MEMOIRS OF THE FACULTY OF SCIENCE KYOTO UNIVERSITY, SERIES OF GEOL. & MINERAL
Vol. XXXV, No. 1, pp. 109–118, pl. 1

Pollenanalytical Study of the Kawakami Lake Deposits in Nagano Prefecture, Japan*

By

Takayoshi NASU

(Received May 22, 1968)

Abstract

In this paper, the writer treated pollen fossils and plant remains collected from sediments of pleistocene dammed-up lake formed at the foot of the Yatsugatake volcanoes. The mother formations of these fossils seems to be forests of the uppermost of montane zone or the lowermost of sub-alpine zone. But considering the tendency to increase or decrease of each taxon, it seems that the pollen diagram indicates the effect of reconstruction of the mother formation after the destruction by volcanic activities. This conclusion leads to the proposition that one must pay attention to the influence of "plant succession" when interpret a pollen diagram obtained from rapidly deposited sediments.

Introduction and Acknowledgements

At the southeastern foot of the Yatsugatake volcanoes in Nagano Prefecture, Central Japan, it has been recognized mainly four terraces along the upper course of the river Chikuma-gawa, from higher to lower, the Nobeyamahara, Akiyamahara, Bappadaira and Ogawaguchi terraces. The highest terrace, which is called the Nobeyamahara terrace, is equivalent to the fill surface of the upper Middle to lower Late Pleistocene Nobeyamahara formation which intercalates the Kawakami lake deposits in the middle part. That lake deposits is considered to be the products in the "dammed-up lake" which was formed rapidly by a pyroclastic flow, and then, it seems that its deposition was carried out in a pause of volcanic activity. In this paper, the writer treated pollen fossils in the lake deposits that has specific characters above mentioned and tried to estimate the vegetation and its changes in consideration of influence of volcanic activity in the pollen diagram.

The writer wishes to thank Prof. Tadao KAMEI for his unfailing guidance in the course of this work, and to Mr. Ikuo ONISHI of Shimane University and Mr. Junichi SAKAI of Shinshu University for their help in pollen analysis. The writer also wishes

* This study was presented partially at the 72 nd annual meeting of the geological society of Japan (*Jour. Geol. Soc. Japan*, Vol. 73, No. 2, pp. 116–117, 1967).

to acknowledge his indeptedness to Prof. Keiji SUZUKI of Fukushima University for his guidance in identification of plant remains, and to Dr. Shimpei KAWACHI of Hokkaido University for his many helpful suggestions in geology.

Geological Outline

The Yatsugatake volcanoes is one of high mountains which is situated in the so-called "Fossa magna" zone of Central Japan, and is consisted of some volcanoes whose altitudes are more than 2000 m and the highest one attains 2900 m above the sea. That volcanoes is divided topographically into two parts, namely, the northern and southern parts.

According to KAWACHI (1961), the activities of the Yatsugatake volcanoes can be classified into two stages, i.e. the Older and Younger stages, by intervention of a large-scale erosional stage. During the Older stage, a pyroclastic flow, which is included in the lower part of the Nobeyamahara formation, dammed up the upper course of the river Chikuma-gawa and temporally formed "Kawakami Lake". This lake was rapidly filled up by inflows supplied from surrounding mountains. Therefore, the lake deposits (30 m in thickness) is rich in rather coarse materials as sand, silt, scoria, volcanic ash and plant fragments. This lake deposits is conformably covered by thick gravel beds and volcanic ejecta, and they are collectively named the Nobeyamahara formation, whose fill top equivalent to the highest river terrace (the Nobeyamahara terrace; relative height is about 120 to 130 m from the present river floor). Namely, the Kawakami lake deposits is included in the middle part of the Nobeyamahara formation.

Although the precise age of the Kawakami lake deposits is not yet clear, it is considered that the horizon of the Kawakami lake deposits is stratigraphically lower than the Wakamiko-Shinmachi plant bed. As this plant bed is overlying on the Nirasaki mud flow and unconformably overlain by the Older loam, it is considred to correspond to the Shimosueyoshi stage of early Late Pleistocene in age (KOBAYASHI and SHIMIZU, 1965). Therefore, the age of the Kawakami lake deposits seems to belong to the Shimosueyoshi or pre-Shimosueyoshi stage.

Sampling Locality

Samples for pollen analyses were obtained from cliffs along by a way leading from Goshodaira to Nobeyamahara through a railway crossing which locates about 1 km southeast of Shinano-Kawakami Station of the railway of Kômi line (Fig. 1). Horizons of 38 samples were numbered in ascending order as No. 1, No. 2, and so on. Among them, samples from No. 1 to No. 7 were obtained from a river side cliff of an altitude of about 1140 m, and others were obtained from a large-scale

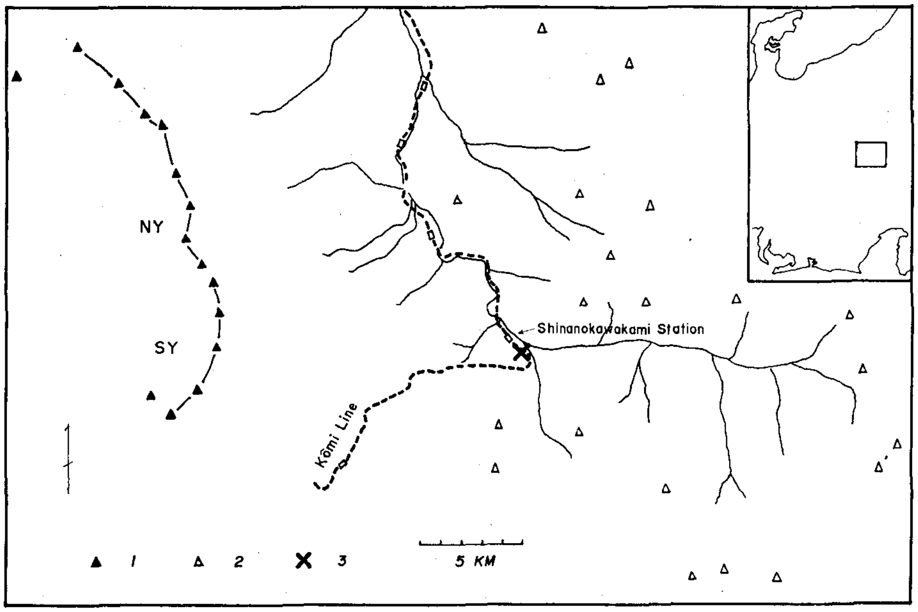

Fig. 1. Map showing the sampling locality
1: Mountains which belong to the Yatsugatake volcanoes
2: Other mountains 3: Sampling locality
NY: The northern part of the Yatsugatake volcanoes
SY : The southern part of the Yatsugatake volcanoes

cliff which locates close by the railway crossing. At this locality, sediments descended slowly toward the northwest. As gravels and sands of about 17 m in thickness were intercalated between No. 7 and No. 8 horizones, therefore, samples could not be obtained there.

Analytical Method

As for sandy and muddy sediments, the pollen analyses were carried on by the method of Shimakura (1956, 1963). But his method was amended partially because the writer intended to treat a large number of samples quickly, so the writer's method will be enumerated in the next.

(1) Sampling

Sample of about 2000 grams, which is absolutely pure and free from contamination, is collected for analysis in each horizon.

(2) Crushing and KOH treatment

After scraping off the surface parts, sample of about 100–200 grams is crushed into pieces. This is treated with 10 per cent KOH for a day or two in 100 cc beaker.

(3) Washing

Transfuse it into 2000 cc beaker, and add water. After a day or a half, take the supernatant fluid off. It is desired to wash several times repeatedly by same process. If the sample is rich in plant fragments, it is passed through a sieve (mesh No. 80 of TYLER standard scale) in this process.

(4) Treatment with mixed acid

After adding the mixed acid (HCl, HNO_3, and water are mixed in equal quantities) of equivalent volume to the sample, heat for three to four minutes in a boiling water-bath.

(5) Wash with water after letting alone for 3 to 6 houres. This process is repeated 4 or 5 times.

(6) Treatment with 10 per cent KOH (equivalent volume to the sample), heat for 4 to 5 minutes in a boiling water-bath.

(7) Wash with water after letting alone for a day or half. This process is repeated several times.

(8) Transfuse it into a watch-glass. After leaving as it is for a half or one hour, gather the pollen-rich materials, and soak up with a squirt. Take the muddy or sandy materials off by repeating (2 or 3 times) the same process. Centrifuge.

(9) Treatment with HF

Mix the 10 per cent HF of ca. 10 cc with the pollen-rich materials in 100 cc poly-ethylene beaker, and let alone for a day or two.

(10) Pour water into it, and also let alone for several days.

(11) Washing by centrifuge (3 or 4 times)

(12) Dehydrate with glacial acetic acid; centrifuge.

(13) Acetorisis treatment

Mix with ca. 1 cc of the Acetorisis liquid (fresh mixture of ca. 9 parts anhydric acid and one part conc. H_2SO_4), and heat up for 30 seconds in a boling water-bath; centrifuge.

(14) Washing with glacial acetic acid. Centrifuge.

(15) Wash with water, 3 or 4 times by centrifuge.

(16) Mounting with glycerol-jelly.

(17) Identification

More than 250 pollen grains of trees and shrubs are identified and counted under a microscope of 400 magnifications, and in particular cases of 1000 magnification. Pollen grains of herbs and fern spores are identified, but they are excluded from the above calculation.

(18) Calculation

The frequency of each pollen taxon is calculated on the basis of total summation of pollen grains of trees and shrubs, and that of herbs is based on the total summation of pollen grains of trees, shrubs and herbs.

Results and Discussions

The results of pollen analyses were shown in Fig. 2 and Table 1. And plant remains collected from four Horizons that is A, B, C and D in ascending order (shown in Fig. 2), were shown in Table 2.

1) The mother formation and the climatic condition

In the pollen diagram, such genera as *Picea, Tsuga**, *Abies* and *Ulmus-Zelkova* show very high rates all over the diagram; and also *Alnus, Betula* and *Pterocarya* show comparatively high rates. On the other hand, such genera as *Fagus, Quercus* and *Cryptomeria* show extremely low rates.

Considering the present forests of Central Japan, the boundaries between *Fagus crenata* forests of the cool-temperate montane zone and *Tsuga diversifolia* forests of cool sub-alpine zone have altitudes of about 1500 to 1600 m (YAMAZAKI, 1959). And *Fagus crenata* , which intermingle with such species as *Quercus crispula* and *Abies homolepis* etc., occupies the altitudinal range from 400 to 1700 m (WATANABE, 1938). At the southeastern piedmont district of the Yatsugatake volcanoes of today, however, there can be found none of develpoed forests of *Fagus crenata*. Nevertheless, as for the temperature alone at this district (annual mean temperature is about 8°C), it is suitable for growth of *Fagus crenata*. From other viewpoint, amount of annual precipitation is suggestive. In this district, annual precipitation is about 1200 mm (normal of annual total precipitation from 1921 to 1950). Considering the facts that *Fagus crenata* forests in present Japanese Islands are extremely developed under moderately humid condition in the cool-temperate zone, i. e. annual precipitation is more than 2000 mm, it seems that *Fagus crenata* at the southeastern piedmont district of the Yatsugatake volcanoes can not growth owing to less precipitation.

Therefore, the low rate of *Fagus* in the pollen diagram may suggest the small quantities of precipitation in those days. At the same time, to take into consideration that *Quercus* pollen also show a low rate and *Tsuga* and *Picea* pollen dominate, it can be safe to estimate that the mother formations of surrounding mountains were those of the sub-alpine coniferous forest zone under cool and/or dry climatic conditions. Furthermore, it can be known that these mother formations would be dominated by trees of *Picea* and *Tsuga*, especially *Picea maximowiczii* and *Tsuga diversifolia* because of aboundant occurrence of their fossil cones and leaves.

2) Changes of pollen composition

In the pollen diagram, each spectrum of *Larix, Ulmus-Zelkova* and *Pterocarya* gradually increases upward. On the other hand, that of *Pinus***, *Abies* and *Betula*

* Pollen grains of *Tsuga* are dominated by those of *Tsuga diversifolia* type.

** Pollen grains of *Pinus* are composed of those of subfamilly Diploxylon type and subfamilly Haploxylon type.

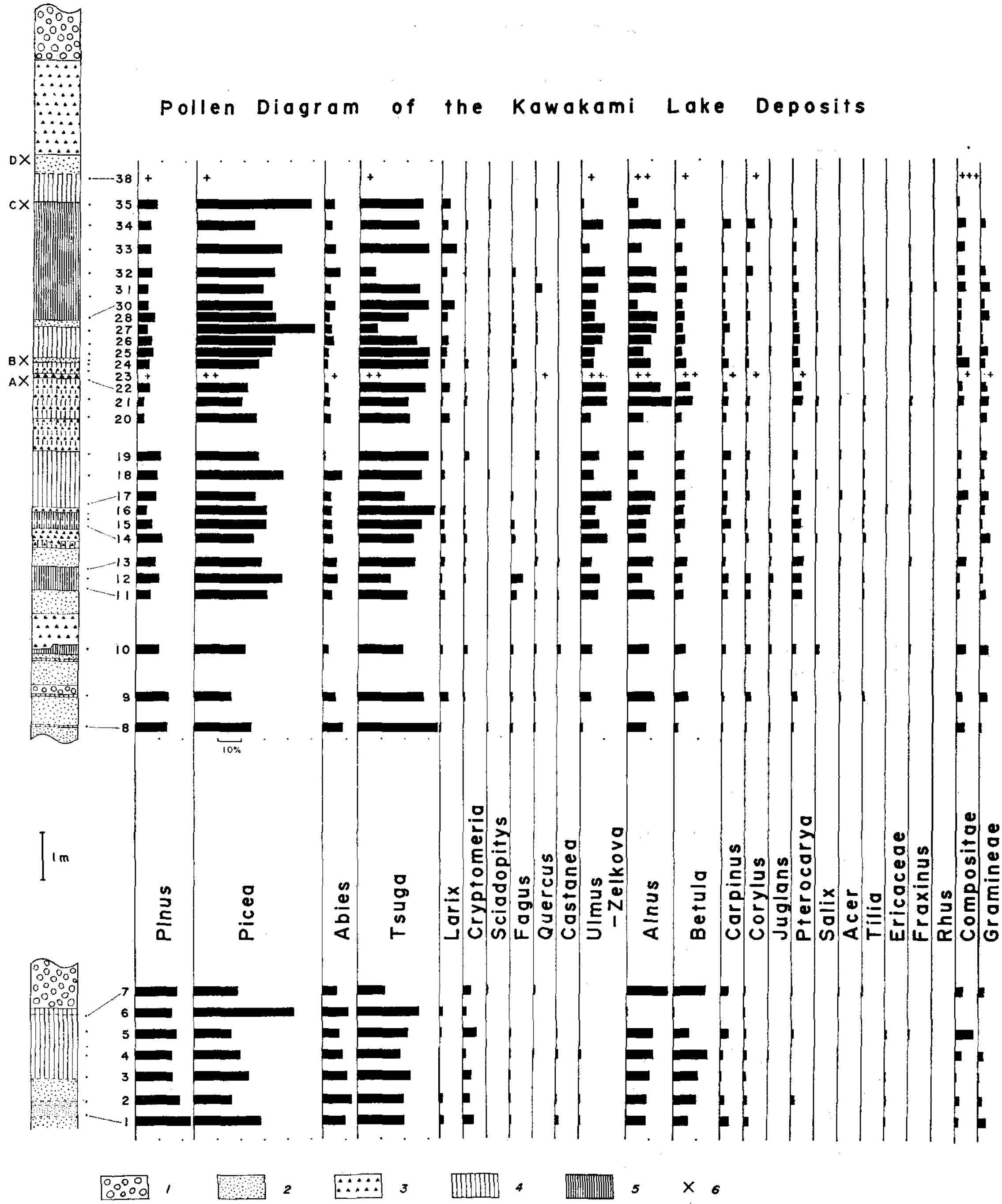

Fig. 2. The pollen diagram of the Kawakami lake deposits
1: Gravel 2: Sand 3: Scoria and volcanic sand 4: Silt 5: Clayey and carbonaceous sediment
6: Horizons collected plant remains

Table 1. Pollen taxa which are not shown in the pollen diagram owing to rare occurrences.

Sample No.	Taxa
35	*Cornus* ?
34	Liliaceae
33	Liliaceae
32	*Polygonum*
31	*Lychnis*, *Persicarya*
28	Oleaceae, Liliaceae
26	*Stellaria*
24	Liliaceae
22	Legminosae, Liliaceae
20	Liliaceae
19	*Patrinia*, Legminosae
18	Liliaceae
16	Liliaceae
14	*Chenopodium*, *Carex*
13	*Polygonum*, Liliaceae
11	*Stellaria*, *Polygonum*, Liliaceae
10	Rosaceae
8	*Lonicera*
2	*Stellaria*

Table 2. List of plant remains obtained from the Kawakami lake deposits. Horizons are shown in Fig. 2. C: Cone L: Leaf Sh: Shoot.

Horizons	Remains	Part of Remains
D	*Tsuga diversifolia* (MAXIM.) MASTERS	C, L, Sh
	Picea maximowiczii REGEL	C, L, Sh
	Picea sp.	C
	Abies sp.	L
	Chamaecyparis obtusa (S. et Z.) ENDL.	Sh
	Musci	
C	*Picea* sp.	L
	Tsuga sp.	L
	Abies sp.	L
	Chamaecyparis obtusa (S. et. Z.) ENDL.	Sh
	Larix leptolepis (S. et Z.) GORDON	Sh
	Musci	
B	*Picea* sp.	L
	Abies sp.	L
	Tsuga sp.	L
A	*Tsuga* sp.	L
	Abies sp.	L
	Picea sp.	L
	Chamaecyparis obtusa (S. et Z.) ENDL.	Sh
	Musci	

oppsitely decreases. And though it show a low rate, *Cryptomeria* also has a decreasing tendency. The contrast between increase of *Picea* and decrease of *Pinus* and *Betula* suggest the plant succession, that the formation of a forest varied from sun trees to shade trees.

The Kawakami lake deposits treated in this paper would be a sedimentary mass deposited rapidly and its depositional time range would be not so long, because the deposits itself is the products of "dammed-up lake" which were formed by a pyroclastic flow and consequently its deposits mainly consist of both inflows derived from volcanic body and plant fragments at that same time. Therefore filling up of Kawakami Lake was carried out in a short time during a pause of volcanic activities in the Older stage*. Accordingly, it is probable to infer that the changes of each pollen ratio would be the result influenced by "plant succession" of reconstruction of coniferous forest after destruction by volcanic activity. In the pollen diagram, however, the detailed process of plant succession is obliterated by abundant supply of pollen grains from neighbouring forests which were not so much influenced by volcanic activities.

Further considering the increasing tendencies of *Larix, Ulmus-Zelkova* and *Pterocarya*; the state of forest reconstruction would have some variation in response to different localities. Namely, coniferous forest was restored at a certain place, and *Larix* forest was reconstructed at other places. And in the valley where was humid, deciduous mixed forest was gradually formed by *Ulmus-Zelkova, Alnus* and *Pterocarya*. These differences would be caused by edaphic condition, regional differences of forest destruction and others.

Conclusions

Regarding from pollen fossils and plant remains which were obtained from the Kawakami lake deposits, it is concluded as follows:

1) The mother formations of these fossils would be coniferous forests of the cool sub-alpine zone and that was mainly composed of *Tsuga diversifolia* and *Picea maximowiczii*. And the climatic conditions during the age of Kawakami Lake were cooler than present, and precipitations in those days were as small quantities as those of present inland area.

2) Forests, which were destructed by volcanic activities, were reconstructed as far as habitat factors permit in each locality. Namely, coniferous forests of *Picea* and

* In private communications, KAWACHI says that the valcanic activity of the Yatsugatake volcanoes during deposition of the Nobeyamahara formation was very violent at the lower part, and after that the volcanic activity became weak at the middle and upper Nobeyamahara formation.

Tsuga or forests of *Larix* were formed on the mountainside, and deciduous mixed forests were formed in the valley.

Deposition of the Kawakami lake deposits were so rapid that the pollen diagram was influenced by plant successions which were above mentioned.

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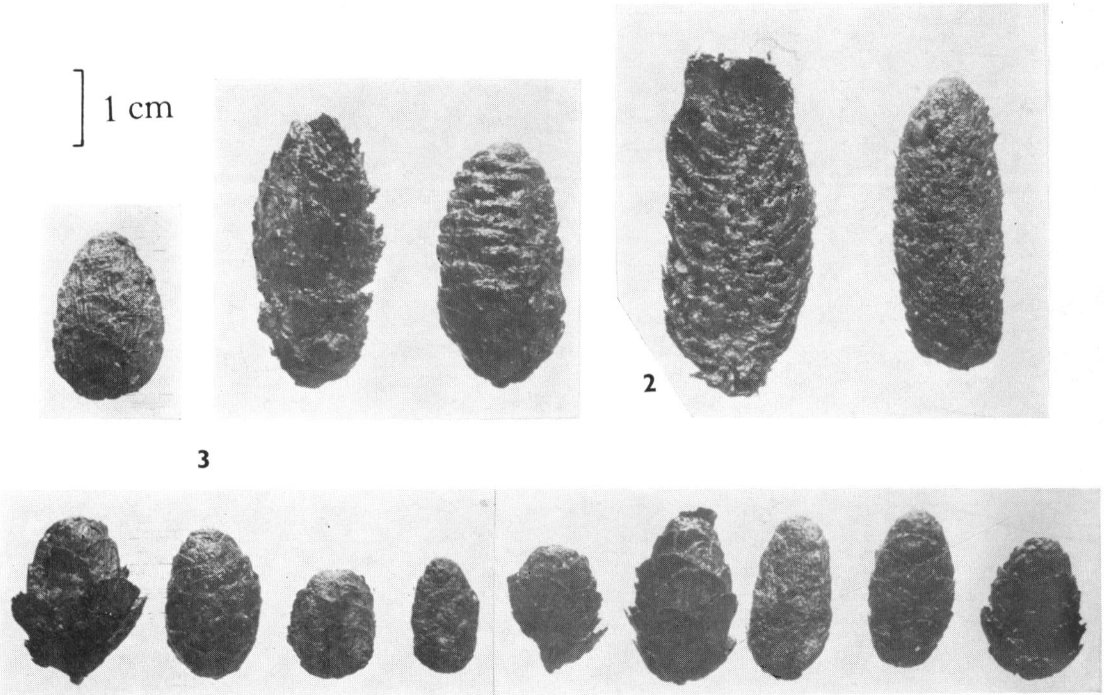
Explanation of Plate 12

1: The cliff from where samples for pollen analyses from No. 8 to No. 38, and plant remains are obtained.
2: *Picea maximowiczii* Regel
3: *Tsuga diversifolia* (Maxim.) Masters

1



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