IGCP ProjectNo 343, IGCP Project No 369

PERI-TETHYS PROGRAMME IN MOSCOW

MOSCOW WORKSHOP
January 16-17, 1996, Geological Faculty, Moscow State University

ABSTRACTS

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MOSCOW, 1996

GENERAL PALEOGEOGRAPHY OF THE URALS DURING LATE CRETACEOUS EPOCH

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The position of North Geographic pole during Late Cretaceous epoch was located within the limits of recent Arctic Ocean. The Tethyan paleobiogeographic region during Cretaceous times corresponded to the Mediterranean region. European paleobiogeographic region was bordered in the south by Tethyan paleobiogeographic region and spread all over the water-masses of entire Europe from the Urals up to the western border of West Europe, and connected with Asian region and West-Siberian province on the east, North-Atlantic region on the west and Arctic region on the North. European region could be subdivided onto two parts: southern Peri-Tethyan belt, including PriCaspian and Mangyshlak, Western Kopetdag, Crimea-Caucasian and other provinces; and Boreal belt, including East-European platform and other provinces. Arctic region could be subdivided onto two segment: Western European segment, and Eastern Asian one, including West-Siberian and other provinces. The Urals mountain country was a natural eastern border for the Peri-Tethyan belt, East-European platform province and Western segment of Arctic region. Generally, from one side, eastern slope of the Urals (=Cis-Urals, Preduralie) belongs to mentioned provinces, from another side - to West-Siberian and East-Asian provinces. Latitude boundaries Peri-Tethyan and boreal belts were somewhat conventional and migrated during the Cretaceous history of Euro-Asia, nevertheless it could be placed within the 40-60 grade of Northern latitude.

Most general and powerful factors that affected the structure and arrangement of boreal Uralian Cretaceous fauna and flora are: the general climate of the planet and global movement of hydrosphere. Total Boreal belt moved from carbonaceous-produced basins from tropic latitudes towards to the North and Cretaceous North Geographic pole. Some periods had a high contrast in temperature from Tethyan (tropical) to boreal latitudes, while in some over periods the climatic grade was more even, and in such case arctic biota did not contrast so much from moderate and Tethyan regions.

During the Cenomanian-Early Turonian episode, the large equatorial transgression led to an expansion of equatorial shelf, and a depth increase for marine basins, with a strengthening of biogeographic zonality, clearly differentiating European from West-Siberian biota.

Late Turonian-Early Campanian episode was a time of contrasting regime. There was an alternation of transgressive-regressive periods. At the end of the Late Turonian stage (terminal Turonian) there was an equatorial regression and a synchronous polar transgression. The beginning of the Coniacian stage was marked by an equatorial transgression, followed by a regression at the end of that period (visible in the Tethyan region), while there was a symmetric transgression in Arctic region. In Early Santonian times, as for the Coniacian, a transgressive-regressive regime occurred. During the Late Santonian-Late Campanian period, there was a stabilization of transgressive-regressive regime. It represents an epoch of equatorial regression and arctic transgression. The beginning of terminal Early Campanian was a time of slow predominance of equatorial transgressions.

The Late Campanian-Maastrichtian episode was a time for unlimited developing of equatorial transgression and correlatively the European (Tethyan-Atlantic) and Pacific fauna invaded polar regions and squeezed out arctic-boreal biotas. It could be identified three great equatorial transgressions: Late Campanian, Early Maastrichtian and Late Maastrichtian ones. They were separated by short periods of regressions.

During Cretaceous times, the western and northern parts of the Tethyan ocean, European region and West-Siberian province had permanent biogeographic connections with the opening Atlantic Ocean and with the Arctic Ocean. Northern areas of Cis-Urals (Polar and PrePolar Preduralie) were connected with Western segment of Arctic region, East-European platform and West-Siberian provinces mainly. Median and southern areas of Cis-Urals were connected with East-European and East Peri-Tethyan provinces. Total West-Siberian province, including Polar and PrePolar Trans-Urals, had biogeographic connections with Western segment of Arctic region, East-European platform and East Peri-Tethyan provinces across the Urals by North-Uralian, Middle-Uralian and Turgay straits.

APTIAN ANOXIC EVENTS OF THE RUSSIAN PLATFORM AND ADJACENT AREA

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The presense ob "black shales" reach in organic matter is very typical for Aptian of the Western Tethys (Breheret J.-G., Delamette M., 1989; Coccioni R., Franchi R., Nesci O., et al., 1989; Gaida K.-H., Gedenk R., Kemper E., et al., 1981; Kemper E., 1982, etc.). Such shales were originated during anoxy in the water mass in slow water convection conditions. Examination of the "black shales' position showed their time coincidence and connection with the global sea-level changes.
The same levels were determined in Aptian of the Russia and NNG countries. They exists in Northern Caucasus, Peri-Caspian, Mangyshlak and Russian Platform. Anoxic origination of those levels is supported by the following features:

- High volume of organic matter, which makes black color of rocks and sections.
- Absence or specific benthic fauna assemblages.
- Absence or slight intensity of bioturbation. Usually only *Chondrites* are found in sections.
- Very fine seasonal stratification of sections, when bioturbation is absent.
- Prevalation of fine - grained clayey sediments.
- Presence of fine-dispersed and concretional pyrite and marcasite.

The anoxy was determined in the following ammonite levels of Northern Caucasus (Mineralovodsky part): *Deshayesites weissi; Deshayesites deshayesi* (the upper part); *Dufrenoya furcata; Parahoplites melchioris* (the upper part); *Acanthohoplites nolani* (the upper part) and *Hypacanthoplites jacobi*.

In the Mangyshlak (central part) it is present in levels: *Epicheloniceras subnodosocostatum* and *Parahoplites melchioris*.
In Peri-Caspian (northern part) anoxy was fixed in zones: *Deshayesites deshayesi* and *Hypacanthoplites jacobi*.
On the Russian Platform (Simbirsk Syneclise) anoxic event was determined in the single level: *Deshayesites deshayesi* Zone and the other part of Lower and Middle Aptian is characterized by dysaerobic conditions.
Correlation of anoxic events shows that the maximal anoxy falls on the *Deshayesites deshayesi* chrone (the "Selli Level") and supports the idea of the high stand of sea-level. The same idea is supported by the general paleogeography of the Russian Platform and it's borders and the far north distribution of Tethyan faunas. The other anoxic levels have the local distribution and connected with the local paleogeographical changes.

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MID-CRETACEOUS EVENT SCALE FOR PERI-TETHYS AREA

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The Mid-Cretaceous is a unique time inside all Cretaceous period. It had specific geological situation with often sealevel oscillations, warm climatic conditions, anoxic oceanigraphic events, which led to hydrocarbon formation (fig.) and extensive tectonic life. All these events took plase simultaneously at least over the Peri-Tethys (fig.) and controlled type of evolution and migration for diiferent macro- and microfauna.

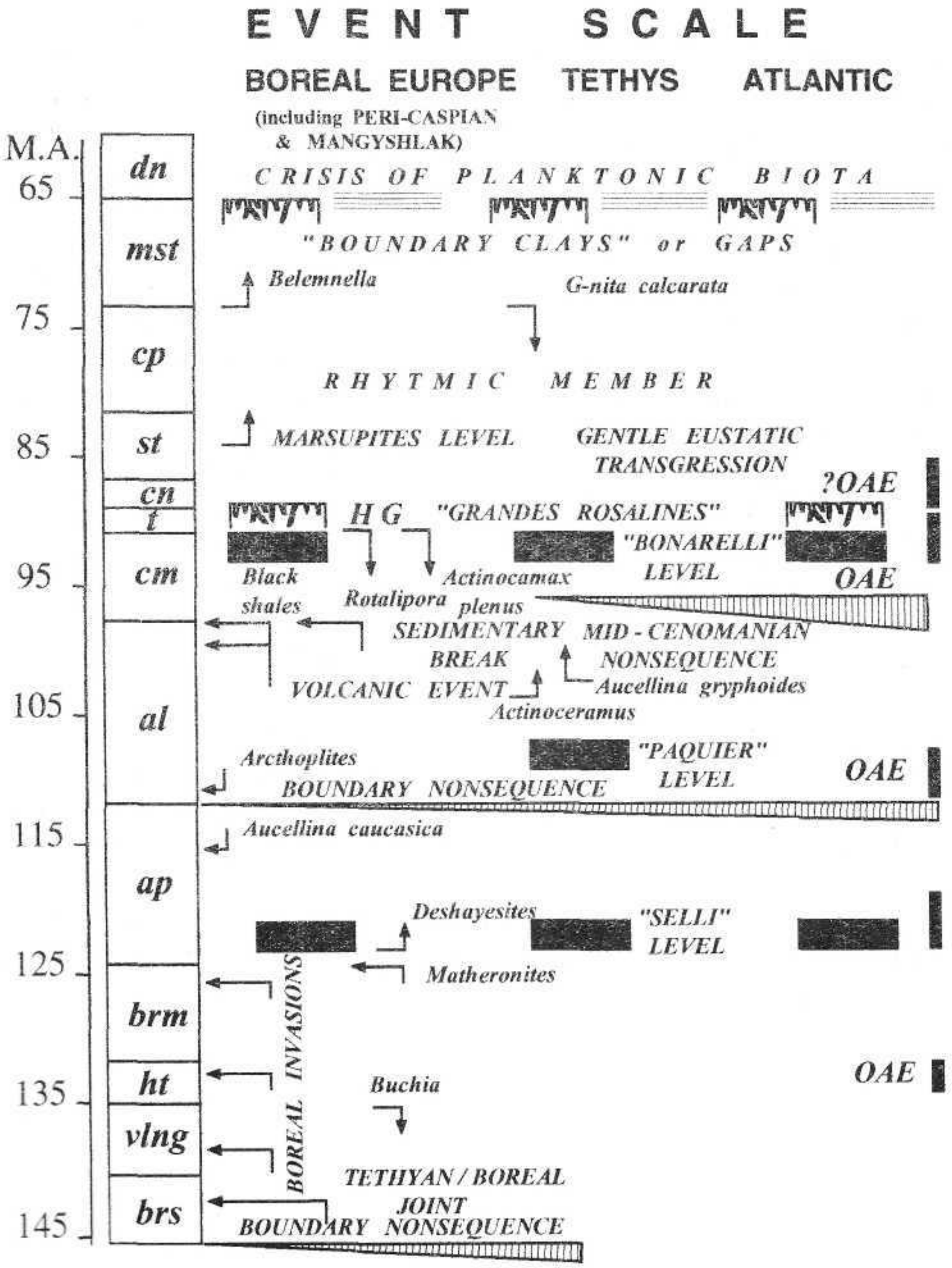

Fig.

ORGANIC GEOCHEMISTRY OF MAIKOPIAN SERIES CAUCASUS REGION

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Majkopian Series(Upper Oligocene-Lower Miocene) is widely spred within Caucasus region. These formation consisting of clay and siliceous-clay rocks,is rich in organic matter (OM) and considered as high potential source rocks. Maicopian series is the oil-bearing one.Majkopian rocks present the main source for oil accumulation along the upper part of region succession (K_2-N).

OM content in the most samples studied is not very high(0,4-0,8%). However,at some levels the increased OM concentration was fixed (2-5%). Horizons with high OM concentrations are confineed to Oligocene part of succession; the thickness and OM content increasing in the west-south-west direction, with maximum concentrations (10%) being established in clay mud vulcano of the Black Sea. Based on the Rock-Eval pyrolysis date, it was found out, that genetic potential of source rocks is rather different:(S_1+S_2) -0,2-20g HC per kg. The hydrogen index(HI), indicator of OM quality -is not very high (150-250), maximum 600 g HC per 1 kg of OM. The Van-Krevelen diagrams show, that OM occurs within the II-III type kerogen interval.

Petrographic studies of kerogen in thin sections have revealed the total content of mixtinite, which in some cases is determined as colloalginite. Allochtonous vitrinite and leiptinite content does not exceed 10%.Data on elemental content of kerogen permit to divide the original OM into two types: the predominantly phytoplanctonic with higt hydrogene concentrations in kerogen (up to 7.8%), i.e. type II kerogen, and the mixed - being formed on account of protein components of plancton and significan investment of humic material - type III kerogen.

OM accumulation occured within different (by depth and isolation) part off the marine basin, being greatly effected by contiinental environment.It is probable, that in some separate short periods of time anoxic accumulation took place.

Rate of OM bituminization is relatively high (6-12%); in some samples it averages 25-30%, with the increased bituminization occuring at lower catagenetic levels($R0<0,5$).

Chromotographic analysis show that bitumoids, obtained from different regions,are to a greater extent similar to each other.They are characterized by prevalence of isoprenoids over n-alkanes, high values of K_i = 1,5-3,7, Pr/Ph near 1 . There the increeased naphthene back ground was established and double-peak distribution n-alkanes with maximum values of C_{15}-C_{17} and C_{22}-C_{23} or C_{22}-C_{23} and C_{29}, as well as slightly increased concentration of odd n-alkanes and high concentration of steranes and hopanes. Isotop content of oil fraction - ^{13}C -28,1-28,9, i.e. being lighter for marine OM.

Thus, Maikopian series of the Caucasusus region is Characterized by the increased OM mixed concentratiens; it has higer oil source potential, which was not significantly realized; in many depressions active HC generation still occurs.

QUANTITATIVE CHARACTERISTICS OF MESOZOIC-CENOZOIC HISTORY OF FORE-CAUCASUS AND NORTH-CRIMEAN SEDIMENTARY BASINS

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Backstripping method was used for the analysis of the history of the region in technique carried out in Geology and Sedimentary Basin Modelling Laboratory of Geological Faculty, Moscow State University. According to data of 128 boreholes from different regions of Fore-Caucasus and Crimea, the next quantitative values of parameters were obtained for Mesozoic- Cenozoic time: 1 - the total basement subsidence; 2 - tectonic subsidence; 3 - basement vertical movements velocity; 4 - tectonic subsidence rate; 5 - sedimentation rate. To unify and totalise the results of all observed wells modelling the procedures of summarization and calculation of average, maximal and minimal estimations of that parameters were used.

The obtained quantitative estimations of tectogenesis, sedimentation and erosion in the development history of the region show the original velocities of these processes (calculated with taking decompaction of sediments in account) and let us to define the following development stages: 1. Early-Middle Triassic; 2. Late Triassic - Earliest Jurassic; 3. Latest Early Jurassic - Early Bathonian; 4. Late Bathonian - Early Callovian; 5. Late Callovian - Late Jurassic; 6. Cretaceous - Eocene; 7. Oligocene - Early Miocene; 8. Middle Miocene - Quarternary.

Stage	Proposed tectonic environment	rates (m/mln.years)		
		tectonic subsidence (uplifting)	verical movements of basement	sedimentation (erosoin)
Early-Middle Triassic***	rifting, postrift subsidence	14.52.(average) 259.22(max) -14.64(min)	33.43(average) 617(max) -27.85(min)	40.12(average) 770(max) -1.18(min)
Late Triassic - Hettangian***	collisional tectonics, molasse basins	0.89 44.74 -15,61	2.46 117.1 -31.17	71.6 135.95 -71.6
Sinemurian-Early Bathonian	rifting, postrift subsidence	3.42 49.12 -4.9	8.58 135.7 -10.79	9.78 151.22 -0.02
Late Bathonian - Early Callovian	orogenic event	5.57 49.46 -6.2	12.31 125.79 -13.81	13.64 125.79 0
Late Callovian - Late Jurassic	tension, weak rifting, postrift subsidence	8.03 91.37 -7.02	23.86 247.57 -13.59	29.7 327.73 0
Cretaceous - Eocene	Aptian-Albian rifting followed by postrift subsidence, complicated by tension and compression events	4.63 42.68 -5.3	12.18 84.17 -10.95	18.3 121.82 0

Oligocene - Early Miocene	compression, early collisional stage	13.88 79.72 -16.0	46.08 264.98 -35.7	73.45 453.78 0
Middle Miocene - Quarternary	collisional climax, molasse basins	11.88 196.06 -155	628.23 46.83 -425.75	105.13 1037 0

**** - for Eastern Pre-Caucasus only*

The every of these stages is defined by distinct estimations of subsidence history, uplifting, sedimentation and erosion. The obtained values are shown in the table. In particular observation the every stage has more complex history. The phases of increasing and decreasing of velocities of geologic processes can be marked. The following explorations in this direction would let us to define and calculate the whole-region events and separate them from local ones.

PALEOGEOGRAPHICAL AND BIOGEOGRAPHICAL RELATIONS BETWEEN BASINS OF RUSSIAN PLATFORM - URALS AND NORTHERN TETHYS BASIN (MOSCOVIAN- EARLY PERMIAN)

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An Eastern European Moscovian basin has been divided into some parts with different kinds of sedimentation and biotas. There are could be recognized next of them: 1- basin of the Russian platform with essentially carbonate sedimentation; 2 - Donetsk basin with very thick near shore carbonate-terrigenous coal-bearing essentially marine sediments; 3 - Near Urals a relatively deep water basin with essentially terrigenous sediments; 4 - Eastern Uralian basin with mainly terrigenous sediments with evaporites. All above mentioned basins have been connected into one within Pricaspian basin.

At least two ephemeral straits could be suggested between Pricaspian basin and Tethyan seas. One strait was situated along western side of recent Aral sea. Another strait is traced along eastern part of recent Caspian sea.

Donetsk basin and Eastern Uralian basin could be treated like the narrow and long bays with different history. The northern boundary of marine sedimentation of Eastern Uralian basin was gradually replaced from North to South duration Moscovian age. Evaporite bodies marked this retreating of near shore line. Marine conditions of sedimentation have been preserved till Early Late Carboniferous in southern part of Eastern Uralian basin and have been ceased to Late Moscovian in northern part of one.

Two very short time ingression of sea have been proved for Eastern Uralian basin duration Late Permian. One of them - Kazanian - was connected with Kazanian sea of Russian platform.

Another ingression - Tatarian - came from Tethys region. This conclusion was made by base of the presence of very specific Tethyan genera of forams Robuloides and Pararobuloides in the South Urals.

The history of Donetsk bay was similar with Eastern Uralian one, but a very important difference should be marked. The time of the ceasing of marine sedimentation with the evaporites in concluding moment of one for this basin is Late Asselian.

The marine sedimentation was preserved till end of the Early Permian in the Preduralian basin. A very complicated sequence of terrigenous and carbonate sediments was laid down duration of Late Carboniferous and Early Permian. Different kinds of Kungurian evaporites (gypsum, anhydrites, dolomites, rock and potash salts) capped a marine sequence of sediments of the Preduralian basin.

The Preduralian basin was opened into Pricaspian one and Moscovian-Early Permian sedimentation both of them is very similar aside of some second rate details. The distribution within Pricaspian basin of the marine carbonate Kazanian sediments there is a difference one from coeval sequence of the Preduralian basin, where the Kazanian stage is represented by the terrigenous sediments only.

The Moscovian-Early Permian biota of above discussed basins have been formed under strong influence by biota of the Tethyan seas. It could be traced amongst all groups of fauna, but especially easy can be shown by the change of taxonomic composition amongst fusulinids, corals, brachiopods, ammonoids.

LATE PALEOZOIC SEDIMENTATION IN PREDURALIAN FOREDEEP (WESTERN SLOPE OF THE SOUTHERN URALS, RUSSIA) AND RADIOLARIAN STRATIGRAPHY

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The Preduralian foredeep is a large tectonic structure spanning an area from the Pricaspian syncline (47 degree N) in the south, to Novaya Zemlya Island (70 degree N) in the north. Along the western slope of the Urals the foredeep is filled with Middle Carboniferous- Permian sedimentary deposits. Toward the western region including the Russian carbonate platform, there are the following facies zones - coarse flysh, fine flysh, pre-flysh, pre-reef. Radiolarians of the Gzhelian-Kungurian age are found in fine grained mostly terrigenous rocks - argillites, cherts, and micrites of fine flysh, pre-flysh, pre-reef facies zones. New radiolarian, fusulind, and conodont data revises established previous radiolarians scheme (corrected scheme is shown in figure).
Geographically, radiolarians are found from Orsk City (50 degree N) to Krasnoufimsk City (57 degree N) (about 1000 km) and are unknown in areas north of this region.

Another ingression - Tatarian - came from Tethys region. This conclusion was made by base of the presence of very specific Tethyan genera of forams Robuloides and Pararobuloides in the South Urals.

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Geographically, radiolarians are found from Orsk City (50 degree N) to Krasnoufimsk City (57 degree N) (about 1000 km) and are unknown in areas north of this region.

The first appearance of radiolarians in Late Paleozoic in the western Urals was contemporaneous with the development of deepwater with cherty-clayish and terrigenous flysh-like sedimentation. The eastern boundary of radiolarian distribution reflects the eastern shore line. Organic buildups were a barrier to radiolarians in the west until Late Artinskian. During the Kungurian time an influence of high salinity water seems to be a western boundary. Numerous invasions of radiolarians could be traced in the sections on the eastern slope of the Preduralian foredeep and in the central portion.

These areas show promise in developing a more refined stratigraphy. Late Paleozoic sediments containing radiolarians are found only in the southern portion of the Preduralian foredeep. A ecreasing of the water temperature along the Preduralian basin can explain this lack of radiolarians to north from Krasnoufimsk City latutude. The area around the Sakmara-Ural River could be considered the most northern boundary of the Tethyan belt radiolarian fauna.

There is a real possibility to use the radiolarian for resolving of a very complicated problem of the Arcric and Tethys Upper Paleozoic sequences correlation.

Figure

stage		horizon	conodonts	radiolarians
Kungurian	upper	Irenskian	Neostreptognathodus pnevi	
	lower	Filippovskian		
Artinskian	upper	Saraninskian		Polyentactinia lautitia
		Sarginskian	Neostreptognathodus pequopensis	Tetracircinata reconda
	lower	Irginskian		Entactinosphaera crassiclathrata-Qiunqueremis arundinea
		Burtzevskian	Sweetoghathus whitei	Rectotormentum fornicatum
Sakmarskian	upper	Sterlitamakskian	Mesogondolella bisselli-Mesogondolella visibilis	Camptoalatus monopterigus
				Entactinia pycnoclada-Tormentum circumfusum
	lower	Tastubskian		Helioentactinia ikka-Haplodiacanthus perforatus
				Copicyntra sp.
			Mesogondolella lata	
			Mesogondolella uralensis	
Asselian	upper	Shikhanskian	Mesogondolella pseudostriata	
			Streptognathodus postfusus-Mesogondolella striata	
	lower	Kholodnolozhskian	Streptognathodus fusus-Mesogondolella simulata	Tormentidae
			Streptognathodus constrictus-Mesogondolella adentata	
			Streptognathodus cristellaris	Latentifistula crux
			Streptognathodus isolatus	

NUMERICAL MODELLING OF THE FORE- AND TRANS- CAUCASUS-CRIMEA MOLASSE BASINS.

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The evolution of the fore- and trans- Caucasus-Crimea molasse basins (Indol-Cuban, Terek-Caspian, Fore-Crimea, Tuapse-Rioni and Kura basins) was controlled by the collisional history of the Great Caucasus-Crimea orogen. There are three main stages of syncollision molasse basin formation: 35-21 Ma ago - early collision, rapid subsidence of future molasse basins; 21-12 Ma ago "soft" collision, slow molasse basin subsidence; 12-0 Ma ago - collisional climax, rapid subsidence of molasse basins, upthrusting of the Great Caucasus to the south, local retrothrusting to the north (see fig.1).

The main scientific purpose of the research project is the building of the integrated kinematic, dynamic and thermal model for these molasse basins due to Cenozoic collision. A foreland basins forms by flexural isostatic response of the lithosphere on the intraplate streses and orogen loading due to collision. The stratigraphy of the basins is the record of the interplay of the lithosphere vertical movement and surface transport processes. If it is possible to reproduce main features of the geological processess in computer models, then our understanding step up from descriptive to more fundamental one based on physical laws. We hope that prepared quantitative model give us the possibility to evaluate the basin forming and governing mechanisms by the quantitative methods.

General plan. We choose three sections crossing out molasse basins and collision zones related with the three main regional tectonic units: Eastern and Western Fore- and Trans-Caucasus and Crimea. The position of these sections are shown on the fig.2. As a first step we plan to carry out kinematic restoration along these profiles, including burial/uplifting history for molasse basins and the rough balanced sections restoration for the orogenic areas in the connecion with the molasse basins evolution. Using these restorations and data of the neotectonic stress distributions, gravity and topography we plan to carry out 2D dynamical modelling of the Great Caucasus and its molasse basins history (flexural bending of the lithosphere due to intraplate stresses and vertical (thrust/fold) loading).

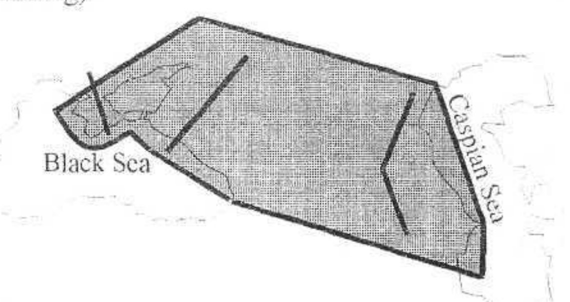
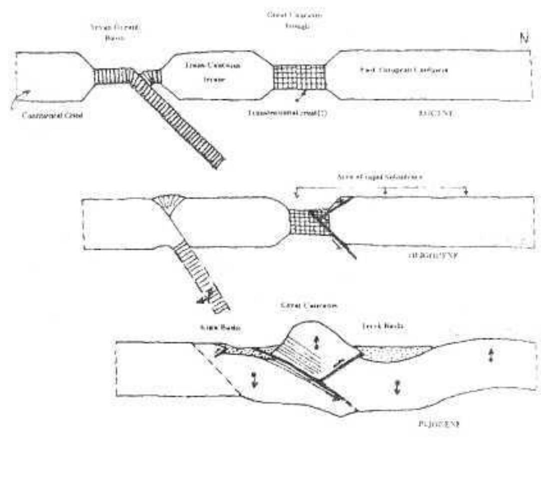
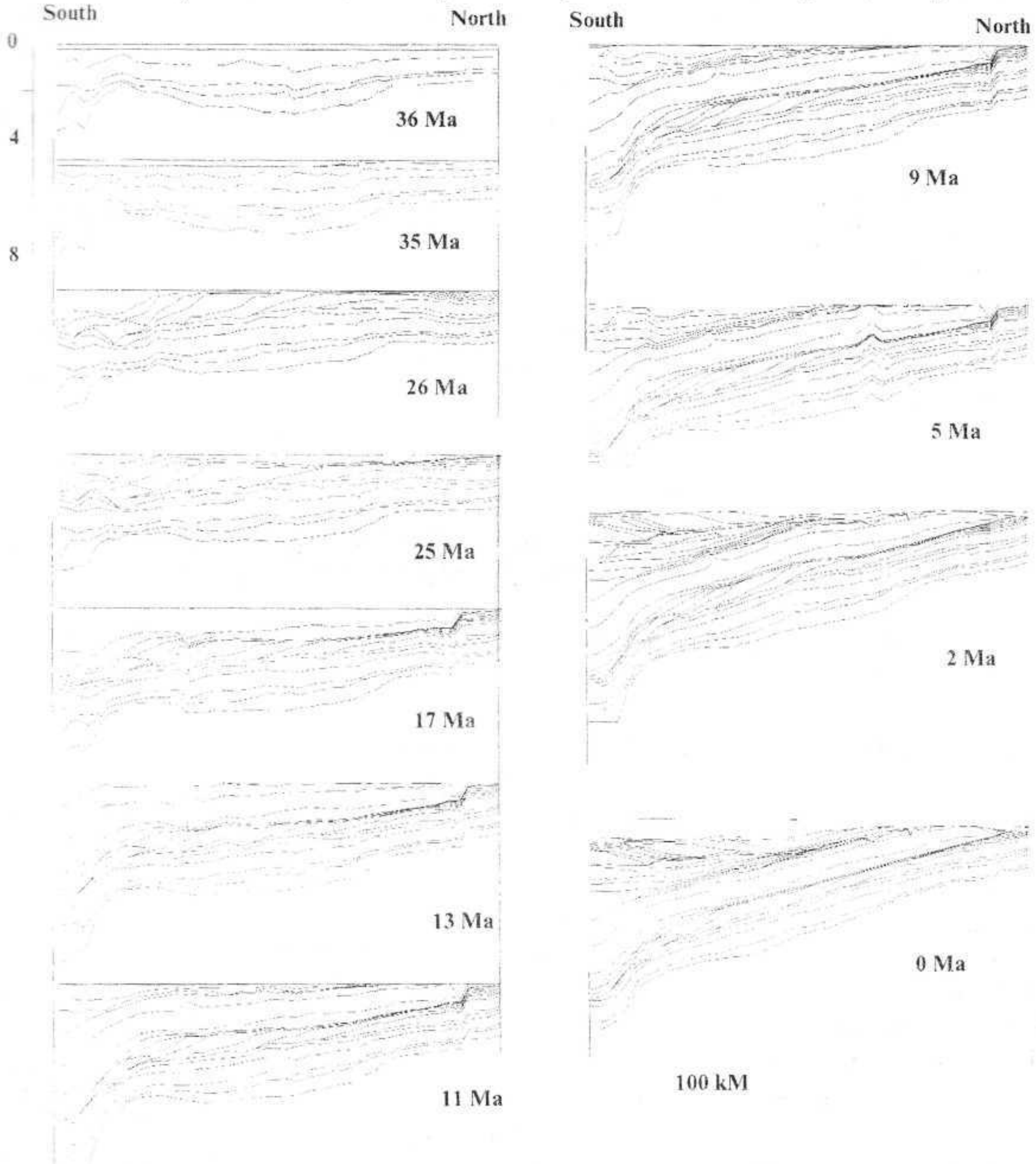


Fig. 1. Area of investigations.



The main **methods of the investigations** are backstripping with lithology-dependent decompaction, combined equal bed length / equal area balanced cross-section restoration, 2D dynamical modelling which include lithospheric flexure, isostasy and simplified surface transport (lithosphere as thin



elastic plate and lithosphere with temperature and compositional controlled plasto-elasto-ductile rheology). We use software prepared in Moscow University and University P.& M.Curie. Research would be carried out by group of Moscow University (A.Nikishin, A.Ershov, S.Bolotov) and group of University P.& M.Curie (M.-F. Brunet, J.Chorovitz) in collaboration with S.Kosova (Central Geophysical Expedition, Moscow).

Current situation. On the base of the detailed stratigraphy and seismostratigraphy we prepare 2D kinematic computer model of the burial-uplifting history for the first cross-section through Eastern Fore-Caucasus molasse basins (see fig.3). The main difficulty in this restoration appear from variable relief of the sedimentation surface (at the same time we can see clinoformal non-compensated sedimentation and erosional river valleys in neighboured areas of the section). So we obtain very detailed history of the vertical lithosphere movement in molasse basin (with 0.1 MA resolution for some stages). These data presents a good quality input/constraints for dynamical modelling of the stress-strain history. The most impotant stages corresponds to the three clinoformal complexes: Maikopian (35.4-17 MA) - abrupt subsidence of very broad area, Sarmatian (13.66-9.3 MA) and Akchagylian (5.15-3.7) - molasse basins formation in foreland area and differential movements in area of flexural bulge.

Near future plan. We plan to carry out balanced sections restoration through the eastern part of Great Caucasus to restore the loading history. After that we plan to do dynamical forward modelling for recent situation and for some key moments in the past.

OIL GENERATION POTENTIAL OF MAJKOP DEPOSITS IN THE EAST PRE-CAUCASUS FOREDEEP

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Majkop Formation affact researchers because of its relation to ore mineral resources and HC basic material. The predominantly clayey content of marine origin,mainly by sapropellic type of OM, presence of oil and gas accumulations make these deposits the example of classic and oil-producing formation. However,there is the distinct discrepancy between generation abilites of these rocks and recovered HC reserves. Such discrepancy is explaned by both genetic factors (quantity and type of OM,catagenetic level transformation, i.e.oil-generation potential, discrepancy between generating and accumulating rocks), and poor researching and extent of exploration of Majkop rocks.

Corg content of Majkop rocks in the East Pre-Caucasus foredeep is 0,3-8,4%,and in Miocene - 0,55%, in Oligocene -2,1%.

There is the direct relationship between C_{org} and generation potential (based on pyrolisis data): C_{org} <1% (S_1+S_2)-0,5 kg/t of rock; 1,5-3% - 2-16 kg/t of a rock. Most of the Khadum succesion is characterzed by medium and higher oil-source potential (based on the classification of Tissot and Welte,1981) due development of Type II kerogen in it: HI=200-700 kg HC/t C_{org}, bitumoid coefficient (β^{HB}) - 3-12%. Within tick clayey bed of the overlying Oligocene and Miocene rocks Type III kerogen is distributed: HI=26-195 kg HC/t C_{org}, β^{HB}=3-16%.

In the platform flank of East Pre-Caucasus foredeep the whole Maj kop Formation occurse within the maturation zone - based on pyrolisis data Tmax=407-438°C;in the Tersk-Caspian trough-within the oil windor: Tmax=430-445°C.Within maturation zone,both rocks proper and OM are cha racterized by higher bitumen content: bitumoid in the rocks -0,01-1%, β^{HB} =9-14%, OPI=0,12-0,18.

This creates prerequisites for formation HC accumulations at early generation stage on account of the own OM.Chromatographic analyses of OM,extracted from clays of the Khadum horizon, as well as of oil from Sovetskoye field have confirmed their genetic relationship.In the platform flank oil and OM being hardly transformed, in the center of the trough - catagenetic level is increasing. Thus analyses of OM from Majkop rocks has'e shown that to the category of source rocks we could refer Khadum clays and marls, rich in OM (C_{org}>2%) and containing Type II kerogen with increased oil generation potential. It's of the most Majkop Formation is not high,as it is characterized by predominance of Type III OM,which transformation products are gaseous HC.

TARKHANIAN-KARAGANIAN STAGE OF DEVELOPMENT OF THE EUXINIAN-CASPIAN BASIN OF THE PARATETHYS

I.A. Gontsharova , *Paleontological Institute RAS*, **I.G. Shcherba,** *Geological Institute RAS.*

Toward the end of the Kozakhurian time (Early Miocene) the area and depth of the Paratethyan basins have been considerably reduced. The relief of basin floor has been leveled significantly, particularly at the shelf of the Euxinian-Caspian Basin, due to subsequent filling of the sediment basins.

At the beginning of the Tarkhanian the hydrogen sulfide contamination has been mostly over, and the normal marine carbonate-clayey deposits have begun to accumulate. The paleobathymetric zonality being retained from the earlier stages, the bottom leveling of the Euxinian-Caspian Basin has been further enhanced. At the mid-Tarkhanian (Terskian) time deepening of the Basin has begun, being culminated in the Late Tarkhanian (Argunian) time.

During all the interval considered (Tarkhanian-Karaganian), as in the Paleogene, the Basin was deepest at the Great Caucasus flysch trough.

Comparing the Tarkhanian time, the Chokrakian basin had its differentiation more pronounced. Elevated areas of the Eurasian and Transcaucasian shelves have shoaled, the subsided troughs (West Kubanian, Terskian, and Iori-Kuraian) have become still deeper. The folded elevations cordilleras have appeared in the axial part of the Basin, resulting in its transversal contraction. The diversified drainage network of the East European plain has established and the fluvial drift has been intensified.

During the Chokrakian, filling of all depressions has been activated by sediments of both northern and southern origin, resulting in general shoaling of the Basin and expansion of the transgression on shelves. The hydrological regime of the Basin has changed as well from the normal marine one with abundant benthos and plankton in the Early Chokrakian (Zyukian time) up to the half-marine regime with a strikingly impoverished fauna in the Late Chokrakian (Brykian) and Karaganian time. The shoaling and folding in the Basin has resulted in the Late Chokrakian (Brykian) time by appearance of an isthmus across the central part of the Great Caucasus. This terrestrial bridge has permitted the African elements of the Belomechetka mammal assemblage (genera Orycteropus and Kubanochoerus) to reach the Stavropol Region (Belomechetka).

The marine connection of the Basin to the Indian-Pacific part of the Tethys, which has been active during the Tarkhanian and Early Chokrakian, has ceased when the Araksian trough has been filled in the Late Chokrakian.

During the Karaganian time depressions have been infilled. Being isolated of the World Ocean and affected by a considerable fluvial drift, the Karaganian Basin has spread still wider than the Chokrakian.

LATE PALEOZOIC EXOTIC BLOCKS IN CRIMEA

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Most ancient (for Crimea) Upper Palaeozoic deposits are located inside the Lozovskaja structure zone of the Gorny Crimea (Slavin, 1969, 1980). This zone up to 12 km width extends in sublatitude direction. It is limited by the Bitak zone in the North as well as by the Gorny Krimea in the South. The specific section of the Lower Mesozoic of the Lozovskaja structure zone is characterized by Upper Triassic normal flysh in the lower part. Eskiordin formation (of Lower Jurassic and Aalen stage of Middle Jurassic age) is located in the upper part of the section. Eskiordin formation is composed by alternation of argillites, sandstones or conglomerates. Two horizons of olistostroms, containing Upper Palaeozoic blocks of limestone are connected precisely with the basal layers of Eskiordin formation by many of investigators. Hudge dimensions of some blocks give evidence of local intrageosynclinal sources of drift.

Most ancient gray or dark - gray limestones contain numerous brachiopods, forams, algae. Limestones are located inside narrow horizon of SE extension from the South marches of Marjino country along the north slope of the Chaban - range. In the East direction the Carboniferous limestone boulders were revealed at the right bank of the Salgir River opposite Lozovski village. Late Namurian - Early Bashkirian age of two blocks was determined by A. Miklcho - Maklay in two blocks being located on the both banks of Salgir River.

Permian sediments are revealed as separate blocks and boulders of various dimensions inside the definite horizon, being located to the North of the Carboniferous limestone zone location. The Permian deposits are represented by limestones and trend in the form of separate cliffs and blocks in a SW - NE direction. They begin in the West with an outcrop along the Marta River and disappear in the environs of the town of Simferopol. Most large - scale in Crimea block of is the hill of Djin - Sofu, forming the cpe on the right bank of Simferopol reservour.Its length is more than 100m, while the thickness is about 50m. The Permian age of the limestones of the Crimea was for the first time established by O. Toumansky in 1917 on the base of the identity of the fauna collected by her on mount Kichkhi - Burnu, along the Marta River with that of the Fusulina limestone of Sicily. The first discovery of these deposits was made in 1901,yet their age has been then determined as Carboniferous and Upper Carboniferous. In 1924 a detailed geological exploration was entered in the region of the development of the Permian deposits of the Crimea and a number of new outcrops was discovered by O.Toumansky. At the Marta River on mount Kichkhi - Burnu there lies a cliff having the appearance of being built up of separate blocks consisting of a light brecciated limestone with ammonoids, brachiopods, trilobites and corals with a multitude of fusulinids. The next outcrops met with in moving from West to East are the Permian limestones between the Bodrak and Alma rivers.

A combined section could be compiled according to O. Toumansky (1941). The Upper Permian part of the section comprises the following units (in ascending order):

Murgabian stage

Almian formation:

Bodrakian horizon:

Pseudoschwagerina sp.

Soramanian horizon:

Neoschwagerina craticulifera, Paraperrinites, Marathonites (Almites), Artinskia (Sicanites), Propinacoceras, Crimites, Paragastrioceras, Popanoceras

Caraimian formation:

Burnian horizon:

Neoschwagerina, Sumatrina, Verbeekina, Cancellina,Pseudodoliolina, Paraceltites, Neostacheoceras

Midian stage

Caraimian formation

Martian horazon:

Neoscwagerina, Yabeina, Pseudodoliolina, Polydiexodina, Neostacheoceras, Tauroceras, Paraceltites, Adrianites

Brachiopods from the Late Permian limestones have been never published.

SCYTHIAN PLATFORM: LATE JURASSIC PALEOGEOGRAPHY AND DYNAMICS

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We compiled a seria of paleogeographical maps, scale 1:2 500 000, for Scythian Platform (North Caucasus-Crimea region) for Early-Middle Callovian, Late Callovian-Early Kimmeridgian and Late Kimmeridgian-Tithonian times. The maps is based on the new data of about 200 wells, 500 thin sections and 5 seismic profiles. Modelling of the burial history was done for 22 deep wells. Orogenic event and uplifting took place before the Callovian which was fixed mainly for N.Caucasus. Early-Middle Callovian - subsidence of the southern part of the Scythian Platform, terrigenous sedimentation, humid climate. The early Callovian sedimentation usually is very similar to the late Bathonian, especially in Crimea. It took place during the high stand, which is supported by equal fauna distribution. The middle Callovian was characterized by intermediate terrigenous - carbonate sedimentation in shallow water conditions. Late Callovian - early Kimmeridgian subsidence has been in the wide area, when carbonate sedimentation and formation of the coral reef belt along the southern platform margin took place. It was the time when Boreal - Tethyan connection still existed. During the late Kimmeridgian - Tithonian - up to early Berriasian the area was separated from the intraplatform Boreal basin, and evaporite formation prevaled under arid climate conditions. The evaporite bath was limited by the land to the north and by the great stromatholite reef to the south. The reef buffered the evaporites from the coral reef, which existed on the south margin of the Scythian Platform. The Late Jurassic basin was a rifted basin along a passive rift margin of the Great Caucasus deep-water trough.

OPENING OF THE BLACK SEA AND SOUTH CASPIAN BASIN: AN ATTEMPT OF RECONSTRUCRION

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The closure of a wide (more than 1500 km) marginal sea which existed south of the Scythian Platform in the Early Mesozoic occured in the Early Cretaceous and possibly continued up to 80 Ma. In Crimea and further to the west, the microcontinent of Pontides, supporting the extinct Bajocian island arc, collided with the Scythian Platform in Early Albian (?). East of Crimea, a narrow remnant of the marginal sea was preserved as the Great Caucasus basin. Opening of the Black Sea began in its western extremity in the Barremian by rifting of the Istanbul block from the Moesian Platform. From the east this rift was limited by an extension of the Pechenega-Camena fault of Northern Dobrogea. In the rest of the Black Sea rifting began presumably in Late (?) Albian that is indicated by rift formation on the northern shelf (Karkinit graben) and rift-type volcanism and subsidence in western Transcaucasus. Transition to spreading in westernmost part of the Black Sea occured most probably in Cenomanian when the northward subduction began under the Istanbul block, causing its southward drift. As seen from the magmatic-sedimentary record of the Adjaro-Trialet and Talysh rifts, seismic data and plate tectonic reconstructions, a basin about 200 km wide was opened in the eastern Black Sea. Transcaucasus and southern Caspian in the Paleocene-Middle Eocene at a spreading rate of about 1 cm/y. Clousure and disconnection of the Black Sea and South Caspian basins began in the Late Eocene due to northward migration of southern Transcaucasus. This work was also supported by Russian Fund for Fundamental Research Grant N 95-05-14252.

Paleogene Siliceous Microfossils of the Middle Volga Region: Detailed Stratigraphy, Correlation and Paleogeography.

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Paleocene-Lower Eocene radiolarians, silicoflagellates and diatoms were studied from the two sections of the Middle Volga region (Granoe Ukho and Kuroedovskie Vyselki). Stratigraphical subdivision, correlation between sections and precise age determinations of the regional zones on microplancton were made.

Siliceous-terrigenous Paleogene sediments of the South Russia can be considered as typical sediments of the marginal epicontinental basin. In the Middle Volga region Paleocene - Lower Eocene deposits are exposed. They are represented by siliceous sandstones, silica clays and diatomits of the Syzran Formation (Paleocene) and by silica clays and sands of the Kamyshin Formation (Lower Eocene). Diatomits and silica clays beds contain abundant and well-preserved Radiolaria, Diatoms and Silicoflagellates. Four Zones on Radiolaria were distinguished in sediments: *Buryella tetradica, Tripodiscinus sengilensis, Petalospyris foveolata and Petalospyris fiscella.* On diatoms Zones *Trinacria heibergiana, Coscinodiscus coronifer, Stephanopyxis ferox* and on silicoflagellates Zones *Cobrisema hastata, Cobrisema dissimmetrica communis* of the so-called boreal schemes were recognized.

Although assemblages of siliceous microfossils differ from the oceanic co-eval associations very much the precise age of the boreal zones was determined on the base of direct correlation with standart zonal scales on silicoflagellates and radiolarians. For example, from sedimements of *Petalospyris foveolata* Zone several species described (Nishimura, 1992) from the *Bekoma bidarthensis* standart radiolarian Zone of the Northwest Atlantic were found and allowed to correlate these two zones.

Middle Eocene sediments in the Middle Volga region have been eroded as a rule and only their remains represented by coarse-grained sands and mica clays are preserved on the river's watersheds.

Paleogeographical map has been made for the Upper Paleocene (Upper Tanethian) time slice on the base of lithological composition of sediments, taxonomical and structural pecularities of microplancton assemblages contained in sections. Available literature data have been used too.

Eocene Microplanctonic Assemblages of the Voronezh Anteclise' Key Sections

Khokhlova I.E., Radionova E.P., Benjamovsky V.N., Tscherbinina E.K, *Geological Institute, RAS.*

Radiolarians, diatoms, nannoplancton and foraminifera were carefully studied from the three key sections (Kantemirovka, Rudaevka and Sergeevka) and Hole 5-93 of the South and Central part of Voronezh anteclise area.

Lower-Middle Eocene sediments of this South Russia part lay unconformingly on marls and limestones of Maastrichtian age. They are wide distributed and composed by sandy clays of Buchack Formation, transgressive-regressive succession of phosphoritic sands, marls and siliceous clays of the Kiev Formation of Ukraine (or Sergeevka and Tishki Formation in Russia) and by sandy clays and siliceous clays of the Khar'kov Formation of Ukraine (or Kas'anovka Formation in Russia). The age of formations has been revised many times and only the latest investigations based on calcareous and especially siliceous microplancton allowed to date these sediments precisely. Possibility of direct correlation with standart zonal scales has been revealed and occured to be a great success.

At the base of Kantemirovka section where marls of the lower part of the Kiev Formation, i.e. Sergeevka Formation are exposed the abundant and diversified foraminifera assemblage was found.

Regional *Globigerina subglobatus- G.index* Zone was distingiushed. It corresponds to the upper part of *Acarinina rotundimarginata (s.l.)* Zone of the Crimea-Caucasus foraminiferal scale and to *Morozovella lehneri (P12)* Zone of the standart zonal scale. Bentic foraminifera are typical for the regional *P.subbotinae-U.spinocostata* Zone which can be traced all over the North Peritethys paleobiogeographic area from Belgium to West Kazakhstan . Marls of the middle part of the Kiev Formation contains nannoplancton of *Nannotetrina quadrata(CP13)* Zone of standart zonal scale (Okada, Bukry, 1980) and belongs to the boundary Lutetian/Bartonian beds. Upper part of Kiev Formation and especially siliceous clays of Khar'kov Formation contain abundant and exellent-preserved radiolarians, diatoms and silicoflagellates of Bartonian age. Zones on siliceous microfossils distinguished in mentioned sections can be correlated with the *Podocyrtis ampla-Podocyrtis mitra* Zones of the standart radiolarian zonal scale.

Paleogeographic map is to be made for the Middle Bartonian time slice. It proved to be clear now that the deepest part of the basin occupied the area approximately in 200 km to the south of Voronezh town in Middle Bartonian time. On the contrary, this time the Middle Volga region can be considered as the land territory.

NORTHERN CAUCASUS AND SYRIA: NEW DATA ON LATE CENOZOIC STRESS AND DEFORMATION FIELDS, AND HORIZONTAL BLOCK MOVEMENTS

M.L.Kopp, V.S.Burtman, *Geological Institute, RAS,* **L.M.Rastsvetaev,** *Geological Faculty, Moscow State University.*

As a result of the 1995th field mesotectonic studies in the Northern Caucasus (Mineralovodsky rise, Laba-Malka and Pshekish-Tyrnyauz zones), a kinematic characteristics of some major faults have been specified. Many of them turned out strike slip faults often demonstrating a normal fault or, rarely, thrust component of displacement. Stress and deformation fields in the Cis-Caucasus part of the Scythian platform resemble to some extent the same ones in the folded part of the High Greater Caucasus and are represented by a submeridional compression and sublattitudional extension, with only difference that the normal faults are characterized by a more widespread occurence. An essential significance of compression faults with converging sides (macro- and minisutures, crumbled zones) was established for internal regions of the Greater Caucasus. Such features are spread not less than overthrusts. In peculiarities of an arrangement of the structures of a different kinematic sign, an axial (of WNW-ESE orientation) lengthening of the Greater Caucasus was determined. It is expressed by a block movement directed from the most compressed part of the Greater Caucasus neck toward the Caspian and Black Sea basins and by a megaboudinage of the orogene in horisontal plane. These results, along with previosly collected data including paleomagnetic measurements, are used for constructing geokinematic maps (for three time intervals) of framing of the South Caspian megadepression.

In 1995 field works are carried also in a region of the El Ghab graben in western Syria and the data processing of our previous studies of intraplate deformation in the western Arabian plate was completed. It was established that stress field of a "strike-slip" type is widely spread not only at the Levantine transform zone but also in a vast adjacent area of the Arabian plate. These studies revealed that the structures of an every kinematic type in the latter, including folds and thrusts of the Palmyra compressional belt, extension structures in basaltic plateau as well as sinistral and dextral wrench structures in Palmyrides, construct a regular ensemble formed as a result of activity of a single reason namely of turning out by a margin of the Arabian plate of an obstacle in the form of the sharp break of the transform fault line at Lebanon.Our mesotectonic data do not imply that the El Ghab transform-related basin is an ordinary rift as it assumed by most researchers. Of all possible models for the El Ghab graben origination, including rift, ramp, subvertical downwarping of its bottom, pull apart, strike slip duplex and fan-shaped splaying of transform fault, the three latters are more probable.

LATE CRETACEOUS OF THE MANGYSHLAK PENINSULA: SEDIMENTARY SEQUENCES AND FINE FORAMINIFERAL ZONATION

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The Upper Cretaceous interval of Mangyshlak area is subdivided into seven sedimentological sequences which represent the complex of genetically related beds, members and formations (fig.1). Sequence I - Upper Albian - Lower Cenomanian; II - Middle Cenomanian-Lower Turonian; III - Upper Turonian-Lower Coniacian; IV - Upper Coniacian-Santonian; V - Lower Campanian; VI - Upper Campanian; VII - Maastrichtian.

The benthonic foraminiferid assemblages in the terrigenous and Chalk facies of Mangyshlak basin are comparable to those recorded in England, France, Germany and etc. All the taxa used in these schemes have been recorded in this regions, but "first appearance datums" of taxa are not identifible.

In the Chalk facies, above the Early Turonian, planktonic foraminiferids are abundant at all levels, but comprise mainly longranging species. Therefore the foraminiferid zones are based largely on the well-documented, common and widespread benthonic genera: *Bolivinoides, Bolivina, Gavelinella, Stensioeina, Lingulogavelinella, Cibicidoides, Neoflabellina.*

26 foraminiferal zones were established in the Upper Cretaceous of the east part of European paleobiogeographic region - Peri-Caspian basin, Mangyshlak (fig. 2).

1.The common occurences of *Gavelinella cenomanica, G. baltica* are referred the base of Lower Cenomanian - "*Gavelinella cenomanica* zone" . Small planktonic foraminiferids (*Hedbergellids* and *Globigerinelloides*) are dominated in the lower part of this subdivision. Calcareous benthonic foraminiferids are dominated in next part of this zone, associated with planktonic and calcareous cemented agglutinans.

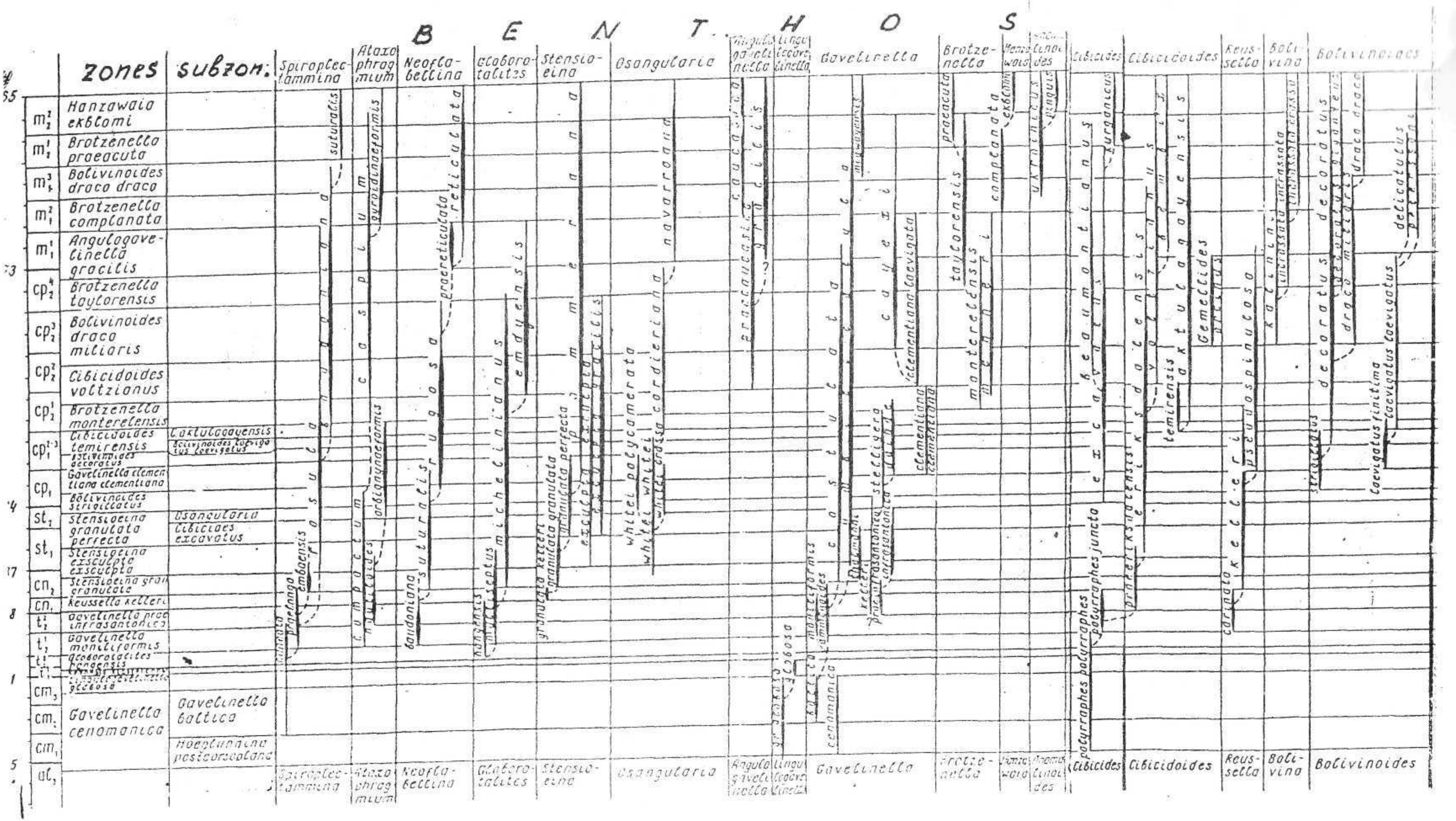
2. Appearance of *Lingologavelinella globosa* is related to the Middle-Upper Cenomanian. This taxa appears always above Mid-Cenomanian erosian surface in more complete Mangyshlak sections and with appearance of *Turrilites costatus/Schloenbachia varians* entrance.

3. Lower Turonian interval of foraminiferal distribution is marked by the presence of a big guantity of *Whiteinella* species (zone "*Grandes Globigerines*" or *Whiteinella archeocretacea*), while the Upper Turonian interval is determined by different *Marginotruncana* and *Marssonella* appearance and *Gavelinella ammonoides-moniliformis* evolution line.

4. The appearance of *Gavelinella ex gr. vombensis* (*=praeinfrasantonica*) gives the base of Coniacian stage. This evolution level inside filogenetic line of *Gavelinella* coincides with appearance *Reusella kelleri* , and with very intresting level in planktonic assemblages: the abundance of flate species of *Marginotruncana coronata/pseudolinneiana/renzi* (zone "Grandes Rosalines". Mass amount of typical *Stensioena granulata granulata, Gavelinella thalmanni, G.vombensis, Osangularia whitei whitei* appearances are fixed in the Upper Coniacian zone. Mass distribution of *Stensioeina exculpta exculpta* is typical for the Coniacian terminal part.

5. Santonian/Campanian boundary is considered to be settled within the *Bolivinoides strigillatus* Zone. The appearance and mass occurences of *Stensioena pommerana, Gavelinella clementiana clementiana, Bolivinoides decoratus* is connected with Lower Campanian, those *of Brotzenella monterelensis* with the Middle Campanian. The Upper Campanian is determined by the *Cibicidoides voltzianus* appearance followed by *Bolivinoides draco miliaris, Bolivina kalinini= B.incrassata* (narrow specimens), upsection by *Brotzenella taylorensis* and in the most terminal part by *Angulogavelinella gracilis stellaria.*

6.Campanian/Maastrichtian boundary is determined on the basis *of Neoflabellina reticulata, Bolivinoides deccurens* appearance and of abundant *Angulogavelinella gracilis*. Middle part of Lower Maastrichtian is distinguished by *Brotzenella complanata* and Upper part *by Bolivinoides draco draco, Anomalinoides subcarinatus*. Upper Maastrichtian is characterized by *Brotzenella praeacuta, Anomalinoides pinguis* appearance and its terminal part by *Hanzawia ekblomi* and *Pseudotextularia elegans* occurences.


B E N T H O S
zones
subzon.
Spiroplectammina
Ataxophragmium
Neoflabellina
Globorotalites
Stensioeina
Osangularia
Angulogavelinella
Lingulogavelinella
Gavelinella
Brotzenella
Hanzawaia
Anomalinoides
Cibicides
Cibicidoides
Reussella
Bolivina
Bolivinoides
m$_2^2$ Hanzawaia ekblomi
m$_2^1$ Brotzenella praeacuta
m$_1^3$ Bolivinoides draco draco
m$_1^2$ Brotzenella complanata
m$_1^1$ Angulogavelinella gracilis
cp$_2^4$ Brotzenella taylorensis
cp$_2^3$ Bolivinoides draco miliaris
cp$_2^2$ Cibicidoides voltzianus
cp$_2^1$ Brotzenella monterelensis
cp$_1^{1-3}$ Cibicidoides temirensis
Bolivinoides decoratus
cp$_1$ Gavelinella clementiana clementiana
Bolivinoides strigillatus
st$_2$ Stensioeina granulata perfecta
st$_1$ Stensioeina exsculpta exsculpta
cn$_2$ Stensioeina granulata granulata
cn$_1$ Reussella kelleri
t$_2^2$ Gavelinella praeinfrasantonica
t$_2^1$ Gavelinella moniliformis
cm$_3$
cm$_2$ Gavelinella cenomanica
cm$_1$
al$_3$
Gavelinella baltica
Hoeglundina postcarscoland
Osangularia
Cibicides excavatus
sutularis
rosaryi
praelonga
embaensis
gyroidinaeformis
orbignyaeformis
reticulata
praereticulata
rugosa
suturalis
baudoniana
michelinianus
emdyensis
hangensis
granulata perfecta
granulata kelleri
navarroana
whitei polycamerata
whitei whitei
cordieriana
praecaucasica
costulata
monteliformis
stelligera
clementiana laevigata
clementiana clementiana
cenomanica
praeacuta
taylorensis
monterelensis
complanata
ekblomi
polyrraphes polyrraphes
polyrraphes juncta
temirensis
Gemellides
pseudospinulosa
carinata
kelleri
decoratus
draco draco
draco miliaris
delicatulus
laevigatus laevigatus
strigillatus
Spiroplectammina
Ataxophragmium
Neoflabellina
Globorotalites
Stensioeina
Osangularia
Angulogavelinella
Lingulogavelinella
Gavelinella
Brotzenella
Hanzawaia
Anomalinoides
Cibicides
Cibicidoides
Reussella
Bolivina
Bolivinoides

CENOMANIAN-TURONIAN ANOXIC EVENT, BIOTIC CRISES AND RED TIDES

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Anoxic event are correlated with Cenomanian/Turonian (C/T) boundary and with accumulation of so-called black shales, black band or sediments rich in organic matter (OM).
Crises of marine biota in C/T boundary accompanied anoxic events and accumulation of layers with high percentage of OM. The death rate of marine invertebrates - ammonites, belemnites, echinids at the C/T boundary is between 5.2% - 6.1% (Alekseev, 1989). There are only deep-water fishes or Chondrites in layers with high OM per cent. No benthic forams and only very rare cosmopolitic forms such as Lenticilina or primitive agglutinated forms occur in the black shale. At the same time many planktic forams, especially highly specialized taxa, disappeared on this level.

The nature of OM is only marine or mixed terrestrial and marine. The general scheme of the events may be as follows: 1) short time eustatic transgression (3 order) were replaced by more short regressive cycles; 2) during this time large territories with lowland surfaces were openeed on the shelves; lowland surfaces and warm climate resulted in the development of lakes/bogs landscapes. There were favourable conditions for the accumulation of terrestrial OM (Mangyshlak terrigenous shallow-water sections for example) and in the weakly acidic wa ters different biophil elements and first of all phosphor concentrated.

Interecalations of these landscapes and new transgressive pulses contribute: 1) input of terrestrial OM into basins; 2) input of phosphor and other biophile elements into basins; 3) their rapidly enter in the biological cycle. Depending of these processes the primary bioproductivity will increase. Especially the rapidly growing bioproduction of phyto and picoplanctic species will form"bloom" that are comparable to the modern "Red Tides". This event have great tofic influence on all marine biota, including zooplankton. Anaerobic diagenesis and diffusion of H_2S into the bottom waters will create stagnant co nditions. The benthic fauna will be killed. Thus "Red Tides"lead to a negative influence on both planktonic and benthonic assemblages, although the mechanism are different.

SCYTHIAN PLATFORM: TECTONIC HISTORY

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Our model of the tectonic history of the Scythian platform is based mainly on our new paleogeographic maps of this area, our computer models of rifted basins subsidence history and analyses of magmatic rocks.

Tectonic history of the Scythian Platform

Early-Middle Triassic-Carnian. Great continental rift system covered by post-rift cover originated along the former Late Paleozoic orogen; it includes East Manych basin, Kayasula basin, Mozdoc basin, Kiliya-Karkinitsky-Azov belt of basins, Tulcea (Dobrogea) basin, rift basins of the Moesian platform and Turan platform, activated Dnieper basin. Rift related magmatism took place in many rifted basins. Compressional tectonics took place in pre-Norian time.

Norian-Rhaetian. Compressional tectonics, origin of molasse basins, orogenic magmatism.

Triassic/Jurassic boundary and Hettangian. Collisional orogeny (possible collision with Transcaucasus terrane, Iran terrane, Western and Eastern Pontides terranes).

Sinemurian-Early Pliensbachian. High stand of the Scythian Platform, origin of a subduction-related(?) magmatic belt along the Great Caucasus belt.

Late Pliensbachian-Toarsian. Rifting along the Great Caucasus-South Crimea belt along the former magmatic belt, origin of the Great Caucasus deep water trough, weak rifting in the uplifted Scythian Platform.

Aalenian-Early Bajocian. Collisional orogenic events in the Crimea, weak compressional events in the Great Caucasus, regional subsidence of the Scythian Platform.

Bajocian-Bathonian. During the Bajocian a huge subduction-related magmatic belt was active in the Transcaucasus-Pontides area. Intra-Bajocian inversion tectonics took place along the Great Caucasus-South Crimean belt. This inversion tectonics followed to Bathonian and had a culmination at the end of Bathonian-beginning of the Callovian as an orogeny along the Great Caucasus-South Crimean belt. Regional subsidence of the Scythian Platform took place in Bajocian-early Bathonian ended by pre-Callovian uplifting.

Callovian-Mid-Berriasian. New rift phase took place in the Callovian-Tithonian along the Great Caucasus-South Crimean belt, in the Dobrogea and the Moesian Platform. The back-arc dynamics of the rifting is proposed. The rifting was accompanied by subsidence of the Scythian Platform.

Berriasian. Orogenic events, uplifting and thrusting-folding took place in the Crimea and Scythian Platform.

Late Berriasian-Barremian. New system of sedimentary basin outlines originated in the Scythian Platform; possibly it was new weak tension phase. Uplifting in pre-Aptian time.

Aptian-Albian. A system of back-arc rifted basins originated to the north of Srednegorie-Pontides-Transcaucasus-Albors magmatic belt. The rifting took place in Pontides, West Black Sea basin, East Black Sea basin(?), Crimea, Great Caucasus.

Late Cretaceous. Back-arc ocean crust spreading in the West Black Sea basin, tension events in the Scythian Platform and Great Caucasus.

Paleocene-Eocene. Intra-Paleocene (pre-Thanetian(?)) compressional event was followed by regional subsidence of the Scythian Platform. Back-arc rift phase in the East Black Sea basin and Great Caucasus trough(?)

Eocene/Oligocene boundary. The north dipping subduction was changed by collision of the Transcaucasus-Pontides area with Tauride-Anatolide terrane. It led to the uplifting of the Transcaucasus region and thrusting in the Caucasus-Black Sea region. The compression have led to rapid subsidence of the southern part of the Scythian Platform (espesially in the Indol-Kuban and Terek-Caspian basins) and marginal parts of the East Black Sea basin.

Oligocene-Early Miocene (Maykop time). Rapid syncompressional subsidence of the southern part of the Scythian Platform and Black Sea have led to origin of deep-water basins which were filled by clay and sandstones. Clinoform sedimentation dominated in the deep basins of the

Scythian Platform. At the end of the Maykop time relative compensation by sediments took place in the Scythian Platfrom.

Middle Miocene-Quaternary. A collision between the Arabia and the Europe took place since the Middle Miocene. This continent-continent collision have led to collision tectonics and orogeny in the Caucasus-South Crimea region, and to syncompressional subsidence of the Black Sea basin and a few molasse basins originated to the north and south of the Great Caucasus-South-Crimean orogen. North Caucasus Indol-Kuban and Terek-Caspian molasse basins underwent five rapid subsidence phases: 16.5-15, 13.6-9.7, 7, 3.7-1.8 and 1.6-0 Ma ago. These times coincide with the main phases of thrusting in the Caucasus. Since the Middle Miocene a syncompressional bulge has been uplifted along the belt of Karpinsky Swell-Donets Basin-Ukrainian Shield.

Dynamics of the Scythian Platform subsidence

We can discuss three main driving mechanisms of the Scythian Platform subsidence in the Jurassic-Eocene. First mechanism - *rifting and postrift thermal subsidence.* It is very realistic model of the subsidence because we have a few rift stages: afret every of the rift phase a postrift subsudence took place. Possibly it was the main mechanism of the Scythian Platform subsidence. Second mechanism - *loading by a new orogen.* Real regional subsidence of the Scythian Platform started in the Aalenian and mainly Bajocian directly(?) simultaneously with orogenic events in the Caucasus-South Crimean belt. So it is very possibly the start of the subsidence was connected with the orogeny. Third mechanism - *subduction-related subsidence of a broad region.* For example the maximum of the volcanic activities of the Transcaucasus-Pontides subduction magmatic belt took place in the Bajocian, Albian-Late Cretaceous and Eocene. Directly at the same times we have maximum of the subsidence of the Scythian Platform and southern part of the Russian Platform. So we think there are the reasons to propose any connections of activity of the subductional magmatism and subduction itself with a broad platformal subsidence.

During the Oligocene-Neogene-Quaternary the dynamics of the Scythian Platform was driven by collision tectonics.There are two main collisional epochs: Oligocene-Early Miocene and Middle Miocene-Quaternary. During the Oligocene-Early Miocene two different processes took place: (1) compression due to collision with Tauride-Anatolide terrane and (2) possible roll-back of the subducted lithosphere followed by detachment of the subducted slab.During the Middle Miocene-Quaternary new collisional epoch took place after a short break. The collision took place between the Europe and Arabia. The collision was irregular with five main phases of shortening: 16.5, 13.6-9.7, 7, 3.7-1.8 and 1.6-0 Ma ago.Each compressional event was accompanied by rapid subsidence of molasse basins followed usually by clinoform sedimentation. The syncompresional bulge to the north of the Scythian Platform molasse basins suffered uplifting since the Middle (Early-?) Miocene. The distance between the bulge axis and orogen axis is nearly 350 km. The greatest compressional event took place in the Sarmatian (13.6-9.7 Ma ago): at this time compressional folds and thrusts originated inside the Russian Platform up to 1200 km to the north of the Great Caucasus.

SCYTHIAN PLATFORM IN MESOZOIC AND CENOZOIC: SERIES OF PALEOGEOGRAPHIC MAPS, SCALE 1:2,500,000

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We have prepared new version of the paleogeographic maps for the Scythian Platform (original scale 1:2 500 000) for the following epochs: Alpine stress-field map; Late Pliocene, Akchagylian; Late Miocene, Meotian; Middle Miocene, Tschokrakian; Early Miocene; Early Oligocene; Late Eocene; Paleocene; Maastrichtian; Santonian; Cenomanian; Middle Albian; Late Albian; Late Barremian; Late Berriasian; Tithonian-Kimmeridgean; Late Callovian-Oxfordian; Early-Middle Callovian; Early Toarcian; Late Sinemurian; Rhaetian; Anisian; Olenekian. This maps show the Mesozoic-Cenozoic history of the Scythian Platform. The legend of the maps shows mainly paleoenvironments (outlines of basins, water-depth, kind of sedimentation, volcanism, tectonic elements and so on).

The maps are based on new schemes of stratigraphic correlations, but there are a lot of stratigraphical questions this time. We prepared chronostratigraphic charts for eastern Pre-Caucasus region and for the Crimea. It is possible to recognize the following stages of the Scythian Platform sedimentary cover history in Mesozoic-Cenozoic:

-*Early Triassic-Carnian* - origin of rifted basins and postrift sedimentary cover;
-*pre-Norian* - hiatus, uplifting, orogenic event;
-*Norian-Rhaetian* - molasse basin origin, orogenic volcanism;
-*pre-Hettangian-Hettangian* - hiatus, uplifting, orogenic event;
-*Sinemurian-Early Pliensbachian* - mainly hiatus, uplifting, volcanism along the Great Caucasus belt;
-*Late Pliensbachian-Toarsian* - high stand of the Scythian Platform, sedimentation in a few rift basins;
-*Late Aalenian-Bajocian-Bathonian* - regional subsidence of the Platform, formation of the platform cover with a few hiatuses;
-*pre-Callovian* - hiatus, uplifting, orogenic event;
-*Callovian-Tithonian* - regional subsidence of the Platform, formation of the platform cover;
-*Berriasian* - mainly hiatus, uplifting with a few sedimentary basins, orogenic event;
-*Late Berriasian-Barremian* - formation of the platform cover with a few hiatuses;
-*Aptian-Albian* - origin of rifted basins, formation of the platform cover;
-*Albian/Cenomanian boundary* - hiatus, uplifting event;
-*Late Cretaceous-Eocene* - regional irregular subsidence, formation of mainly carbonate platform cover with a few hiatuses;
-*Eocene/Oligocene boundary* - rapid change of environments, possible orogenic event;
-*Oligocene-Early Miocene* - rapid subsidence of southern part of the platform, origin of a relatively deep-water trough, clinoform filling of the basin followed by compensated sedimentation;
-*Middle Miocene-Quaternary* - very complicated history of molasse basins with rapid subsidence events, clinoform sedimentation, uplifting events and so on.

accompanied by it overflowing in condition of the levelling of the tectonic relief (Early Ipresian, early Bartonian - Morozovella lehneri Zone, late Priabonian).

Strusture and petroleum of the Dagestan thrust belt, northeastern Caucasus, Russia.

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Exploration boreholes and seismic reflection data in the foothills zone of the northeastern Caucasus obtained during the last time revealed considerable differences between the surface and subsurface structures of area. The new data suggest that this zone may be viewed as a buried thrust belt. The allochthonous assemblage of the belt is formed mainly by stacked north -verging thrust sheets made up mostly of Mesosoic carbonates and sandstones bounded at the top and bottom by conjugate detachment surface. The thrust sheets are interpretated to be inserted into the clastic section of the Terek-Caspian foredeep along the base of Oligocene-Early Miocene mudstones. The blind subsurface trusts have been active since the Late Miocene. Strata above and below the allochthonous unit are characterized by independent styles of deformation. The mildly deformed foredeep clastic create a hinterland-facing monocline that is passivelly uplifted by underthrusting. These rocks mask the subsurace structures . Tectonic wedging in the Dagestan thrust belt was facilitated by the mechanical weakness of the Maycop formation (Oligocene-Lower Miocene) which prevented transmission of the compressional stress across it. The interpretated geometry of the thrust belt front implies shortening ranging from 20 to 50 km.

This interpretation of the regional structure suggests a petroleum exploration play consisting of structural traps within the buried antiformal stacks. Regionally, oil- and gas-bearing Upper Cretaceous and Upper Jurassic carbonate rocks involved in thrust sheets and sealed by Maycop mudstones are considered to be primary prospecting targets.

PARVICINGULA AS INDICATOR OF JURASSIC TO EARLY CRETACEOUS PALEOGEOGRAPHICAL AND SEDIMENTOLOGICAL PALEOENVIRONMENTS WITHIN NORTH PERI-TETHYS

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It is well-known that in the Tethyan Realm Genus Parvicingula has very rare distribution, whereas the content of this genus in the Boreal (Khydjaev, 1931; Sedaeva, Vishnevskaya, 1995) and Australian provinces (Baumgartner, 1993) reaches up to maximum. Besides, the preponderance of parvicingulides can indicate an upwelling conditions or redeposition due to resistent peculiarities.

The study of Parvicingula distribution showed the predominance of this genus in the Kimmeridgian of the Timan-Pechora and Barents regions. The species of this genus are represented by wide ranges of morphotypes. The co-occurence of Arcto-Boreal foraminiferal assemblages together with Jurassic radiolarians and Buchias confirms the possibility to use Parvicingula as paleoclimatic indicator similar to that it has been proposed by Pessagno et al. (1986). The Arcto-Boreal radiolarian assemblage of the Barents-Pechora region includes Crucella crassa (Kozlova), C. squama (Kozlova), Parvicingula haeckeli (Pantanelli), P. burnensis Pessagno & Whalen, P. pizhmica Kozlova, P. pusilla Kozlova, P. santabarbarensis Pessagno. Within Middle Volgian Dorsoplanites panderi ammonite Zone among radiolarians Parvicingula papulata Kozlova, P. conica (Khabakov), P. cristata Kozlova, P. rugosa Kozlova, P. simplicim Kozlova are dominating species. Parvicingulides content is about 90% in the Barents-Pechora region.

Toward south in the Volgian Stage Khudyaev (1931) recognized species belonging to Parvicinula (P.multipora Khuduaev, P. susollaensis Khuduaev, P.khabakovi Khudyaev, P.zyrjanica Khudyaev). The content of parvicingulides in the Susola Basin is about 75%.

The main Kimmeridgian representatives of Moscow region are Parvicingula vera Pessagno & Whalen, P. inornata Blome, P. elegans Pessagno & Whalen. Parvicingulides prevails, forming 50% of this assemblage and in the Middle Volgian, beeing represented by P.haeckeli (Pantanelli), P. hexagonata (Heitzer) (Bragin, in press).

In the Gorodische section (Volga Basin) Parvicingula jonesi (Pessagno) is dominant species of Kimmeridgian and P. blowi (Pessagno) is characteristic in Volgian. Here parvicingulides content is 50-60%. Appearance of the Mediterranean species P. boesii (Parona) is fixed in the uppermost part of Volgian stage.

The North Caucasus Kimmeridgian-Tithonian assemblages includes only rare P. dhimenaensis (Baumgartner) and Berriassian - P. boesii. The content of parvicingulides is less than 5% in the Tethyan Realm.

ABOUT POSSIBILITY TO CORRELATE NORTH PERI-TETHYAN RADIOLARIAN EVENTS WITH OTHERS ZONATIONS

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The Peri-Tethyan radiolarian assemblages are dominantly Boreal in character. These types of Mesozoic zonations have not been described previously. The Oxfordian Amoeboceras alternans Strata contain numerous Parvicingula jonesi and can be correlated with Epistomina uhligi foraminiferal Zone in the North Peri-Tethys. The lower Kimmeridgian Parvicingula vera Zone is probably equivalent to the lower Kimmeridgian Crucella crassa Assemblage of Kozlova (1971, 1995) and correlates with the Buchia concentrica Zone, A. ravni ammonite Zone and Epistomina unzhensis foraminiferal Zone as well. Probably this interval corresponds to Kimmeridge Clay Hydrocarbon Formation of the North Sea which contains a lot of P. jonesi (Dyer, Copestake, 1989).

The middle Volgian Parvicingula haeckeli Zone is correlated as closely as possible with the Parvicingula papulata Zone and belong to the Dorsoplanites panderi Zone which can be correlated with the Evolutinella emeljanzevi-Trachammina septentrionalis or Saracenaria pravoslavlevi foraminiferal Zone (Kozlova, 1995) in Pechora Basin and Lenticulina biexcavata Zone (Ljurov, 1995) in Sysola hydrocarbon Basin and Parhabdolithus embergeri nannoplankton Zone in Middle Volga hydrocarbon Basin. We can trace this Zone in Southern England and North France.

The upper Volgian-lower Berriassian Parvicingula blowi Zone probably corresponds to the Pseudocrolanium planocephala Assemblage established by Kozlova (1995) for Pechora Basin.
The upper Berriassian-lower Valanginian Parvicingula khabakovi - Williriedellum salumicum Zone is widespread in Siberian and Russian platforms within Bojarkia mesezhnikowi Zone. Owing to numerous Parvicingula boesii it is possible to compare this Zone with Tethyan ones.
The Aptian-Albian Crolanium cuneatum Zone and Cenomanian Pseudodictyomitra pseudomacrocephala Zone also can be correlated with Tethyan Zones.

The Turonian Spongotripus aculeatus - Dictyomitra pyramidalis Zone and Coniacian Archaeospongoprunum bipartitum - A. triplum Zone probably correspond to Alievium superbum Zone (Pessagno, 1976) of the Pacific scale.
The Santonian Euchitonia santonica Zone is characteristic Boreal Zone widespread both in Siberian, Russian platforms and in Pre-Caucasus. Campanian Prunobrachium articulatum Zone (Lipman, 1952) and Spongoprunum angustum Zone (Amon & De Wever, 1994) have not analogues in the Tethyan scales.

The direct correlation of Peri-Tethyan radiolarian zonation with oceanic ones and Tetyan is very difficult owing to provincialism.