The so-called Turonian-Coniacian boundary in Japan

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The Mikasa area of central Hokkaido provides a series of reference sections of an Upper Turonian and Coniacian mega-fossil sequence. There are four places within the area where continuous outcrops are visible and these are described in detail. There is considerable variation in the mode of occurrence of ammonite and inoceramid species from place to place, probably as a result of changes in environmental conditions. A revised scheme of zonation is established for the Upper Turonian and the Coniacian in the Japanese province, as shown in Table 1. The boundary between the stages is tentatively drawn between the Zone of *Inoceramus teshioensis-Mytiloides incertus-Subprionocyclus neptuni* below and the Zone of *Inoceramus rotundatus-Forresteria (Reesideoceras) petrocoriensis* above, and is very probably equivalent to the Turonian/Coniaccian stage boundary in the European standard sequence. Some species in the zonal assemblages recognized are useful for tracing the boundary into other regions.

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Introduction

The faunas of the Cretaceous Japanese province are very different from those of Europe, where the stratotypes of the Cretaceous stages are located. Because of this marked faunal dissimilarity, provincial subdivisions such as the Gyliakian, Urakawan etc., have been used for more than 50 years since their proposal by Yabe (1927). This is convenient and I myself once revised the scheme (Matsumoto, 1954, pl. 15), but since geology is a global science, it is desirable to maintain international uniformity in stage terminology. As a result I have endeavoured, sometimes together with my colleagues, to construct a scheme of biostratigraphic subdivisions which would hopefully be used both for intra-provincial and also inter-regional correlation. The scheme in fig. 1 in Takayanagi & Matsumoto (1981) has thus been proposed for the Upper Cretaceous of the Japanese province on the basis of ammonite and inoceramid occurrences.

Although I omit to explain the details of that scheme on this occasion, one can now state approximately the age of a subdivisions in the Japanese province in terms of the international scale. Because of the faunal dissimilarity, however, the correlation is not as precise as is desirable. Speaking strictly the Upper Gyliakian (K4b) and the Lower Urakawan (K5a) in the Japanese scheme are the approximate correlatives of the Turonian and the Coniacian respectively.

When we consider the stage boundary problem, I generally meet difficulty as to how to correlate precisely our 'boundary' with the well defined type boundary which itself is now under debate. In this paper the so-called Turonian-Coniacian boundary is selected, because some contributions may be given from the results of the study of the available material in Japan.

Reference sequences in Hokkaido

Figure 1 is an outline map of the main part of Hokkaido in which the outcrop area of post-Aptian Cretaceous strata is shown. Numbers on the map indicate the locations of reference or provincial standard sequences for the zonation mentioned above. Of 12 localities, the Mikasa district (indicated as 4) is the best for the study of the so-called Turonian-Coniacian boundary.

In the Mikasa district, (formerly the Ikushumbets area – an Ainuan place name), there is an anticline and a thrust, as a result of which strata at and near the boundary are exposed in four

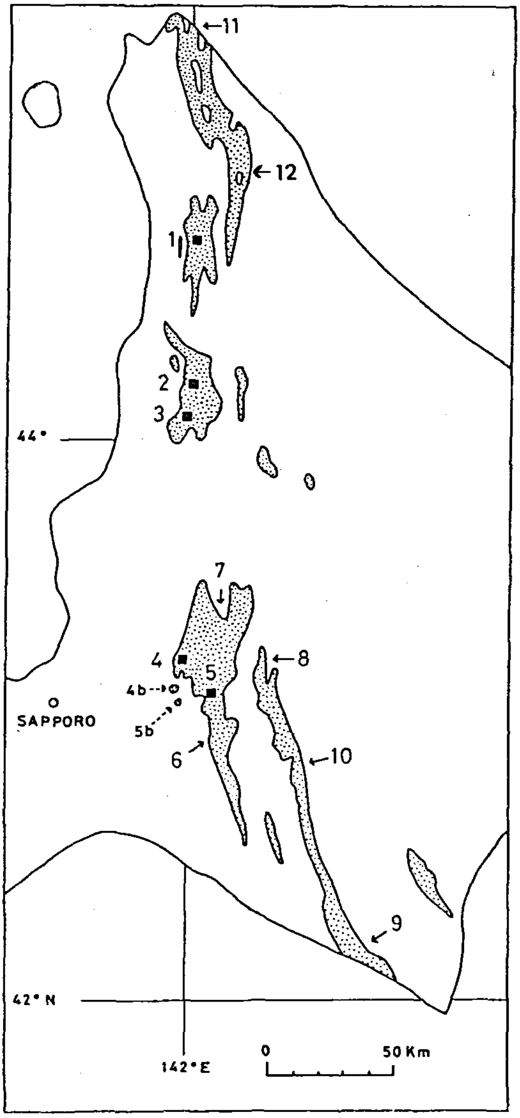

Fig. 1. Map of the main part of Hokkaido, showing the post-Aptian Cretaceous outcrops (stippled). The numbers indicate the location of the reference sequences used for establishing the zonation of the Upper Creaceous. 1: Saku (Teshio), 2: Haboro-Kotambets, 3: Obira, 4: Mikasa (Ikushumbets), 4b: Manji, 5: Oyubari, 5b: Yubari, 6: Hobets, 7: Ashibets, 8: Furano, 9: Urakawa, 10: Hidaka, 11:Soya, 12: Tombets.

places: A. Along the main course of the River Ikushumbets on the eastern wing of the anticline; B. in the Manji dome on the southern extension of the anticline, C. on the Pombets, a tributary of the Ikushumbets on the west side of the anticline; D. along the Pombets Gono-sawa, a tributary of the Pombets, on the west side of the thrust about 2.5 km from C. The detailed mode of occurrence of fossils varies between these localities, because the Cretaceous basin of Hokkaido shows facies change from the near shore shallow marine in the west through intermediate shallow marine to more offshore ones in the east. I shall explain concisely the facts observed in the respective places.

The Ikushumbets Main Stream

Figure 2 shows a route map and a stratigraphic profile of the relevant part along the main stream of the River Ikushumbets on the eastern wing of the anticline. Owing to the meandering of the stream and the horizontal displacement by wrench faults, the fossiliferous strata (mainly fine sandy siltstone with three beds of green sandstone) are repeatedly exposed along the river.

As indicated in the columnar section, the base of the second green-sandstone (GS2) is tentatively designated as the Turonian-Coniacian boundary, because below it occur *Inoceramus teshioensis* Nagao & Matsumoto (It), *Baculites undulatus* d'Orbigny, *Subprionocyclus normalis* (Anderson) (in bed GS1), *Reesidites minimus* (Hayasaka & Fukada) (Rm) and *Madagascarites ryu* Matsumoto & Muramoto (at level of Rm), and because above it occur *Baculites yokoyamai* Tokunaga & Shimizu (By), *Inoceramus rotundatus* Fiege (Ir) with *Didymotis akamatsui* (Yehara), *Prionocycloceras wrighti* Matsumoto (Pw) and then above them abundantly in and near the third green sandstone *Inoceramus uwajimensis* Yehara (Iu) accompanied by *Prionocycloceras sigmoidale* Matsumoto, *Kossmaticeras theobaldianum* (Stoliczka), *Nowakites mikasaensis* Matsumoto and *Scaphites* aff. *S. arnaudiformis* Collignon, among others. At still higher levels within the Coniacian sequence occur *Inoceramus mihoensis* Matsumoto and *I. (Platyceramus) yubarensis* Nagao & Matsumoto and also *Paratexanites orientalis* (Yabe) near the top. (I should point out that *I. rotundatus* was previously, e.g. in Matsumoto, 1954, misidentified with *I. teshioensis*).

On the eastern wing of a gentle syncline to the east of the mapped area in the upper reaches of the Ikushumbets, are the type localities of *Peroniceras latum* Matsumoto & Muramoto and *Sornayceras proteus* Matsumoto in the Zone of *I. mihoensis – I. (P.) yubarensis,* i.e. rather high in

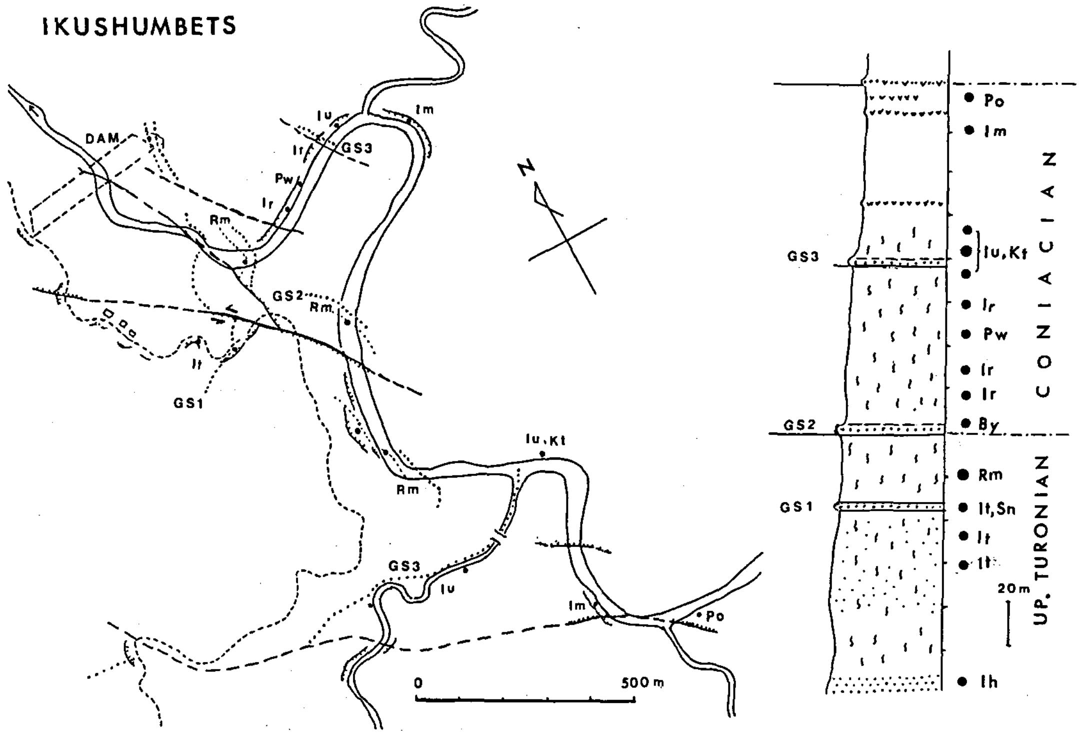

Fig. 2. Route map along the main stream of the Ikushumbets with a stratigraphic profile (right). Abbreviation of selceted species – Po: *Paratexanites orientalis*, Im: *Inoceramus mihoensis*, Iu: *I. uwajimensis*, Kt: *Kossmaticeras theobaldianum*, Ir: *I. rotundatus*, Pw: *Prionocycloceras wrighti*, By: *Baculites yokoyamai*, Rm: *Reesidites minimus*, Sn: *Subprionocyclus normalis*, It: *I. teshioensis* & *I. tenuistriatus*, Ih: *I. hobetsensis*.

the Coniacian (see Matsumoto *et al.*, 1981). Incidentally, the type locality of *Sornayceras omorii* Matsumoto (1965b) is in the same area, and was recorded as probably Upper Coniacian but could be Lower Santonian, as the stage boundary is as yet unsettled. The type locality of *S. wadae* Matsumoto (1971), which resembles *Gauthiericeras margae* (Schlüter) but has a *Peroniceras*-type suture, is in the upper part of the Coniacian in the same area.

Manji Dome

The outcrops of strata at and near the Turonian-Coniacian boundary along the main stream of the Ikushumbets were once excellent, but are now inaccessible, because they are under the waters of an artificial lake above the Katsura-zawa dam. To remedy this deficiency the Manji dome (4b in fig. 1) on the southern extension of the Ikushumbets anticline has been selected for reference. At my suggestion Obata & Futakami 1977 and Tanabe *et al.* 1978 carried out a biostratigraphic study of this area. According to them the Upper Turonian (represented by sandy siltstone and silty fine-grained sandstone) is richly fossiliferous. Here, *Subprionocyclus neptuni* and *Reesidites minimus* occur abundantly along with *S. normalis, Inoceramus teshioensis, I.* sp. aff. *I. inequivalvis* Schlüter, *Baculites undulatus* etc. The two collignoniceratid species show nearly the same vertical range, although they occur alternately in different beds. The authors suggest that *R. minimus* probably preferred a somewhat more offshore environment than *S. neptuni.* In contrast to a wealth of interesting information as to the Upper Turonian of the Manji dome, the Coniacian is poorly developed here, with only *I. mihoensis* as an index species. There is a stratigraphic break above the stage boundary, and the sequence lacks the interval with Lower Coniacian indices.

Pombets

At one place along the creek of the Pombets shown in figure 3, there is again a good outcrop of the Upper Turonian and fortunately a remnant of the overlying Coniacian survives below the unconformity at the base of the Eocene coal bearing formation. The base of the green sandstone indicated in the columnar section can be tentatively designated as the stage boundary, because some Coniacian species, e.g. *I. uwajimensis, Didymotis akamatsui* and *Baculites yokoyamai,* occur above it and because Upper Turonian species occur abundantly in an underlying unit of sandy siltstone, as explained in more detail below.

This Upper Turonian unit is subdivided as shown in fig. 3 and samples of fossils have been collected carefully in accordance with the subdivision, with a quantitative examination of the abundance. The results are reported in a Japanese paper by Matsumoto *et al.* (1981a); to cite from that paper, *Reesidites minimus* is rare at this locality, although found at Ik 2013a at a relatively high level; *Subprionocyclus neptuni* and *S. normalis* are rather rare and found at Ik 2014e and d in the lower part of the unit; other collignoniceratids occur fairly commonly or abundantly at loc. Ik 2012 in the upper part and also rarely at the level of Ik 2014a a relatively low level, including *Lymaniceras planulatum* Matsumoto, *Prionocyclus aberrans* Matsumoto etc.; there is also an example of *Prionocyclus novimexicanus* (Marcou) [= *P. wyomingensis in* Matsumoto, 1971], which may be somewhat transitional in having obscure remnants of outer ventral tubercles, from Ik 2012; no collignoniceratid has been detected from the middle part (main part of Ik 2013) of the unit, where occur such aberrant ammonites as *Nipponites bacchus* Matsumoto & Muramoto and *Eubostrycoceras woodsi* (Kitchin) [= ? *E. saxonicum* (Schlüter)], probably on account of some difference in ecological conditions; *Sciponoceras intermedium* Matsumoto & Obata occurs in the lower part (Ik 2014a-e); scaphitids are sometimes found in the lower to middle part but have not yet been studied sufficiently; *Damesites ainuanus* Matsumoto, *Anagaudryceras limatum* (Yabe), *Inoceramus teshioensis, I. tenuistriatus* Nagao & Matsumoto, *I.* aff. *I. inequivalvis* and *Mytiloides incertus* (Jimbo) occur commonly throughout the sequence.

The Pombets-Gonosawa

In the mapped area (figure 4) of the upper reaches of the Pombets-Gonosawa (sometimes called the Takiyoshi-zawa), there is good exposure of the Coniacian with a part of the Upper Turonian. The green sandstone at the base of the Coniacian becomes less distinct and more silty due to lateral change. The main part is fine sandy siltstone with a more sandy part in the middle of

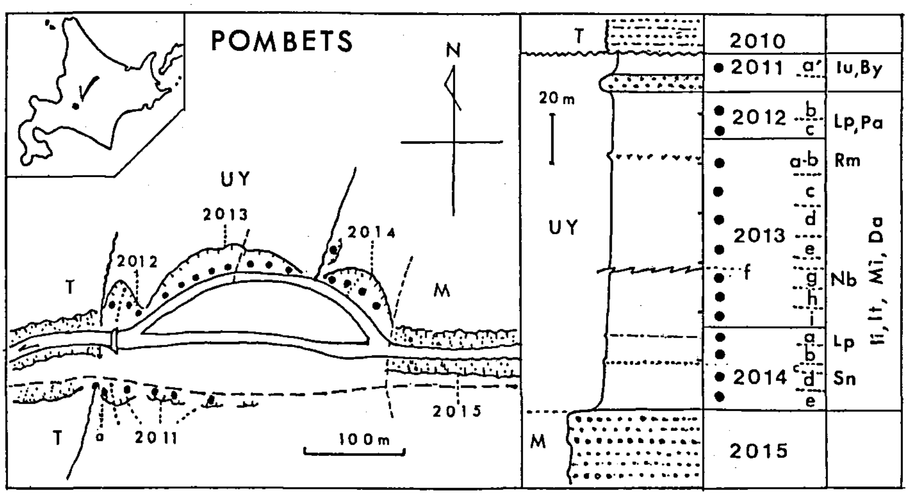

Fig. 3. Route map of the Pombets, with a stratigraphic profile. T: Tertiary, UY: Upper Yezo Group, M: Mikasa Sandstone. Abbreviation of selected species (continued from Fig. 2) – Lp: *Lymaniceras planulatum,* Pa: *Prionocyclus aberrans,* Nb: *Nipponites bacchus,* Sn: *Subprionocyclus neptuni & S. normalis,* Da: *Damesites ainuanus,* Mi: *Mytiloides incertus,* Ii: *Inoceramus* sp. aff. *I. inequivalvis.*.

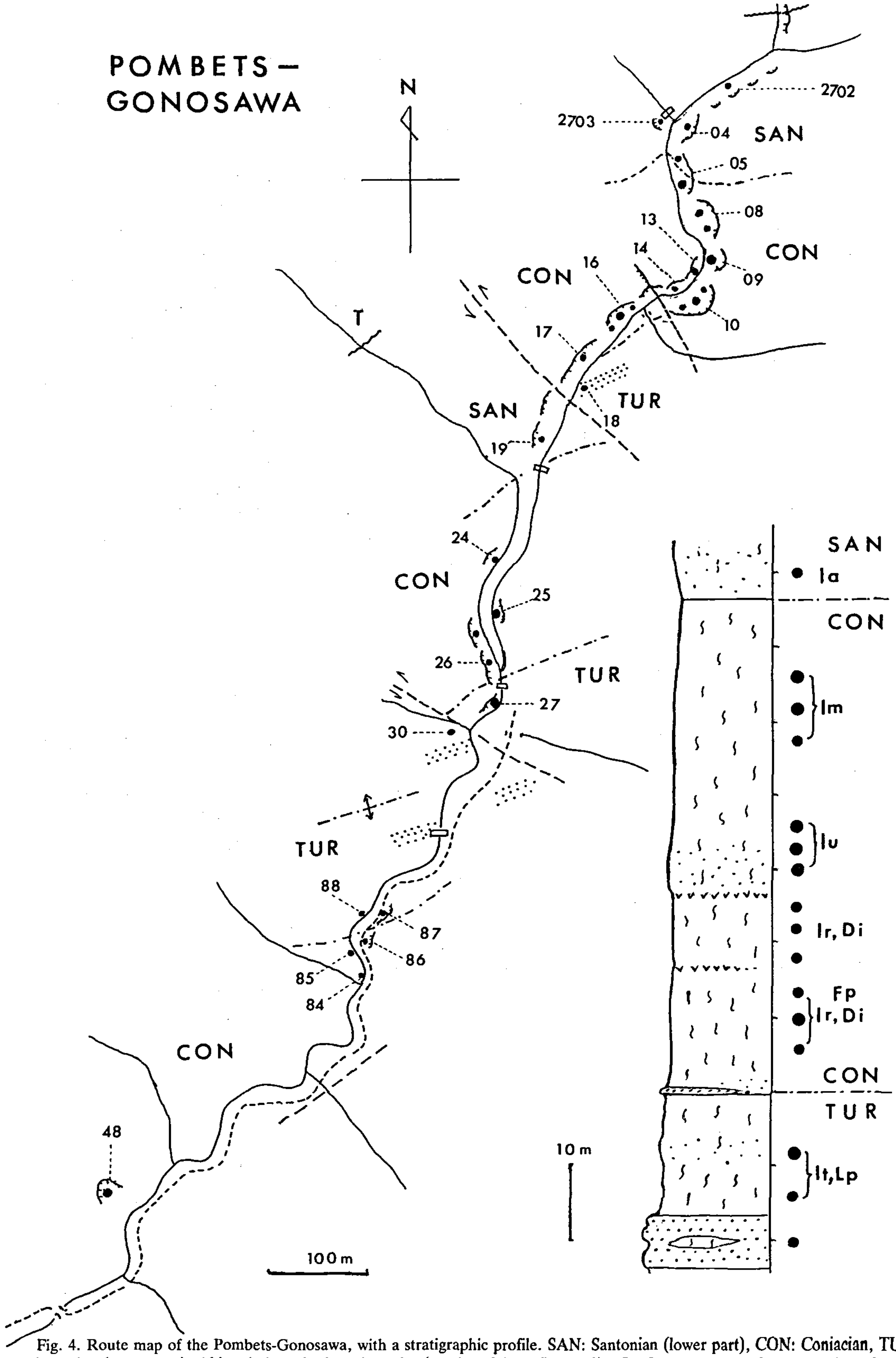

Fig. 4. Route map of the Pombets-Gonosawa, with a stratigraphic profile. SAN: Santonian (lower part), CON: Coniacian, TUR: Turonian (upper part), Abbreviation of selected species (continued from figs. 2, 3) – Ia: *Inoceramus amakusensis*, Di: *Didymotis akamatsui*, Fp: *Forresteria (Reesideoceras) petrocoriensis* and the like. Locality numbers abbreviated for brevity; read Ik 2704 for 04, Ik 2784 for 84 and so on.

the Coniacian and a member of thick bedded or massive sandstone in the Upper Turonian. Owing to NW-SE wrench faults and an anticline, the sequence as shown by the stratigraphic profile in fig. 4 is observable repeatedly with some complementary data among the outcrops.

In this sequence inoceramids occur fairly abundantly and are associated with some ammonites. The upper part of the Upper Turonian, represented by the outcrops at Ik 2727 and Ik 2787–88, contains common *Inoceramus* sp. aff. *I. inequivalvis, I. tenuistriatus, I. teshioensis* and *Lymaniceras planulatum* as well as *Damesites ainuanus* and *Anagaudryceras limatum* and rarely *Reesidites minimus.*

The Coniacian can be divided into three in this sequence. The lower part, represented by Ik 2726a, b, Ik 2716, Ik 2714, Ik 2710 (a-k),Ik 2785 and Ik 2786, contains *Inoceramus rotundatus* Fiege and the like (common), *I. uwajimensis* (few), *Didymotis akamatsui, Anagaudryceras limatum, Forresteria (Reesideoceras) petrocoriensis* (Coquand), *F.* (*R.* ?) sp. and *Harleites* cf. *H. harlei* (de Grossouvre). The middle part, represented by Ik 2726c, Ik 2725, Ik 2713, Ik 2710 (l-m), Ik 2709 and Ik 2748, is characterized by the abundant occurrence of *Inoceramus uwajimensis.* Associated with it there are *F.* (*Forresteria*) *alluaudi* (Boule, Lemoine & Thévenin), *Barroisiceras (Baseoceras) inornatum* Matsumoto, *Kossmaticeras theobaldianum* among many others. The upper part, represented by Ik 2708, Ik 2705 and Ik 2724, is characterized by *Inoceramus mihoensis, I.*(*Cordiceramus*) n. sp. and *I.* (*Platyceramus*) *yubarensis..*

Scaphitids occur throughout the sequence and need further careful study. *Eubostrychoceras woodsi* was found at Ik 2718 in a silty lens in the bedded sandstone of Upper Turonian, whereas *E. indopacificum* Matsumoto [= part of "*E. indicum* (Stoliczka"] occurred at Ik 2710d and *Nipponites sachalinensis* Kawada at Ik 2714, in the lower part of the Coniacian.

Other areas

In addition to the Mikasa district described above, there are several places where biostratigraphic sequences from Upper Turonian to Coniacian are observable. For instance, the Obira and the Haboro areas in northwestern Hokkaido may be interesting in this respect, but biostratigraphic study has not yet been carried out as precisely as in the Mikasa area. There are, however, some records which supplement data from the Mikasa district. For example, *Barroisiceras onilahyense* Basse was found in the middle part of the so-called Coniacian in the Obira area (Matsumoto *et al.,* 1981 b); *Reesidites elegans* Matsumoto & Inoma (*in* Matsumoto, 1971), *Subprionocyclus neptuni* and *Hourcquia mirabilis* Collignon occur in the Upper Turonian Zone of *Inoceramus teshioensis* of the Haboro area. Even within the Mikasa area, the outcrops in the valley of the Ichinosawa, a tributary of the Ikushumbets above the dam, may provide us with data which will supplement those from the submerged exposures. Anyhow, these and other areas are now being studied by geologists of younger generations.

Drawing the boundary on a revised scheme of zonation

On the basis of the biostratigraphic data from our reference sequences described above, as well as what was known previously, a revised scheme of zonation for the so-called Turonian and Coniacian in the Japanese province can be established, as shown in table 1. The stage boundary can be drawn tentatively on this scheme. In the actual reference sequences of the Mikasa district, it is at the horizon corresponding to the base of the second green-sandstone, which separates the Zone of *I. teshioensis* below and the Subzone of *I. rotundatus* (lower part of the *I. uwajimensis* Zone) above.

As is clear from the actual situations in the reference sequences described, what species occurs in how much abundance at which level varies from place to place even within the Mikasa area. This is probably due to changes in ecological and other environmental factors, which may not be always manifested in the lithofacies. For this reason, the previously tabulated Subzones of, in ascending order, *Subprionocyclus neptuni, S. normalis* and *Reesidites minimus* are kept only in the first observed place but are untenable in some other places. In other words, these three species have nearly the same vertical range in the Upper

Overlying		*Inoceramus (Platyceramus) amakusensis*		*Texanites collignoni*	
CONIACIAN	Upper	*Inoceramus mihoensis-* *I. (Platyceramus) yubarensis*		*Paratexanites orientalis* *Sornayceras proteus*	
CONIACIAN	Mid.	*I. (I.) uwajimensis*	*I. (I.) uwajimensis* (dominant)	*Forresteria (Forresteria) alluaudi*	*Barroisiceras onilahyense*
CONIACIAN	Lower		*I. rotundatus*		*Prionocycloceras wrighti-* *F. (Reesideoceras) petrocoriensis*
UPPER TURONIAN		*I. (Inoceramus) teshioensis-* *Mytilodes incertus*	*I.(I.) tenuistriatus-* *I.(I.)* sp. aff. *I.(I.) inequivalvis*	*Subprionocyclus neptuni*	*Reesidites minimus-* *Prionocyclus aberrans-* *Lymaniceras planulatum*
Underlying		*I. (Inoceramus) hobetsensis-* *Mytiloides teraokai*		*Collignoniceras woollgari* (with *C. woollgari bakeri*)	

N.B. Species linked with hyphen (-) are contemporary, occurring in the same zone.

Table 1. A Revised Zonal scheme for the Upper Turonian and Coniacian of Japan.

Turonian of Japan, although *S. neptuni* appears slightly earlier than others. *Lymaniceras planulatum* and *Prionocyclus aberrans,* which are common at a certain level in the Pombets sequence, have likewise nearly the same vertical range as that of *R. minimus.* All of these species are good indices of the Upper Turonian of the Japanese province but their actual mode of occurrence depends probably on environmental conditions, which varies from place to place.

Likewise, *Inoceramus (Inoceramus) teshioensis, I. (I.) tenuistriatus, I. (I.)* sp. aff. *I. (I.) inequivalvis* and *Mytiloides incertus* have nearly the same vertical range almost throughout the Upper Turonian, but what species occurs commonly in a given part of the sequence varies from place to place.

In addition to the above mentioned species, there are some other species which are found fairly frequently in the Upper Turonian, e.g. *Sciponoceras intermedium, Baculites undulatus, Eubostrychoceras woodsi* [= ? *E. saxonicum*], *Nipponites bacchus, Madagascarites ryu, Scaphites planus* Yabe and *Otoscaphites puerculus* (Jimbo). The last three species range downward, whereas *N. bacchus* is found also in the lower part of the Coniacian. *Damesites ainuanus* is so far characteristic of the Upper Turonian but the date of its first appearance is not yet clear. Among rare species, *Prionocyclus novimexicanus* and *Hourcquia mirabilis* are noteworthy records in Japan.

The Coniacian is recognized in Japan by *I. (Inoceramus) uwajimensis, I. rotundatus, I. mihoensis, I. (Platyceramus) yubarensis* and certain associated ammonites, e.g. *Kossmaticeras theobaldianum, Nowakites mikasaensis, Forresteria (Forresteria) alluaudi, F. (Muramotoa) yezoensis* Matsumoto, *F. (M.) muramotoi* Matsumoto, *Barroisiceras (B.) onilahyene, B. (Basseoceras) inornatum, Harleites* cf. *harlei, Yabeiceras orientale* Tokunaga & Shimizu, *Prionocycloceras wrighti, P. sigmoidale, Peroniceras latum, Sornayceras proteus, S. wadae, Ishikariceras binodosum* Matsumoto, *Paratexanites orientalis, P. serratomarginatus* (Redtenbacher), *Eubostrychoceras indopacificum, Scaphites* aff. *S. arnaudiformis, Otoscaphites (Hyposcaphites) matsumotoi* Tanabe, *Baculites yokoyamai* and *B. schencki* Matsumoto. Some of these species seem to occur in a restricted part of the sequence, but the available data are not always sufficient to know the true range.

As a preliminary result of the recent restudy, I can state as follows. The lower part of the Coniacian is characterized by *Inoceramus rotundatus, Didymotis akamatsui, Prionocycloceras wrighti, Harleites* cf. *harlei* and compressed forms of *Forresteria,* including *F. (Reesideoceras) petrocoriensis.* The middle part contains abundant *I. (I.)*

uwajimensis with which are associated *Barroisiceras onilahyense, B. (Baseoceras) inornatum, Yabeiceras orientale, Prionocycloceras sigmoidale* etc. The upper part is characterized by *Inoceramus mihoensis, I. (Platyceramus) yubarensis, Sornayceras proteus* and *S. wadae. Paratexanites orientalis* came from the top. Whether this tripartite subdivision established on the reference sequences can be extended to other areas of the Japanese province or is merely a local division for central Hokkaido should be further examined. The range of *I. mihoensis* overlaps with that of *I. uwajimensis*. The middle zone is tentatively defined by the prolific part of *I. uwajimensis*.

Several species of the phylloceratids, desmoceratids, tetragonitids and gaudryceratids, which are common in the Japanese province, have long vertical ranges and pass across the stage boundary. There are, however, a few species which may be useful for the distinction. For instance, *Damesites ainuanus* and *Tragodesmoceroides subcostatus* Matsumoto are common in the Turonian but absent in the Coniacian; *Damesites damesi* (Jimbo), *D. semicostatus* Matsumoto and *Gaudryceras tenuiliratum* Yabe begin to appear in the Coniacian and range upward. As to the heteromorpha which occur fairly frequently in Japan, e.g. *Scalarites, Polyptychoceras, Hyphantoceras, Pseudoxybeloceras, Neocrioceras, Scaphites* and *Otoscaphites,* further study is required to know precisely the stratigraphic range of each species.

Inter-regional Correlation

Mytiloides incertus is a world-wide index of the Upper Turonian, since it is almost certainly a senior synonym of *M. fiegei* (Tröger), as Matsumoto & Noda (1983) have recently described. *M. fiegei* has been reported from the Upper Turonian of Germany (Tröger, 1967, 1981; Keller, 1982) and England (Bailey et al., 1983). It occurs in the Subzone of *Prionocyclus quadratus,* the highest Upper Turonian in the U. S. Western Interior province (Cobban, personal communication), Upper Turonian of Afghanistan (Sornay, 1974) and possibly also in Brazil (my own examination by courtesy of Dr. P. Bengtson) and Oregon. *M. incertus* is, thus, a very good index of the Upper Turonian for the inter-regional correlation.

Inoceramus teshioensis seems to be so far endemic to the Japanese province, but it is closely allied to *I. costellatus* Woods [= *I. vancouverensis* of Tröger, 1967 (*non* Shumard, 1856)] from the Upper Turonian of England and central Europe, and could be treated as a geographic subspecies of *I. costellatus. I. tenuistriatus* is sometimes cited as occurring outside the Japanese province (e.g. Kauffman, 1978) but is thought to have a longer downward range than in Japan. It is necessary to define this species more precisely. What I listed under *I.* sp. aff. *I. inequivalvis* should also be examined precisely. Among various specimens, I notice preliminarily a form which is allied to *I. inequivalvis falcatus* Heinz (see Keller, 1982) from the upper Middle to lower Upper Turonian of England and central Europe.

Subprionocyclus neptuni is a world-wide index of the Upper Turonian. In the type sequences of the Turonian in the Wessex-Paris basin, the uppermost part of the Upper Turonian is described as being poor in ammonites, but the species is said to range up to the top (Kennedy *et al.*, 1983). In Hokkaido ammonites and inoceramids occur throughout the entire sequence of the Upper Turonian. As shown by the records in the Manji dome (Obata & Futakami, 1977), *S. neptuni* has nearly the same vertical range as *Reesidites minimus,* both ranging up to the top of the Turonian. *Subprionocyclus normalis, Eubostrychoceras woodsi* and *Baculites undulatus* are common species in the Zone of *S. neptuni* of Japan and Europe.

For some reason *S. neptuni* has not yet been found from the Gulf and Interior provinces of North America, where a single available example of *Subprionocyclus* is *S. percarinatus* (Hall & Meek), which is placed between the Zones of *Collignoniceras woolgari* and *Prionocyclus hyatti* by Cobban & Hook (1983). The Western Interior province is rather peculiar in that the zonal subdivision is unusually fine and that the zones are mostly defined by endemic species. At least some, if not all, of the index species may show only a partial range in that province. For instance, the vertical range of *Collignoniceras woollgari* (Mantell), a world wide species of the Middle Turonian, is much more restricted in the Western Interior province than in western Europe or in the Japanese province. This is probably due to paleobiogeographic and environmental factors. It follows that a record of *Prionocyclus novimexicanus* from Japan does not necessarily indicate exactly the synchroneity with the *P. novimexicanus* Zone in the Western Interior, but it does support the correlation of the Upper Turonian between the two regions. As I discussed previously (Matsumoto, 1965a), *Lymaniceras planulatum* is probably a derivative of *Prionocyclus macombi* Meek, but the former seems to have a longer vertical range than the latter, ranging upward. Again it supports the correlation of the Upper Turonian in general between the two regions. Likewise, the occurrence of *Prionocyclus aberrans* and *P. cobbani* in Japan generally supports this correlation, although they are endemic species. To sum up, the available data in Japan are favourable for the correlation of the so-called Upper Turonian in our province with the Upper Turonian defined in standard areas of Europe and North America.

Turning to the Coniacian, the occurrence of *Forresteria, Barroisiceras, Prionocycloceras* and *Peroniceras* in Japan is the best evidence on which to recognize this stage in terms of the international scale, whereas *Inoceramus uwajimensis* and *I. mihoensis* are very useful for correlating various formations of the same stage within the Japanese province. As to the boundary problem I should examine more carefully the zonal succession of selected species.

In the standard sequences of the Coniacian, e.g. Craie de Villedieu in the lower part of the Senonian, southwestern part of the Paris basin, and the type Coniacian of the Aquitaine basin, Kennedy (oral communication at Uppsala, 1981; draft in 1983 in preparation) has recognized a four-fold division into *Forresteria petrocoriensis, Peroniceras tridorsatum, Gauthiericeras margae* and *Paratexanites serratomarginatus* Zones in ascending order. Associated inoceramid species in these ammonite zones are unknown. An inoceramid zonation is better established in Germany, but there was an unfortunate discrepancy about the stage and substage definition between the German and international scales (see Seibertz, 1979, Ernst *et al.*, 1979; Tröger, 1981) and the important ammonite species are not precisely placed in the inoceramid zones. Anyhow, the Upper Turonian Zone of *Inoceramus costellatus-Mytiloides fiegei* is succeeded by the Zone of *I. deformis* [= part of *I. schloenbachi*] in the lower part of the Coniacian, which is followed by the Zone of *I. (Volviceramus) koeneni* and then that of *I. (V.) involutus. I. rotundatus* and *I. waltersdorfensis hannovrensis* are also characteristic of the lower or basal zone, but the former is reported to appear in the uppermost Turonian (Tröger, 1981; Keller, 1982). In addition to the zonal indices, *I. kleini* Müller and *I. (Platyceramus) mantelli* Mercey occur in the main part of the Coniacian.

In the Western Interior Province of the United States, the succession of inoceramid species is stated to be generally in good conformity with that in Germany and the lowest part of the Coniacian is marked by *I. rotundatus* (personal communication from Dr. Cobban), whereas the ammonite zones are indicated by endemic species of *Scaphites*. Some species of *Forresteria* are said to appear in the lower part of the Coniacian (Scott & Cobban, 1964), but I have failed to get more precise information.

Now in Japan *I. rotundatus* and the like are found characteristically in the "lower Coniacian". Noda and I are now studying to see whether *I. waltersdorfensis hannovrensis* is included or not in that faunule. Among the associated ammonites there are compressed forms of *Forresteria* (s.l.), one of which is probably referable to *F. (Reesideoceras) petrocoriensis*, although further careful study is required. Another form is allied to that illustrated by Gale & Woodroof (1981, pl. 1, figs. 1–2) as "*Barroisiceras haberfellneri* (Hauer)" from the Top Rock in the Chalk of Kent (England) slightly below the level with *I. rotundatus*. This ammonite may be, in my opinion, a kind of *Forresteria*. Anyhow, these lines of evidence support the conclusion that the 'lower part of the so-called Coniacian' in the Japanese province is very probably correlated with the Lower Coniacian in the standard or reference sequences in France, Germany, England and the United States. I should remind readers that *I. uwajimensis* is closely allied to *I. stantoni* Sokolow [= *I. acuteplicatus* Stanton] from the United States (Coniacian) and somewhat similar to *I. kleini* from Germany; that *I. (P.) yubarensis* is allied to *I. (P) mantelli* from Europe; that *Didymotis* species may be useful for the recognition of the Coniacian in various areas around the

Pacific and also in Europe; and that *Kossmaticeras theobaldianum* and *Yabeiceras* spp. are useful for the correlation in Indo-Pacific regions. although these species may not necessarily first appear in the basal Coniacian.

To sum up, the boundary tentatively drawn between the Zone of *Inoceramus teshioensis-Subprionocyclys neptuni* below and the Zone of *Inoceramus rotundatus-Forresteria (Reesideoceras) petrocoriensis* above very probably represents the Turonian-Coniacian boundary of the international scale in the Japanese province. Some of the associated species of the two zones are also useful for recognition of the Upper Turonian and Lower Coniacian respectively in more extensive interregional correlation.

In the Mikasa area the Upper Turonian to Coniacian sediments are mostly fine sandy siltstone or silty sandstone, with some beds of sandstone, and planktonic micro-fossils are rare. For the micro-fossil biostratigraphy we must investigate areas where sediments of more off-shore facies accumulated. Although there are some results (see Takayanagi & Matsumoto, 1981), further research is required for the integration of the mega- and micro-fossil biostratigraphy and resolution of the Turonian-Coniacian boundary in the Japanese province.

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Dansk sammendrag

Den stratigrafiske udbredelse af ammoniter og inoceramer i aflejringer fra øvre turonien og coniacien på Hokkaido er beskrevet. Et revideret stratigrafisk skema over øvre turonien og coniacien i den japanske provins er opstillet. Grænsen mellem etagerne drages mellem *Inoceramus teshioensis – Mytiloides incertus – Subprionocyclus neptuni* zonen og *Inoceramus rotundatus – Forresteria (Reesideoceras) petrocoriensis* zonen. Denne grænse svarer formodentlig til turonien-coniacien grænsen i den europæiske standard inddeling.

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