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BIOSTRATIGRAPHY AND CORRELATION OF THE PERMIAN OF JAPAN

by

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(with 2 text-figures and 3 tables)

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Abstract

Permian biostratigraphy is described for seven selected districts in Japan. A new biostratigraphic scheme is presented for the Permian in the Kitakami mountains, based on a number of assemblage zones. New names, Maehama and Nabekoshi Stages are proposed in the Toyoma Series of the Kitakami mountains. An attempt is made to correlate the Japanese Permian in the studied districts.

Intruduction

International Subcommission on Permian Stratigraphy (President- Prof. D.L. Stepanov) of the IUGS is planning to correlate eventually the World Permian. Dr. E.Ya. Leven of the USSR and Minato have been asked to prepare a correlation table of the Permian in the Tethys province. At the request of Dr. Leven Minato in cooperation with Kato made a draft of correlation chart of the Permian of Japan, and sent it to Dr. Leven sometime ago. Then the present authors jointly prepared the second, modified version of the first draft, with explanatory text. We sent this manuscript also to Dr. Leven in 1976.

In 1977 Dr. Leven circulated his view on a kind of Permian standard in the Tethyan realm, based mainly on his data from Central Asia, but combined with data from the other regions. He asked research workers on Permian for comments on his scheme to be sent to Drs. Leven, Minato and S.V. Meyen (Secretary of the Commission). Thus Minato received several letters from some research workers somehow criticizing Leven's scheme.

However, we feel that the first step we should take is to accumulate as many data as possible in connection with local biostratigraphy in many regions,

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before we come to any concrete idea of correlation. We also feel it useful and advisable to publish, if possible, such data as available sources of information on the concerned problem.

It is the aim of the present paper to fulfil such a need. However we are fully aware of that the paper is ineviatably a sketch or an outline of the Japanese Permian, since Minato, to his regret, has not been able to really organize a working group for such a task in correlating the Permian deposits of entire Japan.

Marine Permian deposits are widely distributed throughout Japan. They are known in Hokkaido, Honshu, Shikoku, Kyushu and Okinawa.

Fig. 1 Surface distribution of Palaeozoic sediments and their metamorphosed counterparts in Japan, idicating the locations of important districts for Permian deposits.

For biostratigraphy and correlation, however, seven districts are here purposefully chosen for consideration; namely the Kitakami mountains in N.E. Japan, and the Omi, Akasaka, Atetsu, Akiyoshi, Oita and Kuma mountain districts in S.W. Japan (Fig. 1).

In Japan, the southern Kitakami mountains represent one of the best geologically investigated districts where Palaeozoic deposits are most typically distributed. And the Permian deposits are characterized by detrital as well as carbonate facies. Geology of this district is, however, much complicated owing to the repeated crustal movements. Therefore stratigraphic succession is very difficult to establish there. Also fossils are more or less deformed and often obliterated though they are locally abundant.

Minato presents here a new scheme of biostratigraphy for the Permian of the Kitakami mountains (Fig. 2).

In the other districts, the Permian is represented mostly by carbonate facies except for the Kuma mountain district where detrital facies is more predominant. Fossils are better preserved in these districts than those from the Kitakami mountains. But stratigraphic succession in these districts is by no means complete for the entire Permian, and only fusulinid foraminifers have been extensively searched for. Brief description is made on the Permian of each district.

Apart from the above mentioned two types of sedimentary environments, namely the carbonate facies and the mixed facies of carbonate and detritus, another type of deposits is actually distributed in central and the outer zone of Southwest Japan. They are dominantly volcanic in lithologic character at least with regard to the Lower to Middle Permian.

Thus three different types are recognizable amongst Permian deposits of Japan (Minato & Kato, in Minato, Gorai & Hunahashi (eds.), 1965). But as to the last mentioned type, biostratigraphy is by no means thoroughly investigated as yet, and it is not described here.

Detailed and thorough consideration and comprehension of the Japanese Permian are to be presented in the other occasion when we organize a working group on the problems of Permian correlation in Japan in near future.

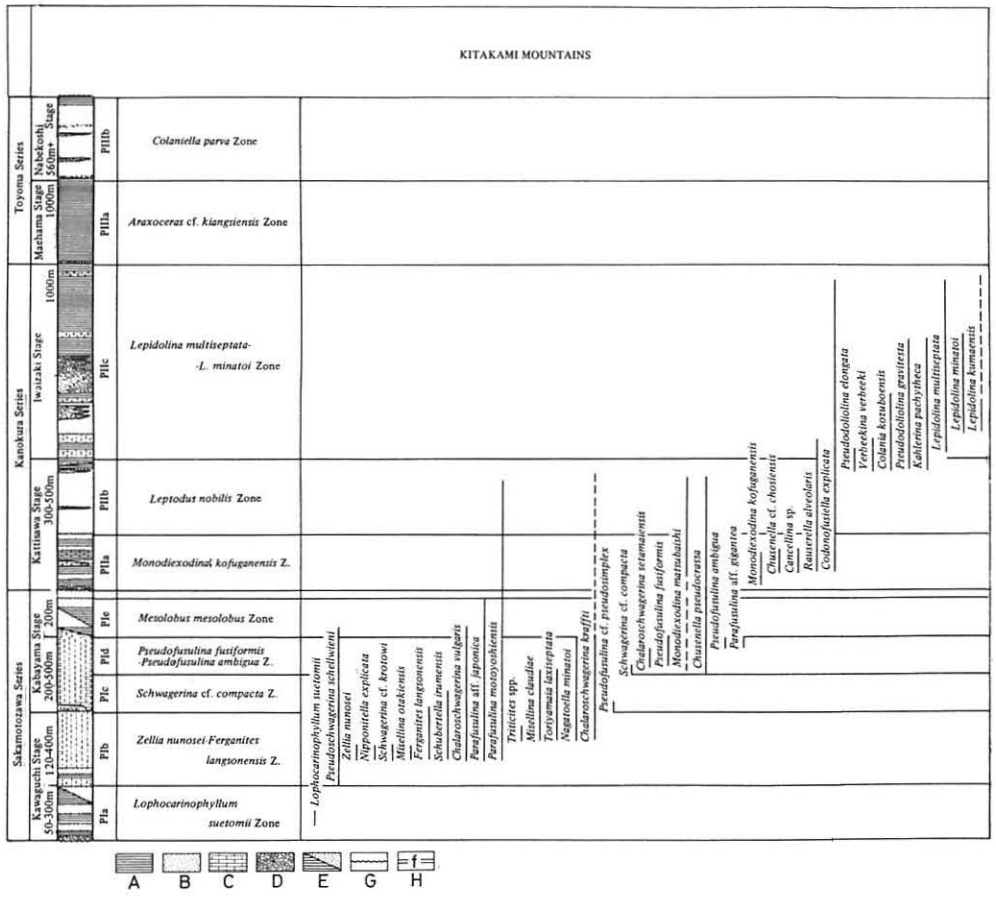
As a matter of fact Minato has long studied the Palaeozoic deposits distributed in a rather narrow strip called the Setamai-Sakari district in the southern Kitakami mountains in cooperation with a number of his students. Without their effort of detailed mapping, we could hardly establish the lithologic sequence and many bio- and assemblage zones of Palaeozoic there.

The Permian deposits are especially well developed in the Setamai-Sakari district. Accordingly description will be based mainly on the data from this district concerning to the Kitakami mountains. Various information sources

may be found from the accompanied list of references.

Although not mentioned in the text, Dr. Y. Fujiwara made a palaeomagnetic study on the Lower Permian sediments, and Dr. N. Minoura has been studying the sedimentary rocks including limestones in the Kitakami mountains. Prof. M. Hunahashi kindly taught us on the lithologic nature of the volcanic rocks and feldspathic sandstones intercalated in the Permian. These studies are actually of great help to establish a sequence of the Permian

Fig. 2 Correlation chart of the Permian of Japan.
A – slate; B – sandstone; C – limestone; D – conglomerate; E – alternation; G – unconformity; H – fault relation.

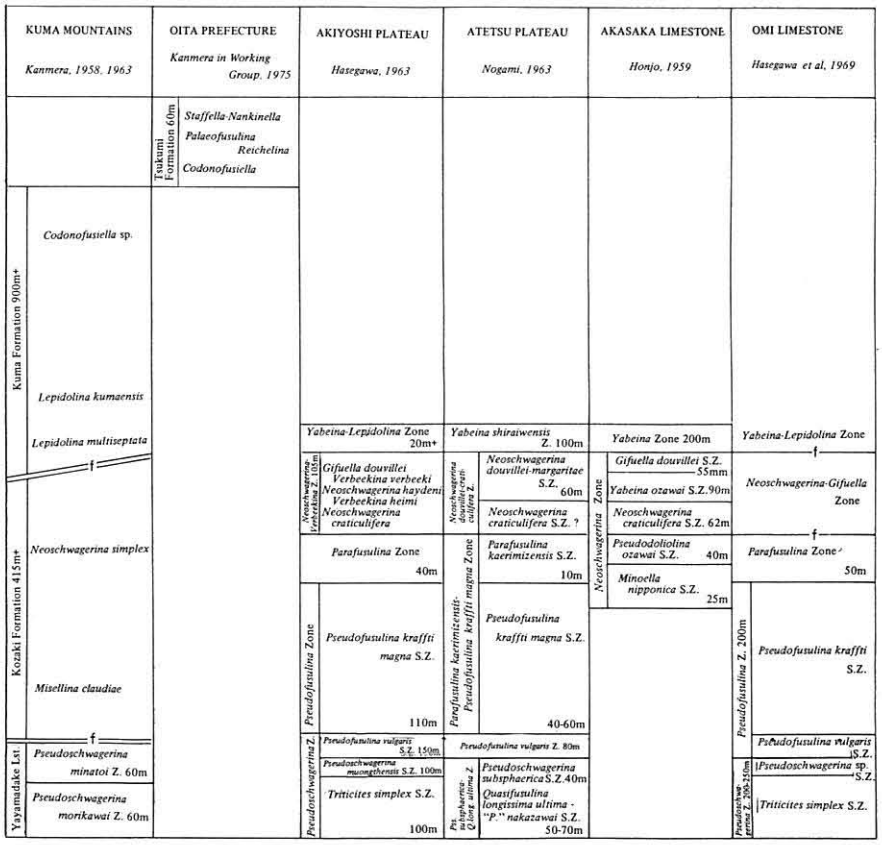


formations of the Kitakami mountains.

Then the Permian developed in Southwest Japan will be stated briefly, based on the researches hitherto carried out by a number of workers including ourselves.

We acknowledge Prof. F. Kahler of Klagenfurt, Austria, Dr. H. Kozur of German Democratic Republic, Dr. H. Taraz of Iranian Geological Survey, Prof. J.B. Waterhouse of the University of Queensland, Australia, for their kind comments on the major divisions on Permian, communicated to Minato.

Before stepping into description we would also like to acknowledge with many thanks Mr. S. Kumano for drawing figures, and Miss E. Mima for typing the present manuscript.



Kitakami Mountains

A. The boundary between the Carboniferous and Permian formations

The Permian deposits unconformably lie on the Carboniferous formations with the basal conglomerate of the Sakamotozawa Series (Minato, 1942; Nagao and Minato, 1943; Yamada, 1959; Kanmera and Mikami, 1965; Saito, 1966, 1968). The basal conglomerate rests directly on the limestone formation (Nagaiwa formation) with *Profusulinella* fauna, entirely lacking in the formations represented by *Fusulinella* – *Fusulina* –, and *Triticites* fauna. In many places, the basal conglomerate is also observed directly resting on the formations correlatable with the lower Tournaisian.

B. The Sakamotozawa Series

The Permian system in the Kitakami mountains is divisible into three series: the Sakamotozawa, the Kanokura and the Toyoma Series in ascending order. Of them the Sakamotozawa Series is lithologically and palaeontologically divided into two units: Kawaguchi Stage and Kabayama Stage.

1. The Kawaguchi Stage

a. *Lophocarinophyllum suetomii* Zone, PIa

The lower half of the stage is composed of conglomerate at its base. Sandstone and slate are predominant upwards. At the type area it is less than 50 m in thickness, but is locally very thick, reaching almost 300 m in thickness. It is lithologically composed of thick feldspathic sandstone, acidic and basic tuffs, coaly slate, etc. besides thick slate and calcareous slate in alternation. Marine fossils are not rare in the last mentioned part of the stage but have not been studied in detail.

The lower half of the Kawaguchi stage may be designated as *Lophocarinophyllum suetomii* Zone, Pla, since this solitary coral has been found rather widely from the calcareous slate, at the middle and lower part of this formation. Fragmental plant remains are also found in the lower part.

Fossils described from this zone may be listed below. All of them indicate the Permian.

Cordaites principalis (Germer), *Wentzelella (Wentzelella)* sp. (Minato and Kato, 1965a), *Lophocarinophyllum suetomii* (Minato), *Waagenoconcha asiatica* Zavodowsky, *Derbyia* sp. (Nakamura, 1972), cfr. *Orthotetes callytharrensis* (Thomas), *Magniderbyia* sp. (Nakamura, 1972), *Streptorhynchus sp.* (Naka-

mura, 1972), and small sized spiriferid resembling *Munella* (Minato MS).

b. *Zellia nunosei-Ferganites langsonensis* Zone, PIb

The upper half of the Kawaguchi stage is mainly composed of limestone, about 120 to 400 m in thickness. This is named as *Zellia nunosei-Ferganites langsonensis* Zone, PIb. This zone is also an assemblage zone; described fossils from this zone will be listed below.

Fusulinids:
Zellia nunosei Hanzawa, *Quasifusulina tenuissima* (Schellwien), *Paraschwagerina (Acervoschwagerina)* sp. (Kanmera and Mikami, 1965), *Paraschwagerina (Paraschwagerina)* sp. (Kanmera and Mikami, 1965), *Nipponitella explicata* Hanzawa, *Ferganites langsonensis* (Saurin), *Rugosofusulina alpina* (Schellwien), *Rugosofusulina rossica* (Schellwien), *Triticites* sp. A (Choi, 1973), *Triticites* sp. B (Choi, 1973), *Triticites* cf. *simplex* (Schellwien), *Nagatoella ikenoensis* Morikawa et Isomi, *Schwagerina* cf. *krotowi* (Schellwien et Dyhrenfurth), *Pseudofusulina ? jenkinsi* (Thorsteinsson), *Pseudofusulina* sp. A (Choi, 1973), *Pseudofusulina pseudoanderssoni* Shyomina, *Misellina claudiae* (Deprat), *Minojaponella elongata* Fujimoto et Kanuma, *Schubertella irumensis* Fujimoto, *Nagatoella minatoi* Kanmera et Mikami, *Paraschwagerina (Acervoschwagerina)* sp. (Choi, 1973), *Pseudoschwagerina schellwieni* Hanzawa, *Chalaroschwagerina vulgaris* (Schellwien et Dyhrenfurth), *Pseudofusulina* aff. *japonica* (Gümbel), *Pseudofusulina kraffti* (Schellwien et Dyhrenfurth), *Parafusulina motoyoshiensis* (Morikawa), *Toriyamaia laxiseptata* Kanmera.

Corals:
Pavastehphyllum (Sakamotosawanella) sakamotosawanum Minato et Kato, *Duplophyllum (Duplophyllum)* cf. *tenueseptatum* Schouppe et Stacul, *Iranophyllum (Laophyllum) nakamurai* Minato et Kato, *Durhamina kitakamiensis* Minato et Kato.

Calcareous Algae:
Anthracoporella magnipora Endo, *Epimastopra japonica* Endo, *Anchicodium magnum* Endo, *Hikorocodium elegantae* Endo, *Macroporella* sp. (Endo, 1951), *Osagia* sp. (Endo, 1951), *Hikorocodium elegantae* Endo, *Gyroporella (?) longipora* Endo, *Diplopora phanerospora* Pia, *Macroporella ?* sp. (Endo, 1952).

Ostracods:
Kirkbya cfr. *subnipponica* Ishizaki, *Kirkbya* sp., *Aurikirkbya ? brevis* Ishizaki, *Aurikirkbya? hinomataensis* Ishizaki, *Aurikirkbya ? lata* Ishizaki, *Aurikirkbya ? tenuis* Ishizaki, *Coronakirkbya hataii* Ishizaki, *Knightina hinomataensis* Ishizaki, *Amphissites kitakamiensis* Ishizaki, *Kellettina ? japonica* Ishizaki, *Kindlella kitanipponica* Ishizaki, *Hataiella ohazamensis* Ishizaki, *Hataiella longa* Ishizaki, *Hataiella minima* Ishizaki, *Roundyella dorsopapillosa* Sohn, *Bairdia iwaizakiensis* Ishizaki, *Bairdia* cfr. *dissimilis* Cooper, *Bairdia* sp. (Ishizaki, 1967).

Gastropod:
Phymatifer pugiloides Hayasaka

Amongst fossils above listed, *Pseudoschwagerina schellwieni* Hanzawa appears slightly earlier than the rest of fossils, *Chalaroschwagerina vulgaris* for instance.

Durhamina kitakamiensis Minato et Kato also is found from the relatively lower part of this zone. *Kindlella kitakamiensis* Ishizaki is said to be very resembled *Ulrichia minuta* described by Harris and Lalicker (1932) from the Wolfcampian, Kansas (Ishizaki, 1967). All the obstracods listed above are actually described by Ishizaki (1967) not from the Setamai-Sakari district but from the northern area, the Tassobe, as *Wentzelella* sp. listed from Pla in the foregoing paragraph.

2. The Kabayama Stage

The Kabayama stage is lithologically divided into two units: the lower half is chiefly composed of limestone, while the upper half is mainly consisting in slate and sandstone in alternation; although the upper half may be locally replaced by carbonate rocks.

The base of the Kabayama stage may be defined as the thin layer of conglomerate in the limestones as diagramatically shown in the correlation chart (Fig. 2). At the type area of the Sakamotozawa series, presence of unconformity is proved below the limestone conglomerate (Mikami, 1965) although in other areas, stratigraphically equivalent conglomerate is observed to be intraformational.

The limestone beds of the Kabayama stage may be divided into two assemblage zones (PIc and PId), and the uppermost part of this stage may be distinguished from both as PIe.

a. *Schwagerina* cf. *compact* Zone, PIc

Fusulinids:
Pseudofusulina aff. *pseudosimplex* (Chen), *Schwagerina* cf. *compacta* (White), *Rugosofusulina* aff. *serrate* Rauser-Chernoussova, *Schubertella* sp. (Choi, 1973), *Toriyamaia laxiseptata* Kanmera, *Nankinella* sp. (Choi, 1973), *Staffella* sp. (Choi, 1973), *Nagatoella minatoi* Kanmera et Mikami, *Paraschwagerina (Acervoschwagerina)* sp. (Choi, 1973), *Chalaroschwagerina vulgaris* (Schellwien et Dyhrenfurth), *Pseudofusulina kraffti* (Schellwien et Dyhrenfurth), *Parafusulina* aff. *japonica* (Gümbel), *Parafusulina motoyoshiensis* (Morikawa), *Misellina claudiae* (Deprat).

Corals:
Waagenophyllum (Waagenophyllum) polyseptata Minato, *Yatsengia kabayamensis* Minato, *Michelinia (Protomichelinia) multitabulata* (Yabe et Hayasaka), *Wentzelophyllum hayasakai* Minato et Kato, *Wentzelophyllum kitakamiense* Minato et Rowett, *Polythecalis* sp.

Calcareous Algae:
Teutloporella cfr. *triasina* Schauroth, *Mizzia velebitana* Schubert, *Atractyliopsis ?* sp. (Endo, 1951), *Macroporella* sp. (Endo, 1951), *Gyroporella longipora* Endo, *Anthracoporella magnipora* Endo, *Macroporella maxima* Endo, *Atractyliopsis (?)* sp. (Endo, 1952).

Gastropod:
Phymatifer aff. *nodocarinatus* (Wanner)

In the southwestern part of the Kitakami mountains (Maiya area), there is a plant bearing formation, composed of slate with carbonaceous matter, which has been called the Rodai Formation (Mabuti, 1932; Onuki et al, 1960; Ueda, 1963). This formation rests on the limestones with *Pseudoschwagerina schellwieni, Zellia nunosei* and *Triticites* cf. *simplex.* Hence, the stratigraphical level of the plant bearing formation may be correlatable with PIc.

The following species is recorded from the Rodai formation (Asama, 1956):
Sphenophyllum cf. *oblongifolium* (Germ. et Kaulf.), *Sphenophyllum Thonii* var. *minor* Sterzel, *Pecopteris* sp., *Odontopteris subcrenulata* Zeiller, *Gigantopteris Whitei* Halle, *Taeniopteris latecostata* Halle, *Taeniopteris* cfr. *Schenckii* Sterzel, *Taeniopteris Nystroemii* Halle, *Cordaites principalis* Germ., *Cordaites (Noeggerathiopsis) Arakawae* Asama, *Zamiopteris glossopteriodes* (Schmalh.) f. *minor* Kawasaki, *Zamiopteris uedae* Asama, *Psygmophyllum flabellatum*

(Lindley et Hutton).

Presence of *Gigantopteris Whitei* is especially worthy of note, since this species is one of characteristic elements of the Shansi formation of Taiyuan, Shansi province, North China (Halle, 1927).

The Rodai formation is overlain by the formation characterized by frequent occurrence of *Monodiexodina matsubaishi* (Fujimoto) probably correspondent to the Lower part of the Kanokura series to be later on described.

b. *Pseudofusulina fusiformis-Pseudofusulina ambigua* Zone, PId

Although the lithological boundary between the preceding assemblage zone and the present zone (PId) is hardly discernible in the field, certain types of fusulinids such as *Pseudofusulina fusiformis, Pseudofusulina ambigua, Parafusulina* aff. *gigantea,* etc. newly appear in this zone. Especially *Pseudofusulina ambigua* occupies the highest level of this zone.

It may be also noted that *Pseudoschwagerina schellwieni* and *Chalaroschwagerina vulgaris* are still found in the lower part of this zone.

Fusulinids:
Monodiexodina kattaensis (Schwager), *Paraschwagerina (Paraschwagerina)* sp. (Choi, 1973), *Paraschwagerina (Acervoschwagerina)* cf. *endoi* Hanzawa, *Chalaroschwagerina setamaiensis* Choi, *Pseudofusulina tschernyschewi* (Schellwien), *Pseudofusulina fusiformis* (Schellwien et Dyhrenfurth), *Pseudofusulina ambigua* (Deprat), *Parafusulina* aff. *gigantea* (Deprat), *Parafusulina* cfr. *multiseptata* (Schellwien), *Nagatoella minatoi* Kanmera et Mikami, *Pseudoschwagerina schellwieni* Hanzawa, *Chalaroschwagerina vulgaris* (Schellwien et Dyhrenfurth), *Pseudofusulina* aff. *japonica* (Gümbel), *Pseudofusulina kraffti* (Schellwien et Dyhrenfurth), *Minojaponella elongata* Fujimoto et Kanuma, *Parafusulina motoyoshiensis* (Morikawa), *Chusenella pseudocrassa* Kanmera, *Nankinella* sp. C (Choi, 1973), *Eoverbeekina* sp. (Choi, 1973).

Corals:
Michelinia (Protomichelinia) multitabulata Yabe et Hayasaka, *Yatsengia kabayamensis* Minato, *Yatsengia ibukiensis* Minato, *Waagenophyllum (Waagenophyllum) polyseptata* Minato.

Calcareous Algae:
Mizzia velebitana Schubert, *Teutloporella* cf. *triasina* Schauroth.

c. *Mesolobus mesolobus* Zone, PIe

The overlying formation on the limestones represented by *Pseudofusulina fusiformis-ambigua* zone is chiefly composed of slate, and alternation of sandstone and slate, 200 m in total thickness. It is locally intercalated by seams of magnetite sandstone especially in the eastern part of the Setamai-Sakari district. Fossils are rare. The described species from this formation are as follows:

Avonia echidniformis Grabau et Chao, *Juresania juresanensis* (Tschernyschew), *Mesolobus mesolobus* (Norwood et Pratten), *Orthotetina* sp. (Nakamura, 1972), *Meekella mexicana* Girty, *Phricodothyris* sp. (Nakamura, 1959), *Schuchertella chaoi* Nakamura, *Derbyia* sp. (Nakamura, 1972), *"Productus" yohi* Chao, *Dictyoclostus* aff. *gruenewaldti* (Krotow), *Dictyoclostus taiyuanfuensis* var. *loczyi* Nakamura, *Dictyoclostus* cf. *inflatiformis* var. *expansus* (Grabau), *Dictyoclostus grabaui* Nakamura, *Dictyoclostus* sp. A (Nakamura, 1960), *Tainoceras kitakamiense* Hayasaka, *Bellerophon (Bellerophon) kitakamiensis* Murata, *"Murchisonia"* sp. (Murata, 1971), *Towapteria nipponica* Nakazawa et Newell, *Waagenoperna (Permoperna) hayamii* Nakazawa et Newell, *Aviculopecten* sp. (Murata, 1971), *Pseudoactinodontophora yabei* Murata.

C. The Kanokura Series

The Kanokura Series rests on the Sakamotozawa Series with basal conglomerate. The conglomerate seems to directly cover the limestones of either PIc or PId and sandstones characterized by *Mesolobus* fauna. Presence of unconformity between the Sakamotozawa and the Kanokura Series is almost doubtless, although the unconformity has not been evidently proved yet in the field.

The lower half of the Kanokura Series has been distinguished as the Kattisawa Stage from the upper half, the Iwaizaki Stage. It may be worth while mentioned that a few fusulinid species show a long geological range extending from the Kabayama Stage until the Kattisawa Stage: e.g. *Parafusulina motoyoshiensis, Chusenella pseudocrassa* and *Monodiexodina matsubaishi.*

1. The Kattisawa Stage

The stage is mainly composed of sandstone and alternation of sandstone and slate, besides conglomerate at its basal part. There are at least two thin layers of limestone in both upper and lower part of this formation. Fusulinids found from the upper limestone are mostly ranging upwards until the lower

part of the Iwaizaki Stage, while the fusulinids of the lower limestone seem to show somewhat older aspect.

Thus the Kattisawa Stage may be divisible into two assemblage zones.

a. *Monodiexodina kofuganensis* Zone, PIIa

Rauserella alveolaris Choi, *Yangchienia kwangsiensis* Chen, *Chusenella choshiensis* Chisaka, *Monodiexodina kofuganensis* Choi, *Cancellia* sp. (Choi, 1973), *Parafusulina iwaizakiensis* (Morikawa), *Monodiexodina matsubaishi* Fujimoto, *Codonofusiella explicata* Kawano, *Chusenella pseudocrassa* Kanmera.

b. *Leptodus nobilis* Zone, PIIb

From the carbonate rocks stratigraphically positioned in the higher level, the following fusulinids, corals, calcareous algae and bryozoa have been described.

Fusulinids:
Rauserella alveolaris Choi, *Monodiexodina matsubaishi* Fujimoto, *Pseudodoliolina gravitesta* Kanmera, *Kahlerina pachytheca* K. Devide et Ramovs, *"Colania" kozuboensis* Choi, *Parafusulina* aff. *mcclouдensis* Skinner et Wilde, *Chusenella* sp. (Choi, 1973), *Pseudodoliolina elongata* Choi, *Codonofusiella explicata* Kawano, *Verbeekina verbeeki* Geinitz.

Corals:
Waagenophyllum (Waagenophyllum) indicum (Waagen et Wentzel), *Parawentzelella (Parawentzelella) iwaizakiensis* (Yabe et Minato), *Parawentzelella (Miyagiella) miyagiensis* Minato et Kato, *Parawentzelella (Miyagiella) motoyoshiensis* Minato et Kato, *Iranophyllum (Iranophyllum) tunicatum* Igo.

Calcareous Algae:
Mizzia velebitana Schubert.

Brachiopods, bryozoa and pelecypods are not seldom found from the lower part of the Kattisawa Stage, but they are more predominant in the upper part. Fossils mainly described from the upper part may be listed below.

Bryozoas:
Fistulipora kesennumensis Sakagami, *F. megastoma* Sakagami, *Meekopora*

delicata Sakagami, *Batostomella* sp. (Sakagami, 1961), *Leioclema globosa* Crockford, *Fenestella* cf. *retiformis* (Scholtheim), *Polypora fujimotoi* Sakagami, *P. hataii* Sakagami, *P. endoi* Sakagami, *P. sugiyamae* Sakagami, *Tabulipora ?* sp. (Sakagami, 1961), *Septopora kawamatae* Sakagami, *Thamniscus* cf. *dubius* (Scholtheim), *Pennirepora kamiyatsenensis* Sakagami, *Hayasakapora ?* sp. (Sakagami, 1961), *Sulcoretepora nipponica* Sakagami.

From Iwaizaki, south of Kesennuma City, Sakagami (1961) recorded the following bryozoans.
Fistulipora cf. *timorensis* Bassler, *Fistulipora* sp., *Meekopora delicata* Sakagami, *Batostomella sponigera* Bassler, *Fenestella rhomboidea* Nikiforova, *Hayasakapora matsudae* Sakagami, *Saffordotaxis morikawae* Sakagami, *Streblascopora delicatula* Sakagami, *Sulcoretepora nipponica* Sakagami.

Brachiopoda:
Isogramma paotechowensis (Grabau et Chao), *Isogramma heritschi* Nakamura, *Permundaria asiatica* Nakamura, Kato et Choi, *P. tenuistriata* Tazawa, *Waagenoconcha humboldti* (d'Orbigny), *W. imperfecta* Prendergast, *Spinomarginifera kueichowensis* Huang, *S. huangi* Nakamura, *Dictyoclostus* aff. *spiralis* (Waagen), *D. sino-indicus* (Frech), *Orthotetina hayasakai* Nakamura, *O. elongata* Nakamura, *O. kayseri* (Jäkel), *O. polita* Fliegel, *O. transversa* Nakamura, *O.* sp. A (Nakamura, 1972), *Meekella* cf. *striatocostata* (Cox), *M.* cf. *eximia* (Eichwald), *M. garnieri* Bayan, *M. nodosa* Nakamura, *M. minatoi* Nakamura, *M.* sp. (Nakamura, 1972), *Schuchertella frechi* Huang, *S.* cf. *beyrichi* (Rothpletz), *Streptorhynchus pelargonatus* Schlotheim, *Derbyia nipponica* Nakamura, *D.* cf. *acutiplicata* Metz, *D.* sp. A (Nakamura, 1972), *Leptodus richthofeni* Kayser em. Hayasaka, *"Productus" flemingi* De Koninck, *"Productus" horridus* Sowerby, *"Productus" vishnu* Waagen, *Dielasma* cf. *biplex* Waagen, *"Spiriferina" cristata* Schlotheim, *Leptodus nobilis* Waagen, *Chonetes blanfordi* Reed, *C. sinuosa* Schellwien, *Linoproductus cora* (d'Orbigny), *Rhynchonella (Uncinulus) jabiensis* Waagen, *Spiriferella* cf. *saranae* mut. *lita* (Fredericks), *Orbiculoidea* sp. (Hayasaka, 1963), *Punctospirifer mesocostatus* Hayasaka, *Martiniopsis cathaysiensis* Grabau, *Geyerella arakii* Hayasaka, *G. koizumii* Hayasaka, *Camarophoria humbletonensis* Howse, *Cancrinella villiersi kozlowskiana* Fredericks, *C. cancriniformis spinosa* Hayasaka et Minato, *Martinia semiplana* Waagen, *M. semiplana* var. *lata* Grabau, *? "Spirifer" lyra* Kutorga, *Neospirifer fasciger* (Keyserling), *Orthotetina kitakamiensis* (Hayasaka), *Orthotetes rugosa* Fredericks, *Kiangsiella* cf. *condoni* (Thomas), *Productella patula* Girty, *Martinia rostrata* Girty, *Rhipidomella* sp., *Derbyia hemisphaerica* Waagen, *Waagenites deplanata* (Waagen), *W. barusiensis*

(Davidson), *"Productus" gratiosus* Waagen, *"P." carinatus* Chi-Thuan, *Anidanthus* sp. (Tazawa, 1976), *Echinoconchus fasciatus* Kutorga, *E. taimyrensis* Einor, *Cancrinella cancriniformis* (Tschernyschew), *Nantanella* sp. (Tazawa, 1976), *Spiriferella keilhavii* (von Buch), *Callispirina ornata* (Waagen).

Pelecypoda:
Parallelodon cf. *longus* Maslennikov, *P.* cf. *tenuistriatus* (Meek et Worthen), *Aviculopinna rectangularis* (Hayasaka), *Aviculopecten hataii* Murata, *A.* cf. *hataii* Murata, *A.* sp. A (Nakazawa et Newell, 1968), *Aviculopecten (Deltopecten) hiemalis* Salter, *Hayasakapecten sasakii* (Murata), *Etheripecten ? hayasakai* (Murata), *Acanthopecten spinosus* Hayasaka, *A. onukii* Murata, *A.* cf. *coloradoensis* (Newberry), *Streblopteria* sp. A (Nakazawa and Newell, 1968), *S. ?* sp. B (Nakazawa and Newell, 1968), *Cyrtorostra* cf. *lunwalensis* (Reed), *Euchondria ? kesennensis* (Hayasaka), *Annuliconcha kitakamiensis* Murata, *Schizodus tobai* (Hayasaka), *Astartella ?* sp. (Nakazawa and Newell, 1968), *Sanguinolites* sp. (Nakazawa and Newell, 1968), *S. kamiyassensis* Nakazawa et Newell, *Wilkingia* sp. (Nakazawa and Newell, 1968), *Waagenoperna (Permoperna) hayamii* Nakazawa et Newell, *Edmondia* sp. (Hayasaka, 1967), *Edmondia* sp. (Nakazawa and Newell, 1968), *Promytilus maiyaensis* Nakazawa et Newell, *Leptodesma (Leiopteria)* sp., *Towapteria nipponica* Nakazawa et Newell, *Enisipteria onukii* Nakazawa et Newell, *Hayasakapecten shimizui* Nakazawa et Newell, *Pernopecten* sp. (Nakazawa and Newell, 1968), *Lopha ? teranosawensis* Nakazawa et Newell, *Neoschizodus (Neoschizodus) kitakamiensis* Nakazawa et Newell, *Netshajewia* sp. (Nakazawa and Newell, 1968), *Stutchburia ?* sp. (Nakazawa and Newell, 1968), *Myoconcha* sp. (Hayasaka, 1967), *Allorisma* sp. (Hayasaka, 1967).

Cephalopoda:
Cibolites cf. *uddeni* Plummer et Scott, *Tainoceras abukumense* Hayasaka, *Tainoceras kitakamiensis* Hayasaka, *Foordiceras akiyamai* Hayasaka, *Paraceltites* aff. *elegans* Girty, *Tyronautilus permicus* Hayasaka, *Foordiceras whynneiformis* Hayasaka et Ozaki, *Agathiceras* aff. *suessi* Gemm., *Propinacoceras* aff. *galilaei* Gemm., *Stacheoceras iwaizakiense* Mabuti, *Hanieloceras intermedium* (Wanner), *Medlicottia* sp. (Hayasaka, 1954).

Conulariida:
Neoconularia rectangularis (Hayasaka), *Neoconularia* sp. (Hayasaka, 1963), *Calloconularia ? kitakamiensis* Murata.

Trilobita:
Pseudophillipsia obtusicauda (Kayser).

Monodiexodina matsubaishi is especially dominant throughout the Kattisawa Stage; *Rauserella alveolaris* also ranges from the lower to the upper division of the stage. Presence of *Cancellina* in the *Monodiexodina kofuganensis* zone is remarkable. While, *Colania kozuboensis* Choi found from the upper part of the Kattisawa Stage very resembles *"Neoschwagerina" douvillei* Ozawa, although *Colania kozuboensis* shows to range further upwards until the lower horizon of the Iwaizaki Stage.

2. The Iwaizaki Stage

The lower part of the Iwaizaki Stage is lithologically changeable from place to place; usually limestone or limestone and slate in alternation. But it is also represented by thick conglomerate with limestone lenses. Therefore, the lowest level of the Iwaizaki Stage has been defined at the first appearance of the *Lepidolina* fauna.

Lepidolina multiseptata-L. minatoi Zone, PIIc

Described fossils from this zone may be listed below:

Fusulinids:
Lepidolina multiseptata (Deprat), *Nankinella* sp. A (Choi, 1973), *Pseudodoliolina gravitesta* Kanmera, *Kahlerina pachytheca* K. Devide et Ramovs, *Lepidolina minatoi* Choi, *Lepidolina kumaensis* Kanmera, *"Colania" kozuboensis* Choi, *Schwagerina acris* Thompson et Wheeler, *Parafusulina* aff. *mcclouden-sis* Skinner et Wilde, *Chusenella* sp. (Choi, 1973), *Pseudodoliolina elongata* Choi, *Pseudodoliolina kanokuraensis* Choi, *Dunbarula kitakamiensis* Choi, *Codonofusiella inuboensis* (Chisaka), *Pseudofusulina chihsiensis* (Lee), *Rauserella pachytheca* Choi, *Verbeekina verbeeki* (Geinitz).

Brachiopoda:
Aulosteges sp. (Hayasaka, 1964), *Spinomarginifera huangi* Nakamura, *Gratiosina gratiosus* (Waagen), *Waagenoconcha humboldti* (d'Orbigny), *Waagenoconcha purdoni* (Davidson), *Martinia semiplana* Waagen, *Scacchinella* cf. *gigantea* Schellwien, *Richthofenia* sp., *Leptodus richthofeni* (Kayser), *Spirifer* cf. *saranae* Vern. mut. *lita* Fredericks, *Productus* sp. (Mabuti, 1935), *Spiriferina cristata* Schlotheim, *Spirifer* sp. (Mabuti, 1935), *Camarophoria* sp.,

Meekella gigantea Hayasaka, *M.* sp. (Koizumi, 1964), *Orthotetina* sp. (Koizumi, 1964), *Geyerella* sp. (Koizumi, 1964).

Ammonoids:
Propinacoceras aff. *galilaei* Gemmellaro, *Tainoceras abukumaensis* Hayasaka, *Foordiceras akiyamai* Hayasaka.

Corals:
Waagenophyllum (Waagenophyllum) indicum (Waagen et Wentzel), *Wentzelloides maiyaensis* Yabe et Minato, *Parawentzelella (Parawentzelella) canalifera sisophonensis* Fontaine, *Wentzelella (Szechuanophyllum) kitakamiensis* Yabe et Minato, *Yatsengia kiangsuensis* var. *mabutii* Minato.

Calcareous Algae:
Mizzia velebitana Schubert

Ostracods:
Holinella elliptica Ishizaki, *Aurikirkbya formula* Ishizaki, *A. subkellettae* Ishizaki, *Kirkbya atolla* Ishizaki, *K. centrotumida* Ishizaki, *K. magniforma* Ishizaki, *K. multicresta* Ishizaki, *K. subnipponica* Ishizaki, *K. subquadriforma* Ishizaki, *Amphissites centronotus* (Ulrich et Bassler), *Ectodemites globosa* Ishizaki, *Polytylites kitanipponica* Ishizaki, *Roundyella neopapillosa* Ishizaki, *Bairdia eucurvia* Ishizaki, *B. nagaiwensis* Ishizaki, *B.* cfr. *oklahomaensis* Harlton, *B. trianguliformis* Chen, *Bairdiacypris deloi* Bradfield, *Ceratobairdia ? ambigua* Ishizaki, *Spinobairdia* sp., *Cavellina ? nipponica* Ishizaki, *Tubulibairdia venusta* (Chen).

Bryozoa:
Fistulipora iwaizakiensis Sakagami, *F.* cf. *timorensis* Bassler, *F.* sp. (Sakagami, 1961), *Meekopora densa* Sakagami, *Ramipora ambigua* Sakagami, *Goniocladia intricata* Sakagami, *Coscinotrypa ?* sp. (Sakagami, 1961), *Batostomella igoi* Sakagami, *B. microstoma* Sakagami, *Dyscritella cylindrica* (Crockford) ?, *Coeloclemis minima* Sakagami, *Fenestella* spp. (Sakagami, 1961), *Polypora* spp. (Sakagami, 1961), *Penniretepora iwaizakiensis* Sakagami, *P. tenuis* Sakagami, *P. akiyamae* Sakagami, *Hayasakapora erectoradiata* Sakagami, *Streblascopora delicatula* Sakagami, *Clansotrypa exillis* Sakagami.

Many fusulinid species characterizing the *Leptodus nobilis* Zone disappear in the earlier half of the present zone. Rugose corals belonging to Waagenophyllidae seem to have been almost extinct in this zone.

Lepidolina minatoi appears to be more dominant in the upper part. *Schwagerina acris* occurs at the highest level with *Lepidolina multiseptata* and *Condonofusiella explicata.*

D. The Toyoma Series

The thick Toyoma Series is lithologically divisible into two major units: the Maehama Stage and Nabekoshi Stage in ascending order. The former of them is mainly composed of slate, with conglomerate at its base, while the latter is chiefly composed of sandstone with intercalations of thin limestone and conglomerate lense.

Characteristic and described fossils from this series may be listed below.

1. The Maehama Stage

Araxoceras cf. *kiangsiense* Zone, PIIIa

Astartella toyomensis Nakazawa et Newell, *Palaeoneilo ogachiensis* Hayasaka, *Bellerophon (Bellerophon) yabei* Murata, *Euphemitopsis kitakamiensis* Murata, *Paraconularia siitai* (Sugiyama), *Araxoceras* cf. *kiangsiense* Chao, *Protocycloceras* cfr. *cyclophorum* (Waagen), *Stacheoceras* cf. *trimuvii* Diener, *Eumedlicottia* sp. (Bando, 1975), *Artinskia* sp. (Bando, 1975).

Among them, *Araxoceras* cf. *kiangsiense* occupies rather higher level than the other species.

2. The Nabekoshi Stage

Colaniella parva Zone, PIIIb

Colaniella parva (Colani), *Paracolaniella leei* Wang, *Lantschichites* sp. (Tazawa, 1975), *Orthothrix* cf. *excavata* (Geinitz), *Tschernyschewia typica* Stoyanow, *Megousia nakamurai* Tazawa, *Megousia auriculata* Muir-Wood et Cooper, *Paramarginifera japonica* Tazawa, *Eolyttonia* cf. *nakazawai* Shimizu, *Palaeofusulina* sp.

From the Toyoma Series the following land plants were recorded by Endo (1950) and Konno (1973):

Neocalamites superpermicus Konno, *Paracalamites iwatensis* Konno, *P. takahashii* (Endo).

Exact horizon for them is, however, difficult to mention at present.

Kuma Mountain District

The Kuma mountain district in central Kyushu is a terrain where Permian clastic sediments are predominantly developed, which is intercalated by large and small limestone lenses at various horizons. Biostratigraphy in the Kuma mountain region was worked out in detail by Kanmera 1954, 1958, 1963. But Permian sediments are so much folded and faulted that a continuous stratigraphic succession is difficult to establish there.

The Yayamadake limestone furnishes a good section for *Pseudoschwagerina* limestone, which is said to unconformably cover the *Triticites* limestone (Kanmera, 1952).

According to Kanmera (1958) the upper part of the Yayamadake limestone is defined as *Pseudoschwagerina* Zone which is further divisible into two fossil Zones.

The lower fossil Zone, *Pseudoschwagerina morikawai* Zone, yields *Pseudoschwagerina morikawai* Igo, *Triticites montiparus* (Möller), *T. ozawai* Toriyama, *T.* aff. *haydeni* (Ozawa), *T.* sp. (Kanmera, 1958), *T. yayamadakensis evectus* Kanmera, *Rugosofusulina prisca* [Ehrenberg (Möller)], *Schwagerina* cf. *alpina* (Schellwien), *Quasifusulina longissima ultima* Kanmera.

The Upper fossil Zone is called *Pseudoschwagerina minatoi* Zone which yields *Pseudoschwagerina minatoi* Kanmera, *Paraschwagerina shimodakensis* Kanmera, *Triticites samaricus* Rauser-Chernoussova, *T. fornicus* Kanmera. *T.* aff. *pusillum* (Schellwien), *T.* sp. (Kanmera, 1958), *Rugosofusulina pristina* Kanmera, *Pseudofusulina regularis* (Schellwien), *Pseudofusulina* sp. (Kanmera, 1958), *Psf. sokensis* Rauser-Chernoussova, *Psf. horrida* Kanmera, *Psf. kumasoana* Kanmera, *Schwagerina stabilis* (Rauser-Chernoussova), *Schw. krotowi* (Schellwien), *Schw. grandensis* Thompson, *Nankinella kotakiensis* (Fujimoto et Kawada), *N. kawadai* (Igo).

The upper part of the Yayamadake limestone is superceded by pyroclastic deposits which produce no fossils.

To the south to the area of the Yayamadake limestone there develops the Kozaki formation consisting of slate and conglomerate in alternation with some limestone lenses which yield fossils. The formation is bounded by faults and is lithologically divided into the lower and upper subformations. The lower part is further faunistically contains two fossil horizons (Kanmera, 1961, 1963).

From the lower part the following fusulinids were described:
Misellina claudiae (Deprat), *Nankinella kozakiensis* Kanmera, *Sphaerulina crassispira japonica* Kanmera, *Minojapanella* sp., *Toriyamaia laxiseptata* Kanmera, *Nagatoella* sp., *Parafusulina (Skinnerella) gruperaensis* Thompson et Miller, *P. (S.) figueroai* Thompson et Miller, *P. (S.) nakamigawai* Morikawa

et Horiguchi, *Monodiexodina kumensis* Kanmera.

From the upper part of the lower subformation the following fusulinids were described:

Neoschwagerina simplex (Ozawa), *Cancellina tenuitesta* Kanmera, *Verbeekina sphaera* Ozawa, *Yangchienia compressa* Ozawa, *Parafusulina (Parafusulina) kaerimizensis* (Ozawa), *P. (Skinnerella)* cf. *sapperi* (Staff), *Pseudodoliolina pseudolepida* (Deprat), *Verbeekina* sp.

Also from the topmost part of the Kozaki formation Kanmera (1963) recorded *Yabeina globosa* (Yabe), *Neoschwagerina minoensis* Deprat, *N. margaritae* Deprat, *Schwagerina* sp.

In between the area of the Yayamadake limestone and the area of the Kozaki formation there is distributed the Upper Permian Kuma formation, which is composed of sandstone, slate and conglomerate in alternation with severel small lenses of limestone. This formation is again in fault contact with the other formations of different ages.

Fossils occur at three different horizons (Kanmera, 1954; Kanmera & Nakazawa, 1973).

From the lowest horizon *Lepidolina multiseptata shiraiwensis* (Ozawa), *Codonofusiella cuniculata* Kanmera and *Schwagerina* aff. *acris* Thompson et Wheeler were obtained.

The middle horizon is characterized by the association of *Lepidolina kumaensis* Kanmera, *L. multiseptata* (Deprat), *Metadoliolina gravitesta* (Kanmera), *Chusenella pseudocrassa* (Kanmera), *Codonofusiella cuniculata* Kanmera, *Dunbarula* sp., *Rauserella* sp., *Reichelina* sp., *Parareichelina subangusta* Sosnina, *Sichotenella maichensis* Sosnina, *Staffella* sp., *Nankinella* sp., *Colaniella* sp., *C. (Wanganella)* sp., and *Nodosaria grandecamerata* Sosnina.

The upper horizon yields *Waagenophyllum indicum* (Waagen et Wentzel), *Wentzelella ?* sp., *Codonofusiella* sp., *Pachyphloia* sp., *Nodosaria mirabilis* Lipina, *N. linae* M-Maklay, *Geinitzina* sp., *Cribrogenerina* sp., *Climaccammina* sp., *Robuloides* cf. *lens* Reichel, *Hemigordius* sp., *Agathammina* sp., and *Archaediscus* sp.

Here it became clear that *Lepidolina kumaensis* occurs later than *Lepidolina multiseptata,* and that it is followed in turn by the uppermost horizon with *Codonofusiella* fauna.

Oita Prefecture

Quite recently the presence of *Codonofusiella – Palaeofusulina* fauna was ascertained by Kanmera both in the Oita and Miyazaki Prefectures (Kanmera &

Nakazawa, 1973; Working Group, 1975).

Uppermost part of the Tsukumi limestone formation in the Oita Prefecture is largely dolomitized in lithologic character. The thickness is about 60 m and the limestone is faunistically divisible into two zones.

Staffella sp., *Nankinella* sp., *Danbarula ?* sp., and *Codonofusiella* sp. occur in the upper, while *Staffella* sp., *Nankinella* sp., *Reichelina changhsingensis* Sheng et Chang, *Palaeofusulina* sp., *Codonofusiella kueichowensis* Sheng occur in the lower.

The mentioned part of limestone of the Tsukumi formation is in fault contact with *Yabeina – Neoschwagerina* limestone and is considered to represent the uppermost Permian there.

A very similar faunal sequence is also known in the Mitai formation in the Miyazaki Prefecture, where *Palaeofusulina* cf. *simplicata* Scheng was obtained.

Akiyoshi Limestone Plateau

In the Akiyoshi limestone plateau Permian limestone is widely developed. Permian there is supposed to be unconformably overlying the Carboniferous limestone. Also an unconformity is suspected between *Parafusulina* limestone and *Pseudofusulina* limestone. Development of carbonate facies is however terminated by the top of *Yabeina shiraiwensis* limestone which is laterally changed into slate facies. Fossils denoting the uppermost Permian has not been recorded from Akiyoshi.

Since Ozawa (1925) there are a number of important stratigraphical as well as palaeontological contributions on the Permian of Akiyoshi (*e.g.* Toriyama (1954–1958); Hasegawa (1958, 1963); Ota et al. (1973)).

According to Hasegawa (1963) Permian fossils from the Akiyoshi limestone are as listed below in descending order:

Limestone of *Yabeina-Lepidolina* zone ..... about 20 m
Fossils: *Lepidolina shiraiwensis* (Ozawa), *L. yasubaensis* (Toriyama), *Schwagerina* spp., *Akagophyllum hasegawai* Minato et Kato, *Waagenophyllum (s.s.) akasakense* (Yabe), *Yatsengia* cf. *ibukiense* Minato, *Ipciphyllum subtimoricum* (Huang), *Pavastehphyllum* sp. and *Lophophyllidium ?* sp.

Limestone of the *Neoschwagerina-Verbeekina* zone;
Gifuella douvillei subzone ..... 25 m
Fossils: *Gifuella douvillei* (Ozawa), *Neoschwagerina* sp. and *"Lonsdaleiastraea" ozawai* Minato

Verbeekina verbeeki subzone ..... 35 m
Fossils: *Verbeekina verbeeki* (Geinitz) and *Schwagerina* spp.

Neoschwagerina haydeni subzone ..... 7 m
Fossils: *Neoschwagerina haydeni* Dutkevich et Khabakov, *N. craticulifera* (Schwag.), *N.* cf. *colaniae* Ozawa, *N.* sp., *Gifuella gifuensis* Honjo, *G.* sp., *Pseudodoliolina pseudolepida* (Deprat), *P. ozawai* Yabe et Hanzawa, *P.* sp. A. and *Pseudofusulina gigantea* (Deprat)

Verbeekina heimi subzone ..... 18 m
Fossils: *Verbeekina heimi* Thompson, *V. verbeeki* (Geinitz), *Pseudofusulina edoensis* (Ozawa), *P. gigantea* (Deprat), *Afghanella schencki* Thompson, *A. ozawai* Hanzawa, *Pseudodoliolina* cf. *pseudolepida* (Deprat) and *P. ozawai* Yabe et Hanzawa

Neoschwagerina craticulifera subzone ..... 20 m
Fossils: *Neoschwagerina craticulifera* (Schwager), *N. irregularis* Honjo, *N. simplex* Ozawa, *N.* sp., *Parafusulina kaerimizensis* Ozawa, *Yatsengia* sp. and *Waagenophyllum* sp.

Limestone of the *Parafusulina* zone ..... 40 m
Fossils: *Parafusulina kaerimizensis* Ozawa, *P. lutugini* (Schellwien), *P.* spp., *Pseudofusulina* sp., *Afghanella schencki* Thompson, *A. ozawai* Hanzawa and *Ipciphyllum subtimoricum* (Huang)

Limestone of the *Pseudofusulina* zone:

Pseudofusulina kraffti magna subzone ..... 110 m
Fossils: *Pseudofusulina kraffti magna* Toriyama, *P. yobarensis* (Ozawa), *P. lepida* (Deprat), *P.* cf. *edoensis* (Ozawa), *P.* cf. *vulgaris globosa* (Schellwien), *Schwagerina krotowi* (Schellwien), *S.* cf. *regularis* (Schellwien), *S.* cf. *kueichihensis* (Chen), *S.* sp. A., *Misellina claudiae* (Deprat), *Nagatoella kobayashii* Thompson, *Schubertella kingi* Dunbar et Skinner, *Staffella yobarensis* Ozawa, *S.* sp., *Akagophyllum yabei* Minato et Kato, *A. akagoense* (Ozawa) and *Yokoyamaella yokoyamai* (Ozawa)

Pseudofusulina vulgaris subzone ..... 150 m
Fossils: *Pseudofusulina vulgaris* (Schellwien), *P. vulgaris megaspherica* Toriyama, *P. globosa exilis* Toriyama, *P. watanabei* (Ozawa), *P. yobarensis* (Ozawa), *P.* cf. *ambigua* (Deprat), *Schwagerina satoi* (Ozawa), *S. etoi* Toriyama, *S.* cf. *krotowi* (Schellwien), *Dunbarinella cervicalis* (Chen), *D.* cf. *densa* Toriyama, *Triticites ellipsoidalis* Toriyama, *T.* spp., *Paraschwagerina akiyoshiensis* Toriyama, *P.* sp., and *Schubertella kingi* (Dunbar et Skinner)

Limestone of the *Pseudoschwagerina* zone:

Pseudoschwagerina muongthensis subzone ..... 100 m
Fossils: *Pseudoschwagerina muongthensis* (Deprat), *P.* sp. A, *Triticites simplex* (Schellwien), *T. ozawai* Toriyama, *T. montipara* (Ehrenberg

Möller), *T. pseudosimplex* Chen, *T. biconica* Toriyama, *T. cullomensis* Dunbar et Condra, *T. suzukii* (Ozawa), *T. haydeni* (Ozawa), *T. noinskyi paula* Toriyama, *T. tantula* Toriyama, *T. arctica* (Schellwien), *T.* cf. *ellipsoidalis* Toriyama, *T.* spp., *Dunbarinella ?* sp., *Schwagerina* cf. *satoi* (Ozawa), *S. regularis* (Schellwien), *Paraschwagerina* cf. *akiyoshiensis* Toriyama and *Schubertella kingi* Dunbar et Skinner

Triticites simplex subzone ..... 100 m

Fossils: *Triticites simplex* (Schellwien), *T. ozawai* Toriyama, *T. montipara* (Ehrenberg Möller), *T. pseudosimplex* Chen, *T. biconica* Toriyama, *T. cullomensis* Dunbar et Condra, *T. suzukii* (Ozawa), *T. noinskyi paula* Toriyama, *T. arctica* (Schellwien), *T.* spp., *Quasifusulina longissima* (Möller), *Schubertella kingi* Dunbar et Skinner

Apart from fusulinids and corals listed above some bryozoans and algae have been added to the faunal as well as floral contents of the Akiyoshi limestone. But other group of fossils, being scarce except for abundant crinoid stem joints, have been little investigated.

Atetsu Limestone Plateau

On the Permian part of the Atetsu limestone there are two major biostratigraphical contributions; namely by Nogami 1961a,b, 1962 and by Sada, 1965.

Here we follow Nogami for the division and faunal contents of the Permian of Atetsu.

Nogami's scheme is tabulated in the accompanied chart, and his zones and subzones with fossil contents are listed below in ascending order.

Pseudoschwagerina subsphaerica – Quasifusulina longissima ultima Zone

Quasifusulina longissima ultima – "Pseudoschwagerina" nakazawai subzone

Oolitic limestone of about 50–70 m thick.

Fusulinids are *Triticites ozawai* Toriyama, *T. montiparus* [Ehrenberg (Möller)], *T. gravitesta* Nogami, *T. obai* Toriyama, *T. haydeni* (Ozawa), *T. pseudoarcticus* Rauser-Chernoussova, *T.* aff. *contractus* (Schellwien), *T.* spp., *"Schwagerina"* aff. *alpina* (Schellwien), *Rugosofusulina* aff. *serrata* Rauser-Chernoussova and *"Pseudoschwagerina" nakazawai* Nogami.

Pseudoschwagerina subsphaerica subzone

Muddy limestone of 40 m thick.

Fusulinids are *Pseudoschwagerina subsphaerica* Nogami, *Paraschwagerina kanmerai* Nogami, *Pseudofusulina atetsuensis* Nogami, *Schwagerina*

primigena Nogami, *Triticites obai* Toriyama, *T. pseudoarcticus* Rauser-Chernoussova, *T.* sp., and *"Schwagerina"* aff. *alpina* (Schellwien).

Pseudofusulina vulgaris Zone

About 80 thick conglomeratic limestone.

Fossils are *Pseudofusulina vulgaris* (Schellwien), *Psf. vulgaris globosa* (Schellwien), *Psf. vulgaris exigua* (Schellwien), *Schwagerina* spp., *Psf. kraffti magna* Toriyama, *Psf. kraffti* form A, *Psf.* aff. *fusiformis* (Schellwien), *Nagatoella kobayashii* Thompson, and *"Triticites" pseudosimplex* Chen.

Parafusulina kaerimizensis – Pseudofusulina kraffti magna Zone

Pseudofusulina kraffti magna subzone

Massive limestone and conglomeratic limestone.

Thickness is about 40–60 m.

Fossils are *Pseudofusulina kraffti magna* Toriyama, *Psf. kraffti* form A, *Psf. globosa exilis* Toriyama, *Psf.* aff. *fusiformis* (Schellwien), *Nagatoella kobayashii* Thompson, *Schwagerina* sp., *Psf. vulgaris* (Schellwien), *Psf. vulgaris globosa* (Schellwien), *Psf.* aff. *edoensis* (Ozawa), *Schwagerina semilucera* Nogami, *Sch. semilucera grande* Nogami, *Rauserella* sp. and *Misellina* sp.

Parafusulina kaerimizensis subzone

Massive limestone of about 10 m thick.

Fossils are *Parafusilina kaerimizensis* (Ozawa), *Pseudodoliolina ozawai* Yabe et Hanzawa, and *Pseudofusulina* aff. *edoensis* (Ozawa).

Neoschwagerina douvillei – N. craticulifera Zone

Neoschwagerina craticulifera subzone

Conglomeratic limestone. Thickness unknown.

Fossils are *Neoschwagerina craticulifera* (Schwager), *Afghanella* sp., *Pseudodoliolina ozawai* Yabe et Hanzawa, *Pseudofusulina* aff. *edoensis* (Ozawa), *Psf. kusamensis* Nogami, *Parafusulina kaerimizensis* (Ozawa), and *Rauserella* sp.

Neoschwagerina douvillei – N. margaritae subzone

Mostly conglomeratic limestone of about 60 m thick.

Fusulinids are *Neoschwagerina douvillei* Ozawa, *N. margaritae* Deprat, *N. cheni* Sheng, *Sumatrina annae* Volz, *Pseudodoliolina pseudolepida* (Deprat), *Pseudofusulina kusamensis* Nogami, *Verbeekina verbeeki* (Geinitz), *Schwagerina globularis* (Gubler), *Neoschwagerina* sp., *Pseudodoliolina* aff. *lepida* (Schwager), *Rauserella* sp., and *Nankinella* sp.

Yabeina shiraiwensis Zone

Yabeina shiraiwensis – Y. sp. A subzone

Lithology is conglomeratic limestone in the lower part and is slate with

limestone lenses in the upper part. Thickness is not described.

Yabeina shiraiwensis Ozawa, *Y.* sp. A, *Sumatrina longissima* Deprat, *Pseudodoliolina pseudolepida* (Deprat), *Schwagerina otai* Nogami, *Verbeekina verbeeki* (Geinitz), *Schwagerina* sp., *Nankinella* sp., *Schubertella ?* sp., *Neoschwagerina margaritae* Deprat, *N. douvillei* Ozawa and *Sumatrina annae* Volz.

Yabeina shiraiwensis subzone

Mostly slate with a maximum thickness of about 100 m.

Fossils are *Yabeina shiraiwensis* Ozawa, *Neoschwagerina* sp. and *Sumatrina* sp.

Akasaka Limestone

The Akasaka limestone occupies a small hill, which is bounded to the west by a fault with non calcareous slate presumably of Permian in age. The limestone is covered by Quaternary sediments to the east. Therefore known succession represents "middle" part of Permian only, although fossils are abundant there.

Since the time of Gümbel (1878), Schwager (1883), Gottsche (1884) and Yabe (1902), Akasaka drew the attension of many palaeontologists.

Biostratigraphical studies are by Deprat (1914), Ozawa (1927), Akasaka Research Group (1956), Honjo (1959).

From the Akasaka limestone Honjo (1959) listed in descending order the following fossils:

Yabeina Zone ..... 100 m

Yabeina globosa (Yabe), *Y. katoi* Ozawa, *Neoschwagerina minoensis* Deprat.

Neoschwagerina Zone

Gifuella douvillei subzone ..... 55 m

Gifuella cf. *douvillei* (Deprat)

Yabeina ozawai subzone ..... 90 m

Verbeekina sphaera Ozawa, *Yabeina ozawai* Honjo, *Pseudofusulina* spp., *Gifuella amicula* Honjo, *G. gifuensis* Honjo, *Neoschwagerina colaniae* Ozawa, *N. haydeni* (D. et K.), *Metaschwagerina ovalis* Minato et Honjo, *Bellerophon* sp.

Neoschwagerina craticulifera subzone ..... 62 m

Neoschwagerina craticulifera (Schwager), *N. irregularis* Honjo, *N. haydeni* (D. et K.)

Pseudodoliolina ozawai subzone ..... 40 m

Pseudodoliolina ozawai Yabe et Hanzawa, *Pseudofusulina* spp., *Verbeekina verbeeki* (Geinitz), *Verbeekina* cf. *heimi* Thompson et Foster

Minoella nipponica subzone ..... 25 m

Neoschwagerina (Minoella) nipponica Ozawa, *N. (M.) eonipponica* Honjo, *N. simplex* Ozawa, *N. sphaerica* M. Maclay, *Verbeekina minatoi* Honjo (MS), *Pseudofusulina* spp., *Pseudodoliolina ozawai* Yabe et Hanzawa

Many fossils other than fusulinids have been described from the Akasaka limestone. They may be listed below.

Yabeina globosa Zone

Pelecypoda:
Etheripecten ? hayasakai (Murata) = *Aviculopecten interstialis* of Hayasaka, 1925, *Hayasakapecten minoensis* (Hayasaka), *H. reticularis* (Hayasaka), *Waagenoperna hayamii* Nakazawa et Newell, = *Liebea sinensis* of Hayasaka, 1925, *Schizodus japonicus* (Hayasaka), *Solenomorpha elegantissima* Hayasaka.

Scaphopoda:
Dentalium akasakaensis Hayasaka, *D. neornatum* Hayasaka, *D. (Laevidentalium)* cfr. *priscum* Münster, *D. (Plagioglypta) herculeum* deKoninck.

Gastropoda:
Bellerophon jonesianus deKoninck, *B. jonesianus hiulciformis* Hayasaka, *Pleurotomaria* aff. *multicarinata* Mansuy, *P. yokoyamai* Hayasaka, *Murchisonia yabei* Hayasaka, *Solenospira multicostata* Hayasaka, *Naticopsis wakimizui* Hayasaka, *N. minoensis* Hayasaka, *N. fasciata* Hayasaka, *N.* cfr. *praealta* Wanner, *Naticella japonica* Hayasaka, *T. magna* Hayasaka, *Spiromphalus yabei* Hayasaka, *Porcellia puzoides* Hayasaka, *Euconospira nipponica* Hayasaka.

Cephalopods:
Koninckoceras sp. = *Stearoceras* sp., *Coelogastrioceras giganteum* Nakazawa, *Stacheoceras* sp.

Corals:
Pseudofavosites sp., *Pseudoromingeria kotoi* (Yabe et Hayasaka), *Waagenophyllum (Waagenophyllum) polyseptatum* Minato, *W. (W.) indicum* (Waagen et Wentzel), *W. (W.). akasakense* (Yabe), *W. (W.) compactum* Minato et Kato, *W. (W.) pulchrum* Hamada.

Trilobita:
Pseudophillipsia obtusicauda Kayser.

Calcareous Algae:
Mizzia velebitana Schubert, *M. yabei* Karpinksky, *Solenopora yabei* Endo, *Epimastopora kanumai* Endo, *Ortonella akasakaensis* Endo. (All these algal species are said to occur also from the *Neoschwagerina* limestone in Akasaka).

Neoschwagerina Zone

Hydrozoa ?:
Stromatopora (Paralleropora) minoensis Yabe et Sugiyama.

Corals:
Praewentzelella honjoi Minato et Kato.

Brachiopods:
Squamularia cfr. *inequilateralis* Gemmelaro, *S. asiatica* Chao, *S. waageni* Frech, *Terebratuloidea* sp., *Leptodus richthofeni* Kayser, *Scacchinella* cfr. *gigantea* Gemmelaro, *Enteletes akasakensis* Ozawa, *E. minoensis* Hayasaka, *E. suessi* Schellwien, *Geyerella* sp.

Echinoid:
Miocidaris spinulifera Nishiyama.

Incertae sedis:
Shikamaia akasakaensis Ozaki.

Omi Limestone

Permian fusulinids at Omi were first described by Hayasaka (1924), which is followed by a number of biostratigraphical works (Kawada, 1954; Fujita, 1958; Hasegawa et al, 1969, etc.).

To date, however, a detailed description on its fauna is still not available, although overall faunal characteristics in the Omi limestone are quite like those of the Atetsu and the Akiyoshi.

Based on the work of Hasegawa et al (1969) the sequence of fusulinids in Omi may be tabulated in descending order as below:

Yabeina-Lepidolina Zone

"Yabeina" hayasakai Ozawa, *Sumatrina annae* Volz, *Reichelina* sp., *Dunbarula* sp., *Kahlerina* sp., *Chusenella* sp.

Neoschwagerina-"Gifuella" Zone

Neoschwagerina craticulifera (Schwager), *Gifuella* sp., *Gublerina* sp., *Pseudodoliolina* sp., *Neoschwagerina* sp.

Parafusulina Zone

Parafusulina kaerimuzensis (Ozawa), etc.

Pseudofusulina Zone

Pseudofusulina kraffti subzone

Pseudofusulina kraffti (Schellwien), *Schwagerina krotowi* (Schellwien), *Nagatoella kobayashii* Thompson, *Yangchienia* sp., *Misellina claudiae* (Deprat), *Staffella* sp.

Pseudofusulina vulgaris subzone

Pseudofusulina vulgaris (Schellwien), *Paraschwagerina akiyoshiensis* Toriyama, *Schwagerina satoi* (Ozawa), *Schwagerina krotowi* (Schellwien), *Eoparafusulina ellipsoidalis* (Toriyama), *Triticites* spp., *Schubertella* sp.

Pseudoschwagerina Zone

Pseudoschwagerina sp. subzone

Pseudoschwagerina sp., etc.

Triticites simplex subzone

Triticites simplex (Schellwien), *Triticites* spp.

Correlation

As described above, ammonoid cephalopods are extremely scarce within the Japanese Permian (Table 1).

Table 1 Sequence of Permian ammonites in the Kitakami mountains (after Bando, 1975)

Age	Series	Ammonoid Zones
Late Permian	Toyoma Series	*Araxoceras* cf. *kiangsiensis* Zone *Eumedlicottia* Zone
Early Permian	Kanokura Series	*Timorites intermedium* Zone *Stacheoceras iwaizakiense* Zone
	Sakamotozawa Series	(Unknown)

They are by no means sufficient for the correlation. The occurrence of corals is quite sporadical in the Japanese Permian. And Bryozoans and algae are both relatively long ranging. Condont studies began only quite recently. Only fusulinids have been studied from various districts of Japan, so far.
They occur abundantly, and therefore we have to rely heavily upon these fusulinids for the sake of Permian correlation (Toriyama, 1967).

Table 2 Succession of Japanese Permian Fusulinids

Palaeofusulina + *Colaniella parva*	
(Araxoceras)	
Lepidolina kumaensis + *L. minatoi*	
Yabeina globosa + *Lepidolina multiseptata*	
"Neoschwagerina" douvillei	
Neoschwagerina margaritae	
Neoschwagerina craticulifera	
Neoschwagerina simplex + *Parafusulina kaerimizensis*	
Cancellina, Minoella, Maklaya	*
Misellina, Toriyamaia, Nagatoella	*
Pseudofusulina kraffti + *P. ambigua*	*
"Pseudofusulina" vulgaris + *Paraschwagerina*	
Pseudoschwagerina + *Triticites*	
Triticites + primitive *Pseudoschwagerina* + *Quasifusulina*	

* distinction between these three assemblages has not been firmly established as yet.

Table 2 is a scheme of fusulinid succession in Japan, which is applicable to carbonate facies, and to such mixed environment that we have in the Kitakami mountains, to some extent.

Figure 2 is an attempt to correlate the Japanese Permian in the districts described above. As may be seen from the figure, three fold division of the Permian System may be tenable in Japan, especially in the Kitakami mountains.

International correlation posed difficulty since the world standard regions for Permian, *e.g.* Uralian and North American basin, are all beyond the Tethyan faunal realm.

With South China, however, the Japanese Permian correlates quite well.

Lower part of the Kawaguchi Stage of the Sakamotozawa Series, with the entry of *Pseudoschwagerina* is correlatable with the Chuanshanian and

Mapingian in China.

The Chihsian in South China now comprises both *Misellina* subzone and *Cancellina* subzone, the latter of which yields *Pseudodoliolina* (Sheng and Lee, 1974). Thus it is correlatable with the upper part of the Kawaguchi Stage and the Kabayama Stage, both of the Sakamotozawa Series, and the lower part of the Kattisawa Stage of the Kanokura Series, from which *Cancellina* sp. was obtained (Choi, 1970). The rest of the Kanokura Series is correlatable with the Maokou limestone which comprises both *Neoschwagerina* and *Yabeina* zones.

In Japan, *Lepidolina kumaensis* and *L. minatoi* occur a little later than the first occurrence of *L. multiseptata*. It is certain that the top part of the Maokou limestone with *Yabeina* fauna corresponds to the Japanese *Yabeina globosa-Lepidolina multiseptata* Zone. But whether the part does include deposits corresponding to the Japanese *L. kumaensis* – *L. minatoi* zone or not is still an open question.

The newly proposed Maehama Stage corresponds to the Wuchiaping limestone based on the common occurrence of *Araxoceras* both in China and Japan. Also the Chinese Changhsing limestone is equivalent to the Nabekoshi Stage in the Kitakami mountains with *Colaniella* – *Palaeofusulina* fauna. Thus almost the whole Lopingian is correlatable with the Toyoma Series (Table 3).

Table 3 Correlation of the Permian of Japan, South China and the USSR

<table>
<tr><th colspan="2">Kitakami Mts., Japan
(Minato et al, this paper)</th><th colspan="3">South China
(Sheng & Lee, 1974)</th><th>U. S. S. R.
(Correlation after Kahler, 1974)</th></tr>
<tr><td rowspan="2">Toyoma Series</td><td>Nabekoshi Stage</td><td rowspan="2">Loping Series</td><td>Changhsing Lst.</td><td>Palaeofusulina</td><td rowspan="2">Tatarian</td></tr>
<tr><td>Maehama Stage</td><td>Wuchiaping Lst.</td><td>Codonofusiella</td></tr>
<tr><td rowspan="3">Kanokura Series</td><td>Iwaizaki Stage</td><td rowspan="5">Yangsing Series</td><td rowspan="2">Maokou Lst.</td><td>Yabeina</td><td rowspan="2">Kazanian
Ufimian</td></tr>
<tr><td rowspan="2">Kattisawa Stage</td><td>Neoschwagerina</td></tr>
<tr><td rowspan="2">Chihsia Lst.</td><td>Cancellina</td><td>Kungurian</td></tr>
<tr><td rowspan="2">Sakamotozawa Series</td><td>Kabayama Stage</td><td>Misellina</td><td>Artinskian</td></tr>
<tr><td>Kawaguchi Stage</td><td colspan="2">Chuanshan Lst.</td><td>Pseudoschwagerina</td><td>Sakmarian
Asselian</td></tr>
</table>

For further international correlation we have no new data of our own. But such an attempt based on fusulinids was presented by Kahler (1974), and we wish to follow him.

Thus the lower part of the Kawaguchi Stage, *Lophocarinophyllum suetomii* Zone, is the Asselian, being situated below the bed with *Pseudoschwagerina schellwieni* and *Zellia* of Sakmarian. The upper part of the Kawaguchi Stage, especially the earlier half of it is correlatable with the Sakmarian with the entry of *Pseudoschwagerina schellwieni.* The Artinskian starts with the appearence of *Pseudofusulina vulgaris* and may be equivalent to the rest of the Sakamotozawa Series. The Kungurian is designated by Kahler as *Cancellina* zone, which in the Kitakami mountains may be equivalent to the lower part of the Kattisawa Stage. The Kazanian and the Ufimian are both thought by Kahler as possible equivalent of *Neoschwagerina* zone, which is correlated with the later half of the Kattisawa Stage of the Kanokura Series. Tatarian starts from the *Yabeina – Lepidolina* zone. Therefore the Iwaizaki Stage of the Kanokura Series and the Toyoma Series may be the Tatarian.

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