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Carbon Isotopic Test of Silurian Oceanic Episodes

Dimitri Kaljo (kaljo@gi.ee) & **Tõnu Martma**

Institute of Geology, 7 Estonia Blvd., Tallinn, 10143, Estonia

Evolution of the environment is mainly a cyclic process, as emphasised by Jeppsson (1990) in his model of oceanic changes, where more humid, cooler Primo (P) episodes alternate with drier and warmer Secundo (S) episodes. This alternation was accompanied by extinctions of taxa, changes in the environmental conditions, especially in climate, sedimentation, bioproduction, etc. The most drastic events occurred at the transition from P to S episodes, other types of oceanic changes (S-P and S-S) are less remarkable. Such changes were fast geologically, needing less than oceanic mixing time (ca 1 ka). For identifying the boundaries of the episodes, conodonts have been used as the main guides (Jeppsson, 1998).

According to the model (Jeppsson, 1990; Heath et al., 1998; Wenzel & Joachimski, 1996) the $\delta^{13}C$ values should be higher in the colder P episodes due to increased planktic productivity and enhanced burial of organic carbon and vice versa, lower in the warmer S episodes. Thus, a transition from a P episode to an S episode should show a negative shift of $\delta^{13}C$. Contrariwise, Bickert et al., 1997 consider high $\delta^{13}C$ values typical of arid S and low values typical of humid P episodes, motivating this view by changes in ocean circulation.

Recent carbon isotope studies in the Baltic Silurian (Kaljo et al., 1998) have revealed four $\delta^{13}C$ positive excursions (Figure 1:early Aeronian, early Sheinwoodian, late Homerian, middle Ludfordian), more or less coinciding with different environmental changes and biotic events (sea level fluctuation, bottom oxygenation, glaciations, extinctions, etc.). As both the evolution of oceanic conditions and carbon isotope cycling are controlled by similar environmental parameters, some correlation of changes was anticipated. To test the idea, the oceanic episodes and carbon isotope excursions were studied together in five core sections of Estonia and Latvia (Kirikuküla, Ohesaare, Ruhnu, Ventspils and Viki).

The data obtained could be summarised as follows. 1. Four different states in the stratigraphical trend of $\delta^{13}C$ values were observed (Figure 1): a stable or slightly changing interval (e.g. middle Wenlock); a small (<2‰) positive excursion (early Telychian, latest Ludfordian); a great (3.6‰) positive shift (early Aeronian, early Sheinwoodian, late Homerian, middle Ludfordian); a notable (>2‰) negative shift (late Rhuddanian, late Aeronian, close to the Wenlock/Ludlow junction, some doubtful ones in the upper Silurian). 2. Most of the oceanic events established in the Baltic cores are in some way connected with the above states of the carbon isotopic curve, e.g. the early Silurian events are all followed by positive $\delta^{13}C$ shifts: the pre-Snipklint S-P Event is followed by a small, but the Ireviken P-S and Mulde S-S events are followed by major positive shifts. The late Silurian Lau P-S Event coincides with a major positive excursion, but events in the Pridoli are marked with negative excursions. Several P-S events (Boge, Valleviken, Linde) and "normal" S-P episode replacements have no reliable carbon isotope signature.

The items above show that the events of the same type (P-S or S-P) may be followed by (or are coinciding with) positive as well as negative excursions. It means that there is no unambiguous relationship between changes of oceanic episodes and carbon isotope fractionation and storage in the Silurian seas. In several cases the carbon isotopic trend is in conflict with model characteristics, e.g. for the Ireviken and Lau P-S events we have major positive excursions and not negative ones as anticipated according to the original model.

Obviously, not all episodes and events suggested earlier can be considered as real global oceanic events. Changes of biota and lithology used to distinguish them are more likely local, not affecting carbon isotope fractionation. Differences in responses of carbon isotopic signatures to certain oceanic events show that main reasons for $\delta^{13}C$ excursions can be rather variable during the Silurian: bio-productivity, burial of organic carbon, type of circulation, sea level changes, etc. Also, glaciations and related effects are valid in many occasions in the early Silurian. This study was partly supported by the Estonian Science Foundation (grant No 3751).