BULLETIN DE L'INSTITUT ROYAL DES SCIENCES NATURELLES DE BELGIQUE SCIENCES DE LA TERRE, 69-SUPP. A: 173-178, 1999
BULLETIN VAN HET KONINKLIJK BELGISCH INSTITUUT VOOR NATUURWETENSCHAPPEN AARDWETENSCHAPPEN, 69-SUPP. A: 173-178, 1999

Report 2

Stratigraphic distribution of lamnoid sharks at Cretaceous and Palaeogene stage boundaries in the Eastern Peri-Tethys

by Viktor I. ZHELEZKO

Abstract

The distribution of lamnoid sharks during the Cretaceous and Palaeogene was studied in the Eastern Peri-Tethys in W. & N. Kazakhstan and in Preuralia. The Santonian/ Campanian, Cretaceous/ Palaeocene, and Palaeocene/ Eocene were given special attention.

Key-words: Cretaceous, Palaeogene, Lamnoid sharks, Eastern Peri-Tethys.

Résumé

La distribution des requins lamnoïdes pendant le Crétacé et le Paléogène a été étudié dans la Peri-Tethys orientale, dans l'ouest et le nord du Kazakhstan et dans le Préural. Les limites santono-campanienne, Crétacé-Paléocène et Paléocène-Eocène ont été particulièrement étudiées.

Mots-clefs: Crétacé, Paléogène, requins lamnoides, Péri-Tethys orientale.

Резюме

Распределение ламноидных акул в меле и палеогене было изучено в восточном Перитетисе, в западном и северном Казахстане и в Преуралье. Особое внимание было уделено изучению сантоно-кампанской, мелово-палеоценовой и палеоцено-эоценовой границам.

Ключевые слова: мел, палеоген, ламноидные акулы, восточный Перитетис

Introduction

The regions of the Eastern Peri-Tethys (mainly Mangyshlak and the NE Pericaspian, Kazakhstan) contain relatively complete sections of all stages of the Cretaceous and Palaeogene systems.

From these sediments (Mangyshlak, Aktyubinskoe Premugodzharia, Ustyurt, Preuralia, Turgay) many elasmobranch teeth were collected (GLÜCKMAN, 1964, 1980; GLÜCKMAN & ZHELEZKO, 1979; ZHELEZKO, 1994, 1995; ZHELEZKO & KOZLOV, 1999). The study of the stratigraphic distribution and of the phylogenetic development of Cretaceous and Palaeogene fishes bring information on the development of the seas and faunas of this extensive territory (Fig. 1).

The best shark teeth material was collected in sediments of Santonian/ Campanian, Cretaceous/ Palaeocene and Palaeocene/ Eocene transitions.

Santonian/ Campanian boundary

The Santonian/ Campanian boundary deposits were studied during several field conferences under the direction of D. P. Naidin and G. N. Papulov (PAPULOV & NAIDIN, 1979; AKIMETS *et al.*, 1979) in Aktyubinskoe Premugodzharia and Mangyshlak (W. Kazakhstan).

In the *Aktyubinsk - Premugodzharie* area, the Altykuduk Fm., unconformably overlying white Albian - Cenomanian sands, contains the following beds:

Kubley beds (Santonian): quartz-glauconitic sands with phosphorites are divided into three beds, from bottom to top:

- bed A: irregular granular sands, with phosphatic pebbles at the base. Fossil content: *Squalicorax santonicus* GLÜCKMANN & ZHELEZKO, 1979, *Eostriatolamia aktobensis* ZHELEZKO, 1988; *fide* NAIDIN (1979) the belemnite *Goniocamax lundgreni uilicus*. Thickness of the fossil bed: 1.5 - 3.5 m.
- bed B: sandy clays, with phosphatic concretions at the base. Fossil content: *Squalicorax papulovi* Zhelezko,1988, *Eostriatolamia aktobensis*; *fide* NAIDIN (1979) the belemnite *Goniocamax lundgreni uilicus*.
- bed C: fine-grained quartz-glauconitic sands, interbedded with clays, and with a phosphoritic bed at the base. Thickness of the bed is 3 - 4 m. Fossil content: *Squalicorax kaupi* (Agassiz, 1843), *Eostriatolamia venusta* (Leriche, 1906), *Archaeolamna macrorhiza* (Cope); *fide* NAIDIN (1979) the belemnites *Belemnitella praecursor praecursor*, *Actinocamax verus fragilis*.

The Kubley beds are characterized by the *Gavelinella infrasantonica* foraminifer complex (BENIAMOVSKII *et al.*, 1979); the higher part of the section - the Zhurun beds - are characterized by the *G. stelligera* complex for the Santonian part of the section and by the *Cibicidoides temiremsis* complex for the Campanian (ibid.).

Zhurun beds (Santonian-Campanian) - the section is described from bottom to top:

- Santonian part: quartz - siltstone sands with a few phosphatic nodules. Fossil content: *Squalicorax kaupi*, *Eostriatolamnia venusta*, *Archaeolamna macrorhiza*; *fide* NAIDIN (1979) the belemnite *Belemnitella praecursor media* and *fide* BOBKOVA (1979) the bivalve *Oxytoma tenuicostata*.

Shark teeth localities
Cretaceous: 1- Aktyubinsk
2- Mangyshlak
Palaeogene: 3- Emba River
4- Tobol River

Fig. 1 — Localities from where shark teeth were studied

– Campanian part: fine-grained sands, clayey siltstones, with phosphorites in basal part. Thickness of the bed: 4 - 6 m. Fossil content: *Squalicorax lindstromi* (DAVIS, 1890), *Eostriatolamia lerichei* GLÜCKMANN & ZHELEZKO, 1979, *Archaeolamna arcuata* (WOODWARD, 1874); *fide* NAIDIN (1979) the belemnites *Paractinocamax grossouvrei pseudoalfridi*, *Actinocamax laevigatus laevigatiformis*, *A. verus fragilis*, *Belemnitella praecursor media* and *B. praecursor mucronatiformis*.

Santonian-Campanian boundary deposits in *Mangyshlak peninsula* have been studied in the Zhalgan, Kush, Aksyrtau and Sulukapy sections. A composite section of the sections in these individual outcrops would be as follows (from bottom to top):

(1) greenish-grey marl, with *Inoceramus undulatoplicatus* (*fide* ATABEKIAN, 1979); in the basal levels the *Stensoeina exculpta* foraminifer complex, in the top levels the *S. granulata perfecta* complex (*fide* BENIAMOVSKII *et al.*, 1979). Thickness: over 5 m. Age: Santonian.

(2) white, coarse-grained chalk, with numerous *Osangularia*. Thickness: 3 to 5 m. Age: Santonian.

(3) white chalk, more sandy in its upper part, with the crinoids *Uintacrinus* and *Marsupites*, the *Gavelinella stelligera* foraminiferal complex (*fide* BENIAMOVSKII *et al.*, 1979) and the shark *Squalicorax kaupi*. Thickness: 3 to 4 m. Age: Santonian.

(4) white, coarse-grained chalk, with the *Gavelinella clementiana* foraminifer complex (*fide* BENIAMOVSKII *et al.*, 1979) in the top levels, and with the echinoid *Offaster pilula* and the shark *Squalicorax kaupi*. Thickness: 6 m. Age: Santonian.

(5) interbedded white chalk and greenish, marly chalk. Fossil content: the echinoids *Micraster schroederi* and *Offaster pilula*, the shark *Squalicorax lindstromi*; also foraminiferal complexes with *Bolivinoides decoratus*/ *Cibicidoides temirensis* (*fide* BENIAMOVSKII *et al.*, 1979). Thickness: 7 to 11 m.

It is difficult to precisely place the Santonian-Campanian boundary in Mangyshlak and in the Pericaspian strata because of the absence of ammonites. The problem is complicated further because Aktyubinsk and Preuralia are part of the Temperate realm and Mangyshlak of the Tethyan realm. The classical index fossils in the Precaspian are belemnites, and in Mangyshlak for this boundary *Marsupites* is used.

Locally, stratigraphical correlation can be undertaken with taxa of the genus *Squalicorax*: bed 4 in the Mangyshlak sections contains the foram complex *Gavelinella clementiana*, the echinoid *Offaster pilula* and the shark *Squalicorax kaupi* - they indicate the Santonian. The lower boundary of the Campanian in the NE Pericaspian correlates with the base of the beds with *Belemnitella praecursor mucronatiformis*, *Paractinocamax grossouvrei pseudoalfridi* ànd *Squalicorax lindstromi*.

Cretaceous/ Palaeocene boundary

The faunal turnover at the K/ T boundary is extensive and occurs in many different fossil groups (NAIDIN, 1976; ALEKSEEV, 1989). Also in the development of elasmobranch sharks this boundary is clearly visible (Fig. 2).

In the Cretaceous basins the main osteodont fishes belonged to the families Cretodontidae, Cretoxyrhinidae, Anacoracidae and Ptychodontidae. From their teeth it is obvious that they were large fishes (7 to 10 m, or even more). They dominated in the pelagic and in the littoral zones. Cretodontidae, Cretoxyrhinidae and Anacoracidae had teeth of the tear-cutting type. Ptychodontidae had huge chewing teeth, with a thick layer of enamel, capable of crushing animals, even those with a thick armour. The acme of the Cretodontidae, Cretoxyrhinidae and Ptychodontidae is situated in the Albian-Santonian time interval. From the Campanian onwards, distinct signs of decrease in number of taxa are seen. In the Anacoracidae the maximum development was in the Santonian-Campanian interval; during the Maastrichtian their number decreased. At the end of the Maastrichtian the last representatives of the Cretodontidae, Cretoxyrhinidae, Anacoracidae, and Ptychodontidae died out.

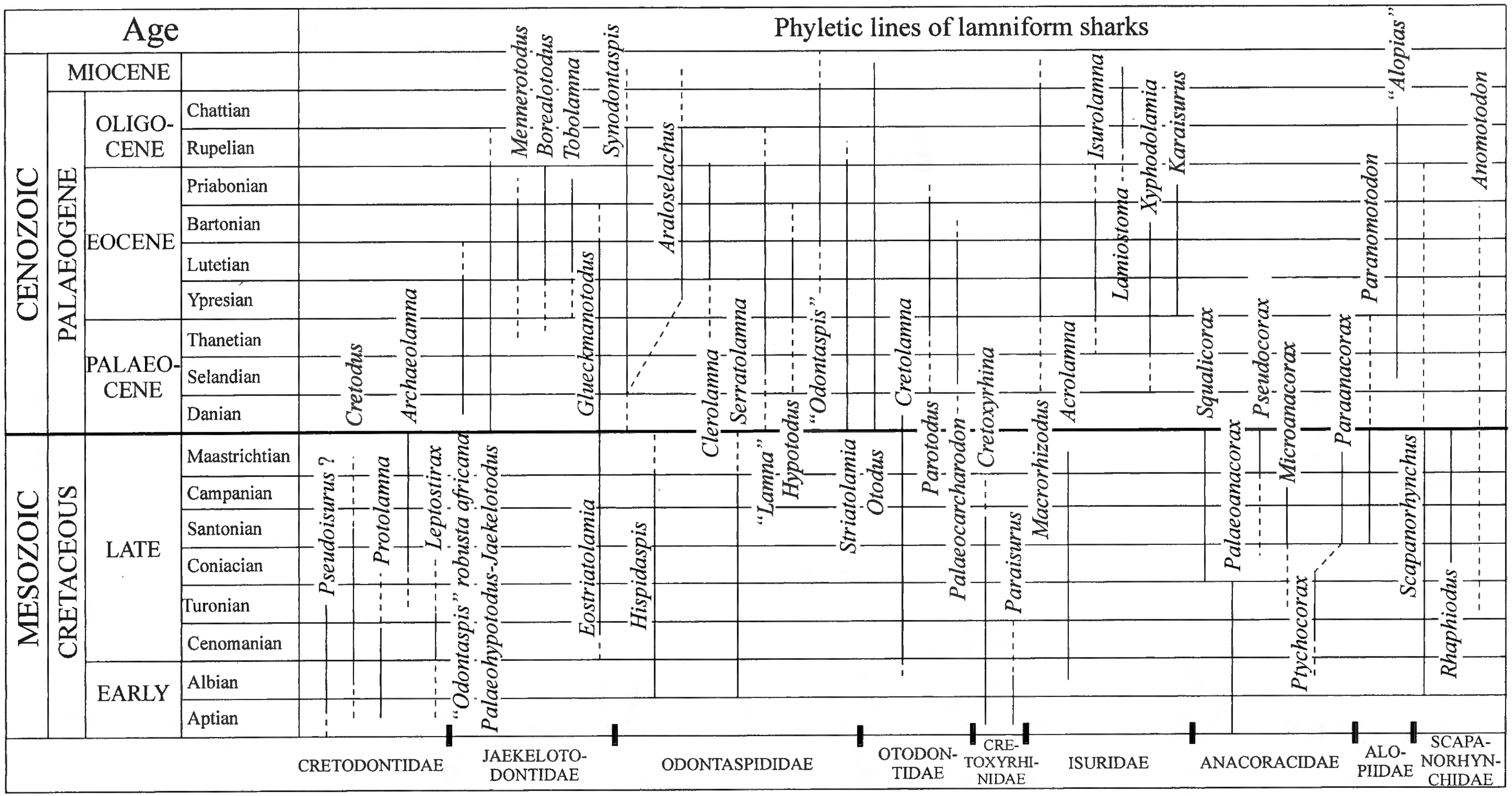
Another group of lamnoid sharks (families Jaekelodontidae, Odontaspididae, Otodontidae, Isuridae, Alopiidae, and Scapanorhynchidae) had their origin in the late Cretaceous, but the main development of this group was in the Palaeogene.

The Scapanorhynchidae had three genera in the Cretaceous: *Scapanorhynchus*, *Raphiodus* and *Anomotodon*; in the Palaeogene the family was less developed. The acme of the Jaekelodontidae was during the Palaeogene; in the Cretaceous the family was represented by the genus *Eostriatolamia*. Similarly, in the Cretaceous, the Odontaspididae were represented by the genera *Hispisdaspis* and *Serratolamna*, the Otodontidae by the genus *Cretolamna*, the Isuridae by the genus *Acrolamna*, the family Alopiidae by the genus *Paranomotodon*; in the Palaeogene the Alopiidae expanded into many taxa of the compound genus *Alopias*. New phylogenetic lines developed for the Jaekelodontidae, Odontaspididae, Otodontidae, Isuridae and Alopiidae in the Palaeogene.

The K/T boundary can be dated by the extinction of the lamnoid

→

Fig. 2 — Distribution of Cretaceous and Palaeogene lamnoid sharks


Age
Phyletic lines of lamniform sharks
CENOZOIC
MESOZOIC
PALAEOGENE
CRETACEOUS
MIOCENE
OLIGO-CENE
EOCENE
PALAEO-CENE
LATE
EARLY
Chattian
Rupelian
Priabonian
Bartonian
Lutetian
Ypresian
Thanetian
Selandian
Danian
Maastrichtian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
Aptian
Pseudoisurus ?
Cretodus
Protolamna
Archaeolamna
Leptostirax
"Odontaspis" robusta africana
Palaeohypotodus-Jaekelotodus
Mennerotodus
Borealotodus
Tobolamna
Synodontaspis
Glueckmanotodus
Eostriatolamia
Hispidaspis
Araloselachus
Clerolamna
Serratolamna
"Lamna"
Hypotodus
"Odontaspis"
Striatolamia
Otodus
Cretolamna
Parotodus
Palaeocarcharodon
Cretoxyrhina
Paraisurus
Macrorhizodus
Acrolamna
Isurolamna
Lamiostoma
Xyphodolamia
Karaisurus
Squalicorax
Palaeoanacorax
Pseudocorax
Microanacorax
Ptychocorax
Paraanacorax
Paranomotodon
"Alopias"
Scapanorhynchus
Rhaphiodus
Anomotodon
CRETODONTIDAE
JAEKELOTO-DONTIDAE
ODONTASPIDIDAE
OTODON-TIDAE
CRE-TOXYRHI-NIDAE
ISURIDAE
ANACORACIDAE
ALO-PIIDAE
SCAPA-NORHYN-CHIDAE

shark families Cretodontidae, Cretoxyrhinidae and Anacoracidae.

The orthodont sharks also were influenced by the K/T boundary. More than 15 families of Cretaceous orthodont sharks are known. The most important among them are: Polyacridontidae, Hexanchidae, Heterodontidae, Squatinidae, Ginglimostomatidae, Rhinobatidae, Squalidae, Dalatiidae.

These small and medium-sized sharks and batoids were part of benthos in littoral waters. They mainly fed on small species of invertebrates and fishes. At the K/T boundary these Selachians show changes at the generic and specific level. In the Palaeogene new orthodont families such as the Myliobatidae, Torpedinidae, Echinorhinidae, Triakidae and Carcharinidae arose. They were the first representatives of the neoselachians, which in recent seas and oceans have a prevalent position.

Palaeocene - Eocene boundary

The Thanetian/ Ypresian boundary was studied in sections at Shatyrlisay (on the Emba River) and at Belinsky/ Ajat on the Tobol River in northern Kazakhstan. For comparative purposes the Marke and Egem quarries in Belgium, and the Thanetian stratotypical section at Herne Bay (England) were also sampled.

The section at Shatyrlisay (Emba River basin) contains Palaeocene and Lower Eocene deposits: clayey to sandy strata with phosphoritic concretions at the base, delimited by erosional surfaces. From bottom to top the following beds have been identified:

(1) white marls with belemnites (Maastrichtian); thickness: more than 3 m;
(2) sands with phosphatic nodules; fossil content: *Striatolamia striata* (Winkler, 1874), *Palaeohypotodus rutoti* (Winkler, 1874); age: Upper Palaeocene;
(3) quartz-glauconitic sands, with phosphatic nodules at the base; fossil content: *Striatolamia striata*, *Otodus obliquus* Agassiz, 1843; age: according to TABACHNIKOVA (1989a) nannoplankton zone UP 8 (upper part of Palaeocene); thickness: 0.6 m;
(4) clayey sands, at the base with phosphoritic concretions; fossil content: *Striatolamia elegans* (Agassiz, 1843), *Otodus obliquus*; age: lower part of the Ypresian; thickness: more than 4 m.

The Belinsky quarry (Tobol River basin) shows the following Palaeogene section, from bottom to top:

(1) conglomerate, without fauna (0.5 m);
(2) siltstone, fine grained sand, weakly carbonaceous, with flint pebbles at the base; fossil content: *Striatolamia striata*; age: Thanetian; thickness: 1.3 to 3.7 m;
(3) interbedded clays and irregularly grained gravel sands; fossil content: *Striatolamia elegans* and *Otodus obliquus*; age: according to TABACHNIKOVA (1989b) nannoplankton zone NP 12, dinoflagellate zone W 6-7 according to VASILJEVA (1990), Lower Ypresian; thickness: 2.3 m;
(4) olive-green clays with pebbles at the base; fossil content: *Striatolamia macrota* (Agassiz, 1843); age: Bartonian; thickness: 1.9 m

Between the Palaeocene and Eocene important changes occurred in the selachians; in some groups (especially the large predators) this development seems to have been progressive whereas in others it seemed more sudden. Many existing groups of smaller sharks had an explosive evolution in the early Eocene.

References

AKIMETS, V. S., BENIAMOVSKII, V. N., GLADKOVA, V. I., ZHELEZKO, V. I. & NAIDIN, D. P., 1979. Foraminifera of the Santonian/ Campanian boundary sediments (Upper Cretaceous) of Mangyshlak. *Byulleten Moskovskogo Obshchestvo Ispitateley Prirody- Serija Geologia* **54**, 6: 113-120. [in Russian].

ALEKSEEV, A. S., 1989. Global biotic crises and mass extinctions in the Phanerozoic history of the world. *In*: MENNER, V. V., Biotic events at the main Phanerozoic boundaries [in Russian].

ATABEKYAN, A. A., 1979. Inoceramids of the Santonian-Campanian boundary strata in the Aktyubinsk district. *In*: PAPULOV, G. N. & NAIDIN, D. P., Eds., The Santonian/Campanian boundary on the East European Platform. *Trudy Instituta Geologii i Geokhimii, Akademya Nauk SSSR - Uralskij nauchnij tsentr*, **148**: 42 - 65. [in Russian].

BENIAMOVSKII, V.N., GLADKOVA, V. I. & KOPAEVICH, L. F. , 1979. Foramimfera. *In*: PAPULOV, G. N. & NAIDIN, D. P. , Eds., The Santonian/Campanian boundary on the East European Platform. *Trudy Instituta Geologii i Geokhimii, Akademya Nauk SSSR - Uralskij nauchnij tsentr*, **148**: 31 - 41. [in Russian].

BOBKOVA, N. N., 1979. Oxytomas from the Santonian-Campanian interval of the Aktyubinsk district. *In*: PAPULOV, G. N. & NAIDIN, D. P. , Eds., The Santonian/ Campanian boundary on the East European Platform. *Trudy Instituta Geologii i Geokhimii, Akademya Nauk SSSR - Uralskij nauchnij tsentr*, **148**: 66 - 70. [in Russian].

GLÜCKMAN, L. S., 1964. Sharks of the Palaeogene and their stratigraphic significance. Nauka Izdatelstvo, Moscow-Leningrad, 299 pp. [in Russian].

GLÜCKMAN, L. S., 1980. Evolution of Cretaceous and Cainozoic lamnoid sharks. Akademia Nauk SSSR, Moscow, 247 pp. [in Russian].

GLÜCKMAN, L. S. & ZHELEZKO, V. I., 1979. Sharks. *In*: PAPULOV, G. N. & NAIDIN, D. P., Eds., The Santonian/ Campanian boundary on the East European Platform. *Trudy Instituta Geologii i Geokhimii, Akademya Nauk SSSR - Uralskij nauchnij tsentr*, **148**: 90-105. [in Russian].

NAIDIN, D. P., 1976. The Cretaceous/Palaeogene boundary. In: Boundaries of geological systems. For the 70 th birthday of Academician V. V. Menner. Nauka, Moscow, pp. 225 - 257. [in Russian].

NAIDIN, D. P., 1979. Belemnitellidae. *In*: PAPULOV, G. N. & NAIDIN, D. P., Eds., The Santonian/ Campanian boundary on the East European Platform. *Trudy Instituta Geologii i Geokhimii, Akademya Nauk SSSR - Uralskij nauchnij tsentr*, **148**: 75 - 89. [in Russian].

PAPULOV, G. N. & NAIDIN, D. P. , Eds., 1979. The Santonian/ Campanian boundary on the East European Platform. *Trudy Instituta Geologii i Geokhimii, Akademya Nauk SSSR - Uralskij nauchnij tsentr*, **148**: 117 pp. [in Russian].

TABACHNIKOVA, I.P., 1989a *in*: BENYAMOVSKY, V.N., LEVINA, A. P., PRONIN, V.G., TABACHNIKOVA, I. P., Palaeocene of the

Turgay depression. *Izvestiya Vysshikh Uchebnykh Zavedenii. Geologiya i Razvedka*, **1989**, 6: 47-55 [in Russian].

TABACHNIKOVA, I.P., 1989b *in*: BENYAMOVSKY, V.N., LEVINA, A. P., PRONIN, V.G., TABACHNIKOVA, I. P., 1989a. Lower Eocene of the Turgay depression. *Izvestiya Vysshikh Uchebnykh Zavedenii. Geologiya i Razvedka*, **1989**, 9: 3-16 [in Russian].

VALSILJEVA, O.N., 1990. Palynology and microphytoplancton of Palaeogene of South Trans Urals. Sverdlovsk. 54 pp. [in Russian].

ZHELEZKO, V. I., 1994. Sharks of the family Jaekelotodontidae from European and middle Asian palaeogeographic provinces. *Byulleten Moskovskogo Obshchestvo Ispitateley Prirody- Geologicheskii Seriya*, **69**, 6: 47 - 62. [in Russian].

ZHELEZKO, V. I., 1995. Biostratigraphy of Palaeogene sediments of the northern Karagia depression (Mangyshlak, Kazakhstan). Akademya Nauk SSSR - Uralskij otdelenie, Ekaterinburg, pp. 6-10. [in Russian].

ZHELEZKO, V. I. & KOZLOV, V. A., 1999. Elasmobranchii and Palaeogene biostratigraphy of Trans Urals and Central Asia. *Materials on Stratigraphy and Palaeontology of the Urals,* **3**. Ekaterinburg: Urals Branch of Russian Academy of Sciences Publ. House, 1999. 324 pp. [in Russian].

Author's address:
Viktor I. ZHELEZKO,
Institute of Geology and Geochemistry,
Urals Brach of the Russian Academy
of Sciences,
Pochtoviy per. 7, 620219 Ekaterinburg,
Russia

Typescript submitted: 15.1.1999

APPENDIX

Stratigraphic distribution of lamnoid shark genera in Cretaceous and Palaeogene.

CRETACEOUS FAMILIES AND GENERA
Family Ptychodontidae Woodward, 1932
Ptychodus Agassiz, 1839.
Heteroptychodus Yabe et Obata, 1930.
Family Cretodontidae Zhelezko, fam. nov. , 1999
? *Pseudoisurus* Glückman, 1957
Cretodus Sokolov, 1965
Protolamna Cappetta, 1980
Archaeolamna Siverson, 1992
Leptostirax Williston, 1900
Family Cretoxyrhinidae Glückman, 1958.
Cretoxyrhina Glückman, 1958.
Paraisurus Glückman, 1957.
Family Anacoracidae Casier, 1947.
Palaeoanacorax Glückman, 1971
Squalicorax Whitley, 1939.
Pseudocorax Priem, 1897.
Microanacorax Glückman, 1979.
Ptychocorax Glückman, 1979.
Paraanacorax Glückman, 1979.
CRETACEOUS AND PALAEOGENE FAMILIES AND GENERA
Family Jaekelotodontidae, Glückman, 1964 (Cretaceous-Palaeogene).
Eostriatolamia Glückman, 1979, Cretaceous.
Palaeohypotodus Glückman, 1964, Palaeogene.
Jaekelotodus Menner, 1928, Palaeogene.
Glueckmanotodus Zhelezko, 1999, Palaeogene.
Mennerotodus Zhelezko, 1985, Palaeogene.
Borealotodus Zhelezko, 1999, Palaeogene.
Tobolamna Zhelezko, 1999, Palaeogene.
Family Odontaspididae Müller & Henle, 1839 (Cretaceous-Palaeogene).
Hispidaspis Sokolov, 1978, Cretaceous.
Serratolamna Landemaine, 1991, Cretaceous.
Synodontaspis White, 1931, Palaeogene.
Araloselachus Glückman, 1964, Palaeogene.
Clerolamna Zhelezko, 1999, Palaeogene.
Hypotodus Jaekel, 1985, Palaeogene.
Striatolamia Glückman, 1964, Palaeogene.
Family Otodontidae Glückman, 1964 (Cretaceous-Palaeogene).
Cretolamna Glückman, 1958, Cretaceous.
Otodus Agassiz, 1843, Palaeogene. (The genus *Carcharocles* is herein included into the genus *Otodus*).
Parotodus Cappetta, 1980, Palaeogene.
Palaeocarcharodon Casier, 1961, Palaeogene.
Family Isuridae Gray, 1851 (Cretaceous- Palaeogene).
Acrolamna Zhelezko, 1990, Cretaceous.
Macrorhizodus Glückman, 1964, Palaeogene.
Isurolamna Cappetta, 1976, Palaeogene.
Lamiostoma Glückman, 1964, Palaeogene.
Xiphodolamia Leidy, 1877, Palaeogene.
Family Alopiidae Gill, 1855 (Cretaceous-Recent)
Paranomotodon Herman *in* Cappetta & Case, 1975, Cretaceous-Palaeogene.
Alopias Rafinesque, 1810, Palaeogene-Recent.
Family Scapanorhynchidae Bigelow & Schroeder, 1948 (Cretaceous-Palaeogene).
Scapanorhynchus Woodward, 1889, Cretaceous-Palaeogene.
Rhaphiodus Glückman, 1980, Cretaceous.
Family Mitsukurinidae Jordan, 1898
Anomotodon Arambourg, 1952, Cretaceous-Palaeogene.
Mitsukurina Jordan, 1818, Palaeogene- recent