THE FIRST COLD PHASE DURING PLIO-PLEISTOCENE TIME IN HOKKAIDO

YAEKO IGARASHI*

(Received September 16, 1975)

Introduction

The Ikeda Formation, typically developed around the town of Ikeda, Tokachi Province, Hokkaido, has been variously interpreted in relation to its age. K. MITANI (1964) considered this formation as Pliocene, based on the following two characteristics: (1) The Ikeda Formation is more or less gently folded and rather steeply tilted in the marginal part of the depositional basin and (2) The upper half of the Ikeda Formation which is largely represented by marine facies includes Pliocene type of fossils such as *Macoma optiva* (YOKOYAMA), *Elphidium* cf. *etigoense* HUSEZIMA & MARUHASHI and *Elphidium yumotoensis* ASANO. The present author estimates that MITANI's view is still correct in general.

However, an obvious climatic change towards colder conditions is now well established in the Ikeda Formation by a detailed stratigraphic and palynologic investigation carried out by the present author. To correctly state it, the climate during the early age of the Ikeda Formation, as inferred from the association of pollen found, is estimated to have been temperate to mild in general; then the climatic conditions tended to be warmer in the earlier phase of the deposition of the middle part of the Ikeda Formation. After this, the climate suddenly changed during the later phase of the deposition of the Middle Ikeda Formation. It turned cold, and then became colder and colder step by step until the earlier time of the deposition of the Upper Ikeda Formation. This is concluded from pollen and spore analysis about one hundred specimens collected from at

least four major floral zones established in 14 localities (Figs. 1, 3).

Stratigraphy of the Ikeda Formation

K. MITANI (1964) divided the Ikeda Formation into two major groups which were slightly modified later on by MINATO *et al.* (1972). The idealized geologic column compiled by MINATO *et al.* is quoted here as Fig. 2. This column has been derived with the results obtained by the research group* of the Ikeda Formation, the Department of Geology and Mineralogy, Hokkaido University.

The present author collected samples from the peaty and silty deposits intercalated in the various horizons of each stratigraphic division of the Ikeda Formation. The localities where the author sampled and observed the stratigraphic section in order to compile an entire sequence of the Ikeda Formation, range from the basal member represented by the Inashibetsu pumice flow to the lower part of the Upper Ikeda Formation (Figs. 1, 3). Stratigraphic positions of the samples for pollen analysis are diagrammatically shown in Fig. 3.

Association of pollen and spores

Analytical method

Fossil pollen and spores were extracted from the samples according to the method of KOH-HF-Acetolysis. About 200 to 400 pollen and spores inclusive of 200 AP grains were counted for each sample.

Most important tree genera and families, supposed to be reliable to restore palaeo-

* Department of Geology and Mineralogy,
Faculty of Science, Hokkaido University

* Drs. M. MINATO, N. MINOURA, Messrs. S. OKADA, S. KUMANO, T. OHTAKE, T. OKA & Y. IGARASHI

Fig. 1. Simplified geologic map of the studied area. Numerals are sample localities.
(After the Research Group of the Ikeda Formation)

climate, are selected and given in Fig. 4. Furthermore, dominant grass or shrub pollen and spores of Pteridophyta and moss are also shown in Fig. 4.

The Lower Ikeda Formation

In the first lignite bearing beds (Localities 10—14, Figs. 1, 3) *Tsuga* is predominant

among conifers and *Picea*, *Abies* and *Pinus* are also present in minor amounts. In addition, *Larix* and Taxodiaceae are found, although more restricted in quantity. Among the broad leaved trees, *Alnus* and *Fagus* are fairly common, with lesser amounts of *Zelkova*, *Castanea*, *Pterocarya*, *Stylax*, of which the latter four suggest a rather warmer climate if we

Fig. 2. Generalized lithologic column of the Ikeda Formation.
(After the Research Group of the Ikeda Formation)

take into consideration the present day flora of the Tokachi Plain. However, also are found such deciduous broad leaved trees as *Ulmus*, *Juglans*, *Stylax*, *Quercus*, *Carpinus*, *Sorbus*, *Acer*, *Fraxinus*, *Tilia*, *Corylus*, *Populus* and *Salix*, which are rather common in the present day forest vegetation in and around the Ikeda town. Furthermore, Osmundaceae and Polypodiaceae are also dominant besides hygrophilous elements such as *Menyanthes*, *Myrica*, *Drosera*, *Sphagnum* etc. Seeds of *Menyanthes trifoliata* LINN. are found out throughout the entire section of peaty deposits above mentioned.

The lower part of the Middle Ikeda Formation

In the second lignite bearing beds (Localities 7-9, Figs. 1, 3), a decrease in frequency of *Tsuga*, *Picea* and *Abies* is characteristic in contrast with an increase of *Fagus*, *Alnus* and *Zelkova* frequency. *Larix* entirely disappears. Among the undergrowth, Polypodiaceae are dominant while Gramineae, *Rumex*, *Sanguisorba* and Liliaceae, more or less adaptable to dry condition, were increasing in number.

The upper part of the Middle Ikeda Forma-

Fig. 3. Columnar sections showing the stratigraphic position of samples.
(After the Research Group of the Ikeda Formation)

tion

The materials obtained from the third lignite bearing beds prove that a remarkable climatic change took place at that time as compared with the climate existing during the deposition of the first and the second lignite bearing beds. Namely, *Picea* became dominant and *Abies* also increased. *Tsuga* is present in minor amounts in these beds with the exception of the uppermost part (Localities 4—6, Figs. 1, 3). *Larix* became common while, in contrast, *Fagus* and *Alnus* suddenly decreased in these horizons. The undergrowth association is the same as that of the lower part of the Middle Ikeda Formation.

The Upper Ikeda Formation

The peaty deposits included in the lower part of the Upper Ikeda Formation is called here tentatively the fourth lignite bearing beds

(Localities 1—3, Figs. 1, 3). During the deposition of these horizons *Picea* became very dominant and *Abies*, *Larix* and *Pinus* are commonly found without exceptions. *Betula* is characteristically abundant. Among the undergrowth, Pteridophyta were generally decreasing in amount but Cyperaceae, Gramineae, *Sanguisorba*, Ericaceae were comparatively common.

In the area where the present author has studied, the upper part of the Upper Ikeda Formation is largely lacking due to erosion. Accordingly, nothing can be stated here on the vegetation and climatic conditions for that time.

Identification of some tree pollen species

Picea

Presence of larger remains of *Picea* cf. *gmelinii*

Fig. 4. Pollen and spores diagram of the Ikeda Formation showing the percentages of important trees and dominant undergrowth.

was reported by TANAI (1961) from the Lower Ikeda Formation. The occurrence of *Picea glehnii* was reported by MATSUI *et al.* (1970) from the Upper Ikeda Formation. Furthermore, YANO (1968) described cones of *Picea jezoensis* from the Lower Pleistocene deposits developed in the Ishikari Lowland. Therefore, the present author believes that the pollen of *Picea* she found in the Ikeda Formation probably belong to either three, two or one of the above mentioned species.

Tsuga

Although larger remains of *Tsuga* have never been found in the Ikeda Formation to date, three species are distinguishable among the pollen observed by the present author.

First of all, large pollen of which the body diameter is generally 80 μ may be identified as *Tsuga diversifolia*. The author directly compared the fossil pollen of the Ikeda Formation with the Recent material. TAKEUCHI (1974) has described pollen of *Tsuga diversifolia* from the Pliocene Kazawa Formation developed at Ichinoseki City, Northeast Honshu. The author's specimens may be conspecific with TAKEUCHI's material.

Smaller sized pollen with the body diameter reaching about 65 μ may be identified as *Tsuga sieboldii* by comparison with the species described by A. TAI (1973) from the Pliocene Osaka Group (ITIHARA, M. *et al.* 1972). The presence of this species in the Lower Ikeda Formation and in the lower part of the Middle Ikeda Formation may be also highly probable as indicated from the association with such temperate tree pollen as *Zelkova*, *Castanea*, *Fagus* etc.

The *Tsuga* pollen almost without hem but with numerous spines are also present. They may correspond to a similar species as the form described by OKAZAKI (1958) as *Tsuga canadensis* type. Such types of species are actually present in the Late Pleistocene deposits of the Ishikari Lowland (IGARASHI, 1975).

Taxodiaceae

Under this heading such genera as *Metasequoia*, *Sequoia*, *Glyptostrobus* and *Cryptomeria* are considered. These are hardly distinguish-

able from each other except for the size of pollen. The pollen now described are rather of a large size (over 30 μ in diameter), so they may be considered to belong to the genus *Cryptomeria*.

Fagus

Two types are distinguished among the pollen of the genus *Fagus*; the smaller one (about 32 μ in diameter) may be assigned to *Fagus japonica*, while the larger one (about 42 to 49 μ) to *Fagus crenata*. The author directly compared fossil pollen with the Recent material.

Forest trees and climatic change during the time of the Ikeda Formation

Before discussing the palaeoclimate and the change of forest trees during the time of the Ikeda Formation, the author wishes to review the present day vegetation of the area where the Ikeda Formation developed. Fortunately a natural forest is still present 4 km west of Obihiro City not far from the town of Ikeda, the type locality of the Ikeda Formation. At a low hill called Kunimiyama, the top of which is about 118 m in altitude, the following forest tree association is known in the natural forest (TATEWAKI & IGARASHI, in press): *Quercus dentata*, *Quercus mongolica* var. *grosseserrata*, *Cercidiphyllum japonicum*, *Kalopanax pictus*, *Acer mono*, *Acer palmatum* var. *matsumurae*, *Carpinus cordata*, *Ostrya japonica*, *Sorbus alnifolia*, *Maackia amurensis* var. *buergeri*, *Magnolia obovata*, *Fraxinus lanuginosa*, *Stylax obassia*, *Rhus trichocarpa*, *Salix hultenii* var. *angustifolia* etc.

Such a vegetation is obviously distinct from the fossil flora estimated from the pollen association found in the Ikeda Formation.

The flora contained in the first lignite bearing beds reminds us of the present day flora propagating in the upper part of the cool temperate zone of Central Honshu (HAYASHI, 1960). In the Lower Ikeda Formation, although *Tsuga diversifolia* and certain amount of *Picea* and *Abies* are found, such temperate form as *Tsuga sieboldii*, *Fagus japonica* and *Zelkova* are also present to some extent. From this fact the author inferred that the past climate in the Tokachi Plain might have

been fairly warmer than the present one.

The pollen association of the second lignite bearing beds shows that the past vegetation might be similar to flora found in the middle part of the present day cool temperate zone of Central Honshu (HAYASHI, 1960). However it is remarkable that *Tsuga* decreases and *Larix* disappears in this phase of the deposition of the Ikeda Formation. In all probability the past climate must have been much warmer in this phase than the foregoing periods.

The climatic conditions drastically changed from warm to cold at some moment during the period between the end of the second lignite bearing beds and the beginning of the third lignite bearing beds. *Larix*, for instance, reappeared and *Fagus* remarkably decreased. *Zelkova* and *Tsuga sieboldii* eventually disappeared at some time during this period.

The author could only investigate on the lower parts of the Upper Ikeda Formation and nothing can be said on the flora of the upper part of the Upper Ikeda Formation. However, so far as the earlier stage of the Upper Ikeda Formation is concerned, the climate is estimated to have become much colder than in any of discussed ages including the present time.

Conclusion

Settlement of the age of the Ikeda Formation is far from a final conclusion at present because of lacking of more reliable data in age determination and geomagnetic stratigraphy. However, the author is now inclined to consider the boundary of climatic change from warm to cold to be placed in the middle part of the Middle Ikeda Formation; viz. between the second and the third lignite bearing beds. It is probable that this remarkable deterioration may represent the Plio-Pleistocene boundary in the Tokachi Plain area. In any way, the base of the third lignite bearing beds is to be designated as the first recorded cold phase in the Ikeda Formation.

Acknowledgement

The author especially acknowledges Prof.

Masao MINATO for his supervision and encouragement during the course of this study. She is also grateful to Dr. Makoto KATO and Dr. Nachio MINOURA for their kind assistance given in the preparation of this paper. Thanks are also expressed to Prof. Toshio TANAI for his kindness in giving information about the larger plant remains from the Neogene. Finally she wishes to thank Prof. L. AGUIRRE for reading the present paper for linguistic purposed.

References

- HAYASHI, Y., 1960 : Taxonomical and phytogeographical study of Japanese conifers. Norin-Shuppan, Tokyo, 233 p. (in Japanese)
- IGARASHI, Y., 1975 : Palynological study of subsurface geology of the coastal plain along the Ishikari Bay, Hokkaido, Japan. *The Quaternary Research (Daiyonki-Kenkyū)*, **14**, 33—53.
- ITIHARA, M., KAMEI, T., MITSUNASHI, T., SUZUKI, K., KUWANO, Y., 1972 : The basis of the Plio-Pleistocene boundary in Japan. International colloquium on the problem "The boundary between Neogene and Quaternary", *Collection of Papers*, II, Moscow 1972, 75—116.
- MATSUI, M., MATSUZAWA, I. and YAMAGUCHI, S., 1970 : On the Osarushinai Formation—Early Pleistocene deposits of Tokachi Plain, Hokkaido. *The Quaternary Research (Daiyonki-Kenkyū)*, **9**, 123—127. (in Japanese with English abstract)
- MINATO, M., HASHIMOTO, S., FUJIWARA, Y. and KUMANO, S., 1972 : Pliocene-Pleistocene deposits of Japan and a preferable Pliocene/Pleistocene boundary in Japan. International Colloquium of the problem "The boundary between Neogene and Quaternary", *Collection of Papers*, II, Moscow 1972, 185—204.
- MITANI, K., 1964 : The geological succession and the epirogenese of the Pliocene age at the "Main part of Hokkaido" Japan. *Report Geol. Survey Hokkaido*, no. 32, 1—36. (in Japanese with English abstract)
- OKAZAKI, Y., 1958 : Stratigraphical and palynological studies of the Honbetsu Group and the Ikeda Formation (Pliocene, Tertiary) in Eastern Hokkaido. *Jour. Hokkaido Gakugei Univ.*, **9**, 230—249.
- TAI, A., 1973 : A study on the pollen stratigraphy

- of the Osaka Group, Pliocene-Pleistocene deposits in the Osaka Basin. *Mem. Fac. Sci. Kyôto Univ., Ser. Geol. Min.*, **39**, 123—165.
- TAKEUCHI, S., 1974 : Geology and palynology of the hilly area southeast of Ichinoseki City, Iwate Prefecture, Japan. *Sci. Rep. Tôhoku Univ., Sec. Ser.* **44**, 65—119.
- TANAI, T., 1961 : Neogene floral change in Japan. *Jour. Fac. Sci. Hokkaido Univ.*, [4], **11**, 119—398.
- TATEWAKI, M. and IGARASHI, T., in press : "Forest vegetation of Kunimiyama Prov. Tokachi, Hokkaido, Japan.
- YANO, M. and ISHIKARI TEICHTAI RESEARCH GROUP 1968 : Outline of the plant remains from the Quaternary deposits in the Ishikari Plain, Hokkaido. *The Quaternary Research (Daiyonki-Kenkyû)*, **7**, 41—48. (in Japanese with English abstract)

北海道の鮮新-更新世における最初の寒冷期

五十嵐 八枝子

(要 旨)

北海道十勝平野に分布する池田層については、古くから多くの研究が行われてきたが、その堆積構造や産出化石により時代を鮮新世とする考えが多かった。近年、北大の調査グループにより、池田層の調査研究が行われつつあり、筆者は、確立された層序に基いて、十勝川中流域に分布する池田層について、花粉分析を行い、その堆積時代の古気候変遷を解明した。

すなわち、下部池田層第Ⅰ夾亜炭層の花 粉 組 成 は、*Tsuga*, *Fagus*, *Alnus* を主とし、これに僅かだが *Tsuga cf. sieboldii*, *Fagus cf. japonica*, *Zelkova*, *Castanea*, *Pterocarya* といった温帯要素を混入しており、現在の池田町周辺より温暖であったと考えられる。

中部池田層第Ⅱ夾亜炭層では、前時代に比べ、針葉樹の全般的な減少と、広葉樹の増加とから、更に、温暖な気候になったと考えられる。

しかし、中部池田層第Ⅲ夾亜炭層では、*Picea*, *Abies* の急増と、代わって、*Fagus* を始めとする広葉樹の減少が見られ、気候の寒冷化が生じたことが示されている。

この傾向は、上部池田層にも見られ、加えて *Larix*, *Pinus*, *Betula* が前時代より増加していることから、寒冷化は進行したと考えられる。

池田層の堆積時代については、現在、絶対年代や古地磁気の測定資料が少なく、最終的に決定できる段階ではない。しかし、中部池田層の第Ⅱ夾亜炭層と第Ⅲ夾亜炭層の間にみられる気候の変化は重要であり、あるいは、鮮新-更新世の境界に該当するものとも推定される。

地 名

Ikeda	池 田	Osarushinai	長流枝内
Inashibetsu	稲士別	Kunimiyama	国見山
Sarubetsu	猿 別		

Explanation of Plate I

1. *Fagus crenata*, sample 9—2
2. *Fagus japonica*, sample 12—6
3. *Tilia*, sample 7—1
4. *Zelkova*, sample 9—1
5. *Taxodiaceae*, sample 1—8
6. *Betula*, sample 6—20
7. *Corylus*, sample 2—16
8. *Ulmus*, sample 6—25
9. *Quercus*, sample 7—3
10. *Sphagnum*, sample 13
11. *Pterocarya*, sample 6—23
12. *Typha*, sample 5—10
13. *Compositae*, sample 11—1
14. *Alnus*, sample 12—1
15. *Thalictrum*, sample 2—2
16. *Osmunda*, sample 12—9
17. *Menyanthes*, sample 5—2
18. *Ericaceae*, sample 6—10
19. *Polypodiaceae*, sample 6—1
20. *Tsuga sieboldii*, sample 12—8
21. *Tsuga canadensis* type, sample 5—10
22. *Tsuga diversifolia*, sample 12—9