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THE 1741-1742 ACTIVITY OF OSHIMA-ŌSHIMA VOLCANO, NORTH JAPAN

by

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(with 7 text-figures and 3 tables)

Abstract

Oshima-Ōshima, a small volcanic island in the Japan Sea, had been in one cycle of eruption during 50 years from 1741 to 1790, after about 1,500 years of dormancy. On about August 18, 1741, the activity started with ejection of andesitic pumice and ash, which was followed by eruption of basaltic tephra. In the early morning on August 29, a violent eruption occurred. Simultaneously a great earthquake (M>7.5) is estiamated to have occurred in the sea bottom near Oshima-Ōshima, which generated a destructive tsunami and triggered a sector collapse of the volcanic body of Nishi-yama. Then, within the new horseshoe-shaped caldera a central cone was produced by eruption of pyroclastics and lavas of basalt. After the intense eruption in 1741-1742, the activity much decreased. A compositional change in reverse order, from andesitic to basaltic, is evident within a short period of eruption, which can be interpreted in terms of a zoned magma chamber.

Introduction

Oshima-Ōshima, a small volcanic island in the Japan Sea, is situated 55 km off the western coast of the Oshima Peninsula, southwest Hokkaido. This island consists of a triple stratvolcano, i.e. Higashi-yama somma, Nishi-yama somma, and central cone (Text-figs. 1 and 2). Although the island is small, 4 x 3.5 km across, the bathymetric chart suggests that the volcanic edifice has a submerged base, 12 km in diameter, from which the summit (737 m a.s.l.) rises 1,700-1,900 m. The volcanic edifice is made up of lavas and pyroclastics, of which about 70 vol.% is alkalic olivine basalt and the rest is calc-alkalic andesite. The geology and petrology of this island have been studied by Katsui and Satoh (1970), Katsui et al. (1977), Yamamoto et al. (1977) and Katsui et al. (1979).

Although Oshima-Ōshima Volcano has been dormant for past two centuries, in 1741 heavy ash falls from the volcano struck the Oshima Peninsula and the northern end of Honshu, and a great tsunami which occurred simultaneously swept up many villages along the Japan Sea coast killing more than 1,475 persons. This activity continued to the next year, and then decreased.

On the basis of historic records, tephrochronology and geology of the volcano, the 1741-1742 eruption of Oshima-Ōshima is considered in this paper.

Historic records of activity

Reliable documents on the historic activity of Oshima-Ōshima Volcano are recorded in old writings such as Fukuyama-hifu, Tsugaru-rekidaikirui, Sado-nendaiki, etc., all of which are reproduced in Katsui et al. (1977). However, since this volcano is an uninhabited island

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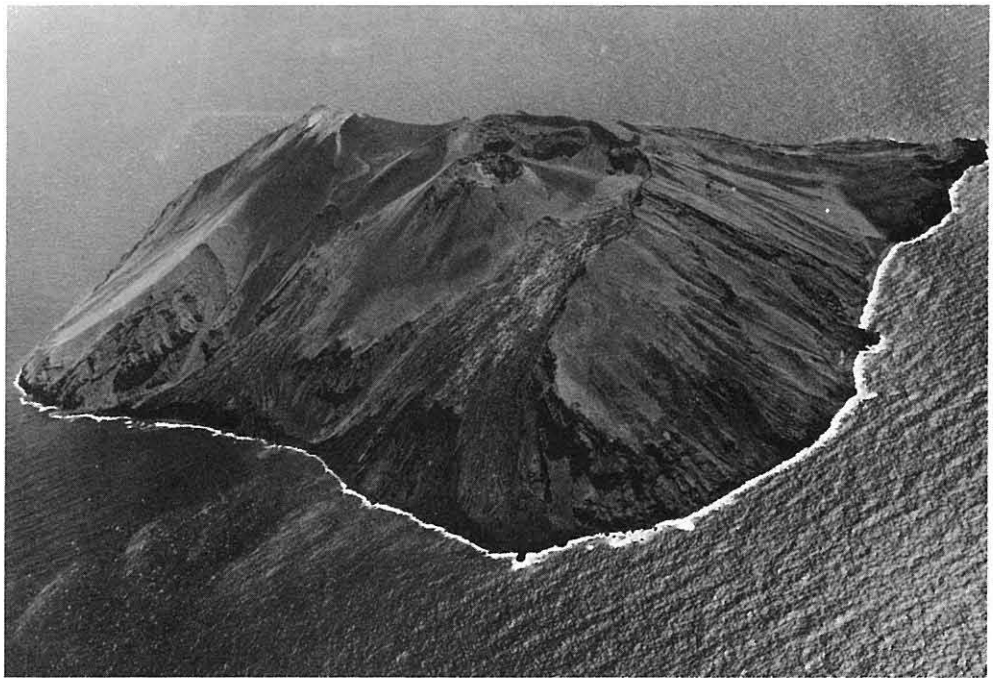
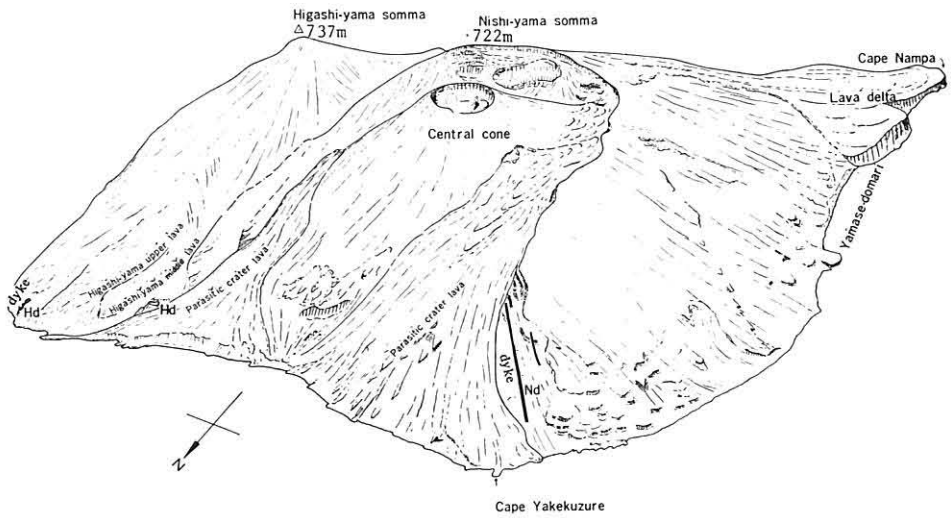


Text-fig. 1 Oshima-Ōshima Island viewed from northwest (Photo by Asahi Press).



Text-fig. 2 Explanatory sketch of Oshima-Ōshima Island, cfr. Text-fig. 1. (Katsui and Satoh, 1970)

55 km remote from the Japan Sea coast of the Oshima Peninsula, the information on activity is mostly limited to ash fall and tsunami which struck the Oshima Peninsula and north Honshu. As shown in Table 1, Oshima-Ōshima volcano was very active in 1741-1742,

Table 1 Recorded eruptions of Oshima-Ōshima Volcano

Year (AD)	Main events
1741 Aug.	Heavy ash-fall on the Oshima Peninsula (10–15 cm in thickness), and a great tsunami which destroyed many villages along the Japan sea coast killing more than 1,475 persons.
1742 Jan., Feb., & May	Ash-fall on the Oshima Peninsula and the Tsugaru District (10 cm in thickness).
1759 Aug.	Ash-fall at Aomori (ca. 2 cm in thickness).
1786	Emission of smoke.
1790 Jan.	Emission of smoke.

then the activity much decreased, and emissions of smoke were observed until 1790. On the basis of the old writings the records of activity during 50 years from 1741 to 1790, are briefly described below.

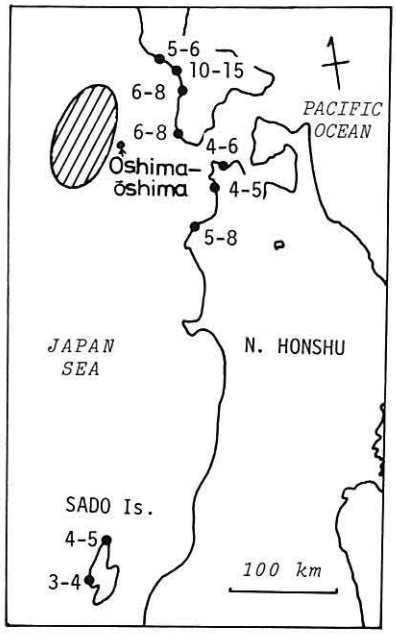
From about August 18, 1741, it was rumoured that an eruption occurred from Oshima-Ōshima Island. On August 25 and 26, heavy ash fell on the villages along the Japan Sea coast of the Oshima Peninsula. Then, the ash-fall became heavier and reached maximum at dawn of August 29. The thickness of the ash-fall deposit was reportedly 10 to 15 cm at Esashi and Matsumae. The ash was described as "whitish gray and black sand" in Fukuyama-hifu, which may be interpreted as deposition of andesitic ash followed by basaltic ash.

The climax of the activity came at approximately 5 A.M. on August 29. There occurred a violent explosion, the noise of which was heard at villages along the Japan Sea coast of the Oshima Peninsula, then the sea level began to withdraw. Soon after, shortly before 6 A.M., a great tsunami came and swept up onto the shores of Oshima Peninsula, giving much damage to low-lying villages from Matsumae to Kumaishi which extend for about 120 km along the Japan Sea coast of the peninsula (Text-fig.3). The damage caused by the tsunami is recorded as follows:

1,467 persons drowned
733 houses swept away
58 houses destroyed
1,521 ships destroyed (after Fukuyama-hifu)

Towards the north of Kumaishi, it caused also some damage including drowned persons. Along the Japan Sea coast of the Tsugaru district, the northern end of Honshu, the tsunami caused the following damage:

8 persons drowned
82 houses swept away



Text-fig. 3 Inundation heights (m) of the 1741 tsunami and its estimated source area (shaded). (Hatori and Katayama, 1977)

53 ships destroyed (after Tsugaru-rekidaikirui)

Further south, at the Sado Island in the Japan Sea, about 350 km SSW of Oshima-Ōshima, the tsunami swept the low-lying villages and destroyed many houses (after Sado-nendaiki).

Subsequent to the great activity of August 1741, there were several records of black ash-fall on the Oshima Peninsula and the Tsugaru district. On January 22, 1742, black ash fell at Matsumae and deposited about 10 cm in thickness. In the next month, on February 8 similar black ash fell on the Oshima Peninsula, and during February 8 to 22 black ash also fell on the Tsugaru district where it deposited about 10 cm in thickness. Then, on May 18, ash-fall including reddish Pele's hairs, 20-30 cm in maximum length, was recorded in the Oshima Peninsula.

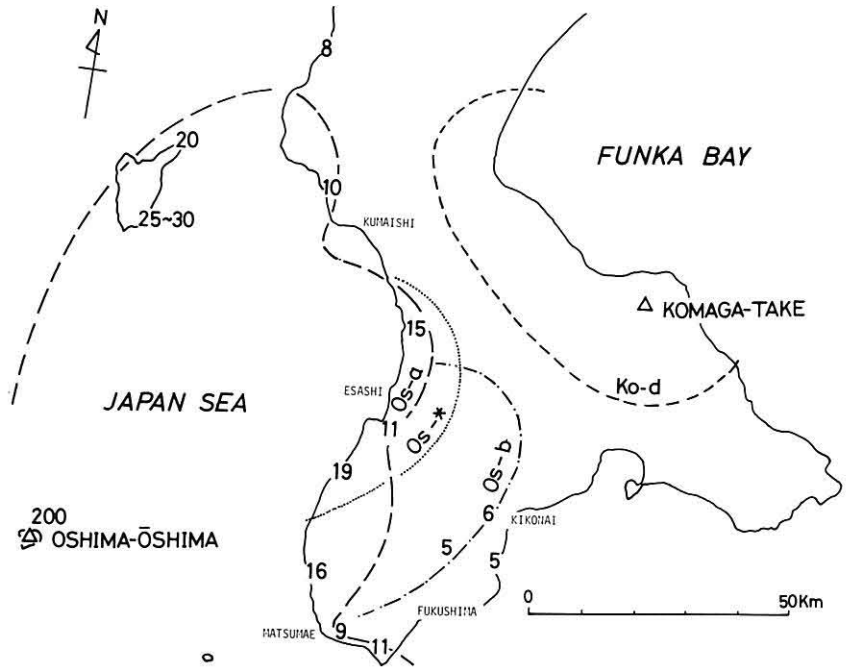
Seventeen years after the 1741-1742 eruption, Oshima-Ōshima volcano seems to have renewed its activity. On August 19, 1759, an ash cloud coming from northwest was observed at Aomori, soon after ash-fall including Pele's hairs, about 20 cm in maximum length, deposited 1.5-1.8 cm in thickness. Then 27 years later, emissions of smoke from Oshima-Ōshima were observed from the Oshima Peninsula in 1786 and 1790. Probably, Oshima-Ōshima Volcano was active during several years in this term. Since then, there is no record of activity for past two centuries, except weak fumaroles (81°C in maximum temperature) on the central cone which were observed in recent years (1955, 1967, 1971 and 1975).

Tephrochronology

A yellowish white ash-fall deposit of the name of Os-a, several to 20 cm in thickness, is widely distributed on the Japan Sea side of the Oshima Peninsula. Inferred from the time

needed for development of the peat layer (21 cm in thickness) above the ash deposit, the Os-a ash dates back to 210 years before 1950, which corresponds to the 1741 eruption of Oshima-Ōshima Volcano (Yamada, 1958).

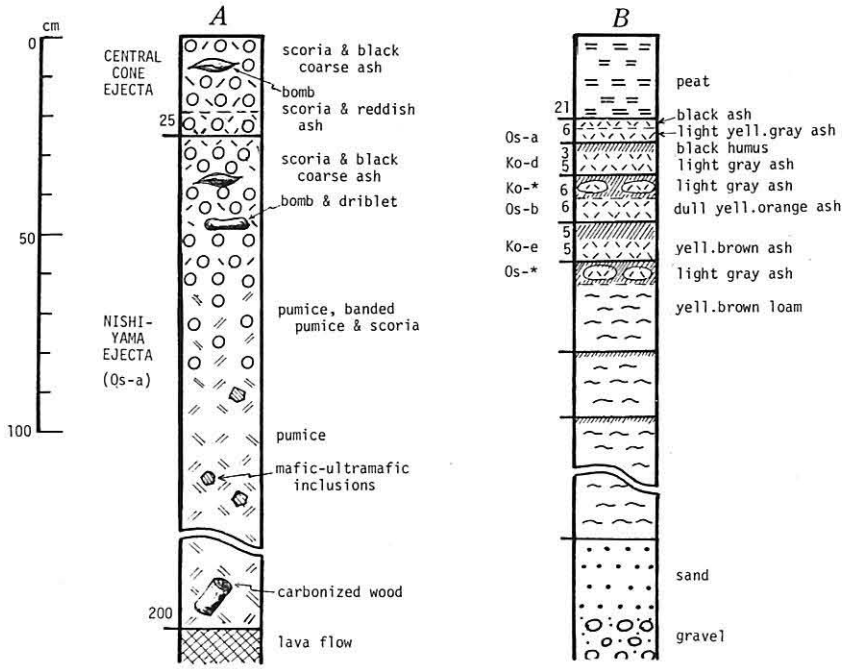
The distribution pattern of the Os-a ash-fall deposit may also suggest that it was derived from Oshima-Ōshima Volcano by westery wind (Yamada, 1958). However, a regional field survey by Sasaki et al. (1970) showed a more complicated pattern (Text-fig.4). Probably, the



Text-fig. 4 Distribution of the ash-fall deposits from Oshima-Ōshima (Os-a, Os-b and Os-*) and Komaga-take (Ko-d), represented by 10 cm thickness contours. Figures are thickness of the Os-a ash-fall deposit in cm. Data from Yamada (1958), Sasaki et al. (1970) and the present writers.

Os-a ash-fall deposit comprises several fall units, the distribution axes of which are different each other in direction.

According to the writer's observation, the Os-a ash-fall deposit consists of two layers at Matsumae and Fukushima; the lower is yellowish white ash of hornblende andesite with abundant glass shards, whereas the upper dark gray-black ash of olivine-augite basalt with or without hornblende phenocryst (Text-fig.5). There is no evidence of considerable time gap between both layers. The upper layer, several cm in thickness, is obscured in places due to development of black humus on the surface, hence it has been overlooked. The presence of the upper layer of basaltic ash at Matsumae and Fukushima coincides with the historic records of "black sand or ash falls" in 1941 and 1742, which deposited at the southwestern end of the Oshima Peninsula and the northern end of Honshu.



Text-fig. 5 Columnar sections of the Os-a and other tephras.
A: southern slope of Nishi-yama, Oshima-Ōshima, B: Fukushima and Kikonai, Oshima Peninsula.

Age	Komaga-take	Oshima-Ōshima
1929 AD	Ko-a pumice fall	
1905 AD	Ko-b pumice fall	
1856 AD	Ko-c_1 pumice fall	
1765? AD	Ko-c_2 pumice fall	
1741-'42 AD		Os-a ash fall
1640 AD	Ko-d pumice fall	
	Ko-* ash fall	
1700±130 y.BP		Os-b ash fall
	Ko-e ash fall	
2750±110 y.BP		Os-* ash fall
	Ko-f pumice fall	

~~~ : intercalated by humus layers.
* : specific name not yet given.
Data from Sasaki *et al.* (1970, 1971) and Katsui et al. (1975)

Table 2 Correlation of tephras from Komaga-take and Oshima-Ōshima

On the Oshima-Ōshima Island, a successive deposit of andesitic pumice-fall (lower) and basaltic scoria-fall (upper) covers Nishi-yama and Higashi-yama. This deposit was named the Nishi-yama ejecta by Katsui and Satoh (1970), and its total thickness attains 2 m at the southern slope of Nishi-yama. A ^{14}C age, 760±70 y.B.P. (GaK. 1604), which was determined on a carbonized wood burried in the pumice bed, indicates that the pumice eruption
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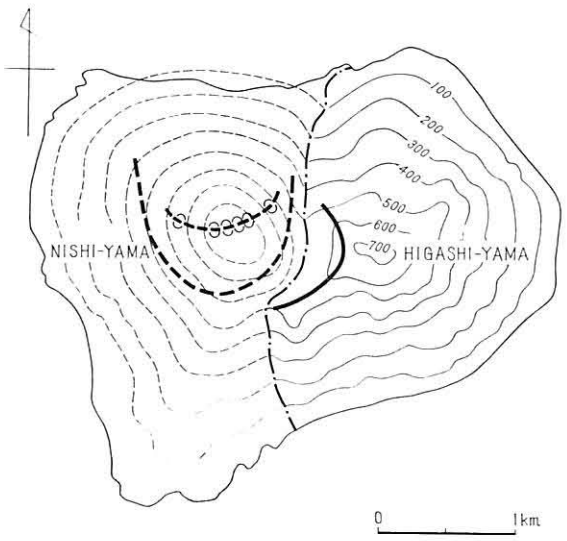
occurred after this date. The sequence from andesitic to basaltic tephras can be correlated with the Os-a ash-fall deposit at Matsumae and Fukushima of the Oshima Peninsula.

Older ash-fall deposits (Os-b and Os-*) derived from Oshima-Ōshima Volcano, most probably from Nishi-yama, are also found on the Japan Sea side of the Oshima Peninsula (Sasaki et al. 1970). These ash deposits are intercalated with those from Komaga-take Volcano, which enables us to estimate the age of activity of the remote volcanic island Oshima-Ōshima by correlation of both tephras. As shown in Table 2, Oshima-Ōshima Volcano has repeated explosion at an interval of 1,000-2,000 years at least in late Holocene, and the 1741-1742 eruption occurred after about 1,500 years of dormancy.

The 1741-1742 Eruption

Oshima-Ōshima Volcano consists of Higashi-yama, Nishi-yama and central cone, in descending order. Higashi-yama has been fairly dissected due to marine erosion and exposes radial dikes. On the west side of Higashi-yama, the second stratovolcano of Nishi-yama was formed by repeated eruption of andesite and basalt, the surface of which is thickly covered by a successive deposit of andesitic and basaltic tephras (the Nishi-yama ejecta). Although the volcanic edifice of Nishi-yama is not so dissected, the summit of which was destroyed by a sector collapse to form a horseshoe-shaped somma opening to the north, 1.3 km in diameter and 160 m in maximum height from the bottom. Inferred from the restored map of Nishi-yama before the formation of somma, the volume of the vanished summit by collapse amounts to about 0.4 km^3 (Text-fig.6).

It is most likely that the northern half of Hishi-yama was destroyed by a big landslide at the culminant eruption on August 29, 1741. This sector collapse might have caused a destructive tsunami due to rushing of debris into the sea, as in the case of the 1640 eruption of Komaga-take Volcano, the landslide of which generated a tsunami that drowned about 700 people along the coast of Funka-Bay (Katsui et al., 1975). According to Hatori and



Text-fig. 6 Restored map of Nishi-yama before the sector collapse, contour intervals 100 m. The outer broken line (bold) indicates the position of somma, and the inner one an arcuate fissure along which the central cone craters are aligned. (Katsui and Satoh, 1970)

Katayama (1977), however, the inundation heights of the 1741 tsunami are estimated to have reached 6-10 m along the Oshima Peninsula, 4-6 m at Tsugaru, and 3-5 m at the Sado Island (Text-fig.3). The Imamura-Iida's tsunami magnitude is decided as m=3 which corresponds to 10^{23} ergs in kinetic energy. Considered from the enormous amount of energy, the tsunami may not have been caused by the landslide of Nishi-yama, but by a big earthquake, M= 7.5 or more, as considered by Hatori and Katayama (1977). The source area of the tsunami estimated by them extends 100 km or more in the NE-SW direction along a bathymetric line of 3,000 m off the Oshima Peninsula. The old writings, however, report only eruption, ash-fall and tsunami. Neither earthquake shocks nor their resultant damage were described by old chroniclers. It seems that the chroniclers might have taken notice of the former evidences alone which caused much damage. The simultaneous occurrence of the landslide and the tsunami in August 1741 suggests that the earthquake shock may have triggered the sector collapse of Nishi-yama, as recently observed in the 1980 eruption of Mt. St. Helens (Christiansen, 1980).

Table 3 Chemical compositions of the 1741 and subsequent products of Oshima-Ōshima volcano

	1	2	3	4	5
SiO_2	57.35	51.33	48.71	50.92	49.90
TiO_2	0.53	0.91	0.99	0.93	1.09
Al_2O_3	17.45	17.66	16.16	18.26	16.05
Fe_2O_3	2.90	4.16	6.09	1.89	5.03
FeO	3.48	5.03	4.18	5.79	5.55
MnO	0.05	0.08	0.13	0.12	0.14
MgO	2.58	5.05	8.78	5.53	7.03
CaO	6.99	9.80	11.06	9.98	10.51
Na_2O	3.88	3.10	2.16	3.13	2.15
K_2O	2.99	2.22	1.32	1.91	1.92
P_2O_5	0.42	0.57	0.38	0.42	0.23
H_2O (+)	1.50	0.39	0.78	0.56	0.26
H_2O (−)	0.24	0.10	0.02	0.06	0.06
Total	100.36	100.40	100.76	99.50	99.92
colour index	20.68	32.91	41.68	31.34	41.20

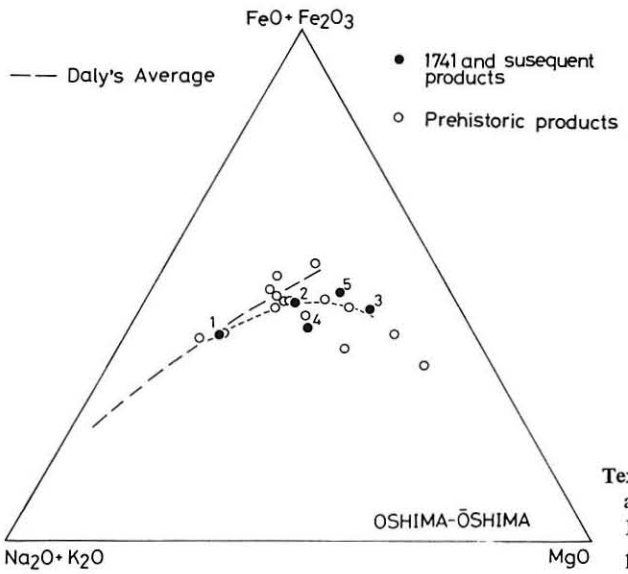
Analyst; 1–4 M. Yamamoto, 5 Y. Katsui

1. Hypersthene- and augite-bearing biotite-hornblende andesite, a pumice of the Nishi-yama ejecta.
2. Olivine-augite-hornblende basaltic andesite, a scoria of the Nishi-yama ejecta.
3. Olivine-augite basalt, a scoria of the Nishi-yama ejecta..
4. Olivine-augite basalt, a lava of the central cone.
5. Olivine-augite basalt, a lava of the parasitic crater of the central cone.

Note: Nos. 1-3 are 1741 products, Nos. 4-5 are of either 1742 or subsequent eruptions.

Subsequently, within the horseshoe-shaped somma, eruptions of basalt proceeded to form a new central cone, about 200 m high from the bottom. Flank eruptions along an arcuate fissure (Text-fig.6) also occurred, issuing aa lavas of basalt which flowed into the sea at the northern coast. Records of frequent heavy ash-falls including Pele's hairs on the Oshima Peninsula and the Tsugaru district in the first half of 1742, indicate that the formation of the central cone completed already in this term. Then, the activity declined and ceased in 1790.

During the 1741-1742 activity the essential materials changed from calc-alkalic hornblende andesite to silica-undersaturated olivine-augite basalt in composition, as listed in Table 3. As shown in Text-fig.7, the trend of this variation follows that of the pre-historic products of Oshima-Ōshima Volcano. Ultramafic and mafic inclusions such as dunite, wehrlite, clinopyroxenite, and hornblende gabbro which show a typical cumulus texture, are



Text-fig. 7 AFM diagram for the lavas and pyroclastics from Oshima-Ōshima. Data of the 1741 and subsequent products are given in Table 3.

abundantly found in the pumice-fall deposit of Os-a and the pre-historic tephras and lavas of calc-alkalic andesite in Oshima-Ōshima (Yamamoto et al., 1977). Taking such inclusions into account, Yamamoto et al. (1977) and Katsui et al. (1979) showed that the calc-alkalic andesite magma derived from the basaltic magma through a two-step process of fractional crystallization involving early separation of olivine and clinopyroxene and later separation of pargasitic amphibole and calcic plagioclase from the magma. The reversed order of eruption from andesitic tephras to basaltic tephras and lavas within a short period during 1741-1742, indicates the presence of a compositionally zoned magma chamber which was formed through the above process during the long period of quiescence for about 1,500 years before the eruption.

Concluding Remarks

The 1741-1742 and subsequent activities of Oshima-Ōshima Volcano represent one cycle of eruption which occurred after about 1,500 years of dormancy. The activity started with ejection of andesitic tephras which was followed by eruption of basaltic ones. In the culminant phase of eruption, a big sector collapse occurred at the Nishi-yama volcanic body, which was probably triggered by a supposed earthquake that caused a destructive tsunami on August 29, 1741. Subsepuently, during the first falf of 1742, eruptions of basalt proceeded to form a central cone within the horseshoe-shaped somma. During the 1741-1742 activity a conspicuous change in composition of the volcanic products from hornblende andesite to olivine-augite basalt, is noticed, which indicates that the basaltic magma proceeded fractional crystallization to form a compositionally zoned magma chamber before the eruption.

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