Post-crisis recovery of Campanian desmoceratacean ammonites from Sakhalin, far east Russia

ELENA A. YAZYKOVA

VSEGEI, Srednii pr. 74, 199026 St Petersburg, Russia

Abstract: The Santonian–Campanian boundary in Sakhalin marks a major Cretaceous mass extinction event. In the late Santonian there was a decrease in the taxonomic diversity of ammonoids as well as significant changes in shell morphology which were probably related to a global regression event. However, the fauna of the Pacific region is endemic and precise correlation between the Pacific and European regions is impossible. In this paper the stratigraphic position of the boundary between the Santonian and Campanian in Sakhalin is revised and the post-crisis recovery of the ammonoid diversity is discussed. Detailed sampling of the Santonian–Campanian sequence of Sakhalin (Naiba section, Orlovka section and others) allows identification of the phyllogenetic links between the different ammonite morphotypes in the pre-crisis communities. Comparison with adjacent regions in northeast Russia and Japan is also attempted. The ammonite extinctions at the Santonian–Campanian boundary are a good marker for stratigraphic correlation. During the crisis event ammonites of the superfamilies Acanthocerataceae and Desmocerataceae were affected most strongly whereas phylloceratids and lytoceratids were not significantly changed at that time. Heteromorphic ammonites are not discussed here. The pre-crisis community is characterized by a predominance of Acanthocerataceae, while the Desmocerataceae had a subordinate role. Representatives of these two groups form a community with large-size shells and strong ornamentation and this is not seen in the ammonites of the post-crisis community. The maximum occurrence of the Superfamily Desmocerataceae is recorded in the Middle Campanian, when the first diversification occurred (Family Pachydiscidae). Zonal correlation of the Santonian to Campanian succession of northeast Russia and Japan is discussed.

Ammonoid evolution was interrupted by several mass extinction events during the Late Cretaceous. One of the most important crises occurred at the Santonian–Campanian boundary and strongly affected the studied groups. The Late Santonian sea-level changes mark a worldwide regression (Matsumoto 1977; Hancock & Kauffman 1979; Hancock 1993) and it was probably those changes in the environment that were the main reason for the reductions of taxonomic diversity and the changes in the shell morphology of the ammonites.

The Sakhalin's Santonian to Campanian marine terrigenous succession with ammonite fossils consists mostly of sandstones and black shales with a total thickness of up to 2000 m. Typical facies are shales with beds and lensoid beds of sandstones up to 1 m thick, tuffaceous sandstones and siltstones. In the Santonian the sandstone facies was widespread while the mudstone facies is more common in the Campanian. Numerous fossils have been found, mainly in marly nodules that form 'concretion beds' in some sections. The ammonite distribution in the Sakhalin succession is quite variable, ranging from single specimens to great abundance in the different sedimentary units. Discussion of the evolution of the Campanian ammonites and their population dynamics is based on detailed sampling of the Bykovskaya and Krasnoyarkovskaya Formations (Fig. 1) as well as three sections of the Zhonkierskaya Formation located along the Orlovka and Onora Rivers and in the Cape of Zhonkier (Fig. 2).

The Naiba section is the reference stratigraphic section for Sakhalin Island (Poyarkova 1987). Three Campanian ammonite zones (*Anapachydiscus* (Neopachydiscus) naumanni, *Pachydiscus (P.) egertoni* and *Canadoceras multicostatum*) have been recognized in this section (Zonova *et al.* 1993). The underlying Santonian and Maastrichtian deposits contain a continuous sequence of ammonite zones (Zonova *et al.* 1993).

Ranges of the ammonite species have been precisely established in the Sakhalin section and this allows the identification of regionally useful ammonite zones (Fig. 3). In addition to this, specimens from synchronous deposits of Kam-

From Hart, M. B. (ed.), 1996, *Biotic Recovery from Mass Extinction Events*, Geological Society Special Publication No. 102, pp. 299–307

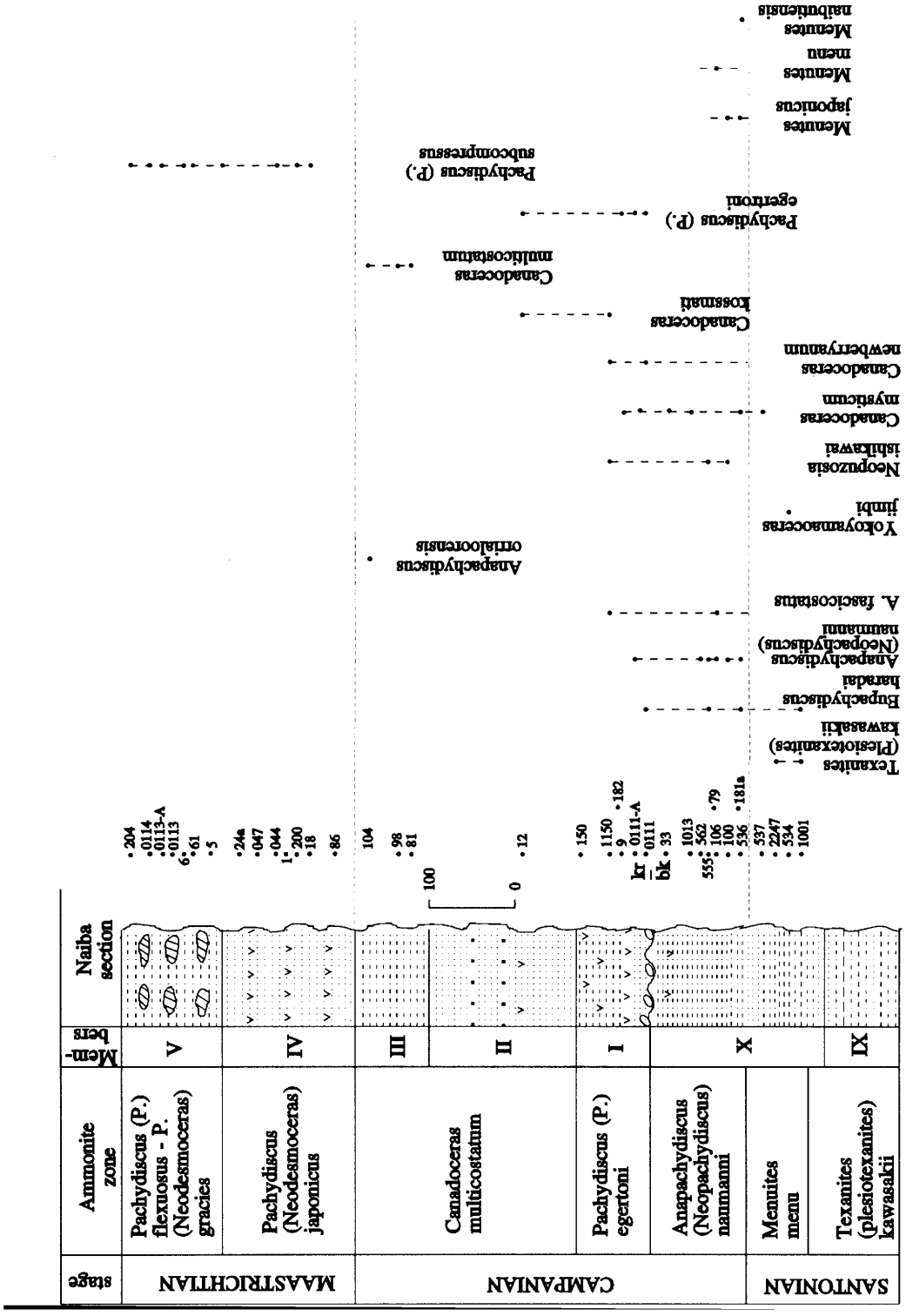

Fig. 1. The Santonian–Maastrichtian stratigraphic section with ammonoids, Bykovskaya and Krasnoyarkovskaya Formations.

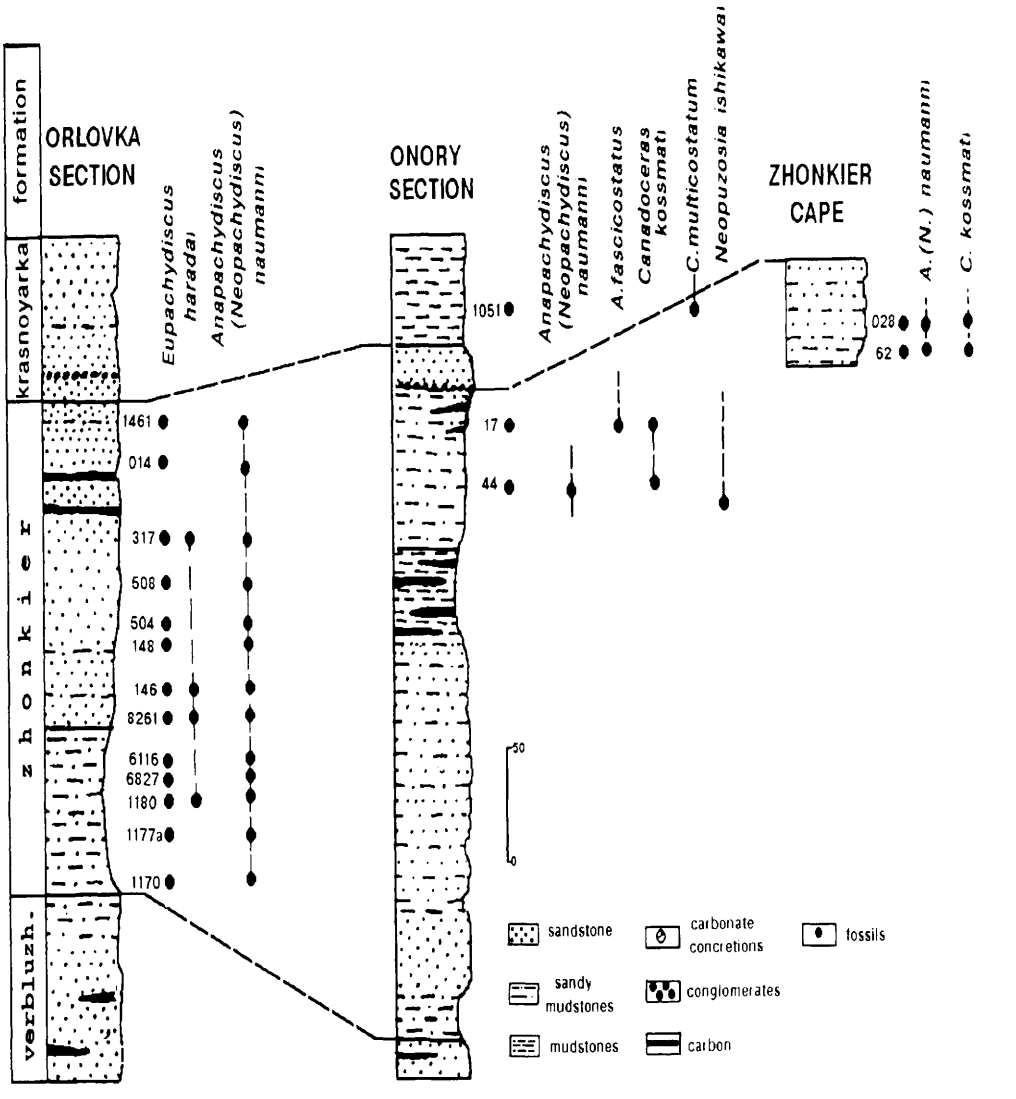

Fig. 2. Santonian–Campanian stratigraphic sections with ammonoids, zhonkierskaya formation.

chatka, Korjakia (northeastern Russia) and Shikotan Island (Kuril Islands) have also been used for comparative analysis.

Extinction

The Santonian ammonite fauna began to change from the beginning of the Late Santonian regression. In Sakhalin this event is recognized by an abrupt decrease of the taxonomical and morphological diversity of the Superfamily Acanthoceratacea (Order Ammonitida) in the section of the *Texanites (Plesiotexanites) kawasakii* Zone. The acanthoceratids which dominated from the Cenomanian to Coniacian interval by number of species and abundance in the sample localities is represented in the Santonian succession by only *Texanites (Plesiotexanites) kawasakii* (Kawada). Moreover, this species dis-appeared during the final extinctions at the Santonian–Campanian boundary. No taxa from the Superfamily Acanthoceratacea are known above this boundary in Sakhalin. However, rare representatives of this Superfamily have been found in the Lower Campanian succession of Japan (Matsumoto & Haraguchi 1978) and this suggests that their existence in far east Russia is still open to revision.

The other studied Superfamily is the Desmo-

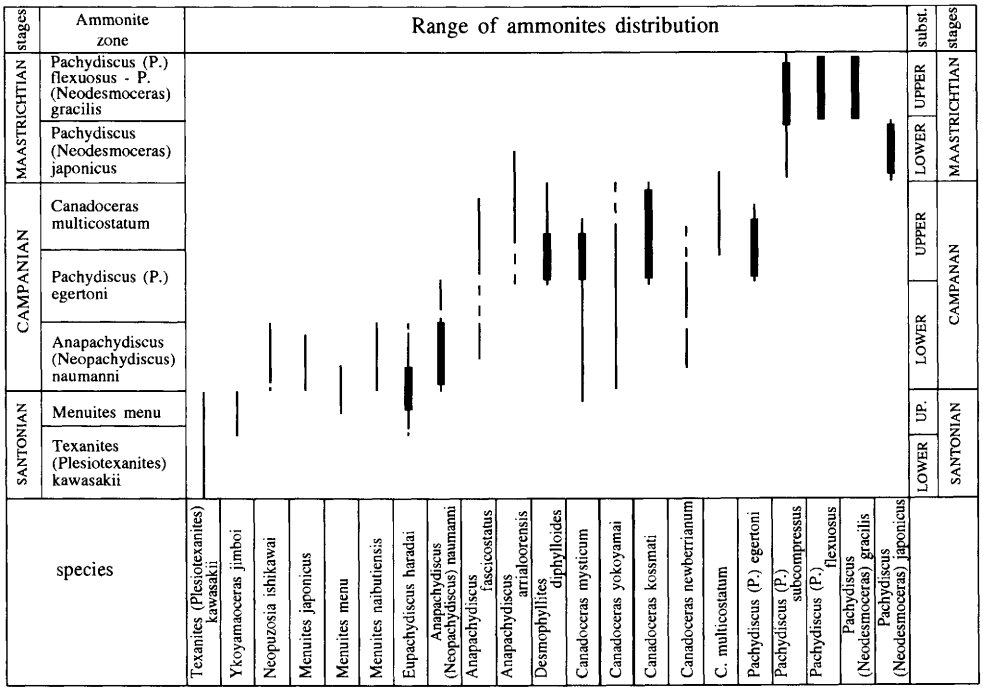

Fig. 3. Stratigraphic distribution of the Santonian–Maastrichtian ammonites (Superfamilies Desmoceratoceae and Acanthoceratoceae), Sakhalin Island.

cerataceae. Desmoceratids have a subordinate role in the Cenomanian to Early Santonian interval being represented only by *Yokoyamaoceras jimboi* Matsumoto and *Neopuzosia ishikawai* Jimbo. The former disappeared during the crisis event whereas the latter continued into the post-crisis interval and gave rise to a new lineage (Fig. 4).

New representatives of the Family Pachydiscidae (Superfamily Desmoceratoceae) appeared during this event or immediately after it. They were *Eupachydiscus haradai* Jimbo and *Canadoceras mysticum* Matsumoto (Fig. 5).

In general, the pre-crisis community of the Coniacian to Santonian ammonites consisted of two Superfamilies (Acanthoceratoceae and Desmoceratoceae). They had large-size shells and distinct ornamentation with strong coarse riblets, 'plicae', 'spines' and high strong tubercles that were arranged in several rows on the shell surface. Some forms had a deep construction, high collars and pointed keel. Such coarse elements have not been found in the post-crisis ammonite community in Sakhalin. Similar features of the pre-crisis community are typical for northeast Russia that has been established by comparative analysis of the northeast Russia and Sakhalin material.

The crisis is expressed more clearly in sections described by Japanese geologists. According to their data there are two families (Collignoniceratidae and Muniericeratidae) of the Superfamily Acanthoceratoceae in the Santonian *Texanites (Plesiotexanites) kawasakii* Zone (Matsumoto & Kanie 1979; Toshimitsu *et al.* 1991). The former consists of eight species (Matsumoto & Haraguchi 1978) and the latter contains approximately ten species (Matsumoto & Obata 1982). Some taxa which disappear in the early Campanian have also been found (Matsumoto & Haraguchi 1978). Such sharp differences in the number of described species between Japan and Sakhalin may be explained by the lack of detailed studies of the Sakhalin succession or by some differences in the environment. In either case, the last representatives of the Superfamily Acanthoceratoceae contain only one species that disappears in the latest Santonian. The Superfamily Desmoceratoceae survived to the post-crisis interval and reached its maximum abundance in the Campanian (Fig. 5). Two other Cretaceous ammonoid orders (Phylloceratida and Lytoceratida) formed long-lived lineages and were not significantly changed during this event (Fig. 4). Heteromorphic ammonites, which are widespread in Sakhalin are not discussed

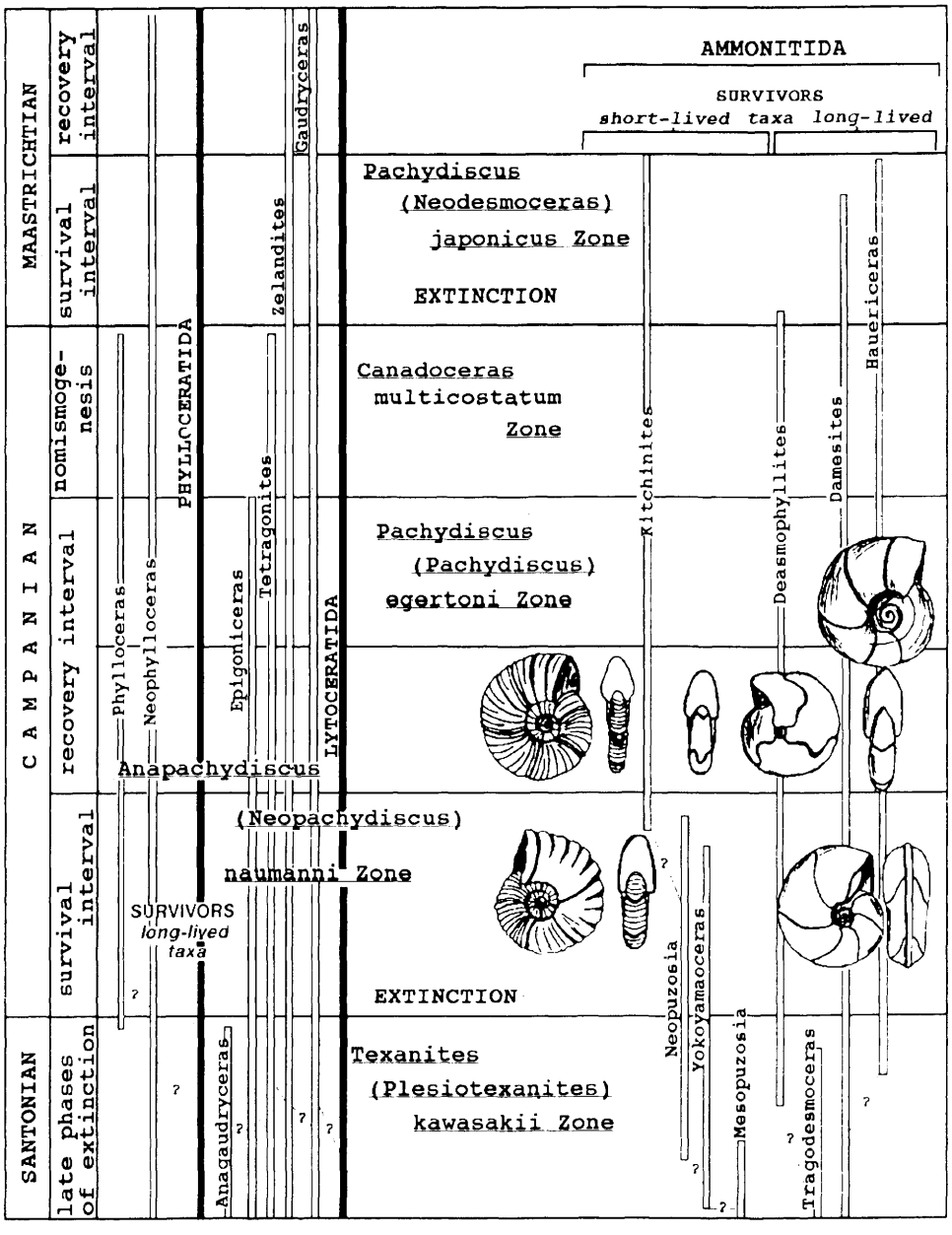

Fig. 4. Recovery of Campanian Ammonoidea in the Sakhalin sections.

here. The behaviour of this group across the event will be described in another paper.

Survival

This interval corresponds to the first half of the *Anapachydiscus (Neopachydiscus) naumanni* Zone (Figs 4, 5). During that time long-lived taxa of the Family Desmoceratacae (genera *Neopuzosia*, *Damesites*, *Desmophyllites* and *Hauericeras*) continued their existence and representatives of the genus *Kitchinites* appeared (Fig. 5). The genus disappeared during the Early Campanian. All these genera, except *Neopuzosia*, are conservative lines that continued up into Maastrichtian. The youngest sedimentary units containing *Neopuzosia* are of the Early Campanian age.

The first examples of the new Family Pachydiscidae (Superfamily Desmoceratacae) ap-

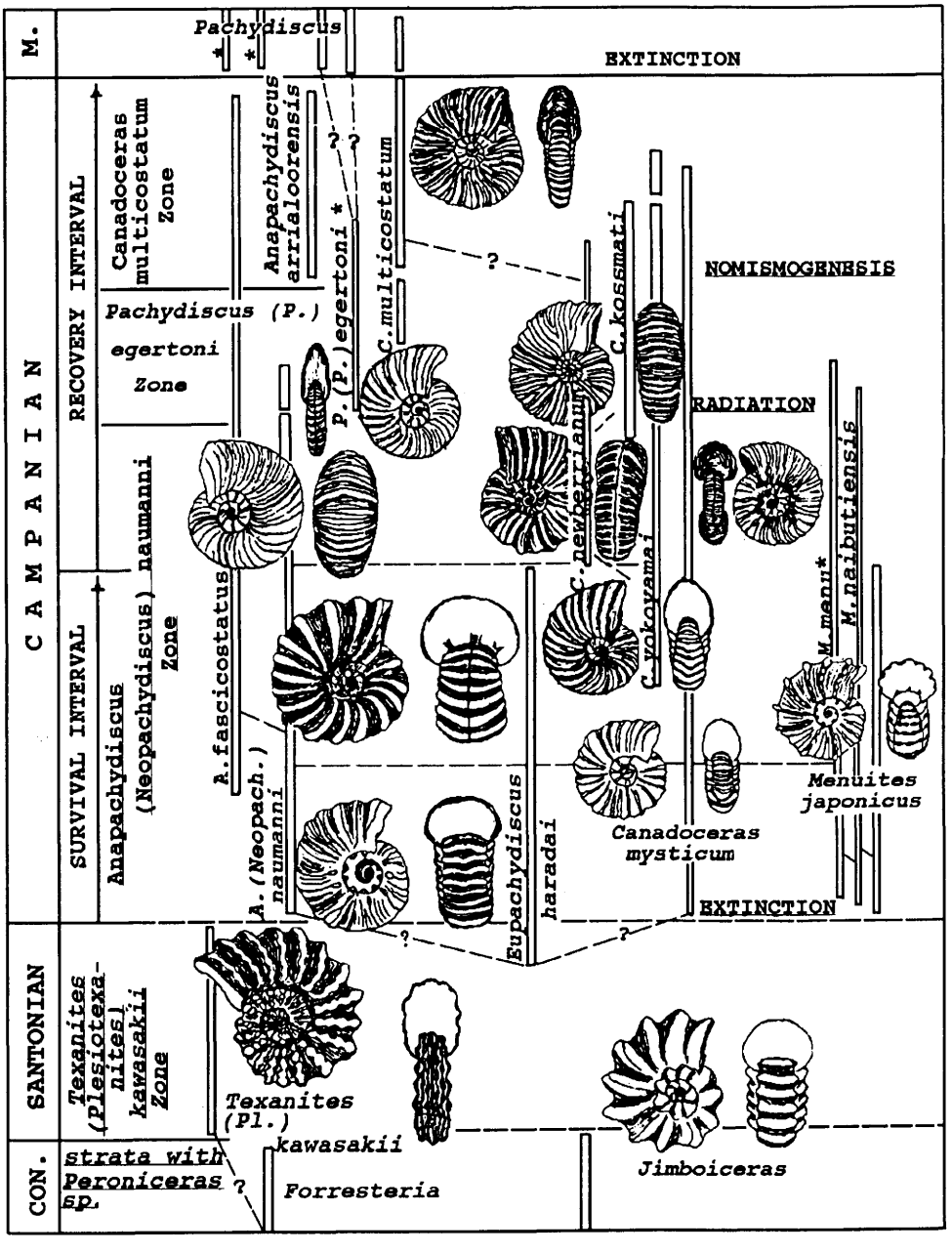

Fig. 5. Recovery of Campanian ammonoidea in the Sakhalin sections. —— Zone boundaries; –?– phyllogenetic links; · — · — interval boundaries; * immigrant species.

peared in the Late Santonian. They are represented by *Eupachydiscus haradai* Jimbo and a species which arose from it, *Canadoceras mysticum* Matsumoto. The boundary between the Santonian and Campanian stages is established by the first appearance of *Anapachydiscus (Neopachydiscus) naumanni* Yokoyama and *Inoceramus nagaoi* Matsumoto & Ueda. Both genera appear together in large numbers. There is some similarity between the Pacific Ocean species *A. (N.) naumanni* and *Eupachydiscus levyi* which is widespread in the Lower Campanian of Middle Asia. The same can be said of the Pacific Ocean species *Inoceramus nagaoi* and *I.*

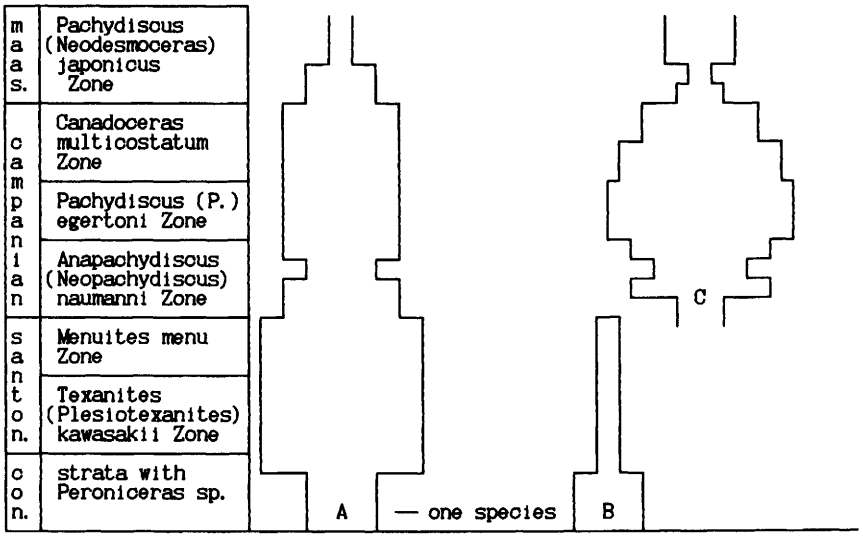

Fig. 6. Dynamics of the taxonomic diversity of some of the families of the Cretaceous Ammonoidea: A, Desmoceratidae; B, Collignoniceratidae; C, Pachydiscidae.

azerbaidjanensis. The latter has been found in the Lower Campanian of the southern USSR, Bulgaria and the USA.

Immediately after the extinction event there was the appearance of the short-lived taxa such as *Menuites menu* (Forbes), *M. naibutiensis* Matsumoto, *M. japonicus* Matsumoto. These continued the lineage of the genus *Anapachydiscus* (Kennedy & Klinger 1993) but without further development. The first species is widespread in Tethys whereas the other two are endemic. All of them disappeared in the Campanian (Fig. 5).

Recovery

This interval corresponds to the second half of the *Anapachydiscus (Neopachydiscus) naumanni* and *Pachydiscus (P.) egertoni* Zones. The beginning of this interval is characterized by the total extinction of *Eupachydiscus haradai*, gradual reduction of *Anapachydiscus (Neopachydiscus) naumanni* and by the appearance of new species of the genus *Canadoceras* in increasing numbers.

Morphological innovations are expressed by simplification of the shell sculpture ornamentation. It became finer as the coarse elements disappeared and the shell size decreased.

The genus *Canadoceras* is represented by five species during the time of its maximum abundance on Sakhalin and in northeastern Russia and by seven species in Japan. The Sakhalin assemblage consists of *Canadoceras mysticum* Matsumoto, *C. kossmati* Matsumoto, *C. yokoyamai* (Jimbo), *C. newberryanum* Meek, *C. multicostatum* Matsumoto. The latter is known from the Campanian of Madagascar and South Africa whereas the others are endemic.

Simultaneously, there was the development of a new species, *Anapachydiscus fasciostatus*, from *A. (Neopachydiscus) naumanni*. However, species immigrants *Anapachydiscus arrialoorensis* (Stoliczka) and *Pachydiscus (P.) egertoni* (Forbes) also appeared in the *Pachydiscus (P.) egertoni* Zone during the acme of the genus *Canadoceras*. *Desmophyllites diphylloides* (Forbes) appeared at the beginning of the Campanian associated with species of the Tethyan region as well as other species. These data indicate a significant level of ammonite migration.

Pachydiscus (P.) egertoni gave rise to many new species that were widespread in Maastrichtian of Sakhalin and northeast Russia, as well as in Japan.

Nomismogenesis

This interval corresponds to the *Canadoceras multicostatum* Zone. It is characterized by a relative stabilization of the ammonoid development. There are all the above-mentioned post-crisis species, together with some of the conservative, long-lived, lineages of phylloceratids, lytoceratids and desmoceratids (Figs 4, 5).

The number of specimens decreases abruptly directly before the Campanian–Maastrichtian

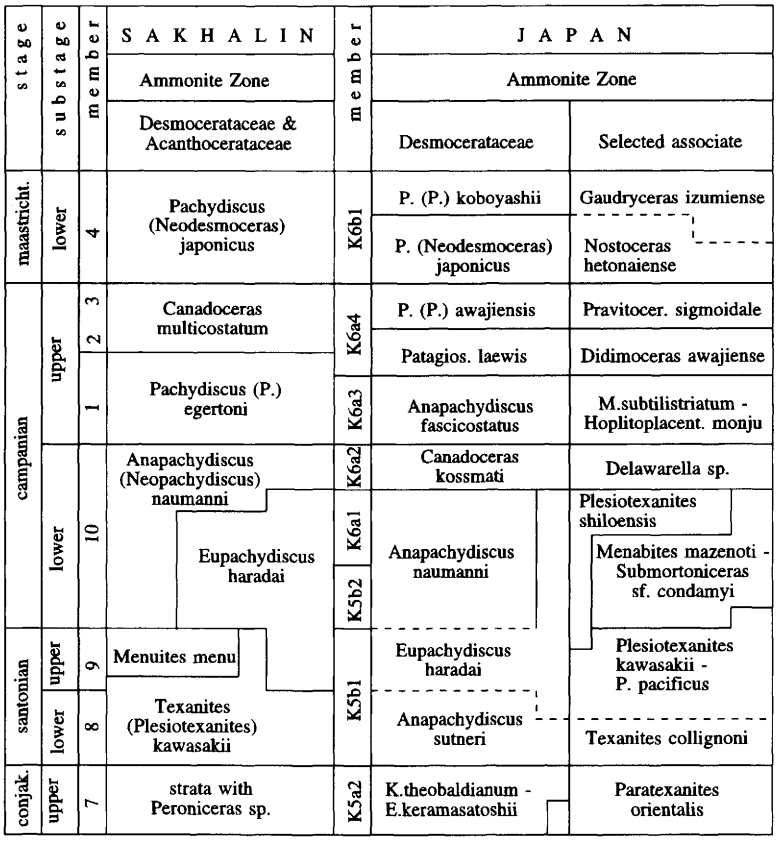

Fig. 7. Zonal ammonite divisions of the Santonian–Campanian in Sakhalin (by author) and in Japan (according to Toshimitsu *et al.* 1995).

boundary. This was another extinction event, probably related to the beginning of a Late Campanian regression. There was a reduction in the taxonomical diversity of the group and marked changes of the shell morphology occurred during that event. All but one species of the Family Pachydiscidae disappeared. A large specimen of *Canadoceras multicostatum* has been found in the Lower Maastrichtian sequences of Sakhalin.

The next taxonomical 'explosion' took place in the Late Maastrichtian, when the Family Pachydiscidae reached its acme. Moreover, at the same time there was an abundance of desmoceratids, phylloceratids and lytoceratids prior to the total extinction of ammonoids at the end of the Cretaceous.

Conclusions

The dynamics of taxonomic diversity of the Late Cretaceous ammonoids shows a definite sequence of events (Fig. 6). At first there was a mass extinction event followed by a survival interval with a single taxon which then gave rise to new morphotypes. These morphotypes indicate the beginning of a recovery phase that finishes with the acme of many groups. This is caused by an adaptive radiation based on local speciation as well as inward migration. After that the ammonoid development enters the nomismogenesis stage prior to a new extinction event. The author's zonal scheme of the Santonian to Campanian succession of Sakhalin clearly correlates with that of Japan (Fig. 7) and may be used in northeast Russia as well.

Research was supported by the Russian Fundamental Research Foundation (grant 94-05-17589, leader Professor T. N. Koren). I am very grateful to Dr T. D. Zonova (St Petersburg, VSEGEI) for helpful discussion and criticism.

References

HANCOCK, J. M. 1993. Transatlantic correlations in the Campanian–Maastrichtian stages by eustatic changes of sea-level. *In:* HAILWOOD, E. A. &

KIDD, R. B. (eds) *High Resolution Stratigraphy*. Geological Society, London, Special Publication, **70**, 241–256.

——— & KAUFFMAN, E. G. 1979. The great transgression of the Late Cretaceous. *Journal of the Geological Society, London*, **136**, 175–186.

KENNEDY, W. A. & KLINGER, H. C. 1993. On the affinities of Cobbanoscaphites Collignon, 1969 (Cretaceous Ammonoidea) *Annals of the South African Museum*, **102**, (7), 265–271.

MATSUMOTO, T. 1977. On so-called Cretaceous Transgressions. *Paleontological Society of Japan, Special Papers*, **21**, 75–84.

——— 1984. Some Ammonites from the Campanian (Upper Cretaceous) of the Northern Hokkaido. *Paleontological Society of Japan, Special Papers*, **27**, 1–34.

——— & HARAGUCHI, Y. 1978. A new Texanitinae ammonite from Hokkaido. *Transactions and Proceedings of the Paleontological Society of Japan, New Series*, **110**, 306–318.

——— & KANIE, J. 1979. Two ornate ammonites from the Urakawa Cretaceous area, Hokkaido. *Science Report of the Yokosuka City Museum*, **226**, 13–20.

——— & ——— 1982. On three Cretaceous keeled ammonites from the Urakawa area, Hokkaido. *Science Report of the Yokosuka City Museum*, **229**, 9–22.

——— & OBATA, I. 1982. Some Interesting Ancanthoceras from Hokkaido. *Bulletin of the National Science Museum, Series C (Geology & Paleontology)*. **8(2)**, 67–92.

POYARKOVA, Z. N. (ed.) 1987. [The Reference section of Cretaceous deposits in Sakhalin (Naiba section).] Nauka, Leningrad [in Russian].

ZONOVA, T. D., KASINZOVA, L. I. & YAZYKOVA, E. A. 1993. *In:* ZONOVA, T. D. & ZHAMOIDA, A. I. (eds) *Atlas of the main groups of the Cretaceous fauna from Sakhalin*. Nedra, St Petersburg [in Russian].