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The Ludfordian carbon isotope excursion in the Vidukle core, Lithuania, its relations with the Lau Oceanic Event and environmental background in NW Baltica

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Five to six notable positive carbon isotope excursions have been ascertained in the Silurian (Kaljo et al., 1998, Munnecke et al., 2003). The most prominent one is widely observed in the upper Ludlow (Ludfordian) of Baltica, Laurentia, Perunica and Australia, indicating true global dimension of this stable isotope event. Due to its stratigraphical position, the excursion has been connected with the Lau Oceanic Event established by Jeppsson (1998) based on different environmental processes and conodont biodiversity changes. Extraordinarily high carbon isotope values (11.2‰ in Scania; Wigforss-Lange, 1999) and serious biodiversity changes in several groups of biota (corals, graptolites, vertebrates, conodonts and acritarchs; see references in Kaljo et al., 1998) occurring approximately in the same interval of the Ludfordian make the event really intriguing. A detailed study of relationships between these two processes and their environmental background is needed to find out real reasons for both the isotope and biotic changes.

A continuous section (320 m) of terrigenous-carbonate rocks of the Wenlock and Ludlow was studied in the Vidukle core in central Lithuania. A total of 113 whole rock samples were analysed. The rock content of the rather deep shelf section shows a general upward shallowing trend interrupted by two relative deepening episodes of the sea in the earliest and latest Ludlow. The Wenlock comprises the Riga Formation (Fm) (claystones with graptolites) and the Siesartis Fm (graptolitic mudstones, limestone interbeds); the Ludlow includes the Dubysa Fm (mainly mudstones with graptolites, higher more calcareous and shelly fauna), the Mituva Fm (limestones, oncolites) and the Ventspils Fm (limestones, silty marls).

The carbon isotope trend shows the following main tendencies and excursions:

1. In the upper part of the Riga Fm the $\delta^{13}C$ values remain below or close to 0‰. In the Siesartis Fm twice slightly higher values were registered: 1.3‰ at 1299.5 m and 1.6‰ at 1284.4 m. Paškevičius et al. (1994) recorded from these levels graptolites, which allow us to date these weak shifts as the *Monograptus ludensis* Biozone. This is a more exact dating than that suggested by Kaljo et al. (1998).

2. The Dubysa Fm shows also low values – in the lower beds below 0‰, but higher, maximum values reach 0.7‰. In the top a negative shift until –1.5‰ (at 1178 m) was recorded. The shift is dated by the last occurrences of *Bohemograptus bohemicus tenuis* and the appearance of *Polygnathoides siluricus* (Paškevičius et al. 1994).

3. In the Mituva Fm the carbon isotope trend changes completely, values of the positive $\delta^{13}C$ excursion reach 8.2‰ (at 1147 m) and beginning from 1178 m (see item 2), the whole shift is 9.7‰. The excursion (values over 2‰) occupies nearly the entire formation (1159–1120 m). A negative shift (–1.2‰) similar to that at the start of the excursion occurs at the boundary with the Ventspils Fm. The excursion is dated based on the last occurrences of *Polygnathoides siluricus* just below the main shift and the appearance of *Ozarkodina wimani* and *O.* aff. *crispa* in the upper part of the excursion (Paškevičius et al., 1994). The true *O. crispa* appears above the negative shift at 1100 m. The conodont occurrences allow us to identify the excursion as the middle Ludfordian.

4. The carbon isotope trend above the last excursion and negative shift returned to ca 1‰ values in the uppermost Ludlow and lowermost Pridoli.

CaO, MgO and the terrigenous component (t.c.) show the following distribution pattern in the Ludlow part of the Vidukle core: (1) The t.c. of the rocks is dominating over the carbonates – clearly in the Dubysa Fm, but slightly in the Mituva Fm. The CaO content is variable but increasing up to the top of the Mituva Fm, where a set-back (down to 21%) occurs. The MgO content is low and varies mainly below 5%, changing parallel to t.c. (2) The $\delta^{13}C$ positive shift coincides with beds where the CaO + MgO content is stably over 40%; both negative shifts occur in the rocks with a high clay content.

Based on the data from the Vidukle core, the following conclusions can be made:

1. The Wenlock carbon isotope excursions are in good accordance with earlier data from Baltica and elsewhere, and the $\delta^{13}C$ values partly reflect the depth of the sedimentary basin.

2. The peak values of the Ludfordian excursion occur in the limits of the Lau Event defined by conodonts, but the rising and falling limbs are at least in part located before and

after the Event, i.e. the processes that caused the carbon isotope excursion started before the Lau Event.

3. The positive excursion began and ended with negative shifts, which are well correlated with certain sedimentological changes, thus evidencing oceanic and climatic processes characteristic of more humid episodes; the positive excursion itself could be referred to an arid episode. The carbon isotope pattern seems to be typical of the event.

4. The environmental change was rather rapid – its implication in terms of the rise in $\delta^{13}C$ values through 30 m was 0.3‰ per metre or 1‰ per 70 000 years, but the last 4‰ were added only in 54 000 years.

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