Spores and pollen from the Middle Permian Kanokura Formation in the Kamiyasse area, southern Kitakami Mountains, northeast Japan

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Abstract

The following four species of pollen and five species of spores are described from the lower Kanokura Formation (KN1 Member) in the Kamiyasse area, southern Kitakami Mountains, northeast Japan: pollen *Alisporites* sp., *Limitisporites* sp., *Cordaitina* cf. *vulgaris* and *Crinalites* cf. *sabinensis* and spores *Ahrensisporites* cf. *thorsteinssonii*, *Apiculatisporis* sp., *Cyclogranisporites* sp., *Gondispora* cf. *obstaculifera*, and *Leiotriletes ulutus*. This is the first record of the Permian microflora from Japan. The Kamiyasse microflora suggests a Middle Permian in age.

Key words: Kanokura Formation, Middle Permian, pollen, southern Kitakami Mountains, spores.

Introduction

Middle Permian spores and pollen are first described from the lower part of the Kanokura Formation in the Kamiyasse area, southern Kitakami Mountains, northeast Japan. The Permian plant fossils in Japan have been successively investigated by Asama (1956, 1967, 1974a, b, 1981, 1989) from the Setamai and Maiya areas in the southern Kitakami Mountains and the Takakurayama area in the Abukuma Mountains. However, there have been no report on the Permian microflora in Japan. Therefore the following is the first reliable data of the Permian microflora in not only the southern Kitakami Mountains but also Japan.

The Permian stratigraphy and fossils of the Kamiyasse area have been studied by many authors (see Tazawa, 1976, p. 175). The Permian shallow marine sediments in the Kamiyasse

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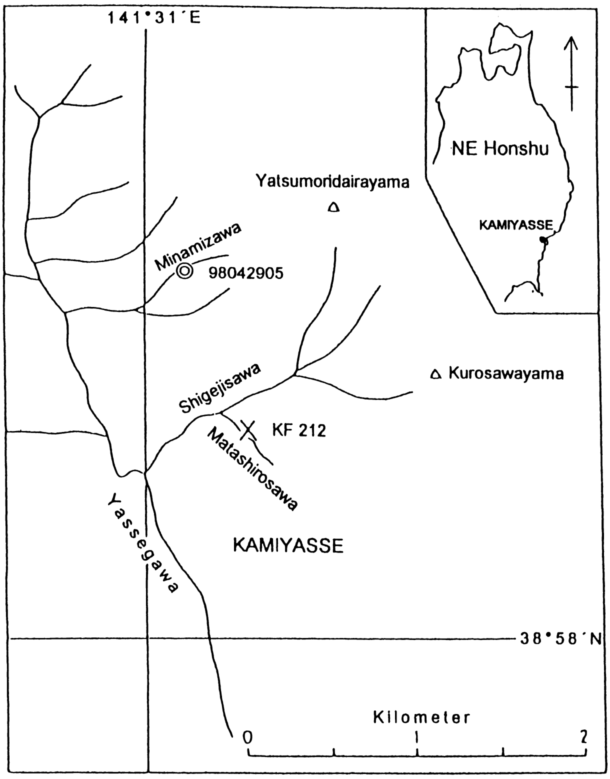

Fig1. Map showing the localities of palynological sample (98042905) and the brachiopod sample (KF212) in the Kamiyasse area, southern Kitakami Mountains.(Modified from Tazawa and Takaizumi, 1987).

area are stratigraphically classified into three formations, the Lower Permian Sakamotozawa Formation, the Middle Permian Kanokura Formation and the Upper Permian Toyoma Formation, and being totally about 2,400 m thick (Tazawa, 1973, 1978). According to Tazawa and Takaizumi (1987), the Kanokura Formation of this area is about 1,100 m in thickness, and is subdivided into the following four members in ascending order: (1) KN1 Member, shales with layers of sandstone and conglomerate, 500 m in thickness; (2) KN2 Member, sandstones and arenaceous or argillaceous, impure limestones, 150 m in thickness; (3) KN3 Member, massive limestones with layers of conglomerate, sandstone and shale, 130 m in thickness; and (4) KN4 Member, shales with layers of sandstone and limestone, 320 m in thickness.

The palynological samples in this study were collected from several points in the Kamiyasse area, and only one sample from the shale of the lower part of the KN1 Member of the Kanokura Formation at the point 98042905 in the Minamizawa Valley, Kamiyasse area contained spores and pollen (Figs. 1, 2). Fossils are rather poor through the KN1 Member, although a brachiopod *Poikilosakos kamiyassensis* was described by Tazawa and Takaizumi (1987) from shale of 130 m below the base of the KN2 Member at Loc. 212 in the Matashirosawa Valley, a tributary of the Shigejisawa Valley, Kamiyasse area (see Figs. 1, 2). The KN1 Member is correlated with the *Monodiexodina kofuganensis* Zone of Minato et al. (1978), namely, the lowermost fossil zone of the Middle Permian Kanokura Formation in the

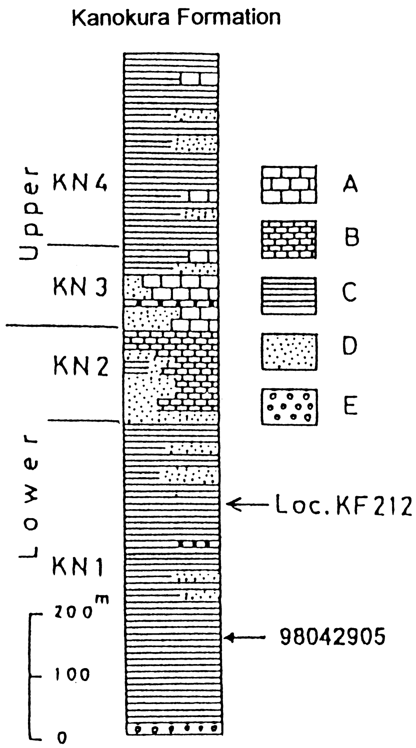

Fig.2. Columnar section of the Kanokura Formation in the Kamiyasse area, showing the horizons of the palynological sample (98042905) and brachiopod sample (KF212). A: massive limestone, B: bedded impure limestone, C: shale, D: sandstone, E: conglomerate. (Modified from Tazawa and Takaizumi, 1987).

southern Kitakami Mountains (Tazawa and Takaizumi, 1987).

The preservation of the spores and pollen from Kamiyasse is not so good as those from the Lower Carboniferous Hikoroichi Formation in the Hikoroichi area, southern Kitakami Mountains. The latter microflora was studied by Yang and Tazawa (in press). Processing of samples from the Kanokura Formation involved crushing the samples to pea size or even finer, and then demineralisation in dilute 35% HCL and 40% HF. Standard oxidation reagents did not react at all with the carbonized organic residues from the Kamiyasse samples and so a very strong oxidation agent — fuming HNO_3 plus KCL, "fuming Schulze's solution", was used. The times required for oxidation using "fuming Schulze's solution" varies from sample to sample as in Hikoroichi (Yang and Tazawa, in press) and western Yunnan (Yang, 1993). In general, suitable oxidation will be achieved after seconds of oxidation. However, oxidation times for the Kamiyasse samples varied from one to several minutes even when heating the oxidation tube in a beaker of boiling water. Using this technique, most of spores and some disaccate pollen became to turn light yellow and only some thin-walled palynomorphs changed to brown or yellow after oxidation for minutes within the fuming Shulze's solution. Most spores or pollen are broken. This may result from long transportation in sedimentary process or the preparation of slide-making due to heating or drying of the mounting medium. In spite of such poor preservation, there are still some palynomorphs which are optically identifiable. Permanent slides were made with the rapid mounting medium Entellan.

Table 1. A tentative correlation of spores and pollen from Kamiyasse, NE Japan with those of N. China and Canadian Arctic Archipelago.

New classification Jin et al.,1997		Traditional standard, S. Urals Chuvashov, 1993	North China Yang et al., 1986 (*Gao,1997*)	Southern Kitakami, Japan modified from Minato et al., 1979 (*Yang and Tazawa*, This Paper)		Canadian Arctic Nassichuk, 1995 (*Utting, 1994*)
Lopingian	Changhsingian	?	Shiqianfeng Fm.	Toyoman	U. Toyoma Fm.	?
	Wuchiapingian		Upper Shihhotse Fm.		L. Toyoma Fm.	
Guadalupian	Capitanian	Tatarian	*Patellisporites meishanensis* *Macrotorispora media* **Lower Shihhotse Fm** *Radiizonates solaris* *Potonieisporites bharadwajii*	Kanokuran	U. Kanokura Fm.	Degerbols Fm
	Wordian	Kazanian				Trold Fiord Fm *A.thorsteinssonii - S. nanuki*
	Roadian	Ufimian	Shanxi Fm *Sinulatisporites sinensis* *Gulisporites cochlearis*		L. Kanokura Fm. *Aisporites - Limitisporites* *Cordaitina cf. vulgaris*	Assistance Fm *A.plicatus - J.compactus*
Cisuralian	Kungurian	Kungurian				
				Sakamotozawan	U. Sakamotozawa Fm.	Great Bear Caps Fm. *L.. monstruous - V. costabilis*
	Artinskian	Artinskian	Taiyuan Fm		L. Sakamotozawa Fm.	Rannes Fm
	Sakmarian	Sakmarian				Belcher Channel Fm
	Asselian	Asselian				

The Kamiyasse microflora

The identifiable palynological assemblage from the lower Kanokura Formation in the Kamiyasse area includes some non-taeniate bisaccate pollen, monosaccate pollen, and one possible alete pollen, as well as several trilete spores. The following spores and pollen can be diagnosed: *Ahrensisporites* cf. *thorsteinssonii, Alisporites* sp., *Apiculatisporis* sp., *Cordaitina* cf. *vulgaris, Crinalites* cf. *sabinensis, Cyclogranisporites* sp., *Gordonispora* cf. *obstaculifera, Leiotriletes ulutus, L.* sp., and *Limitisporites* sp.

Among them, *Limitisporites, Alisporites* and *Cordaitina* are very common elements distributed in the Permian in the Euramerican Realm in terms of megaplant phytogeography. They are very common and relatively abundant in the Shanxi Formation (Kunguarian to Roadian) of Taiyuan, North China. The typical North China type *Gulisporites - Sinulatisporites* are not found so far in the Kamiyasse microflora, and it is probably due to the lower diversity and poor preservation. The Kamiyasse microflora is still in some degree comparable to the one from Taiyuan, North China. One more interesting thing is that some elements such as monosaccate pollen *Cordaitina* cf. *vulgaris* and one possible alete pollen *Crinalites* cf. *sabinensis* as well as trilete spores *Ahrensisporites* cf. *thorsteinssonii* resemble very closely to those originally described from the Middle Permian Assistance and Trold Fiord Formations in the Sverdrup Basin, Canadian Arctic Archipelago. Therefore, the Kamiyasse microflora is tentatively correlated with the palynological assemblages from the

Shanxi Formation of North China as well as from the Assistance Formation of Canadian Arctic Archipelago (Table 1). The palynological dating seems to be consistent with the previous opinion of Tazawa and Takaizumi (1987), who considered that the KN1 is correlated with the *Monodiexodina kofuganensis* Zone of Minato et al. (1978), i.e., lower Middle Permian (Kungurian).

All the specimens of spores and pollen are registered with number NU-P9—NU-P11 and housed in the Department of Geology, Faculty of Science, Niigata University.

Systematic palynology

The suprageneric classification used in this paper is mainly followed from that of various authors, especially Potonié and Kremp (1954), Dybová and Jachowicz (1957), Dettmann (1963), and Neves and Owens (1966).

Anteturma Sporites H. Potonié, 1893
Turma Triletes Reinsch emend. Dettmann, 1963
Suprasubturma Acavatitriletes Dettmann, 1963
Subturma Azonotriletes Luber emend. Dettmann, 1963
Infraturma Laevigati (Bennie and Kidston) R. Potonié, 1956
Genus *Leiotriletes* (Naumova) Potonié and Kremp, 1954

Leiotriletes ulutus Utting, 1994
Pl. 1, fig. 4.

1994 *Leiotriletes ulutus*, Utting, p. 33, pl. 1, figs 4-8.

Material.— Two specimens logged from NU-P10.

Description.— Acamerate trilete miospores. Amb subtriangular with concave inter-radial margins, angular junction with flatly to convex radial extremities, forming prominent ‘shoulders’. Laesurae distinct, straight, length approximately three quarters of radius. Exine laevigate to punctate, approximately 0.5 μm thick. Contact area slightly darker than the rest of proximal surface.

Diameter.— 25- 28 μm.

Remarks.— Although the Kamiyasse specimens are slightly small in size, they can still be circled into *L. ulutus* by the amb shape and slightly darker contact area.

Infraturma Apiculati (Bennie and Kidston) Potonié, 1956
Subinfraturma Granulati Dybová and Jachowiez, 1957
Genus *Cyclogranisporites* Potonié and Kremp, 1954

Cyclogranisporites sp.
Pl. 1, fig. 2.

Material.— One specimen logged from NU-P9.

Description.— Miospore radial, trilete. Amb circular to subcircular. Laesurae distinct, extending approximately 2/3 of radius, often open, three apical pila mark often seen in the joint of the tetrad mark. Ornament punctate or fine grana. Exine 0.5-1 μm thick and often infrareticulate. Curvaturae imperfect partly seen on the specimen.

Diameter.— 70 μm.

Remarks.— The present specimen from Kamiyasse is put into the genus *Cyclogranisporites* because of its circular exine with a granulose ornamentation. Due to the insufficient material, any specific species or new species can not be set yet.

Subturma Zonotriletes Waltz, 1935 (see Luber and Waltz, 1941)
Infraturma Auriculati (Schopf) Dettmann, 1963
Genus *Ahrensisporites* Potonié and Kremp, 1954

Ahrensisporites cf. *thorsteinssonii* Utting, 1994
Pl. 1, fig. 3 .

Compare.—
1994 *Ahrensisporites thorsteinssonii* Utting, p. 40, pl. 3, figs. 8-11.

Material.— One specimen logged from NU-P9.

Description.— Trilete acamerate miospore. Amb subtriangular, slides slightly convex to straight. Laesurae open and extend almost to apices, bordered by thin associated folds. Proximal surface laevigate. Exine approximately 1 μm thick. In the interradial areas, a more or less arcuate fold or band, here preferring to use torus for these separate interradial bands, 1.5 μm thick and 1 to 2 μm wide. Outer side of torus wavy with relief up to 1.5 μm; inner sides of torus with small vacuoles. There is an ornament of low scattered coni approximately 0.5 μm high, and 0.5 to 1 μm wide on the exine within torus.

Diameter.— 57.5 μm

Remarks.— The specimen from Kamiyasse conforms very closely to the specimens of *A. thorsteinssonii* Utting described by Utting (1994) with its similar interradial band and small vacuoles as well as low scattered coni.

Infraturma Cingulati (Potonie and Klaus) Dettmann, 1963
Genus *Gordonispora* Van der Eem, 1983

Gordonispora cf. *obstaculifera* Utting, 1994
Pl. 1, fig. 5.

Compare.—
1994 *Gordonispora obstaculifera* Utting, p. 43, pl. 3, figs. 23-25.

Material.— One specimen logged from NU-P11.

Description.— Trilete miospores. Amb subcircular, laesurae sinuous to straight, bordered by labra. Exine thickened differentially at equatorial margin to form a cingulum approximately 2 μm broad and 1.5 μm thick. Proximal surface laevigate. A concentric band occurs approximately mid-way between pole and margin on distal surface, 1 to 2 μm broad.

Diameter.— 27.5 μm.

Remarks.— This specimen recorded from Kamiyasse conforms very closely to the specimens of *G. obstaculifera* by its unique concentric and wavy band located in mid-way between pole and margin.

Anteturma Pollenites Potonié, 1931
Turma Saccites Erdtman, 1947
Subturma Monosaccites (Chitaley) Potonié and Kremp, 1954
Genus *Cordaitina* Samoilovich, 1953

Cordaitina cf. *vulgaris* (Zauer) Varyukhina, comb. Utting 1994
Pl. 1, fig. 6.

Compare.—
1965 *Pseudocordaites vulgaris* Zauer, pl. 29, figs. 4a-c.
1971 *Pseudocordaites vulgaris* Varyukhina, p. 98, 99, pl. 10, figs. 5a, b.

Material.— Two specimens logged from NU-P9.

Description.— Monosaccate pollen. Amb subcircular to circular. Trilete barely visible. Laesurae short and of unequal length (3-10 μm). Inner body not well defined, smooth, often with secondary arcuate folds, exine 1 μm thick. Saccus with vermiculate pattern on proximal and distal surfaces, forming irregular shaped thickening of elements with the diameter of 4 μm. Saccus 1 μm thick. Width of overlap onto body 2 to 4 μm, radial brochi usually near equator (0.3 μm wide).

Diameter.— 65-68 μm.

Remarks.— These specimens from Kamiyasse are attributed to *C. vulgaris* by their monosaccate with vermiculate pattern saccus and radial brochi near equator.

Subturma Disaccites Cookson, 1947
Infraturma Disacciatrileti Leschik emend. Potonié, 1958
Genus *Alisporites* Daugherty emend. Nilsson, 1958

Alisporites sp.
Pl.1, fig. 8, 9.

Material.— Three specimens logged from NU-P9.

Description.— Disaccate haploxylonoid pollen. Amb of pollen laterally oval although most of specimens are broken. Sacci vary from greater than semicircular, to semicircular, to crescentic, exoexine thin, coarsely intrareticulate, brochi less than 1μm diameter, slightly radial elongation occurs toward proximal sacci base. Corpus oval to circular in shape, intexine approximately 1μm thick, finely granulate. Coppula occasionally oval, laevigate to intrapunctate. Cappa thin, laevigate to not clear.

Diameter.— 52.5-55μm.

Remarks.— Despite the poor preservation, these specimens can still be undoubtedly referred to the genus *Alisporites* by a distinct corpus bordered by bases of sacci always with significant intermarginal overlapping area, proximally to subequatorially attached, intrareticulate.

Genus *Limitisporites* Leschik, 1956

Limitisporites sp.
Pl. 1, fig. 1.

Material.— One specimen logged from NU-P10.

Description.— Disaccate pollen, diploxylonoid. Amb of pollen laterally oval. Sacci slightly greater than semicircular, an attachment zone of sacci as crescentic often observed, exoexine 0.5 μm, coarsely intrareticulate. Corpus circular to oval, the detailed cappa and cappula not clear due to the preservation, curved folds running transversely near the poles of the longitudinal axis.

Diameter.— 85 μm.

Remarks.— The specimen from Kamiyasse is put into the genus *Limitisporites* by the presence of trilete mark reduced to a single longitudinal slit and attachment zones of sacci as crescentic, curved folds running transversely near the poles of the longitudinal axis.

Turma Aletes Ibrahim, 1933
Genus *Crinalites* Utting, 1994

Crinalites cf. *sabinensis* Utting 1994
Pl. 1, fig. 7.

Compare.—
1994 *Crinalites sabinensis* Utting, p. 64, pl. 9, figs. 19-23.

Material.— One specimen logged from NU-P10.

Description.— Shape subcircular to oval, laevigate to intrareticulate. Exine single layered, smooth, 1.5 to 2 μm thick. A possible narrow, smoothly curved suture passes from one side to the other side of the grain.

Diameter.— 99 μm.

Remarks.— The specimen from Kamiyasse is tentatively attributed to the genus *Crinalites*, because of the possible existence of narrow curved suture which passes from one side to the other side of the grain, but different from in size, bigger than the previous one, and exine more or less intrareticulate. So far there is no enough specimen in this study for erecting new species under the genus *Crinalites*. Therefore, the present specimen is temporary compared to *C. sabinensis* remaining the size difference with *C. sabinensis* and open to be argued later.

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Explanation of Plate 1

Middle Permian spores and pollen from the lower part of the Kanokura Formation in the Kamiyasse area, southern Kitakami Mountains, NE Japan. The spores and pollen are illustrated at the magnification of ×850 unless otherwise stated.

Fig. 1. *Limitisporites* sp., NU-P10, proximal view, high focus.
Fig. 2. *Cyclogranisporites* sp., NU-P9, proximal view, high focus.
Fig. 3. *Ahrensisporites* cf. *thorsteinssoni* Utting, NU-P9, proximal view, high focus.
Fig. 4. *Leiotriletes* cf. *ulutus* Utting, ×100, NU-P10, proximal view, median focus.
Fig. 5. *Gordonispora* cf. *obstaculifera* Utting, ×100, NU-P11, proximal view, median focus.
Fig. 6. *Cordaitina* cf. *vulgaris* (Zauer) Varyukhina, comb. Utting, ×900, Nu-P9, distal view, high focus.
Fig. 7. *Crinalites* cf. *sabinensis* Utting, ×900, NU-P10, distal view, median focus.
Figs.8-9. *Alisporites* sp., NU-P9, 8, ×850, distal view, median focus, 9, ×850, proximal view, high focus.

Plate 1