Correlation of the late Pliocene Mushono-Shiraiwa Tephra Beds in the Kobiwako and Kakegawa Groups to the Kyp-NA11-Jwg4 Tephra Beds in the Niigata region, central Japan

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Abstract

The correlation of the late Pliocene Mushono Tephra Bed in the Kobiwako Group, the Shiraiwa Tephra Bed in the Kakegawa Group and the Kyp, NA11, Jwg-4 and their correlative Tephra Beds in the Niigata region was performed. The correlation of the Mushono Tephra Bed to the Shiraiwa Tephra Bed was also confirmed by chemical composition of glass shards, especially on the FeO contents of 1.6-1.8% in average. The Mushono-Shiraiwa Tephra Bed was correlative to the Nkw and Dgc Tephra Beds in the Tomikura area, eastern Arai City, the Kyp Tephra Bed in the Higashikubiki area, the Sgs Tephra Bed in the Hachikoku area, the NA11 Tephra Bed in the Ojiya area and the Jwg-4 Tephra Bed in the Chuo and Nishiyama Oil Fields. These tephra beds commonly have primary pyroclastic deposits at the base of the beds that can be interpreted as subaqueous fallout origin. These correlative tephras in central Japan cover more than 300x250Km^2 area, which implies one of the prominent eruptions in late Pliocene around 2.35Ma. The source volcanic area can be supposed in the northern Chubu Mountains based on the distribution of the deposits.

Key words: correlation, Mushono Tephra Bed, Shiraiwa Tephra Bed, Kyp, Nkw, Sgs, NA11, Jwg-4, Kobiwako Group, Niigata region, widespread tephra, subaqueous fallout, late Pliocene, central Japan

Introduction

The Mushono Tephra Bed in the Kobiwako Group is one of the prominent late Pliocene widespread Tephra Beds and so far correlated to the Koyashiro Tephra Bed in the Tokai Group (Yoshikawa et al., 1991) and the Shiraiwa Tephra Bed in the Kakegawa Group (Satoguchi et al., 1996) in the Pacific Ocean side of central Japan. In this paper, correlation of the Mushono-Shiraiwa Tephra Bed to the tephra beds in the Niigata region of the Japan Sea side

Recieved 1, December 2003

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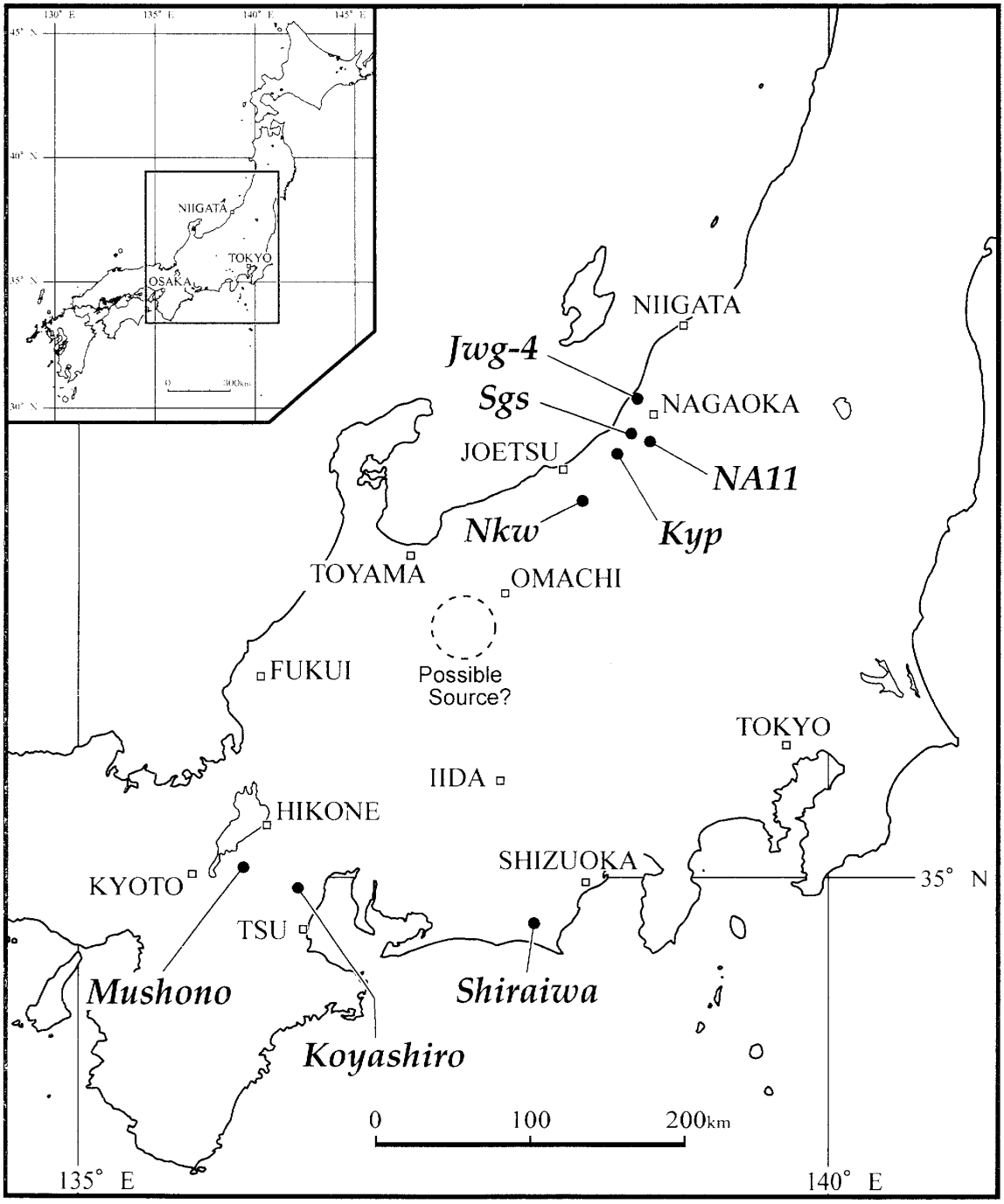

Fig.1. Locations of the Mushono, Koyashiro, Shiraiwa, Nkw, Kyp, Sgs, NA11 and Jwg-4 Tephra Beds in the central Honshu Island. Possible volcanic source area is also assigned.

was examined (Fig.1). In the Niigata region, the correlative tephra beds (Fig.2) are mostly intercalated in the marine sediments.

We are acknowleged to Dr. Kyoko Kataoka of the Research Institute for Hazards in Snowy Areas, Niigata University for suggestive comments and Mr.Hironori Hiranaka of Graduate School of Science and Technology of Niigata University for arrangement of figures, and also to Mr.Toyoki Aoki, Miss.Makiko Tan and Haruna Yahagi of Niigata University in field cooperation. Financial aid was partly indebted

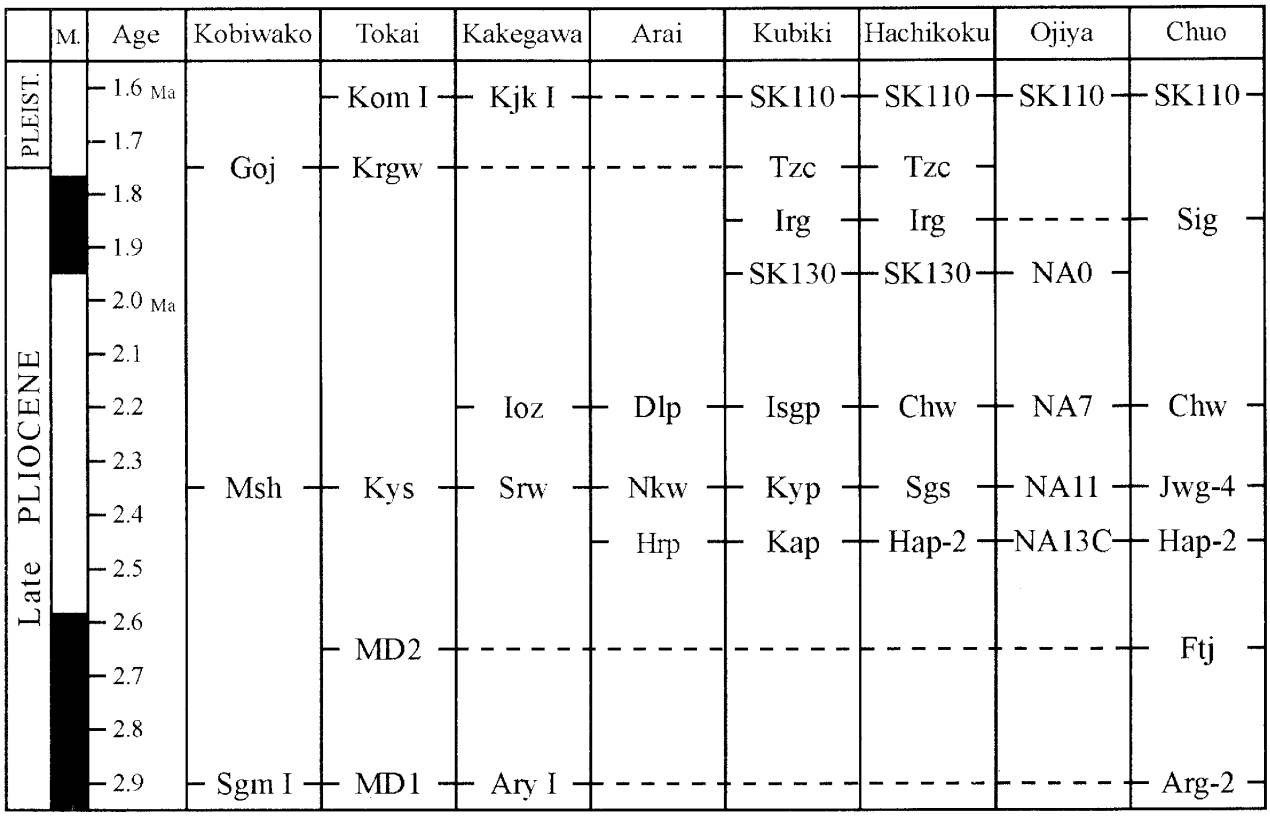

Fig.2. Stratigraphic horizon and correlation of the Mushono (Msh) Tephra Bed in the Kobiwako Group, the Koyashiro (Kys) Tephra Bed in the Tokai Group, the Shiraiwa (Srw) Tephra Bed in the Kakegawa Group, the Nakaguri (Nkw) Tephra Bed in the Arai area in the Niigata region, the Kamiyoriai (Kyp) Tephra Bed in the Higashikubiki area, the Suganuma (Sgs) Tephra Bed in the Hachikoku area, the NA11 Tephra Bed in the Ojiya area and the Jwg-4 Tephra Bed in the Chuo and Nishiyama Oil Fields in the central Niigata region. Stratigraphic relations to the other tephra beds so far reported and magnetic polarity (M) are also shown. The correlation of the Iozumi (Ioz) Tephra Bed in the Kakegawa Group to the Chw Tepha Bed is based by Aoki (1999). Abbreviations for Tephra names are Kom I (Komeno I), Kjk I (Kamihijikata I), Goj (Gokenjaya), Krgw (Karegawa), MD (Minamidani), Sgm I (Sagami I) and Ary I (Arigaya I).

to the Ministry of Education and Science of Japan to Kurokawa, titled 「Precise correlation of Miocene to early Pleistocene in Japanese Islands by means of widespread tephra beds」 (grant-in-aid 12640440).

The Mushono Tephra Bed

The Mushono Tephra Bed is intercalated in the fluvio-lacustrine Gamo Formation of the Kobiwako Group (Takaya, 1963; Kaigake Research Group, 1972). At the type locality at Mushono, Minakuchi Town in Shiga Prefecture, it is composed of medium-sand size to silt sized ashes with pumices, and about 2m thick (Fig.3). The basal 5cm is fine sand to silt sized and was interpreted as primary pyroclastic fallout origin (Kataoka, 2003). It grades upwards from very fine sand to silt size. Lamination is observed through the deposit. This part was interpreted as deposit of resedimentation in fluvio-lacustrine environments

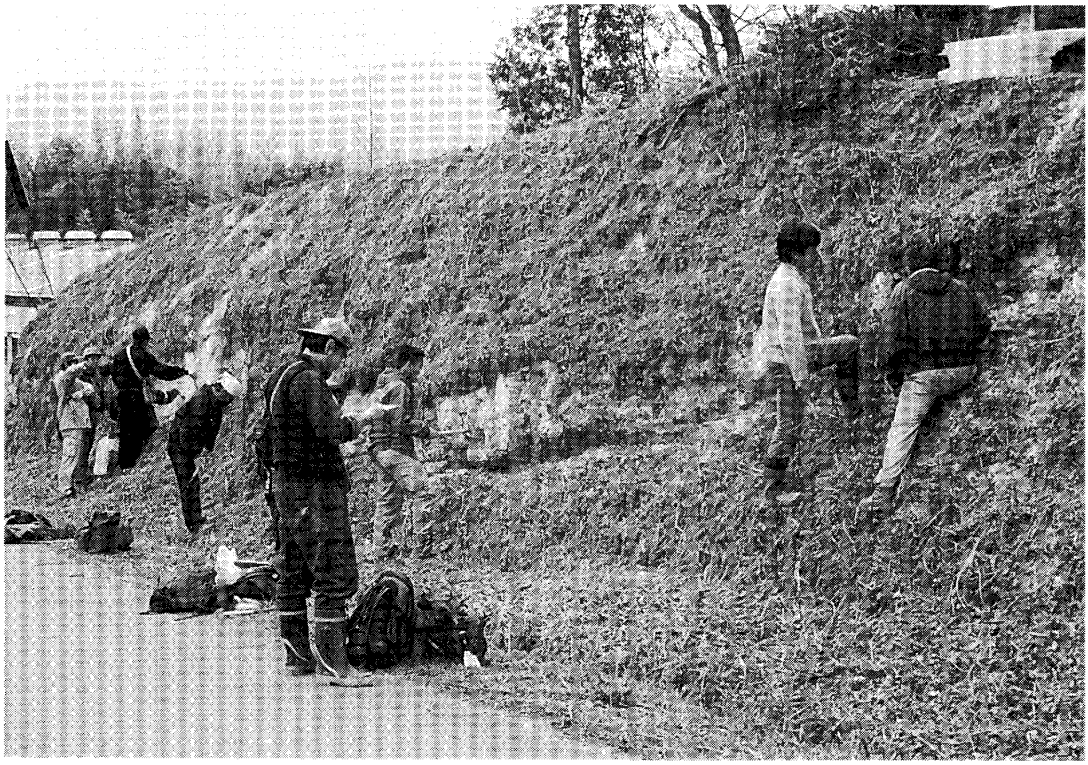

Fig.3. Outcrop of the Mushono Tephra Bed in the Kobiwako Group at Mushono, Minakuchi Town in Shiga Prefecture. The Mushono Tephra Bed continues to the uppermost of the cliff and about 2m thick.

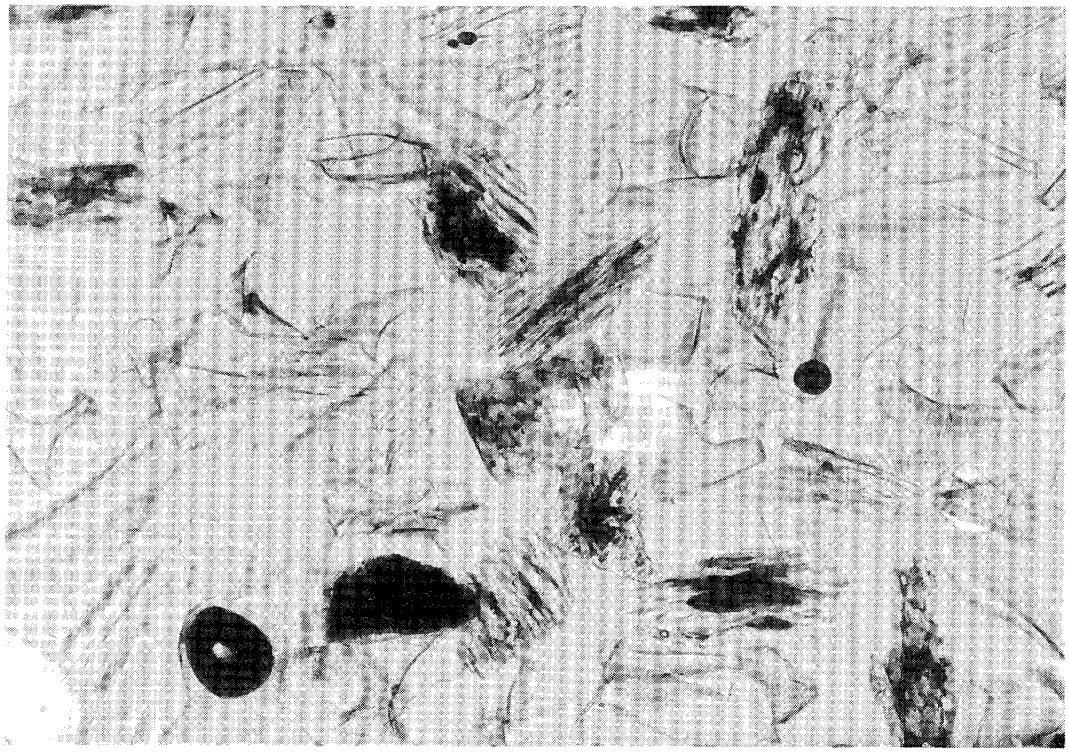

Fig.4. Components of the Mushono Tephra at base in 3ϕ-4ϕ fraction. The platy glass shards are dominant with bubble-junction and fibrously vesiculated types shards. (The width of the photo is about 1.2mm. The photo was taken under the upper nicol 30° rotated from the crossed position as same the following photos).

(Kataoka, 2003).

The Koyashiro Tephra Bed is intercalated in the mainly fluvial Sakuramura Formation of the Tokai Group. Its locality is about 20km apart in ESE direction from the Mushono Tephra Bed beyond the Suzuka Mountains. At the type locality at Onbegawa, Suzuka City in Mie Prefecture (Miyamura et al., 1981), it is 175cm thick. The basal 5cm of primary fallout is medium to fine sand-sized. Upwards it grades into silt, including pumices up to 4mm in diameter (Yoshikawa et al.,1991).

The Shiraiwa Tephra Beds

The Shiraiwa Tephra Bed is intercalated in the marine Horinouchi Formation of the Kakegawa Group in Shizuoka Prefecture on the Pacific Ocean side. It is 10-15m thick (Fig.5) and the basal 5-30cm is sand sized. It grades into silt size, making fine alternation (Mizuno et al., 1987).

The Kyp-Nkw-Dgc Tephra Beds

In the Niigata region on the Japan Sea side, the Kyp (Kamiyoriai) Tephra Bed (Takano et al., 1989) is intercalated in the marine Tamugigawa Formation. At the type locality of the Ishiguro River route in Takayanagi Town in the Higashikubiki Hills, it is 190cm thick (Fig.8). The basal 8cm grades from fine sand to very fine sand size and is interpreted as submarine fallout origin. In the upper part, it is very fine sand to silt size and composed of about 45 thin micro-units as laminae, showing upward thickening.

The Kyp Tephra Bed was correlated to the Nkw Tephra Bed in the Tomikura anticlinal area near the boundary of Niigata and Nagano Prefectures (Kurokawa et al., 1995). The Nkw Tephra Bed is intercalated in the fluvial Doro Formation and more than 3m thick. The basal 15cm is medium to fine sized, and the upper part is composed of two grading units (70cm and 230 cm thick) from fine sand to silt size.

The Dgc (DSR-24) Tephra Bed in the Doro Formation in the Tomikura area was correlated to the Sgs Tephra Bed (Kurokawa et al., 1995), that is the Dgc and Nkw Tephra Beds in the Doro Formation was proved to be a same Tephra Bed by the present correlation. The Dgc Tephra Bed is about 15m thick and basal 8cm is coarse to medium sand sized and in the overlying 47cm, it grades from coarse sand to very fine sand size. The upper 14.5m is a resedimentated deposit composed of laminated very fine sand to silt sized ash and contains pumice clasts.

The Sgs-NA11-Jwg4 Tephra Beds

The Sgs Tephra Bed is intercalated in the marine silt of the Suganuma Formation in the Hachikoku Oil Field, central Niigata Prefecture. At the type locality of the Kunisawa River route, Oguni Town, it is 120cm thick (Kurokawa et al., 1990) (Fig.7). The basal 6cm of fallout origin is fine sand to very fine sand sized, and upwards it grades from very fine sand to silt size. Parallel- or trough-cross-laminae are present in this part containing a small amount of pumices up to 5mm. The Sgs Bed at Ishiguro River route in Kurokawa et al. (1993), 30m below the Kyp Tephra Bed, is not correlated to the Sgs Tephra Bed.

The NA11 Tephra Bed is intercalated in the marine mud of the Ushigakubi Formation in the southern Higashiyama Hills (Tokuhashi, 1985). The NA11 Tephra Bed was correlated to the Sgs Tephra Bed (Kurokawa and Miura, 1993). At the type locality of the Nobegawa route, eastern Ojiya City, it is 60cm thick (Fig.10). The basal 7cm is fine sand to very fine sand size, and upwards it grades into silt size, containing small amount of pumices in the upper part.

The Jwg-4 Tephra Bed (Kurokawa and Sawaguri, 1990) is intercalated in the marine mud of the Nishiyama Formation in the Chuo and Nishiyama Oil Fields in central Niigata Prefecture. The Jwg-4 Tephra Bed was correlated to the Sgs and NA11 Tephra Beds (Kurokawa and Miura, 1993). At the type

Fig.5. Field occurrence of the Shiraiwa Tephra Bed in the Kakegawa Group at Shiraiwa, Kikugawa Town in Shizuoka Prefecture. The Shraiwa Tephra Bed is more than 10m thick.

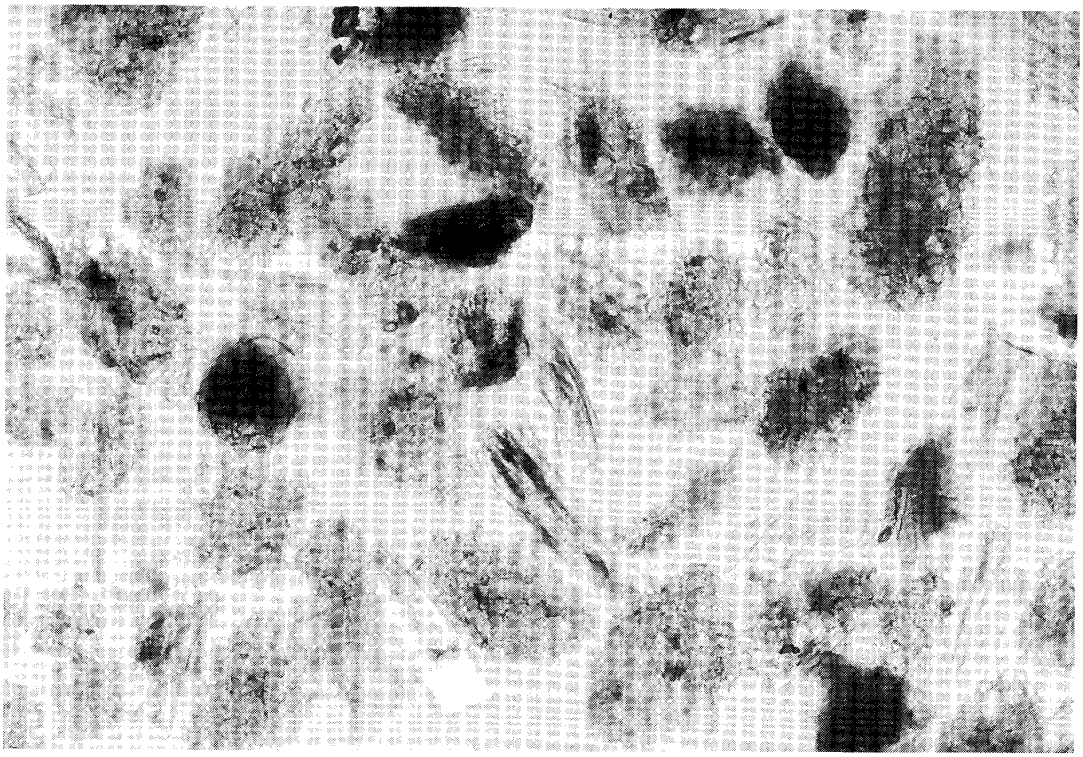

Fig.6. Components of the Shiraiwa Tephra (upper part) in 3ϕ-4ϕ fraction. The platy and fibrously vesiculated shards are dominant besides micro-volcanic fragments.

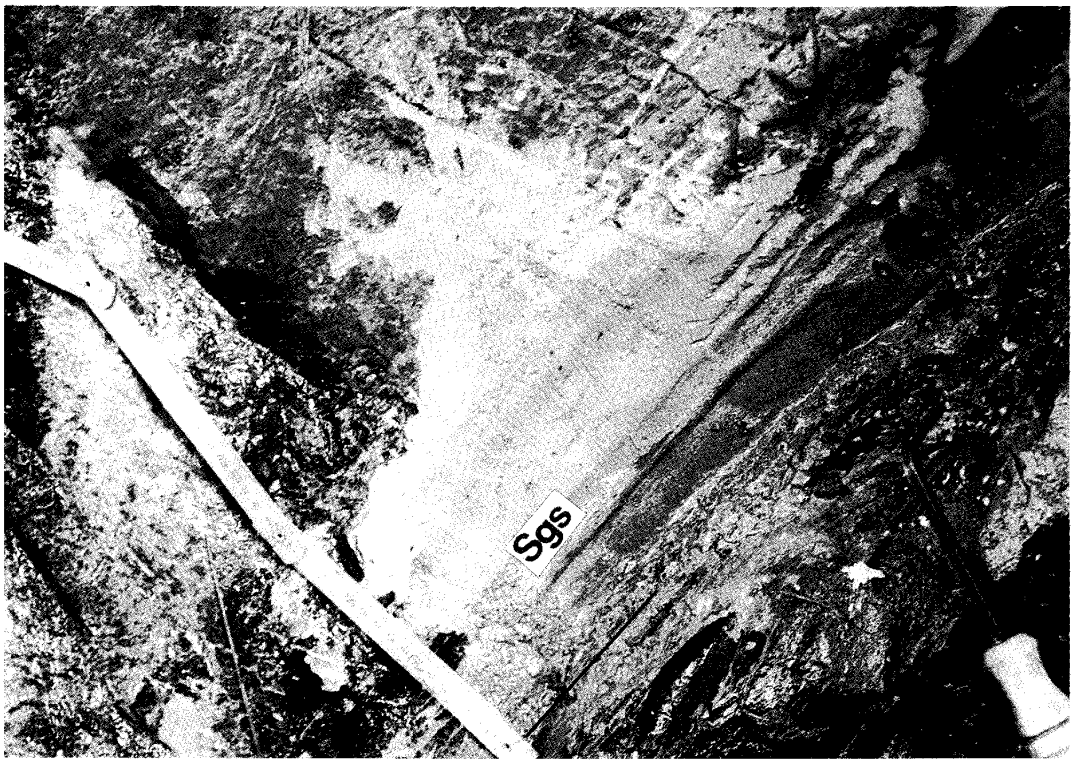

Fig.7. Field occurrence of the Sgs Tephra Bed in the Suganuma Formation at Kunisawa River, Takeishi, Oguni Town in central Niigata Prefecture (Kurokawa et al., 1990). It is about 120cm in total thickness.

Fig.8. Field occurrence of the Kyp Tephra Bed in the Tamugigawa Formation at road side along the Ishiguro River, Kamiyoriai, Takayanagi Town in the Higashikubiki Hills. It is about 190cm in total thickness. The Kyp also crops out in the River floor under the Irinoshima Bridge.

Fig.9. Field occurrence of the Jwg-4 Tephra Bed in the Nishiyama Formation at Jorakuji, Izumozaki Town in the Chuo Oil Field in the central Niigata Prefecture. It is about 10cm in total thickness.

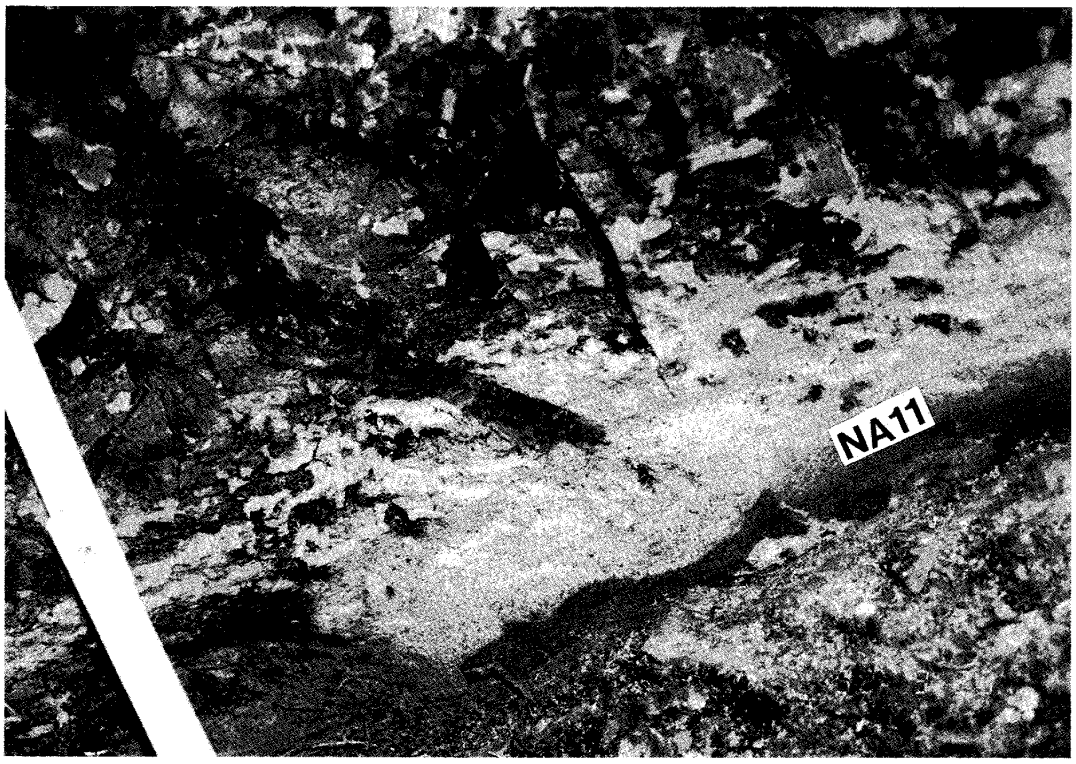

Fig.10. Field occurrence of the NA11 Tephra Bed in the Ushigakubi Formation at Nobegawa, Ojiya City in the southern Higashiyama Hills. It is about 60cm in total thickness.

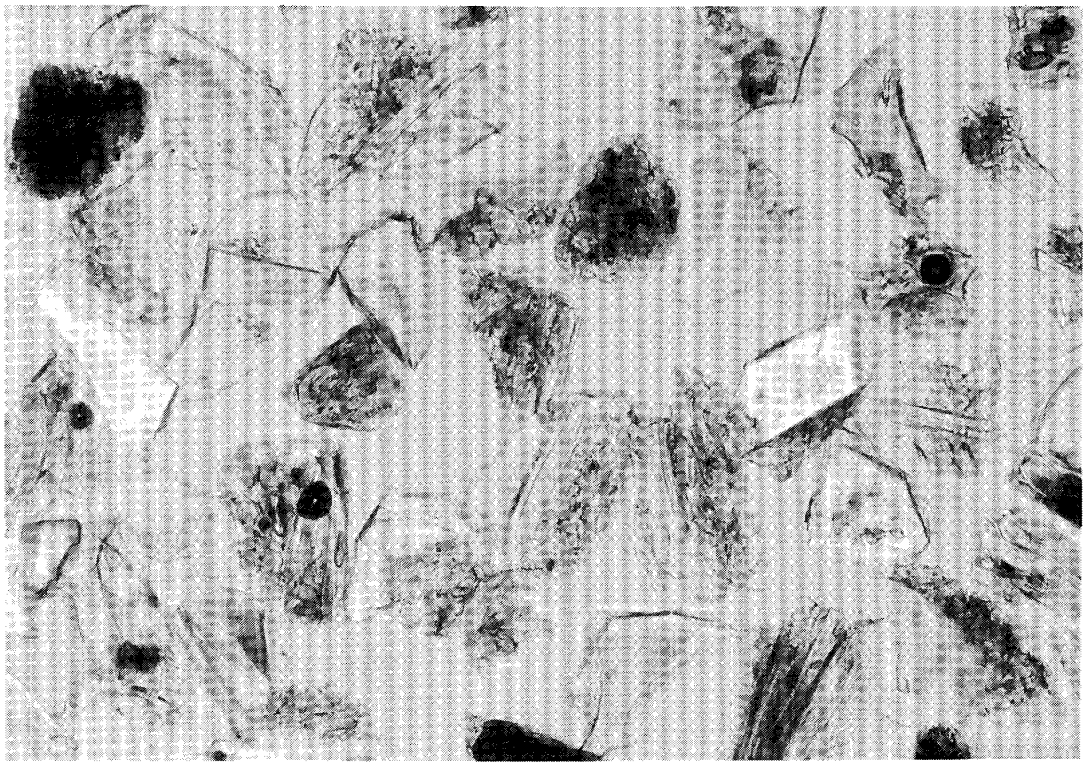

Fig.11. Components of the Nkw Tephra (upper part) at Nakaguri, eastern Arai City, in 3ϕ-4ϕ fraction. The platy, bubble-junction and fibrously vesiculated shards are dominant.

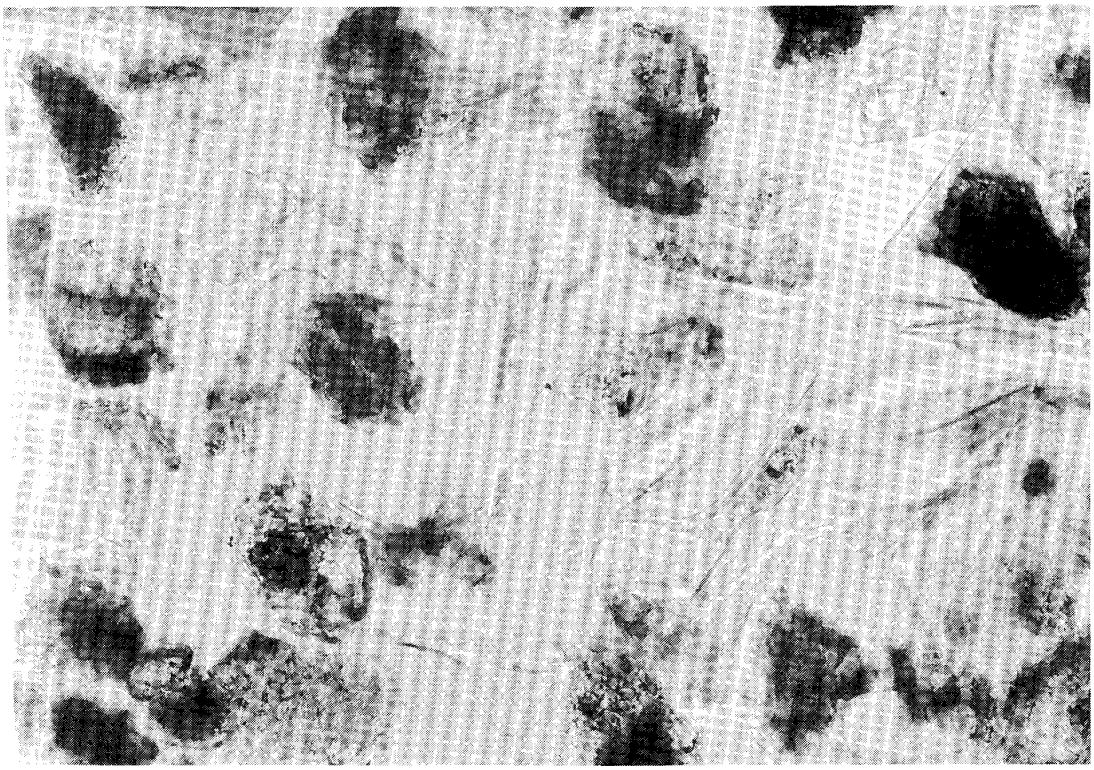

Fig.12. Components of the Kyp Tephra (upper part) at Kamiyoriai, Takayanagi Town, in 3ϕ-4ϕ fraction. The platy, bubble-junction and fibrously vesiculated shards are dominant besides micro-volcanic fragments.

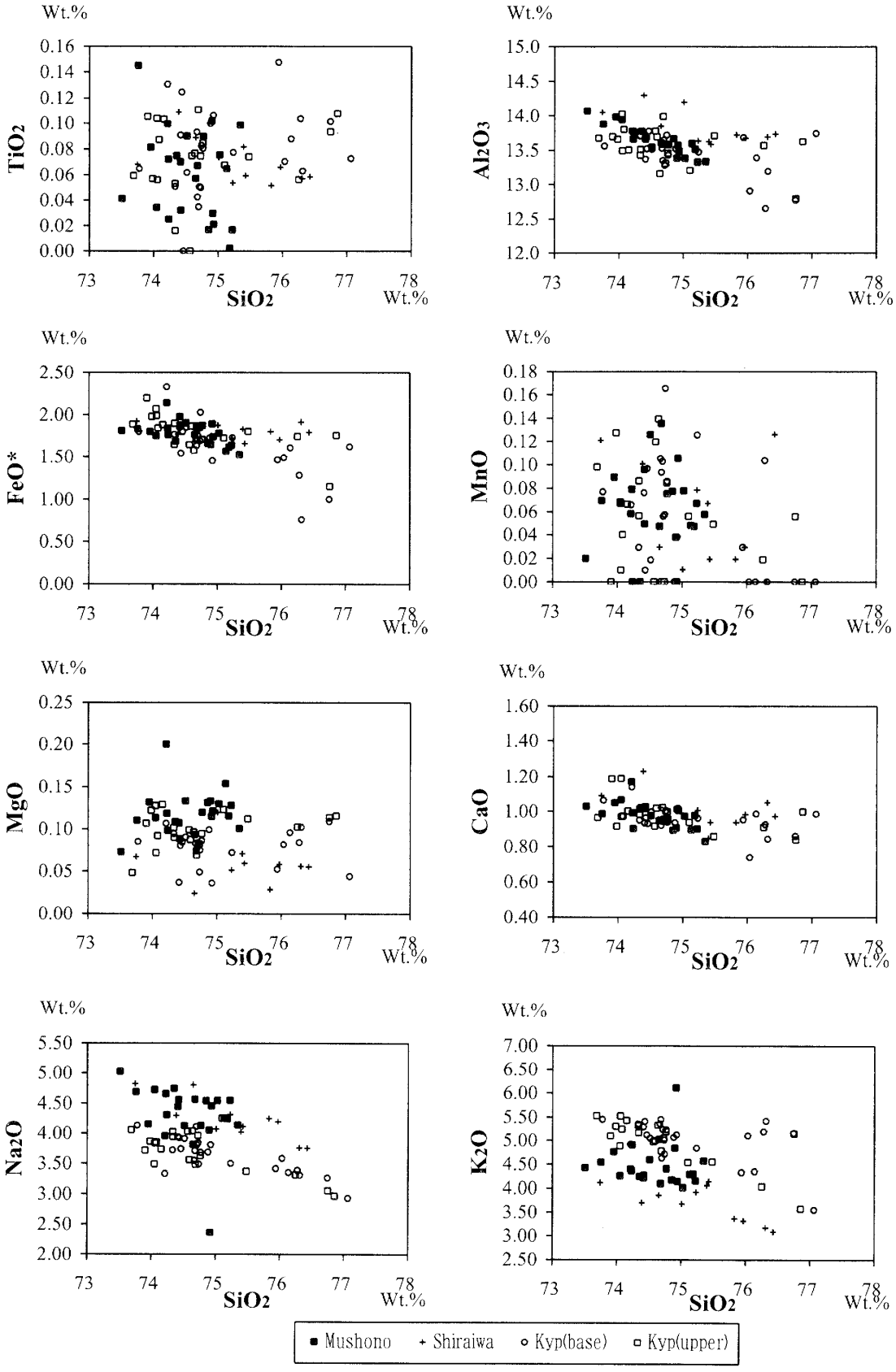

Fig.13. SiO_2-oxides diagrams of the chemical composition of the glass shards of the Mushono, Shiraiwa and Kyp Tephras (total oxide weights were converted to 100%). Sampling localities are shown in Table 1.

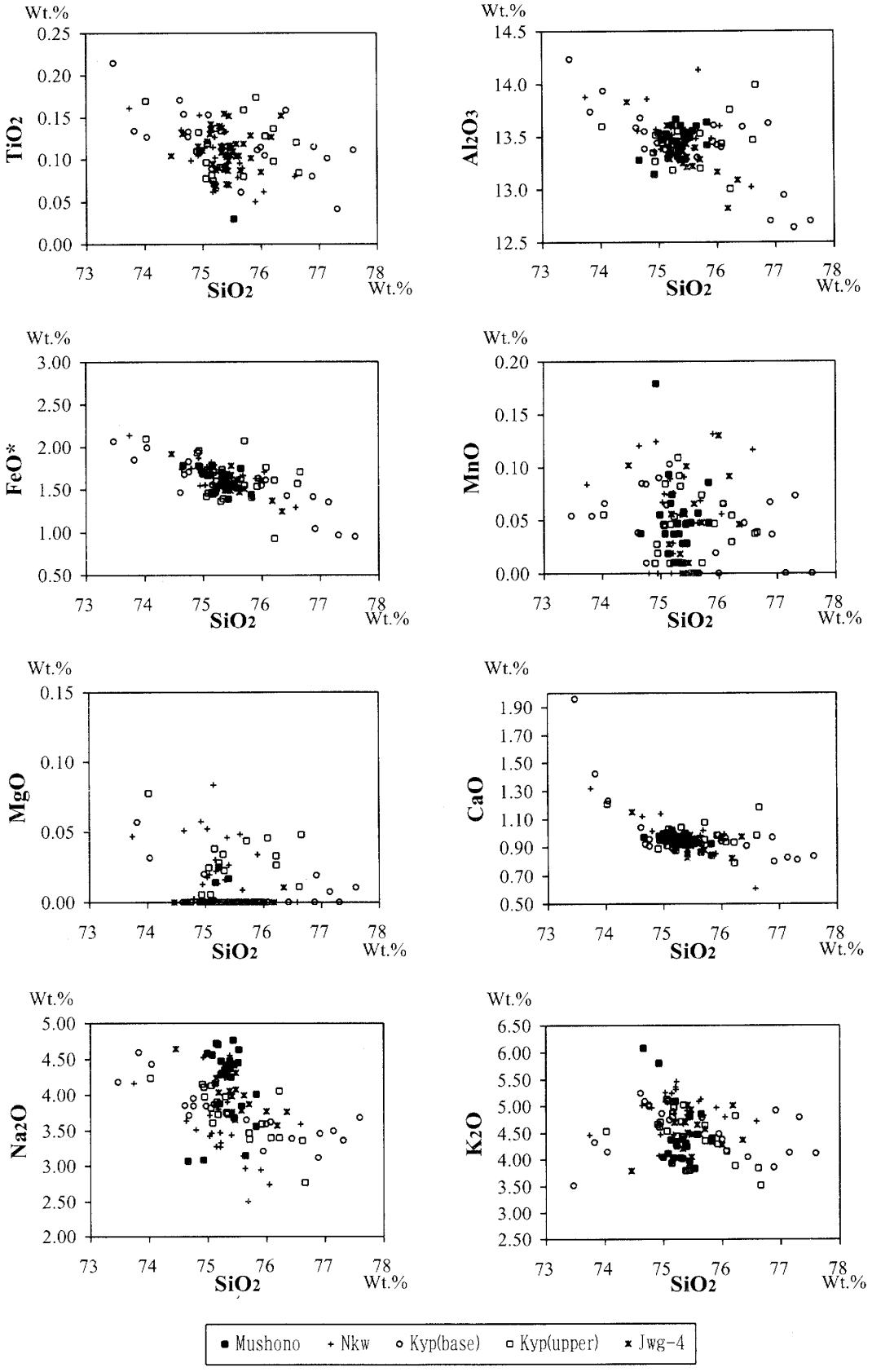

Fig.14. SiO_2-oxides diagrams of the chemical composition of the glass shards of the Mushono, Nkw, Kyp and Jwg-4 Tephras (total oxide weights were converted to 100%). Sampling localities are shown in Table 1.

Table 1. Chemical composition of the glass shards of the Mushono, Shiraiwa, Nkw, Kyp and Jwg-4 Tephras sampled at each type locality in weight percent. Total oxides weights were converted to 100%. FeO* denots total Fe as FeO. The average (Ave.) and standard deviation (S.D.) are also shown. (n) shows numbers of analysed grains and (r) shows an analytically same round. Sampling localities are the Mushono at Mushono, Minakuchi Town in Shiga Prefecture, the Shiraiwa at Shiraiwa, Kikugawa Town in Shizuoka Prefecture, the Nkw at Nakaguri, Arai City in Niigata Prefecture, the Kyp at Kamiyoriai, Takayanagi Town in Niigata Prefecture, the Jwg-4 at Jorakuji, Izumozaki Town in Niigata Prefecture.

TePhra Bed	SiO_2		TiO_2		Al_2O_3		FeO*		MnO		MgO		CaO		Na_2O		K_2O		n	r
	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.	Ave.	S.D.		
Mushono	75.32	0.27	0.10	0.03	13.47	0.13	1.58	0.11	0.05	0.04	0.00	0.01	0.95	0.04	4.17	0.51	4.37	0.58	25	1
Mushono	74.58	0.49	0.06	0.04	13.64	0.20	1.78	0.14	0.06	0.04	0.12	0.03	0.98	0.07	4.31	0.51	4.48	0.45	23	2
Shiraiwa	75.31	0.82	0.07	0.02	13.82	0.25	1.79	0.09	0.05	0.05	0.06	0.03	1.00	0.10	4.22	0.35	3.67	0.38	11	2
Nkw	75.26	0.55	0.11	0.03	13.50	0.22	1.64	0.18	0.07	0.05	0.03	0.02	0.97	0.13	3.56	0.54	4.88	0.38	23	1
Kyp(upper)	75.32	0.93	0.12	0.05	13.51	0.40	1.69	0.31	0.05	0.04	0.04	0.08	1.04	0.29	3.74	0.37	4.49	0.45	22	1
Kyp(upper)	74.75	0.92	0.07	0.03	13.55	0.29	1.80	0.21	0.05	0.05	0.10	0.02	0.98	0.09	3.71	0.35	4.98	0.49	20	2
Kyp(base)	75.25	1.88	0.13	0.08	13.50	0.54	1.68	0.66	0.05	0.03	0.05	0.14	1.10	0.47	3.77	0.40	4.47	0.52	21	1
Kyp(base)	75.12	0.88	0.08	0.03	13.44	0.30	1.64	0.31	0.06	0.05	0.08	0.02	0.96	0.08	3.63	0.29	5.01	0.44	24	2
Jwg-4	75.49	0.39	0.11	0.02	13.34	0.21	1.60	0.16	0.04	0.04	0.00	0.00	0.94	0.07	4.03	0.30	4.44	0.38	20	1

locality of the Jorakuji route, Izumozaki Town in the Chuo Oil Field, it is about 10cm thick (Fig.9). The basal 3cm is fine sand to very fine sand size, and upwards it grades from very fine sand to silt size, containing small amount of pumices. Weak lamination is present. In the overlying mud deposit, sporadic pumices of 1-2mm are contained. In the Nishiyama Oil Field at Tanaka, Izumozaki Town, the Jwg-4 Tephra Bed is also found. The basal layer is very fine sand size and 1cm thick (Kurokawa et al., 1992).

Correlation

The correlation of these Tephra Beds was examined in their horizon, petrography and chemical composition of glass shards. These Tephra Beds are all in the late Pliocene as so far documented (Fig.2).

In petrography, these tephras show similar characteristics. In the basal part, they are mainly composed of glass shards with 2-20% plagioclase and small amounts (less than 0.5%) of quartz and mafic minerals. Shape of the glass shards are similar among these Tephras. Platy glass shards are dominant and bubble-junction type and fibrously vesiculated shards are accompanied in common (Figs.4, 6, 11, 12). Besides, shards with acicular inclusions are also accompanied. Brown-colored glass shards are also contained in these Tephras. As for the mafic minerals, iron ores dominate and zircon, hornblende, biotite and small amount of orthoproxene are accompanied.

Chemical composition of the glass shards of the Mushono, Shiraiwa, Nkw, Kyp and Jwg-4 Tephras are shown in Figs.13, 14 and Table1. EPMA analyses were made by JXA8600SX micro-analyser of Niigata University at 15keV with

beam diameter of 20 μm, calibrated by oxide ZAF method. These results show similar composition, especially characterized by higher FeO contents (about 1.6-1.8% in average) compared with those of tephras of neighboring horizon. The correlation of the Mushono Tephra Bed in the Kobiwako Group to the Shiraiwa Tephra Beds in the Kakegawa Group by Satoguchi et al. (1996) is also confirmed on these chemical composition of the glass shards as shown in Fig.13 and Table 1.

Thus, the Mushono, Koyashiro, Shiraiwa, Nkw, Dgc, Kyp, Sgs, NA11 and Jwg-4 Tephra Beds can be correlated each other. The extension of the distribution area is more than 300x250Km^2 in central Japan, which implies one of the prominent eruptions in late Pliocene. The age estimation of this Tephra Bed in the Jorakuji route, using the Ftj (2.65Ma) and the Sig (1.85Ma) Tephra Beds as control points and asuming the steady sedimentary rate, assigns the age around 2.35Ma. The source volcanic area can be supposed in the northern Chubu Mountains based on its distribution. The thickness of this Tephra Bed, the Mushono-Kyp Tephra Bed as the general name, gets thicker southwestwards in the Niigata region.

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