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Let the Volgian stage stay in the Jurassic

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Abstract

In 1996 the Volgian Stage was divided into the Jurassic and Cretaceous units, removed from the Geological Time Scale, and substituted by the Tithonian Stage according to the guidelines of the Interdepartmental Stratigraphic Committee of the Russian Federation (ISC RF). Consequently, the Upper Volgian Substage including three zones (five subzones) was placed into the Berriasian Stage (the Cretaceous) proceeding from ammonite fauna, and the Cretaceous lower boundary was defined by the base of the *Kachpurites fulgens* Zone. Some stratigraphers, however, contested that decision and suggested to restore the former status of the Volgian Stage. Their idea has been validated by magnetostratigraphic studies carried out in 2003 in Jurassic-Cretaceous boundary strata in the Nordvik Peninsula (the Laptev Sea), which bear the most complete record of Boreal deposition and biostratigraphy. The new data prove that the Volgian Stage, in its nearly full stratigraphic volume, rather belongs to the Jurassic period.

Keywords: Volgian stage; Jurassic-Cretaceous boundary; magnetostratigraphy; Boreal-Tethyan correlation

Introduction

Correlation of Boreal and Tethyan strata deposited in different climate zones remains a key problem in the Mesozoic stratigraphy. International subcommissions on Jurassic and Cretaceous stratigraphy are especially concerned with correlating the boundary stages (Volgian and Tithonian, Ryazanian and Berriasian) and constraining the Jurassic-Cretaceous boundary. The Volgian, the terminal Jurassic stage in the Boreal realm, distinguished in seven countries over an area of more than 25,000,000 km^2, is a critical stratigraphic marker in the northern circum-Boreal Earth. It is a tool of Panboreal correlation and a reliable age tie for reconstructions of paleogeography and deposition environments in oil and gas basins of Northern Eurasia and in the Arctic shelves. Proving that the Volgian Stage is recognizable on a subglobal scale may warrant appealing to the International Commission on Stratigraphy for restoration of the Volgian Stage, as parallel to the Tithonian Stage, in the International Time Scale. This study is an important step toward solving the problem.

The stratigraphic range of the Volgian Stage largely depends on the position of the Cretaceous lower boundary which remains an open point at the International Subcommission on Cretaceous stratigraphy. The question was discussed in 1995 for the last time by the Working Group on the Berriasian Stage and the Jurassic-Cretaceous boundary in Brussels. The members decided to consider the Berriasian as the basal stage of the Cretaceous system and recommended to define its GSSP (Global Standard Section and Point) either at the base of the Jacoby Zone or at the base of the overlying Occitanica Zone in one of two sections in southeastern Spain (Zakharov et al., 1996). That was assumed to be the Jurassic-Cretaceous boundary in the Tethyan realm, whereas the boundary in areas of Boreal deposition remained indefinite for the lack of reliable zone-by-zone correlation of the terminal stages in the two systems. Most stratigraphers agree that the Cretaceous lower boundary in the Panboreal superrealm should be defined at the base of the Upper Volgian substage (base of the *Kachpurites fulgens* Zone), and, hence, the entire substage should belong to the Cretaceous system. However, even this compromise solution may be unacceptable if one takes the base of the Occitanica Zone for the lower boundary of the Cretaceous.

Discussion on the boundary position

More than forty years ago Casey (1963) supposed that some part of the Upper Volgian Substage might correspond to the Jacobi Zone. According to Casey, the base of the Boissieri

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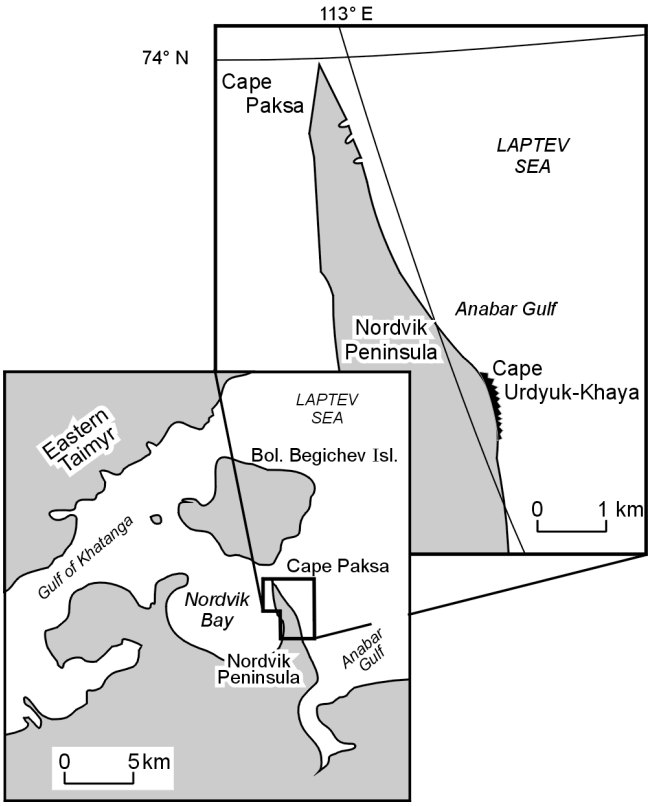

Fig. 1. Generalized geography of northern East Siberia and location of Upper Jurassic-Lower Cretaceous section in Nordvik Peninsula, Urdyuk-Khaya Cape.

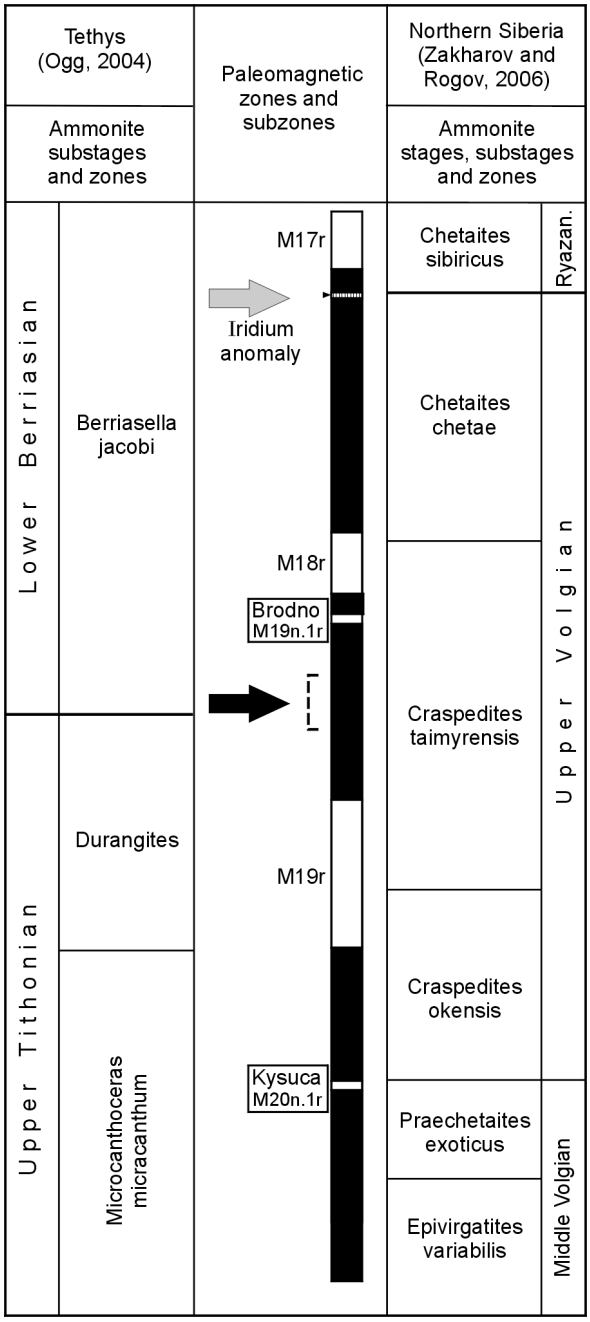

Fig. 2. Boreal-Tethyan correlation of Jurassic-Cretaceous boundary strata, from magnetostratigraphic data. Magnetic zones of normal (black) and reverse (white) polarity. Kysuca and Brodno are subzones of reverse polarity. Arrows show position of Jurassic-Cretaceous boundary, according to paleomagnetic data and correlation of magnetic zones in Tethyan sections and in Nordvik section (dark arrow) and according to classic division and to Ir anomaly found in northern Eurasia (gray arrow). Ryazan. stands for Ryazanian Stage.

Zone coinciding with the base of the Ryazanian Stage was the most convenient marker of the Berriasian lower boundary. The idea first received no support but later Kutek and Zeiss (1975) accepted it and grounded the correlation by coexistence of Subboreal and Subtethyan ammonite assemblages in Lower and Middle Volgian strata in Poland. For years Zeiss had insisted on moving the Cretaceous lower boundary from the base of the Ryazanian Stage to the base of the *Kachpurites fulgens* Zone of the Upper Volgian Substage. A similar correlation was suggested by Hoedemaeker, who for thirty years has persisted in the opinion that the lower boundary of the Cretaceous lies at the base of the Occitanica Zone (Hoedemaeker, 1990). Subdivision of the Volgian into the Jurassic and Cretaceous units has been approved by Sasonova and Sasonov (1979) and, lately, by Sey and Kalacheva (1999), and by Baraboshkin (1999, 2004). Although all attempts of direct correlation of the Volgian and Ryazanian Stages, from the Panderi Zone to the base of the Rjasanensis Zone, with the Tithonian and Berriasian ammonite succession in the Mediterranean have failed, many stratigraphers still believe that the base of the Upper Volgian Substage would coincide with the Berriasian base. According to this idea, the Middle-Upper Tithonian boundary would follow the Lower-Middle Volgian boundary.

Boreal-Tethyan correlation: state of the art

The Volgian and Ryazanian Stages occupy an area of more than 25,000,000 km^2 north of 55° N (Zakharov, 2003). The Tithonian and Berriassian stages in the Tethyan realm cover a far larger area from the western Mediterranean to southeastern Asia and from the Caribbean basin to South America. The stratigraphic interval from the base of the Volgian to the top of the Ryazanian Stages embraces about 25 ammonite zones and subzones and spans over 10 million years while the Tithonian and Berriasian Stages are divided into 16 ammonite zones and subzones. Today, acceptable correlation has been

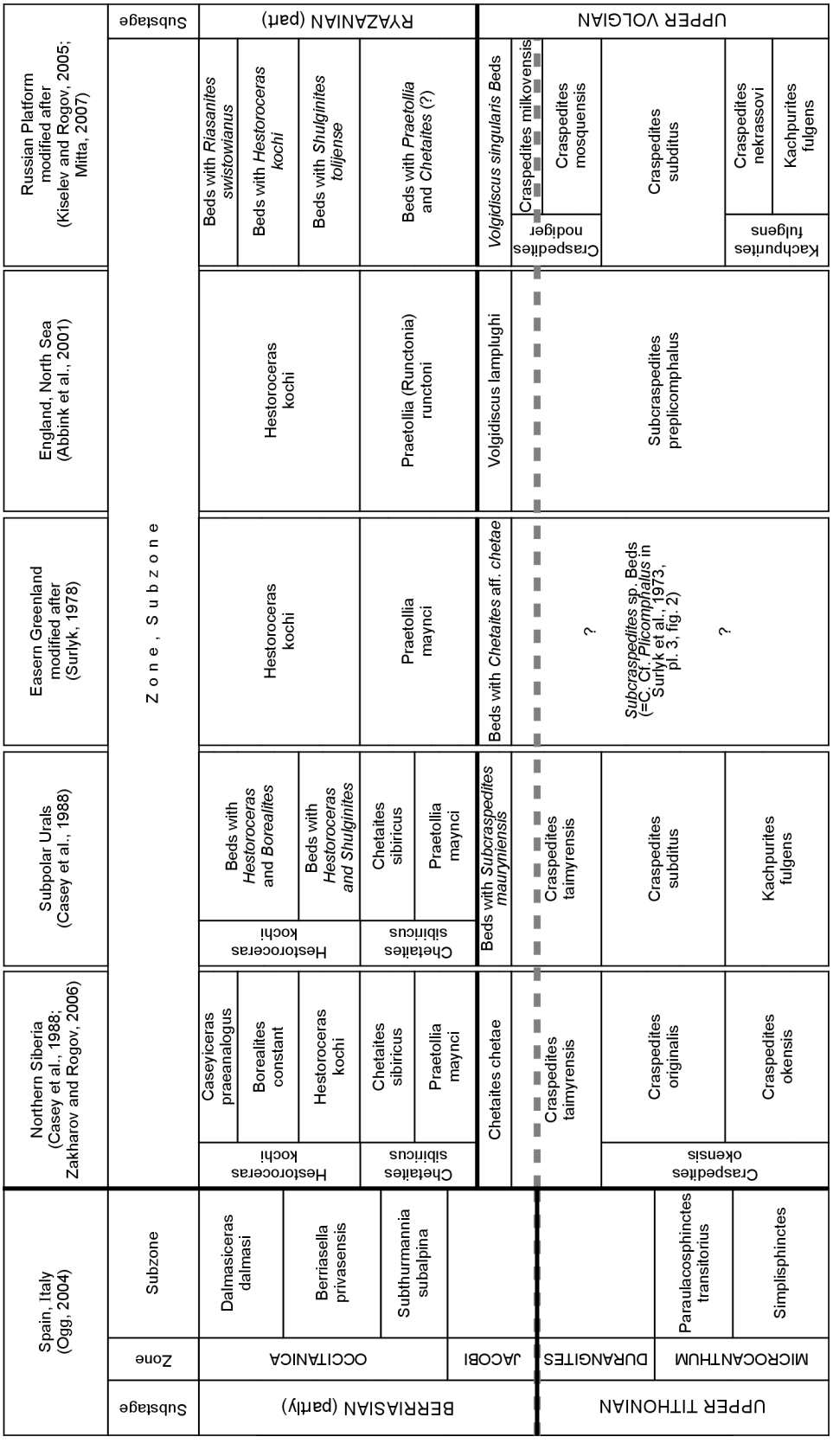

Fig. 3. Correlation chart of Boreal Jurassic-Cretaceous boundary strata. Position of Jurassic-Cretaceous boundary is shown according to magnetostratigraphic Boreal-Tethyan correlation (dashed line) and according to direct zone correlation within Boreal strata (solid line).

achieved only for the Tithonian and Volgian basal layers (till the base of the Panderi Zone in Eastern Europe) due to the presence of Tethyan ammonite assemblages in Boreal deposits. However, the entire Upper Volgian Substage and the lower Ryazanian has received reliable biostratigraphic correlation neither with the Tithonian nor with the Berriasian. For the lack of solid zone correlation of the Jurassic-Cretaceous boundary strata, the boundary between the two systems in Boreal areas remains undefined. Recently Mitta (2007) has discovered Tethyan ammonites, which together with Riasanites swistowianus represent the Berriasian Occitanica Zone, at the very base of the Ryazanian Stage in a section near Moscow, and at least three separate assemblages below, with *Hectoroceras kochi* (upper), *Schulginites tolijense* (middle) and *Praetollia* sp.–*Chetaites* (lower). Therefore, two lower zones of the Boreal Berriasian are present in the Russian plate. Literally, these finds leave no place even for the uppermost Volgian Stage in the Berriasian (and in the Cretaceous as a whole) but direct correlation between Boreal and Tethyan zone successions has not been accomplished yet.

Magnetostratigraphic data

To challenge the correlation of Boreal and Tethyan strata, we, jointly with specialists from the Czech Academy of Sciences and Charles University in Prague, applied independent magnetostratigraphic studies of the Jurassic-Cretaceous boundary strata (Houša et al., 2007). The method has proved to be efficient in both stratigraphic and geodynamic applications. We selected the best section of Boreal Jurassic-Cretaceous boundary strata in the Nordvik Peninsula, Laptev Sea coast (Fig. 1). In 2003 we sampled, at a high density, an interval of 27 m spanning two upper zones of the Middle Volgian Substage, all zones of the Jurassic Upper Volgian Substage and the Cretaceous *Chetaites sibiricus* Zone (with the *Praetollia maynci* and *Chetaites sibiricus* Subzones). As a result we correlated the Tethyan and Boreal boundary strata of the two systems and thus restricted the possible Jurassic-Cretaceous boundary in the Boreal realm and constrained the stratigraphic volume of the Volgian Stage.

Earlier Czech geophysicists developed a magnetostratigraphic time scale using data from the Puerto Escano (Cordoba province, southern Spain), Bosso Valley (Umbria, central Italy), and Brno (Zilina, western Carpathians, Slovakia) sections. Their detailed correlation of the Jurassic-Cretaceous boundary strata by microbiostratigraphy and magnetostratigraphy showed a consistent succession of Calpionellidae and magnetic zones M20n, M19r, and M18r. Furthermore, they recognized the Kysuca excursion (Kysuca Subzone) of reverse polarity in the normal-polarity zone M20n and the Brodno excursion (Brodno Subzone) in M19n in all sections they sampled. The same succession of magnetic zones and events as in Tethyan sections was found in the Urdyuk-Khaya section (Nordvik Peninsula, Laptev Sea) within the interval from the top of the Middle Volgian Substage to the base of the Ryazanian Stage (Fig. 2). Direct correlation of the Tethyan succession of magnetic zones with those in the Urdyuk-Khaya section showed that the Jurassic-Cretaceous boundary falls into the *Craspedites taimyrensis* Zone which is the age equivalent of the *Craspedites nodiger* Zone in the East European Platform.

Discussion and conclusions

According to the magnetostratigraphic evidence, the position of the Jurassic-Cretaceous boundary in the Boreal realm is defined by the *Craspedites nodiger–C. taimyrensis–Subcraspedites preplicomphalus* Zones (Fig. 3). Literal following the magnetostratigraphic results would require that the Jurassic-Cretaceous boundary were shifted either up (by the partisans of placing it at the Upper Volgian base) or slightly down (by the more conservative thinkers). However, any possible compromise would hardly satisfy everybody because the correlation is by biostratigraphy. Therefore, the search for markers of direct biostratigraphic Boreal-Tethyan correlation will continue. In addition to the above arguments, the former position of the Jurassic-Cretaceous boundary at the base of the *Praetollia maynci* Subzone in the Boreal realm is consistent with the existence of an Ir anomaly in a 5 cm thick layer of phosphate-bearing limestone found at the base of the *Praetollia maynci* Subzone in northern Siberia (Zakharov et al., 1993) and in the Norwegian shelf of the Barents Sea (Dypvik et al., 1996). The Ir anomaly is expected to show up in more complete sections and can be a good tie of the Boreal Jurassic-Cretaceous boundary. This choice means that the Volgian Stage, in its full stratigraphic range, rather belongs to the Jurassic system.

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