INTAS PROJECT 1994-1414

BIO-EVENTS AT THE K/T BOUNDARY ON THE SOUTHERN MARGIN OF THE WHITE CHALK SEA - PALAEOBIOLOGY, PALAEOBIOGEOGRAPHY, SEQUENCE STRATIGRAPHY, GEOCHEMISTRY AND GEOCHRONOLOGY.

FINAL MEETING: MOSCOW MARCH 23 - 25, 1998

(Historical Geology, Geological Faculty, Moscow State University (MGU), Vorobievy gory, Moscow, Russia)

PROGRAMME

ABSTRACTS

ADDRESSES of PARTICIPANTS

MΓY – MSU

KBIN-IRSNB

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- In June 1996 we met at "Polygon" (geological fieldcamp of Moscow University in Crimea) and studied the beautiful Cretaceous and Palaeogene sections of Mountain Crimea - macro and micro-palaeontologically.
- In September 1996 we met in Freiberg/Sachsen at the occasion of the Fifth International Cretaceous Symposium and presented first results of our project - concerning mainly faunas of the Campanian-Maastrichtian.
- In December 1996 two of us participated in the K/T boundary meeting at the Société géologique de France in Paris.
- In June 1997 some of us met again at Polygon (Crimea) to continue detailed faunal studies of Upper Cretaceous strata.
- In October 1997 we participated in the final meeting of IGCP 362 at Stara Lesna (Slovakia) and papers were presented in connection with our project work.
- In November 1997 a LEICA-WILD MZ 12 binocular microscope (complete also with photographic equipment) which we bought with our grant money, was transported from Brussels to Moscow and installed in the Department of Historical and Regional Geology of the Geological Faculty (Moscow State University).

Now today we are having our final meeting for INTAS project 94-1414 and we discuss our latest results. Micro- and macrofaunal studies, biostratigraphical studies, sedimentological, geochemical and tectonic results are being presented. We did not succeed in completing all the goals we set ourselves in the project, but an undoubted advance was made in the knowledge of the outcrops we are interested in, and the work is being continued.

I would like to express my sincere thanks to all the participants for their enthusiasm and cooperation throughout the project, to the Royal Belgian Institute of Natural Sciences for unstinting material and moral assistance, and to the Department of Historical and Regional Geology, Geological Faculty, Moscow State University especially for friendship and repeated hospitality since 1980, and help in organising this final meeting.

Annie V. Dhondt
Coordinator of INTAS 94-1414

Brussels, February 28, 1998.

INTRODUCTION

An interest in Russian Cretaceous faunas and their obvious similarities with those from western Europe ànd the first meeting with Russian Cretaceous specialists [M. A. Pergament in Dresden (1975), D. P. Naidin in Lawrence, Kansas (1976)] made me decide to apply for an exchange fellowship (Cultural exchange USSR-Belgium) to the USSR in 1978. In those days very few Belgians applied for such grants - the USSR was a vast, largely unknown and slightly feared territory. I was granted a fellowship at the first try but my departure was somewhat delayed because of the geopolitical situation.
I arrived in Moscow on March 15, 1980. A first glance at the golden domes of the Kremlin in the setting sunlight, and the snowy parks around it, enchanted me and ever since this sight represents for me the very essence of Russia.
During that first visit I studied many fossils in Moscow (MGU, PIN and MGRI), in Lwow, in Novosibirsk and in Tbilissi. In the two months I spent in the USSR, besides studying as many Cretaceous bivalves as I could, I made friends with colleagues and learnt about aspects of the history, art and architecture of that vast territory.
In 1981-1982 I was granted another exchange fellowship and worked in Moscow, and this time also in Leningrad (VSEGEI, LGU, Gornij Institut).
These two consecutive visits and resulting friendships with many colleagues formed the beginning of a continuous interest in the USSR and its Cretaceous, especially when it became clear that many Cretaceous faunas were indeed largely identical with those from western Europe, which I had been studying.

The world changed and in the early nineties contacts became a lot easier. When INTAS started asking for research proposals we decided to try our luck. At about the same time an excursion in the Cretaceous of Mangyshlak (Kazakstan) was organised, under the scientific direction of Prof. D. P. Naidin. It took place in May 1994. It became an unforgettable event - the magnificent outcrops and the wild and grandiose landscape deeply impressed all participants.

Some of the Mangyshlak sections show a very good K/T transition, with a clay layer with Iridium, some others have a small hiatus at the K/T boundary (see abstract of D. P. Naidin in this volume).
These Mangyshlak sections gave us the idea for submitting a project to INTAS in which we planned to compare K/T transitions in Mangyshlak, in Crimea and around Maastricht - three regions with good Maastrichtian and reasonable Danian outcrops and an important macrofauna from shallow water environments.

At the occasion of the "Second International Symposium on Cretaceous Stage Boundaries" in Brussels (September 1995) all participants of 94-1414 INTAS project met, and studied the newly discovered K/T boundary outcrop at the Geulhemmer Berg near Maastricht.

INTAS 94-1414 officially started in November 1995. Its financial input allowed a more intense collaboration, which culminated in several meetings listed below:

PROGRAMME

Saturday 21.3.1998:
arrival (participants from Western Europe):
6.05 p. m. (flight LH 3308)

Sunday 22.3.1998:
visit of Moscow (departure 10.30 a.m. at MGU, Klubnij Chast).

SCIENTIFIC MEETING

Monday 23.3.1998 at Kathedra of Historical and Regional Geology, MGU, Vorobjevy Gory, building A, floor 5, room 509.

Presentation of Papers on K/T boundary and related Topics:

10 a.m.: Opening of the meeting - Welcoming of the participants
Introduction

10.15 a. m. - 11.15 a. m.
F. Robaszynski (Faculté Polytechnique, Mons, Belgium)
CRETACEOUS STAGE BOUNDARIES AND K/T BOUNDARY IN CENTRAL TUNISIA.

11.15 a. m. - 11.45 a. m.
D. P. Naidin (Moscow State University, Moscow, Russia)
TWO TYPES OF CRETACEOUS-TERTIARY BOUNDARY.

11.45 a. m. - 12.10 p. m.
Coffee break

12.10 a. m. - 12. 40 p. m.
E. Keppens* , S. Felder**, S. Normand ** & M. Streel **
(*Vrije Universiteit Brussel, Brussels, Belgium; ** Laboratoires de Paléontologie, Université de Liège, Liège, Belgium)
POLLEN AND OXYGEN ISOTOPIC RESPONSE TO CLIMATIC CHANGES IN THE UPPER MAASTRICHTIAN AT THE ENCI-QUARRY, MAASTRICHT, THE NETHERLANDS.

12.40 p. m. - 1.10 p. m.
A. Yu. Guzhikov, E. A. Molostovsky (Saratov State University, Saratov, Russia)
N. A. Bondarenko and T. V. Lyubimova (Kuban University, Krasnodar, Russia)
CRETACEOUS-PALAEOGENE TECTONIC ACTIVITY IN THE CAUCASUS AND TRANS-CAUCASIA REFLECTED IN SCALAR MAGNETIC CHARACTERISTICS.

1.10 p. m. - 1.30 p. m.
Yu. D. Zakharov*, N. G. Ukhaneva*, A. V. Ignatyev*, K. Tanabe**, Y. Shigeta ***, T. B. Afanasyeva*, & A. M. Popov (*Far Eastern Geological Institute, Vladivostok, Russia ** Geology, University of Tokyo, Japan *** National Museum, Tokyo, Japan)
PALAEOTEMPERATURE CURVE FOR THE LATE CRETACEOUS OF THE NORTH-WESTERN CIRCUM-PACIFIC.

1.30 p. m. - 2.30 p. m.
Lunch

2.30 p. m. - 3 p. m.
A. M. Nikishin (Moscow State University, Moscow, Russia)
LATE CRETACEOUS TECTONICS OF EASTERN EUROPE.

3.30 p. m. - 4 p. m.
R. R. Gabdullin (Moscow State University, Moscow, Russia)
RHYTHMICALLY BEDDED CARBONATES: BELOW AND ABOVE THE K/T BOUNDARY.

4 p. m. - 4.30 p. m.
A. S. Alekseev*, Kopaevich, L. F.** and Ovechkina, M. N. * (* Moscow State University, Moscow, Russia and Palaeontological Institute of the Russian Academy of Sciences, Moscow, Russia; ** Moscow State University, Moscow, Russia)
LATE MAASTRICHTIAN OF NORTH SARATOV REGION (RUSSIAN PLATFORM, VOLGA RIVER): FORAMINIFERAL AND NANNOFOSSIL BIOSTRATIGRAPHY AND BIOTIC EVENTS.

4.30 p. m. - 5 p. m.
L. F. Kopaevich*, V. N. Beniamovskii**, A. S. Alekseev* and M. N. Ovechkina* (* Moscow State University, Moscow, ** Geological Institute of the Russian Academy of Sciences, Moscow, Russia)
FORAMINIFERAL AND NANNOFOSSIL BIOSTRATIGRAPHY OF THE MAASTRICHTIAN-DANIAN TRANSITION IN CRIMEA.

5 p. m. - 5.30 p. m.
A. V. Dhondt (Royal Belgian Institute of Natural Sciences, Brussels, Belgium)
BIVALVIA AT THE K/T BOUNDARY NEAR MAASTRICHT, IN CRIMEA AND IN MANGYSHLAK.

5.30 p. m. ......

PARTY

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Tuesday 24.3.1998 at Kathedra of Historical and Regional Geology, MGU, Vorobjevy Gory, building A, floor 5, room 509.

10 a. m. - 10.30 a. m.
E. V. Kotetishvili (Geological Institute, Academy of Sciences, Tbilisi, Georgia)
UPPER CRETACEOUS AMMONITES AND THEIR EXTINCTION - INTERPRETATION OF DATA FROM THE CAUCASUS AND COMPARISON WITH MANGYSHLAK, CRIMEA AND THE MAASTRICHT AREA.

10.30 a. m. - 11 a. m.
J. W. M. Jagt (Natuurhistorisch Museum Maastricht, Maastricht, The Netherlands)
LATE CRETACEOUS-EARLY PALAEOGENE ECHINODERM FAUNAS AND THE K/T BOUNDARY IN THE MAASTRICHTIAN TYPE AREA.

11 a. m. - 11.30 a.m.
A. V. Markov & A. N. Soloviev (Palaeontological Institute of the Russian Academy of Sciences, Moscow, Russia)
NEW DATA ON PALAEOCENE-EOCENE ECHINODERMATA OF THE FAMILY PERICOSMIDAE FROM THE MANGYSHLAK PENINSULA (WEST KAZAKHSTAN).

11.30 a.m. - 12 noon
Coffee break

12 noon - 12.30 p. m.
V. I. Zhelezko (Institute of Geology and Geochemistry, Urals Branch of the Russian Academy of Sciences, Ekaterinburg, Russia)
THE DEVELOPMENT AND CHANGE OF LAMNOID SHARKS FROM THE EUROPEAN PALEOGEOGRAPHIC AREA AT THE CRETACEOUS/PALAEOGENE BOUNDARIES.

12.30 p. m. - 1 p. m.
D.P. Naidin* and **V. N. Beniamovskii**** (* Moscow State University, Moscow, ** Geological Institute of the Russian Academy of Sciences, Moscow, Russia)
THE PALAEOCENE SECTION AT BAKHCHISARAY (CRIMEA).

1 p. m. - 1.20 p. m.
Conclusions of the Scientific Meeting

1.20 p. m. - 2.20 p. m.
Lunch

2.20 p. m. - 3.20 p. m.
Visit of the MGU Museum

3.20 p. m. - 6 p. m.
- **Report on INTAS 94-1414 - scientific, financial.**
- **Possibility of applying for a second term.**

4.15 p. m. - 4.45 p. m.
Tea break

Wednesday 25.3.1998
10 a.m. - 1 p.m.
Discussion with individual researchers at M.G.U., and at the Academy Institutes PIN and GIN.

3 p.m. - 5 p.m.
Visit of the Palaeontological Museum of the PIN

Thursday 26.3.1998

Departure (participants from Western Europe): from MGU: 11.30 a.m.
(Flight Moscow - Frankfurt/Main LH 3357 - 2.30 p.m.)

ABSTRACTS

Late Maastrichtian of north Saratov Region (Russian Platform, Volga River): Foraminiferal and nannofossil biostratigraphy and biotic events

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In the northern part of Saratov Region the marly sequence of relatively deep-water Maastrichtian overlies the different levels of the Upper Cretaceous with a stratigraphic and angular unconformity. At the top of local uplifts the Maastrichtian cuts the black clays of the uppermost Albian Paramonovo Formation. Previous studies (Baryshnikova, 1966; Digas, 1976; Kurlaev *et al.*, 1981; Musatov, 1995) show the presence of Upper Maastrichtian strata with abundant, relatively warm-water plankton. The rocks are very poor in macrofossils - only a few levels containing small bivalves, ammonites and rare belemnites were discovered. For age determination we use the benthic foraminiferal zonation for EPO (Beniamovskii & Kopaevich, 1998). We have studied three areas 60 km north and north-east of Saratov:

1. Klyuchi. 51° 59,N, 46° 30, E. Two overlapping sections with erosional K/T boundary were measured and sampled. The lowermost 3.5 m of composite section below the hiatus belong to the *Neoflabellina reticulata-Bolivina decurrens* Zone (BF10a) of upper Lower Maastrichtian. Interval 3.5-8 m belongs to the *Bolivinoides draco draco* Zone (BF11) of the same age. The first appearance of *Stensioeina praecaucasica* and *Hanzawaia ekblomi* at levels 8-9 m, shows the presence in the last part of section (8-20.5 m) of the topmost Maastrichtian *H. ekblomi* Zone. Among planktonic Foraminifera the small *Heterohelix* and *Globigerinelloides* are dominant. Additional important taxa are *Archaeoglobigerina*, *Hedbergella*, and rare *Globotruncanella*. In the lower part of the section (sample KL2/13) rare *Globotruncanita stuarti* occur, but in the top of the Maastrichtian (5 m) the relatively abundant globotruncanids (*Globotruncana arca*, *G. ventricosa*) and large sculptured heterohelicids (*Pseudotextularia elegans*, *Planoglobulina)* begin to have an important role, especially in the last meter of the Maastrichtian. The nannofossil assemblage from the lower part of the section (0-4.3 m) is not conclusive and could be Campanian or Lower Maastrichtian. From level 4.3 m above the clay layer upwards the marls belong to the *Nephrolithus frequens* Zone of the Upper Maastrichtian. The clay layer at the base of the BF11 Zone contains a few rostra of *Belemnella sumensis praearkhangelskii.* The occurrence of this last subspecies was previously mentioned by Naidin (1975) from the Saratov Region (50 km further south). At the surface of chalky marls of the middle part of the *Hanzawaia ekblomi* Zone several loose small rostra of *Neobelemnella kazimiroviensis* were found. The Lower Palaeocene Syzranian opokas contain only a few benthic foraminifera not yet identified. Coccoliths are represented only by reworked Cretaceous forms, but in the basal part *Thoracosphaera operculata* occurs abundantly.

2. Tyoplovka. 52°06 N, 46°04 E. The exposures in this locality are not as good as in Klyuchi and it was possible to study only the basal part (6 m) of the Maastrichtian, just above the Albian clays. The Maastrichtian is represented mainly by trepel-like laminated marls with numerous radiolarians and abundant small planktonic Foraminifera *Heterohelix* and *Globigerinelloides*. with rare *Pseudotextularia elegans* and *Planoglobulina*. By nannofossils these marls belong to the *N. frequens* Zone.

3. Lokh. 52°08 N, 45°52 E. The 28.5 m of light grey marls which probably overlie the Cenomanian or Turonian-Coniacian (no base was seen) are exposed in this locality. The top of the section is covered by soil and the contact with the Palaeocene was not observed. In mid part of the section (11.1 m above the base) a prominent erosional hardground with numerous burrows to a depth of 0.6 m below and with glauconitic sands above, was found. In the lowermost part of the section only one belemnite rostrum of the *Belemnella sumensis* group was found. The glauconitic sands above this hardground contain numerous, but often heavily eroded rostra of the *B. sumensis* group. At

this level a few moulds of *Hoploscaphites constrictus* were found. The assemblage of benthic Foraminifera from below the hardground are characteristic for the BF10a Zone, and the one from above for BF 11 Zone.

The general composition of the foraminiferal fauna is close to that from Poland (Lublin area and Vistula Valley) Maastrichtian (Peryt, 1980; Gawor-Biedowa 1992) situated at the same latitude (about 51° N) and it contains an important admixture of Western Siberian taxa (f.i. *Pullenia dampelae*, *Spiroplectammina kasanzevi*, *Cibicides kurganicus*, *Bulimina* ex gr. *inflata*, *Gyromorphina allomorphinoides*). In the uppermost Maastrichtian, just below the K/T boundary, a warm-water planktonic foraminiferal assemblage was recognised in the Klyuchi section that reflects the terminal Maastrichtian elegans-Transgression which can be traced throughout the European Chalk Sea.

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Bivalvia at the K/T boundary near Maastricht, in Crimea and in Mangyshlak

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The Campanian represents possibly the moment of widest marine expansion in Europe. In the Lower Maastrichtian marine strata are still very widely distributed - from England to the Aral Sea in Kazakhstan - but on average they represent a somewhat shallower facies than in the Campanian. During the Upper Maastrichtian large areas which were still marine in the Lower Maastrichtian had become continental. This was especially true in extensive Tethyan areas of southern Europe (development of the Garumnian facies).

During the Maastrichtian, the northern part of this vast expanse contains a fairly homogeneous fauna. On the southern border of this white chalk sea, well developed, very fossiliferous Upper Maastrichtian deposits exist, sometimes overlain by Danian deposits. Across the K/T boundary sedimentation was only rarely continuous, and the Upper (uppermost) Maastrichtian sea was relatively shallow in this southern part. In three areas [(1) the Maastrichtian stratotypical area, Limburg, The Netherlands-Belgium; (2) south western Crimea, The Ukraine; (3) Mangyshlak Peninsula, W. Kazakhstan] which knew a more or less continuous sedimentation across the K/T boundary, the faunal evolution in the uppermost Maastrichtian and near the K/T boundary was followed.

In the Maastricht area, the Upper Maastrichtian is mainly represented by the Maastricht Fm., which consists of a typical calcarenite. Stratigraphically most of the Maastricht Fm. is part of the *junior* Zone. Only the uppermost member (Meerssen Chalk) belongs to the *kazimiroviensis* Zone. At the quarry Curfs (near Geulhem) the Meerssen Chalk is unconformably overlain by Palaeocene calcarenites. The Houthem Fm. of Danian age, is outcropping also as a calcarenite. The age of the Geulhem Member is Lower to Middle Danian (Jagt *et al.*, 1996; Jagt, 1996). The terminal Maastrichtian event (in the Meerssen Member of the Maastricht Fm., in the Maastricht area is accompanied by a cooler water fauna with rare *Belemnella kazimiroviensis*.

In S. Crimea near Bakhchisaray (in the Alma and Belbek River valleys) and near Belogorsk extensive Maastrichtian chalks (sometimes marly sandstones) are overlain generally unconformably by Palaeocene and/or Eocene limestones (sandstones) (Naidin *et al.*, 1984; Nikishin *et al.*, 1993). The upper Upper Cretaceous was lithologically described and subdivided by Alekseev (1989). The youngest Cretaceous strata [member XXIV of Alekseev (1989) with a thickness of up to 5 m] form a short transgressive impulse, resulting in marls with numerous *B. kazimiroviensis*, and numerous bivalves (f.i. many pectinids, oysters).

The zonation generally used, is based on belemnites, for macrofauna, on planktonic foraminifera and calcareous nannofossils for microfauna for the Maastrichtian (Nikishin *et al.*, 1993; Alekseev & Kopaevich, 1997). Also used are "units" representing faunal assemblages (Alekseev, 1989).

In N. Mangyshlak the relatively deep-water chalk Maastrichtian sections at Kyzylsay and Koskak have a terminal chalk unit (2-2.5 m) containing an assemblage with belemnites and planctonic forams - bivalves are relatively rare but occur.

It must be noted that the *kazimiroviensis* Zone in Crimea and in Mangyshlak comprises the complete Upper Maastrichtian.

The lowermost Danian, often separated from the Maastrichtian by a short time hiatus, as far as present in the three areas (Naidin & Kopaevich, 1988), contains a not very diversified, fairly cool water fauna. The climate must have warmed up progressively and the Upper Danian fauna especially in Crimea is definitely a warm water fauna.

The strata of the Maastrichtian stratotypical area are highly fossiliferous. These fossils were described, figured and/or mentioned already by Faujas de Saint Fond (1799-1802), von Schlotheim (1813, 1820), Goldfuss (1833-1841), d'Orbigny (1850). From the macrofauna the very numerous and diverse bivalve fauna is probably the most species rich. Because of the limitations of the preservation in calcarenites not all taxa were preserved but only those with a mainly calcitic shell (such as Pectinidae, Limidae, Spondylidae, Anomiidae, Mytilidae, Modiolidae, "*Lithophaga*", Ostreacea, Pinnidae, Pteriacea) or those with a very thin shell (Pholadomyidae, *Liopistha*) - rarely also steinkerns of Nuculacea, glycymerids, arcids, *Cucullaea*, "*Trigonia*," and heteromorphs. Recently in the Maastricht area Jagt (1996) has clearly shown that changes within the Maastricht Fm. were important. Herein we shall try to give a detailed account of bivalve faunas within the members of the Maastricht Fm., and give a brief account of what is known on bivalves from the overlying Houthem Fm. (Danian).

The Upper Cretaceous strata from the Bakhchisaray region in Crimea have been studied since the beginning of the 19th century. The numerous bivalves typical for these strata immediately attracted the attention of geologists and palaeontologists. Thus Fischer de Waldheim described several taxa from there (f.i. 1834: *Alectryonia deshayesi*, 1835 *Pycnodonte radiata*). In 1842 Rousseau in Huot in Demidoff described *Ostrea mirabilis* from the same region and strata. These descriptions were widely known. Fossils from the uppermost Cretaceous strata in Bakhshisarai are mentioned in d'Orbigny (1850) f.i. and most collections of the main museums contain specimens from "Bakhshisarai".

In the last 50 years only two major works described Upper Cretaceous bivalves: the inoceramids were treated by Dobrov and Pavlova in Moskvin (1959) and many other bivalve taxa were described by Sobetski (1977).

Fossils of the Cretaceous of Mangyshlak did not receive attention till this century and the Upper Cretaceous bivalves have never been studied monographically.

The bivalve faunas from the three areas concerned bring complementary data for the evolution and extinction of such bivalve groups as the rudists (only around Maastricht), inoceramids (*Tenuipteria* only in Maastricht and Mangyshlak), exogyrine oysters and the Neitheinae. They also illustrate that that f.i. the Pycnodonteine oysters survived the K/T boundary without the slightest problem. This can be explained by their adaptation to deeper seawater.

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Rhythmically bedded Carbonates: below and above the K/T Boundary

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Examples of rhythmically bedded carbonate successions, including the K/T boundary can be found on the Russian platform (Sengeley and Volsk sections) and in adjacent regions such as Crimea (Besh-Kosh section).

The Sengeley (Ulyanovsk region, Russia) and the Volsk sections (Saratov region, Russia) are situated inside Ulyanovsk-Saratov aulacogen. Both outcrops were investigated in quarries. The Besh-Kosh section (Bakhchisaray region, the Ukraine) was described from the slope of the Besh-Kosh mountain (second chain of Crimean mountains).

The first type of carbonate sections is represented by highly fossiliferous Maastrichtian chalks and marls and poorly fossiliferous Palaeocene siliceous marls, sandy opokas (Sengeley and Volsk sections).
The Maastrichtian primary chalk (first meters) - marly chalk, marl (centimeters-decimeters) rhythms are covered by Palaeocene siliceous marls (decimeters)-sandy opokas (decimeters) diagenetic rhythms. The Sengeley section contains Lower Maastrichtian (10.5 m) and Palaeocene (more than 30 m). The Volsk section consists of Lower Maastrichtian (about 40 m), Upper Maastrichtian (visible thickness 25 m) and Palaeocene (more than 30 m). The rhythmicity in the Maastrichtian of the Sengeley section is established by distribution of:
- calcium carbonate and carbon dioxide concentration;
- volume of bioturbated rocks, quantity of ichnocoenoses, maximal borrow diameter, volume of pyrite and limonite, comprising borrows;
- remnant saturated magnetisation (Jrs), destructive field of remnant saturated magnetisation (H'cs) and Jrs-H·cs correlation and taxonomic diversity of macrofossils.

Rhythms in the Maastrichtian of the Volsk section are defined by the same distribution of characteristics as in the Sengeley section, plus cyclic oscillations
in organic carbon content, colour differentiation and weathering profile.
The Maastrichtian rhythmically bedded chalks and marls of the first type are considered to be formed by dilution and solution cycles. Palaeocene rhythms are defined by lithological and colour differentiation, and by the weathering profile. The nature of these Palaeocene rocks is not clear: diagenetic rhythms or primary cyclicity with diagenetic overprint. The stratigraphic position of the basement of Palaeocene (Danian or Selandian) in the investigated sections is discussed because of diagenetic alteration of rocks and absence or reworking of main groups of index-fossils.

A second type can be observed in fossiliferous Besh-Kosh section, including Maastrichtian marls, sandy marls (total thickness - 75 m, both substages) and Danian limestones and carbonate clays (26 m) and Montian reddish limestones and marly limestones (more than 6 m).
Maastrichtian primary marl (decimeters)-sandy marl (decimeters-first meters) rhythms transform into Danian primary bioclastic limestone (first meters)-carbonate clay (centimeters) rhythms. The same celebrities of thickness are typical for Montian limestones and marly limestones.
Rhythmicity in Maastrichtian of Besh-Kosh section is established by distribution of:
- calcium carbonate, carbon dioxide and organic carbon concentration;
- volume of bioturbated rocks, quantity of ichnocoenoses;
- P/B relation;
- also by weathering profile and thickness distribution.

The origin of Maastrichtian part of the section is believed to be mostly connected with dilution cycles (solution cycles are suitable for the interpretation of a few intervals of the section). Elements of rhythms in the Palaeocene part usually have erosional boundaries. Clay (Danian) or marly limestones (Montian) couplets are thought to be the result of dissolution of limestones (solution cycles). Montian rocks have traces of diagenetic alteration. The Montian part of the Besh-Kosh section can be interpreted as diagenetically alterated Danian rocks. The rhythms are distinctly identified by the weathering profile and the thickness distribution.

Cycles of dilution and solution are responsible for the occurrence of rhythmically bedded carbonates in the Maastrichtian, when sedimentation took place in the shallow basin with active hydrodynamic conditions, with periodical occurrence of stratified water masses, caused by change of current direction and/or eustasy. The Volsk and Sengeley sections are not typical Boreal or Tethyan, their position is transitional. The Besh-Kosh section is an example of a typical Tethyan type. Cycles of solution or diagenetic dissolution are responsible for origin of Palaeocene rhythms. The Besh-Kosh section is very similar to the Agost and Zumaya sections (Spain). All three sections have the same type of rhythms (lithology, thickness)(ten Kate & Sprenger, 1992) . A few groups of couplets (below and above K/T boundary) have the same thickness and the same stratigraphic position in these sections. It proves the a climatic-orbital control for the deposition of rocks. Thus, Milankovitch cycles could have influenced the studied rhythms.

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Cretaceous-Palaeogene tectonic activity in the Caucasus and Trans-Caucasia reflected in scalar magnetic characteristics

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A number of reference sections were examined to assess the influence of geologic events at the Cretaceous-Palaeogene boundary upon magnetic properties of the sedimentary sequences.
For a petromagnetic study, a few Cretaceous-Palaeogene sections were selected from the various structural-facies zones in the Caucasus and in Trans-Caucasia. The rock magneticity was correlated according to the most accessible parameter for express measurements, namely magnetic susceptibility (k). Comparative data from various regions are given below.

AREA	AGE	k (0,00001 SI units) min-max	average
Trans-Caucasia (Nagorny Karabakh, Adgi-Dere area)	Maastrichtian uppermost Palaeocene - Eocene	1 - 10 5 -140	3 90
S. E. termination of the Caucasus (NE Azerbaidjan, Yunus-Dag range)	Maastrichtian Palaeocene - lowermost Eocene	2 - 9 2 - 48	5 30
N.W. termination of the Caucasus (Black Sea coast in Gelendgik area, near Beta)	Upper Maastrichtian Danian	1 - 20 9 - 40	5 15
North Caucasus (Dagestan, village Aimaki area; Kabarda, Kheu rives, etc.	Maastrichtian Danian	0 - 6 0 - 6	3 3

The scale interval examined is represented by various combinations of lithofacies.
In Trans-Caucasia (Nagorny Karabakh) the light-grey Maastrichtian limestones are overlain by stratigraphically discordant terrigenous-carbonate deposits of the uppermost Palaeocene. In this region the Upper Cretaceous beds are low-magnetic, and the uppermost Palaeocene and Eocene are distinguished by their increased magneticity within the section.
In sections from North-East Azerbaidjan the Cretaceous-Palaeogene boundary is less clearly developed, but still clearly enough, in its magnetic properties. Highly magnetic variegated Palaeocene marls overlie the low-magnetic limestones and marls of the Maastrichtian stage.
In the carbonate flysch deposits from the north-western termination of the Caucasus a slight, but statistically significant, magneticity increase was also revealed near the Cretaceous-Palaeogene boundary as the result of a detailed (layer-by-layer) petromagnetic study.
In the sections studied, the petromagnetic boundary does not exactly coincide with the Cretaceous-Palaeogene boundary in its modern interpretation, but the later one is not reliably confirmed here. By analogy with sections from the south-eastern Caucasus and Trans-Caucasia, the increase of rock magneticity may be supposed to reflect changes in sedimentation settings at the Cretaceous-Palaeogene boundary.
Petromagnetic research of the reference sections of the flysch zone suites is essential to solve this problem.
In the North Caucasus, the Mesozoic-Cenozoic boundary is practically not recognisable in the natural magneticity of the rocks. Maastrichtian and Danian deposits alike are equally low in

magneticity.
Proceeding from the peculiarities in the geologic structure of the region, one may suppose, that the increased magneticity of the lowermost Palaeogene in the sections from Nagorny Karabakh, Azerbaidjan and the western Caucasus, is the result of tectonic activation in the region at the Mesozoic-Cenozoic boundary, which resulted in enhanced drift of highly magnetic terrigenous material. Correlations of petromagnetic data and information on the palaeogeographic (geodynamic) settings in the Caucasus in the Cretaceous-Palaeogene (Kazmin, 1996), reveal the following regularity: the intensity of the recorded magnetic susceptibility splash decreases with the increasing distance from the Trans-Caucasian volcanic arc, down to a complete levelling of the k values in the Maastrichtian and Danian of the North Caucasus. This fact makes it possible to conclude, that the Palaeocene-Eocene Caucasian marginal palaeobasin obtained terrigenous material mainly from island arc "volcanites", with drift taking place both southwards and northwards. This petromagnetic border line is in its essence an event boundary and it can be used as an accepted Cretaceous-Palaeogene boundary in the West Caucasian flysch sections. Such sections cannot be easily stratified because microfaunal remains are practically non existing and lithologically the Cretaceous-Palaeogene sequence is monotonous.

The results presented here do not exhaust the possibilities of the petromagnetic method in reconstructions of geologic events at the Cretaceous-Palaeogene boundary.

The efficiency of the petromagnetic data in solving the problems of stratigraphy and palaeogeography was previously tested by the authors on Permian, Triassic, Cretaceous and Neogene deposits from various geologic provinces. Further petromagnetic study of Cretaceous-Palaeogene deposits from the Caucasus and adjacent regions may help f.i. in solving some other problems associated with regional correlations of the sections, in revealing sedimentation rhythms, in reconstructions of palaeogeochemical settings.

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Late Cretaceous-Early Palaeogene echinoderm Faunas and the K/T Boundary in the Maastrichtian Type Area

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The past few years have seen a considerable increase in the number of papers documenting various aspects of the type Maastrichtian. Of note is the recently discovered, anomalous K/T boundary section at Geulhemmerberg (Brinkhuis & Smit, 1996), which has allowed the relative 'completeness' of the Maastrichtian type section, and of the overlying lower Palaeocene strata to be determined. Until recently, the K/T boundary in the Maastricht area was generally assumed to represent a hiatus of considerable duration, and to equate with the so-called *Vroenhoven Horizon*. Nanno-, micro- and macrofossil analyses have now indicated the K/T boundary to actually be lower in the sections and correspond to the *Berg en Terblijt Horizon*. The hiatus has turned out to be far less extensive than previously assumed.

In addition, Schiøler *et al.*'s (1997) recent sequence-stratigraphic interpretation of the type Maastrichtian, as based on dinoflagellate and other palynomorph distribution, is another step forward. This holds true also for the record in the Maastrichtian type area of index coleoid and ammonoid taxa that characterise both Tethyan and boreal/north temperate realms (Jagt, 1998a). Lastly, the strontium isotope profile (Vonhof & Smit, 1996) has enabled a first correlation with Spain and Tunisia, and comes up with a sedimentation rate of *c.* 10 cm/ka for the higher part of the type Maastrichtian. The anomalous thickness of subunit IVf-6 (Meerssen Member) has been ascribed to rapid subsidence, possibly triggered by reactivation of local tectonics, and ultimately linked to the Deccan Trap volcanism. Of note is that this 'event' more or less coincides with the demise of rudistid bivalves and many scleractinian corals in the area, and the first appearance datum of coleoids typical of east European regions [*Belemnella (Neobelemnella) kazimiroviensis*].

For ongoing studies of echinoderm faunas from Cretaceous-Palaeogene strata in the area copious material is available from the late(st) Maastrichtian Meerssen Member (Maastricht Formation) and early/middle Danian Geulhem Member (Houthem Formation). Based on taxonomic composition of these faunas, palaeobiological interpretations are attempted, which in turn are to lead to conclusions on what happened across the K/T boundary. Data below are thus preliminary.

In the Meerssen Member **crinoids** are predominantly represented by stalkless forms (comatulids), typical of shallow-water, subtropical settings; isocrinids are rare (Jagt, 1998b). The lower Geulhem Member, however, has stalked forms only (bourgueticrinids/bathycrinids); comatulids do not return until the upper part of this Member. The earliest Danian bourgueticrinids show strong paedomorphic traits (Kjaer & Thomsen, in prep.), the interpretation of which has only just started.

Asteroids comprise mostly goniasterids and astropectinids, both in the Meerssen and Geulhem members. The first member has yielded a number of 'endemic' species of *Metopaster*, and distinctive astropectinids. Early Palaeocene taxa correspond closely to type Danian faunas, and include such index species as *Metopaster spenceri*, *M. kagstrupensis* and *Crateraster anchylus*. However, here too, a considerable 'endemic' element is represented.

Of quite a number of **ophiuroid** species, more or less complete specimens are known from the Meerssen Member, suggesting obrution to have occurred regularly in shallow-water settings. Ophiuroid diversity is highest during the early Maastrichtian (> 35 species; Rügen and Møn, see Kutscher & Jagt, in prep.), but apparently dwindles across the boundary. The number of species crossing the boundary is low.

Echinoid genus/species composition across the boundary varies considerably; between 10 and 20% of species (all cidarids) survive. Hemiasterids (infaunal selective deposit feeders), holasterids (shallow infaunal/semi-infaunal selective deposit feeders), cassidulids (infaunal bulk sediment swallowers), faujasiids (infaunal selective deposit feeders) and the genus *Orthopsis* (epifaunal browser) suffer heavy losses. Cidarid diversity (epifaunal generalists) is comparable, psychocidarines characterising the early Palaeogene. The number of saleniids (epifaunal generalists) increases markedly during the early Palaeogene. Nearshore, hardground grazers include arcopeltids and arbaciids, equal in numbers across the boundary, but *within* the Geulhem Member confined to the upper part. This part of the unit also yields shallow-water, more protected firm bottom forms (phymosomatids), and shows the highest diversity amongst cidarids -inhabitants of more protected environments. Infaunal selective particle feeders living in perireefal coarse, permeable sands (holectypids, conulids) are comparable in diversity, but not in composition. **Holothuroids** have not been considered (yet), since the generally coarse-grained biocalcarenite facies types have not been very conducive to their preservation.

The picture that emerges is one of eradication of (very) shallow-water settings prior to and across the K/T boundary, with the early Palaeogene characterised by the influx of 'cold' Atlantic waters, resulting in low diversity faunas. The succession of 'events', and the impact of local topographies on them, still need to be determined.

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Pollen and Oxygen Isotopic response to climatic changes in the Upper Maastrichtian at the ENCI-quarry, Maastricht, The Netherlands.

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A 190 m, Upper Campanian-Upper Maastrichtian stretch of chalk near Liege, Belgium (CPL and CBR quarries at Hallembaye) and Maastricht, the Netherlands (ENCI quarry), has been investigated in parallel by several methods, among which clay mineralogy, palynology, and carbon and oxygen isotope geochemistry.

The clay fraction (smaller than 2 µm) predominantly consists of smectite, accompanied dy degraded illite or mica and by an illite-chlorite (10-14C) mixed-layer. As presented in Akodad *et al.* (1994), in the smectite population, both a structural and genetic, and a qualitative and quantitative differentiation can be made between a neoformed volcanogenic (halmyrolitic) montmorillonite and a neoformed paedogenic (reworked vertisols) beidellite. These smectitic components are organised in metric clay cycles or genetic sequences yielding repeated patterns that consist, from base to top, of:

1. a mixing of beidellite and montmorillonite (this admixture characterizes all lowstand deposits),
2. a predominantly beidellitic phase (cf. transgressive phase),
3. locally, an illite-montmorillonite phase (cf. condensed section), and
4. a montmorillonite phase (cf. highstand deposits)

The "clay-cyclicity" coincides remarkably with "palyno-cycles" based on quantitative analyses of pollen and spores, bearing hallmarks of climatic changes. Spectral analysis of the smectite content variation and its stratigraphic distribution reveals periodicities of 400ka and of 100 ka (cf. excentricity cycles) and of 41 ka (cf. obliquity), but did not reveal precession cycles.

Throughout the section in the ENCI quarry, although only one bulksample about every one meter has been analysed, the oxygen isotopic composition clearly follows an overall evolution from about -2‰ at the bottom to about 0‰ at the top (see Figure 1). If this shift is exclusively attributed to a change in the seawater temperature (i.e. if the isotopic composition of the seawater remained unchanged) it would correspond to a cooling of 8 °C throughout this major part of the Upper Maastrichtian.

Of the section in the ENCI quarry, a small part of 2.60 m, just below the Nivelle Horizon in the upper part of the late Maastrichtian Gulpen Formation, has been analysed in detail (samples every 5 cm) for spores and pollen content and for carbon and oxygen isotopic composition. Palynological and stable isotope results of the carbonate phase (mainly consisting of coccoliths) co-vary remarkably, displaying two cycles that may be interpreted as climatic fluctuations. Figure 2 shows a δ18O curve varying roughly between -1.6‰ and -1.0 ‰ (on the PDB scale). Less negative values which maybe considered a sign of cooling of the sea water coincide with larger amounts of pollen of the type Normapolles and Triporates. They are supposed to represent temperate forest elements of a vegetation also containing subtropical elements of palms. Also the amounts of spores and Bisaccates pollen follow similar fluctuations. Trends to more negative values of δ18O are accompanied by reversed palynological evolutions. The δ13C of the carbonate phase also follows the fluctuations of the δ18O and of the pollen contents. The climatic palaeoecological or sedimentological interpretation of these signals is not obvious and requires further research but independently the apparent cyclicity and its "wavelength" is interesting.

Supposing that a stratigraphic height of 5 cm in this section corresponds to 1 ka, the climatic maxima (and minima) are 20 to 25 ka apart, an order of magnitude that obviously reminds of the Milankovich precession cycle. This detailed study is being further worked on.

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Figure 1

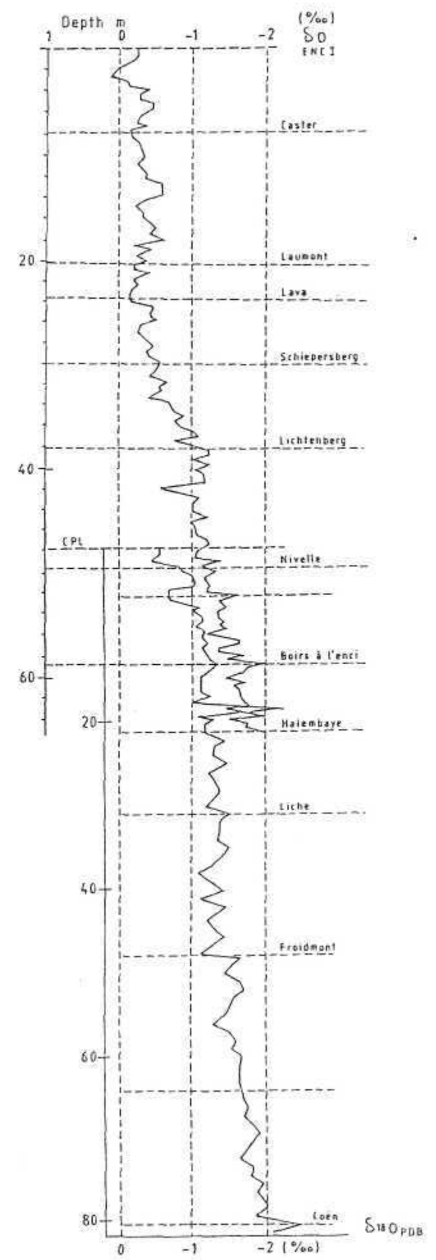
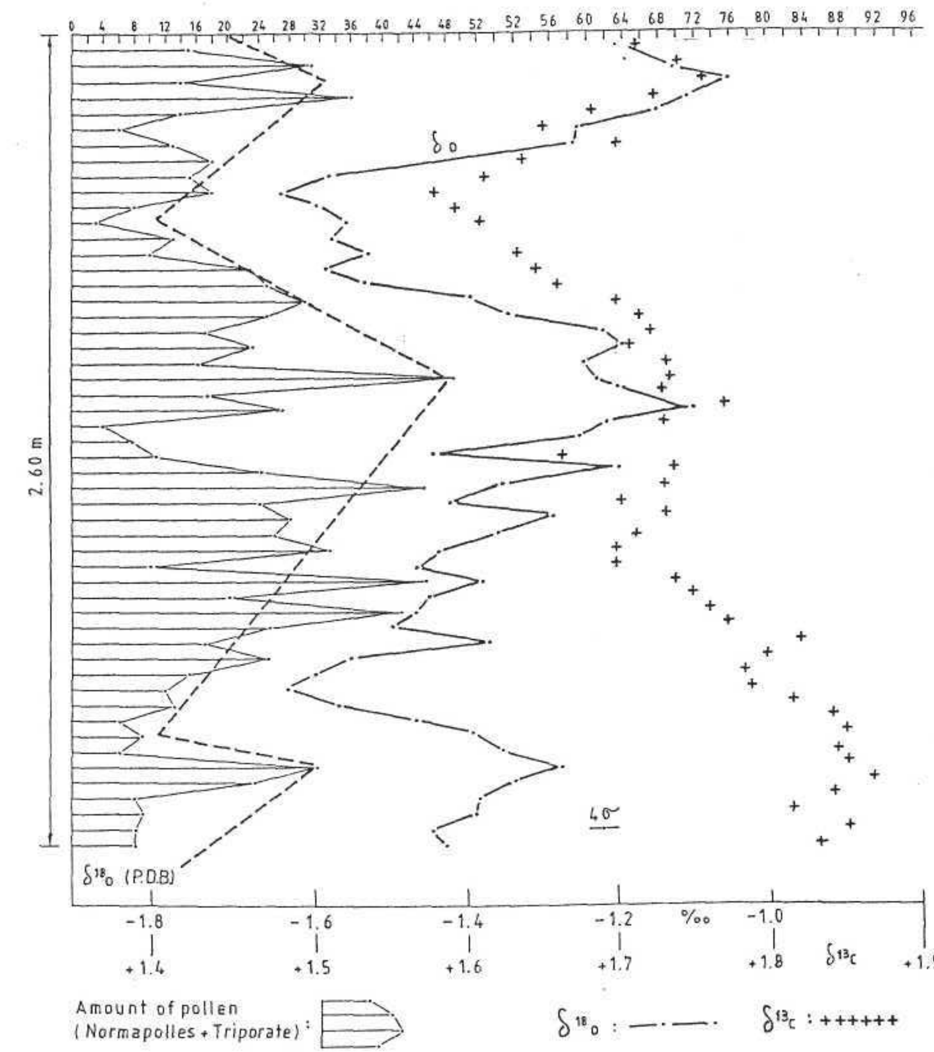


Figure 2



Maastrichtian-Danian transition in Mountain Crimea

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The Maastrichtian-Danian boundary was studied in Mountain Crimea by f.i. Weber (1923), Maslakova (1959), Naidin (1964), Maslakova & Voloshina (1969), Gorbach (1972), Maslakova & Nguyen Van Ngoc (1975), Maslakova & Kamenetsky (1986), Beniamovski & Kopaevich, 1998. In most sites the boundary coincides with a hardground and a stratigraphic gap of different amplitude. We have studied the most complete sections in South-Western, Central and Eastern Crimea.

1. **Belbek section**. South-Western Crimea, right bank of Belbek River, 44° 39 N, 33°49 E.
The terminal Maastrichtian siltic marls of unit XXIV which reflect the short transgressive episode and contain abundant large rostra of *Neobelemnella kazimiroviensis* (samples B-1 - B-11) contain a poor planktonic foraminiferal assemblage of *Heterohelix globulosa*, *Rugoglobigerina* aff. *rugosa* and *Globotruncana* sp. The planktonic forms are relatively abundant only in topmost 0.5 m of unit XXIV. The presence of frequent smooth-shelled and ornamented ostracods is very characteristic for this unit. The benthic foraminifera mainly belong to shallow-water taxa: *Gaudryina rugosa*, *G. variabilis*, *Cibicidoides spiropunctatus*, *C. bembix*, *C. voltzianus*, *Gavelinella midwayensis*, *G. danica*, *Brotzenella praeacuta*, *B. monterelensis*, large lenticulinids and nodosariids. The appearance of Western Siberian *Spiroplectammina kelleri* and *Cibicidoides kurganicus* in sample B-6 and *Pullenia dampelae* in sample B-9 can reflect the short event of cold water invasion through Orsk Strait crossing the South Urals. The sandstone unit above the prominent hardground in top of the unit XXIV previously thought to be basal Danian, could be latest Maastrichtian and contains abundant and well preserved belemnite rostra at the base and sparse rostra up to 1.7-2.1 m up. This sandstone contains abundant *Gaudryina rugosa*, *Spiroplectammina kelleri*, *Arenobulimina* sp., *Cibicidoides spiropunctatus*, *C. voltzianus*, *Gavelinella danica*, *Brotzenella praeacuta*, *B. monterelensis*, *Bolivina incrassata*, large lenticulinids and nodosariids. No planktonic were found.
The general taxonomic composition of the assemblage is the same as in unit XXIV. The calcareous sandstones above the last belemnite do not contain planktonic foraminifera. In its benthic assemblage the *Gavelinella danica, Cibicidoides succedens*, *Gavelinella midwayensis*, *Brotzenella praeacuta* are the most important forms that permit to date this unit as Danian.

2. **Akkaya section**, Central Crimea. 45°05 N, 34°39 E.
The K/T boundary interval is similar to those of shallow-water Belbek section and foraminifera distribution is close.

3. **Klementiva Mountain section**, Eastern Crimea, 44°58 N, 35°15 E.
Here, the thick (100 m) sequence of dark gray siltic marls overlies the Middle Albian clays with unconformity in the south slope of this mountain. The second unit (15 m) is alternation of siltic marls and fine-grained calcareous glauconitic sandstones. The thick sandstone bed 2-5 m is in the top of section. The lowermost level of first unit belongs, probably, to upper Lower - lower Upper Maastrichtian. The last 80 m of this unit is *Nephrolithus frequens* Zone. Their foraminiferal assemblage is characteristic for warm-water deep-water open marine tropical environment with dominance by large globotruncanids (*Globotruncanita stuarti*, *Rosita contusa*, *Rugoglobigerina* etc.) and heterohelicids (*Pseudotextularia*, *Planoglobulina*, *Ventilabrella*, *Racemiguembelina*) characteristic for the Upper Maastrichtian. The second unit (sample KL-12) has an impoverished foraminiferal assemblage with sparse benthic forms. In sample KL-17 the *Anomalinoides grosserugosa* occurs. This species is characteristic for Danian. The nannofossil assemblage consists of typical and predominant Cretaceous forms such as *Lithraphidites*, *Cribrosphaerella ehrenbergii*, *Praediscosphaera*, *Micula decussta* etc. But rare Danian *Cruciplacolithus tenuis* (sample Kl-14) and *Prinsius dimorphosus* (sample Kl-18) also occur here. Palaeontological data support the Danian age for second unit with sandstone interlayers.
It is in good accordance with the presence in the basal sandstone bed of shocked quartz grains

(Gurov & Gurova 1994).

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Upper Cretaceous Ammonites and their Extinction Interpretation of Data from the Caucasus and Comparison with Mangyshlak, Crimea and the Maastricht Area.

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The problem of mass extinction of large faunal groups arises at the boundary between the Mesozoic and Cenozoic erathems. At that moment ammonites belemnites, dinosaurs and other faunal groups knew a mass extinction.
Looking for reasons of the ammonite extinction, we came to the conclusion, after considering the numerous, occasionally contradictory hypotheses expressed previously on this boundary, that two factors at least influenced the happenings at the K/T boundary.
One is cosmic: in the section Tetri-Tskaro (Georgia) in a 1-3 mm thick layer, Jan Smit noted the increased iridium content - 3,46 -5,34h. This event took place at the Maastricht-Danian boundary, when the last ammonites went extinct.
The second factor is connected with the evolution within the ammonites. In order to clarify the condition of this group at the moment of cosmic catastrophe, we should consider its dynamics during the last epoch of Mesozoic in the Caucasus and compare it with the occurrences of the Maastricht area, Crimea and Mangyshlak at the same time.
- Maximum number of genera occurred during the Cenomanian (19-in Caucasus, 6-in Crimea, 14-in Mangyshlak);
- In Turonian times the number decreased, in Crimea and Mangyshlak it decreased by half (respectively 11, 3, 6);
- In Coniacian and Santonian times it reached its minimal number (3 - in the Coniacian, 6 - in the Santonian), in Crimea and Mangyshlak ammonites are not recorded so far in this interval;
- In Campanian times they increased (9, 3, 1,5 - in Maastricht area) ;
- In Maastrichtian times it increased even more (16, 6, 2,6).

In the Campanian-Maastrichtian interval the decrease in speciation is fixed - each genus is re presented by 1-2 species. The most widespread are *Hoploscaphites constrictus* (Sow.), *Pachydiscus neubergicus* Hauer, *P. gollevillensis* (d'Orb.), *Glyptoxiceras retrorsum* (Schlüter), *Diplomoceras cylindraceum* (Defr.), etc.

Thus, a reduced diversity of ammonites is observed below the Cretaceous-Palaeogene boundary. Here in abrupt simplification of organisation (return to ceratitic type of suture line), heteromorphism.

Resulting from the above, it is difficult to deny that ageing of the ammonitic branch among the cephalopods existed, but this phylogenetic extinction was incomplete because of the cosmic catastrophe which took place at the end of the Maastrichtian.

Two types of Cretaceous/Tertiary boundary

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1. Type I is represented by the apparently continuous Maastrichtian to Danian passage with so-called "boundary clays".
Type II differs by the presence of a small hiatus and the absence of an angular unconformity between Maastrichtian and Danian strata.

2. The numerous published variants of the history of events at the Cretaceous/ Tertiary boundary are based only on the interpretations of geological sections with "boundary clays".

3. We can form a comprehensive image of the events only when taking into account the data of both types of transition.

4. The data on both types of transition indicate that the Cretaceous/ Tertiary boundary was characterised by widespread unstable physiogeographic and ecological conditions.

5. The main reasons for this instability were the eustatic fluctuations of the oceanosphere.

6. The steep sea level fall (which caused the hiatus at the boundary) seems to reflect a very strong but temporary increase in the capacity of the Pacific Ocean basin.

The Palaeocene Section at Bakhchisaray (Crimea)

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1. The section consists of two outcrops: Suvlukaya and Staroselie, both exposed on the right slope of the deep valley of the Churuksu River in the vicinity of the town Bakhchisaray. This Palaeogene outcrop is one of the most complete Palaeogene sections in Europe. It has been well known for a long time and was illustrated in several papers (f.i. Vasilenko, 1952; Zhizhchenko, 1965; Muratov & Nemkov, 1960; Nemkov & Barhotova, 1961; Gorbachik *et al.*, 1971; Naidin & Beniamovskii, 1994).

2. Abundant and well preserved macro- and microfossils distinguish the sections at Bakhchisaray from those of other parts of the European palaeobiogeographical province.

3. The Staroselie outcrop begins with uppermost Maastrichtian carbonate sandstone (9-10 m) with belemnites (*Neobelemnella kazimiroviensis*), ammonites (*Hoploscaphites* gr. *constrictus*, *Pachydiscus neubergicus*), bivalves (a. o. *Pycnodonte mirabilis*), benthic Foraminifera (f.i. *Brotzenella praeacuta*, *Hanzawaia ekblomi*) (bed 1).
The Maastrichtian is overlain by hard, organogenic-detrital (bryozoa-serpulids or bryozoa-serpulids-crinoids) Danian limestones (beds 2-4) (24 m), with bivalves (f. i. *Pycnodonte beshkoshensis*), brachiopods (f.i. *Danocrania tuberculata*), echinoids (f.i. *Echinocorys sulcata*), benthic Foraminifera (f.i. *Anomalinoides danicus*).
The upper bed (5) of the exposure at Staroselie consists of very hard organogenic-detrital Montian limestones with numerous "hardgrounds" (13-16 m). It contains bivalves (a.o. *Corbis montensis*), gastropods (a.o. *Turritella montensis*), echinoids (*Echinantus* spp.), benthic Foraminifera (a.o. *Protoelphidium sublaeve*, lower part of bed 5, and *Pararotalia saxorum*, upper part of bed 5).

4. The exposure at Suvlukaya (beds 6 and 7) is the continuation of the exposure at Staroselie (Suvlukaya is situated 0.5 km to the east of Starocelje).
Bed 6 consists of Thanetian marls (13-14 m) which can be subdivided into three biostratigraphical units:
a- *Cyprina morrisi* horizon,
b- *Pholadomya konincki* / *Cyprina morrisi* horizon,
c- *Pycnodonte antiqua* horizon.
The marls of bed 6 are characterised mainly by the planktonic foraminiferan *Acarinina mcannai* (= *A. subsphaerica*) and by the benthic foraminiferans *Stensioeina beccariiformis* and *Bulimina trigonalis*. The top of bed 6 is uneven, with thalassinoid borings filled with sediments from the overlying beds.
Bed 7 consists of Ypresian calcareous clays (17-18 m) with f.i. the bivalve *Pseudamussium corneum*, the planktonic foraminiferans *Morozovella aequa*, *M. subbotinae*, small benthic foraminiferans *Vaginulonopsis eofragaria*, *Hanzawaia ammophilla*, larger benthic foraminiferans *Operculina semiinvoluta*, *Nummulites crimensis*, *Assilina leymeriei*.

5. The authors believe that the Palaeocene should be subdivided into Lower Palaeocene (the Danian and the Montian Stages) and Upper Palaeocene (the Selandian and the Thanetian stages) (Naidin & Beniamovskii,1989). They do not agree with Bignot (1993) and Jenkins & Luterbacher (1992) denying the validity of the Montian stage.

6. The Bakhchisaray section can be correlated with eustatic sea-level changes. Two sequences - Danian-Montian limestones and Thanetian marls - correspond to two transgression-regression cycles.

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Late Cretaceous tectonics of Eastern Europe

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The East European relatively stable platform (region) was bounded during the Late Cretaceous to the West by the Polish Trough (Tornquist Line) and North Atlantic continental rift system, to the South - by the Black Sea-Great Caucasus belt of deep-water back-arc troughs, to the East - by the Uralian inactive orogen, and to the North - by the Barents Sea area.
Two main sedimentary basins were inside the East European Platform during the Late Cretaceous: the Peri-Tethyan basin in the southern part and the Barents Sea basin in the northern part; they were separated at the Early/Late Cretaceous boundary. The Polish Trough had rift phases at the Permian/Triassic boundary and in the Late Jurassic. It had a postrift gentle subsidence in the Early Cretaceous.
In the beginning of the Late Cretaceous rapid syncompressional subsidence took place (Dadlez *et al.*, 1995) transformed to inversion tectonics since the Santonian(?) with inversion maximum at the Cretaceous/Paleogene boundary (Ziegler, 1990; Kutek, 1997). Back-arc rifting along the Black Sea-Great Caucasus Trough took place since the Aptian-Albian. The rifting transformed to local ocean crust spreading in the West Black Sea basin during the Cenomanian-Turonian-Coniacian(?) (Nikishin *et al.*, 1997). Compression stress events took place in the Santonian, in the pre-late Maastrichtian(?), at the Maastrichtian/Danian boundary, and at the Danian/Thanetian and Thanetian/Ypresian boundaries. The rifting and compressional tectonics took place in a back-arc tectonic environment: subduction related magmatic belt goes along Pontides-TransCaucasus region. The subduction related volcanism was irregular in time with possible gap in the Maastrichtian-Palaeocene (Koronovsky *et al.*, 1997). Accretion of continental terranes to magmatic belt took place in the late Late Cretaceous in the Trans Caucasus area (Nikishin *et al.*, 1997).

The Uralian belt was a relatively stable and uplifted area. It separated the Peri-Tethyan basin of Eastern Europe from the West Siberian basin. Vertical movements inside the Barents Sea shelf took place in the Late Cretaceous in connection to rifting in the North Atlantic-Arctic area.

The Southern part of the East European Platform and Scythian Platform were a large sedimentary basin during the Late Cretaceous. The region as a whole underwent regional tectonic subsidence. Compressional events took place possibly since the Santonian. Generally during the Santonian-Danian interval many syncompressional inversion structures originated: inside the Donets Basin and Kanev Swell (?)), along the Pre-Volga belt (Don-Medveditsa Dislocations, Saratov Dislocations and others), along the northern margin of the Pachelma Basin (Oka-Tsna and Sura-Moksha swells), along the Middle-Russian (Soligalich) Aulacogen (Sukhona Swell), along the Vyatka Aulacogen (Vyatka Swell), and others. The compression tectonics were followed by the Danian regional uplift of the East European Platform.

The timing of compressional tectonics is not well constrained yet, but it is possible to recognise Subhercynian and Laramide tectonic phases similar to those in Western Europe. The reasons of intraplate compression tectonics are badly known. We can discuss two main models: start of collisional tectonics in the Tethyan orogenic belt or phases of global reorganisations of plate kinematics.

Dramatic changes of environments and biotic events at the Cretaceous/Palaeogene boundary in Eastern Europe were connected with tectonic events at that time with proposed culmination at the Maastrichtian/Danian boundary.

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Cretaceous Stage boundaries and K/T boundary in central Tunisia

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Importance of the Cretaceous of central Tunisia
1. Palaeogeographic position
Central Tunisia is situated between a platform to the south and a basin to the north and a distal sedimentation took place in a very subsiding region. As a result a thick sedimentary lithological succession which often contains all the terms of the deposition sequence (SMW or LST, TST and HST). The sedimentation is largely continuous and the palaeontological assemblages are of a mixed type, containing both platform organisms [such as bivalves (including rudists), echinoderms and also ammonites and inoceramids) and basin organisms [such as planktonic and benthic foraminiferans, nannoplancton and dinoflagellates].
2. Limited tectonics
A few vertical faults influence the succession. The correlations between partial sections is achieved by characteristics beds. The tectonics are nevertheless sufficient for a dip between 15 and 30° which allows good observation of the beds, easy collecting of fossils and sampling of non alterated levels.

The Cretaceous-Danian series in central Tunisia
From Albian to Maastrichtian the succession has a thickness of almost 3700 m, distributed over several formations, from top to bottom:
- El Haria Marls (700 m, of which 200 m are Cretaceous): Upper Maastrichtian.
- Abiod Limestones and Marls (500 m): Upper Campanian to Lower Maastrichtian.
- Aleg Marls (1250 m): middle Turonian to Campanian.
- Trilogy of Bireno Limestones - Annaba Marls - Bahloul Limestones (250 m): Upper Cenomanian - Lower Turonian.
- Fahdène Marls (1500 m): Albian - Cenomanian.

Stage boundaries
1. Albian - Cenomanian boundary
- Before the Brussels CSB meeting (1995): appearance of *Mantelliceras*.
- Since Brussels 1995: appearance of *Rotalipora globotruncanoides (= brotzeni)* which is earlier than the appearance of *Mantelliceras*.
  - In Tunisia: *R. globotruncanoides* is present together with many *Mantelliceras* and *Stoliczkaia* specimens.
    Now *Stoliczkaia* is present in the basal Cenomanian and *Mantelliceras* is no longer the first appearing Cenomanian ammonite genus.
    Note: the Cenomanian is the beginning of an important transgressive pulse, its base is generally marked by a level with phosphates (in Tunisia, in Algeria, in the Paris Basin and also in SE France, even in the proposed boundary stratotype)
2. Cenomanian - Turonian boundary
- Before the Brussels CSB meeting (1995): appearance of *Pseudaspidoceras flexuosum* (recommendation of the Copenhagen 1983 meeting).
- Since Brussels 1995: appearance of *Watinoceras devonense*, which means a zone lower.
  - In Tunisia: in 1990 the boundary was placed at *P. flexuosum*, at the top of the Bahloul Fm. Now the boundary has to be placed within the Bahloul Fm.
    Note: importance of δ13C of OAE 2 for long distance correlations (Pueblo - Dover - Menoyo - Kalaat).
3. Turonian - Coniacian boundary
- Before the Brussels CSB meeting (1995): appearance of *Forresteria petrocoriensis*
- Since Brussels 1995: appearance of *Cremnoceramus rotundatus*, which means earlier.
  - In Tunisia: the characteristic inoceramids are not present and the appearance of

Palaeotemperature curve for Late Cretaceous of the north-western circum-Pacific

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Two main trends in change of the Late Cretaceous temperature conditions in the northwestern circum-Pacific can be recognized (Fig. 1):
(1) generally, general palaeotemperatures are thought to show a recurrent warming trend in the Turonian-Campanian, which reaches a temperature maximum in the late Middle Santonian and a temperature minimum in the earliest Santonian and perhaps in the latest Santonian - early Campanian;
(2) during the Maastrichtian, temperatures decrease sharply, only a slight warming is seen in the early Late Maastrichtian. Turonian temperatures received for the Koryak Upland are very similar to those of Hokkaido, which agrees with Herman's (1996) palaeobotanic evidence from Kamchatka region. The existence of the Coniacian-Santonian transition thermal maximum was expected first by Lowenstam & Epstein (1954) (on calcitic belemnite rostra) and was discussed by many workers. It is not confirmed neither by palaeobotanic nor by aragonite isotopic results. δ13C values reflecting, apparently, some peculiarities in change of the ocean bioproductivity in general are heavier in the Turonian, Coniacian, early Late Maastrichtian, and especially in the Middle Santonian (+2.47 ‰ for Hokkaido), and lighter through earliest and latest Santonian, Early Campanian, and Early-Middle Maastrichtian, which agrees more or less with diversity of the Sakhalin mollusk fauna.

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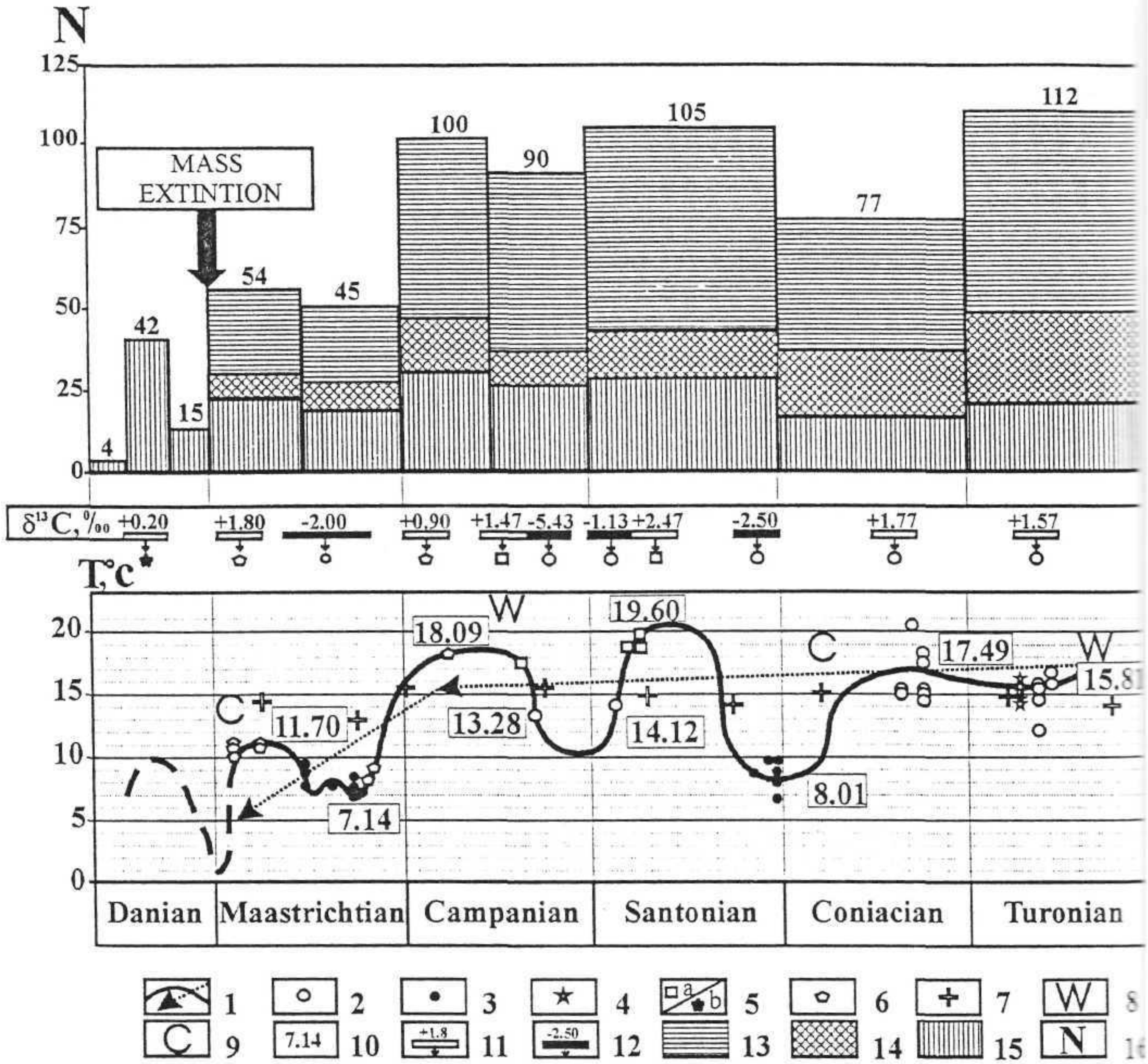

Explanation of figure

Text-fig. 1. - Palaeotemperature curve for Late Cretaceous of the northwestern circum-Pacific (Hokkaido, Sakhalin, Koryak Upland) based on isotopic data.

1 - isotopic palaeotemperature curve and its general trends,
2 - aragonitic ammonoid shell from Hokkaido,
3 - aragonitic ammonoid shells from South Sakhalin,
4 - aragonitic ammonoid material from the Koryak upland,
5 - aragonitic inoceramid bivalve material from Hokkaido (a) and non- inoceramid bivalve shell material from South Sakhalin (b),
6 - well preserved brachiopod shells from South Sakhalin,
7 - calcitic belemnite rostra from the Russian Platform (Teiss & Naidin, 1973),
8 - temperature maximum in palaeobotanic data (Krassilov, 1985; Goldberg, 1987; Wolf & Upchurch, 1987; Herman & Lebedev, 1991; Herman, 1996),
9 - temperature minimum in palaeobotanic data (Krassilov, 1985; Wolf & Upchurch, 1987),
10 - oxygen-isotopic palaeotemperature, °C,
11 - δ13C positive values,
12 - δ13C negative values,
13 - ammonoid species diversity (Sakhalin),
14 - inoceramid bivalve species diversity (Sakhalin),
15 - non-inoceramid bivalve species diversity (Sakhalin),
16 - species abundance.

The development and change of Lamnoid sharks of European paleogeographic area on Cretaceous/Paleogene boundaries

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Lamnoid sharks form an isolated taxonomic group of elasmobranch fishes differing from other selachians by peculiarities of anatomy, histology, physiology, embryology, tooth formula and osteodentine teeth structure which are found only in this group.

The first representatives of the order Lamniformes appear in the Jurassic. In the Cretaceous they greatly flourish. In the Palaeogene their progressive development continues. In modern seas and oceans their role among shark fishes has decreased, however even now they are represented by a rather big group of fishes, which includes representatives of the genera *Lamna*, *Carcharodon*, *Isurus*, *Alopias*, *Odontaspis*, *Cetorhinus*, *Mitsukurina*, *Scapanorhinchus*.

Cretaceous and Palaeogene Lamniformes are divided into the following families: Cretoxyrhinidae, Anacoracidae, Odontaspididae, Otodontidae, Scapanorhinchidae, Lamiostomatidae, Alopiidae, Cetorhinidae.

Cretaceous families

1. Cretoxyrhinidae - are large pelagic sharks with the tear-cutting tooth system type. The first representatives of this family appear in the Early Cretaceous (*Protolamna*, *Paraisurus*). Variability of the group quickly increases and in the Cenomanian it reaches 7 genera. After the Cenomanian a sharp decrease of the number of genera has been observed. In the Late Campanian and Maastrichtian the family is represented by only two genera: *Cretoxyrhina* and *Archaeolamna*, the last representatives of which die out at the end of the Maastrichtian.

2. Anacoracidae - is characteristic for the Cretaceous; a group of sharks with its tooth system of cutting type arranged in a peculiar manner. The first representatives of this family appears in the Albian. In Cenomanian-Turonian and Coniacian times, compared to other sharks this family played in the seas of European paleogeographic area an insignificant role. Beginning with the mid-Late Cretaceous the family Anacoracidae occupied different biotopes. Their remains are met both in open sea facies and in nearshore shallow water zones. The family flourishes during the Santonian and Campanian, where it is known from 4 genera: *Ptychocorax*, *Squalicorax*, *Paraanacorax* and *Microanacorax*. During the Campanian the first of these genera dies out and by the end of the Maastrichtian - the three remaining ones are extinct. Except for the enumerated genera in the family Anacoracidae in the Santonian- Maastrichtian were present by two other genera: *Paracorax* and *Pseudocorax*, which also die out at the end of the Maastrichtian. All the representatives of the family Anacoracidae die out in the Maastrichtian.

Cretaceous and Cainozoic families

3. Odontaspididae include 8 genera of pelagic and nearshore sharks: *Odontaspis*, *Synodontaspis* (Cretaceous-Recent), *Hispidaspis* (Cretaceous), *Hypotodus*, *Jaekelotodus*, *Palaeohypotodus*, *Striatolamia* (Palaeogene), *Odontaspis* (Palaeogene-Recent). *Odontaspis* and *Synodontaspis* are undoubtedly related genera. These genera contain different representatives of Lamniformes with odontaspidid dentition features.

Cretaceous and Palaeogene branches of the genera are surely of polyphyletic origin and should be related to different phyletic lines.

The representatives of the Cretaceous genus *Hispidaspis* die out in Maastrichtian times.

The Palaeogene epoch was favourable for odontaspidid development. The appearance of the majority of these genera occurred in the Early Palaeocene.

4. Otodontidae were the largest pelagic sharks of the Cretaceous, Palaeogene and Miocene seas and oceans. There are 5 genera in the family: *Cretolamna* (Cretaceous), *Otodus*, *Carcharocles* (Palaeogene), *Megaselachus* (Miocene) and *Parotodus* (Palaeogene).

The first four genera form an almost uninterrupted phyletic series of species subsequently changing during time. The time of appearance of the genus *Parotodus* is not well known. The first

representatives of the genus were found in Lower Ypresian deposits of the Eastern Precaspian.
5. Scapanorinchidae - is a peculiar group of nearshore-sea and deep-water sharks, includes two genera: *Scapanorhinchus* (Cretaceous-Recent) and *Anomotodon* (Cretaceous-Miocene).
To the genus *Anomatodon* belong incomplete species of Cretaceous and Palaeogene sharks. It is impossible to trace their family ties and the character of evolutionary transformations of the tooth systems. Representatives of the genus *Scapanorhinchus* are characteristic for Santonian and Lower Campanian, and are much more seldom and mainly in deep-water facies of the outer shelf zone.
6. Lamiostomatidae. To this family belong *Acrolamna* (a Cretaceous genus) and four Cainozoic genera: *Macrorhizodus*, *Isurolamna*, *Lamiostoma* and *Xyphodolamia*. The first appearance of the genus *Acrolamna* is Albian, the maximum took place in the Cenomanian - Early Campanian interval, in the Late Campanian the decline happened and in the Maastrichtian - full extinction. *Macrorhizodus*, *Isurolamna* and *Xiphodolamia* appear in the Palaeocene. Rare Palaeocene teeth of the genus *Macrorhizodus* are more common in Ypresian and Lutetian. A great number of remains of this genus can be observed in Bartonian and Priabonian deposits, beginning with Oligocene it marked a sharp decrease in the presence of this genus. Maximum quantity of *Xiphodolamia* teeth is found in Ypresian sediments. The maximum occurrence of the genus *Isurolamna* is connected with Lutetian and Bartonian. *Lamiostoma* - is a typical genus of Oligocene Lamnoid sharks.
7. Alopiidae are represented by two genera: *Paranomotodon* (Cretaceous) and *Alopias* (Palaeogene-Recent). Family ties are not established between these genera. The genus *Paranomotodon* is characteristic for the Cenomanian-Campanian interval, in the Maastrichtian they are known. The first finds of the genus *Alopias* come from Ypresian sediments. An increase of teeth can be observed in the Lutetian and Bartonian sediments.
8. Cetorhinidae - the giant recent sharks. They eat plankton. The first species of this family appeared in the Oligocene and included the genus *Cetorhinus*.

Conclusions

The history of Cretaceous and Cainozoic Lamniformes is clearly divided into three stages of development: Cretaceous, Palaeogene and Neogene-Quaternary. Each of them is characterized by a specific stage of group development (evolutionary level, appearance of and predominance of families and genera, which possess characteristic features of organisation, reflecting each level).

The Cretaceous "stage" is characterised by domination of the Cretoxyrhinidae, Anacoracidae and Scapanorhinchidae.
The Palaeogene "stage" differs by the acme of the families Odontaspididae, Otodontidae, Lamiostomatidae and Alopiidae. Cretaceous genera of these families made up only a small part of the total number of Cretaceous elasmobranchs.
Cretaceous and Palaeogene genera of elasmobranchs represent phyletic lines. The family ties between them are not established, except for the continuous development of the phyletic series *Cretolamna* (Cretaceous) - *Otodus* (Palaeogene). Thus, Cretaceous Lamnoid shark association from the European palaeogeographical area, sharply differs from the Palaeogene shark complex. The Cretaceous/Palaeogene boundary is dated by the extinction of two families of Cretaceous sharks (Cretoxyrhinidae and Anacoracidae) and the change of the shark generic content for the other families.

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