Tarkhanian and Chokrakian of the Eastern Paratethys: state of knowledge and correlation

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The stratigraphic extent of the Tarkhanian and Chokrakian varies widely in the opinion of different scientists. We include all "*spirialis*"-clays of the hypostratotype into the Tarkhanian and place the boundary at their top. This level of faunistic change coincides with the structural and facial reorganisation of the basin and can be traced all over its territory.

A series of sections extends from Crimea through Pre-Causasus to the West Georgian Dzhgali locality in the Megrelian Depression (Figs. 1, 2). Tarkhanian deposits are usually dominated by clay; sands and limestones, often with bioherms, and only subordinate clay characterise the Chokrakian. Karaganian deposits represent mostly sands and clays, sometimes with stromatolites. The thickness of Tarkhanian sediments varies from 120 m to 450 m (in depressions), that of Chokrakian reaches up to 700 m.

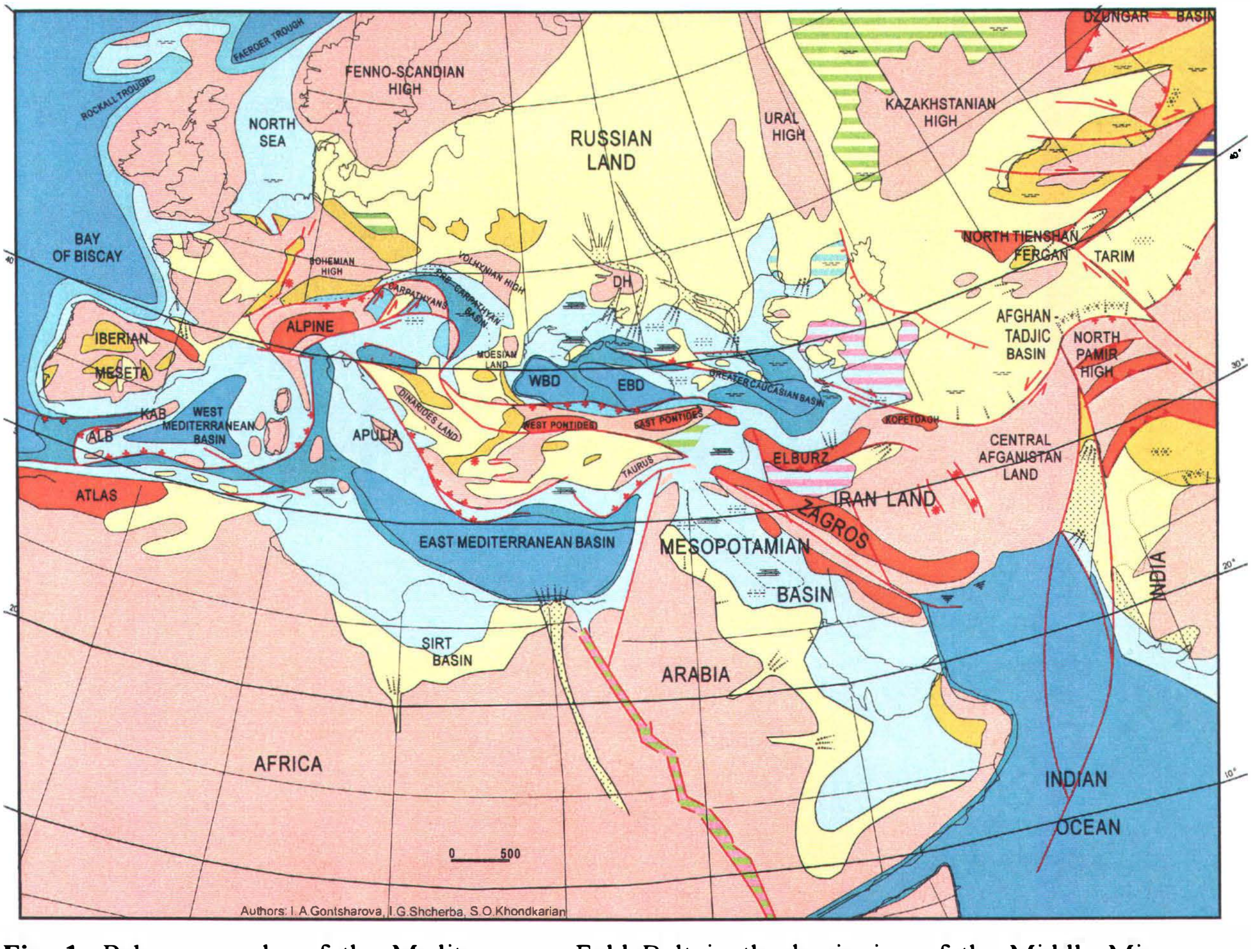

Fig. 1: Paleogeography of the Mediterranean Fold Belt in the beginning of the Middle Miocene (Chokrakian - Early Badenian - Langhian). Authors: GONCHAROVA, SHCHERBA, KHONDKARIAN.

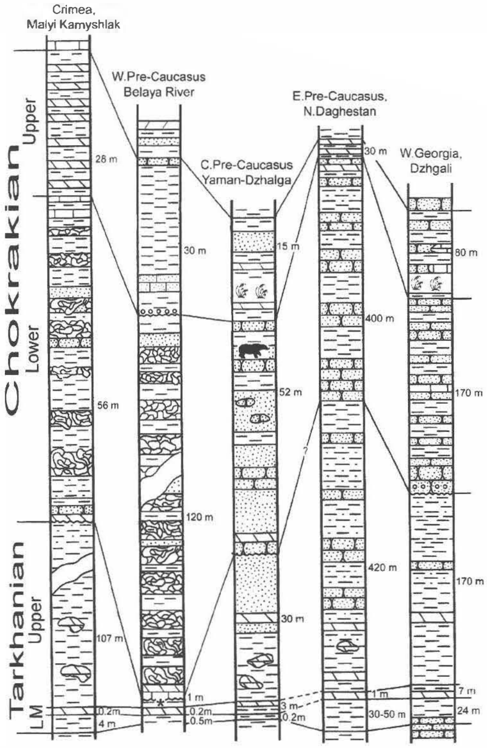

Fig. 2: Correlation of sections extending from Crimea through Pre-Caucasus, and also the West Georgian section at Dzhgali in the Megrelian Depression (modified after GONCHAROVA 1989).

Intra-basin subdivision is based on well known benthic foraminifera and molluscs. A benthic foraminiferan zonal scheme was developed by BOGDANOWICZ (1965, 1974) for the Tarkhanian and Chokrakian (Fig. 3). The zones largely coincide with data on molluscs (BOGDANOWICZ & GONCHAROVA 1976).

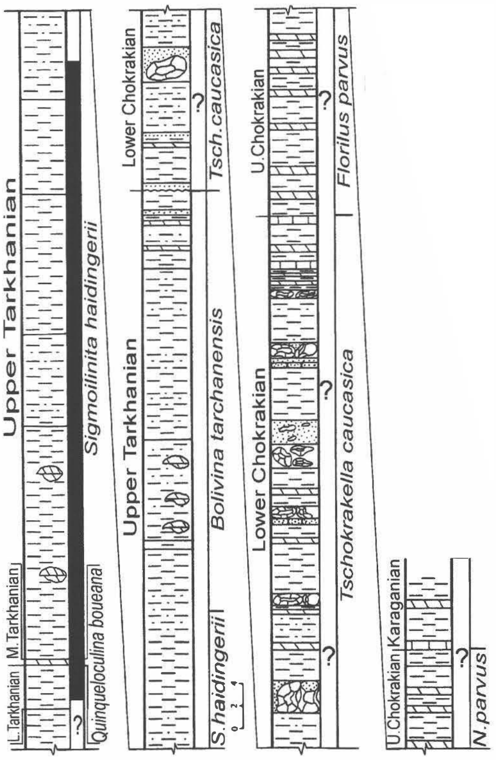

Fig. 3: Hypostratotype of Tarkhanian and Chokrakian Regional Stages (Crimea, Kerch Peninsula, Malyi Kamyshlak) after GONCHAROVA (1989), showing additionally benthic foram zones after BOGDANOWICZ (1965, 1974) and paleomagnetic data after PEVZNER (pers. comm.).

In the Early Tarkhanian a normal oxygen regime was restored and a marine fauna re-appeared. Few endemic brackish elements (*Rzehakia dubiosa* HOERNES = *R. socialis* RZEHAK, *Congeria nucleolus* RZEHAK, *Saccamina zuramakensis* BOGDANOWICZ), inherited from the

Kozakhurian, persisted locally into the lower Upper Tarkhanian. A similar persistence occurs in brackish facies of the Karpatian. The fauna reaches its climax in the Middle Tarkhanian and experiences impoverishment during the Late Tarkhanian. In the hypostratotype this starts abruptly at 11.5 m above the base and becomes more gradual upsection. ANANIASHVILI (1999) also reports an impoverishment of molluscs at the same level in Skelya section. The Early Chokrakian is marked by a distinct enrichment of the fauna, which, however, nearly disappeared in the Late Chokrakian. The Karaganian is characterised by a diversification of a fauna which is endemic to the Eastern Paratethys. The benthic foraminiferan zones are unfortunately based mainly on endemic species and cannot easily be correlated with the zones of the Central Paratethys.

Biostratigraphic data

Planktic foraminifera are low diverse in the Tarkhanian. The prevailing taxon is *Globigerina tarchanensis* SUBBOTINA & CHUTZ. The most recent and complete data are reported by TROFIMOVICH (in ANANIASHVILI 1999) from the Skela section. This is located at the eastern wing of the anticline where the hypostratotype (Fig. 4) crops out in the other wing.

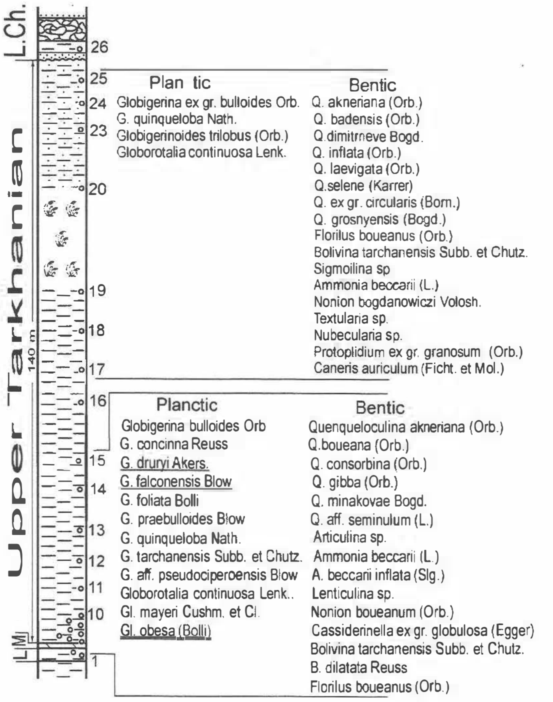

Fig. 4: Foraminifera identified by TROFIMOVICH (in ANANIASHVILI 1999) in Skela section.

In the lower part of the section (42 m thick, samples 2 – 15) 12 species are recorded, the upper part (72 m thick, samples 17 – 25) brought forth 4 species. No precise data on the individual samples are given and no correlation of the two assemblages with a biozonal scheme is presented by the author. The lower assemblage, however, includes 2 species which are characteristic for the Badenian and one species which was not found above the Karpatian till now (according to CICHA et al. 1998). IVANOVA (1999) and BARG & IVANOVA (2000), however, report *Globigerioides bisphaericus* and *Globoquadrina dehiscens* from the Middle and Upper Tarkhanian in bore-holes in the Alma Depression in Crimea (from deposits of 4 m and 0.6 – 4.5 m thickness). They attribute these deposits to the zone of *Globigerinatella insueta.* No planktic foraminifera are recorded in the Chokrakian.

Nannoplankton data of the Tarkhanian are contradictory in respect to biostratigraphic zonation ANDREYEVA-GRIGOROVICH & SAVYTSKAYA (2000) place the entire Tarkhanian into zone NN5, KONENKOVA & BOGDANOVICH (1994) put the NN4/NN5 boundary in the lower part of the Upper Tarkhanian 1.5 m above the marl and IVANOVA et al. (1998) and BARG &

IVANOVA (2000) 5 m above the marl. The Chokrakian deposits are poor in nannoplankton, however, BOGDANOVICH (in BARG 1993) identified still zone NN5 in the overlying Karaganian. In addition, the radiolarian horizon, above the Karaganian, can be correlated with the Welician.

Some interesting results are presented by the first studies of dinocysts in the Eastern Paratethys. In the lower Upper Tarkhanian ZAPOROZHETS (1999) identified *Tuberculodinium vancampoae*, index of the Lower Miocene Subzone VII b of DA COSTA & DOWNIE (1979), *Hystrichosphaeropsis obscura* and *Lingulodinium machaerophorus*. This assemblage can be correlated with the Karpatian and upper part of the Burdigalian, respectively (Tab. 4).

The diatoms *Coscinodiscus grunowii* PANTIC and *Coscinodiscus* (or rather *Cestodiscus* - RADIONOVA 1991) *stokesianus* GREW. from NE Bulgaria (TEMNIKOVA-TOPALOVA & KOZYRENKO 1982) indicate similarities to both the Karpatian *Raphidodiscus marylandicus* – zone and the Lower Badenian diatom assemblage. However, the Chokrakian content considered in this study is not clear. To my knowledge, from other Chokrakian deposits diatoms are known but not studied.

Pteropods (planktic gastropods) have never been specifically studied in the Eastern Paratethys. They were only identified incidentally by various authors (Table 1). Their taxonomic position or stratigraphic range have never been evaluated. The six identified species were assigned to the genus *Limacina*, however, without detailed taxonomic study. The only exception is the identification of *L. valvatina* and *L. andrussovi* by JANSSEN (1984), their record, however, is problematic: *L. valvatina* was sampled in the talus at Cape Tarkhan and originates from Tarkhanian – Chokrakian beds, *L. andrussovi* was found in gypsum bearing sandy limestones of Cape Kop-Kocheghen and belongs probably to Konkian or Karaganian.

	Eastern Paratethys						Central Paratethys			
	Tarkhanian			Chokrakian		Konkian	Karpatian	Badenian		
	L	M	U	L	U			Moravian	Welician	Kosovian
L. andrussovi andrussovi (Kittl)						+ (AJ)		?	+ (G)	
L. andrussovi tschokrakensis (Zh.)			+(Zh)							
L. konkensis (Zh.)						+ (LI)				
L. nucleata (Zh.)			+(LI)							
L. subtarchanensis (Zh.)		+(Zh)		+ (LI)						
L. tarchanensis (Kittl)	+(MN)	+(MN)	+(NT)	+ (Zh)		+ (AJ)	+ (G)	+ (G)		
L. valvatina (Reuss)	+ (AJ)							+ (BH)	+ (BH)	+ (BH)

Tab. 1: Distribution of pteropods (*Limacina*), found in the upper Lower - lower Middle Miocene of Eastern Paratethys [for the Central Paratethys, data for Austria, Poland and Hungary are after JANSSEN (1984, 1990), BOHN-HAVAS & ZORN (1995); for Romania after GHEORGIAN et al. (1966); Identfication by: JANSSEN (1984), BOHN-HAVAS & ZORN (1995), GHEORGIAN et al.(1966)], ILJINA in GONTSHAROVA (1989), NOSSOVSKY et al. (1976, 1984), ZHIZHCHENKO (1959). In the Eastern Paratethys, only the records are used which are properly located in the section (except *L. valvatina*).

Tarkhanian and Chokrakian bivalves are well studied (Table 2) and nearly all recorded species (92 of the Tarkhanian, 71 of the Chokrakian) have been revised. Both faunas are equally similar to the Karpatian and Badenian: 54% of the Tarkhanian and 52% of the Chokrakian fauna correspond with that of the Badenian; correspondence with the Karpatian fauna is 35% and 31%. All these values are lower than those between the Karpatian and Badenian (63%). For the Tarkhanian, Chokrakian and Badenian the data are based on GONCHAROVA (1989) and STUDENCKA et al. (1998). The preliminary list of Karpatian bivalves is based on CICHA et al. (1967) and PAPP et al. (1973), on studies of Cepreghy-Meznerics and personal studies of collections at the Hungarian Natural History Museum in Budapest and at the Institute of Palaeontology, University of Vienna. Because of the incomplete knowledge of Karpatian bivalves, these data are very preliminary. In particular, as our study of Badenian bivalves does not include clayey facies, which is, however, very important for the Karpatian. Nevertheless it is obvious that Tarkhanian and Chokrakian faunas are very similar to those of the Karpatian and Badenian. Unfortunately, bivalve data do not allow intrabasinal stratigraphic subdivision. Even pectinids, accurate biostratigraphic tools in the Central Paratethys, are of no help. Six pectinid species occur in the Tarkhanian and Chokrakian, two of which are endemic for the Eastern Paratethys. *L. corneus denudatus* occurs in the Lower, Middle and Upper Tarkhanian and is considered to be characteristic for the lower part of the *Flabellipecten besseri* zone (Lower Badenian) of Poland and Ukraina (STUDENCKA 1999). It is, however, also found in the Egerian of Hungary as well as in the Ottnangian (PAPP et al. 1973) and Karpatian (CICHA et al. 1967). More indicative is the Paratethyan endemic *Palliolium bittneri* (TOULA) in Sartaganian beds of Konka, which characterizes the upper subzone of *F. besseri* zone (Upper Badenian).

	number of species	species (%) in common to:	
		Karpatian	Badenian (343 spp.)
Tarkhanian	92	35	54
Chokrakian	71	31	52
Karpatian	187	—	63

Tab. 2: Bivalvian statistics.

According to ILJINA (1993), Tarkhanian benthic gastropods are, like bivalves, more similar to that of the Badenian than to the Karpatian ones. The Chokrakian gastropod associations are quite different due to changed basin connections and coincidence to Karpatian and Badenian gastropods is low.

The mammals of the upper Lower Chokrakian locality Belomechetka in the Western Pre-Caucasus (Table 3) attributed to Zone MN5 by GABUNIA (in MURATOV & NEVESSKAYA 1986) and VISLOBOKOVA (1990), to Zone MN6 by AGADZHANYAN (in MURATOV & NEVESSKAYA 1986), and to the upper MN5 – lower MN6 by LOPATIN (pers. comm.). The fauna needs, however, a taxonomic revision. Younger mammals (Tarkhanian or possibly Lower Chokrakian) of Kyzyl-Bulak (Transkaspa) are referred to MN5 by LOPATIN (pers. comm.), but need also to be revised.

According to AKHMETYEV (1993), the Tarkhanian represents one of the Neogene climatic optima dated into the latest Early Miocene. This is supported by thermophilous mollusc genera (*Pteria, Perna, Isognomon, Atrina, Limaria, Chama, Gibbula, Turritella, Calyptrea*), by a mesophilous subtropical flora, by the presence of sargassan algae, by lunulitiform bryozoans, termites, cockroaches, the thermophilous ant *Dolichoderus*, and a warm water ichthyofauna.

Belomechetka

(Chokrakian in Central Pre-Caucasus; MN5 after GABUNIA, 1986, VISLOBOKOVA pers.comm., MN5-MN6 after LOPATIN pers. comm., MN6 after AGADZANJAN 1986)

Shizogalerix sp.
Amphechinus sp.
Albanensia sp.
Mycrodyromys koenigswaldi De Bruijn
Protalactaga sp.
Cricetodon caucasicus (Argyr.)
C. meieni Freud.
Megacricetodon minor (Lart.)
Democricetodon gailladi (Schaub.)
Deperetomys sp.
Bizantinia sp.
Fahlbuschia sp.
Amphicyon caucasicus Gab.
Lapictis sp.
Pseudaelurus sp.
Percrocuta abessalomi Gab.
Gomphotherium sp.
Platybelodon danovi (Boriss.), *P. jamandzalgensis* Belj. and Gab.
Deinotherium sp.
Anchitherium sp.
Paranchitherium karpinski Borris.
Beliajevina caucasica (Boriss.)
Aceratherium sp.
Chilotherium sp.
Caucasotherium efremovi N. Ver.
Bunolistriodon sp.
Kubanochoerus robustus Gab.
Dorcatherium sp.
Lagomeryx sp.
Micromeryx sp.
Dicrocerus belometschetkense Gab.
Paradicrocerus flerovi Gab.
Heteroprox sp.
Palaeotragus sp.
Paratragocerus caucasus Sok.
Kubanotragus miocenicus Sok.
Hypsodontus mioccenicus Sok.
Orycteropus sp.

Kyzylbulak

(Tarkhanian-L. Chokrakian? In Transcaspian; MN5 after LOPATIN pers. comm.)

Cricetodon sp.
Zygolophodon sp.
Anchitherium aurelianense Cuv.
Aceratherium sp.
Conohyus sp.
Micromeryx sp.
Dicerocerus aralensis Basch.
Stephanoceras sp.

Tab. 3: Mammalia in Belomechetka and Kyzylbulak

Magnetostratigraphic data are contradictory. TRUBIKHIN (1998) records revers polarity for the Tarkhanian and correlates the lower part of the Tarkhanian-Chokrakian interval with Chron C5Br. In contrast, PEVZNER (pers. comm.) found the Tarkhanian to be of normal polarity and correlates this interval with Chron C5Cn (Fig. 3).
According to GONCHAROVA et al. (2001), the Kozakhurian and Tarkhanian are tectonically quiet intervals. This is in contrast to the tectonic reorganisation during the Early Chokrakian as well as the Early Badenian of the Central Paratethys, where the Styrian phase represents an important tectonic event for the development of the Northern Peri-Tethys.

Conclusion

We cannot rely on the contradictory data on planktic foraminifera, calcareous nannoplankton and magnetostratigraphy, as well as on insufficient or not indicative data of benthic foraminifera and diatoms. Hence, we have to deal with data on dinocysts, molluscs (marine fauna with inherited brackish species), climate, and tectonics, which unanimously show that at least the lower Upper Tarkhanian belongs to the Lower Miocene and is therefore below the base of the Badenian (Table 4). The upper part of the Upper Tarkhanian can be correlated to the Badenian (Table 4), although direct evidence for this correlation is missing. The Chokrakian can be correlated to the Lower Badenian (except for its lowermost part). The calcareous nannoplankton (NN5) of the Chokrakian and the abundance of gypsum in the Karaganian makes a correlation of the Chokrakian with the Middle Badenian unlikely. The Konkian most probably correlates to the Upper Badenian (Kosovian).

Ma	EPOCH		Mediterranean stages	Planktic foram zones	Nannoplankton zones	Central Paratethys regional stages			Planktic foram zones	Benthic foram zones		Eastern Paratethys regional stages		Phases of tectogenesis
11	MIOCENE	UPPER	Tortonian	M13	NN 8-9	Pannonian						Sarmatian	Upper	Attic
		MIDDLE	Serravalian	M12										
12				M11		Sarmatian s.s.							Middle	
				M10	NN6-7									
13				M9									Lower	
				M8										
14				M7		Badenian	Upper	Kosovian	*Velapertina indigena*	*Bulimina Bolivina*		Konkian	Veselyankian Sartaganian	
15							Middle	Wieliczian	*Globigerina decoraperta* *Globigerina druryi*	*Spiroplectamina carinata*		Karaganian	Kartvelian Varnian Arkhashenian	
16			Langhian	M6 M5	NN5		Lower	Moravian	*Orbulina suturalis* *Praeorbulina glomerosa*	LAGENIDAE	upper lower	Chokrakian	Brykian Zyukian	Styrian
												Tarkhanian	Argunian Terskian Kuvinian	
17		LOWER	Burdigalian	M4	NN4	Karpatian			*Globigerinatella insueta*			Kozakhurian		
18				M3	NN3	Ottnangian						Sakaraulian		
19				M2	NN2	Eggenburgian								

Tab. 4: Correlation chart of Middle Miocene regional stages of the Central and Eastern Paratethys and Mediterranean stages (GONCHAROVA et al. 2001).

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