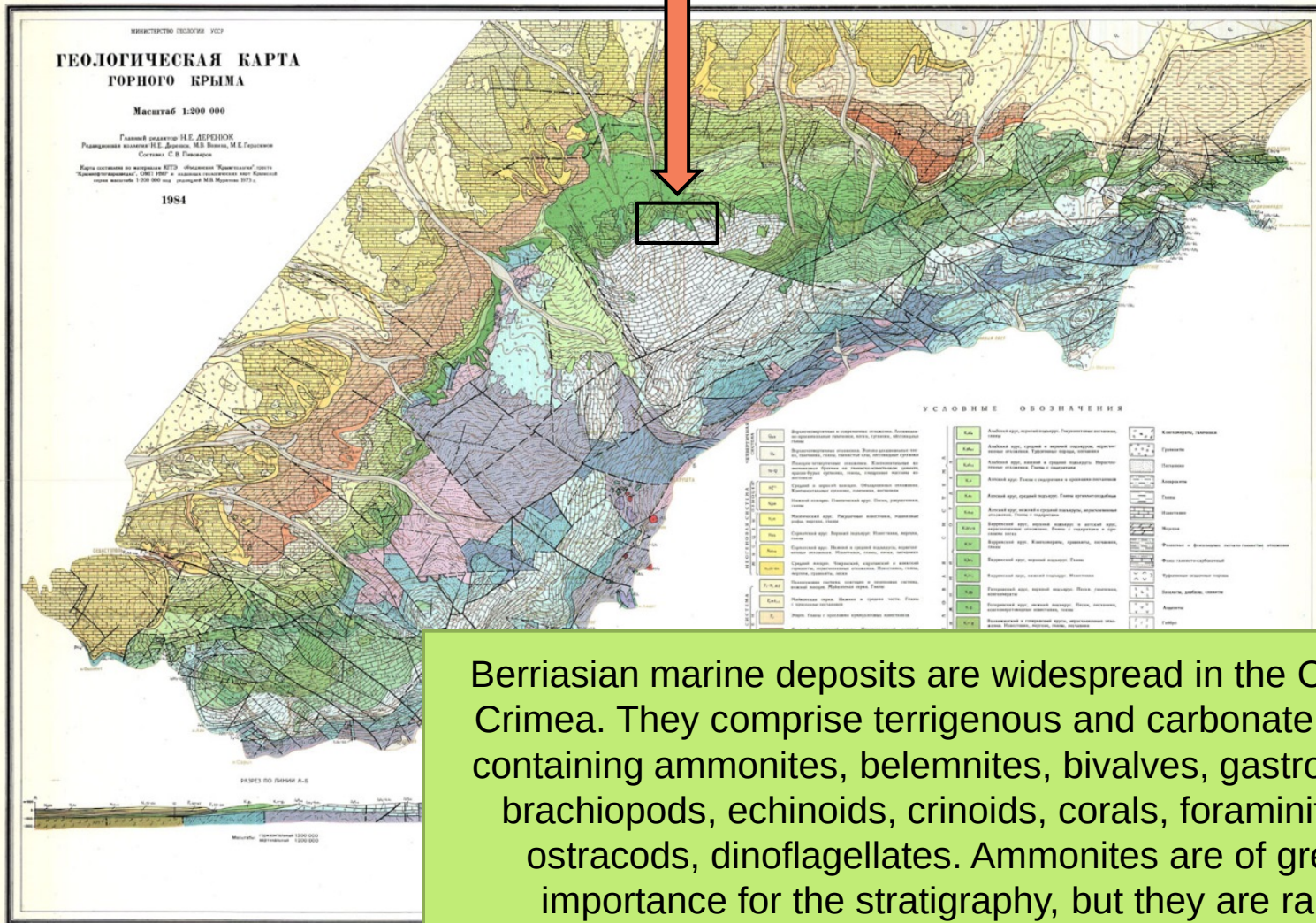


Berriasian of the Central Crimea: biostratigraphy

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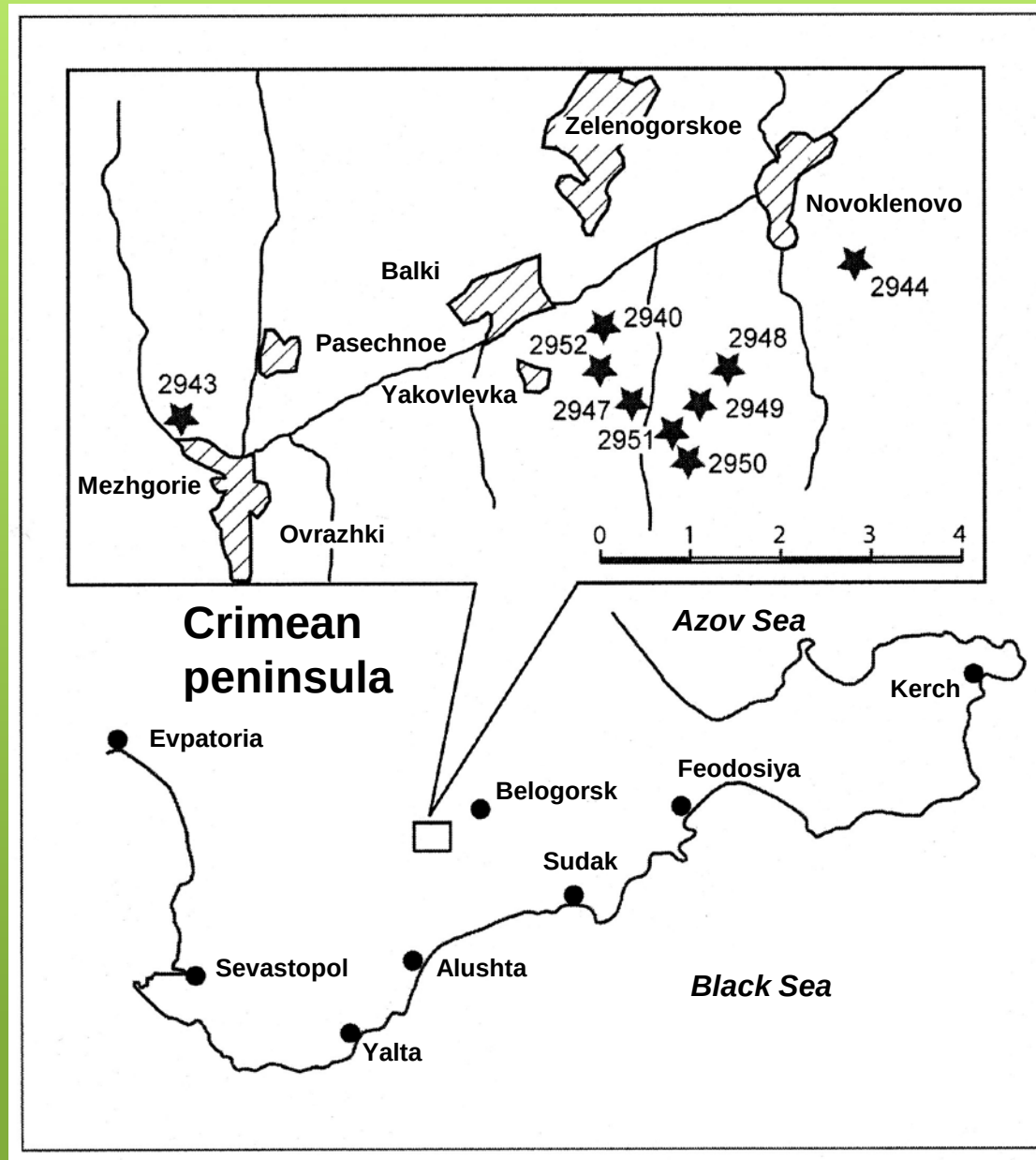
Geological map of the Mountainous Crimea and the area of the field works



Berriasian marine deposits are widespread in the Central Crimea. They comprise terrigenous and carbonate rocks containing ammonites, belemnites, bivalves, gastropods, brachiopods, echinoids, crinoids, corals, foraminifers, ostracods, dinoflagellates. Ammonites are of great importance for the stratigraphy, but they are rare in carbonate deposits.

All the authors took part in sampling and section investigation: E.Yu. Baraboshkin, V.K. Piskunov and E.S. Platonov conducted sedimentological studies, A.Yu. Guzhikov, A.G. Manikin and M.I. Bagaeva collected and analyzed paleomagnetic data, V.V. Arkadiev and T.N. Bogdanova identified and described ammonites, T.N. Bogdanova – bivalves, A.A. Fedorova – foraminifers, Yu.N. Savelieva – ostracods, O.V. Shurekova – dinoflagellates.

Location of studied berriasian sections in Central Crimea

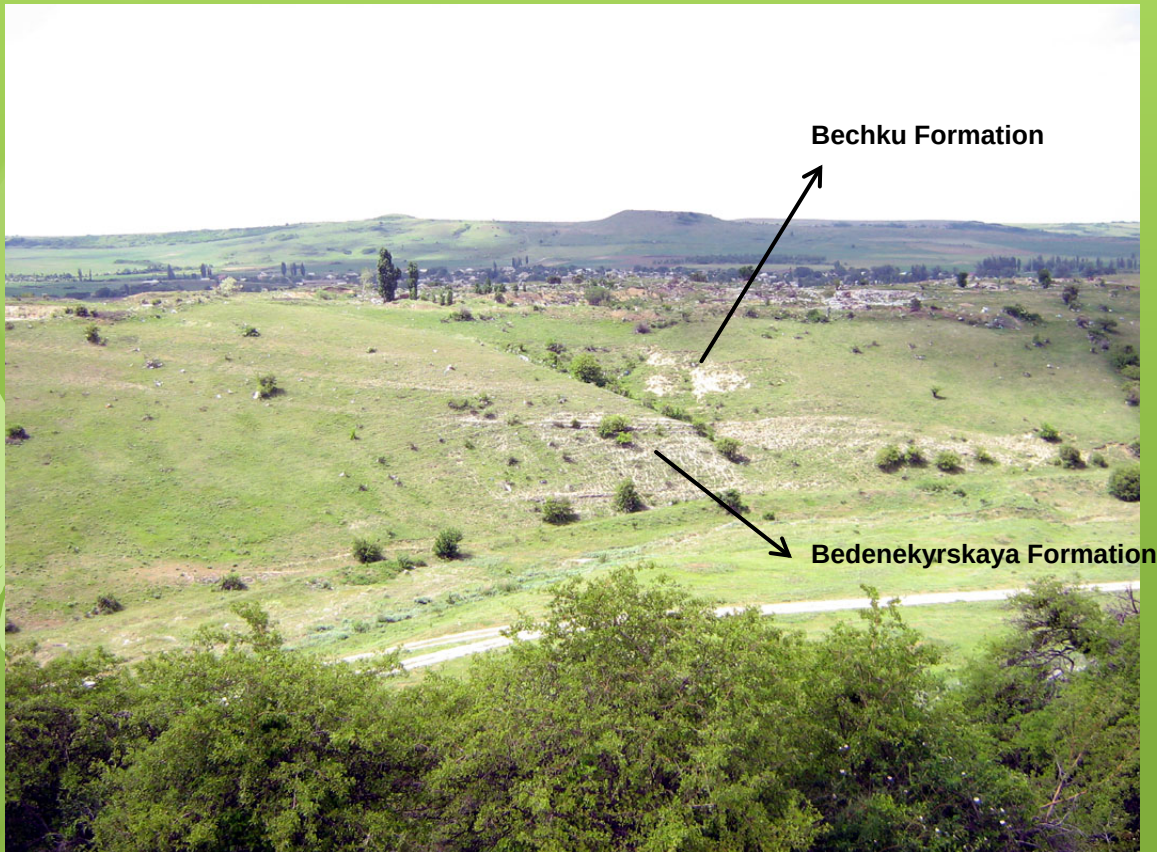




Bedenekyrskaya Formation
(limestone) outcrop in Enysarayi
Ravine.
Berriasian, Occitanica zone.



Contact of Bedenekyrskaya Formation
(limestone) with Bechku Formation (clay,
sandstone) in Enysarayi Ravine.



Sandstone in the basis of
Bechku Formation

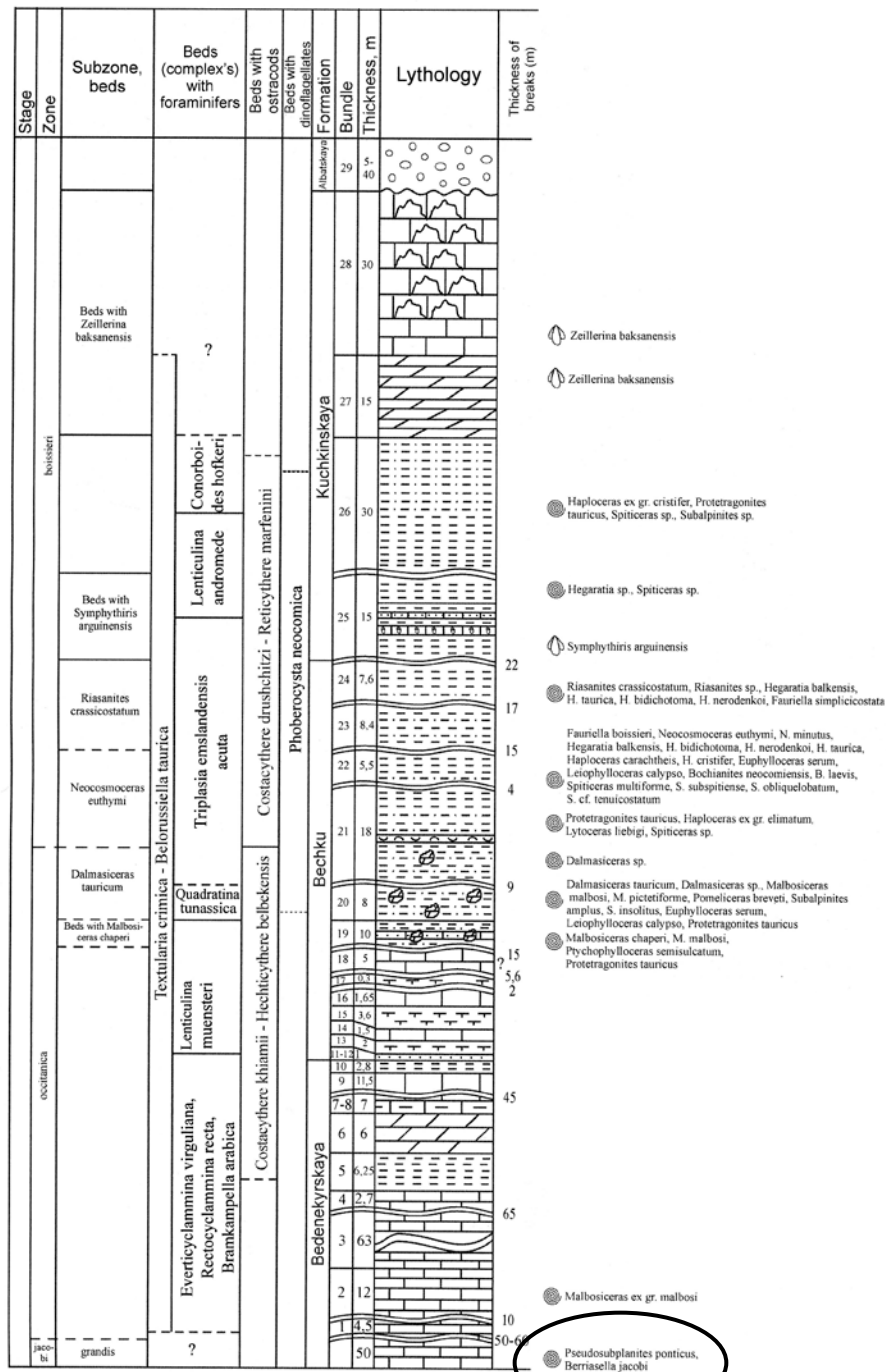
Bechku Formation outcrops near Balki village (clay). Boissieri Zone, Neocosmoceras euthymi subzone.





Kuchkinskaya Formation, coral-algal bioherms. Mezghorie village, Upper Berriasian.





Summary section of Berriasian deposits in Central Crimea

As a result of the study, a new biostratigraphical scheme of the Berriasian deposits of the Central Crimea is proposed (Arkadiev et al., in press). This summary section includes more than 10 Individual outcrops. Lower part of this section – carbonate Bedenekyrskaya Formation. In the basis of the section T.N. Bogdanova has found ammonites *Pseudosubplanites ponticus* and *Berriasella jacobi*.



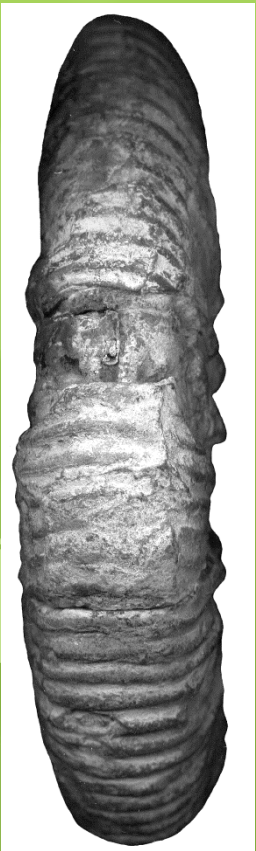
Berriasella jacobi Maz.



Malbosiceras ex gr. *malbosi* (Pictet) are found in the lower part of carbonate section, over the beds with *Pseudosubplanites ponticus* and *Berriasella jacobii*. For this reason we suppose this limestone's to be from Occitanica zone.

Malbosiceras chaperi (Pictet).

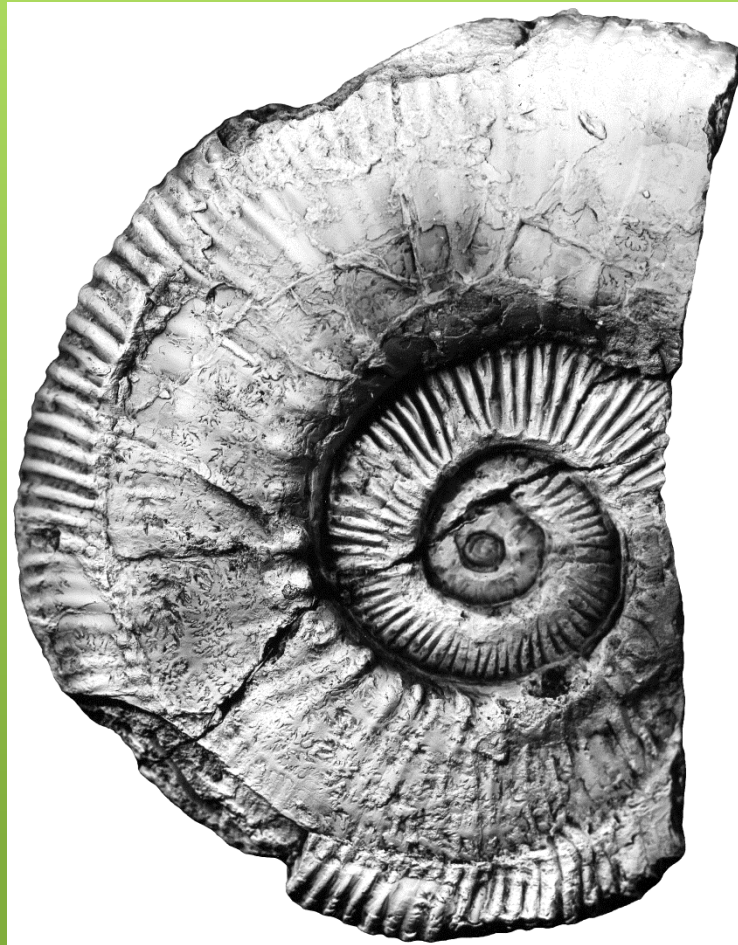
We distinguish the beds with *Malbosiceras chaperi*.



Pomeliceras breveti (Pomel) – one of the ammonites from Occitanica zone.



Fauriella boissieri (Pictet) – zonal species of Upper Berriasian



Subzone *Neocosmoceras euthymi*



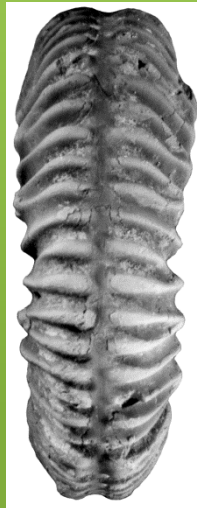
Neocosmoceras euthymi (Pictet)



Neocosmoceras minutus Arkadiev et Bogdanova



Hegaratia nerodenkoi (Bogdanova et Kvantaliani)



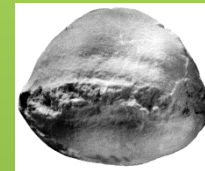
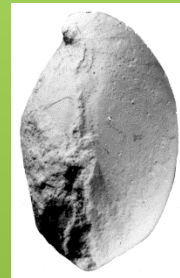
Hegaratia balkensis (Bogdanova et Kvantaliani)

In the upper part of the section ammonites were not found.
In this part of the section S.V. Lobacheva distinguished
beds with *Symphythyris arguinensis* and beds with
Zeillerina baksanensis (brachiopods).



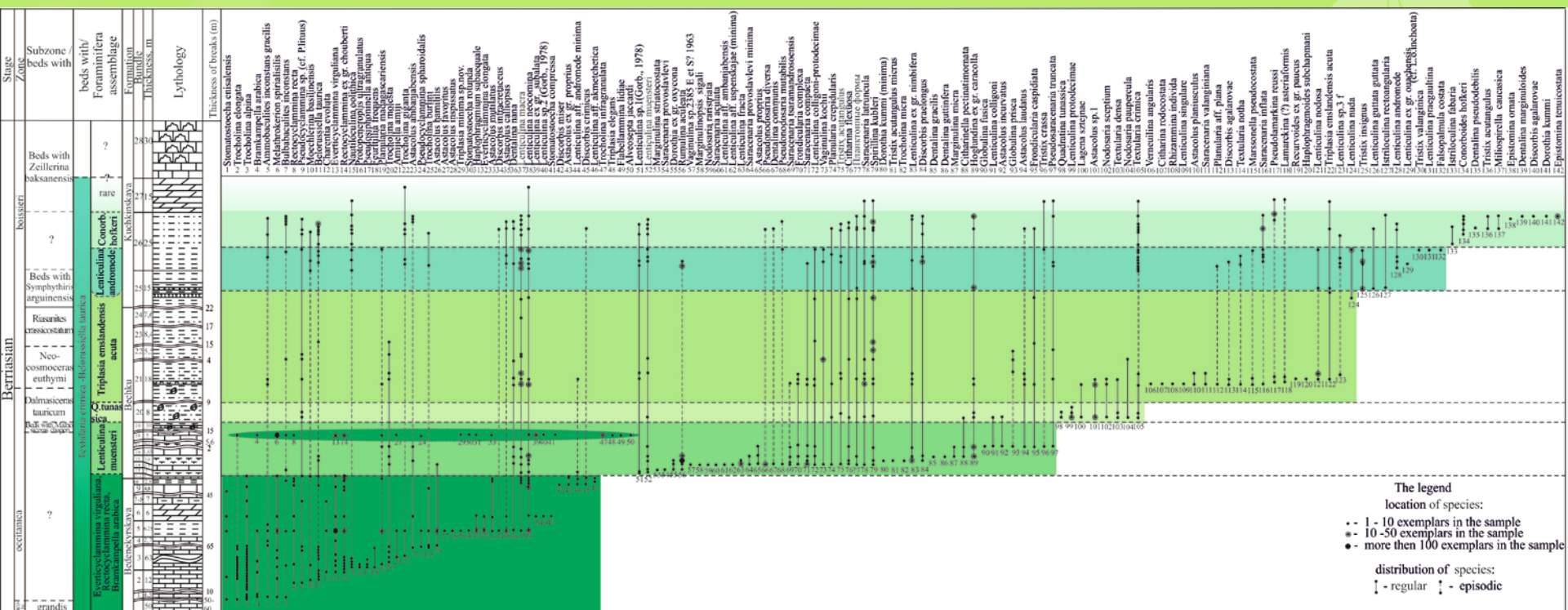
Symphythyris arguinensis (Mois.).
Upper Berriasian, village Balki.

Beds with *Zeillerina baksanensis*



Zeillerina baksanensis Smirnova.
Upper Berriasian, village Mezghorie

The beds with brachiopods are conditionally
Berriasian

[illegible]

More than 200 species of 63 genera have been found.

Agglutinated benthos dominates in the lower part of the section, while calcareous benthos forms are predominant in middle and upper parts.

Foraminifers are characteristic of the Beds with *Textularia crimica* - *Belorussiella taurica*, distributed all over the territory of the Mountain Crimea (Feodorova, 2004).

Six subsequent foraminifers assemblages have been distinguished.

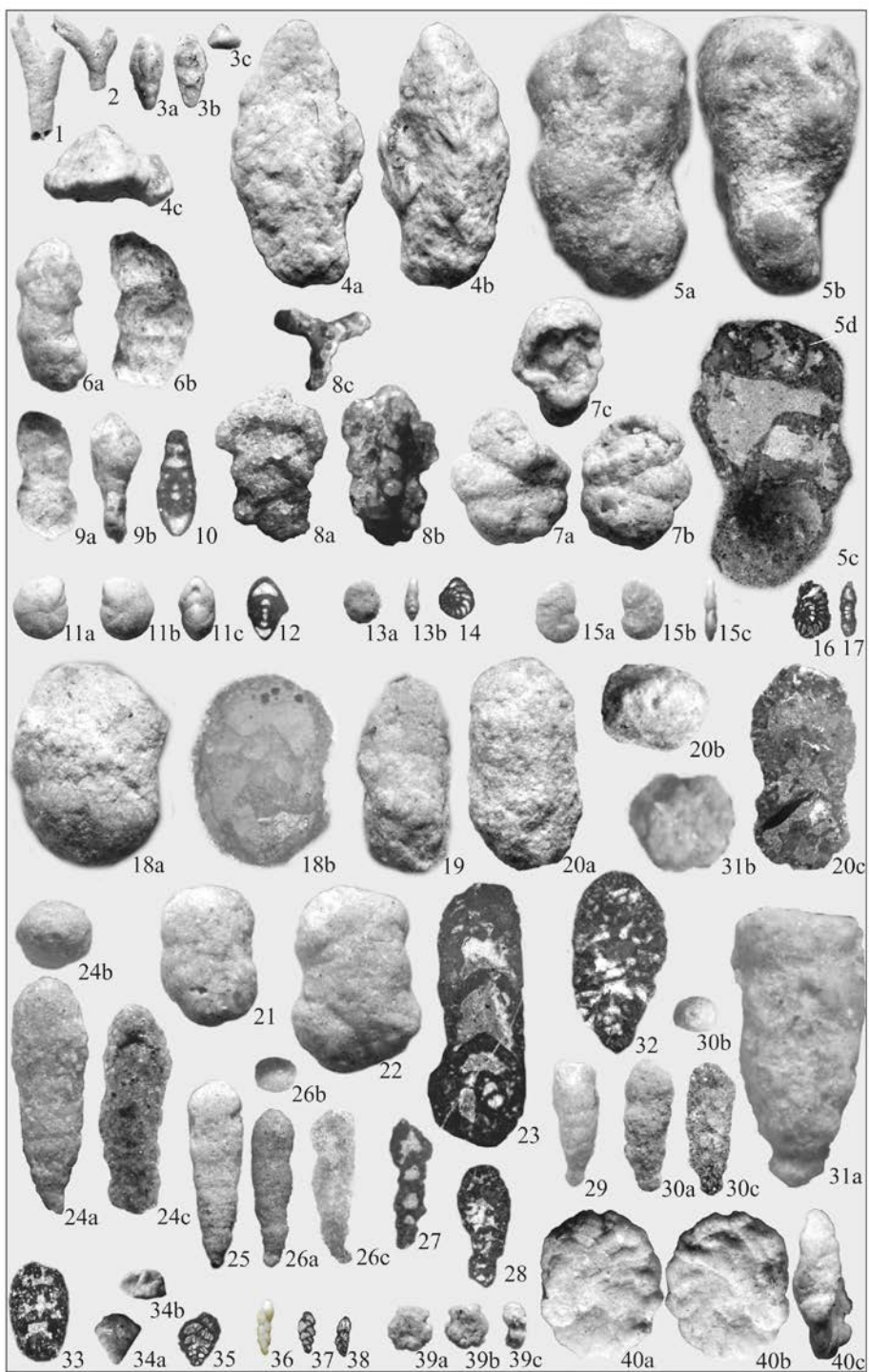


Plate 1 Foraminifera

The expansion X 20

Fig. 1,2 - *Rumulina aculeata* Wright

Fig. 3 - *Triplasia minima* sp.nov.

Fig. 4 - *Triplasia* cf. *elegans* (Mjatl)

Fig. 5,7 - *Haplophragmium subaequale* (Mjatl)

Fig. 6 - *Haplophragmium elongatum* Dain

Fig. 8 - *Triplasia emslandensis acuta* Brat. et Brand.

Fig. 9, 10 - *Charentia evoluta* Gorbachik.

Fig. 11, 12 - *Melathrokerion spirialis* Gorbachik

Fig. 13, 14 - *Stomatostoecha compressa* Gorbachik.

Fig. 15-17 - *Stomatostoecha enisalensis* Gorbachik.

Fig. 18-22 - *Everticyclammina virguliana* (Koechl.).

Fig. 23 - *Everticyclammina elongata* Gorbachik.

Fig. 24 - *Rectocyclammina arrabidensis* Remalho.

Fig. 25-27 - *Rectocyclammina chouberti* Hottinger

Fig. 28 - *Rectocyclammina* ex gr. *chouberti* Hottinger.

Fig. 29, 30 - *Rectocyclammina recta* Gorbachik.

Fig. 31 - *Trochamijiella* sp.

Fig. 32 - *Amijiella amiji* (Henson).

Fig. 33 - *Bramkampella arabica* Radmond.

Fig. 34, 35 - *Textularia crimica* (Gorbachik) .

Fig. 36-38 - *Belorussiella taurica* Gorbachik.

Fig. 39 - *Trochammina neocomiana* Mjatluk

Fig. 40 - *Alveosepta jaccardi* (Schrodt).

Plate 2 Foraminifera

The expansion: fig. 1-37 X 35, fig. 38-57 X 60

Fig. 1 - *Lenticulina muensteri* (Roemer).; Fig. 2 - *Lenticulina andromede* Espitalie et Sigal. ; Fig. 3 - *Lenticulina colligoni* Espitalie et Sigal. ; Fig. 4 - *Lenticulina ongkodes* Espitalie et Sigal. ; Fig. 5 - *Lenticulina aquilonica* Mjatluk. ; Fig. 6 - *Lenticulina* aff. *uspenskajae* K.Kuznetsova (var. minima). ; Fig. 7 - *Lenticulina bifurcula* Bartenstein et Brand.

Fig. 8 - 1-*Lenticulina macra* Gorbatchik. ; Fig. 9 - *Lenticulina* ex gr. *nimbifera* Espitalie et Sigal. ; Fig. 10 - *Lenticulina* ex gr. *nodosa* (Reuss); Fig. 11 - *Lenticulina fracta* Espitalie et Sigal.; Fig. 12 - *Lenticulina neocomina* Romanova.; Fig. 13 - *Lenticulina* ex gr. *guttata* (ten Dam); Fig. 14 - *Lenticulina* ex gr. *subalata* Reuss.; Fig. 15 - *Lenticulina ambanjabensis* (Espitalie et Sigal).; Fig. 16 - *Lenticulina ambanjabensis* (Espitalie et Sigal) ; Fig. 17 - *Lenticulina* ex gr. *neocomina* Romanova.; Fig. 18 - *Lenticulina* sp. (L. sp.1 Gorbatchik, 1978).; Fig. 19 - *Lenticulina* cf. *eichenbergi* Bartenstein et Brand. ; Fig. 20 - *Lenticulina eichenbergi* Bartenstein et Brand.

Fig. 21 - *Astacolus* aff. *proprius* K.Kuznetsova.; Fig. 22 - *Astacolus mutilatus* Espitalie et Sigal.; Fig. 23 - *Astacolus proprius* K.Kuznetsova. Fig. 24 - *Astacolus folium* (Wisn.).; Fig. 25 - *Saracenaria latruncula* (Chalilov). Fig. 26 - *Saracenaria* ex gr. *tsaramandrosoens* Espitalie et Sigal.; Fig. 27 - *Saracenaria aculata* Espitalie et Sigal.; Fig. 28 - *Saracenaria* cf. *inflata* Pathy; Fig. 29 - *Saracenaria compacta* Espitalie et Sigal.; Fig. 30 - *Pseudosaracenaria truncata* Pathy.; Fig. 31 - *Saracenaria tsaramandrosoensis* Espitalie et Sigal.; Fig. 32 - *Saracenaria provoslavlevi* Fursenko et Polenova. Fig. 33 - *Planularia* ex gr. *crepidularis* Roemer. ; Fig. 34 - *Planularia* sp. , Fig. 35,36- *Planularia madagascariensis* Espitalie et Sigal.

Fig. 37 - *Citharina flexuosa* (Bruckmann).

Fig. 38 - *Frondicularia* cf. *cuspidata* Pathy. ; Fig. 39 - *Frondicularia crimica* Schokhina.; Fig. 40 - *Frondicularia complexa* Pathy. ; Fig. 41 - *Frondicularia hastata* (Roemer); Fig. 42 - *Citharina* ex gr. *orbigny* (Marié). Fig. 43 - *Discorbis crimicus* Schokhina.

Fig. 44 - *Dentalina communis* Reuss. ; Fig. 45 - *Dentalina nana* Reuss.

Fig. 46 - *Trocholina burlini* Gorb. ; Fig. 47 - *Trocholina infragranulata* Noth.

Fig. 48 - *Epistomina caracolla* (Roemer). ;

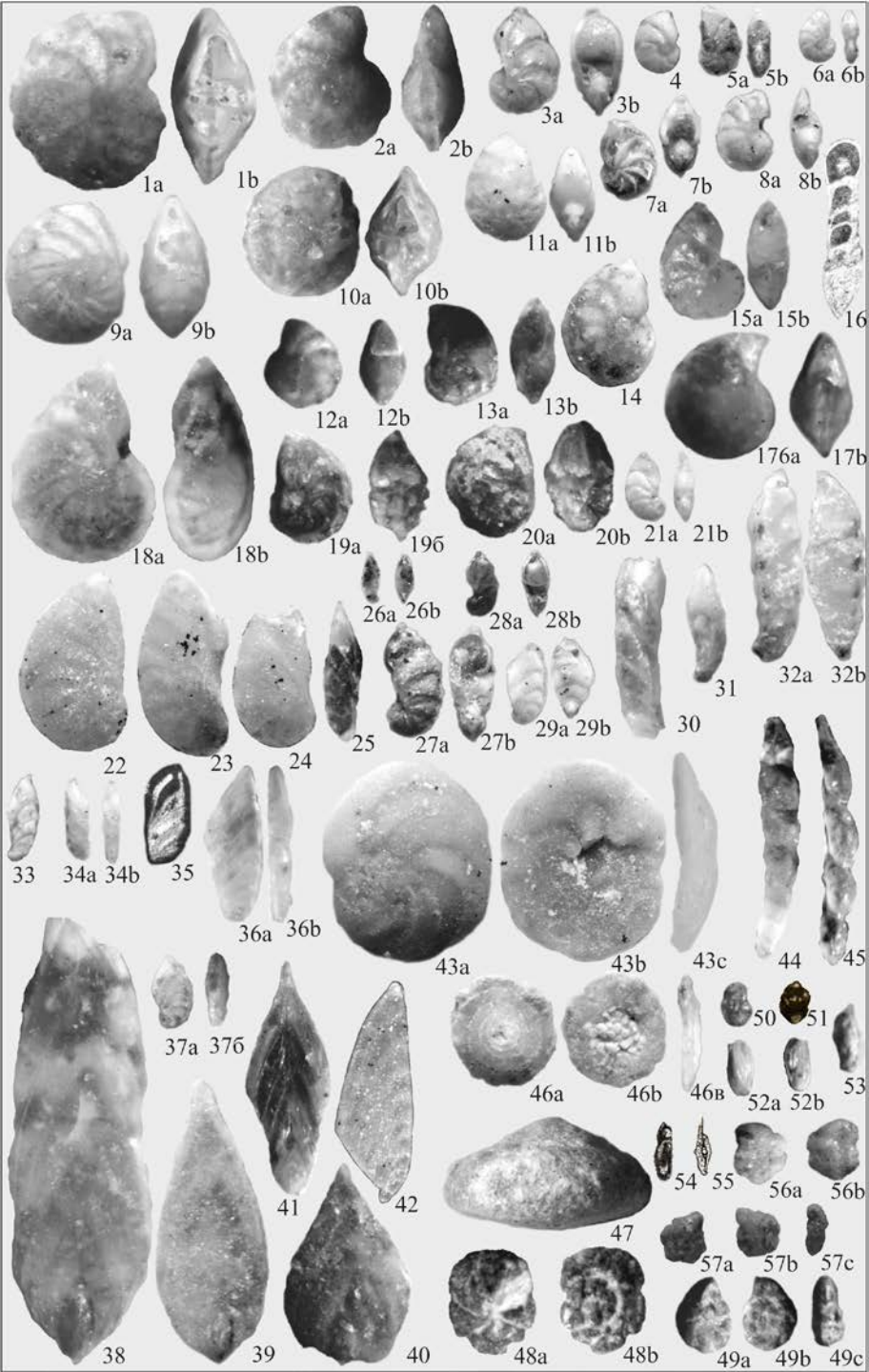
Fig. 49 - *Conorboides hofkeri* (Bart. et Brand).

Fig. 50, 51 - *Quinqueloculina mitchurini* Dain. ; Fig. 52 - *Sigmoilina* sp.

Fig. 53,54 - *Istriloculina fabaria* Mats. et Temirb. ;

Fig. 55 - *Istriloculina rectoangularia* Mats. et Temirb.

Fig. 56,57 - Planktonic foraminifers

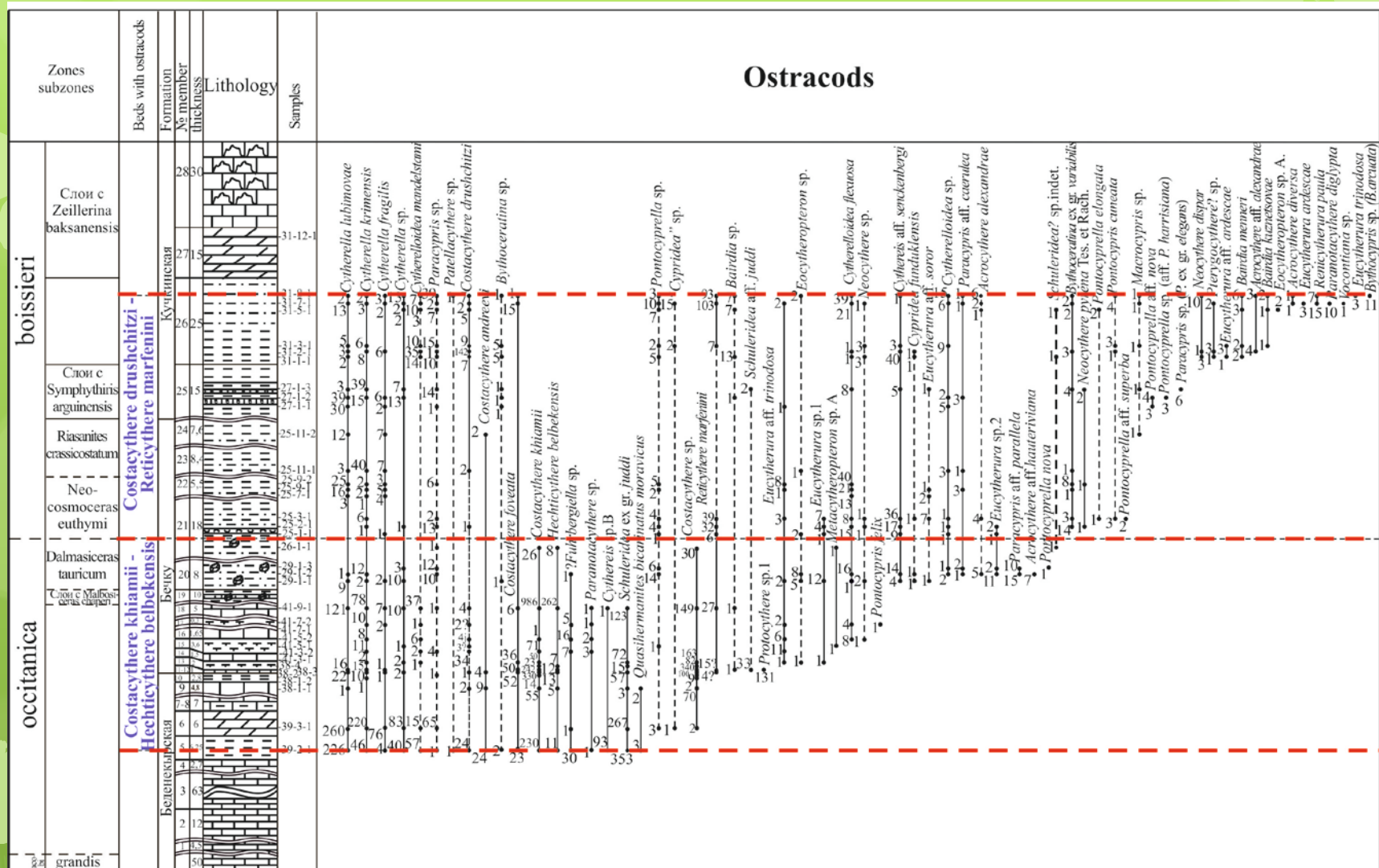


Foraminifera assemblages from the Berriasian sediments of the Tethys Ocean periphery

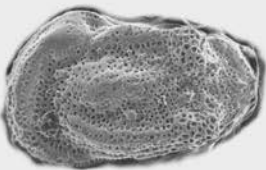
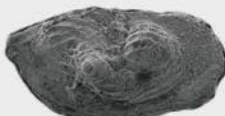
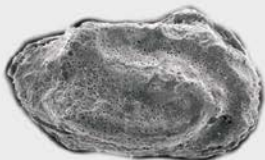
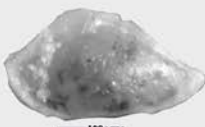
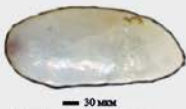
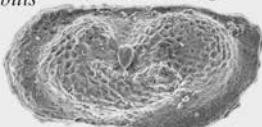
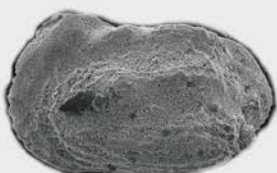
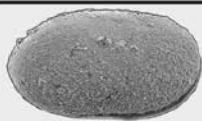
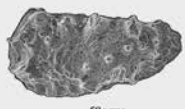
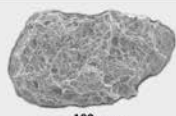
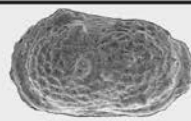
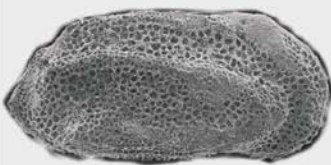
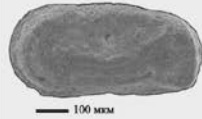
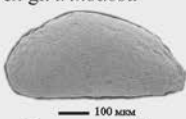
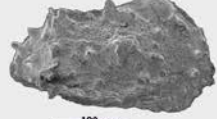
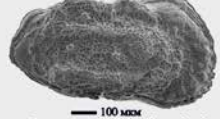
Standart a-zone	France		Italy	Madagascar	Syria	Caucasus		Caspian area	N.Caspian	Crimea		Central Crimea						
	Septfontaine, 1974; Pelissie, 1984 Busnardo et al., 1965; Gorbachik, 1978;Bassoullet, 1997		Septfontaine,1974; Azema et al., 1978	Espitalie et Sigal, 1963	Gorbachik, Kuznetzova, 1994	Pract- ical..., 1991	Socheva nova, 1990	Todria, 2005	Mjatluk, 1980; Practical..., 1991	Feodorova, 2004	Kuznetzova, Gorbachik, 1985; Gorbachik, Mokhomad,1999	Feodorova, 2004	Present report					
Reboulet et al., 2011	a-ZONE	f-zone/assemblage	f-zone/assemblage	f-assemblage	f-assemblage	f-zone/assemblage		a-zone	f-beds with	f-assemblage	a-zone	f-zone/beds	a-zone	f-zone/beds	subzone/ beds with	beds with/assemblage		
Subthurnannia boissieri	Th.otopeta	Pertransiensis	Neotrocholina valdensis	zone "D"		busnardoii, L. eulterata нет данных		Survives spasskensis		R.excellens, Lenticulina lideri	?	K.rotunda	Lenticulina busnardoii	Thurnm. ottopeta	?	Beds with Zeillerina baksanensis	?	
	Thurmanniceras alpillensis	Callisto	Neotrocholina valdensis	Flanbellamina patula, Astacolus microdictyotos, Lenticulina haesitans, Trochammina neocomiana, Lenticulina nimbifera, L. bifurella, L. saxonica, L. ambanjabensis, L. dineontos, L. tsaramandrosensis, L. andromede, Marginulinopsis embaensis, Marginulina gracilissima, M. pyramidalis, Vaginalina intumescentis var. eulter, V. sparsicostata, V. rudocostata, V. siliquaeformis, Nodosaria marchariaensis, Citharina cristellarioides, C. transversalis, C. thorenensis, Lingulina praelonga, Ammobaculites cf. reophacoides, Haplophragmoides aff. pacalis, Frandicularia barbatula, F. tsaramandrosensis, F. hexareuata, F. majungaensis, Tristix explanata, Rectoglandulina brandi, Astacolus mutilatus, Saracenaria compacta		Haplophragma laplophragmoides, L. concavus, L. modesta		?		Recurvoides valanginicus, R. embensis, Astacolus ambanjabensis	Belorussiella taurica, Ammobaculites ex gr. inconstans, A. ex gr. agglutinans, A. sp., Nautiloculina oolithica, Quinloqueloculina mitchurini, Q. sp., Lenticulina cf. kugleri, Lenticulina sp.1	Fauriella boissieri	Triplasia emslandensis	Triplasia emslandensis	?	Conorboides hofkeri	?	
	B. picteti	Picteti	ед. фораминиферы										Conorboides hofkeri - Conorbina heteromorpha	Triplasia emslandensis	Fauriella boissieri		Lenticulina andromede	
	Malbosciceras paramimounum	Boissieri	Paramimounum	Marssonella trochus										Conorboides hofkeri - Conorbina heteromorpha	Triplasia emslandensis		Triplasia emslandensis acuta	
Subthurnannia oceitania	Dalmasiceras dalmasi	Dalmasi	not found						Riasantes rjasensis	Ammobaculites granulum, Lenticulina andromede, L. dzharmyschensis		Dalmasiceras dalmasi - Euthymiceras euthymi						
	Berriaseella privasensis	Privasensis																
	Subthurnannia subalpina	Subalpina	Lenticulina eichenbergi															
			Lenticulina eichenbergi, L. gr. cultrata, L. nodosa, L. aff. muensteri, Patellina cf. suberectacea, Marssonella cf. oxycona, Spirillina aff. minima, Glomospira															
Berriaseella jacobii		Grandis	Rhizammina indiviza, Lenticulina praegaultina, L. aff. nodosa, L. polygonata, L. macra, Astacolus incurvatus, Vaginalina recta, Frandicularia cf. hastata, Dentalina nana, Globospirillina															
		Jacobi	neocomina, Glomospira gaultina, Spirillina minima, S. kubleri															
			"Conspicospirillina" basileensis, Protopenneroplus trochilangulata, Nautiloculina ovalitica, Pseudocyclammina titmus, Evertecyclammina virgulianna, Fertililla frequens, Tristix explanata															
			Protopenneroplus trochilangulata, Pseudocyclammina titmus, Evertecyclammina virgulianna, Fertililla frequens, Tristix explanata															
Globuligerina gulekensis																		
Cconorboides hofkeri - Conorbina heteromorpha																		
Buccicrenata italica																		
Saracenaria latruncula																		
Bramkampella cf. arabica, Choffatella ex gr. pyrenaica, Everticyclammina cf. salevensis, Pseudotextulariella cf. salevensis, "Hamaouina cf. caucasica", Trocholina ex gr. alpina, T. cf. cherchia, Protopenneroplus cf. trochilangulata, Nautiloculina? sp. Tamasia cf. evoluta																		
Evertecyclammina cf. virgulianna, Rectocyclammina cf. elongata, Pseudocyclammina cf. titmus, Rectocyclammina cf. choffati, Nautiloculina? sp. Tamasia cf. evoluta																		
Pseudosubplanites ponticus - P. euxinus																		
Protopenneroplus ultragranulatus - Sifoninella antiqua																		
Rectocyclammina cf. virgulianna																		
Pseudosubplanites grandis - Berriaseella jacobii																		
Protopenneroplus ultragranulatus - Sifoninella antiqua																		
Grandis																		
?																		

Identified species are known from the Tithonian – Valanginian of Crimea, Caucasus, Caspian area, Syria, France, Italy, Madagascar. Assemblage with *Evertecyclammina virgulianna*, *Rectocyclammina recta*, *Biamkampella arabica* from the lower part of the studied Berriasian section of the Central Crimea is most comparable with coeval assemblages from Syria, North Caspian, Caucasus, France and Italy. Assemblages from the middle and upper parts of the section are similar to those of the Madagascarian “zone D”. Comparison of foraminiferal assemblages from Central Crimea with the coeval ones from France is problematical due to sparse foraminifera occurrence in the stratotype area.

The distribution of Ostracods in the Central Crimea



Beds with ostracods were established on the base of ostracod systematic and quantitative composition analysis.
 Bed names were given according to the abundance and co-occurrence of species.

substage	Beds with ostracods	the index - species	ostracod assemblage							
boissieri	Costacythere drushchitzi - Reticythere marfenini	 <i>Costacythere drushchitzi</i>	 100 microm <i>Cytherella lubimovae</i>	 100 microm <i>Cytherella krimensis</i>	 30 microm <i>Pontocyprrella nova</i>	 100 microm <i>Bythoceratina ex gr. variabilis</i>	 100 microm <i>Bythoceratina sp.</i>			
		 <i>Reticythere marfenini</i>	 100 microm <i>Reticythere marfenini</i>	 100 microm <i>Bairdia sp.</i>	 30 microm <i>Pontocyprrella sp.</i>	 30 microm <i>Paracypris sp.</i>	 100 microm <i>Patallacythere sp.</i>			
occitanica	Costacythere khiamii - Hechtythere belbekensis	 <i>Costacythere khiamii</i>	 100 microm <i>Cytherella krimensis</i>	 50 microm <i>Eucytherura ex gr. trinodosa</i>	 100 microm <i>Eucytherura sp.</i>	 50 microm <i>Eucytherura sp.</i>	 100 microm <i>Paranotacythere sp.</i>	 50 microm <i>?Fuhrbergiella sp.</i>		
		 <i>Hechtythere belbekensis</i>	 100 microm <i>Cytherelloidea flexuosa</i>	 100 microm <i>Paracypris felix</i>	 50 microm <i>Eocytheropteron sp.</i>	 100 microm <i>Costacythere andreevi</i>	 100 microm <i>Cythereis sp.</i>	 100 microm <i>Cytherelloidea mandelstami</i>	 100 microm <i>Costacythere drushchitzi</i>	 100 microm <i>Costacythere khiamii</i>

There was found abundant ostracod assemblage.

The studied ostracods belong to 16 families, total 85 species of 34 genera were determined.

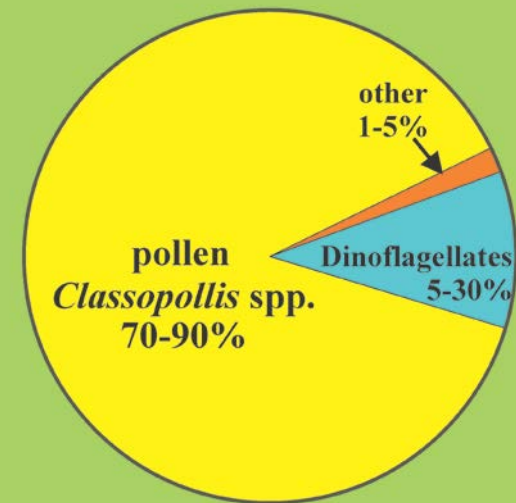
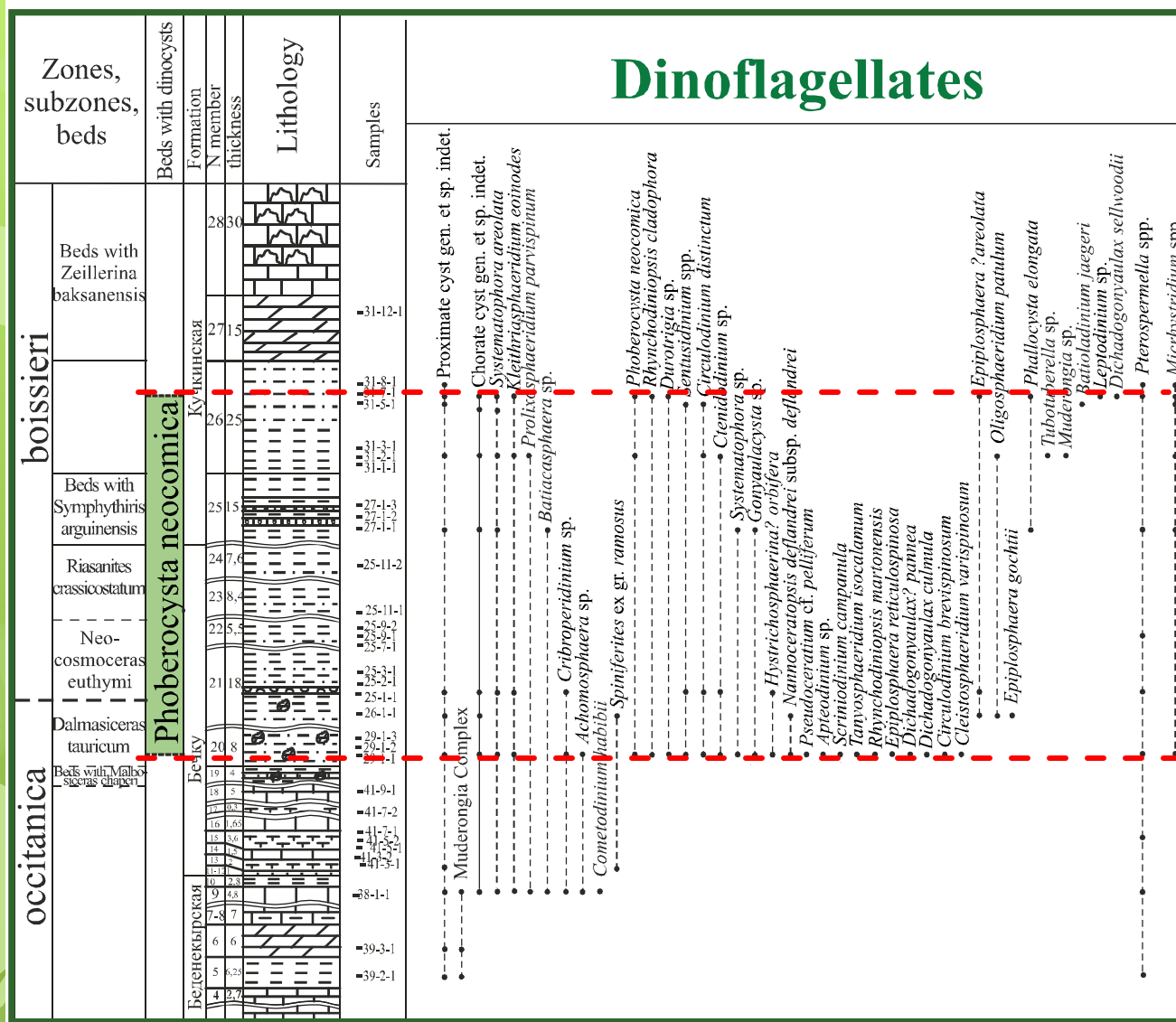
45 species of 24 genera were found in the lower part of section (the part of the occitanica ammonite zone).

71 species of 28 genera were found in the upper part of section (the part of the boissieri ammonite zone).

Scheme of comparison between beds with ostracods in the Central Crimea and beds from the South-Western Crimea, North Caucasus, and Central Asia.

stage	Standart a-zone	Mountain Crimea (Аркадьев и др., 2008, 2010, 2011)		Central Asia (Андреев, 1986)	North Caucasus (Колпенская и др., 2000)	Central Crimea (Тесакова и др., 2010)	SW Crimea (Berriasian., 2012)	Central Crimea (Berriasian., 2012)	Central Crimea present report
		a-zone		ostracods zones	beds with ostracods	beds with ostracods	beds with ostracods	beds with ostracods	beds with ostracods
BERRIASIAN	Otopeta	val.	Otopeta	marine ostracods aren't found					
	Alpillensis	?							
	Boissieri	Boissieri		Quasiherma- nites sp - Cytherel- loidea sp.		Hechticythere kavkasensis	Costacythere drushchitzi	Costacythere drushchitzi - Reticythere marfenini	Costacythere drushchitzi - Reticythere marfenini
						Costacythere drushchitzi			
						Schuleridea aff. juddi, Neocythere pyrena, Clitocythereidea paralubrica			
	Occitanica	Occitanica		Protocythere praetriplicata - Neocythere dispar - Costacythere granifera mangischla- kensis	Protocythere praetriplicata	Costacythere mesezhnikov	Costacythere drushchitzi	Costacythere khiamii - Hechticythere belbekensis	Costacythere khiamii - Hechticythere belbekensis
	Jacobi	Jacobi		Klentnicella sp.		P. ponticus	Costacythere foveata Valendocythere khiamii		

The studied ostracod species are known, mostly, from the Berriasian –Hauterivian of the Crimea, North Caucasus, Central Asia, England, France, Germany, Poland. Bed assemblages are most similar to those from the Berriasian of North Caucasus (Uruk River). But correct correlation was not success. Lower beds were found by authors in South-West Crimea (subsone tauricum).



Pollen *Classopollis* dominates over other palynomorphs absolutely. Percentage of dinoflagellates reaches 30%.

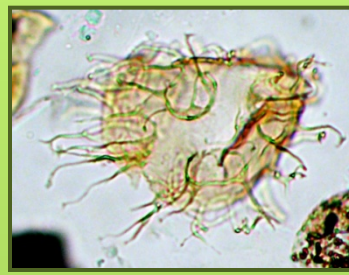
The taxonomical diversity of dinocysts is relatively high despite on rare occurrence. Beds with **Phoberocysta neocomica** were established on the base of dinocysts' distribution analysis.



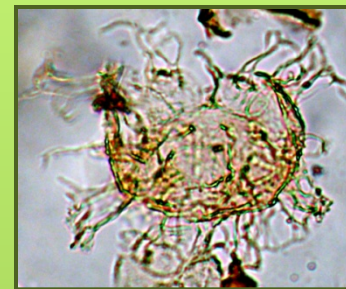
Oligosphaeridium patulum



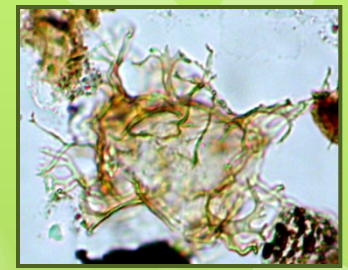
Kleithriasphaeridium eoinodes



Systematophora areolata



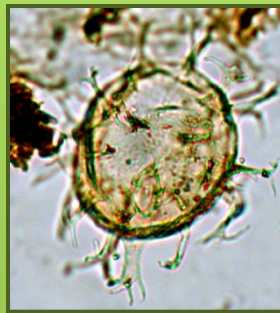
Hystrichosphaerina? orbifera



Systematophora daveyi



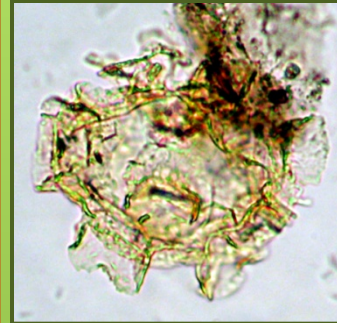
Cometodinium habibii



Achomosphaera neptunii



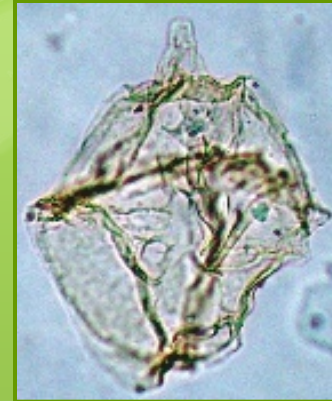
Phoberocysta neocomica



Amphorula metaelliptica



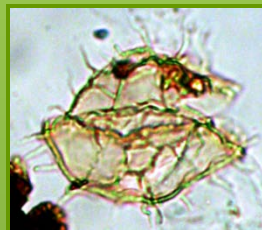
Tanyosphaeridium isocalamum



Scriniodinium campanulum



Dichadogonyaulax bensonii



Dichadogonyaulax? pannea



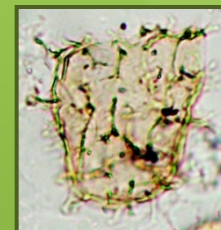
Epiplosphaera? areolata



Valensiella pygmaea



Ctenidodinium elegantulum



Amphorula expirata

50 μ



The dinocyst's assemblage includes about 30 species. Chorate dinocysts with long or short processes predominate over proximate cysts. It is typical for a warm-water basin.

Standart a-zone		Mountain Crimea		France		Central Crimea		Russian Plate		N-W Europe		East Canada	
		(Аркадьев 2006)		(Monteil, 1992b)		(present report)		(Митта, 2007)	(Iosifova, 1996)	(Fisher and Riley, 1980)		(Williams, 1975)	
		a-zone		a-zone	Dino- zone	a-zone	Beds	a-zone	Beds	a-zone	Dino- zone	b-zone	Dino- zone
Berriasian	Otopeta	valang. Otopeta		valang. Otopeta		valang. Otopeta		valang. ?		valang. Paratollia		valang. Keyser- lingi	
	Boissieri	Boissieri		Boissieri		Boissieri		Tzikwinianus		Albidum	Phobero- cysta neocomica		
										Stenom.		Volgensis	
										Icenii			Phobero- cysta neocomica
	Occita- nica	Occita- nica		Occita- nica	Dichado- gonyaula bensonii	Occita- nica	Phobero- cysta neocomica	Rjasanensis	Riazanian assem- blage	Kochi			
	Jacobi	Jacobi								Runctoni	Okensis		
						Jacobi		Praetollia, Cheta- ites milcovensis		Portland			
Tithonian								Volga		Portland		Tithonian	

Dynocyst's assemblage with *Phoberocysta neocomica* is compared with assemblages of Berriasian dinocysts zones and beds of France, Russian Plate, and Berriasian – Valanginian of North-West Europe and East Canada. In addition, beds with *Phoberocysta neocomica* have been distinguished by authors in South-West Crimea and East Crimea.

Conclusions:

1. All standard zones have been distinguished on the base of ammonites— Jacobi, Occitanica and Boissieri.
2. 6 foraminifer complexes have been distinguished.
3. Two beds with ostracods have been distinguished: *Costacythere khiamii* – *Hechtythere belbekensis* and *Costacythere drushchitzi* – *Reticythere marfenini*
4. Beds with dinoflagellates have been distinguished - *Phoberocysta neocomica*

Thank you for your attention!

