

Correlation of the late Pliocene Tzw-Smg-Tnkw-Jic Tephra Beds in the Niigata region, northeast Japan

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Abstract

The late Pliocene Tzw Tephra Bed is intercalated in the middle Nishiyama Formation 10m above the Ftj-UN Tephra Bed in the Chuo Oil Field. The Tzw was correlated to the Smg Tephra Bed in the Nishiyama Oil Field and also to the Tnkw Tephra Bed in the Kuwae Formation along the Tainai River, northern Niigata region by means of their horizon, field occurrences, petrography and chemical composition of glass shards. The Smg Tephra Bed was so far correlated to the Jic Tephra Bed in the Kawauchi Formation in Sado Island. Thus, the Tzw-Smg-Tnkw-Jic Tephra Bed was revealed to be one of the widespread fallout tephra beds of late Pliocene in the Niigata region, distributed in the area of more than 100x60km². This Tephra Bed is possibly situated between the two geologically important marker horizons; that is above the boundary of the fossil diatom zones of the *Neodenticula koizumii* - *N.kamtschatica* Zone and the *Neodenticula koizumii* Zone, and also just below the boundary of the Gauss and Matuyama Chrons in magnetostratigraphy. The age of the Tzw Tephra Bed as the general name is assumed to be around 2.6Ma.

Key words: Tzw Tephra Bed, Smg, Tnkw, Jic, correlation, Pliocene, Niigata

Introduction

The late Pliocene is notable in the environmental changes and the tephra marker beds play the important roles in the stratigraphic resolution. In this paper, the new widespread Tephra Bed of about 2.6Ma, namely the Tzw-Smg-Tnkw-Jic Tephra Bed is revealed. This Tephra Bed was found in the Nishiyama and Chuo Oil Fields, the Tainai river route in the Kitakanbara area and also in the Sado Island in the Niigata region (Fig.1). This Tephra Bed

possibly indicates important geological horizon above the boundary of the fossil diatom zone of the *Neodenticula koizumii* - *N.kamtschatica* Zone and the *N.koizumii* Zone, and below the boundary horizon of the Gauss and Matuyama Chrons in magnetostratigraphy. This useful marker Tephra Bed is expected to be found in wider areas.

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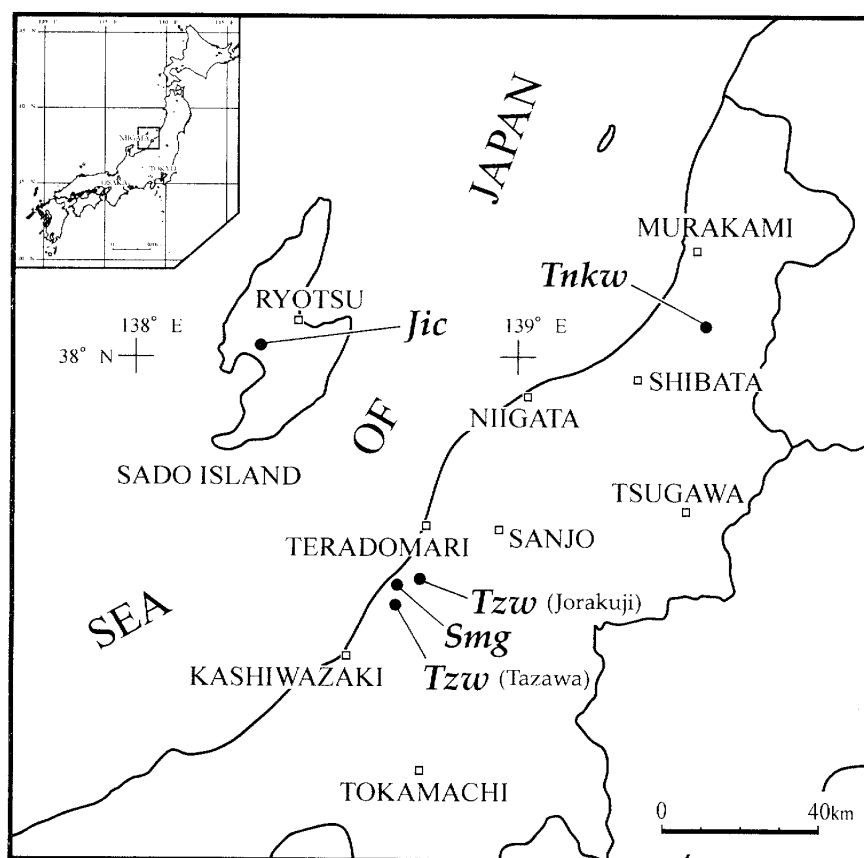


Fig.1. Location of the Tzw, Smg, Tnkw and Jic Tephra Beds in the Niigata region.

geological indications on the Tainai River route. Financial aid was partly indebted 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).

Tzw Tephra Bed in the Chuo Oil Field

[type locality] The type locality of the Tzw Tephra Bed was assigned at Jorakuji route, Izumozaki Town in the Chuo Oil Field (Kurokawa and Sawaguri, 1990).

[horizon] At the type locality, the Tzw Tephra Bed is intercalated in the marine silt of the middle Nishiyama Formation (Figs.3,7). The Tzw is situated about 10m above the Ftj Tephra Bed and about 15m below the Hap-2 Tephra Bed. At the Tazawa route in Nishiyama Town, about 4km southwest from the Jorakuji route, it

is situated 16m above the Arg-2 Tephra Bed.

[field occurrence] At Jorakuji, it is white ash bed of 9cm thick. Basal 0.5cm is silt-sized and upwards it grades from very fine sand size to silt size. At Tazawa, it is 13cm thick (Fig.9). Basal 0.5cm is also silt-sized and upwards it grades from very fine sand size to silt size. The basal part is somewhat bioturbated.

[petrography] It is mostly composed of platy and bubble-junction type glass shards with fibrously vesiculated shards (Fig.8). Brown glass shards are also accompanied. At Tazawa, micro opaque grains of 1-10 μ m of possibly biogenic origin are found on the shards (Fig.10). Mafic minerals are hornblende, orthopyroxene, biotite and clinopyroxene.

Smg Tephra Bed in the Nishiyama Oil Field

[type locality] The type locality of the Smg Tephra Bed was assigned at the Shimoyamada

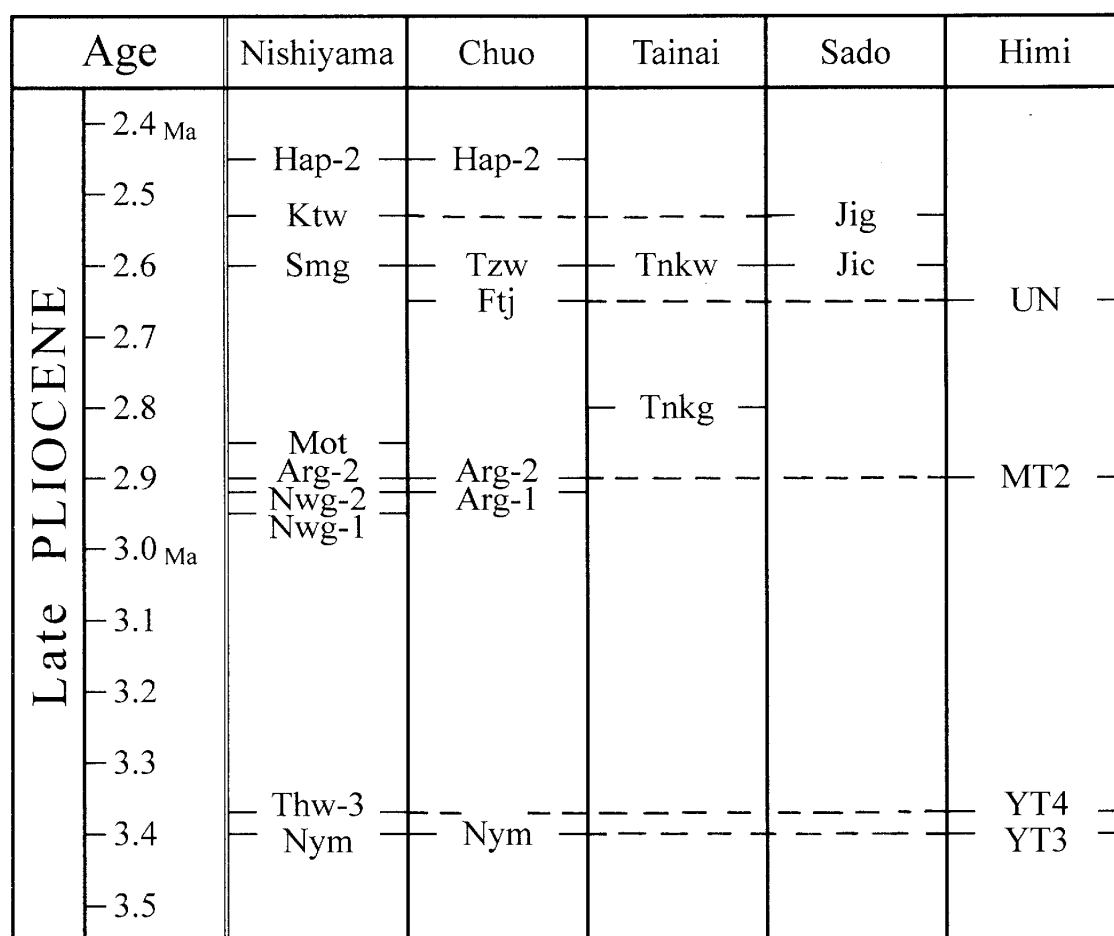


Fig.2. Correlation of the late Pliocene prominent Tephra Beds in about 3.4-2.4Ma in the Nishiyama and Chuo Oil Fields, Tainai River route and Sado Island and the horizon of the Tzw, Smg, Tnkw and Jic Tephra Beds. The correlative Tephra Beds in the Himi regions, Toyama Prefecture are also shown. Correlation of the Arg-1 Tephra Bed to the Nwg-2 Tephra Bed is after Higuchi and Kurokawa (2003b). Correlation of the Thw-3 Tephra Bed to the YT4 Tephra Bed in the Himi Group is after Higuchi and Kurokawa (2003a).

route, Nishiyama Town in the Nishiyama Oil Field (Kurokawa et al., 1989).

[horizon] At the type locality, it is intercalated in the marine silt of the middle Nishiyama Formation, 120cm below the one of the Gos Tephra Beds (2cm thick). Stratigraphic relation to other tephra beds is not known in this route.

[field occurrence] At Shimoyamada, it is white ash bed of 12cm thick (Fig.4). Basal 0.5cm is silt-sized and the above 5cm grades from fine sand to very fine sand size, and upper 7cm is silt size, gradually grades into tuffaceous silt. Weak lamination and bioturbation are recog-

nized.

[petrography] It is mostly composed of platy and bubble-junction type glass shards with fibrously vesiculated shards (Fig.11). Brown glass shards are also accompanied. Mafic minerals are hornblende, orthopyroxene, biotite and clinopyroxene.

Tnkw Tephra Bed in the Tainai River route

[type locality] (newly defined) The type locality of the Tnkw Tephra Bed is assigned at the Tainai River route, Natsui, Kurokawa



Fig.3. Field occurrence of the Tzw Tephra Bed at Jorakuji, Izumozaki Town in the Chuo Oil Field. The Tzw is intercalated in the middle Nishiyama Formation and 9cm thick (right upwards).



Fig.4. Field occurrence of the Smg Tephra Bed at Shimoyamada, Nishiyama Town in the Nishiyama Oil Field. The Smg is intercalated in the middle Nishiyama Formation and 12cm thick.



Fig.5. Field occurrence of the Tnkw Tephra Bed at Tainai River route, Natsui, Kurokawa Village in the Kitakanbara area. The Tnkw is intercalated in the upper Kuwae Formation and 5cm thick.

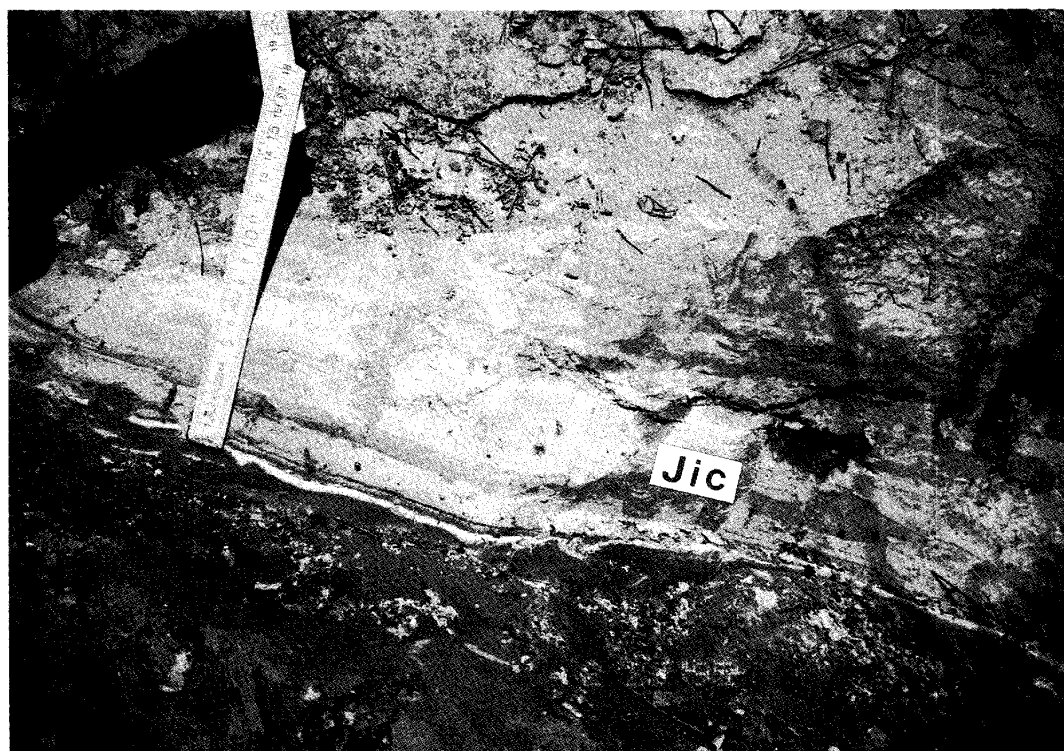


Fig.6. Field occurrence of the Jic Tephra Bed at Kamiyabase, Sawada Town in Sado Island (Kurokawa and Tomita, 1995). The Jic is intercalated in the Kawauchi Formation and 9cm thick.



Fig.7. Occurrence of the Tzw Tephra Bed at Jorakuji route (Kurokawa et al.,1999). It is intercalated in the Goken andesitic tephra zone (Gos) of the middle Nishiyama Formation, making a gorge.



Fig.8. Components of the Tzw Tephra at Jorakuji in the Chuo Oil Field in 3ϕ - 4ϕ fraction (as same the following microphotographs) (photo was taken under the upper nicol at 30° rotated from crossed position). It is mostly composed of platy and bubble-junction type glass shards.

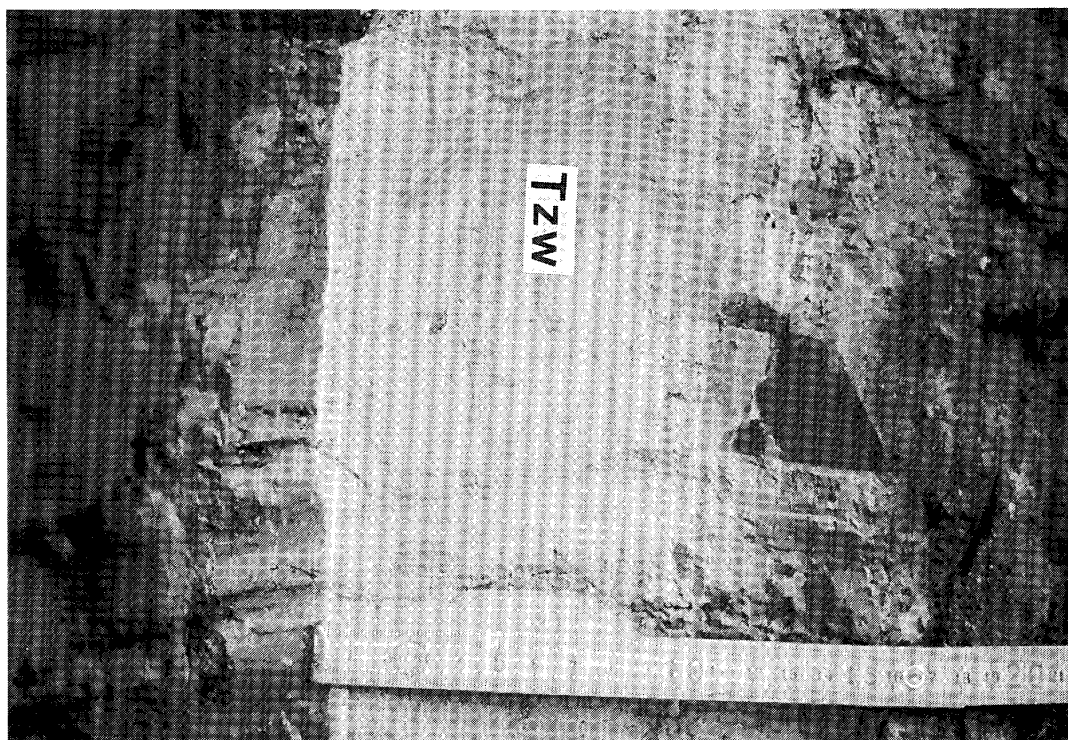


Fig.9. Field occurrence of the Tzw Tephra Bed at Tazawa, Nishiyama Town in the Chuo Oil Field (Kurokawa and Sawaguri, 1990). It is intercalated in the middle Nishiyama Formation and 13cm thick.

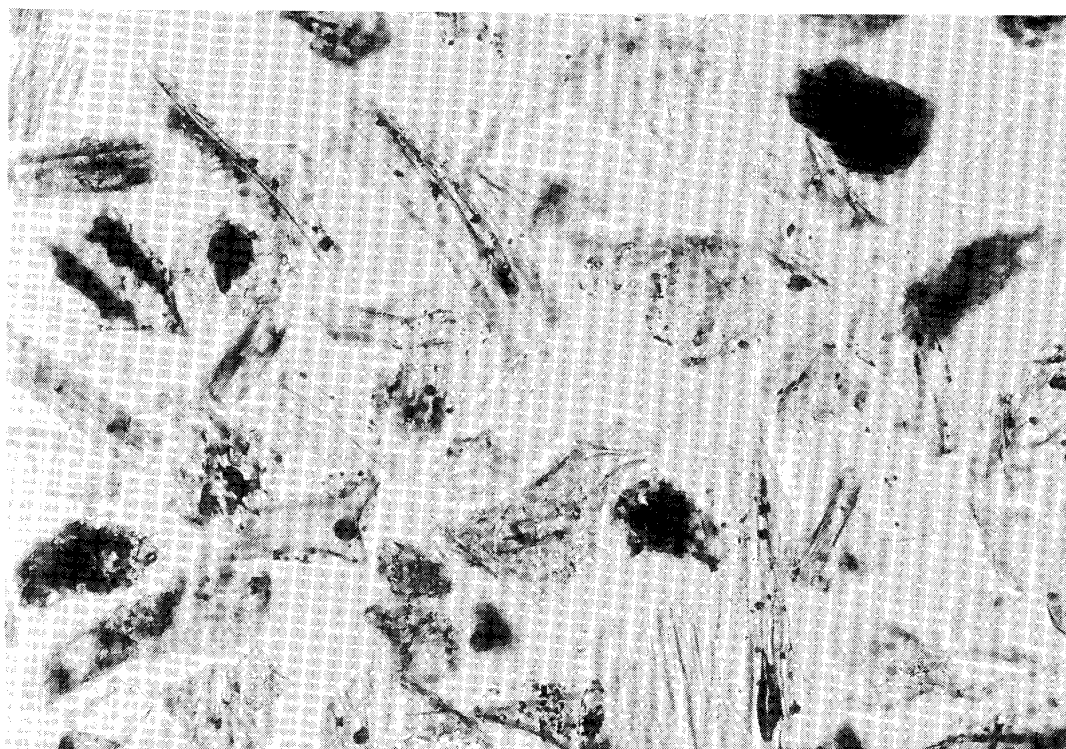


Fig.10. Components of the Tzw Tephra at Tazawa in the Chuo Oil Field. It is mostly composed of platy and bubble-junction type glass shards attached to micro opaque grains.

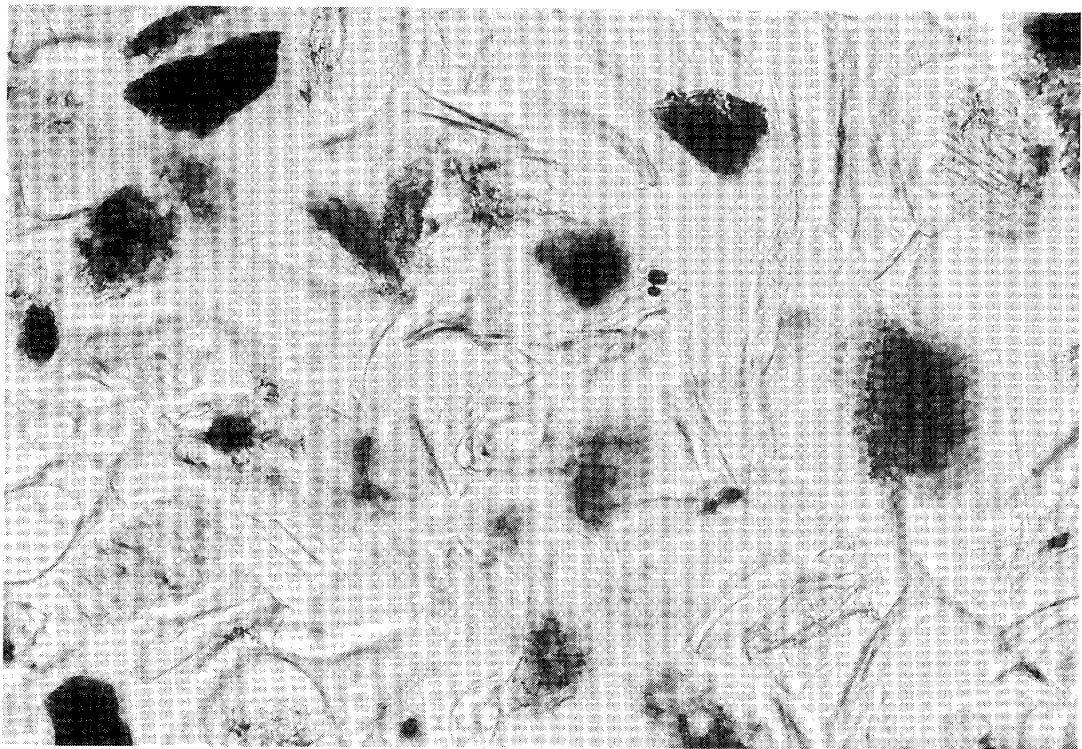


Fig.11. Components of the Smg Tephra at Shimoyamada in the Nishiyama Oil Field. It is mostly composed of platy and bubble-junction type glass shards.



Fig.12. Components of the Jic Tephra at Kamiyabase, Sawada Town in Sado Island. It is mostly composed of platy and bubble-junction type glass shards.

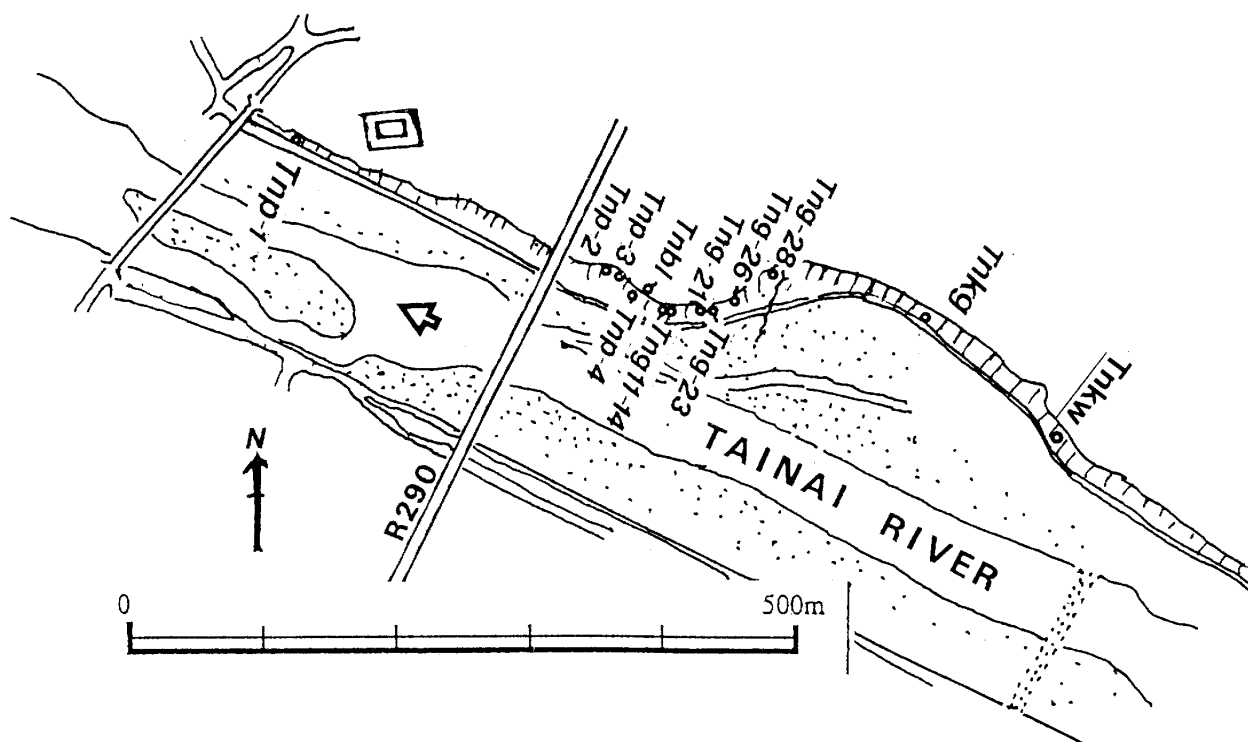


Fig.13. Location of the Tnkw Tephra Bed along the Tainai River, Natsui, Kurokawa Village in the Kitakanbara area (modified from Kurokawa et al., 1999a).

Village, Kitakanbara-Gun, Niigata Prefecture (Fig.13).

[horizon] At the type locality, the Tnkw Tephra Bed is intercalated in the marine sandy silt of the Kuwae Formation, 52m above the Tnkg Tephra Bed (8cm thick) (Fig.14) (Kurokawa et.al., 1999).

[field occurrence] At the Tainai River route, the Tnkw is white ash bed of 3-5cm thick (Fig.5). Its bedding is disturbed by bioturbation.

[petrography] It is mostly composed of platy and bubble-junction type glass shards with fibrously vesiculated shards (Fig.15). Brown glass shards are also accompanied. Micro opaque grains of 1-10 μ m of possibly biogenic origin are found on the shards. Hornblende and biotite are found as mafic minerals.

Jic Tephra Bed in Sado Island

[type locality] The type locality of the Jic

Tephra Bed was assigned at Kamiyabase, Sawada Town in Sado Island, Niigata Prefecture (Kurokawa and Tomita, 1995).

[horizon] At the type locality, it is intercalated in the marine silt of the middle Kawauchi Formation, 13m below the Jig Tephra Bed. The Jig Tephra Bed was revealed to be correlative to the Ktw Tephra Bed in the Nishiyama Formation (Kurokawa and Tomita, 1995) (Fig.2).

[field occurrence] At Kamiyabase, it is white ash bed of 9cm thick (Fig.5). Basal 0.5cm is also silt-sized and the above 2cm grades from fine sand to silt size, and upper 7cm is again grades from very fine sand to silt size. Weak lamination and bioturbation are recognized.

[petrography] It is mostly composed of platy and bubble-junction type glass shards with fibrously vesiculated shards (Fig.12). Brown glass shards are also accompanied. Mafic minerals are hornblende, orthopyroxene, biotite and clinopyroxene.



Fig.14. Location of the Tnkg and Tnkw Tephra Beds in the Kuwae Formation (dipping rightwards) at the cliff along the Tainai River. The Tnkg Tephra Bed is situated behind the signboard and the Tnkw Tephra Bed behind the building at the right end of the photograph.

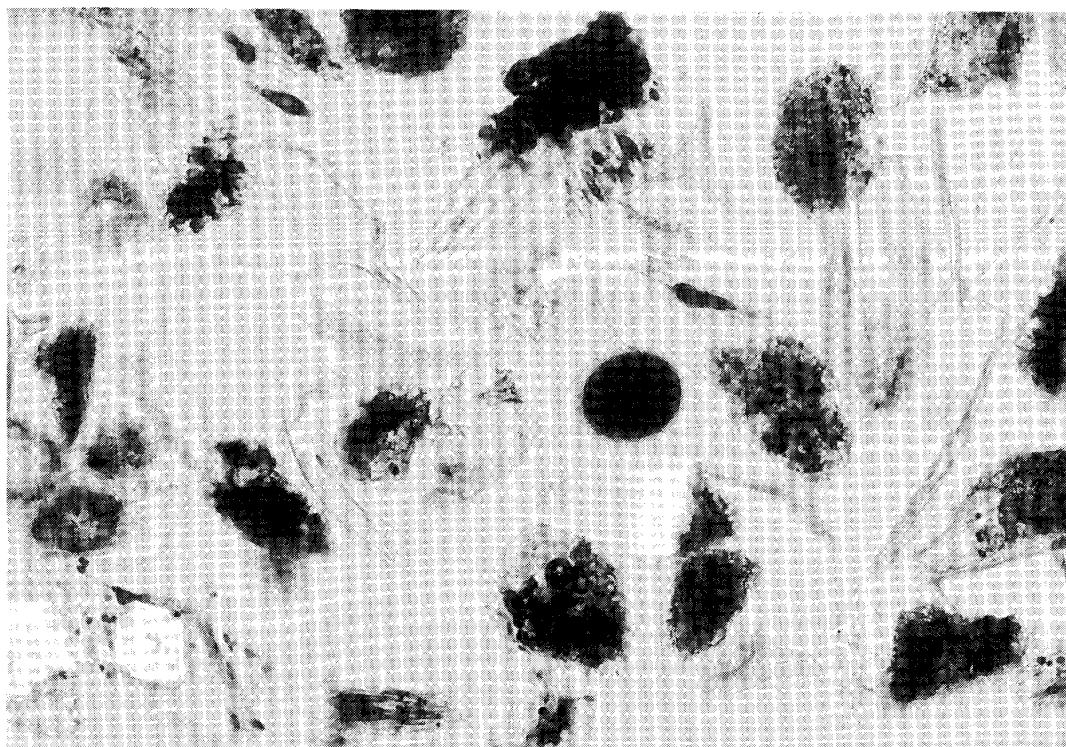


Fig.15. Components of the Tnkw Tephra at Natsui (Tainai River). It is mostly composed of platy and bubble-junction type glass shards, attached to micro opaque grains.

Correlation of the Tzw-Smg-Tnkw-Jic Tephra Beds

(1) Methods of correlation

The correlation of the Tzw, Smg, Tnkw and Jic Tephra Beds was examined by their horizons, field occurrences, petrography of components and chemical composition of glass shards. As so far, the Smg was correlated to the Jic, and the correlation between the Smg and Tzw Tephra Beds was also suggested by Kurokawa and Tomita (1995).

In correlative examination, components were examined on the fraction of 3ϕ - 4ϕ (1/8-1/16mm) fraction. EPMA analyses were made by JXA8600SX microanalyser of Niigata University at 15keV with beam diameter of 20 μ m, calibrated by oxide ZAF method.

(2) Correlation

[Stratigraphic horizon] In the Chuo Oil Field, the Tzw Tephra Bed is situated in the middle Nishiyama Formation about 10m above the Ftj Tephra Bed and about 15m below the Hap-2 Tephra Bed. In Sado Island, the Jic Tephra Bed is intercalated 13m below the Jig Tephra Bed, which is correlative to the Ktw Tephra Bed in the Nishiyama Oil Field (Kurokawa and Tomita, 1995) (Fig.2). The Ktw Tephra Bed (Kurokawa et al., 1992) is 9m below the Hap-2 Tephra Bed in the Nishiyama Oil Field (Kurokawa et al., 2002). Thus, the Tzw and Jig Tephra Beds occupy the similar horizon assumed of about 15-22m below the Hap-2 Tephra Bed. The Smg Tephra Bed was already correlated to the Jic Bed. The Tnkw Tephra Bed in the Tainai River route is situated at around the boundary of the fossil diatom zones of the *Neodenticula koizumii* - *N.kamtschatica* Zone and the *Neodenticula koizumii* Zone (Hiramatsu and Miwa, 1998). This implies similar horizon to the Tzw-Jic-Smg Tephra Beds.

[Field Occurrences] These Tephra Beds is fine-sand to silt sized, and besides the bioturbated

Tnkw Bed, the Tzw, Smg and Jic Beds have silt-sized thin basal layer of about 0.5mm in common. The occurrence of these tephras can be interpreted to be submarine fallout deposits.

[Petrography] They are mostly composed of platy and bubble-junction type glass shards with fibrously vesiculated shards in common. Brown glass shards are also accompanied in these tephras. Mafic minerals are also similar, that is hornblende, biotite, orthopyroxene and clinopyroxene.

[Chemical composition of glass shards]

Chemical composition of the glass shards of these Tephras are shown in Table1 and Fig.16. They all show similar composition. Especially, TiO_2 (0.24-0.30%) and MgO (0.24-0.27%) contents are characteristic among the tephras of the near horizon. Thus, the Tzw-Smg-Tnkw-Jic Tephras are safely correlative. The name of the Tzw Tephra Bed is proposed as the general name of these tephra beds.

Geological Implications

The geological horizon of the Tzw Tephra Bed (the Tzw-Smg-Tnkw-Jic Tephra Bed) implies very important marker horizon. In the Jorakuji route, the Tzw Tephra Bed is situated at the upper most part of the Gauss Chron in magnetostratigraphy (Kishi and Miyawaki, 1996). In the Himi Group, Toyama Prefecture, the UN Tephra Bed, which is correlative to the Ftj Tephra Bed in the Niigata region (Kurokawa and Tomita, 2000) (Fig.2), is situated just above the boundary of the fossil diatom zones of the *Neodenticula koizumii* - *N.kamtschatica* Zone and *Neodenticula koizumii* Zone (Cronin et al., 1994). Thus, the Tzw-Smg-Tnkw-Jic Tephra Bed possibly assigns the horizon between the two important marker horizons; above the boundary of the *Neodenticula koizumii* - *N.kamtschatica* Zone and *Neodenticula koizumii* Zone in the diatom biostratigraphy and near below the boundary of the Gauss and Matuyama Chrons in magnetostratigraphy. The Tzw Tephra Bed covers more than 100x60km² area

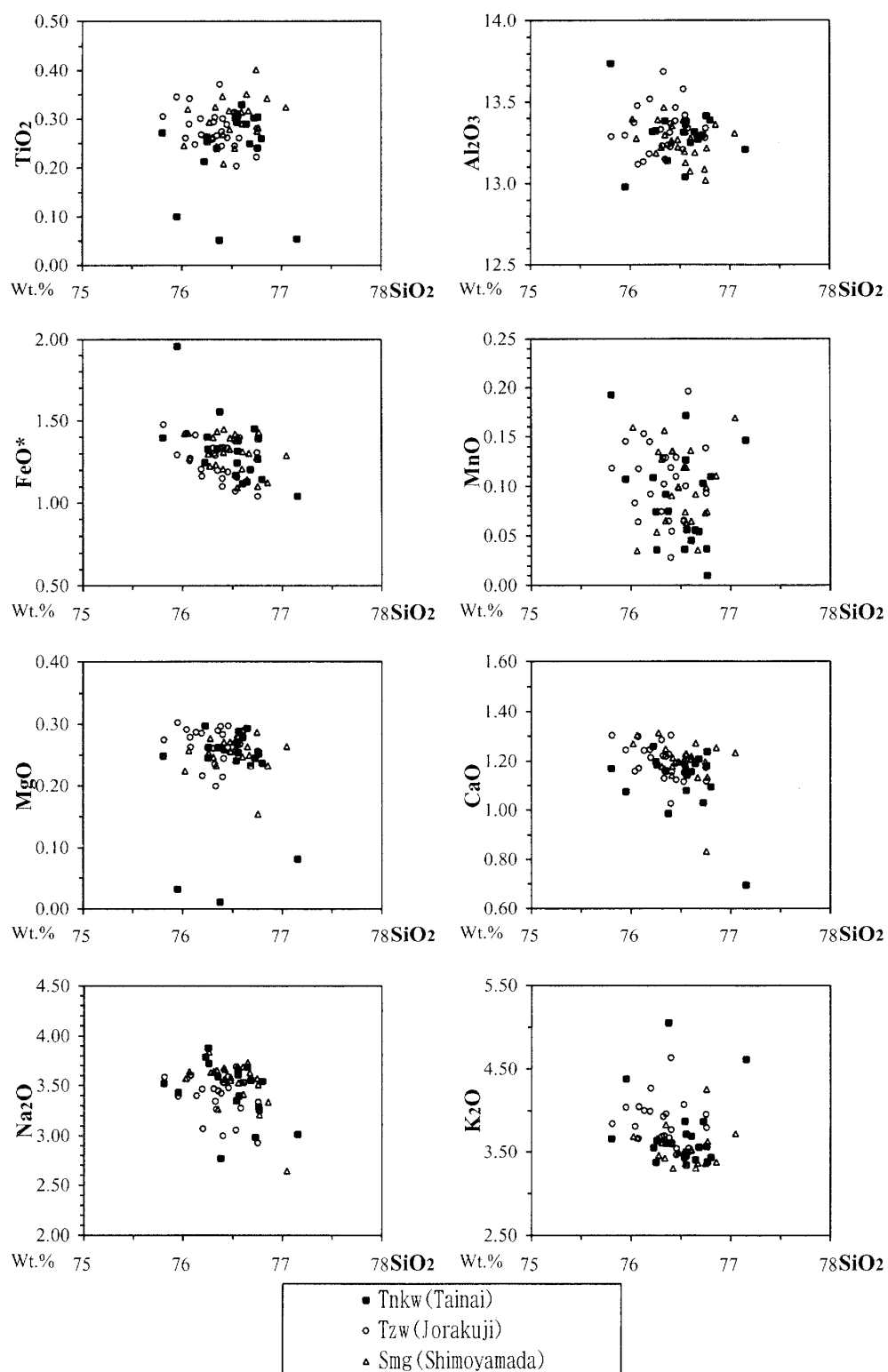


Fig.16. SiO_2 -oxides diagrams of the glass shards of the Tzw, Smg and Tnk Tephra (total oxides weights were converted to 100%).

Table 1. Chemical composition of the glass shards of the Tzw, Smg, Tnkw and Jic Tephra by EPMA analyses (total oxides weights were converted to 100%). The average (Ave.) and standard deviation (S.D.) and the ranges are also shown. (n) shows numbers of analysed grains and (r) shows analytical rounds.

Tephra bed	Sample Locality	SiO ₂		TiO ₂		Al ₂ O ₃		FeO*		MnO		MgO		CaO		Na ₂ O		K ₂ O		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.		
Tnkw	Tainai	76.33	0.84	0.26	0.11	13.37	0.33	1.35	0.24	0.09	0.05	0.24	0.11	1.16	0.20	3.49	0.33	3.72	0.46	20	1
Tzw	Jorakuji	76.33	0.24	0.28	0.04	13.33	0.14	1.27	0.12	0.10	0.04	0.26	0.03	1.19	0.07	3.40	0.21	3.83	0.28	24	1
Smg	Shimoyamada	76.51	0.24	0.30	0.04	13.03	0.11	1.31	0.11	0.10	0.04	0.25	0.03	1.20	0.09	3.53	0.24	3.55	0.20	25	1
Smg	Shimoyamada	76.98	0.27	0.26	0.04	13.24	0.10	1.33	0.12	0.06	0.04	0.27	0.02	1.34	0.06	3.47	0.21	3.05	0.15	25	2
Jic	Kamiyabase	76.94	0.23	0.24	0.04	13.22	0.13	1.35	0.13	0.04	0.04	0.26	0.02	1.32	0.05	3.53	0.17	3.09	0.14	25	2

Tephra	Locality	SiO ₂	TiO ₂	Al ₂ O ₃	FeO*	MnO	MgO	CaO	Na ₂ O	K ₂ O	r
Tnkw	Tainai	76.2–76.8	0.24–0.33	13.1–13.4	1.12–1.45	0.04–0.13	0.23–0.30	1.03–1.26	3.26–3.88	3.34–3.87	1
Tzw	Jorakuji	75.8–76.6	0.24–0.35	13.1–13.5	1.04–1.48	0.05–0.15	0.20–0.30	1.11–1.30	3.26–3.69	3.43–4.07	1
Smg	Shimoyamada	76.1–76.8	0.21–0.35	13.0–13.4	1.10–1.45	0.05–0.17	0.22–0.29	1.13–1.31	3.21–3.74	3.30–3.83	1
Smg	Shimoyamada	76.6–77.7	0.19–0.33	13.1–13.4	1.06–1.51	0.00–0.15	0.22–0.31	1.20–1.50	2.86–3.78	2.80–3.35	2
Jic	Kamiyabase	76.3–77.3	0.16–0.30	13.0–13.5	0.99–1.62	0.00–0.15	0.22–0.31	1.19–1.41	3.23–3.77	2.85–3.40	2

and the geological age is assumed to be around 2.6Ma.

References

- Cronin T.M., Kitamura, A., Ikeya, N., Watanabe, M. and Kamiya, T. (1994) Late Pliocene climate change 3.4–2.3Ma: a paleoceanographic record from the Yabuta Formation, Sea of Japan. *Paleogeography Paleoclim. Paleocol.*, Vol.108, 437–455.
- Higuchi, Y. and Kurokawa, K. (2003a) Correlation of the YT4 Tephra Bed in the Himi Group to the Thw-3 Tephra Bed in the Nishiyama Formation in Niigata, central Japan. *Rept. Grant-in-aid to Kurokawa* [Precise correlation of Miocene to early Pleistocene in Japanese Islands by means of widespread tephra beds], 295–299. **
- Higuchi, Y. and Kurokawa, K. (2003b) Stratigraphic relation between Nwg and Arg Tephra Beds of late Pliocene in the Niigata region, central Japan. *Rept. Grant-in-aid to Kurokawa* [Precise correlation of Miocene to early Pleistocene in Japanese Islands by means of wide spread tephra beds], 301–307. **
- Hiramatsu, C. and Miwa, M. (1998) Neogene microfossil biostratigraphy of the Kitakanbara area in Niigata Prefecture and the geomorphology of an unconformity at the base of the Kuwae Formation. *Jour. Japan. Assoc. Petrol. Tech.*, vol.63(4), 301–314. *
- Kishi, K. and Miyawaki, R. (1996) Plio-Pleistocene fold development in the Kashiwazaki Plain and vicinity, Niigata Prefecture. *Jour. Geography (Chigaku Zasshi)*, vol.105(1), 88–112. *
- Kurokawa, K., Ishiyama, N., Fujiwara, Y. and Watabe, Y. (1992) Geology of the Nishiyama Oil Field in the Niigata region, central Japan with special reference to the unconformity between Nishiyama and Haizume Formations viewed from tephra markers. *Mem. Fac. Educ., Niigata Univ. (Natural Sci.)*, vol.33(2), 101–163. *
- Kurokawa, K., Nagata, R. and Yoshida, T. (1999a) Volcanic ash layers in the Uchisugawa and Kuwae Formation in the northern Shibata City and along Tainai River, Niigata Prefecture, especially on the Znp-Ywg ash layer found from the Kuwae Formation. *Mem. Fac. Educ. and Human Sci., Niigata Univ. (Natural Sci.)*, vol.2(1), 1–32. *
- Kurokawa, K., Niwayama, K. and Terai, N.

- (1989) Pliocene sedimentation in the southern Nishiyama Oil Field, Niigata Prefecture, with special reference to tephra markers. *Mem. Fac. Educ., Niigata Univ. (Natural Sci.)*, vol.31(1), 15-42.*
- Kurokawa, K., Sakai, H. and Higuchi, Y. (2002) Pliocene and early Pleistocene widespread tephra beds in the Chuo and Nishiyama Oil Fields in Niigata region, central Japan. *Excursion Guidebook of the 109th Geol. Soc. Japan*, 119-129.*
- Kurokawa, K. and Sawaguri, T. (1990) Subaqueous tephra markers in the central part of the Chuo Oil Field, westward of Nagaoka City, central Japan and their correlative implications. *Mem. Fac. Educ., Niigata Univ. (Natural Sci.)*, vol.31(2), 53-87.*
- Kurokawa, K. and Tomita, Y. (1995) Volcanic Ash markers in the Nakayama and Kawachi Formations in northwestern Sado Island, central Japan. *Mem. Fac. Educ., Niigata Univ. (Natural Sci.)*, vol.37(1), 13-65.*
- Kurokawa, K. and Tomita, Y. (2000) The UN-MD2 Ash: a late Pliocene widespread tephra deposit in central Japan. *Earth Science (Chikyu Kagaku)*, vol.54(5), 337-341.
- Kurokawa, K., Tomita, Y., Aoki, T., Sawaguri, T. and Maruyama, E. (1999b) Volcanic ash layers in the Nishiyama Formation along the Jorakuji route, Niigata, central Japan with special reference to the correlation of the Jjj and Sig ash layers. *Mem. Fac. Educ. and Human Sci., Niigata Univ. (Natural Sci.)*, vol.1(2), 63-101.*

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