



EGU24-18468, updated on 11 Mar 2024
<https://doi.org/10.5194/egusphere-egu24-18468>
EGU General Assembly 2024
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Changes in the response of the carbon cycle to astronomical forcing during the Silurian Ireviken biogeochemical event

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The Silurian Ireviken Event is a biogeochemical event characterised by extinctions among several marine groups and a major perturbation to the global carbon cycle. In the Altajme core from Gotland, Sweden, the associated Ireviken Carbon Isotope Excursion (ICIE) reaches peak values of $\sim 6\text{‰}$. Within the ICIE, the main peak of -6‰ ($\delta^{13}\text{C}_{\text{carb}}$) is superimposed by multiple short-term and small amplitude positive peaks ($+1.00\text{‰}$ $\delta^{13}\text{C}_{\text{carb}}$), while the tail of the main peak is superimposed by multiple small amplitude negative peaks (-1.55‰ $\delta^{13}\text{C}_{\text{carb}}$). To understand the processes behind these recurrent small amplitude peaks, the high-resolution XRF scanning data of the Altajme core were used to identify astronomical cycles to put astrochronological constraints on the $\delta^{13}\text{C}_{\text{carb}}$ curve. Based on the XRF data and its resulting astrochronology, the small amplitude positive and negative $\delta^{13}\text{C}_{\text{carb}}$ peaks occur during insolation minima in intervals enriched in carbonate relative to the surrounding lithology. The XRF proxy data indicates that during times when elevated carbonate content coincides with elevated $\delta^{13}\text{C}_{\text{carb}}$ values, insolation minima induced an arid environmental state in the basin. This led to decreasing runoff and a strong anti-estuarine circulation, which in turn lowered pelagic productivity and increased photozoan carbonate production, resulting in the deposition of carbonates with elevated $\delta^{13}\text{C}_{\text{carb}}$ values. This contrasts to the concomitant insolation maximum, which induced a semi-arid state in the basin, resulting in some runoff, a (sluggish) anti-estuarine circulation in the basin, some pelagic productivity and carbonates being primarily produced by heterozoans, resulting in the deposition of marly carbonates with low $\delta^{13}\text{C}_{\text{carb}}$ values. The XRF proxy data indicates that during times when carbonate-rich intervals coincide with more negative $\delta^{13}\text{C}_{\text{carb}}$ values, insolation minima induce a semi-arid state in the basin, resulting in some runoff, a (sluggish) estuarine circulation in the basin, some pelagic productivity and carbonates being primarily produced by heterozoans resulting in the deposition of marly carbonates with low $\delta^{13}\text{C}_{\text{carb}}$ values. This contrasts with the concomitant insolation maximum which induced humid conditions in the basin, resulting in increased runoff, a (strong) estuarine circulation and high primary productivity, leading to the deposition of marly shales with higher $\delta^{13}\text{C}_{\text{carb}}$ values. The shifting baseline climatic conditions during the Ireviken Event are inferred to have changed the response of the depositional environments to astronomical forcing, in changing (carbonate) productivity and circulation, which in turn modulated the carbon cycle, resulting in an imprint of astronomical cycles in the ICIE.

How to cite: Arts, M., Cramer, B., Calner, M., Rasmussen, C. M. Ø., and Da Silva, A.-C.: Changes in the response of the carbon cycle to astronomical forcing during the Silurian Ireviken biogeochemical event, EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024, EGU24-18468, <https://doi.org/10.5194/egusphere-egu24-18468>, 2024.