MESOZOIC FLORAL SUCCESSION OF NAGATO MOUNTAINLAND, WESTERN JAPAN

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ABSTRACT

Floral succession in Triassic and Jurassic formations of Nagato mountainland, western Japan were carried out by the author and determined the stratigraphical boundary between the horizons of *Dictyophyllum* Series and *Onychiopsis* Series of Ôishi exists at some limited horizon between the uppermost of Higashi-Nagano formation and the middle of Nishi-Nakayama formation of the Toyora Group.

NAGATO mountainland of the western Japan has been famous for Mesozoic plant fossils since the palaeobotanical works of Yokoyama (1891, 1905) and Yabe (1922). In this mountainland there developed Triassic and Jurassic plant beds of various stages, some of them have been worked as coalfields. In the recent three decades Ôishi (1932-40), Konno, the present writer (TAKAHASI, 1950-51) and Hozioka (1938) took up their palaeobotanical works on the plant fossils from this mountainland. On the other hand, stratigraphical works on the Mesozoic formations were carried out by Kobayashi (1941), Matsumoto (1949), Hase (1951) and others. Fortunately, the Triassic plant beds are alternated with marine shell-bearing beds and the Jurassic plant beds are intercalated with marine ammonite beds; hence the exact geological ages of the plant horizons are decided. As it was mentioned previously by Kobayashi (1938, 1942), the ages of the Mesozoic floras of our country are older than those of Europe; namely the ages of the floras of Rhaeto-Liassic aspect go down to the Noric Carnic and Ladonic, and the ages of the floras of Upper Jurassic type go down to the Middle and Lower Jurassic. In the early years the writer made efforts to settle the precise geological position of the plant fossils already described or reported by the above-mentioned palaeobotanists in the Mesozoic formations and also added numerous fossil species.

Geological ages of the Mesozoic formations of this mountainland are settled as follows:

Geological Ages		Geological Systems			
Cretaceous	Upper	Yahata Group			
	Middle, Lower	Kammon group	Shimonoseki subgroup		
			Wakino subgroup		
	Low. Most	Toyonish group	Yoshimo formation		
			Kiyosue formation*		
Jurassic	Upper, Middle, Lower	Toyora group	Utano formation*		
			Nishi-Nakayama formation*		
			Higashi-Nagano formation*		
Triassic	Noric, Carnic	Miné (or Habu) group	Aso for.*	Kamosho for.	
			Momonoki for.*	Yamanoi for.*	
			Hirabara for.*	Nakatsuka for.*	
	Ladonic	Atsu (or Tsubuta) group	Kumanokura for.*	Idenoue for.*	
			Hongo for.	Hiramatsu for.*	
			Ominé region	Tsubuta region.	

*Plant-bearing formations.

At this place we must pay special attenbed to some horizons. (1) Kiyosue plant tion of Ôishi is divided stratigraphically by an unconformity into two parts; Toyora group, the lower and Kiyosue formation of Toyonishi group, the upper; (2) fossil localities of Tsubuta of Ôishi belong to Idenoue formation, not to Yamanoi formation.

Next are presented the tables of Triassic and Jurassic plant fossils.

It is noticeable that the Gondwana element *Rhipidopsis* occurs in the lower part of Hiramatsu formation, *Thinnfeldia* comes in the middle part of Hirabara formation and Palaeozoic type *Plagiozamites* survives in the lower part of Momonoki formation.

Stratigraphical boundary between the horizons of *Dictyophyllum* series and *Onychiopsis* series of Ôishi (1940) has become very clear, namely *Nilssonia brevis* (Brongn.), belonging to the former series comes out from the uppermost horizon of Higashi-Nagano formation and *Zamites toyoraensis* Oishi and *Cycadites* sp., both belonging to the latter series, come out from the middle horizon of Nishi-Nakayama formation. So we can clearly say that the boundary between the two series exists at some limited horizon between the uppermost of Higashi-Nagano formation and the middle of Nishi-Nakayama formation.

(1) TSUBUTA FOSSIL FLORA

	Hiramatsu Formation	Idenoue Formation
Equisetales		
Neocalamites carrerei (Zeill.)	×	×
Equisetites takaianus Konno (m.s.)	×	...
E. sp.	×	×
Filicales		
Clathropteris sp. indet.	...	×
Dictyophyllum japonicum Yok.	×	...
D. nathorsti Zeill.	...	×
D. sp.	×	...
D. sp. or *Thaumatopteris* sp.?	×	...
Cladophlebis denticulata (Brongn.)	×	×
C. haiburnensis (L. & H.)	...	×
C. sp.	×	×
Ginkgophyta		
Rhipidopsis sp.	×	...
Phoenicopsis angustifolia Heer	×	...
P. sp.	...	×
Ginkgoacean cone	...	×
Coniferales		
Elatocladus sp.	...	×
Pityophyllum longifolium (Nath.)	×	×
Podozamites lanceolatus (L. & H.)	...	×
P. sp.	×	×
Cycadocarpidium swabii Nath.	×	×
C. n. sp.?	×	...
Stenorachis elegans Ôishi	×	×
S. sp. ? (Seed)	...	×
Swedenborgia sp.	...	×
Plantae incertae sedis		
Taeniopteris minensis Ôishi	×	×
T. sp.	×	×

(2) MINÉ FOSSIL FLORA

	Yamanoi f.	Hirabara f.	Momonoki f.	Aso f.
Bryophyta				
Hepaticites Oishii	...	...	×	...
Huzioka & Tak. (m.s.)	...	...	...	...
Equisetales				
Annulariopsis inopinata Zeill. ?	...	...	×	...
Lobatannularia ensifolia Halle	...	...	×	...
Neocalamites carrerei (Zeill.)	×	×	×	×
N. hoerrensis (Schimp.)	×	...	×	×
Equisetites multidentata Ôishi	...	...	×	×
E. naitoi Konno (m.s.)*	*Nakatsuka f.	...	...	...
E. n. sp. α	×	...	...	...
E. n. sp. β	...	...	×	...
E. sp. α, Ôishi (m.s.)	...	...	×	...
E. sp. β, Ôishi (m.s.)	...	...	×	...
E. sp.	×	×	×	...
Phyllotheca sp.	×	...	...	...
Filicales				
Todites goeppertianus (Münst.)	...	...	×	...
T. recurvatus Harris	...	...	×	...
T. williamsoni (Brongn.)	...	...	×	...
Clathropteris meniscoides Brongn.	...	...	×	...
C. obovata Ôishi	×	...	×	...

	Yamanoi f.	Hirabara f.	Momonoki f.	Aso f.
C. sp.	...	...	×	...
Dictyophyllum japonicum Yok.	×	...	...	×
D. nathorsti Zeill.	×	...	×	...
D. sp.	...	...	×	...
D. sp. indet.	×	...	×	...
Thaumatopteris kochibei (Yok.)	×	...	...	...
Hausmannia dentata Ôishi	...	...	×	...
H. sp.	...	...	×	...
Cladophlebis denticulata (Brongn.)	×	...	×	×
C. haiburnensis (L. & H.)	×	×	×	...
C. nebbensis (Brongn.)	×	...	×	×
C. pseudodelicatula Ôishi	...	...	×	...
C. cfr. *pseudodelicatula* Ôishi	...	...	×	...
C. raciborskii Zeill.	...	...	×	...
C. cfr. *raciborskii* Zeill.	...	...	×	×
C. raciborskii integra Ôishi & Tak.	×	...	...	...
C. cfr. *raciborskii integra* Ôishi & Tak.	...	...	...	×
C. williamsoni (Brongn.)	...	...	×	...
C. n.sp. α, Ôishi (m.s.)	...	...	×	...
C. n. sp. β, Ôishi (m.s.)	...	...	×	...
C. n. sp. γ, Ôishi (m.s.)	...	...	×	...
C. sp.	...	...	×	...
Cycadophyta				
Ctenis ? sp.	×	...	...	...
Nilssonia acuminata Presl	...	...	...	×
N. inouyei Yok.	×	...	...	×
N. simplex Ôishi	×	...	...	...
N. sp.	...	...	×	...
Pterophyllum yamanoiensis Ôishi & Tak.	×	...	...	...
P. sp.	×	...	...	...
P. ? sp. indet.	×	...	...	...
Zamites n. sp. Ôishi (m.s.)	...	...	×	...
Z. n. sp. Ôishi (m.s.)	...	...	×	...
Plagiozamites minensis Tak.	...	...	×	...
Sagenopteris nilssoniana (Brongn.)	×	...	...	...
Thinnfeldia sp. ?	...	×	...	...
Ginkgophyta				
Baiera elegans Ôishi	...	...	×	...
B. muensteriana (Presl)	...	...	×	...
B. paucipartita Nath.	×	...	×	...
B. sibirica Heer	...	...	×	...
B. sp.	...	...	×	...
Ginkgoites digitata huttoni Seward	...	...	×	...
Czekanowskia rigida Heer	×	...	×	...
C. sp.	...	...	×	...
C. ? sp.	×	...	...	...
Phoenicopsis sp.	×	...	×	...
Coniferales				
Podocarpites ushioi Naito (m.s.)	...	...	×	...
Elatocladus sp.	...	...	×	...
Nageiopsis rhaetica Ôishi	...	×	...	...
Araucarioxylon sp.	...	...	×	...
Pityophyllum longifolium (Nath.)	×	...	×	×
Podozamites atsuensis Tak.	...	×	×	...
P. concinnus Ôishi & Huz.	...	...	×	...
P. cfr. *distantinervis* Font.	...	...	×	...
P. lanceolatus (L. & H.)	×	...	×	×
P. nagatoensis Tak.	×	×	...	...
P. oishii Tak.	...	...	×	...
P. schenkii Heer	×	...	×	...
P. n. sp. Ôishi (m.s.)	×	...	...	...
P. sp.	×	...	×	...
Cycadocarpidium erdmanni Nath.	...	×	...	...
C. swabii Nath.	...	×	...	...
C. sp.	...	...	×	...

	Yamanoi f.	Hirabara f.	Momonoki f.	Aso f.
C. sp. ?	×	...	...	...
Cfr. *Leptostrobus laxiflora* Heer	×	...	...	...
Stenorachis elegans Ôishi	...	...	×	...
Swedenborgia cryptomeroides Nath.	...	×	...	...
Stachyotaxus elegans Nath.	...	...	×	...
Plantae incertae sedis				
Pachypteris sp.	...	...	×	...
Taeniopteris lanceolatus Ôishi	...	...	×	×
T. minensis Ôishi	×	...	×	×
Cfr. *T. nabaensis* Ôishi	×	...	...	...
T. richthofeni (Schenk)	×	...	...	...
T. n. sp., Ôishi (m.s.)	...	...	×	×
T. sp.	×	×	×	...

(3) TOYORA AND TOYONISHI FOSSIL FLORAS

	Toyora G.			Toyonishi G.
	Higashi-Nagano f.	Nishi-Nakayama f.	Utano f.	Kiyosue f.
Bryophyta				
Thallites yabei (Krysht.)	...	...	×	×
Equisetales				
Equisetites endoi Konno (m.s.)	...	...	×	...
Filicales				
Phlebopteris takahasii Huzioka	...	×	...	...
Coniopteris burejensis (Zall.)	...	...	×	...
C. hymenophylloides (Brongn.)	...	...	×	...
Onychiopsis elongata (Geyl.)	...	×	×	×
Adiantites sewardi Yabe	...	...	×	×
A. toyoraensis Ôishi	...	...	×	...
Sphenopteris goepperti Dunk.	...	...	×	×
Cladophlebis denticulata (Brongn.)	...	...	×	×
C. deltifolia Ôishi	...	...	...	×
C. exiliformis (Geyl.)	...	...	×	...
C. (*Klukia* ?) *koraiensis* Yabe	...	...	...	×
C. lobifolia (Phill.)	?	...	×	...
C. toyoraensis Ôishi	...	...	×	×
C. sp.	...	...	×	×
Cycadophyta				
Nilssonia brevis (Brongn.)	×	...	...	...
N. densinerve (Font.)	...	...	×	...
N. compta (Phill.)	...	...	×	...
N. nipponensis Yok.	...	...	×	...
N. orientalis Heer	×	...	×	×
N. schaumburgensis parvula Yabe	...	...	×	...
N. sp.	...	×	×	...
Cfr. *Pseudoctenis brevipennis* Ôishi	...	...	×	...
P. sp.	...	...	×	...
Dictyozamites falcatus (Morris)	...	...	...	×
D. kawasakii Tateiwa	...	...	...	×
D. sp.	...	...	...	×
Otozamites beani (L. & H.)	...	...	×	×
O. klipsteinii (Dunk.)	...	...	×	×
Cycadites sp.	...	×	...	...
Pseudocycas sp. ?	...	...	×	...
Pterophyllum propinquum Goepp.	...	...	×	×
P sp.	...	...	...	×
Ptilophyllum pecten (Phill.)	...	...	×	...
P. pachyrachis Ôishi	...	...	×	...

	Toyora G.			Toyonishi G.
	Higashi-Nagano f.	Nishi-Nakayama f.	Utano f.	Kiyosue f.
P. sp.	...	...	×	...
Zamiophyllum buchianum (Ett.)	...	...	×	...
Cfr. *Z. megaphyllus* (Phill.)	...	...	×	...
Cfr. *Z. Hoheneggeri* (Schenk)	...	...	...	×
Z. toyoraensis Ôishi	...	×	...	×
Z. yabei Ôishi	...	×	...	...
Sagenopteris petiolata Ôishi	...	...	×	×
Ginkgophyta				
Ginkgoites digitata (Brongn.)	...	...	×	×
G. sibirica (Heer)	×	...	×	...
Czekanowskia rigida Heer	...	...	×	...
Phoenicopsis sp.	...	...	...	×
Coniferales				
Araucarites cutchensis Feist.	...	...	×	...
Brachyphyllum expansum (Sternb.)	×	×	×	...
B. toyoraensis Tak.	...	...	×	...
B. sp.	...	...	...	×
Elatocladus constricta (Feist.)	...	...	×	×
Palissia sp.	...	...	×	...
Nageiopsis longifolia Font.	...	...	×	...
Cfr. *Podozamites distantinervis* Font.	...	...	×	...
P. sp.	...	...	×	×

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