ISSN 1028-334X, Doklady Earth Sciences, 2006, Vol. 411, No. 8, pp. 1218–1221. © Pleiades Publishing, Inc., 2006.
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GEOLOGY

Givetian Deepwater Sediments in the Western Slope of the Subpolar Urals

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Presented by Academician B.S. Sokolov January 25, 2006

Received February 1, 2006

DOI: 10.1134/S1028334X06080125

In 1996, the author of the present paper first described and sampled macro- and microfossils in the Givetian section of deepwater sediments in the Subpolar Urals. The section outcrops in exposure 86 on the left bank of the Bol'shaya Nadota River near the western foothill of Mt. Olysya. The Givetian sediments are confined to the tectonically complicated area sandwiched between the Elets and Lemva facies that are characterized by wide development of reverse faults and thrusts (Fig. 1). The section (total thickness ~50 m) is largely composed of shales and their phyllite-type varieties with limestone lenses. In the lower part of the section, shales enclose a limestone member (Fig. 2). The entire rock sequence shows a normal succession with beds dipping to east-northeast at an angle of 30°. In the upstream part of the outcrop, shales at the top of the member have tectonic contact with upper Visean limestones that dip to northeast at an angle of 45°.

The rock sequence outcropping in exposure 86 terminates the Nadotamyl'k shaly formation, which is widely developed in the Bol'shaya Nadota basin and at upper reaches of the Lemva River. In 1947, A.V. Khabakov first defined the Nadotamyl'k Formation as an Upper Devonian sequence. Subsequently, Voinovskii-Kriger [1] suggested that this sequence may correspond to the entire Devonian. At present, the age of the Nadotamyl'k Formation is considered Lower (Emsian)–Middle Devonian [2]. By lithology, it can be subdivided into three members.

The lower member consists of dark gray to black shales and their phyllite-type varieties (apparent thickness 8 m). Its upper part contains numerous small concretion-shaped limestone lenses, some of which are composed of nodular stromatoporoid colonies. The lenses also enclose fragments of colonial rugose coralla and rare brachiopod shells. Stromatoporoids are represented by three species, two of which are first described from this section [3] and the third form is *Trupetostroma porosum* Lec. Like rugose corals and brachiopods encountered here, these species indicate the Givetian age of host rocks.

The lower part (9 m) of the overlying carbonate member is composed of gray to dark gray, mostly coarse-grained detrital limestones. Paleontological remains occur only in the middle part of the member, where Coeleneterata representatives (tabulates and rugose corals) characteristic of the Givetian Stage have been found.

The upper part (3 m) of the carbonate member consists of dark gray to black fine-grained detrital compact limestones. Macrofossils from these rocks are represented by numerous coenostea of a new stromatoporoid species and tabulate form of *Crassialveolites crassus* Lec. characteristic of Givetian sediments. Remains of the rugose coral *Temnophyllum heterophylloides* (Frech) known in both Givetian and Frasnian sequences are substantially less common. The rocks in question enclose a very representative conodont assemblage consisting of two *Icriodus*, six *Polygnathus*, and four *Schmidtognathus* species. Such an assemblage unambiguously testifies to the Givetian age, while the occurrence of *Schmidtognathus hermanni* Zieg. and *Polygnathus cristatus* Hinde indicates that the carbonate member belongs to the *hermanni–cristatus* Zone of the standard Devonian conodont scale. On the western slope of the Urals, such an assemblage has never been found before.

The examined section is crowned by a thick (3 m) member of shales and their phyllite-type varieties with rare lenses of detrital and clayey limestones, which frequently grade into marls. Macrofaunal remains are mostly confined to the middle part of the member. The Givetian age of the member is evident from the presence of two species of the tabulata genus *Crassialveolites* in its uppermost layers. A third form of this genus, *Cr. obtortus* (Lec.), occurs in both Givetian and Frasnian stages. Accompanying rugose corals are also con-

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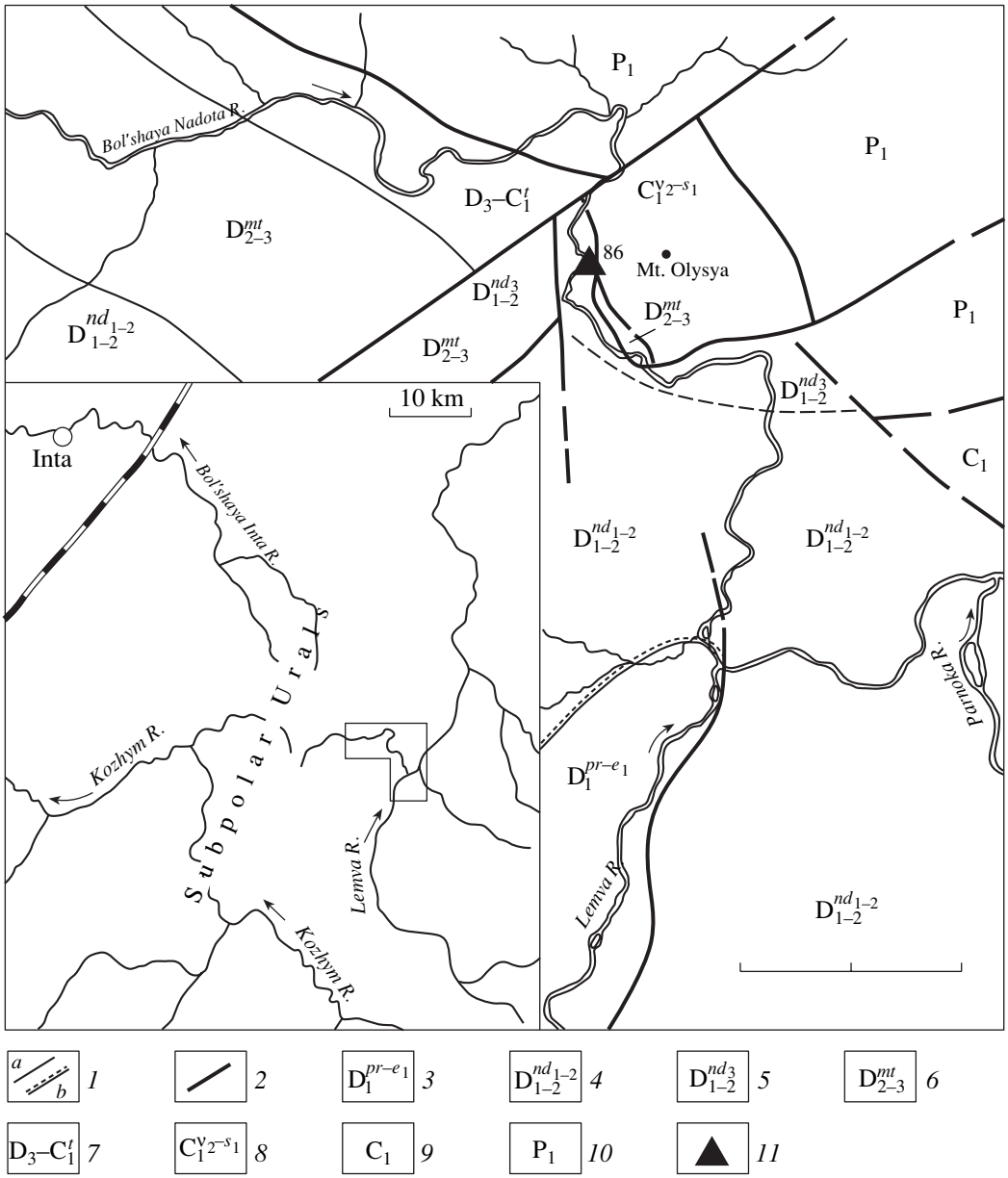

Fig. 1. Location of the examined section. The schematic geological structure is based on original data and materials from [1, 2]. (*1*) Stratigraphic boundaries: (*a*) conformable, (*b*) unconformable; (*2*) tectonic fractures; (*3*) early Pragian–Emsian reefal buildup; (*4, 5*) Nadotamyl'k Formation: (*4*) lower and middle subformations, (*5*) upper subformation; (*6*) Matyashor Formation; (*7*) undivided Famennian–Tournaisian strata; (*8*) late Visean–early Serpukhovian biohermal buildup; (*9, 10*) undivided sediments: (*9*) Lower Carboniferous, (*10*) Lower Permian; (*11*) section location.

sistent with this age estimate. Conodonts found in the lower part of the member and near its roof confirm the Givetian age of the host rocks as well.

The lithological characteristic of the section and stratigraphic distribution of the fossils allow several important inferences.

First, the lithology of the examined sections suggests their accumulation in relatively deepwater settings of the neritic sea basin or in the upper part of the continental slope. This is evident from the sediment composition, lack of hiatuses in the sections, and good preservation of macrofossils. The macrofossils usually represent skeletal fragments that were transported to burial areas by mudflows. Concretion-shaped limestone lenses imply mobilization of carbonate material of the main clayey matrix during diagenesis. Carbonate sediments were accumulated in shallower settings of the neritic zone.

Second, the stratigraphic distribution of all the faunal remains indicates the Givetian age of the host rocks, on the one hand, and defines several stratigraphic reference levels, on the other. The first of them corresponds

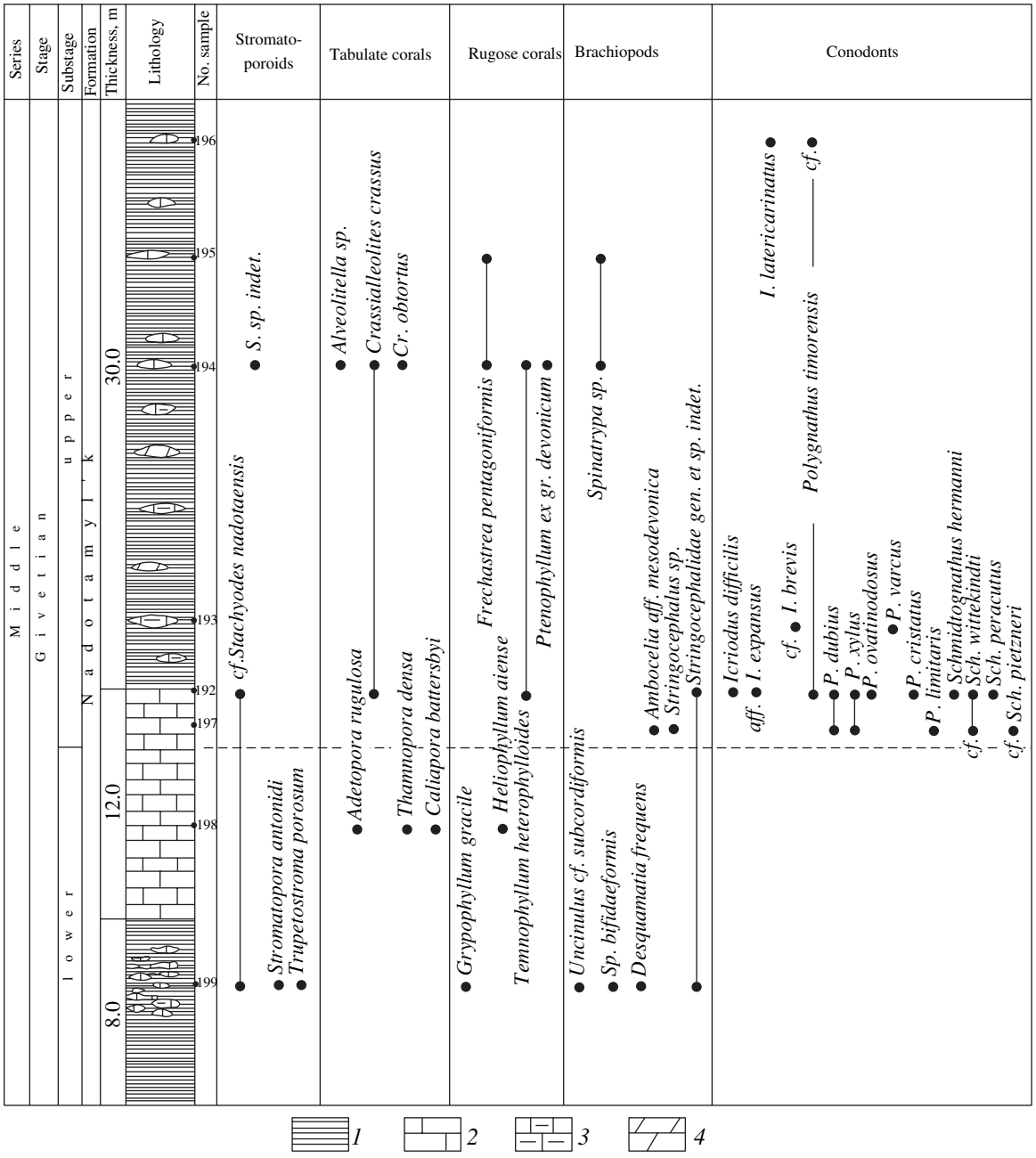

Fig. 2. Stratigraphic section of the upper Nadotamyl'k Subformation. (*1*) Shale and its phyllite-type variety; (*2, 3*) limestones: (*2*) detrital, (*3*) clayey; (*4*) marl.

to the base of the upper part of the carbonate member. The shaly member below this level and the lower part of the carbonate member lack conodonts. Most of the macrofossils found here are well known from sections of the Givetian Cheslav Horizon in the Bel'sk–Elets tectonic zone on the western slope of the Urals and from coeval strata on the eastern slope of the Urals [4, 5]. The appearance of such a representative conodont assemblage from the *hermanni–cristatus* Zone in the upper part of the carbonate member above the level under consideration is explainable by their intense radiation due to the eustatic sea level rise that followed regression and biotic crisis (Taghanic Event) [6]. In the Bel'sk–Elets tectonic zone, this level corresponds to the terrigenous Pashiiskii Horizon that represents the basal part of the transgressive systems tract.

The next level coincides with the base of the shaly member. It is marked by sharp reduction in the fossil abundance and diversity. The quantity and size of limestone lenses decrease upward through the section. This is accompanied by a decrease in the admixture of silty quartz grains. This implies the deepening of the basin

during the accumulation of sediments. A similar trend is also noted for sections of the Kynovskii Horizon in the Bel'sk–Elets tectonic zone of the western Urals [4]. This fact and the presence of common forms of fossils in the sections under consideration suggest synchronism in the accumulation of these sediments.

At present, the problem of the division of the Givetian Stage into two or three substages is being discussed actively in the Subcommission on the Devonian Stratigraphy. The base of the *hermanni–cristatus* Zone is considered the most distinct level [7, 8]. Most Uralian geologists also consider this level as the most optimal boundary between the lower and upper substages of the Givetian Stage.

ACKNOWLEDGMENTS

Fossils were determined by O.V. Bogoyavlenskaya (stromatoporoids), V.Yu. Lukin (tabulates), A.I. Pershina, Yu.A. Yudina (brachiopods), and A.V. Zhuravlev (conodonts). The author is grateful to all of them.

This work was supported by the Russian Foundation for Basic Research (project no. 04-05-96021) and the IGCP Project 499 "Devonian Terrestrial and Marine Settings: From the Continent to the Shelf."

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