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THE RUSSIAN PLATFORM AS A KEY REGION FOR VOLGIAN/TITHONIAN CORRELATION: A REVIEW OF THE MEDITERRANEAN FAUNAL ELEMENTS AND AMMONITE BIOSTRATIGRAPHY OF THE VOLGIAN STAGE

MIKHAIL A. ROGOV[1]

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Key words. Jurassic, Volgian, Tithonian, Boreal-Tethyan correlation, ammonites, biostratigraphy, Russian Platform.

Abstract. A review of the ammonite faunas and biostratigraphy of the uppermost Kimmeridgian - lowermost Middle Volgian of Central Russia is presented. The major role of the Sub-mediterranean ammonites in the Volgian assemblages is described, providing additional detail to the existing scheme of Tithonian-Volgian correlations. The base of the Tithonian and the base of the Volgian are coincident, based on the association of *Neochetoceras steraspis-Lingulaticeras solenoides*. The Klimovi Zone corresponds to most of the Hybonotum Zone. However, the top of the Hybonotum Zone, based on the distribution of *Paralingulaticeras*, falls within the Sokolovi Zone. The allocation of a Tenuicostata Subzone (with two horizons: *neoburgense* and *puschi*) in the Pseudoscythica Zone is proven. The *neoburgense* horizon may be correlated with the *ciliata* and *penicillatum* horizons of Neuburg and, probably, with the Semiforme Zone. The findings of *Lingulaticeras blaschkei*, *Pseudolissoceras*, and *Sutneria* in the Panderi Zone of the Middle Tithonian suggest that the base of the Middle Volgian may not be younger than the Middle Tithonian Fallauxi Zone.

Riassunto. Viene fornita una revisione delle faune ad ammoniti e della biostratigrafia dalla sommità del Kimmeridgiano alla parte più bassa del Volgiano medio della Russia centrale. Viene descritto il ruolo principale degli ammoniti submediterranei nelle associazioni Volgiane. Ciò permette di specificare l'esistente schema di correlazione Titoniano-Volgiano. Fondandosi sull'associazione *Neochetoceras steraspis-Lingulaticeras solenoides*, la base del Titoniano e la base del Volgiano coincidono. La Zona a Klimovi corrisponde alla maggior parte della Zona ad Hybonotum. Tuttavia la parte sommitale della Zona ad Hybonotum, basata sulla distribuzione di *Paralingulaticeras*, ricade nella Zona a Sokolovi. Nella Zona a Pseudoscythica viene dimostrata la ripartizione di una Sottozona a Tenuicostata (con due orizzonti: *neoburgense* e *puschi*). L'orizzonte a neoburgense può essere correlato con gli orizzonti a *ciliata* e *penicillatum* di Neuburg e, probabilmente, con la Zona a Semiforme. I ritrovamenti nella Zona a Panderi dei medio-titoniani *Lingulaticeras blaschkei*, *Pseudolissoceras* e *Sutneria* suggeriscono che la base del Volgiano medio può non essere più giovane della Zona a Fallauxi del Titoniano medio.

Introduction

Over the last few decades several papers devoted to the analysis of mixed Boreal-Tethyan associations of Mollusca, and Tithonian-Volgian correlations (Zeiss 2001; Kutek & Zeiss 1997; Hoedemaeker 1991; Sachs et al. 1979; Mesezhnikov 1989; Sey & Kalacheva 1993, 1997; Schweigert 1993, 1994, 2000; Scherzinger & Schweigert 1999) have been published. Unfortunately, material from the Russian Platform was either not studied during those investigations, or only ammonites never described and illustrated before were mentioned.

Material and Methods

This paper is based on the author's field investigations and collections, and on data collected by P.A. Gerasimov, M.S. Mesezhnikov and V.V. Mitta. The ammonites illustrated are kept in the Geological Institute of Russian Academy of Sciences (RAS) (author's collection, no. GIN MIV, MK), Paleontological Institute of RAS (P.A. Gerasimov's collection, no. PIN 4861) and in the State Vernadsky Museum (V.V. Mitta's collection, authors collection, no. SGM BX 17) in Moscow. Unfortunately, the majority of the collection of M.S. Mesezhnikov (S. Petersburg, VNIGRI) remained inaccessible. Also, most of the Kimmeridgian-Middle Volgian ammonites with Tethyan affinities, quoted by M.S. Mesezhnikov (Mesezhnikov et al. 1977; Blom et al. 1984; Mesezhnikov 1989; Yakovleva 1993) have not yet been recovered from his collection.

Hitherto, only one outcrop of the Russian Platform (Gorodishchi, Fig. 1,3) yielding an Upper Kimmeridgian-Middle Volgian ammonite succession composed of Sub-mediterranean ammonites has been discovered. Last year all the levels containing Tethyan ammonites, identified in the Gorodishchi section, were traced through a number of localities in the middle Volga area (Fig. 1), since it is important to ascertain that the sequences of Sub-mediterranean ammonites in different sections are coincident. As a result, the wide distribution of these ammonites throughout the middle Russian Sea became apparent.

1 Geological Institute of Russian Academy of Sciences, Pyzhevskii Lane, 7, 119017, Moscow, Russia. E-mail: mrogov@pisem.net

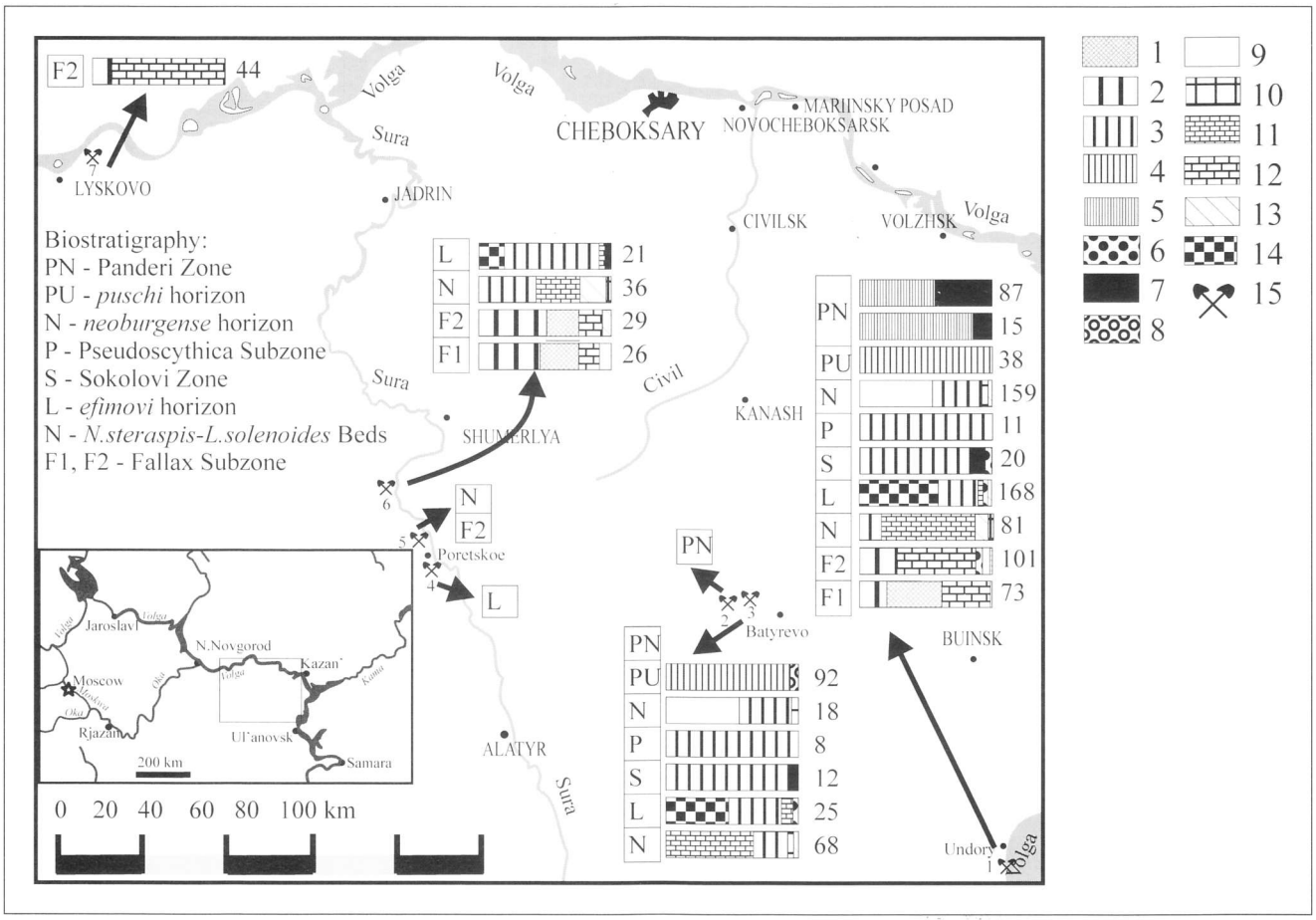

Fig. 1 - Outcrops location, framework of the sections and composition of the ammonite assemblages from the uppermost Kimmeridgian to lowermost Middle Volgian of the Volga Area. Outcrops: 1 - Gorodishchi, 2 - Pervomayskoe, 3 - Polevye-Bikshiki, 4 - Poreckoe, 5 - Ryapino, 6 - Murzicy, 7 - Isady.
Captions for the ammonite assemblages: Sub-boreal ammonites with a gray pattern 1 - *Aulacostephanus*, 2 - *Sarmatisphinctes*, 3 - *Ilowaiskya*, 4 - *Pseudovirgatites*, 5 - *Zaraiskites+Acuticostites*, 6 - *Gravesia*, 7 - Boreal ammonites (*Subdichotomoceras, Dorsoplanites, Pavlovia*), 8 - *Isterites*, 9 - *Aspidoceras* s.l., 10 - *Sutneria*, 11 - *Neochetoceras+Haploceras*, 12 - *Neochetoceras, Taramelliceras+Glochiceras* s.l., 13 - *Lingulaticeras*, 14 - *Paralingulaticeras+Fontannesiella*, 15 - outcrops locality.

Ammonites, zonal nomenclature and correlation

Since there are different approaches in comparing the base of the Tithonian and Volgian stages (Schweigert 1994; Hantzpergue et al. 1998), it is necessary to begin this review with a description of the characteristics of the uppermost Kimmeridgian Fallax Subzone (Autissiodorensis Zone).

Upper Kimmeridgian
Autissiodorensis Zone Ziegler, 1962

Fallax Subzone Ilovaisky, 1941. This subzone is widely distributed in the middle Volga area. Based on the distribution of ammonites, this subzone may be subdivided into two parts, which can be further considered as faunal horizons. Both levels are known also from Poland (Kutek & Zeiss 1997), but the ammonite associations of the Russian platform are more diverse. The lower part of the Fallax Subzone contains numerous *Sarmatisphinctes fallax* (Ilovaisky) [M, m], *Aulacostephanus subundorae* (Pavlov), *A. jasonoides* (Pavlova), *A.* ex gr. *autissiodorensis* (Cotteau), more rarely *Neochetoceras* cf. *subnudatum* (Font.), *Lingulaticeras solenoides* (Quenstedt) and unfrequent *Aspidoceras* sp. The upper part of the subzone contains mainly *Sarmatisphinctes* sp. nov. [M, m]. Microconchs of this species differ from *S. fallax* (Ilovaisky) [m] in its low rib coefficient (usually about 2.5; for example see Kutek & Zeiss 1997, pl. 20, fig. 1). Macroconchs have a lower point of rib furcation that makes them very similar to *Ilowaiskya klimovi* (Ilovaisky [M]. As the evolutionary tendencies of micro- and macroconchs in the *Sarmatisphinctes - Ilowaiskya* lineage are variable (see also data on the Klimovi Zone), the genus *Ilowaiskya* can be subdivided further into micro- and macroconchiate subgenera, also accepted for coeval perisphinctid ammonites of Southern Germany (Schweigert 1996). Except for *Sarmatisphinctes* sp. nov., this level includes common *Lingulaticeras solenoides* (Quenstedt) (Rogov 2002b, pl., fig. 1) and *Neochetoceras* ex gr. *subnudatum* (Font.) (Rogov 2002a, pl. 1, fig. 1, 2); *Ochetoceras* ex gr. *zio* (Oppel) (Pl. 1, fig. 15), *Aspidoceras* sp. ind., *Gravesia* sp. ind. and *Aulacostephanus* cf. *jasonoides* (Pavlov), though their presence, up to the base of the Lower Volgian, is extremely rare. It is important to note that *Ochetoceras*, as well as *Aulacostephanus* do not extend into the Tithonian and can be considered as genera characteristic of the Kimmeridgian (Schweigert, pers. comm. (for *Ochetoceras*)). Among the oppeliids it is possible to note the presence of ?*Taramelliceras* aff. *franciscanum* (Fontannes) (Gorodishchi, Isady sections; Rogov 2002a, pl. 1, fig. 3; Pl. 1, fig. 7) and *Neochetoceras* cf. *rebouletianum* (Berckhemer & Hölder) (Isady section, Pl.1, fig.8; very close to *N. rebouletianum* in Schweigert 2000, pl. 2, fig. 5) near the top of the Fallax Subzone. *Neochetoceras* cf. *rebouletianum* (not illustrated) was also quoted from the Upper Kimmeridgian of the North Subcaspian region (Bogdanov 1934) permitting the correlation of the uppermost Fallax Subzone with the *rebouletianum* horizon of the Southern Germany (Rogov 2002a).

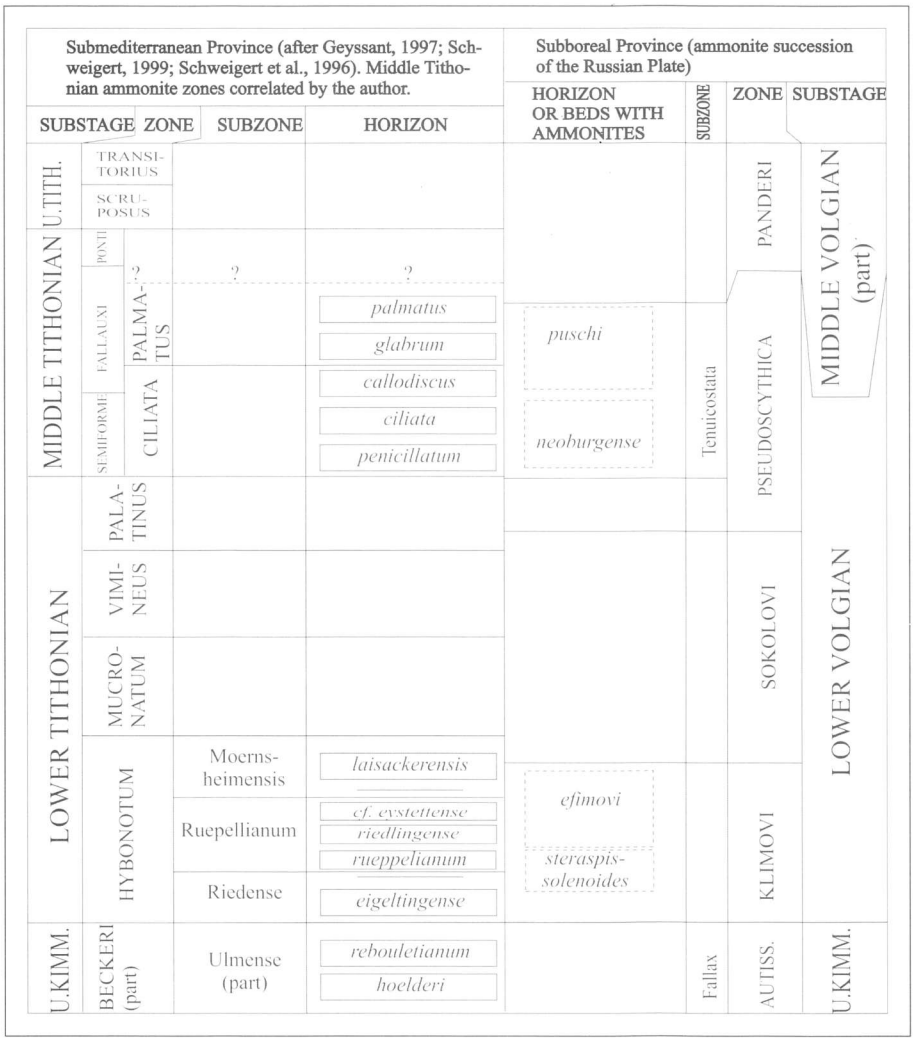

Fig. 2 - Scheme of the Tithonian-Volgian correlation based on ammonite distribution. Abbreviations: U.Kimm. – Upper Kimmeridgian, Autiss. - Autissiodorensis.

Lower Volgian

Klimovi Zone Michailov, 1964

In the middle Volga area the Klimovi zone is subdivided into the *Neochetoceras steraspis-Lingulaticeras solenoides* Beds (at the base of the zone) and the *lithographicum efimovi* horizon.

• *N. steraspis - L. solenoides* Beds Rogov, 2002. *N. steraspis* (Oppel) (Pl.1, fig.10-11) occurrences are numerous, whilst *Ilowaiskya klimovi* (Ilovaisky), *Lingulaticeras solenoides* (Quenstedt), *Sutneria* aff. *bracheri* Berckhemer are more rare (Pl.1, fig.1).These beds may correspond to the *rueppellianum* and *riedlingensis* horizons and an unnamed horizon (Schweigert & Zeiss 1998) between the *rueppellianum* and *eigeltingense* horizons of Southern Germany (Swabia). A number of horizons from Southern Germany also contain *Neochetoceras* ex gr. *steraspis* (Oppel) and *Lingulaticeras solenoides* (Quenstedt) (Schweigert, pers. comm.), while *Paralingulaticeras* are absent or very rare (as in the *riedlingensis* horizon). The separate level with *N. praecursor* Zeiss (*eigeltingense* horizon) has not been found yet in the Russian Platform, but an ammonite very close to *N. nodulosum* Berckhemer & Hölder (microconchiate counterpart of *N. praecursor*) was discovered in the Murzicy section (not in situ) (Pl.1, fig.9).

• *efimovi* Horizon Rogov, 2002. The variable species *Paralingulaticeras efimovi* (Rogov) (Pl.1, fig.12-13) is common, including morphs resembling *P.* ex gr. *haeberleini* (Oppel) (Rogov 2002b, pl., fig. 4) and *P. percevali* (Fontannes) (Rogov 2002b, pl., fig.7) in the uppermost part, passing into the Sokolovi Zone. *Neochetoceras* cf. *steraspis* (Oppel), *Fontannesiella* sp. (Pl.1, fig.14), *Haploceras* sp. (Pl.1, fig.6), and *Gravesia* (including *G.* cf. *gravesiana* (Orb.)) are rare. *Ilowaiskya* are represented by *I. klimovi* (Ilovaisky) [M, m] and *Ilowaiskya* sp. nov. [m] characterized by a very high point of rib furcation. The first appearance of *Subdichotomoceras (Sphinctoceras)* also occurs in this horizon. Russian *Paralingulaticeras* and *Fontannesiella* differ from the European genera in the absence of ventrolateral tubercles and in the small shell size. Nevertheless, type of ribbing and spectrum of variability within Russian and typical Mediterranean ammonites are the same. Thus, Russian specimens may be considered as endemic species of the genera *Paralingulaticeras* and *Fontannesiella*. The *efimovi* horizon corresponds approximately to the cf. *eystettense-moernsheimensis* horizons of Southern Germany (Fig.2). The level with numerous *Paralingulaticeras* is absent in Swabia (Schweigert, pers. comm.) and Poland. Probably these ammonites penetrated into the middle Volga area from the Northern Caucasus, where dimorphs of *Paralingulaticeras - Fontannesiella prolithographicum* (Fontannes) occur.

Sokolovi Zone Ilovaisky, 1941

Eventually, it will be possible to subdivide this zone into two faunal horizons, a *sokolovi* horizon below and a *pavida* horizon above, as it is done for the zone in Poland (Kutek & Zeiss 1997), but at present data are insufficient. According to Mesezhnikov (Mesezhnikov et al. 1977; Blom et al. 1984), *I. sokolovi* (Ilovaisky) occurs near the base of the zone, together with *Paralingulaticeras haeberleini* (Oppel), *P. percevali* (Fontannes). In the upper part of the Sokolovi Zone, *Ilowaiskya pavida* (Ilovaisky) [M, m] is present together with rare Boreal ammonites (*Subdichotomoceras (Sphinctoceras)*). The base of the Sokolovi Zone (based on the presence of *Paralingulaticeras)* lies within the Hybonotum Zone (Rogov 2002b), and the top is located within the Palatinus Zone (Kutek & Zeiss 1997).

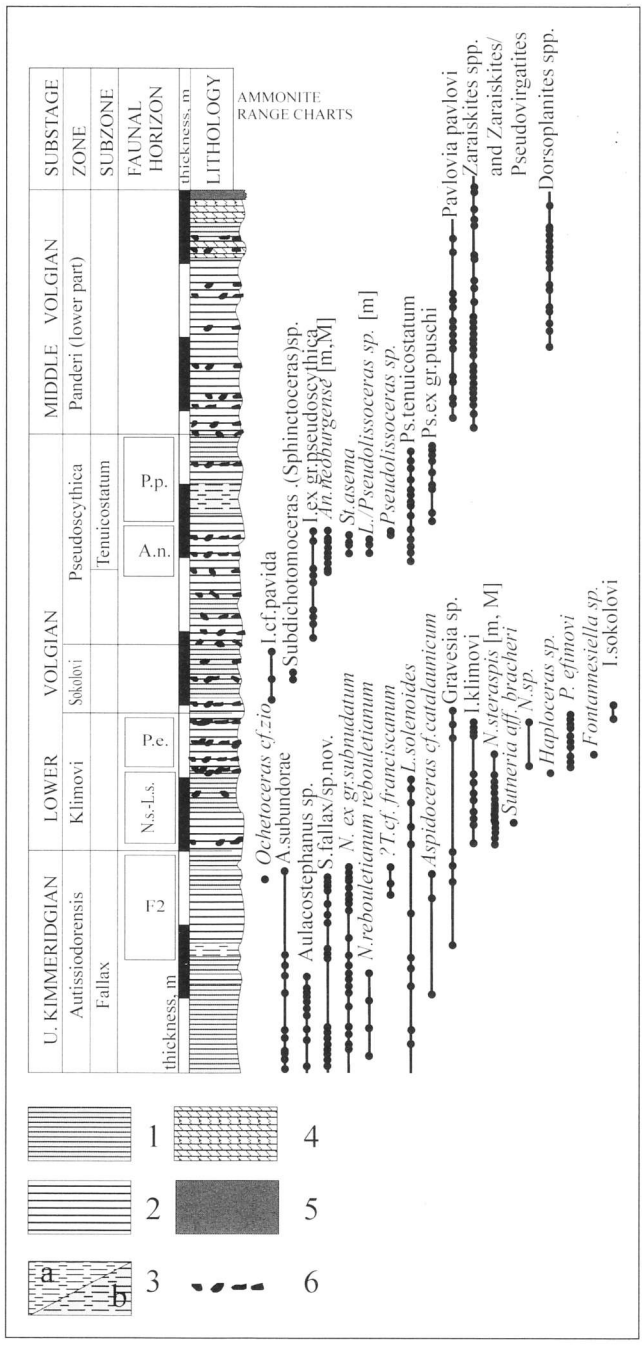

Fig. 3 - Ammonite range charts in the Gorodishchi section (from the uppermost Kimmeridgian to lowermost Middle Volgian). Abbreviations: A. – *Aulacostephanus*; A.n. – *neoburgense* horizon; An – *Anaspidoceras*; F – *Fontannesiella*; F2 – Fallax Subzone, upper part; I – *Ilowaiskya*; L – *Lingulaticeras*; T – *Taramelliceras*; N – *Neochetoceras*; N.s.-L.s. – *Neochetoceras steraspis-Lingulaticeras solenoides* Beds; P – *Paralingulaticeras*; P.e. – *efimovi* horizon; P.p. – *puschi* horizon; Ps. – *Pseudovirgatites*; S – *Sarmatisphinctes*; St. – *Sutneria*.
Lithology: 1 - dark-gray clay; 2 – gray calcareous clay; 3 – silt: a – gray, b – dark-gray; 4 – marl; 5 – bituminous shaly clay, 6 – phosphorite nodules.

Pseudoscythica Zone Ilovaisky, 1941

The Pseudoscythica Zone is subdivided into two subzones - Pseudoscythica and Tenuicostatum.

Pseudoscythica Subzone Ilovaisky, 1941. In the majority of sections, only *I. pseudoscythica* (Ilovaisky) [M, m] is known from this level. *I. schaschkovae* (Ilovaisky) and *I. ianschini* (Ilovaisky) (Kutek & Zeiss 1997) probably occur in the same subzone.

Tenuicostatum Subzone Zeiss, 1977

• *neoburgense* Horizon Rogov, 2002. *Anaspidoceras neoburgense* (Oppel) [M, m] is very common (Pl.1, fig.16). *Ilowaiskya* cf. *pseudoscythica* (Ilovaisky), *Pseudovirgatites tenuicostatum* (Michailov) (Pl.1, fig.18; this species is considered as *Pseudovirgatites* because of the low position of the point of rib furcation in the inner whorls), *Sutneria asema* (Oppel) (Pl.1, fig.2,3) and *?Pseudolissoceras* sp. (Rogov 2002b, pl., fig.10) are rarer. With the exception of the ammonites, other mollusca from the *neoburgense* horizon have a Sub-mediterranean origin. Belemnites are represented only by *Hibolithes*, and a very diverse bivalve assemblage includes common *Myophorella*, and large *Liostrea*. For the first time since the Oxfordian *Procerithium* is found at this level. This Neoburgense event is not defined in Poland and, probably, is connected to an increasing influence of the North-Caucasian Basin. The *neoburgense* horizon is widely distributed in Central Russia. In addition to the Volga area, *A. neoburgense* (Oppel) is known also from the Ural River (Ilovaisky & Florensky 1941, pl. 23, fig.42, 42a) and from the Moscow area (Sasonov 1953; not illustrated). The presence of the *A. neoburgense* (Oppel) and *S. asema* (Oppel) *neoburgense* horizon is correlated with the *penicillatum* and *ciliata* horizons of Neuburg (Fig.2). This horizon, probably corresponds to the Semiforme Zone of the other Tethyan areas, in which the species *A. neoburgense* (Oppel) and *S. asema* (Oppel) also are very numerous (Kutek & Wierzbowski 1986; Főzy et al. 1994).

• *puschi* Horizon Kutek and Zeiss, 1974. The index species of the Puschi Zone of Poland (Kutek & Zeiss 1974) was later replaced by the Tenuicostatum (Zeiss 1977), but the first name is more preferable in Russia, as *P. tenuicostatum* (Michailov) also occurs in the *neoburgense* horizon. It is probable that Mesezhnikov's (1982) opinion that *P. tenuicostatum* (Michailov) occurs throughout the Pseudoscythica Zone was wrong. In the Gorodishchi section *P. tenuicostatum* (Michailov) and *P. puschi* Kutek & Zeiss (Rogov 2002, pl., fig.13) occur approximately in identical amounts, but in the Polevye-Bikshiki section *P. tenuicostatum* (Michailov) strongly prevails. *Danubisphinctes* sp. juv. (Pl.1, fig.17) also occurs sporadically in the Polevye-Bikshiki sections and rare *Pseudovirgatites* aff. *seorsus* (Oppel) are known from the Gorodishchi section (Fig.1, 3). Based on the presence of *Danubisphinctes spurius* (Schneid) in the coeval deposits of Poland, the upper part of the Tenuicostata Subzone can be compared with the uppermost Palmatus Subzone of Neuburg.

Middle Volgian

Panderi Zone Rosanov, 1906

Some researchers (e.g. Callomon & Birkelund 1982; Hantzpergue et al. 1998; Scherzinger & Schweigert 1999) suggest the presence of a gap between the Lower and Middle Volgian. However, due to the gradual changes in the Pseudovigratitinae-Virgatitinae lineage, this is considered improbable. In the lowest 0.5 m of the Panderi Zone in the Gorodishchi section, Dorsoplanitinae occur together with ammonites, which are closer to *Pseudovirgatites*, than to *Zaraiskites*. Therefore, we cannot be sure that the base of the Panderi Zone in Russia and the base of the Scythicus Zone of Poland are coincident. The allocation of the detached level with *Zaraiskites contradictionis* (Ilovaisky) and *Z. diprosopa* (Ilovaisky), as proposed by Zeiss (2001), is questionable. These ammonites are found together with *Zaraiskites scythicus* (Vischniakoff), *Dorsoplanites panderi* (d'Orbigny), *Pavlovia pavlovi* (Michalski) (Mikhailov 1964) and correspond closely to the variability of *Z. scythicus* (Vischniakoff). Only the ammonites named by Ilovaisky (1941, p.128, pl. 26, fig. 50) as *Z. contradictionis* var. B differ appreciably from *Z. scythicus* (Vischniakoff). These ammonites, which resemble *Ilowaiskya*, are found in the phosphate nodules horizon in Vetlianka. It is possible that they were redeposited from the Lower Volgian.

The Panderi Zone of the Central Russia still cannot be subdivided into faunal horizons. However, the presence of *Zaraiskites regu-*

laris Kutek in the bituminous shales of the Gorodishchi section and *Z. quenstedti* (Rouillier), *Z. scythicus* (Vischniakoff) in the lower part of Panderi Zone suggests that in the future it will be possible to trace also in Central Russia the horizons identified in Poland by Kutek (1994). *Z. regularis* Kutek occurs also in the northern areas of the Russian platform (Sachs 1976, pl. 22, fig. 2).

In addition to *Zaraiskites*, also *Dorsoplanites panderi* (d'Orbigny), *D. dorsoplanis* (Vischniakoff), *Pavlovia pavlovi* (Michalski), *Acuticostites acuticostatus* (Michalski), *A. bitrifurcatus* Mitta (Mitta 1993) are found in the Panderi Zone. Ammonites with a Tethyan affinity are very rare. According to Mesezhnikov (Mesezhnikov et al. 1977; Blom et al. 1984; Yakovleva 1993), in the Gorodishchi section the Panderi Zone contains unfrequent *Pseudolissoceras, Sutneria, Glochiceras*. Unfortunately, these ammonites have yet to be found in his collection stored in VNIGNI (S. Petersburg). Rare *Lingulaticeras blaschkei* Cecca & Enay (Pl.1, fig. 13,14) are known from the Panderi Zone of Chuvashiya and the Tver area (Rogov & Egorov 2002, fig. 1.2 a, b), as well as in the Fallauxi Zone (Richteri Subzone) of Ardèche (Cecca & Enay 1991). The presence of this species and ammonites of the genera *Pseudolissoceras* and *Sutneria*, indicates that the lower part of the Panderi Zone cannot be younger than the Middle Tithonian Fallauxi Zone (Rogov 2002b). On the other hand, findings of *Zaraiskites regularis* Kutek in the Upper Tithonian of the Carpatho-Balkan zone allows us to compare the uppermost part of the Panderi Zone with the part of Upper Tithonian Calpionella Zone A (Kutek 1994; Kutek & Zeiss 1997). At present a more precise correlation of the Panderi-Virgatus boundary with the Tethyan zonal succession is not possible.

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PLATE 1

All illustrated in natural size and collected by the author, except for marked specimens.

1. *Sutneria* aff. *bracheri* Berckh. Klimovi Zone, *N. steraspis – L. solenoides* Beds. Gorodishchi. (x2) GIN MIV 667/1; 2. *Sutneria* cf. *asema* (Opp.). Pseudoscythica Zone, Tenuicostatum Subzone, *neoburgense* horizon. Gorodishchi (x2). GIN MK 576; 3. Sutneria asema (Opp.). Pseudoscythica Zone, Tenuicostatum Subzone, *neoburgense* horizon. Gorodishchi (x4). GIN MK 609; 4, 5. *Lingulaticeras blaschkei* (Cecca & Enay). Panderi Zone. 4 - Pervomayskoe. SGM BX 17/1. Collected by V.V. Mitta; 5 - Kimry (Tver area). PIN 4861/25. Collected by P.A. Gerasimov; 6. *Haploceras* sp. juv. Klimovi Zone, *efimovi* horizon. Gorodishchi. SGM 572-7 (x2); 7. *?Taramelliceras franciscanum* (Font.). Autissiodorensis Zone, Fallax Subzone. Isady. GIN MIV 285; 8. *Neochetoceras cf. rebouletianum* (Berckh. & Hölder). Autissiodorensis Zone, Fallax Subzone. Isady. GIN MIV 284; 9. *Neochetoceras nodulosum* Berckh. & Hölder. Klimovi Zone, not in situ (*?N. steraspis-L .solenoides* Beds). Murzicy. GIN MIV 630; 10. *Neochetoceras cf. steraspis* (Opp.). Klimovi Zone, *N. steraspis - L .solenoides* Beds. Polevye-Bikshiki. GIN MIV 655; 11. *Neochetoceras cf. steraspis* (Opp.). Klimovi Zone, *N. steraspis - L. solenoides* Beds. Gorodishchi. SGM 572-22; 12, 13. *Paralingulaticeras efimovi* Rogov. Klimovi Zone, *efimovi* horizon. Gorodishchi. 12 – SGM 572-21; 13 - Holotype SGM 572-11; 14. *Fontannesiella* sp., Klimovi Zone, *efimovi* horizon. Gorodishchi. SGM 572-6; 15. *Ochetoceras cf. zio* (Opp.). Autissiodorensis Zone, Fallax Subzone. Gorodishchi. GIN MIV 692/1; 16. *Anaspidoceras neoburgense* (Opp.) [m], Pseudoscythica Zone, Tenuicostatum Subzone, *neoburgense* horizon. Polevye-Bikshiki. GIN MK 607; 17. *Danubisphinctes* sp. juv. Pseudoscythica Zone, Tenuicostatum Subzone, *puschi* horizon. Polevye-Bikshiki. GIN MK 589; 18. *Pseudovirgatites tenuicostatum* (Michailov), Pseudoscythica Zone, Tenuicostatum Subzone, *puschi* horizon. Polevye-Bikshiki. GIN MK 582.

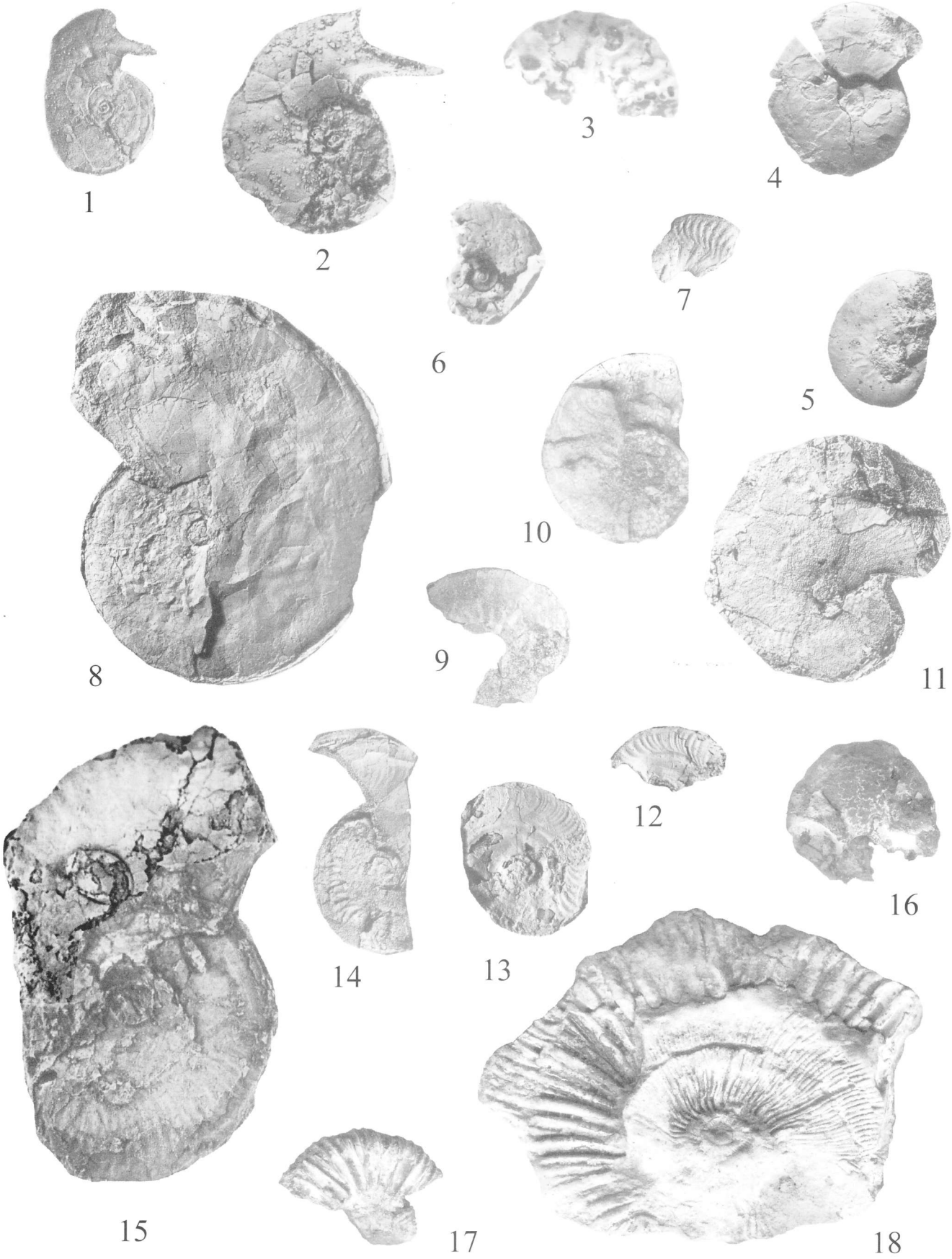

PLATE 1

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