Permian and Triassic exotic limestone blocks of the Crimea

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ABSTRACT

Exotic limestone blocks of Permian and Triassic age occur in the Middle Triassic-Middle Jurassic Crimean olistostrome complex of the Marta and Alma River basins and in the Simferopol area. Rich assemblages of small foraminifers, fusulinids, brachiopods, rare ammonoids, and sphinctozoans occur in these blocks. Fossils from Permian blocks indicate the presence of zonal assemblages for the Bolorian, Kubergandian, Murgabian, Midian, Dzhulfian, and Dorashamian stages. The *Neoschwagerina simplex* fusulinid zone is extended upward based on the presence in our material of Kubergandian ammonoids with *Neoschwagerina simplex* Ozawa. Comparison of the fauna from Triassic blocks to assemblages from other regions of the Tethys indicates that the age is Late Triassic Rhaetian corresponding to the *Vandaites sturzenbaumi* ammonoid zone.

KEY WORDS
Upper Triassic, Rhaetian, Permian, exotic blocks, Crimea, foraminifers, fusulinids, brachiopods, ammonoids, sphinctozoans.

RÉSUMÉ

Les blocs exotiques calcaires du Permien et du Trias en Crimée.

Les blocs exotiques de calcaire permiens et triasiques de la Crimée appartiennent à l'unité olistostromale d'Eskiordin (Trias moyen-Jurassique moyen) et ont été trouvés dans les bassins-versant des rivières de Marta, d'Alma et dans la région du lac (réservoir) de Simferopol. Les blocs permiens contiennent des petits foraminifères et des fusulines ainsi que des brachiopodes, de rares ammonoïdes et des sphinctozoaires dont nous présentons l'inventaire. La distribution des assemblages fossilifères couvre la fin du Permien inférieur (Bolorien) ainsi que tout le Permien supérieur, du Kubergandien au Dorashamien. La présence conjointe d'ammonoïdes et de brachiopodes d'âge Kubergandien avec *Neoschwagerina simplex* Ozawa est signalée. L'analyse des micro- et macrofaunes des blocs triasiques ainsi que des comparaisons avec les faunes semblables d'autres régions téthysiennes permettent d'attribuer aux assemblages décrits un âge rhétien.

MOTS CLÉS
Trias supérieur, Rhétien, Permien, blocs exotiques, Crimée, foraminifères, fusulinides, brachiopodes, ammonoïdes, sphinctozoaires.

INTRODUCTION

For this study, our team investigated Permian and Triassic exotic limestone blocks occurring at several localities in the area between Simferopol and the Marta River Basin. Limestone samples containing remains of several different faunal groups were obtained. Carbonate microfacies were studied by A. Baud, small foraminifers by G. P. Pronina (Permian and Triassic) and V. Ja.
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Vuks (Triassic), brachiopods by G. V. Kotlyar, ammonoids by Y. D. Zakharov, sphinctozoans by G. V. Belyaeva, and fusulinids by V. I. Davydov and M. K. Nestell.

HISTORY

Fokht (1901) studied the oldest deposits then known from the Crimea. He named the "Taurida Beds", and dated them as Late Triassic.
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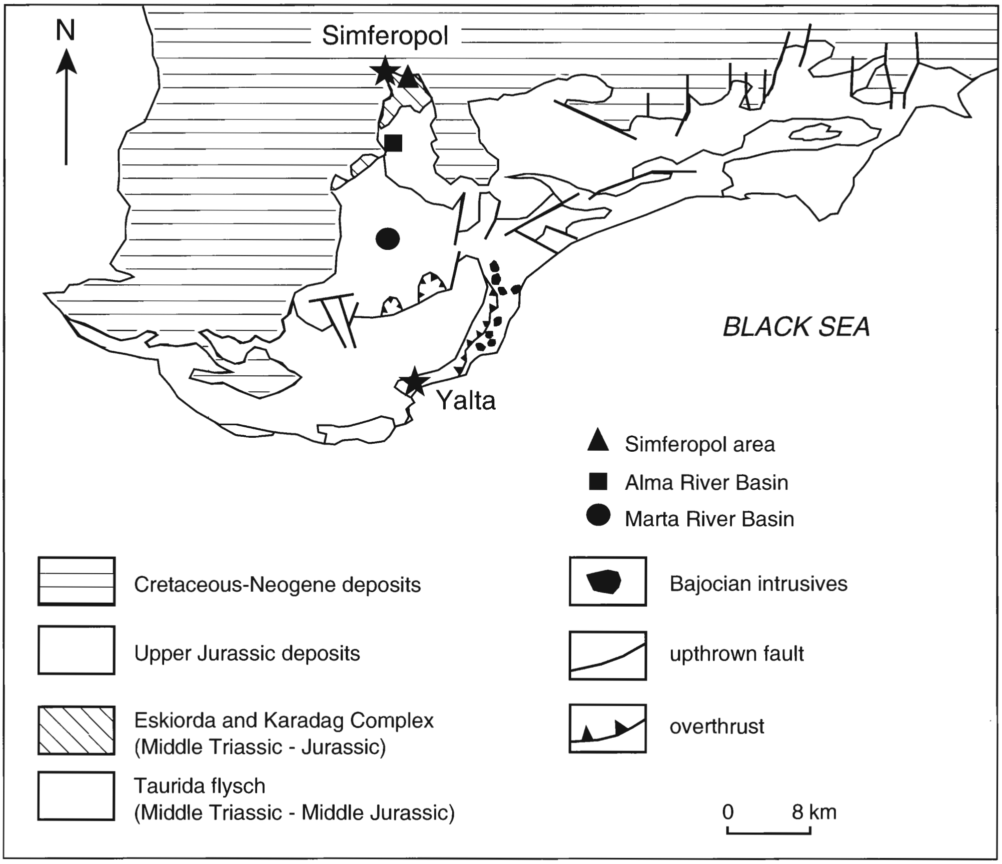

FIG. 1. — Sketch geological map of South Crimea (after Mileev *et al.* 1989).

a shallow-water conglomerate (Rhaetian-Liassic) facies present in the northern part of the Kacha uplift. Muratov (1949) divided the Taurida beds into three parts: (1) a lower unit of Late Triassic age; (2) a middle unit, the Eskiorda Formation; (3) an upper unit, both of early and middle Liassic age. Logvinenko *et al.* (1961) proposed a more detailed subdivision of the Taurida Series and considered the lower part to be of Early and Middle Triassic age.

Study of outcrops in the valley of the right tributary of the Bodrak River (Dagis & Shvanov 1965; Shvanov 1966) has shown that the Taurida Series rock ranges in age from Middle Triassic to Early Jurassic. The most common subdivision scheme of the Taurida Series has been given in Early Jurassic. The most common subdivision scheme of the Taurida Series has been given in "Geology of the USSR" (Anonymous 1969), where the Upper Triassic, Lower Taurida and the Liassic Upper Taurida (Eskiorda) formations were proposed with two types of lithofacies for each unit. Koronovsky & Mileev (1974) conducted research on the Eskiorda Formation in the Bodrak River Valley and proposed a broader Carnian-Pleinsbachian stratigraphic range for it. On this basis, they increased the rank of this unit to a Series and considered it as an equivalent of the Taurida Series rock; they also stated, that the Eskiorda Formation (or Series) in the Bodrak River area represented a tectonic melange.

GEOLOGICAL SETTING (Fig. 1)

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The oldest stratigraphic unit cropping out in the

Crimean Mountains is the Taurida flysch of Middle Triassic to Toarcian age (Shalimov 1960, 1963). The underlying units and basement have never been observed, but geophysical seismic data indicates a thin carbonate-clastic unit overlying granitic basement (Muratov *et al.* 1984).
The Taurida flysch is overlain with a structural unconformity either by Upper Jurassic deposits in the south and east of the Kacha uplift, or by Lower Cretaceous deposits in the north and west. In some parts of the Kacha uplift, the Taurida flysch is allochthonously overlain by the Eskiorda unit. The Taurida flysch makes up the core of the Kacha uplift. Mileev *et al.* (1989) distinguished the Alma unit for the proximal flysch in the core of the uplift, and the overlying Patil unit for the distal flysch. The Alma unit is exposed in the Belbek, Kacha, Marta, Alma, Salgir and Bodrak River valleys. It consists of predominantly gray, thin bedded fine sandstone and shale with reworked coalified plants debris. Commonly, the Alma unit is exposed only in river valley floors; in the Bodrak River Valley it is recorded in the middle and upper parts of slopes, and there is overthrusting the Patil unit. In the Alma River (Drovyanka Village and near Partizanskoe Village) and Salgir River basins, the Alma unit contains a Carnian and lower Norian fauna. Near Drovyanka Village (Alma River Basin), middle Liassic foraminifers occur in the shale. Near the mouth of the Marta River, Pliensbachian crinoids occur, and in the flysch of the Petropavlovsk quarry, bivalve mollusks of Toarcian-lower Bajocian age have been described. The age of the Alma unit is considered to be Middle Triassic to Bajocian. The Patil unit is exposed only in the Bodrak River Valley and differs from the Alma unit by a greater thickness of flysch couplets with mudstone dominating the couplets. A middle Liassic to Aalenian fauna occurs near Prochladnoe Village.

The Taurida flysch and its Aalenian to Eocene stratigraphic cover are separated from the North Crimean cover units (Jurassic-Eocene) by the north dipping Eskiorda unit. Originally named and interpreted as the basal part of the Taurida flysch by Moiseev (1932), and later by Shalimov (1960, 1963), this unit has been recently mapped in detail and reinterpreted by Mileev *et al.* (1989) as a composite and dismembered tectonic complex. It is the best exposed within the Lozovaya shear zone of the Kacha uplift (northern part of the core) and north of it, but it also occurs overthrust above the Taurida flysch in the Bodrak and Marta River valleys. According to the lithological and biostratigraphical contents, these authors subdivided the Eskiorda tectonic complex into the Mender (Ladinian-Sinemurian), Dzhidair (Bajocian), Kichik (Norian), Chenk (Middle-Upper Triassic?), Saraman (Late Triassic-Bajocian) and Bitak (Toarcian-Bathonian) subunits. The lithology consists mainly of fine to coarse terrigenous clastics. The turbiditic flysch sequence characterises the lower subunits and was probably deposited in shallow marine conditions because coal and coarse sandstone occurs in the upper Saraman subunit (Mileev *et al.* 1989). These authors regard the Eskiorda complex as equivalent in age to the Taurida unit.
Most of the exotic limestone blocks occur in the Mender subunit and some in the Saraman subunit. They are interpreted as olistholiths (oliststromes for the older Carboniferous to Sinemurian part), and as tectonic incorporated blocks (melange) for the younger Late Liassic-Cretaceous part. Their origin is still controversial. Some geologists believe that they originated from the north (south of Scythian Plate margin), whereas others consider that they were transported from the south.
The Mender subunit (Ladinian-Sinemurian) is composed mainly of shale with thin beds of fine-grained quartzitic sandstone. It occurs in the northwestern part of the Kacha uplift, in the Bodrak, Alma and Salgir River valleys. The Saraman subunit is composed of highly mature, light gray, massive, quartzitic sandstone with beds of fine- and medium-pebbly conglomerate and with rare silty clay interbeds. It occurs on the northern slope and on the southern limb of the Kacha uplift, in the Salgir, Alma, Bodrak and Marta River valleys. Based on macro- and microfauna occurrences (Mileev *et al.* 1989), the Saraman is Late Triassic-early Bajocian in age.

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HISTORY AND THE AGE INTERPRETATION OF THE EXOTIC BLOCKS

Fokht (1901) first recorded the occurrence of Permian limestone blocks within the Triassic-Jurassic complex. Previous researchers had assigned these blocks to different stratigraphic horizons of the Permian System. Toumansky (1931, 1935, 1937a, b) distinguished ammonoid, fusulinid, and trilobite assemblages in certain blocks, and studied the Permian faunas from these exotic blocks in the most detail. She considered them to belong to the biostratigraphic "horizons": Bodrakian, Soramanian, Burnian, and Martian. Initially, she presumed that the Soramanian assemblage was similar to that found in the Gaptank Formation in West Texas and to be of Late Carboniferous age (*Uddenites* zone). Subsequently, Toumansky (1941) concluded that the limestone with this ammonoid assemblage corresponded to the lower part of the Permian Leonard Formation in West Texas of North America, the lower part of the Bitauni Formation on Timor Island, and the upper part of Buztere beds in the Southeastern Pamirs. In her study of Permian ammonoids of the Central Pamirs, Toumansky (1963) correlated the Burnian and Martian ammonoid assemblages of the Crimea with the Kubergandian assemblage from the Pamirs. According to Bogoslovskaya (1984), the Burnian assemblage is similar to the ammonoid assemblage in the Kuberganda Formation of the Pamirs, and is Roadian in age. The so-called "Martian (Martovsky or Martinsky)" assemblage is considered to be Wordian.

The Late Triassic age of certain limestone block is mainly derived from occurrences of Anisian and Norian-Rhaetian brachiopods (Dagis 1963; Dagis & Shvanov 1965).

CRIMEA-PONTIDES (NORTHERN TURKEY) TENTATIVE CORRELATIONS (FIGS 2 , 3)

The Crimean Mountains and the central Pontides (Turkey) represent the conjugate rift margin

The Crimean Mountains and the central Pontides (Turkey) represent the conjugate rift margin of the Western Black Sea oceanic basin (Fig. 3).

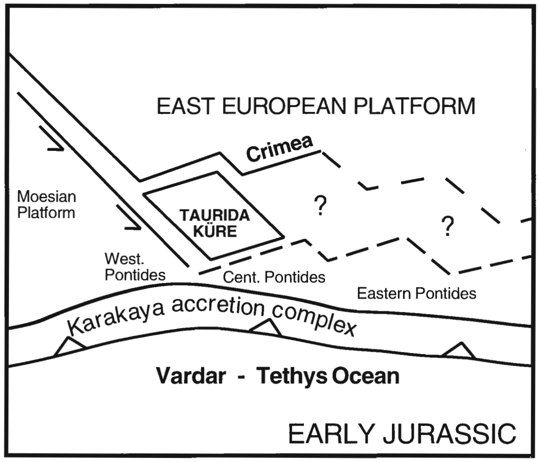

Fig. 2. — Early Jurassic reconstruction, following opening of Küre/Taurida basins; schematic and not scale (simplified and modified from Banks 1997).

Prior to the opening of the Western Black Sea oceanic basin initiated in Barremian-Aptian time and completed in Cenomanian time (Görür 1988), southern Crimea and central Pontides occupied neighbouring positions (Fig. 2, see also reconstruction schemes recently proposed by Banks and Robinson *in* Banks 1997).

In the Crimea (this paper) as well as in the central Pontides (Aydin *et al.* 1986; Yilmaz *et al.* 1997), there are occurrences of flyschoids successions. In the Crimean Mountains and the central Pontides, the oldest rocks exposed are a sequence of basinal turbiditic mudstones and siltstones of similar age (Triassic-Early Jurassic). These formations were disrupted during the Cimmerian orogenesis at the end of the Middle Jurassic (Sengör 1984).

As was proposed before (Marcoux & Baud 1996; Marcoux *et al.* 1993) the equivalent of the "Taurida flysch" from the Crimea would correspond to the Küre series of the Akgöl Formation (Aydin *et al.* 1986; Yilmaz *et al.* 1997) from the central Pontides. This hypothesis was proposed again recently (Robinson & Kerusov 1997).

At the moment, only Triassic exotic blocks (olistoliths) have been described within the Küre/Akgöl series, for instance Hallstatt facies limestones of late Anisian and Ladinian (Önder 1990;

Akgöl series, for instance Hallstatt facies limestones of late Anisian and Ladinian (Önder 1990; L. Krystyn, pers. comm. 1992). Future detail

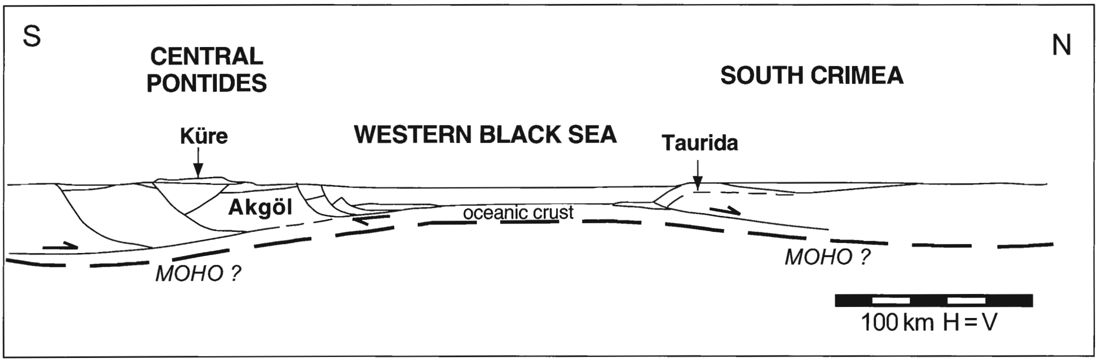

FIG. 3. — Schematic structural cross section of the eastern part of the western Black sea from northern Turkey (Central Pontides) to Crimea Mountains (South Ukraine) (simplified and modified from Banks 1997).

investigations might also demonstrate the occurrence of Late Palaeozoic blocks, similar in age to those from the Crimea described in this paper.

PERMIAN EXOTIC BLOCKS

Permian exotic blocks were studied in the Marta and Alma River basins and in the Simferopol area. Correlation of these blocks and locations of fossils are shown in Table 1.

MARTA RIVER BASIN

In limestone exposed on the slopes of Kichkhi-Burnu Mountain in the Marta River Basin, Toumansky (1941) recorded two "horizons with fauna" (fusulinids, ammonoids, trilobites) which she called Burnian and Martian. She correlated the Burnian "horizon" with the upper part of the Leonardian, and the Martian "horizon" with the Wordian. In later studies, it was ascertained that these so-called "horizons" were not valid, and the assemblages were correlated to the Permian Murgabian, Darvazian and Pamirian stages (Einor & Vdovenko 1959; Licharew 1966).

In the Marta River Basin, the largest Permian block (65 × 35 × 15 m) is located on the right flank of one of the right tributaries of the Marta River, 5 km upstream from the Verkhorechye Village (Loc. 110; Figs 4A, 5). Here light gray and pinkish-gray non-bedded algal-fusulinid (reefogenic?) limestone forms Kichkhi-Burnu
and pinkish-gray non-bedded algal-fusulinid (reefogenic?) limestone forms Kichkhi-Burnu
Mountain. Several smaller blocks located nearby, also contain abundant and diverse foraminifers, brachiopods, trilobites, gastropods, and ammonoids. Some of these blocks contain distinct lithologies separated by breccia zones and contain different fossil remains. Peripheral parts display clastic textures (rounded and semirounded fragments of gray boundstone with light-colored carbonate cement), as well as micritic limestone of a pinkish or beige tint. The north-western margin of the main block appears to contain the oldest sediments.

Loc. 110/sample 1

The limestone of this sample is a well-sorted skeletal grainstone containing calcareous algae, foraminifers, gastropods, calcareous sponges and brachiopod fragments. It is interpreted as being deposited in a high energy, shallow marine palaeoenvironment.

Small foraminifers. *Tuberitina collosa* Reitlinger, *Mendipsia conili* (Nguyen Duc Tien), *Endothyra* sp., *Climacammina valvulinoides* Lange, *Deckerella* sp. 2, *Tetrataxis* sp., *Globivalvulina graeca* Reichel, *Palaeotextularia pingguoensis* Lin, *P.* sp.(= *P. longiseptata* Lipina *in* Zheng 1986), *Pachyphloia sphaerula* Sosnina, *Langella* sp., *Neodiscus* aff. *N. milliloides* A. M.-Maclay.

Fusulinids. *Parafusulina vinogradovi* Leven, *P.* cf. *P. multiseptata* (Schelwien), *P.* aff. *P. nakamigavai* Morikawa & Horiguchi, *P.* aff. *P. yunnanica* Sheng, *P. crassispira* Leven, *P. muratbekovi* Leven, *P. undulata* Chen, *Armenina asiatica* Leven, *A. karinae* (Kochansky-
P. muratbekovi Leven, *P. undulata* Chen, *Armenina asiatica* Leven, *A. karinae* (Kochansky-
Devide & Ramovs), *A. salgirica* A. M.-Maclay,

Tethyan scale (Leven 1980, 1996; Kotlyar & Pronina 1995)		Assemblages (Toumansky 1931, 1941, 1963)	Marta River Basin 110/1	110/2	110/3	110/4	110/5	110/6	110/7	110/8	110/9	110/10	110/20	110/21	Alma River Basin 129	112	113	122 a	122 b	122 c	122 d	Simferopol area 123/2	123/3	111/1	111/2	111/3	111/3a	111/7	125/1	125/2
	Dorashamian																SF													
	Dzhulfian														SF		F	SF	SF F	SF F										
Midian	*Yabeina*																				SF F									
Midian	*Neoschwagerina margaritae*	Martian																				F			SF F	F	SF F	SF		
Murgabian	*Neoschwagerina craticulifera*	Martian					SF F			Br																				
Kubergandian	*Neoschwagerina simplex* / *Praesumatrina*	Burnian	SF F Br A ST	SF Br	F Br	SF F		SF F	SF F		SF F Br	Br A ST	SF F	SF F Br		A								F					SF F	F
Kubergandian	*Cancellina cutalensis*	Burnian	A													A														
Bolorian	*Misellina claudiae*	Soramanian																					F							

TABLE 1. — Distribution of fossil localities and correlation of Permian exotic blocks in the Crimea. **SF**, small foraminifers; **F**, fusulinids; **A**, ammonoids; **Br**, brachiopods; **ST**, sphinctozoans.

A. sphaera (Ozawa), *Cancellina* cf. *C. primigena* Hayden, *C. praeneoschwagerinoides* Leven, *C. phlonghprabensis* Toriyama & Kanmera, *Neoschwagerina simplex tenuis* Toriyama & Kanmera, *N.* aff. *N. simplex* Ozawa, *Praesumatrina schellwieni* (Deprat).

Sphinctozoans. *Colospongia* sp., *Crymocoelia zacharovi* Belyaeva, *Vesicotubularia prima* Belyaeva, *Paradeningeria martaensis* Belyaeva, *Sollasia* sp.

Brachiopods. *Acosarina* sp., *Rugaria molengraaffi* (Broili), *Urushtenia murina* (Grant), *Neoplicatifera* sp., *Comuquia* cf. *C. modesta* Grant, *Marginifera carniolica* (Schellwien), *Transennatia gratiosa* (Waagen), *Bilotina acantha* (Waterhouse & Piyasin), *Linoproductus* aff. *L. kaseti* Grant, *Compressoproductus mongolicus* (Waagen), *Ogbinia dzhagrensis* Sarytcheva, *Uncinunellina siculus* (Gemmellaro), *Anomaloria glomerosa* Grant, *Permophricodothyris caroli* (Gemmellaro), *Martinia ceres* (Gemmellaro).

Ammonoids. *Propinacoceras* sp., *Prostacheoceras tauricum* (Toumansky), *Cardiella kussica* (Toumansky). Apparently, the ammonoids described by Toumansky (1931) also originated

(Toumansky). Apparently, the ammonoids described by Toumansky (1931) also originated

from Locality 110/1. These were identified as *Parapronorites konincki* Gemmellaro, *Propinacoceras galilaei* Gemmellaro, *P.*? *soramanse* Toumansky, *P.*? *almense* Toumansky, *Medlicottia*? *volgi* Toumansky, *Thalassoceras karpinskyi* Toumansky, *Agathiceras suessi* Gemmellaro, *A. planum* Toumansky, *A. bodraki* Toumansky, *A. katsche* Toumansky, *A. bachui* Toumansky, *A. anceps* Gemmellaro, *Cardiella kussica* (Toumansky), *Neocrimites* (*Sosiocrimites*) *biassalensis* Toumansky, *Aricoceras* aff. *A. ensifer* (Gemmellaro), *Palermites* cf. *P. distefanoi* (Gemmellaro), *Prostacheoceras multidentatum* (Toumansky), *P. burnense* (Toumansky), *Stacheoceras mediterraneum crimense* Toumansky, *S. andrussowi* Toumansky, *S. bosei* Toumansky, *S. borissiaki* Toumansky, *S. vogti* Toumansky, *S.* cf. *S. tietzei* Gemmellaro, *S. tepense* Toumansky, *Tauroceras wanneri* (Toumansky), *T. serobiculatus martensis* (Toumansky), *Paraceltites hoefori sophiensis* Toumansky.

Trilobites and single fragments of isolated tetracorals belonging to the family Plerophyllidae (most likely to the genera *Pentaphyllum* and *Ufimia*) where noted by Toumansky (1935), who also indicated that small bivalves and gastro-

Ufimia) where noted by Toumansky (1935), who also indicated that small bivalves and gastro-

pods were also present at this locality.

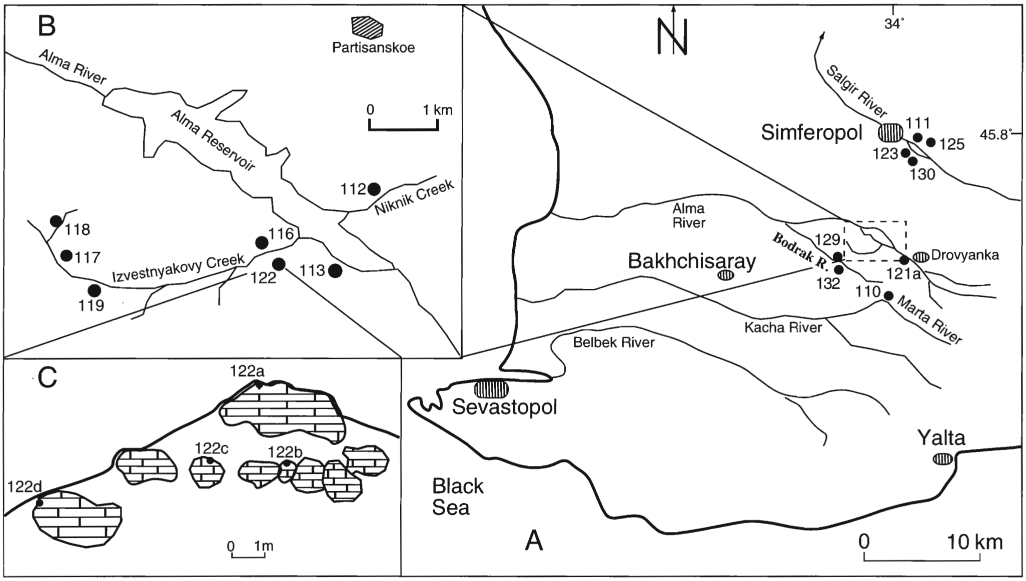

FIG. 4. — **A**, map of the study area with localities of the Permian and Triassic exotic blocks; **B**, location of Permian exotic blocks in the Alma River Basin; **C**, location of the upper Midian (Capitanian) and Dzhulfian limestone blocks on the right side of Izvestnyakovy Creek in the Alma River Basin. Site is on the left side of a trail going up from the Alma Reservoir and is in dense forest.

Loc. 110/sample 4

This sample, located at the northern margin of the block (Fig. 5), consists of medium sorted skeletal grainstone, with *Lithocodium*, coated grains, intraclasts, foraminifers, gastropods and other shell fragments.

Small foraminifers. *Palaeotextularia* sp., *Deckerella* sp. 2, *Climacammina valvulinoides* Lange, *Palaeospiroplectammina* ex gr. *P. conspecta* Reitlinger, *Polytaxis* sp., *Orthovertella* sp., *Neodiscus* aff. *N. milliloides* A. M.-Maclay.

Fusulinids. *Minojapanella* sp., *Parafusulina cincta* Reichel, *P.* cf. *P. erratoseptata* Kling, *P. crassiseptata* Leven, *P.* cf. *P. undulata* Chen, *P. japonica* (Guembel), *P. nakamigawai* Morikawa & Horiguchi, *Pseudofusulina* aff. *P. hisamatsui* Morikawa.

Loc. 110/sample 2

This sample is a reefoidal boundstone with encrusted skeletal elements and cavities filled with biosiltite.

Loc. 110/sample 3

Loc. 110/sample 3

This sample is from a small (about 0.7 m across) block. The limestone consists of a well-sorted skeletal grainstone with intraclasts and with coated grains formed from calcareous sponges, foraminifers, gastropods, brachiopod spines and bryozoans.

Fusulinids. *Neofusulina tumida* (Ozawa), *Yangchienia* cf. *Y. compressa* (Ozawa), *Parafusulina cincta* Reichel, *Armenina sphaera* (Ozawa), *Neoschwagerina simplex* Ozawa, *N. simplex tenuis* Toriyama & Kanmera, *Praesumatrina neoschwagerinoides* (Deprat).

Brachiopods. *Acosarina* sp., *Neoplicatifera* sp., *Transennatia gratiosa* (Waagen), *Uncinunellina* cf. *U. amor* (Gemmellaro).

Loc. 110/samples 6, 7

These samples consist of a poorly sorted calcirudite, with biocalcarenite packstone pebbles, fragments of oncoidal crust, calcareous algae, foraminifers, gastropods, bryozoans, brachiopods and shell fragments. Internal fissures are filled with fine-grained calcarenite. The environment of deposition is interpreted as marine forereef.

Small foraminifers. *Tuberitina collosa* Reitlinger,

of deposition is interpreted as marine forereef.
Small foraminifers. *Tuberitina collosa* Reitlinger,

Mendipsia conili (Nguyen Duc Tien), *M.* sp.,

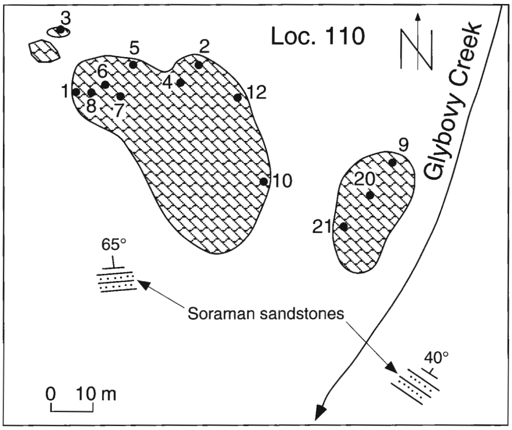

FIG. 5. — Location of collection sites at the Kichkhi-Burnu Permian limestone blocks in the Marta River Basin (Loc. 110). Matrix consists of the Soraman sandstone (Pliensbachian).

Lasiodiscus sp. 1, *Palaeotextularia* sp. (= *P. longiseptata* Lipina *in* Zheng 1986), *Deckerella media permiana* Wang, *Palaeospiroplectammina* ex gr. *P. conspecta* Reitlinger, *Tetrataxis maxima* Schellwien, *T.* sp., *Globivalvulina graeca* Reichel, *Calcivertella* sp., *Orthovertella* sp., *Neodiscus* aff. *N. milliloides* A. M.-Maclay, *Pachyphloia sphaerula* Sosnina, *P. ovata* (Lange), *Nodoinvolutaria jilinica* Han.

Fusulinids. *Neoschwagerina simplex* Ozawa, *Cancellina* sp., *Praesumatrina rossica* A. M.-Maclay, *Neofusulinella nana* A. M.-Maclay.

Loc. 110/sample 5

This sample consists of a poorly sorted biocalcirudite, with calcareous algae, foraminifers, aggregates and encrusting laminated microbial mats (*Sphearocodium*).

Small foraminifers. *Globivalvulina* sp., *Palaeotextulariida* indet.

Fusulinids. *Yangchienia haydeni* Thompson, *Y. tobleri* Thompson, *Parafusulina sapperi* (Staff), *P. japonica* (Gumbel), *P. nakamigawai* Morikawa & Horiguchi, *Pseudofusulina* cf. *P. uenoensis* Kobayashi, *Armenina saraburiensis* Toryama & Kanmera, *Verbeekina verbeeki* (Geinitz), *Cancellina sephaputi* Kanmera & Toriyama, *Neoschwagerina colaniae* Ozawa, *N.* ex gr. *N. pinguis* Skinner, *N. craticulifera* (Schwager), *Pseudodoliolina ozawai* Yabe & Hanzawa, and *Prae-*

Skinner, *N. craticulifera* (Schwager), *Pseudodoliolina ozawai* Yabe & Hanzawa, and *Prae-*
sumatrina grandis Leven.

Loc. 110/sample 10

At this locality near the eastern side of the block, the talus is composed of slightly marly gray limestone yielding remains of brachiopods, ammonoids and trilobites.

Brachiopods. *Enteletes* cf. *E. sublaevis* Waagen, *E. geniculatus* Licharew, *Linoproductus* aff. *L. kaseti* Grant, *Ogbinia dzhagrensis* Sarytcheva.

Sphinctozoans. *Colospongia* sp., *Crymocoelia zacharovi* Belyaeva, *Vesicotubularia prima* Belyaeva, *Paradeningeria martaensis* Belyaeva, *Sollasia*? sp.

Ammonoids. *Propinacoceras* sp., *Prostacheoceras tauricum* (Toumansky), *Cardiella kussica* (Toumansky).

Loc. 110/samples 9, 20, 21

Southeast of the main block at this locality there is a smaller block exposed along the Glybovy Creek (Fig. 5). The lithology of the block consists of a poorly sorted calcirudite to calcarenite packstone, with reefboundstone clasts, fragments of oncoidal crust, calcareous algae, foraminifers, crinoids, bryozoans, brachiopods and shell fragments. Internal fissures are filled with micrite. This lithology and fauna indicate a marine forereef palaeoenvironment.

Small foraminifers. *Tuberitina collosa* Reitlinger, *Atjussella* sp., *Mendipsia* sp., *Dagmarita* sp., *Globivalvulina* sp., *Neodiscus* aff. *N. milliloides* A. M.-Maclay.

Fusulinids. *Neofusulinella lantenoisi* Deprat, *N. saraburiensis* Toriyama, Kanmera & Ingevat, *N. nana* A. M.-Maclay, *Armenina salgirica* A. M.-Maclay, *Armenina prisca* Toriyama & Kanmera, *Verbeekina* sp., *Praesumatrina neoschwagerinoides* (Deprat), *Cancellina primigena* Hayden, *C. saraburiensis* Kanmera & Toriyama, *C.* (*Shengella*) *elliptica* Yang, *Neoschwagerina simplex* Ozawa, *Parafusulina granumavenae* (Roemer), *P.* aff. *P. tchuenkovi* Leven, *P.* aff. *P. yabei* Hanzawa, *Chusenella tingi* Sheng.

Brachiopods. *Neoplicatifera* sp., *Marginifera carniolica* (Schellwien), *Rostranteris inflatum* (Gemmellaro).

Limestone of the main body of the Marta block (Loc. 110) is characterised by two assemblages of fusulinids: an assemblage of the *Neoschwagerina*

Limestone of the main body of the Marta block (Loc. 110) is characterised by two assemblages of fusulinids: an assemblage of the *Neoschwagerina*

simplex zone (Loc. 110/1, 3, 4, 9, 20, 21) and the assemblage of the *Neoschwagerina craticulifera* zone (Loc. 110/5). According to Bogoslovskaya (1984), two ammonoid assemblages are recorded in the Marta block: (1) an older one of Roadian (Burnian) age; (2) a younger one of Wordian (Martian) age. Zakharov (this work) found only the Roadian ammonoid assemblage (Loc. 100/1, 10). Small foraminifers (Loc. 110/1, 2, 4, 6, 7, 9, 20, 21) are Roadian or Kubergandian. The brachiopod assemblage (Loc. 110/1-3, 9, 10, 21), is most probably also of a same age. The Roadian ammonoids, small foraminifers and brachiopods occur with fusulinids of the *Neoschwagerina simplex* zone.

ALMA RIVER BASIN

Exotic blocks and pebbles of Permian limestone within Eskiorda Serie are also recorded in the Alma River Basin, in the areas of the Bodrak River, and Izvestnyakovy and Niknik creeks (Fig. 4B).

Loc. 129

Many blocks of different ages have been observed in the Bodrak River area. Here we are describing a new Permian block (Loc. 129) discovered in 1996 (Fig. 4A). This isolated block is located on the right bank of the river near Trudolubovka Village.

The block from which this sample (Loc. 129) was obtained is about 0.5 m across. It is a biocalcirudite with carbonate-quartzitic cement and rounded millimetre to centimetre sized pebble clasts of lime mudstone, calcareous sponges, radiolarian lime mudstone, corals, and foraminifers. There are also single ooids in the matrix. This texture indicates an exposure of a Permian sequence reworked in a high-energy shallow platform marine environment with quartzitic terrigenous input.

Small foraminifers. *Lasiodiscus tenuis* Reichel, *Globivalvulina* sp., *Agathammina* sp., *Nodosaria caucasica mirabilis* K. M.-Maclay, *Pachyphloia cukurkoyi* Civrieux & Dessauvagie.

Loc. 122

On the right bank of Izvestnyakovy Creek, about 350 m upstream from its mouth, several blocks

Loc. 122

On the right bank of Izvestnyakovy Creek, about 350 m upstream from its mouth, several blocks

(Loc. 122) of gray and light gray crinoid limestone (about 15 × 6 m) were discovered (Fig. 4C). They contain remains of algae, and sphinctozoans – *Colospongia* cf. *C. salinaria* (Waagen & Wentzel), *Vesicotubularia prima* Belyaeva.

Loc. 122a

This sample consists of a clast-supported calcirudite with encrusted microbial elements and biocalcarenite with foraminifers. Diagenesis showing radiaxal cement and internal filled cavities of silty mudstone indicates an upper shoreface marine depositional environment.

Small foraminifers. *Eotuberitina reitlingerae* A. M.-Maclay, *Mendipsia conili* (Nguyen Duc Tien), *Lasiodiscus tenuis* Reichel, *Lasiotrochus* sp., *Postendothyra* sp., *Climacammina* sp., *Palaeospiroplectammina* sp., *Dagmarita* sp., and *Geinitzina* sp.

Loc. 122b

This sample is a clast-supported calcirudite from a perireefal environment containing foraminifers, calcareous algae, bryozoans and brachiopods.

Small foraminifers. *Eotuberitina reitlingerae* A. M.-Maclay, *Tuberitina collosa* Reitlinger, *Lasiodiscus tenuis* Reichel, *Neoendothyra* sp., *Postendothyra* sp., *Palaeotextularia* sp. 3, *Climacammina* sp. 1, *C. verbeeki* Lange, *C.* ex gr. *C. valvulinoides* Lange, *Deckerella* sp., *Palaeospiroplectammina* sp., *Tetrataxis* sp., *Abadehella* sp., *Agathammina* sp., *Multidiscus* sp., *Nodosaria sagitta* K. M.-Maclay, *N. planocamerata* Sosnina, *Langella perforata langei* Civrieux & Dessauvagie, *Geinitzina araxensis* G. Pronina, *G. spandeli* Tcherdynzev, *G. uralica simplex* K. M.-Maclay, *Pachyphloia robusta* K. M.-Maclay, *Pseudotristix solida* Reitlinger, *Ichtyolaria primitiva* Civrieux & Dessauvagie, and *Hubeirobuloides* sp.

Fusulinids. *Codonofusiella* cf. *C. erki* Rauser, and *Reichelina changhsingensis* Sheng & Chang.

Loc. 122c

This sample is a reefal boundstone with a *Microcodium* type of encrustation and radiaxal cement.

Small foraminifers. *Lasiodiscus minor* Reichel, *Neoendothyra* sp., *Globivalvulina* sp., *Hemigordius* sp., and *Geinitzina* sp.

Small foraminifers. *Lasiodiscus minor* Reichel, *Neoendothyra* sp., *Globivalvulina* sp., *Hemigordius* sp., and *Geinitzina* sp.

Fusulinids. *Yangchienia* cf. *Y. thompsoni* Skinner & Wilde, *Chusenella* sp., *Nankinella* cf. *N. ovata* A. M.-Maclay, and *Reichelina cribroseptata* Erk.

Loc. 122d

This sample is a calcirudite of poorly sorted broken clasts in a bioclastic matrix.

Small foraminifers. *Mendipsia conili* (Nguyen Duc Tien), *Tuberitina collosa* Reitlinger, *Lasiodiscus minor* Reichel, *Deckerella* sp., *Endoteba controversa* Vachard & Razgallah, *Dagmarita* sp., *Globivalvulina cyprica* Reichel, *G. vonderschmitti* Reichel, *Postendothyra novizkiana* (Sosnina), *P. micula* (Sosnina), *Neoendothyra ornata* Sosnina, *Tetrataxis conica* Schellwien, *Abadehella* sp., *Orthovertella sphaerica* G. Pronina, *Baisalina pulchra* Reitlinger, *Sphairionia* (*Pseudosphairionia*) *tienii* G. Pronina, *Nodosaria* cf. *N. partisana* Sosnina, *Pseudolangella geranossensis* G. Pronina, *P. filumiformis* G. Pronina, *P. dzhagadzurensis* G. Pronina, *Rectoglandulina gerkei* Sosnina, *Pachyphloia rimula* Sosnina, *P. cukurkoyi* Civrieux & Dessauvagie, *P. minutissima* Sosnina, *Partisania* sp. 1, and *Rectostipulina* sp.

Fusulinids. *Rauserella* sp., *Reichelina cribroseptata* Erk, *Dunbarula nana* Kochansky-Devide & Ramovs, *Lantchichites* cf. *L. minimus* Chen, *Codonofusiella* cf. *C. kueichowensis* Sheng, *Yangchienia thompsoni* Skinner & Wilde, *Chusenella* cf. *Ch. splendens* (Skinner), *Ch.* cf. *Ch. cyri* (Skinner), *Kahlerina pachytheca* Kochansky-Devide & Ramovs, *Verbeekina* cf. *V. furnishi* Skinner & Wilde, *Neoschwagerina schuberti* Kochansky-Devide, *N. haydeni* Dutkevich & Khabakov, *N. kojensis* Toumansky.

Loc. 113

On the left bank of Izvestnyakovy Creek about 550 m upstream from the mouth (Fig. 2B), we found a small block (40 cm × 80 cm) of gray microcrystalline limestone.

Loc. 113 is a calcirudite with ooid grainstone and with biowackestone clasts. The skeletal elements consist of sponges, shell fragments and foraminifers.

Small foraminifers. *Deckerella* aff. *D. elegans* Morozova, *Climacammina valvulinoides* Lange,

Small foraminifers. *Deckerella* aff. *D. elegans* Morozova, *Climacammina valvulinoides* Lange,

Endoteba controversa Vachard & Razgallah, *Postendothyra guangxiensis* (Lin), *Abadehella* cf. *A. coniformis* Okimura & Ishii, *Globivalvulina graeca* Reichel, *G. vonderschmitti* Reichel, *Agathammina* ex gr. *A. rosella* G. Pronina, *Midiella zaninettiae* (Altiner), *Multidiscus* sp. 1, *M.* sp. 2, *Calcitornella* sp. 2, *Nodosaria* cf. *N. globocularis* Sosnina, *N. dorachamensis* G. Pronina, *N. mirabilis caucasica* K. M.-Maclay, *Pachyphloia* ex gr. *P. pigmobesa* Wang, *P. paraovata* K. M.-Maclay, *P. angulata* K. M.-Maclay, *Pseudotristix* sp., *Geinitzina* sp., *Colaniella* ex gr. *C. minima* Wang, and *C.* ex gr. *C. lepida* Wang.

Fusulinids. *Minojapanella*? sp., *Pseudodunbarula minima* (Sheng & Chang), *P.* aff. *P. arpaensis* Chedija, *Paradunbarula dallyi* Skinner, and *Reichelina changhsingensis* Sheng & Chang.

Loc. 112

On the opposite side of the Alma River Valley (Fig. 4B) along Niknik Creek (Loc. 112), gray fine-grained sandstone crops out which contains an isolated block (about 3 m across) of gray brecciated limestone with "boulder" jointing with ammonoid remains.

Ammonoids. *Propinacoceras* sp., *P.* sp. indet., *Agathiceras* sp., *A.* sp. indet., *Cardiella kussica* (Toumansky), *Adrianites*? sp., *Tauroceras* sp., *Paraceltites*? sp. This assemblage is Roadian or Kubergandian age.

SIMFEROPOL AREA

The geology of the Simferopol area is described in Moiseev (1937). During this study the exotic blocks were examined at Cape Dzhien-Safu, near Marjino Village, and east of Simferopol Reservoir (Fig. 6A).

Loc. 111

On the western end of Cape Dzhien-Safu at Simferopol Reservoir (Loc. 111) there is a large, northwest trending, elongate block of limestone (Fig. 6). It is about 180 m along the long axis. On the marginal parts, it is composed of black and dark gray microcrystalline limestone which is massive, fissured, and contains pockets of accumulations of fusulinid shells (Loc. 111/1).

Loc. 111/sample 1

Loc. 111/sample 1

Fusulinids. *Parafusulina crassispira* Leven, *P.* aff.

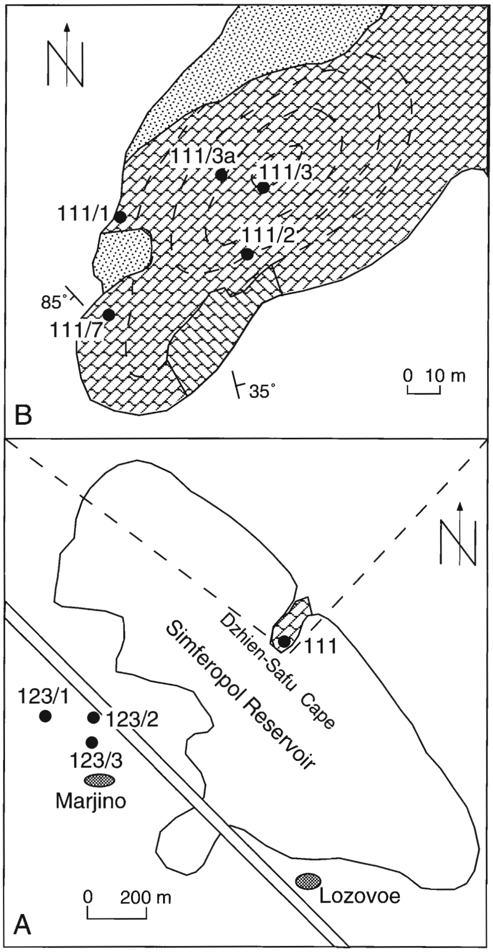

FIG. 6. — **A**, location of the Permian limestone block (Cape Dzhien-Safu) and pebbles (Marjino Village) near the Simferopol Reservoir; **B**, collection sites at the lower Midian (Wordian) limestone block (Loc. 111) in the western part of Cape Dzhien-Safu.

P. dronovi Leven, *Chusenella* sp., *Eopolydiexodina* aff. *E. zulumartensis* Leven, *Armenina salgirica* A. M.-Maclay, *Verbeekina verbeeki* (Geinitz), *Cancellina praeneoschwagerinoides* Leven, *C. cutalensis* Leven, *C. tenuitesta* Kanmera, *Neoschwagerina simplex* Ozawa, *Praesumatrina rossica* A. M.-Maclay, *Pseudodoliolina ozawai* Yabe & Hanzawa. The age is Kubergandian.

Loc. 111/sample 7
Small foraminifers. *Tuberitina collosa* Reitlinger, *Mendipsia conili* (Nguyen Duc Tien),
Loc. 111/sample 7
Small foraminifers. *Tuberitina collosa* Reitlinger, *Mendipsia conili* (Nguyen Duc Tien),
Globivalvulina vonderschmitti Reichel, *Postendothyra* sp., *Tetrataxis* ex gr. *T. linea* Ozawa, and *Abadehella* sp.
Fusulinids. *Sumatrina* sp., *Rauserella* sp., and *Cancellina* cf. *C. primigena* (Hayden). The age is early Midian.

Loc. 111/samples 2, 3, 3a
These samples consist of dense biocalcarenite packstone with foraminifers and intraclasts, and are interpreted to be deposited in a marine inner shelf environment.
Small foraminifers. *Eotuberitina reitlingerae* A. M.-Maclay, *Tuberitina collosa* Reitlinger, *Mendipsia conili* (Nguyen Duc Tien), *M.* sp., *Tetrataxis maxima* Schellwien, *T. scita* Lin, *T. linea* Ozawa, *Abadehella hunanensis* (Lin), *Globivalvulina vonderschmitti* Reichel, *G.* aff. *G. permiana* Tcherdynzev, *Postendothyra novizkiana* (Sosnina), *P. ussurica* (Sosnina), *Calcivertella* sp.
Fusulinids. *Afghanella* cf. *A. sumatrinaeformis* (Gubler), *Sumatrina rossica* A. M.-Maclay, *Kahlerina* sp., and *Rauserella* sp. The age is early Midian.

Loc. 123
At Marjino Village (Loc. 123), several small blocks of fossiliferous limestone were found (near the foundation of a house under construction and not available for future study) among coarse-grained Liassic tuffogenic sandstone and conglomerate (Fig. 6A). These samples consist of calcareous quartzitic sandstone with foraminifers.

Loc. 123/sample 2
Fusulinids. *Chusenella deprati* Ozawa, *N.* cf. *N. kojensis* Toumansky, *N. pinguis* Skinner, *N.* aff. *N. minoensis* Deprat, *Colania* aff. *C. akasakensis* (Morikawa & Suzuki), *Yabeina opima* Skinner, *Y. archaica* Dutkevich, *Y.* cf. *Y. globosa* Yabe, *Y. orbiculata* Chedija, *Y. inonyei* Deprat, and *Neoschwagerina craticulifera* (Schwager). This assemblage is of late Midian age.

Loc. 123/sample 3
Northwards, at the margin of the village on the hill slope, we found a separate limestone block measuring about 0.5 × 0.5 m (Fig. 6A).
Northwards, at the margin of the village on the hill slope, we found a separate limestone block measuring about 0.5 × 0.5 m (Fig. 6A).

Fusulinids. *Neofusulinella saraburiensis* Toriyama, Kanmera & Ingevat, *Misellina aliciae* (Deprat), *M. otakiensis* (Huzimoto), *M.* aff. *M. termieri* (Deprat), and *M. claudiae* (Deprat). This assemblage is of Bolorian age.

Loc. 125

Along the eastern side of Simferopol Reservoir (Loc. 125), two limestone blocks were found on the watershed (Fig. 2A). The first one is about 0.8 × 0.5 m, and the second one about 0.5 × 0.5 m. Based of the fusulinid data, the age of limestone from locality 125 is Kubergandian.

Loc. 125/sample 1

This block is composed of dark gray, almost black microcrystalline limestone. The microfacies consists of a mud-supported biocalcarenite rich in foraminifers.

Small foraminifers. *Tuberitina collosa* Reitlinger, *Atjussella grandis* G. Pronina, *Diplosphaerina* aff. *D. maljavkini* (Mikhalov), *Mendipsia* sp., *Endothyra saucra* (Lin), *Globivalvulina graeca* Reichel, *Palaeospiroplectammina* ex gr. *P. conspecta* Reitlinger, *Calcitornella* sp. 1, *Calcivertella* sp., *Agathammina* sp., *Neodiscus* aff. *N. milliloides* A. M.-Maclay, *Nodosaria* sp. (= *N. longissima* Suleimanov *in* Zheng 1986), *Pachyphloia ovata* (Lange).

Fusulinids. *Yangchienia* cf. *Y. compressa* (Ozawa), *Dunbarula*? cf. *D. cascadensis* (Thompson, Wheeler & Danner), *Chusenella schwagerinaeformis* Sheng, *Armenina* aff. *A. prisca* Toriyama & Kanmera, *A. sphaera* (Ozawa), *A. saraburiensis* Toriyama & Kanmera, *Misellina ovalis* (Deprat), *M.* aff. *M. confragaspira* Leven, *M. termieri pamirensis* (Dutkevich), *M. claudiae* (Deprat), *Cancellina primigena* (Hayden), *C.* aff. *C. praeneoschwagerinoides* Leven, *C. dutkevitchi* Leven, *C. cutalensis* Leven, *C. pamirica* Leven, and *Praesumatrina neoschwagerinoides* (Deprat).

Loc. 125/sample 2

Fusulinids. *Yangchienia* sp., *Sichotenella*? sp., *Neofusulinella lantenoisi* Deprat, *Dunbarula*? sp., *Chusenella chihsiaensis* (Lee), *Armenina asiatica* Leven, *Cancellina dutkevitchi* Leven, *C. cutalensis* Leven, *C. zarodensis* Sosnina, *C. sphaera* A. M.-
Leven, *Cancellina dutkevitchi* Leven, *C. cutalensis* Leven, *C. zarodensis* Sosnina, *C. sphaera* A. M.-
Maclay, *C. verae* (Toumansky), *C.* aff. *C. nipponica* (Ozawa), *Neoschwagerina simplex tenuis* Toriyama & Kanmera, and *Praesumatrina neoschwagerinoides* (Deprat).

ANALYSIS OF FAUNAL ASSEMBLAGES

Ammonoids

The Early Permian (probably, Bolorian) and the Late Permian (Kubergandian or Roadian) (Loc. 110/1, 10) age of the Crimea limestone blocks is established based on the ammonoid data. As was correctly noted by Toumansky (1931, 1937a, 1963), the oldest ammonoids of the Crimea blocks are forms of the Soramanian assemblage, that she discovered in one of dark gray limestone blocks of Kichik-Soraman Mountain. This assemblage is comprised of representatives of *Propinacoceras*, *Sicanites*, *Agathiceras*, *Gastrioceratacea*e, *Almites*?, *Cardiella*, and *Crimites*. The Early Permian age of the assemblage is confirmed by the presence of representatives of *Crimites-C. gemmellaroi*, *C. hanieli*, *C.* sp. indet., and apparently *Almites-A.? pigneum*. Species of the genus *Cardiella* are not found in deposits older than Bolorian. Therefore, it would be most logical to assume that the limestone blocks containing these ammonoids belong to the Bolorian stage of the Lower Permian.

The generic composition of ammonoids from limestone blocks on the right side of one of the tributaries of the Marta River in the area of Kichkhi-Burnu Mountain [*Parapronorites*, *Propinacoceras*, *Medlicottia*?, *Thalassoceras*, *Agathiceras*, *Cardiella*, *Neocrimites* (*Sosiocrimites*), *Aricoceras*, *Palermites*, *Prostacheoceras*, *Tauroceras*, and *Paraceltites*] (with respect to our new evidence) is almost identical to the Kubergandian assemblage, that confirms the relevant conclusion initially drawn by Toumansky (1963). Noting the similarity of this assemblage with ammonoids from limestone of the Sosio Permian blocks, Toumansky (1963) correctly noted the absence of reliable representatives of *Waagenoceras* as well as *Hyattoceras*, *Doryceras*, *Clinolobus*, *Epiglyphioceras* (all known from Sicily). This list can be extended by the following genera: *Aristoceratoides*, *Altudoceras*, *Hoffmannia*, and *Sizilites*. Most of these genera are also not found
Aristoceratoides, *Altudoceras*, *Hoffmannia*, and *Sizilites*. Most of these genera are also not found
in the stratotype of Kubergandian stage.

We assume that the light grey limestone of Kichkhi-Burnu Mountain is of Kubergandian age [forms from the Kubergandian deposits of Southeastern Pamirs defined by Toumansky (1935) and Bogoslovskaya (Chedija *et al.* 1986) as *Popanoceras* are assigned to the genus *Tauroceras* in the present paper]. Grey limestone on the right-bank of the Alma River (Niknik Creek) yielding *Propinacoceras*, *Agathiceras*, *Cardiella*, *Adrianites*, *Stacheoceras*, and *Paraceltites*? is apparently of Kubergandian age.

Small foraminifers

Analysis of the Permian small foraminifers shows that there are five assemblages of different ages.

The oldest assemblage is found in two localities: in the Marta River Basin (Loc. 110/1, 2, 4, 6, 7, 9, 20, 21), and on the eastern flank of the Simferopol Reservoir (Loc. 125/1; Figs 4A, 5). The most typical species of the assemblage are *Neodiscus* aff. *N. milliloides* A. M.-Maclay and *Nodoinvolutaria jilinica* Han. The first occurs in the lower part of the Gnishik Formation (the *Neodiscus milliloides* zone) of Transcaucasia (Pronina 1990), and in the Qixia Group (*Eolasiodiscus-Neodiscus maopingensis* zone) of Daxiakou, Xingshan County, Hubei Province, China (Zheng 1986). However, it has been identified there as *Neodiscus maopingensis* Wang & Sun and *Glomospira duplicata* Lipina. *Nodoinvolutaria jilinica* Han has been known previously from the Miaoling Formation of northeastern China, that belongs to the *Neoschwagerina* zone (Han 1982). In addition to *Neodiscus* aff. *N. milliloides* A. M.-Maclay, the following species are in common within the Qixia Group – *Palaeotextularia pingguoensis* Lin, *P.* sp. (= *P. longiseptata* Lipina) and *Endothyra saucra* (Lin) (Zheng 1986). The presence of *Neodiscus* aff. *N. milliloides* A. M.-Maclay in this assemblage, a zonal species and index of the same named zone of Transcaucasia, permits us to correlate the assemblage of small foraminifers from Loc. 110 (except Loc. 110/5) and Loc. 125/1 to the *Neodiscus milliloides* zone of Transcaucasia, and to the *Eolasiodiscus-Neodiscus maopingensis* zone of Hubei Province of China. The last zone is correlated to the small foraminifer *Pseudo-*

zone of Hubei Province of China. The last zone is correlated to the small foraminifer *Pseudo-*

vidalina delicata-Langella-Neodiscus maopingensis zone and the fusulinid *Neoschwagerina simplex-Cancellina neoschwagerinoides* zone of the Xiangboan Stage of China (Sheng & Jin 1994), that correspond to the Kubergandian stage of the Tethyan scale or the Roadian of the stand-ard scale.

The second assemblage of small foraminifers has been recognised in the limestone of Cape Dzhien-Safu, Simferopol Reservoir (Loc. 111/2, 3, 7; Fig. 6B). Among the numerous foraminifers present, the following species are diagnostic – *Tetrataxis scita* Lin, *T. linea* Ozawa, *Abadehella hunanensis* (Lin), *Globivalvulina vonderschmitti* Reichel, *G.* aff. *G. permiana* Tcherdynzev, *Postendothyra novizkiana* (Sosnina), and *P. ussurica* (Sosnina). All species of this association occur in the Arpa Formation of Transcaucasia (Kotlyar *et al.* 1989). In addition, *Abadehella hunanensis* (Lin) and *Tetrataxis scita* Lin are known from the Douling Formation of the Chinese Province of Hubei and correlated with the upper part of the Maokou Formation of China (Lin 1985). Thus, the assemblage of small foraminifers from Cape Dzhien-Safu is considered to be early Midian of the Tethyan scale or late Wordian of the standard scale.

The third assemblage of small foraminifers was found in the limestone block on the right side of Izvestnyakovy Creek in the Alma River Basin at Loc. 122d (Fig. 4C). This assemblage contains a mixed fauna which occurs in the Arpa Formation [species: *Sphairionia* (*Pseudosphairionia*) *tienii* G. Pronina, *Pseudolangella geranossensis* G. Pronina, *P. dzhagadzurensis* G. Pronina, and *P. filumiformis* G. Pronina], and in the Khachik Formation (species: *Deckerella* sp. 1, *Globivalvulina cyprica* Reichel, *G. vonderschmitti* Reichel, *Orthovertella sphaerica* G. Pronina, *Baisalina pulchra* Reitlinger, *Septagathammina* sp., *Rectoglandulina gerkei* Sosnina, *Pachyphloia rimula* Sosnina, and *Partisania* sp. 1) of Transcaucasia (Kotlyar *et al.* 1989; Pronina 1990). The age of the association from Loc. 122d is most likely late Midian of the Tethyan scale or Capitanian of the standard scale. The early Midian species are probably

Tethyan scale or Capitanian of the standard scale. The early Midian species are probably

reworked.

The fourth assemblage of small foraminifers was found in the limestone block at locality 122b (Fig. 4C). This association is represented by species occurring in the uppermost Khachik and Dzhulfa formations, and in the lower part of the Akhura Formation of Transcaucasia (Kotlyar *et al.* 1989; Pronina 1990). Therefore, the age of this assemblage is considered to be Dzhulfian.

The fifth and the youngest association of small foraminifers has been found in a limestone block from Izvestnyakovy Creek in the Alma River Basin (Loc. 113; Fig. 4B). This assemblage contains a mixed fauna, that occurs in the uppermost Khachik and Dzhulfa formations and the lower part of the Akhura Formation (*Deckerella* aff. *D. elegans* Morozova, *Nodosaria mirabilis caucasica* K. M.-Maclay, *Agathammina* ex gr. *A. rosella* G. Pronina, and *Multidiscus* sp. 1), and in the Dorasham and the upper part of the Akhura Formations [*Postendothyra guangxiensis* (Lin), *Nodosaria dorachamensis* G. Pronina, *Pachyphloia paraovata* K. M.-Maclay, *P.* ex gr. *P. pigmobesa* Wang, *Pseudolangella dorachamensis* G. Pronina, *Colaniella* ex gr. *C. minima* Wang, and *C.* ex gr. *C. lepida* Wang] of Transcaucasia (Pronina 1990). Therefore, it is impossible to establish the exact age, but most likely, this assemblage is Dorashamian (Changsingian), and the Dzhulfian species are reworked.

Fusulinids

Fusulinids from the Crimea Permian exotic blocks have been studied by various workers (Toumansky 1941; Einor & Vdovenko 1959; Miklukho-Maklay 1963), and they have been correlated to various stratigraphical levels of Early Permian to Late Permian age. Davydov (1991) investigated fusulinids from 13 exotic blocks and numerous limestone pebbles. He recognized the following biostratigraphic levels: (1) *Misellina alicia*, *M. claudiae* of upper Bolorian age (Loc. 123/3); (2) *Cancellina cutalensis* of Kubergandian age (Loc. 125); (3) *Praesumatrina*, *Neoschwagerina simplex* (Loc. 110/1, 3, 4, 9, Loc. 111/1) of Lower Murgabian age; (4) *Neoschwagerina craticulifera*,
(Loc. 110/1, 3, 4, 9, Loc. 111/1) of Lower Murgabian age; (4) *Neoschwagerina craticulifera*,
Afghanella, *Sumatrina* of Murgabian age (Loc. 110/5); (5) *Neoschwagerina margaritae* of Midian age (Loc. 110/1a); (6) *Yabeina opima* of Midian age (Loc. 123/2); (7) *Pseudodunbarula minima*, *Paradunbarula dallyi* of Dzhulfian age (Loc. 113). According to Davydov (1991), the Crimea fusulinid succession ranging from Bolorian (Kungurian) to Late Permian (Dzhulfian) are typical Tethyan assemblages and are very similar to the fusulinid faunas from Elburz, Iran (Lys *et al.* 1978). The fusulinids from several Crimean exotic blocks (Loc. 110/20, 21, Loc. 122a-d) have been studied recently by Nestell (Pronina & Nestell 1997).

Six fusulinid assemblages appear to be present in the Crimean blocks.
The first assemblage occurs in a small limestone block at the margin of the Marjino Village within Simferopol area (Loc. 123/3). The most important forms are: *Misellina claudiae* (Deprat), *M. aliciae* (Deprat), *M. otakiensis* (Fujimoto), *M.* aff. *M. ermieri* (Deprat). According to Davydov (1991) and Leven (1980) these species are most characteristic for late Bolorian.

The second one is the most diverse and abundant. It occurs in the largest limestone block exposed in Marta River Basin (Loc. 110, except Loc. 110/5), and in a small block on the eastern side of the Simferopol Reservoir (Loc. 125/1, 2, Loc. 111/1). The most important and typical species of this assemblage are: *Neoschwagerina simplex* Ozawa, *Cancellina* (*Shengella*) *elliptica* Yang, *Cancellina* sp., *Praesumatrina neoschwagerinoides* (Deprat), *Chusenella schwageriniformis* Sheng, *Ch. chihsiaensis* (Lee), *Parafusulina* sp., and *Eopolydiexodina* sp. This assemblage belongs to the *Neoschwagerina simplex*-*Cancellina neoschwagerinoides* zone of the Xiangboan Stage of China (Sheng & Jin 1994). The age is most likely late Kubergandian.

The third assemblage occurs on the top of the largest limestone block from the Kichkhi-Burnu Mountain (Loc. 110/5). With the exception of some older reworking species such as *Armenina saraburiensis* Toriyama & Kanmera, *Cancellina*
some older reworking species such as *Armenina saraburiensis* Toriyama & Kanmera, *Cancellina*
sethaputi Kanmera & Toriyama and others, this

assemblage contains the typical Murgabian and even early Midian forms. Among them are *Verbeekina verbeeki* (Geinitz), *Neoschwagerina craticulifera* (Schwager), *N. colaniae* Ozawa, *N.* ex gr. *N. pinguis* Skinner, *Afganella schenki* Thompson, *Sumatrina* sp. Therefore, the age of this assemblage is considered to be Murgabian.

The fourth assemblage occurs in a limestone block at Cape Dzhien-Safu, Simferopol Reservoir (Loc. 111/2, 3, 3a). The most characteristic species are *Eopolydiexodina* sp., *Afghanella* cf. *A. sumatrinaeformis* (Gubler), *A.* sp., *Sumatrina rossica* A. M.-Maclay, *S. longissima* Deprat, *S. brevis* Leven, and *Kahlerina* sp. These species are early Midian in age in spite of the presence of older taxa (*Neoschwagerina simplex*, *Verbeekina*, *Armenina*). There is possibly some reworking of older forms in this block. However, there is clearly a definite internal stratigraphic succession present in parts of this block and until closely spaced samples are studied, the precise age of the block is not clear.

The fifth assemblage has been recognised in the limestone block on the right bank of Izvestnyakovy Creek in the Alma River Basin (Loc. 122d). The assemblage consists of mixed early Midian (late Wordian) and late Midian (Capitanian) species. Most likely, the age is late Midian or Capitanian. A late Midian (Capitanian) assemblage also has been found in small pebbles near Marjino Village (Loc. 123/2). Present in these pebbles are *Neoschwagerina craticulifera* (Schwager), *N.* cf. *N. kojensis* Toumansky, *N. pinguis* Skinner, *Yabeina opima* Skinner, *Y.* cf. *Y. globosa* Yabe, and *Y. orbiculata* Chedija.
The sixth fusulinid assemblage is from the limestone block at localities 122b and 113. It is probably Dzhulfian is age and contains *Codonofusiella* cf. *C. erki* Rauser and *Reichelina changhsingensis* Sheng & Chang.

Brachiopods
Permian brachiopods are confined to the largest limestone block in the Marta River Basin that is named Kichkhi-Burnu Mountain (Fig. 5). The analysis of brachiopod associations from separate
limestone block in the Marta River Basin that is named Kichkhi-Burnu Mountain (Fig. 5). The
parts of this block permits two assemblages to be distinguished.
The oldest and most representative assemblage is characteristic of most of the Marta River block (Loc. 110/1-3, 7, 9, 10, 21). These assemblages are characterised by a predominance of Bolorian-Kubergandian species. *Rugaria molengraaffi* (Broili), *Urushtenia murina* (Grant), *Comuquia modesta* Grant, *Transennatia gratiosa* (Waagen), *Bilotina acantha* (Waterhouse & Piyasin), *Linoproductus kaseti* Grant, *Anomaloria glomerosa* Grant, *Phricodothyris asiatica* (Chao) occur in the Rat Buri Limestone of Thailand (Grant 1976). *Rugaria molengraaffi* (Broili) is described from the Bitauni block of Timor (Broili 1915), *Enteletes geniculatus* Licharew, *Echinoconchus fasciatus* (Kutorga), *Phricodothyris asiatica* (Chao), *Hemiptychina darvasica* Tschernyschew are known from Bolorian-Kubergandian deposits of the Darvaz, *Echinoconchus fasciatus* (Kutorga) and *Marginifera carniolica* (Schellwien) – from the Trogkofel Limestone of the Carnic Alps and Karawanken (Schellwien 1900). A number of species have also been described from Murgabian and Midian deposits in some regions of the Tethys. *Ogbinia dzhagrensis* Sarytcheva is known from the Gnishik Formation of Transcaucasia (*Neoschwagerina simplex* and *N. craticulifera* zones), and *Enteletes sublaevis* Waagen is from the Wargal Formation in Salt Range of Pakistan, *Martinia ceres* (Gemmellaro), *Rostranteris inflatum* (Gemmellaro) is from the Sosio Permian blocks of Italy. However, these species are also frequently recorded in deposits older than Murgabian and Midian. This assemblage occurs with the small foraminifers and fusulinids of the *Neoschwagerina simplex-Cancellina neoschwagerinoides* zone, that is attributed to the Chihsian Series (Sheng & Jin 1994) and with Kubergandian (Roadian) ammonoids. So, the age brachiopod assemblage from the above-mentioned localities is most likely late Kubergandian.

The second assemblage occurs only at the top of Kichkhi-Burnu Mountain (Loc. 110/8). It is extremely scarce and is represented only by a few species – *Ogbinia dzhagrensis* Sarytcheva, *Transennatia gratiosa* (Waagen), *Uncinunellina* cf.
extremely scarce and is represented only by a few species – *Ogbinia dzhagrensis* Sarytcheva,

U. amor (Gemmellaro), and *Permophricodothyris pulcherrima* (Gemmellaro). All of the species are characteristic of Murgabian and lower Midian (or Upper Wordian) deposits in the Tethyan Realm, although they also occur in older formations.

However, it should be added that previously other Midian and younger species have been reported from the Marta River block. Species of Dorashamian age, such as *Geyerella tschernyschewi* Licharew, "*Plicatifera*" cf. "*P.*" *bajarunassi* Licharew, *Richthofenia caucasica* Licharew, *Leptodus richthofeni* Kayser, *Camarophoria paronae* Gemmellaro, and *Jisuina nikitini* Gemmellaro, have been reported (Einor & Vdovenko 1959; Licharew 1966). Therefore, within Kichkhi-Burnu Mountain there are probably blocks of various ages, even of younger age than Midian.

Sphinctozoans

Permian sphinctozoans of the Crimea are represented by five genera – *Colospongia* Laube, *Crymocoelia* Belyaeva, *Vesicotubularia* Belyaeva, *Paradeningeria* Senowbary-Daryan & Schafer, 1979 and, *Sollasia* Steinmann, 1882. Representatives of *Colospongia* are wide-spread in Upper Carboniferous-Upper Triassic deposits of the former USSR. Species of this genus occurring in the Crimea are very similar in the shape of chambers, character of their function, size and abundance of vesicles to *C. salinaria* (Waagen & Wentzel) known from the Upper Permian of China and India, as well as from the Upper Triassic of North America, and the European Alps.

The species *Crymocoelia zacharovi* Belyaeva, the type species of the recently established genus, was described from the Permian of the Crimea, and representatives of the genus are as yet unknown from other places. The nature of the porosity of the catenulate branches of this retrosiphonate type allows the Crimean form to be assigned to the family Sebargasiidae. Within this family, these forms are most similar to *Amblysiphonella* Steinmann, 1882. That genus is the most abundant among fossil sphinctozoans from a systematic viewpoint and its age ranges
the most abundant among fossil sphinctozoans from a systematic viewpoint and its age ranges
from the Ordovician to the Upper Triassic. However, *Crymocoelia*, unlike closely similar forms, is noted for a complex porosity of the siphon wall, that is very rare for sphinctozoans.

Vesicotubularia prima Belyaeva was also first described from the Crimea and is similar to the previous genus. These forms are very peculiar sphinctozoans, where an important part of the skeletal structure is their vesicular (bubble) tissue. Representatives of the genus *Vesicocaulis*, particularly *V. alpinus* Ott from the Upper Triassic of the Alps is noted for an aporate character. Such taxa are most closely related to the described Crimean form in their shape and skeletal structure. Representatives of the genus *Vesicocaulis* are known only from Triassic deposits of the Alps, Pamirs and a few other regions.

Until recently, the genus *Paradeningeria* was known only from the Upper Triassic of the Pamirs, Alps, Himalayas, and North America. Permian representatives of *Paradeningeria* in the Crimea belong to the recently established species, *P. martaensis* Belyaeva. Species of the genus *Sollasia* are prevalent in the Upper Permian of Cambodia, Tunisia, Sicily, Venezuela, Texas, and the Far East part of Asia. Isolated occurrences are known in the Triassic of the North Caucasus and the Far East.

Generally, the collection of sphinctozoans from the Permian of the Crimea is rather small and, thus, is probably poor in terms of its systematic composition. The taxa, *Crymocoelia zacharovi* and *Vesicotubularia prima*, are not diagnostic for determining the age of investigated blocks. As far as the other taxa are concerned, *Colospongia* cf. *C. salinaria*, representatives of the genera *Paradeningeria* and *Sollasia* have a wide age distribution from Late Permian to Late Triassic.

Summary of the Permian

1. Study of Crimean Permian exotic limestone blocks demonstrates that carbonate sedimentation from the late Bolorian to practically the end of the Permian occurred in the basin from which these blocks were derived. A depositional environment on a shallow carbonate shelf is indicated for these limestone blocks are predominantly reefogenic.
ted for these limestone blocks are predominantly reefogenic.

2. The analysis of all faunal groups from the

Permian exotic blocks and pebbles shows that they contain rich assemblages of primarily small foraminifers and fusulinids. Brachiopods, ammonoids, trilobites, and sphinctozoans are minor constituents of these assemblages.

3. The distribution of fossils points not only to different ages for the various isolated blocks, but also in certain blocks to different ages of various parts of the same block. Sometimes an internal stratigraphic structure is evident in the larger blocks, for example, at the large block at Dzhien-Safu. Mixing of zonal species is often observed, that interferes with precise age determination, even to stage level (Loc. 122).

4. The taxonomic composition of all studied groups definitely points to the Tethyan composition of the faunas. Almost all zonal assemblages of the Bolorian, Kubergandian, Murgabian, Midian, as well as of the Dzhulfian and Dorashamian are present. Fusulinid associations display the greatest similarity to the Elburz assemblages of northern Iran (Davydov 1991). Small foraminifers are comparable with those found in similar age sediments in China, the Far East and Transcaucasia. The brachiopods are like those from Sicily, Thailand and Iran, and ammonoids are comparable with Sicily and Central Asia assemblages.

5. A new Permian small block was discovered on the right bank of the Bodrak River with a small foraminifers fauna. The age of the assemblage from this block is most likely Dzhulfian or Dorashamian (Changsingian).

6. New data concerning the stage to which the *Neoschwagerina simplex-Praesumatrina neoschwagerinoides* zone belongs is most important. Ammonoids found together with a fusulinid assemblage of this zone are clearly Kubergandian or Roadian, according to Zakharov. A Kubergandian (Roadian) age is also confirmed by the small foraminifers of the *Neoschwagerina simplex* zone and, to a certain extent, by brachiopods whose assemblage is dominated by Bolorian and Kubergandian species. This data of the conclusion fully confirms previous researchers concerning assignment of the *Neoschwagerina simplex-Praesumatrina neoschwagerinoides* zone to the Kubergandian (Sheng & Jin 1994; Kotlyar & Pronina 1995).

simplex-Praesumatrina neoschwagerinoides zone to the Kubergandian (Sheng & Jin 1994; Kotlyar &

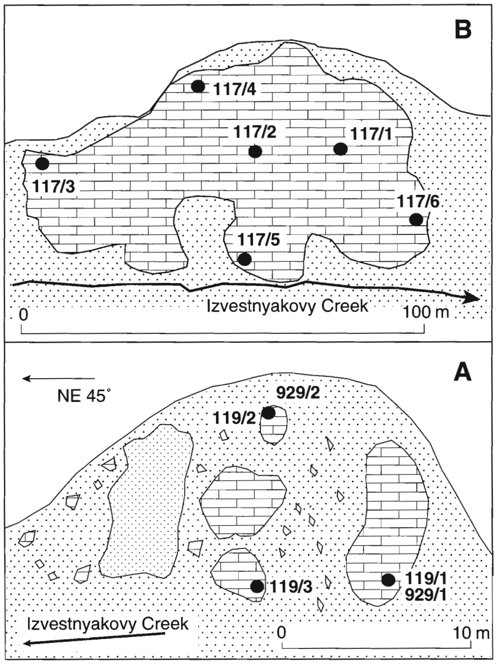

FIG. 7. — Locations of collection sites at the Triassic exotic blocks along Izvestnyakovy Creek in the Alma River Basin; **A**, locality 117; **B**, locality 119. Matrix consists of the deposits of the Mender subunit (Eskiorda Complex).

TRIASSIC EXOTIC BLOCKS

ALMA RIVER BASIN

Triassic limestone blocks occur mainly in the area of Izvestnyakovy Creek and in the Bodrak River area in the Alma River Basin (Fig. 4B). On Izvestnyakovy Creek (Fig. 4B) there are four localities (Locs 116-119) from which Pronina & Vuks (1996) have described the foraminifera. In the Bodrak River at Shvanov Ravine (Loc. 132), a brachiopod assemblage has been determined by Dagis (Dagis & Shvanov 1965).

Loc. 116

This locality crops out on the left bank of Izvestnyakovy Creek about 750 m from its mouth. There are blocks of grey and light gray micritic limestone in size up to 4.5 m across. The main block is a calcilutite wackestone containing small fragments of echinoids and crinoids. Other elements are foraminifers and brachiopods.

main block is a calcilutite wackestone containing small fragments of echinoids and crinoids. Other

Foraminifers. *Tolypammina irregularis* (Salaj, Borza & Samuel), *Pilamminella gemerica* (Salaj), *Gaudryina triadica* Kristan-Tollmann, *Malayspirina* ex gr. *M. alpina* (Zaninetti & Broennimann), "*Calcitornella*" *gebzeensis* Dager, *Coronipora etrusca* (Pirini), *Semiinvoluta bicarinata* Blau, *S. clari* Kristan, *Lamelliconus turris* (Frentzen), *Arenovidalina chialingchiangensis* Ho, *Ophthalmidium lucidum* (Trifonova), *O. triadicum* (Kristan), *Sigmoilina bystrickyi* Salaj, Borza & Samuel, *Nodosaria* cf. *N. dipartita* Kristan-Tollmann, *N.* sp. 1, *Pseudonodosaria* cf. *P. vulgata multicamerata* (Kristan-Tollmann), *Pachyphloides*? sp., *Austrocolomia canaliculata* (Kristan-Tollmann), *Dentalina zlambachensis* Kristan, *Lenticulina rectangula* Kristan-Tollmann, *Duostomina* sp.
Brachiopods. *Euxinella anatolica* (Bittner), *Laballa suessi* (Winkler), *L. slavini* Dagys, *Sinucosta emmrichi* (Suess), *Zugmayerella koessenensis* (Zugmayer), *Oxycolpella oxycolpos* (Emmrich), *Neoretzia superbescens* (Bittner), *Amphiclina intermedia* Bittner, *A. taurica* Moiseev, *Rhaetina turcica* (Bittner), *Triadithyris gregariaformis* (Zugmayer), *Zeilleria bukowski* (Bittner), *Aulacothyropsis almensis* (Moiseev).

Loc. 117 (Fig. 7B)
This is a giant limestone block (100 m × 60 m), occuring on the left bank of Izvestnyakovy Creek about 1.5 km upstream from Loc. 116, and showing an inhomogeneous texture. Due to the non-stratified aspect of the block, the general micritic matrix pink colored in some part, and the presence of numerous cavities with geopetal calcitic cement, we consider that this block is part of a mudmound. Three sampled sites have been analysed from this block.

Loc. 117/sample 1
Foraminifers. *Tolypammina irregularis* (Salaj, Borza & Samuel), *T. gregaria* Wendt, *Spiroplectammina spiralis* Salaj, Borza & Samuel, *Trochammina almtalensis* Koehn-Zaninetti, *Duotaxis inflatus* (Kristan-Tollmann), *Textularia* ex gr. *T. exigua* (Schwager), *Endoteba kuepperi* (Oberhauser), *Malayspirina* sp., *Meandrospirella*? sp., *Semiinvoluta bicarinata* Blau, *S. clari* Kristan,
(Oberhauser), *Malayspirina* sp., *Meandrospirella*? sp., *Semiinvoluta bicarinata* Blau, *S. clari* Kristan,
Arenovidalina chialingchiangensis Ho, *Nodosaria simplex* (Terquem), "*Frondicularia woodwardi*" Howchin, *Austrocolomia* sp., *Lenticulina goettingensis polygonata* (Franke), *Diplotremina astrofimbriata* Kristan-Tollmann, *Duostomina* sp.
Brachiopods. *Euxinella anatolica* (Bittner), *Crurirhynchia kiparisovae* Dagys, *Laballa slavini* Dagys, *Zugmayerella koessenensis* (Zugmayer), *Sinucosta emmrichi* (Suess), *Oxycolpella oxycolpos* (Emmrich), *Neoretzia superbescens* (Bittner), *Amphiclina intermedia* Bittner, *A. taurica* Moiseev, *Rhaetina taurica* Moiseev, *Triadithyris gregariaformis* (Zugmayer). Besides these, Dagis (1963, 1974) determined *Rhaetina* cf. *R. pyriformis* (Suess), *R. turcica* (Bittner), *Zeilleria bukowski* (Bittner), *Aulacothyropsis almensis* (Moiseev).

Loc. 117/sample 2
A brachiopod assemblage analogous to locality 117/1 has been collected from pink micritic limestone. Only three species – *Amphiclina intermedia* Bittner, *Rhaetina taurica* (Bittner), and *Zeilleria bukowski* (Bittner) – are absent from those listed in Loc. 117/1.

Loc. 117/sample 3
Foraminifers. *Tolypammina irregularis* (Salaj, Borza & Samuel), *T. gregaria* Wendt, *Ammobaculites* sp., *Duotaxis inflatus* (Kristan-Tollmann), *Gaudryina triadica* Kristan-Tollmann, *G. racema* Trifonova, *Planiinvoluta deflexa* Leischner, *Semiinvoluta bicarinata* Blau, *Angulodiscus parallelus* (Kristan-Tollmann), *Arenovidalina chialingchiangensis* Ho, *A. depressa* (Luperto), *Ophthalmidium carinatum* Leischner, *O. fusiformis* (Trifonova), *O.* cf. *O. martanum* Farinacci, *O. tori* Zaninetti & Broennimann, *Sigmoilina schaeferae* Zaninetti, Altiner, Dager & Ducret, *Nodosaria* cf. *N. angulocamerata* Efimova, *N.* cf. *N. elongata* (Salaj, Borza & Samuel), *N.* aff. *N. shablensis* Trifonova, *Lenticulina* sp., *Astacolus* sp., *Turrispirillina* sp.
Brachiopods. *Euxinella anatolica* (Bittner), *Robinsonella mastakanensis* Moiseev, *Laballa slavini* Dagys, *Zugmayerella koessenensis* (Zugmayer), *Sinucosta emmrichi* (Suess), *Oxycolpella oxycolpos* (Emmrich), *Neoretzia superbescens* (Bittner), *Rhaetina pyriformis* (Suess), *R. gregaria* (Suess), *Zeilleria moisseievi* Dagys, *Z. austrica* (Zugmayer).
Ammonoids. *Megaphyllites* sp.
Zeilleria moisseievi Dagys, *Z. austrica* (Zugmayer).
Ammonoids. *Megaphyllites* sp.
Crinoids and corals are also present.

Loc. 118
This block (4.5 m × 2.0 m) is located 135 m upstream from Loc. 117 on Izvestnyakovy Creek and is composed of light gray micritic limestone. It has yielded the following brachiopods – *Rhaetina taurica* Moiseev, *Neoretzia superbescens* (Bittner), *Zeilleria austrica* (Zugmayer).

Loc. 119
Down the creek from locality 117, four limestone blocks ranging from 1.5-5 m across were found, as well as smaller angular limestone fragments (Fig. 7A).

Loc. 119/sample 1, 929-1
This is the largest block, about 5 m across, and consists of a coarse biocalcarenite grainstone with radiaxal cement and mud late infilling. The skeletal elements are crinoids, brachiopods, echinoids, gastropods, sponges, foraminifers and intraclasts. The environment is of a shallow, high-energy carbonate platform.
Foraminifers. *Tolypammina gregaria* Wendt, *Trochammina almtalensis* Koehn-Zaninetti, *T. jaunensis* Broennimann & Page, *Duotaxis inflatus* (Kristan-Tollmann), *D. metula* Kristan, *Gaudryina triadica* Kristan-Tollmann, *G. triassica* Trifonova, *Palaeolituonella meridionalis* (Luperto), *Textularia* ex gr. *T. exigua* (Schwager), *Endoteba austrotriadica* (Oberhauser), *E. kuepperi* (Oberhauser), *Malayspirina bicamerata* (Salaj), *M. wirtzi* (Koehn-Zaninetti), "*Calcitornella*" *gebzeensis* Dager, *Planiinvoluta carinata* Leischner, *Coronipora etrusca* (Pirini), *Semiinvoluta bicarinata* Blau, *S. clari* Kristan, *S. violae* Blau, *Lamelliconus turris* (Frentzen), *L. multispirus* (Oberhauser), *Trochonella granosa* (Frentzen), *Arenovidalina chialingchiangensis* Ho, *Ophthal-midium exiguum* Koehn-Zaninetti, *O. fusiformis* (Trifonova), *O. leischneri* (Kristan-Tollmann), *O. lucidum* (Trifonova), *O. triadicum* (Kristan), *Sigmoilina bystrickyi* Salaj, Borza & Samuel, *S. plectospira* (Oravecz-Scheffer), *Galeanella panticae* Zaninetti & Broennimann, *Miliolipora cuvillieri* Broennimann & Zaninetti, *Ophtalmipora*? sp., *Nodosaria* sp. 1, *Septalingulina* cf. *S. tetrasepta* He & Norling, *Austrocolomia* ex gr. *A. canaliculata* (Kristan-Tollmann), *Lenticulina rectangula* Kristan-Tollmann, *Astacolus* sp., *Duostomina* sp.
& Norling, *Austrocolomia* ex gr. *A. canaliculata* (Kristan-Tollmann), *Lenticulina rectangula*

Brachiopods. *Oxycolpella oxycolpos* (Emmrich), *Rhaetina pyriformis* (Suess).

Loc. 119/sample 2, 929-2
This sample is a fine-grained, mud supported biocalcilutite with crinoids, foraminifers, thin-shelled ostracods and bryozoan fragments. The numerous cavities with light mud infilling are typical of a mudmound on a shallow slope.
Foraminifers. *Gaudryina triassica* Trifonova, *Coronipora etrusca* (Pirini), *Semiinvoluta bicarinata* Blau, *Angulodiscus* ex gr. *A. expansus* (Kristan-Tollmann), *Paraophthalmidium* sp., *Ophthalmidium fusiformis* (Trifonova), *O.* cf. *O. martanum* Farinacci, *O.* sp. 1, *Quinqueloculina*? *nucleiformis* Kristan-Tollmann, *Sigmoilina bystrickyi* Salaj, Borza & Samuel, *S. plectospira* (Oravecz-Scheffer), *S. schaeferae* Zaninetti, Altiner, Dager & Ducret, *Nodosaria* cf. *N. elongata* (Salaj, Borza & Samuel), *N. nitida elongata* Franke, "*Frondicularia woodwardi*" Howchin, *Austrocolomia canaliculata* (Kristan-Tollmann), *A. marschalli* Oberhauser, *Lenticulina* sp.
Brachiopods. *Euxinella anatolica* (Bittner), *Septaliphoria fissicostata* (Suess), *Crurirhynchia kiparisovae* Dagys, *Laballa suessi* (Winkler), *Oxycolpella oxycolpos* (Emmrich), *O. robinsoni* Dagys, *Amphiclina taurica* Moiseev, *Triadithyris gregariaformis* (Zugmayer).

Loc. 119/sample 3
This block consists of graded, resedimented pinkish fine wackestone – coarse skeletal packstone with echinoids, crinoids, brachiopods and foraminifers. This is a considered to be a distal slope deposit.
Foraminifers. *Tolypammina gregaria* Wendt, *Coronipora etrusca* (Pirini), *Semiinvoluta bicarinata* Blau, *Lamelliconus turris* (Frentzen), *Ophthalmidium leischneri* (Kristan-Tollmann), *O. lucidum* (Trifonova), *Sigmoilina bystrickyi* Salaj, Borza & Samuel, *S. schaeferae* Zaninetti, Altiner, Dager & Ducret, *Miliolipora cuvillieri* Broennimann & Zaninetti, *Nodosaria* sp. 1, *Rectoglandulina*? sp., *Lenticulina* sp., *Duostomina* sp., *Turrispirillina*? *licia licia* Blau.

Loc. 121a
Loc. 121a
Numerous exotic blocks of gray limestone occur

near Drovyanka Village. The species *Monotis caucasica* (Wittenburg) and *M. haueri* Kittl were found (determination of A. Moiseev and I. Polubotko).

Loc. 132

A brachiopod assemblage of Shvanov Ravine contains *Costirhynchia mentzeli* (Buch), *Hirsutella hirsuta* (Alberti), *Mentzelia* sp., *Koeveskallina koeveskalliensis* (Boeckh), *Punctospirella* cf. *P. fragilis* (Schlotheim), *Costispiriferina* cf. *C. manca* (Bittner), *Angustothyris angustaeformis* (Boeckh). This assemblage is of Anisian age. However, we cannot confirm that this assemblage is coming from an exotic block, and not from the matrix.

SIMFEROPOL AREA

Loc. 130

The second important location of Triassic exotic blocks is in the Salgir River Basin in the Simferopol area (Fig. 4A). Some blocks, separated from each other, were observed near Petropavlovka Village (Loc. 130) in the sandstone and conglomerate of the Eskiorda Series.

The block of Loc. 130 is a crinoid and algal lime-packstone yielding abundant brachiopods, single ammonoids, bivalves, and gastropods. The brachiopod assemblage contains – *Euxinella anatolica* (Bittner), *Laballa seessi* (Winkler), *L. slavini* Dagys, *Sinucosta emmrichi* (Suess), *Zugmayerella koessensis* (Zugmayer), *Oxycolpella oxycolpos* (Emmrich), *Amphiclina taurica* Moiseev, *Rhaetina taurica* Moiseev, *Lobothyris* sp., *Zeilleria bukowski* (Bittner), *Aulacothyropsis elmensis* (Moiseev). This data is compiled from earlier workers (Moiseev 1932; Dagis 1963, 1974; Shalimov & Slavin 1973).

The following ammonoids occur with these brachiopods: *Paracladiscites diuturnum* Mojsisovich, *Arcestes* ex gr. *A. intuslabiatus* Mojsisovich, and *Platites* sp. Shevyrev (1990) correlated to the upper Rhaetian or the *Choristoceras marshi* zone of the standard scale.

ANALYSIS OF FAUNAL ASSEMBLAGES

Ammonoids

Ammonoids are rare in the pink limestone out-

Ammonoids

Ammonoids are rare in the pink limestone out-
cropping on the upper part of Izvestnyakovy Creek (Loc. 117/3). Only one shell, *Megaphyllites* sp., was preserved well enough to be determined by us. Representatives of this genus are recorded from the upper part of the Lower Triassic into the Upper Triassic. Within the Alpine Region, they are known only from the upper Anisian to Rhaetian.

Foraminifers

Pronina & Vuks (1996) gave the first detailed information about Triassic foraminifers of the Crimea. All of the foraminifers that were studied occur in exotic blocks (Locs 116, 117, 119; Figs 4B, 7). The assemblages are of similar generic and specific composition, which allows them to be considered the same age. They are characterized by the presence of miliolids and involutinids, the most significance foraminifers for dating Lower Mesozoic deposits.

In this assemblage, the following species are known in Norian-Rhaetian deposits: *Semiinvoluta clari* Kristan, *Angulodiscus parallelus* (Kristan-Tollmann), *A.* ex gr. *A. expansus* (Kristan-Tollmann), *Sigmoilina bystrickyi* Salaj, Borza & Samuel, *S. schaeferae* Zaninetti, Altiner, Dager & Ducret, *Galeanella panticae* Zaninetti & Broennimann, *Miliolipora cuvillieri* Broennimann & Zaninetti. In addition, species are present that occur in deposits not older than the Rhaetian, and sometimes even in younger deposits: *Semiinvoluta bicarinata* Blau, *Trochonella granosa* Frentzen, *Ophthalmidium leischneri* (Kristan-Tollmann), *Septalingulina tetrasepta* He & Norling, and *Turrispirillina? licia licia* Blau.

Considered together, the foraminiferal assemblages of the Crimea are similar: to the late Norian (Sevatian)-Rhaetian of the Khodz Group of the Northwest Caucasus (Efimova 1975; Anonymous 1991); to the late Norian (Lacian-Sevatian) *Miliolipora cuvillieri* standard zone of the Carpathian-Balkan and Hellenic Realm (Salaj *et al.* 1983, 1988); to the upper Norian Kocagedik unit of Turkey (Altiner & Zaninetti 1981); and to the Norian-Rhaetian Asinepe Limestone of Seram, Indonesia (Al-Shaibani *et al.* 1983).

Accordingly, we conclude that the age of the foraminiferal assemblages of the Crimea can be

Accordingly, we conclude that the age of the foraminiferal assemblages of the Crimea can be
either late Norian or Rhaetian. Most likely, the

age is Rhaetian, because species are in the associations whose distribution is limited to the Rhaetian. However one Rhaetian index species, *Triasina hantkeni* Majzon, was not found in the Crimea blocks.

Brachiopods

Moiseev (1926, 1932) studied the first Triassic brachiopods from exotic blocks of the Crimea. Later, the numerous brachiopods collected by Moiseev, Shalimov, and Slavin were determined and partly described by Dagis (1963, 1974). The brachiopod assemblages were considered to be the of mixed Norian-Rhaetian age.

Dagis identified the Middle Triassic brachiopod assemblage in Shvanov Ravine in the Bodrak River Basin (Loc. 132). It contains *Costirhynchia mentzeli* (Buch), *Hirsutella hirsuta* (Alberti), *Mentzelia* sp., *Koeveskallina koeveskalliensis* (Boeckh), *Punctospirella* cf. *P. fragilis* (Schlotheim), *Costispiriferina* cf. *C. manca* (Bittner), and *Angustothyris angustaeformis* (Boeckh). These brachiopods are of Anisian age (Dagis & Shvanov 1965). However, we cannot confirm that this assemblage is characteristic of the exotic blocks, and not of the matrix.

New investigation of the brachiopod assemblages from the numerous limestone blocks and pebbles of the Crimea confirms the specific composition, and more precisely, defines their stage and zonal position. Analysis of all Triassic brachiopod associations from investigated exotic blocks shows that there is only one distinctive brachiopod assemblage of Rhaetian age. It occurs in the large (Loc. 117) and smaller (Locs 116, 118, 119) limestone blocks and pebbles exposed in the Alma River Basin, and in the valley of Izvestnyakovy Creek (Fig. 4B, 7). The same brachiopod assemblage has been found in the Salgir River Basin near Petropavlovka Village (Loc. 130).

Rhaetian species from different regions of the West Tethys dominate this assemblage. They are – *Robinsonella mastakanensis* Moiseev, *Septaliphoria fissicostata* (Suess), *Laballa suessi* (Winkler), *Zugmayerella koessenensis* (Zugmayer), *Sinucosta emmrichi* (Suess), *Oxycolpella oxycolpos* (Emmrich), *Neoretzia superbescens* (Bittner),

(Winkler), *Zugmayerella koessenensis* (Zugmayer), *Sinucosta emmrichi* (Suess), *Oxycolpella oxycolpos* (Emmrich), *Neoretzia superbescens* (Bittner),

Rhaetina gregaria (Suess), *R. pyriformis* (Suess), *Triadithyris gregariaformis* (Zugmayer), *Zeilleria austrica* (Zugmayer), and *Z. bukowski* (Bittner).

The Crimea brachiopod assemblage is most similar to the Rhaetian brachiopods from the Koessen beds of Alps (Dagis 1974). The following species are common – *Septaliphoria fissicostata* (Suess), *Laballa suessi* (Winkler), *Zugmayerella koessenensis* (Zugmayer), *Sinucosta emmrichi* (Suess), *Oxycolpella oxycolpos* (Emmrich), *Rhaetina gregaria* (Suess), and *Triadithyris gregariaformis* (Zugmayer). The Crimea brachiopod assemblage is also similar to Rhaetian brachiopods of Drnava Slovenia. The common forms are *Septaliforia fissicostata* (Suess), *Laballa suessi* (Winkler), *Zugmayerella koessenensis* (Zugmayer), *Sinucosta emmrichi* (Suess), *Neoretzia superbescens* (Bittner), *Rhaetina pyriformis* (Suess), *Triadithyris gregariaformis* (Zugmayer), and *Zeilleria austrica* (Zugmayer) (Dagis 1974). Likewise, the assemblage is comparable to *Majkopella manzavini* beds of Turkey. The common forms are *Euxinella anatolica* (Bittner), *Laballa suessi* (Winkler), *Sinucosta emmrichi* (Suess), *Rhaetina turcica* (Bittner), *Zeilleria austrica* (Zugmayer), and *Z. bukowski* (Bittner) (Bittner 1892). Finally, they are similar to the brachiopods collected from exotic blocks of Balkanian. The common forms are *Zugmayerella koessenensis* (Zugmayer), *Sinucosta emmrichi* (Suess), *Oxycolpella oxycolpos* (Emmrich), *Amphiclina intermedia* Bittner, *Rhaetina gregaria* (Suess), and *R. turcica* (Bittner) (Dagis 1963).

The red limestone of the upper part of the Khodz Group of the Northwest Caucasus, that lies above beds with *Monotis caucasica*, is the same age as the Crimea exotic blocks. They both contain species in common – *Euxinella anatolica* (Bittner), *Crurirhynchia kiparisovae* Dagys, *Zugmayerella koessenensis* (Zugmayer), *Sinucosta emmrichi* (Suess), *Oxycolpella oxycolpos* (Emmrich), *Neoretzia superbescens* (Bittner), *Amphiclina intermedia* Bittner, *A. taurica* Moiseev, *Rhaetina turcica* (Bittner), *R. pyriformis* (Suess), *Zeilleria bukowski* (Bittner), and *Z. moisseievi* Dagys.

All the above-mentioned brachiopod assemblages, considered earlier as Norian-Rhaetian, are actually the youngest Rhaetian associations. We

All the above-mentioned brachiopod assemblages, considered earlier as Norian-Rhaetian, are actually the youngest Rhaetian associations. We

agree with Shevryev (1990, 1995) that they can be attributed to the *Vandaites sturzenbaumi* zone. Co-occurrence of these brachiopod assemblages and such ammonoid species as *Paracladiscites diuturnus* Mojsisovich, *Arcestes* ex gr. *A. intuslabiatus* Mojsisovich, and *Platites* sp., that were established as beds with *Platites-Rhacophyllites* near Petropavlovka Village (Shevyrev 1995), allow us to specify the stage and zonal position of this association. An analogous, but more diverse, ammonoid association occurs together with Rhaetian brachiopods in other regions of the Tethys, including the Northwest Caucasus in the upper part of the Khodz Group. It is represented by the presence of *Paracladiscites diuturnus* Mojsisovich, *Megaphyllites insectus* (Mojsisovich), *Stenarcestes leiostracus* Mojsisovich, *Arcestes* ex gr. *A. intuslabiatus* Mojsisovich, *Rhacophyllites debilis* (Hauer), *Platites polydactilus* (Mojsisovich) (Shevyrev 1995). Everywhere in the West Tethys, Rhaetian brachiopod assemblages usually occur in pink or red limestone.

The Norian-Rhaetian, but not Rhaetian age, of the above-mentioned mixed brachiopod association has been determined by the presence in these beds of Norian ammonoids. However, Shevyrev (1990) believes that the appearance and great development of heteromorph ceratites is an important event in the Late Triassic ammonoid succession. It allows one to consider the Rhaetian as important in the development of Triassic ammonoids. Nevertheless, we are following Dagis (Dagis & Dagis 1990) in drawing the Rhaetian lower boundary at the base of the *Cachloceras suessi* zone.

Summary of the Triassic

1. Triassic exotic blocks contain rich assemblages of foraminifers, brachiopods, rarer ammonoids, bivalves, and sphictozoans. Reworked forms are practically absent.

2. The taxonomic composition of the brachiopods and ammonoids shows the greatest similarity to Rhaetian assemblages of the West Tethys, the Northwest Caucasus, the Alps, the Carpathians, and Turkey. The foraminifers are most similar to those in the Northwest Caucasus, the Carpathian-Balkan and Hellenic Realm, Carpathians, and Turkey. The foraminifers are most similar to those in the Northwest Caucasus, the Carpathian-Balkan and Hellenic Realm, Turkey, and Indonesia.

3. Some limestone blocks (Loc. 121a) containing abundant *Monotis* belong to the *Sagenites quinquepunctatus* zone of the Sevatian (Dagis & Dagis 1990), or to the upper part of the Norian.

4. The analysis of faunal elements from Triassic exotic blocks (Locs 116-119, 130) allows us to consider that they are of Rhaetian age and according to Dagis & Dagis (1990) belong to the *Vandaites sturzenbaumi* zone.

5. The Anisian fauna from the Bodrak River Basin probably does not come from an exotic block.

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