
MIKHAIL A. ROGOV

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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.


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...), Paleontological Institute of RAS (P.A. Gerasimov’s collection, no. PIN 4861) and in the State Vernadsky Museum (VV. Mitta’s collection, authors collection, no. SGM...) 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 (Gorodishche, 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 Gorodishche 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
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 assemblages of the Russian platform are more diverse. The lower part of the Fallax Subzone contains numerous Sarmatisphinctes fallax (Ilovaisky) [M, m], Aulacostephanus subundu-rae (Pavlov), A. jasonoides (Pavlov), A. ex gr. autissiodorensis (Cotteau), more rarely Neochetoceras cf. submadatum (Font.) Lingulaticeras solenoides (Quenstedt) and un frequent Aspidoceras sp. The upper part of the subzone contains mainly Sarmatisphinctes fallax (Ilovaisky) [M, m]. Macroconchs 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 Ilovaisky klímovi (Ilovaisky) [M]. As the evolutionary tendencies of micro- and macroconchs in the Sarmatisphinctes - Ilovaiskya lineage are variable (see also data on the Klímovi Zone), the genus Ilovaiskya 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. submadatum (Font.) (Rogov 2002a, pl. 1, fig.1,2); Neochetoceras ex gr. zio (Oppel) (Pl., fig.15), Aspidoceras sp.ind., Gravesia sp.ind. and Aulacostephanus jasonoides (Pavlov), though their presence, up to the base of the Lower Volgian, is extremely rare. It is important to note that Neochetoceras, as well as Aulacostephanus do not extend into the Tithonian and can be considered as genera characteristic of the Kimmeridgian (Schweigert, pers. comm. (for Neochetoceras)) among the oppellids it is possible to note the presence of Taramelliceras aff. franciscanum (Fontannes) (Gorodishchi, Isady sections; Rogov 2002a, pl.I, fig.3; Pl.I, fig.7) and Neochetoceras cf. rebouletianum (Berekhchner & Hölder) (Isady section, Pl.I, 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).
**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 efimovi horizon.

- *N. steraspis* - *L. solenoides* Beds Rogov, 2002. *N. steraspis* (Oppel) (PL1, fig.10-11) occurrences are numerous, whilst *Ilovaiskya klimovi* (Ilovaisky), *Lingulaticeras solenoides* (Quenstedt), *Sutneria aff. bracheri* Berckheimer are more rare (PL1, fig.1). These beds may correspond to the ruppeleanum and riedlingensis horizons in 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 (riedlingensis horizon) has not been found yet in the Russian Platform, but an ammonite very close to *N. nodolatum* Berckheimer & Hólder (microconchiate counterpart of *N. praecursor*) was discovered in the Murzicy section (not in situ) (PL1, fig.9).

- *efimovi* Horizon Rogov, 2002. The variable species Paralingulaticeras *efimovi* (Rogov) (PL1, fig. 12-13) is common, including morphs resembling *P. ex gr. haeblerani* (Oppel) (Rogov 2002b, pi., fig. 4) and *P. percevali* (Fontannes) (Rogov 2002b, pi., fig.7) in the uppermost part, passing into the Sokolovi Zone. Neochetoceras cf. *steraspis* (Oppel), Fontannesiella sp. (PL1, fig.14), Haploceras sp. (PL1, fig.6), and Gravesia (including G. *cf. gravesiana* (Orb.)) are rare. *Ilovaisky* are represented by *I. klimovi* (Ilovaisky) [M, m] and *Ilovaiskya* 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. eystetten-moensheimensis 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, sokolovi horizon below and pavida horizon above, as it is done for the zone in Poland (Kutek & Zeiss 1997), but at present data are insufficient. According to Mesenhnikov (Mesenhnikov et al. 1977; Blom et al. 1984), *I. sokolowi* (Ilovaisky) occurs near the base of the zone, together with Paralingulaticeras *haeblerani* (Oppel), *P. 7 percevali* (Fontannes). In the upper part of the Sokolovi Zone, *Ilovaisky 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).
Pseudoscythica Subzone Ilovaisky, 1941. In the majority of sections, only \textit{I. pseudoscythica} (Ilovaisky) [M, m] is known from this level. \textit{I. schachkovae} (Ilovaisky) and \textit{I. ianschini} (Ilovaisky) (Kutek \\& Zeiss 1997) probably occur in the same subzone.

Tenuicostatum Subzone Zeiss, 1977

- \textit{neoburgense} Horizon Rogov, 2002. \textit{Anaspisoceras neoburgense} (Oppel) [M, m] is very common (PL1, fig.16). \textit{Ilovasiya} cf. \textit{pseudoscythica} (Ilovaisky), \textit{Pseudovirgatites} \textit{tenuicostatum} (Michailov) (PL1, fig. 18; this species is considered as \textit{Pseudovirgatites} because of the low position of the point of rib furcation in the inner whorls), \textit{Satteria asema} (Oppel) (PL1, fig.2,3) and \textit{Pseudolissoceras} sp. (Rogov 2002b, pl., fig. 10) are rarer. With the exception of the ammonites, other moluscos from the \textit{neoburgense} horizon have a Sub-mediterranean origin. Belemnites are represented only by \textit{Hibolithes}, and a very diverse bivalve assemblage includes common \textit{Myophorella}, and large \textit{Liostrea}. For the first time since the Oxfordian \textit{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. In addition to the Volga area, \textit{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 \textit{P. neoburgense} (Oppel) and \textit{S. asema} (Oppel) horizon is correlated with the \textit{penicillatum} and \textit{cielata} horizons of Neuburg (Fig.2). This horizon, probably corresponds to the Semisferne Zone of the other Tethyan areas, in which the species \textit{A. neoburgense} (Oppel) and \textit{S. asema} (Oppel) also are very numerous (Kutek \\& Wierzbowski 1986; Fözy et al. 1994).

- \textit{puschi} Horizon Kutek and Zeiss, 1974. The index species of the \textit{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 \textit{P. tenuicostatum} (Michailov) also occurs in the neoburgense horizon. It is probable that \textit{Mesarzhnov}’s (1982) opinion that \textit{P. tenuicostatum} (Michailov) occurs throughout the \textit{Pseudoscythica} Zone was wrong. In the Gorodishchi section \textit{P. tenuicostatum} (Michailov) and \textit{P. puschi} Kutek \\& Zeiss (Rogov 2002, pl., fig. 13) occur approximately in identical amounts, but in the Polevye-Blikshiki section \textit{P. tenuicostatum} (Michailov) strongly prevails. \textit{Danubisphinctes} sp. juv. (PL1, fig.17) also occurs sporadically in the Polevye-Blikshiki sections and rare \textit{Pseudovirgatites aff. seorsus} (Oppel) are known from the Gorodishchi section (Fig.1, 3). Based on the presence of \textit{Danubisphinctes spurius} (Schneid) in the coeval deposits of Poland, the upper part of the Tenuicostata Subzone can be compared with the uppermost Palaeus Subzone of Neuburg.

Middle Volgian

Panderi Zone Rosanov, 1906.

Some researchers (e.g. Callomon \\& Birkelund 1982; Hantzpergue et al. 1998; Scherzinger \\& Schweiger! 1999) suggest the presence of a gap between the Lower and Middle Volgian. However, due to the gradual changes in the Pseudovirgatitinae-Virgatitinae lineage, this is considered improbable. In the lowest 0.5 m of the Panderi Zone in the Gorodishchi section, Dorosplanitinae occur together with ammonites, which are closer to \textit{Pseudovirgatites}, than to \textit{Zaraikites}. 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 \textit{Zaraikites contradictiosis} (Ilovaisky) and \textit{Z. diprosopa} (Ilovaisky), as proposed by Zeiss (2001), is questionable. These ammonites are found together with \textit{Zaraikites scybius} (Vischniakoff), \textit{Dorosplanites panderi} (d’Orbigny), \textit{Pavlovia paulovi} (Michalski) (Michailov 1964) and correspond closely to the variability of \textit{Z. scybius} (Vischniakoff). Only the ammonites named by Ilovaisky (1941, p.128, pt. 26, fig. 50) as \textit{Z. contradictiosis} var. B differ appreciably from \textit{Z. scybius} (Vischniakoff). These ammonites, which resemble \textit{Ilovasiya}, are found in the phosphate nodules horizon in Vetlinka. It is possible that they were redeposited from the Lower Volgian.

The Panderi Zone of the Central Russia cannot be subdivided into faunal horizons. However, the presence of \textit{Zaraikites regul-
ris Kutek in the bituminous shales of the Gorodishchi section and Z. quenstedti (Rouillier), Z. scyticus (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 VNI GNI (S. Petersburg). Rare Lingulaticeras blaschkei Cecca fit 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 &c 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.

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