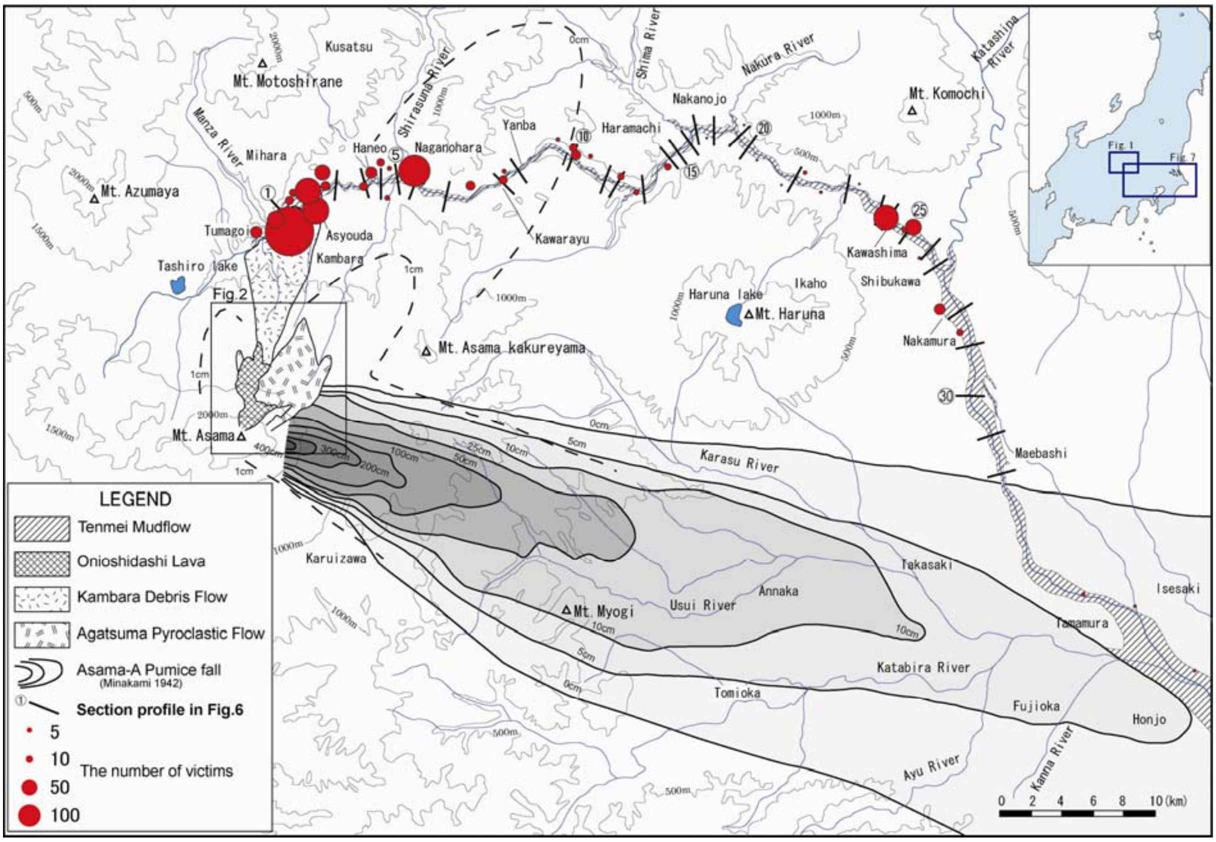


**Fig.1 Disaster map of Asama Volcano eruption in 1783 (Inoue et al., 1994, Inoue, 1995, 2009)**

historical documents and images recorded the events. These records have been exhaustively compiled by Hagiwara (1923-2007) and were published recently (Hagiwara, 1985-95). The contour line of Asama-A pumice fall was original in Minakami (1942).

The first eruption was noticed on May 8 or May 9 (April 8 or April 9, Tenmei 3, Japan old lunar calendar). Fig.2 shows the landform classification map of the northern flank of Asama Volcano (Inoue, 1995). The long eruption in three month issued a volcanic cone,

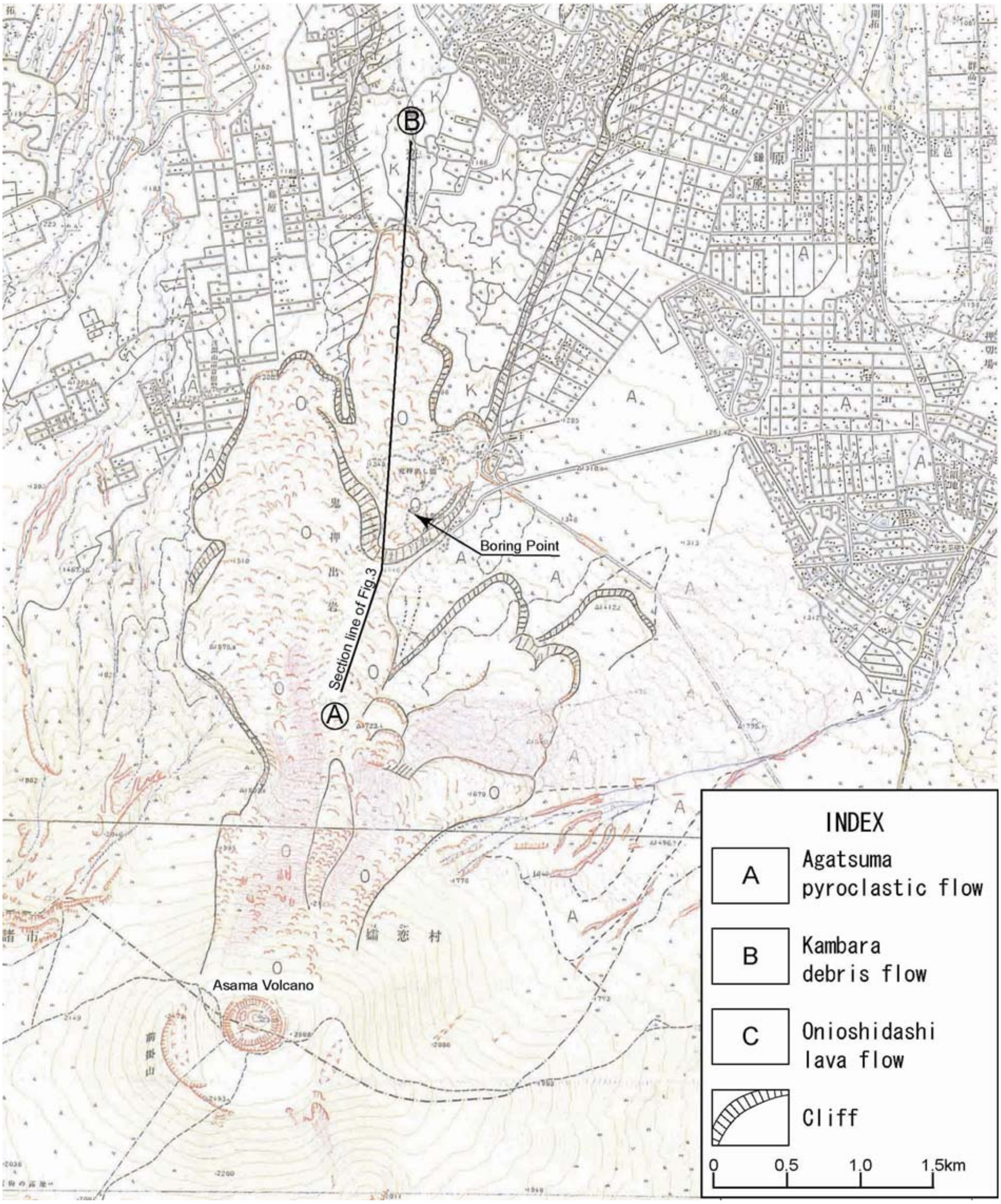


**Fig.2 Landform classification map of northern part of Asama Volcano (Inoue, 1995)**

andesitic pumice falls, pyroclastic flows and lava flows (Aramaki, 1963, 1993). On August 2, the tephra-fall from the Plinian eruption column became so intense and continuous in Karuizawa of the Nagano Prefecture, where the inhabitants prepared for evacuation. In the afternoon of August 4, the Agatsuma pyroclastic flow spread north-eastward down to 8 km from the summit. Coincidentally, hot lahars, caused by slumping of steep slopes, thickly covered with fallout pumice.

The climactic phase attained late at night and maintained until the morning of August 5 (July 8, Japan old lunar Calender), during which the Onioshidashi lava overflowed from the northern lowest rim of the summit crater. At 10 a.m. on August 5, a part of the northern flank suddenly collapsed, probably triggered by a strong earthquake. It gave rise to the generation of debris avalanche which destroyed Kambara Village and then was called Kambara debris avalanche (Inoue 1995, 2009). At the same time, the flank failure resulted in an explosive decompression of the inner massive part of the Onioshidashi lava flow to produce a Pelean nuee ardent. The debris avalanche turned into volcanic lahar (called Tenmei mud flow). Tenmei mud flows cascaded into the Agatsuma River and the Tone River which caused a disastrous flood 160 km downstream from the summit and reached Edo (present-day Tokyo) at 2 p.m. the next day. More than 1,500 people were killed by this disaster.

The Kambara debris avalanche was distributed inside a parabolic area, with a fan shaped of 30 degree issued from a semi-circular depression with a diameter of 700 meters, which was located 4 km north of the summit (Yamada et al., 1993a, b). Aerial photo interpretation and field survey revealed that many gigantic blocks of essential lithic blocks were scattered in an area of 18.1 $km^2$, and the volume of essential lithic blocks was estimated to be $1.94\times 10^6\ m^3$ for blocks of longer than 5 m in diameter and $4.40\times 10^6\ m^3$ for blocks of smaller than 5 m in diameter. The largest block was 49 meters in diameter, 10 meters high, and 9200 $m^3$ in volume. The survey of several testpits clarified that the Kambara debris flow deposit was 2.2 meters thick in average and thus amounted $4.70\times 10^7\ m^3$ in total volume. Paleomagmatic measurement of the essential lithic blocks indicated that these blocks were deposited at a temperature above the Curie point (about 400℃) even 65 km downstream from the summit. The pipe-structure, which was observed in several testpits was attributed to upward stream segregation, which was derived from sufficient water and incandescent essential lithic blocks in the deposits.
Fig.3 shows the geological section of the northern flank of Asama Volcano along the A-B line in Fig.2. Yamada et al. (1993a) carried out a borehole penetration of 72.8m in depth in this area and clarified that the old ground surface was about 65 m below the present surface. Assuming that the hollow was then a swamp with a water depth of 50 m and that water in

the swamp completely overflowed in the eruption, Kambara debris avalanche originated from wet condition. Inoue et al. (1994) interpreted that the semi-circular depression was a swamp; “Yanai marsh” of 10～25 million $m^3$ in capacity, and considered that this was reasonable enough to the hydrological balance of Tenmei mudflow along Agatsuma and Tone river. As to what caused the overflow of water from the hollow, “Yanai marsh”, many things remained to be seen but, for the present, there can be two alternatives.

(1) Onishidashi lava flow started as the result of a summit eruption, which penetrated into the swamp and displaced water from it. Kambara debris avalanche then cascaded down to the northern flank of Asama Volcano (Hayakawa, 1995, 2007).

(2) Since a lateral steam explosion occurred from the hollow at the same time of this summit eruption, the Kambara pyoclastic avalanche was overflowed by a landslide (kosuge and Inoue, 2007).

Historical pictures and documents suggested the overflowing water during the eruption. Fig.4 shows the historical map of Asama Volcano eruption in 1783, which was copied by Hagiwara (1989), where the Yanai marsh was presented at the semi-circular depression area of Onioshidashi lava flow in the upper northern flank of Asama Volcano. Fig.5 shows the historical map of Asama Volcano, which was owned by Iijima. The volcano was drawn in case of lateral eruption.

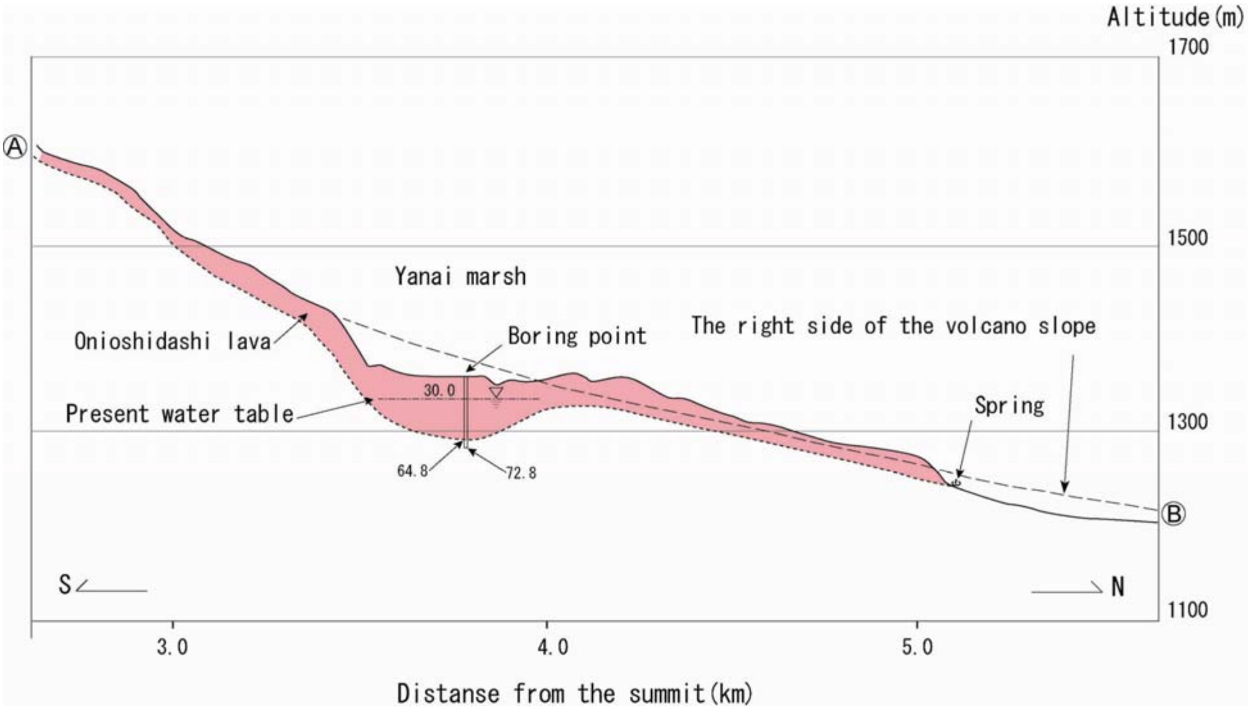


**Fig 3 Geological section of northern flank of Asama volcano (Inoue et al., 1994)**

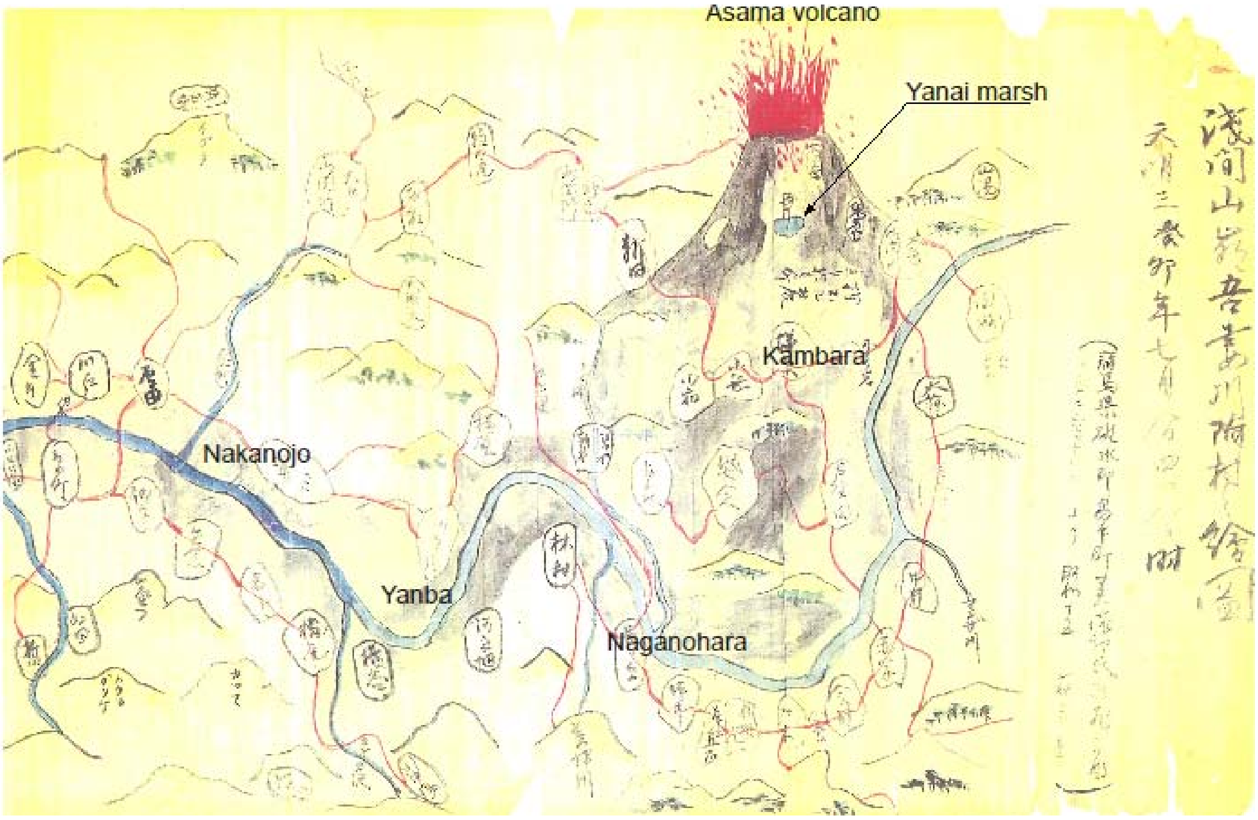


**Fig.4 Historical map of Asama Volcano in 1783 (copied by Susumu Hagiwara)**

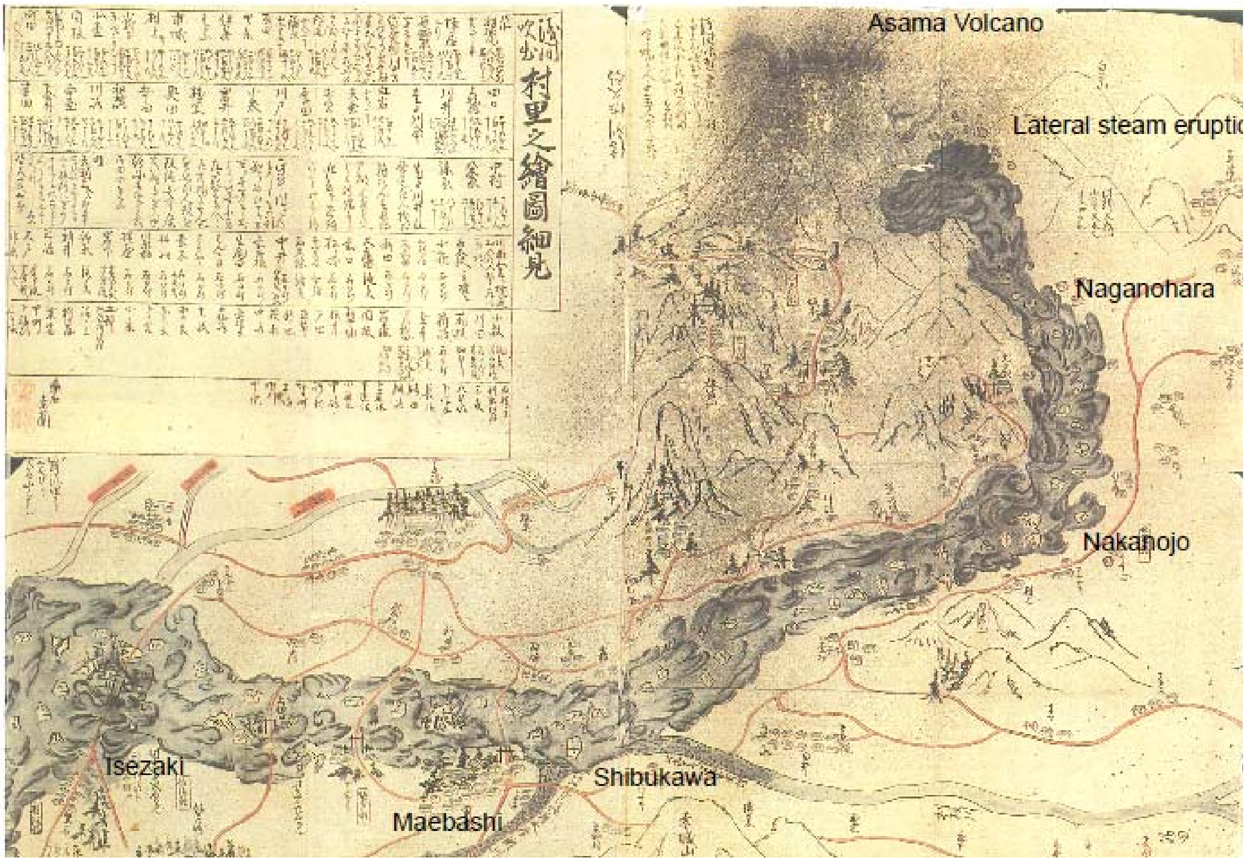


**Fig.5 Historical map of Asama Volcano in 1783 (owned by Eiichiro Iijima)**

## CATASTROPHIC MUD FLOWS ALONG AGATSUMA AND TONE RIVER

Tenmei volcanic mud flow rushed down more than 200 km via the Agatsuma River, the Tone River and the Edo River to reach as far as Edo (present-day Tokyo), and caused casualties of more than 1,500 people. After running into the Tone River, the flow turned into a highly dense flood stream, which ran as far as 270 km in distance to reach the Pacific Ocean at Choshi City of the Chiba Prefecture. Additionally, a part of the flood flow diverted to the Edo River at 160 km in distance and reached Tokyo Bay at 2 p.m. the next day. Yamada et al. (1993b) have estimated the velocity of the mudflow and its discharge at the main affected place by the hydraulic calculation based on the results of the survey. Fig.6 shows the state of the Tenmei mudflow, which descended along the Agatsuma and Tone Rivers by the hydraulic calculation. The hydraulic calculation of the mudflow, based on the Manning formula estimated a water level of about 25 to 70 m in depths, a flow velocity of about 5 to 23 m/s and a discharge of 50,000$m^3$ to 230,000$m^3$/s for the section Mihara (No.1) to Shibukawa city (No.27) in Fig.1. The mud flow took about 106 minutes to reach Shibukawa, which is about 70 km from the Asama crater. This result generally agrees with what was indicated in old records (Hagiwara, 1985-95, Seki & Moroda, 1999). In these affected areas, victims, horses, and crushed houses were washed away and scattered. Inhabitants of downstream areas gathered the bodies of victims and gave them proper burials. Some people were rescued alive after being washed away by mud flows as far as 4-40 km downstream. The names of 25 survivors were recorded in the historical documents.

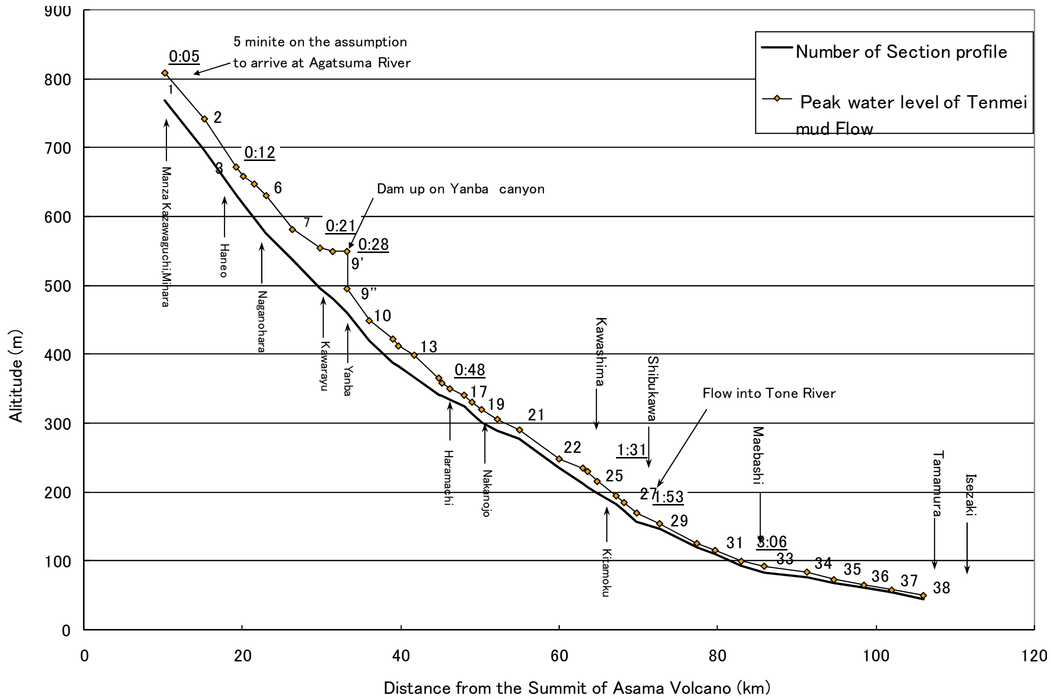


**Fig.6 Topographic profile of the Agatsuma & Tone Rivers and Peak water level of Tenmei mud flow**

Those who remained in seriously damaged areas gradually started restoration works with support from the Edo Shogunate, feudal clans (Han), village headmen, and philanthropists. Historical documents revealed that 477 people died and only 93 people survived in Kambara Village in the northern flank of Asama Volcano, where the most serious damage was observed. The survivors lived on rice, which was donated by philanthropists, formed new families, and were able to successfully rebuild the village. In addition, various types of restoration projects were implemented in affected areas. As a consequence, 227years after the disaster, almost no trace of damage can be observed. Fig.7 shows the distribution of Tenmei memorial stone monuments along with the Tone River. To honor the souls of the departed and to preserve the memory of the disaster for a long time, the inhabitants of the affected areas built stone monuments on the 3 rd, 33 rd, 100 th, 150 th and 200 th anniversaries and also held memorial services.

**Photo 1 Kambara Kannon Temple in the northern flank of Asama Volcano (by Inoue)**

**Photo 2 Tenmei memorial stone monuments in Toyazuka,Isezaki City (No.84-86)**

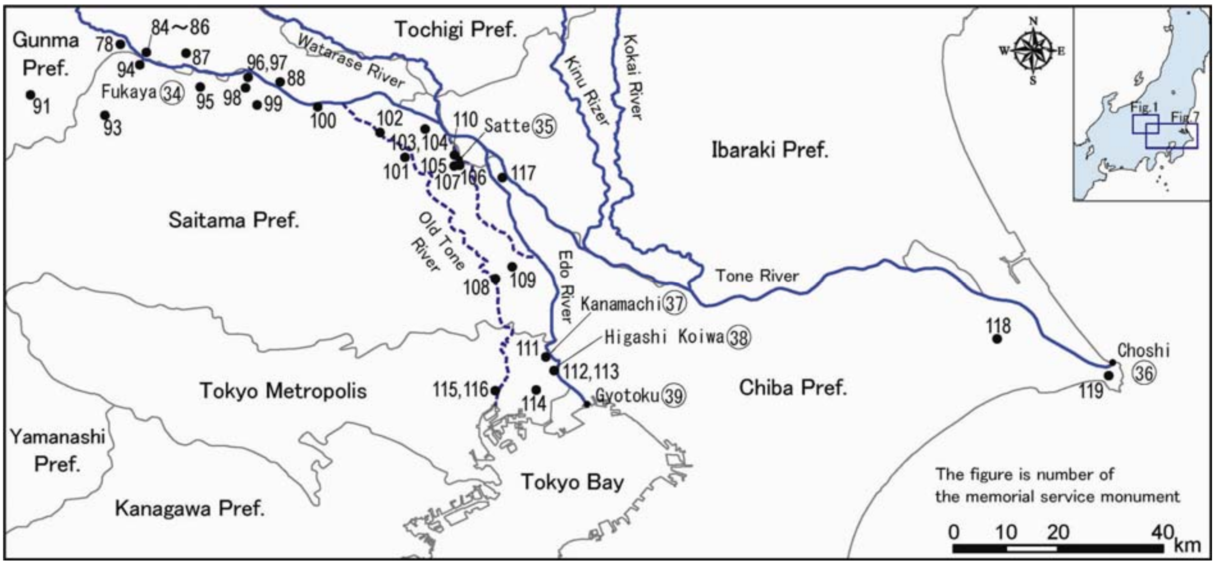


**Fig.7 Distribution of Tenmei memorial stone monuments in Tone River (Inoue,2009)**

## CONCLUSION

This study analyzed the sediment and flood-induced disasters caused by the eruption of Asama Volcano in 1783 by many historical documents and images. The eruption in 1783 issued a large amount of pyroclastic fall, lava flows, pyroclastic flow, debris avalanche and lahar (mud flow). Since this disaster had a serious impact on the society of that time, various historical documents and images recorded the event. Kambara debris avalanche cascaded down the northern flank of the volcano and rushed into the Agatsuma River to induce the Tenmei mud flow. This mud flow ran down more than 200 km in distance and caused casualities of more than 1,500 inhabitants. Some of the restoration projects and memorial stone monuments are presented based on this analysis resulting together from the outcomes of field research and photographic records collected therein.

**REFERENCES** *: in English,**: in Japanese with English abstract, ***: in Japanese


Aramaki S. (1956). “The 1783 activity of Asama volcano,” Part Ⅰ, *Japan Journal of Geology and Geography*, 27, 189-229.*

Aramaki S. (1957). “The 1783 activity of Asama volcano,” Part Ⅱ, *Japan Journal of Geology and Geography*, 28, 11-33.*

Aramaki S. (1963). “Geology of Asama Volcano,” *J. Fac. Sci. Univ. Tokyo*, 2(14), 229-443.*

Aramaki S. (1993). “Geological Map of Asama Volcano 1:50,000” *Geological Survey of Japan***

Inoue K. (1995). “Distribution and mode of the Kanbara Pyroclastic flow-cum-mudflow of the 1783 Eruption in Asama Volcano” *Koei Forum*, 4, 25-46. **

Inoue K. (2009). “Sediments Flood Disasters Caused by Volcanic Eruptions, --Asama Tenmei Eruption and Kambara Debris Avalanche--,” *Kokon Shoin*, 204p. ***

Inoue K., Ishikawa Y., Yamada T., Yajima S. and Yamakawa K. (1994). “Distribution and Mode of the Kambara Pyoclastic Flow-cum-Mudflow of the 1783 Eruption in Asuma Volcano,” *Journal of the Japan Society of Engineering Geology*, 35(1), 12-30.**

Inoue M. (1998). “Structure of the Onioshidashi lava flow of Asama volcano,” *Master’s Thesis, Kanazawa Univercity*, ***

Inoue M. (2002). “Sequence of Bulk-rock Chemistry of the Onioshidashi Lava Flow, the 1783 Eruption of Asama Volcano.” *Geographical Report of Kanazawa Univ.*, 10, 17-23. **

Hagiwara S. (1985,86,89,93,95). “Compilation of the historical documents on Tenmei eruption of Mt. Asama.” *Cultural Work Promoter of Gunma Prefecture*, Ⅰ,372p., Ⅱ,484p., Ⅲ,381p., Ⅳ, 343p., Ⅴ,354p. ***

Hayakawa Y. (1995). “Field excursion guide to Asama volcano.” *Journal of Geography,* 104, 561-571. **

Hayakawa Y. (2007). “Geological Map of the Northern Part of Asama Volcano 1:25,000” *Hon-no-Rokuyon-Kan****

kosuge Y. and Inoue K. (2007). “Suggestion of mechanism for the outbreak of Kambara debris avalanche and Temmei mud flow on Asama volcano in 1783.” *Proceeding of Japan Society of Erosion Controle Engineering in 2007,* p.486-487***

Minakami T. (1995). “On the distribution of volcanic ejecta, (Part Ⅱ) The distribution of Mt. Asama pumice in1783.” *Bulletin of Earthquake Research Institute of University of Tokyo ,* 20, 93-106. **

Seki T. & Moroda Y. (1999). “Local History Study on the Disaster Caused by Asama’s 1783 Eruption –Archaeological check on the data and the time of the Asama pumice fall ‘A’ fell on the North-East Area–,” *Gunma Archaelogical Research Foundation,* 16, 43-60. ***

Tamura C. & Hayakawa Y. (1995). “Reconstruction of the 1783 Asama eruption from the ancient literature,” *Journal of Geography.* 104(6), 843-864

Verhoogen J. (1951). “Mechanics of ash formation,” *American Journal of Science,* 249, 729-739.

Yamada T., Ishikawa Y., Yajima S., Inoue K., and Yamakawa K. (1993a). “Study on the Actural Situation of a Catastrophic Sediment Discharge associated with the Eruption of 1783 in the Northern Flank of Mount Asama,” *Journal of the Japan Society of Erosion Control Engineering,* 45(6), 3-12. **

Yamada T., Ishikawa Y., Yajima S., Inoue K., and Yamakawa K. (1993b). “Study on the Actural Situation of a Catastrophic Mud Flows associated with Mount Asama Eruption in 1783 along the Agatsuma and Tone Rivers,” *Journal of the Japan Society of Erosion Control Engineering,* 46(1), 18-25. **

Yasui M., Koyaguchi T. and Aramaki S. (1997). “Plinian Eruption in the 1783 Activity of Asama Volcano Inferred the Deposits and the old Records,” *Bulletin of Volcanological Society of Japan,* 42, 281-297.

Yasui M. & Koyaguchi T. (1998). “Formation of a pyroclastic cone in the 1783 Plinian eruption of Asama volcano,” *Bulletin of Volcanological Society of Japan,* 43(6), 457-465. **

Yasui M. & Koyaguchi T. (2004). “Sequence and eruptive style of the 1783 eruption of Asama Volcano, central Japan: a case study of an andesitic explosive eruption generating fountain-fed lava flow, pumice fall, scoria flow and forming a cone.” *Bulletin of Volcanology,* 86, 243-262.*