

# Mid-Ludfordian carbon isotope records from open marine settings – deep-water clay-dominated and carbonate shelf (Lithuania)

Sigitas Radzevičius<sup>1</sup>, Wojciech Kozłowski<sup>2</sup>, Andrej Spiridonov<sup>1</sup>, Ieva Kaminskaitė-Barauskienė<sup>1</sup>, Gailė Žalūdienė<sup>3</sup>, Andrius Garbaras<sup>4</sup> and Anna Cichon-Pupienis<sup>3\*</sup>

<sup>1</sup> Department of Geology and Mineralogy, Vilnius University, M. K. Čiurlionio 21/27, 03101 Vilnius, Lithuania

<sup>2</sup> Faculty of Geology, University of Warsaw, Żwirki i Wigury Str., 93, 02-089 Warsaw, Poland

<sup>3</sup> Laboratory of Bedrock Geology, Nature Research Centre, Akademijos str. 2, 08412 Vilnius, Lithuania

<sup>4</sup> Department of Nuclear Research, Center for Physical Sciences and Technology, 10221 Vilnius, Lithuania

\* Corresponding author, email anna.cichon-pupienis@gamtc.lt



During the Lau/Kozłowski biocrisis Silurian faunas underwent a decline in marine biodiversity on a global scale, which affected a various range of taxonomic groups, most notably conodonts and graptolites. This bioevent is linked to the largest positive carbon isotope excursion (Mid-Ludfordian CIE) recorded in the Phanerozoic which apparently coincided with a period of global cooling and eustatic sea level fall. These environmental changes are evidenced by corresponding changes in the sedimentary facies.

The studied Šilalė-5 core section from Western Lithuania represents relatively deep-water clay-dominated sedimentation on the shelf of the Baltica paleocontinent at low latitudes. This 18 meter-long section is dominated by argillaceous sediments with carbonate intercalations characteristic for mixed siliciclastic – carbonate depositional

settings, which emerged due to the lateral coexistence of carbonate and siliciclastic depositional environments. The measurement of whole-rock carbon isotope ratios has revealed the presence of ~ 7 meter-thick positive excursion, with  $\delta^{13}\text{C}_{\text{carb}}$  values reaching +5.69 ‰. This coincides with prominent lithofacies change, i.e. the occurrence of fine-grained limestone interlayered with mudstone with a distinct 'varve-like' texture typical for Toliai Mb. positioned at the boundary of Dubysa and Pagėgiai Reg. Stages. The mid-Ludfordian age of the  $\delta^{13}\text{C}_{\text{carb}}$  anomaly is evidenced by graptolite assemblage (*Pristiograptus* ex. gr. *dubius* (Suess), *Bohemograptus tenuis* (Bouček) and *Polonograptus* sp.) found in the lowermost core interval preceding the onset of  $\delta^{13}\text{C}_{\text{carb}}$  anomaly and being characteristic of the pre-Kozłowski graptolite event interval.

The core section from the Lapgiriai-1 borehole in Middle Lithuania recorded a positive  $\delta^{13}\text{C}_{\text{carb}}$  excursion at a comparable stratigraphic level. However, the anomaly is considerably more pronounced, reaching a maximum value of +7.51 ‰ and spanning approximately 60 meters in thickness. The onset of  $\delta^{13}\text{C}_{\text{carb}}$  excursion coincides with deposition of a few meters-thick limestone, predominantly clayey organogenous-detrital, fine-grained and nodular, placed within a packet of marls. This limestone in the Lapgiriai area was found to be oil-saturated and maintained as possible hydrocarbon reservoir. The limestone has been considered as the upper part of the Nova Beds within the uppermost Dubysa Reg. Stage, and towards the east – a break in sedimentation appears at this stratigraphic level (Lapinskas, 2000: Structure and petroliferosity of the Silurian in Lithuania. Inst. Geol., Vilnius). The core section represents sedimentation within an open marine carbonate shelf. Lithofacies change is coupled with changing pattern of carbon isotope excursion. The growing limb of the positive  $\delta^{13}\text{C}_{\text{carb}}$  anomaly is coeval with deposition of marls with detritus and limestone nodules/interlayers. Upward the section, marly facies pass into more calcareous packets of clayey, fine-grained and horizontally wavy-laminated organogenous finely to coarsely detrital limestones with stromatoporoids, crinoids and brachiopods and marl interlayers of Mituva Fm. (Pagėgiai Reg. St.) that correspond to the peak and falling limb of  $\delta^{13}\text{C}_{\text{carb}}$  excursion. The uppermost several meters of the section is represented by clayey, fine-grained and detrital horizontally wavy-laminated limestone with marls of Ventspils Fm.

At present stage of the research we can conclude that the new data confirms the more suppressed pattern of carbon isotope excursion in the deep water section compared to the shallower section.

**Keywords:** Silurian, Baltica, graptolites, stable carbon isotopes.