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The Devonian Stratigraphic Succession and Evolution of the Baltic Sedimentary Basin

Ervīns Lukševičs, Ģirts Stinkulis, Tomas Saks, Konrāds Popovs and Jānis Jātnieks

Abstract Facies analysis, biostratigraphic and taphonomic studies, a re-evaluation of signatures of worldwide events, and a new mathematical model of the Baltic sedimentary basin (BSB) have together enabled a better understanding to be gained of the development of the Devonian basins in the Baltic area. We have established four stages of basin evolution: (a) remnant basin stage (Lochkovian); (b) shallow epeiric basin stage, with mainly siliciclastic sedimentation (Pragian–early Frasnian); (c) shallow epeiric basin stage, with mainly carbonate sedimentation (Frasnian); and (d) infilling stage of the progressively narrowing shallow epeiric basin, with mixed sedimentation (Famennian).

Keywords East European Craton · Lithostratigraphy · Basin modelling · Sea-level changes · Shallow epeiric sea · Siliciclastic and carbonate sedimentation

The Palaeozoic Baltic BSB is situated on the western margin of the East European Craton (EEC). The basin extends over the territory of the present-day Baltic States and the Kaliningrad region, part of the Leningrad and Pskov regions of Russia, Belarus, and the northeastern part of Poland, as well as wide areas of the Baltic Sea (Lukševičs et al. 2012). It is one of the classic distribution areas of Devonian deposits around the Old Red Sandstone continent. The basin has been well studied, and the lithostratigraphic subdivision of the Middle–Upper Devonian of the Baltic, represented by siliciclastic and carbonate deposits of the wide, shallow epeiric sea, is particularly well established (e.g., Stinkulis 2003; Mark-Kurik and Põldvere 2012). The sequence of biotic and sea-level changes has been studied in detail for about half a century, and recently an attempt was made to compare the pattern of sea-level change for the BSB with global sea-level changes and to correlate the

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succession with the sequence of the Devonian global events established in the marine record (Lukševičs and Stinkulis 2012).

An integrated study of the sedimentation, including the use of modern facies analysis and a sequence-stratigraphic approach, biostratigraphic and taphonomic studies, a re-evaluation of signatures of world-wide events, and a new 3-D geological model of the BSB (Virbulis et al. 2012), have together enabled a better understanding to be gained of the evolution of the Devonian basins of the Baltic area. The main part of the Middle Devonian succession has already been subdivided into stratigraphic sequences (Pontén and Plink-Björklund 2009; Tänavsuu-Milkeviciene et al. 2009; Tovmasjana and Stinkulis 2012), and the results of a preliminary sequence-stratigraphic analysis of the Frasnian and Famennian sequence of the BSB have allowed global sea-level changes to be better distinguished from the influence of local tectonic processes.

This study subdivides the development of the basin into four stages: (a) remnant basin stage, corresponding to the Lochkovian; (b) shallow epeiric basin stage with mainly siliciclastic sedimentation during Pragian–early Frasnian time; (c) shallow epeiric basin stage with mainly carbonate sedimentation, corresponding to the major part of the Frasnian; and (d) infilling stage of the progressively narrowing shallow epeiric basin, with mixed sedimentation during the Famennian. In each of the stages, the sedimentary facies show their own particular characteristics. The remnant basin stage corresponds to the Gargždai Series distributed mainly in the Polish–Lithuanian depression and two separate areas in northern and eastern Latvia; the two latter locations could contain deposits of continental origin. The Gargždai Series is overlain by a disconformity and in places with an angular unconformity by the deposits of the Ķemeri Regional Stage (RS), which are distributed more extensively and correspond to the beginning of the second stage of basin evolution in the? Pragian or early Emsian. A very wide transgression and establishment of predominantly siliciclastic sedimentation took place in the latest Emsian or earliest Eifelian (Pärnu RS) and continued until the early Frasnian, except during Narva time when carbonates of the Narva RS were mainly formed.

A significant transgression in the BSB started in the early Frasnian, which coincides with the development of a predominantly carbonate succession. The production of carbonates ceased near the Frasnian–Famennian boundary, and the latest Frasnian sequence in the Baltic is represented by sandy and clayey deposits of the Amula Fm. Carbonate production recovered in the early Famennian, starting with the Joniškis Fm., but was interrupted multiple times by the development of mainly siliciclastic sedimentation represented by the Mūri, Tērvete, Ketleri, and Šķervelis fms. The Tērvete Fm. yields traces of the most significant drop of sea level during the middle–late Famennian. The Šķervelis Fm. shows signatures of the long-lasting subaerial exposition of the rocks, thus corresponding to the start of a major eustatic fall and coinciding with the latest Famennian mass extinction. The distributions of deposits, biotas, and facies suggest a diminution of the depositional area since the maximum transgression in the earliest Frasnian, thereby showing good coincidence with the global sea-level curve (Haq and Schutter 2008). The retreat of the depocentre of the palaeobasin towards the west during the late

Frasnian and the Famennian was likely caused by tectonic subsidence in the western part of the eastern Baltics. The results of the study and the methods used should help to substantially improve the stratigraphic subdivision and correlation of sedimentary rock sequences in shallow epeiric sea basins.

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