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Carbon isotope chemostratigraphy and conodonts of the Middle–Upper Ordovician succession in the Tungus Basin, Siberian Craton

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Abstract

Stable carbon isotope chemostratigraphy has been applied for correlation of Ordovician marine sedimentary successions of many continents, but not yet for those located on the Siberian Craton. In this study we present the first $\delta^{13}C$ data from the Middle and Upper Ordovician successions of the Tungus Basin, the extensive Palaeozoic intracratonic basin on the Palaeocontinent Siberia. Carbon isotope curves from two separate areas of the craton, from the Kulyumbe River and Podkamennaya Tunguska River regions, demonstrate a great similarity. Three global carbon isotope events can be recognized in the Tungus Basin: the Mid-Darriwilian Excursion (MDICE), the Upper Kukruse Low, and the lower rising interval of the Guttenberg Excursion (GICE). These data partly support the previous inter-continental stratigraphic correlations but also suggest that the base of the Upper Ordovician in the Siberian succession lies at a lower level than previously thought. Although the conodont fauna in Siberia differs almost completely from that in Baltoscandia, the distribution of selected Upper Ordovician conodont taxa do not contradict the isotope chemostratographic conclusions.

Keywords: Ordovician; Siberia; Tungus Basin; Carbon isotopes; Chemostratigraphy; Conodonts

1. Introduction

Secular variations of $\delta^{13}C$ in marine carbonates have become an important tool in regional and global correlation of sedimentary successions. The stable carbon isotope chemostratigraphy is especially useful in correlation of separated marine basins and continents with different faunas and depositional environments. Numerous publications have dealt with Ordovician $\delta^{13}C$ chemostatigraphy in Baltoscandia (e.g., Kaljo et al., 2004, 2007; Ainsaar et al., 2010; Bergström et al., 2011a), North America (e.g., Saltzman and Young, 2005; Young et al., 2005; Bergström et al., 2010a), China (e.g., Zhang et al., 2010; Munnecke et al., 2011), and elsewhere. These data are summarized in the Ordovician generalized global $\delta^{13}C$ curve (Bergström et al., 2009) and in regional $\delta^{13}C$ chemostratigraphic zonation schemes (e.g., for Baltoscandia; Ainsaar et al., 2010). Numerous outcrops are located in the extensive area of Palaeozoic deposits in Siberia. Although most of them occur in remote and difficult-to-access regions, the stratigraphy and palaeontology of these successions have been studied by numerous geological expeditions during the last century (Kanygin et al., 2010a, and references therein). However, the $\delta^{13}C$ chemostratigraphy has not been applied to the Ordovician successions of the Siberian Craton. A few of stable isotope studies of the Cambrian strata in the Tungus Basin have included also the Tremadocian interval (Kouchinsky et al., 2008), but the main part of the extensive marine sedimentary succession in the region has not been studied in sense of this method. In our paper we present the results of the first $\delta^{13}C$ studies from the Middle and Upper Ordovician sections located in the Kulyumbe River and Podkamennaya

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Tunguska River areas in the Tungus Basin and compare them with the data from Baltoscandia. To test the chemostratigraphic correlations, conodonts were studied from the selected intervals in these sections.

2. Geological setting

During the early Palaeozoic, the Siberia Palaeocontinent was located in low latitudes and was slowly moving from the southern hemisphere (Cambrian–Early Ordovician) to the northern hemisphere (Late Ordovician–Silurian) (Cocks and Torsvik, 2007). The central part of the continent was occupied by an extensive intracratonic Tungus Basin (Fig. 1; Kanygin et al., 2010a, 2010b). Sedimentation of warm-water tropical carbonates during the Early Ordovician was replaced by deposition of cool- or temperate-water carbonates during the Darriwilian, although the palaeocontinent was still located in low latitudes (Dronov, 2013). The Ordovician sedimentary succession of the Siberian Craton, including the Tungus Basin, has been divided into regional stages based on biostratigraphic data (Kanygin et al., 2006, 2010a, and references therein). Based on lithological criteria the extensive Tungus Basin has been subdivided into several structural-facies zones. The sections studied by us represent the Igarka-Noril'sk Zone (Kulyumbe area) and South-Tunguska Zone (Podkamennaya Tunguska area), both located on the western margin of the Tungus Basin (Kanygin et al., 2006, 2010a). Recent sequence stratigraphic studies by Dronov et al. (2009) and Kanygin et al. (2010b) resulted in recognition of nine depositional sequences in the Ordovician succession of Siberian Craton.

The Lower Ordovician and the lower part of the Middle Ordovician (Ust'rybnaya and Il'tyk formations; Fig. 2) are represented by a succession of warm-water carbonates, mainly dolomites and limestones with stromatolites (Kanygin et al., 2010b; Dronov, 2013). These carbonates are overlain by siliciclastic-dominated units (e.g., dolomitic siltstone and sandstone of the Guragir Formation in the Kulyumbe area, quartzose sandstone of the Baykit Formation in the Podkamennaya Tunguska area; Fig. 2). The uppermost Middle Ordovician and Upper Ordovician succession is represented by cool-water carbonates and fine-grained siliciclastics in the basin (Kanygin et al., 2010b; Dronov, 2013). In the Kulyumbe area the studied succession includes the Angir, Amarkan, and Zagornyi formations and in the Podkamennaya Tunguska area the Ust' Stolbovaya, Mangazea, and Dolbor formations (Fig. 2).

The Angir and Zagornyi formations are characterized by argillaceous wackestones and packstones with thin layers of bioclastic limestones, whereas the Amarkan Formation consists of carbonate-rich siltstone and sandstone with occasional bioclastic limestone layers (Tesakov et al., 1982; Kanygin et al.,

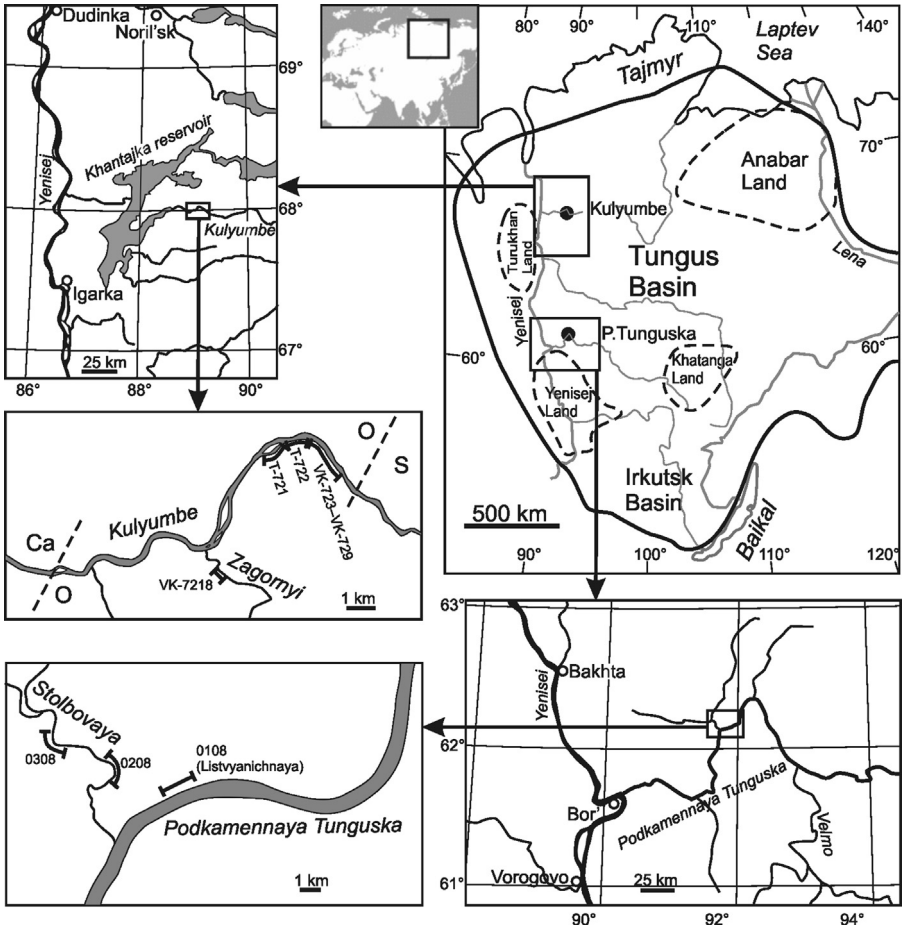

Fig. 1. Position of the Tungus Basin and location of the studied sections. Palaeogeography of the Siberian Craton according to Kanygin et al. (2010b). Ca – Cambrian; O – Ordovician; S – Silurian.