Cyclostratigraphic calibration of the Miaolingian Series (Middle Cambrian, Southern Scandinavia, Sweden)

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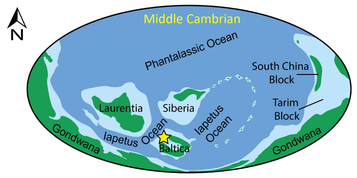
Outstanding Student & PhD candidate Presentation contest

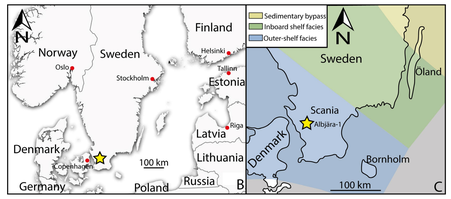
I: The middle Cambrian of Southern Sweden

1 Introduction

Despite the significance of the Cambrian period for the history of life on Earth, its time scale remains remarkably poorly defined due to several challenges, including the paucity of high-precision radioisotope age data, generalized endemism (particularly during the lower Cambrian), and a lack of well-preserved exposures. To overcome these challenges, new studies combining multiple approaches (e.g., cyclostratigraphy, sequence stratigraphy, C isotope analyses) on continuous sections are essential. In this study we conducted a multi-proxy approach on the continuous middle Stage 4-lower Guzhangian succession recorded in the Albjara-1 drill core. We built a new dataset of TOC and $\delta^{13}C$ for the entire succession in order to increase our understanding of the C cycling in this interval, resolve the DICE isotopic excursion and integrate our work within the global ^{13}C framework. Then, we scanned the core with an XRF core scanning instrument to build a high-resolution elemental proxies dataset (e.g., Ti, Si, Al, etc.) to explore the record of orbital forcing in the core and construct a floating Astronomical Time Scale (ATS) for the studied interval.

2 Localisation





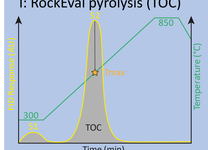
The Albjära-1 drill core (Scania, Southern Sweden) recorded a continuous sequence of black shales known as "The Alum Shale" ranging from the upper Wuliuan (Miaolingian) to the Lower Ordovician on the northern margin of the paleocontinent Baltica.

3 Material & Methods

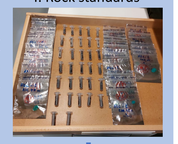
- Middle Stage 4 to lower Guzhangian interval that includes the DICE
- 27 m long core from the Alum Shale
- TOC and $\delta^{13}C_{org}$ measured on **151 samples** (15 cm sampling step)
- ICP-MS (**50 samples**) to calibrate XRF data
- mm-scale resolution (**29,000 data points**) with an XRF core scanner (Stockholm University)
- Biostratigraphic resolution based on more than 230 photographs of agnostids trilobites and brachiopods

A: C geochemistry

I: RockEval pyrolysis (TOC)



I: Rock standards



II: Spectrometer ($\delta^{13}C$)

$$\delta^{13}C = \left(\frac{\left(\frac{^{13}C}{^{12}C}\right)sample}{\left(\frac{^{13}C}{^{12}C}\right)standard} - 1 \right) x\ 1000$$

II: ICP-MS laboratory (trace and major elements)

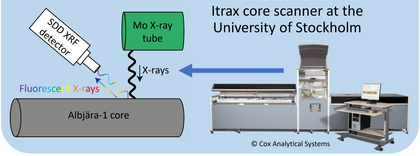
Actlabs

B: XRF measurements

I: Washing the core (deionised water)

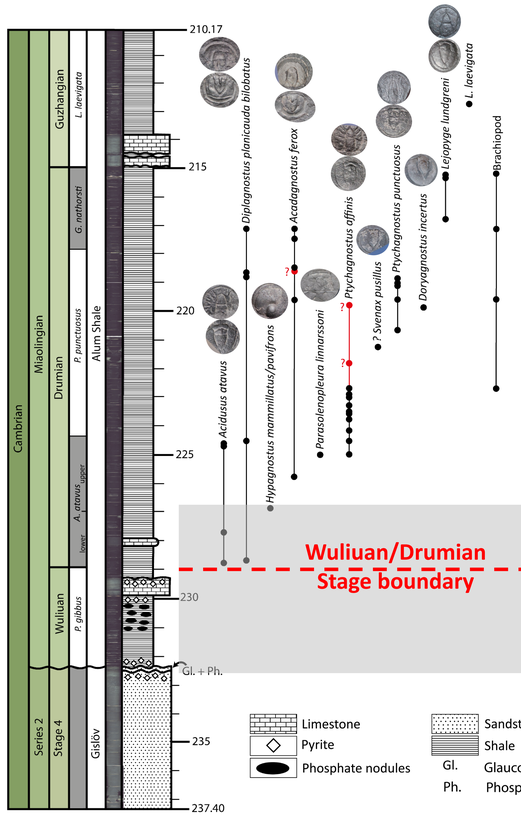
II: Fill in the cracks of the core with a Cl-rich dough

III: XRF measurements with the Itrax core scanner at the University of Stockholm

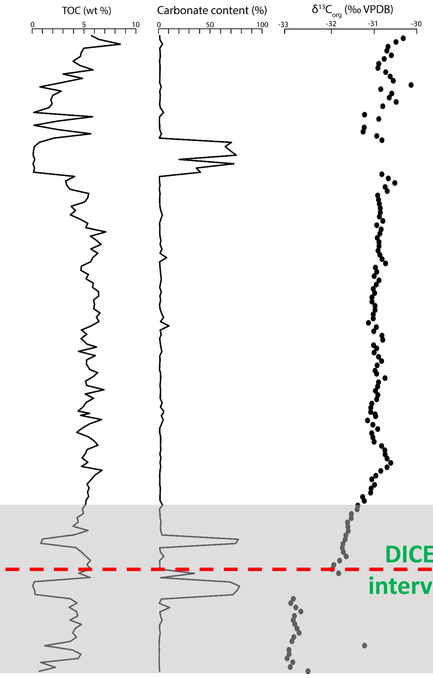


II: Already obtained results

4 Biostratigraphy



5 Geochemistry

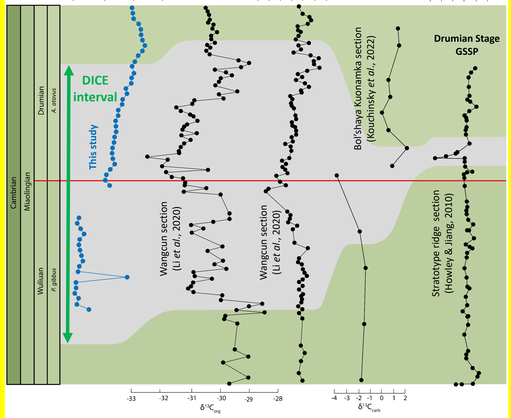


- <u>The TOC varies from 0.06 to 8.51 wt %</u>
  - *L. laevigata* biozone: TOC values slightly decrease from 8.51 to 1 wt%
  - *G. nathorsti* - *P. gibbus* biozones: TOC values remain around a mean value of 5 wt%
- <u>The carbonate content varies from 0.32 to 77.62 wt%</u>
  - Limestone intervals: 34.31 to 77.62 wt%
  - Shale intervals: 0.32 to 4.82 wt%
- <u>$\delta^{13}C_{org}$ values range from -33 to -27 ‰</u>
  - The lighter carbonate values (-29 to -27‰) have been removed from the present graph and will not be discussed here.
  - *L. laevigata* - uppermost *A. atavus* biozones: $\delta^{13}C_{org}$ values are around -31 ‰
  - *A. atavus* biozone: $\delta^{13}C_{org}$ values slightly decrease from -31 to -32 ‰
  - *P. gibbus* biozone: $\delta^{13}C_{org}$ values are around -33 ‰
- The negative $\delta^{13}C_{org}$ value of around -33‰ and the slightly older age of the DICE (upper Wuliuan to lower Drumian) are in the range of the observations made by *Li et al.* (2020) in South China.

III: What does it mean?

6 Discussion

- Our well-defined biostratigraphic framework indicates that the shift in $\delta^{13}C_{org}$ within the lower part of the core corresponds to the DICE, with a minimum peak of -33‰ located below the Wuliuan/Drumian Stage boundary. This suggests that the DICE occurred at a slightly older age in Baltica than in the type locality in Laurentia.



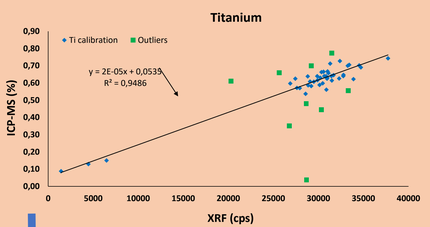
- The earlier onset of the global DICE event in South China (Gondwana) and Sweden (Baltica) followed by Northern Siberia and Laurentia, suggest three possible explanations:
  1) The DICE global excursion is slightly asynchronous with a westward shift from Gondwana to Laurentia.
  2) The fossil index taxa first appeared in Laurentia and then migrated eastward, leading to an erroneous age of the onset of the DICE.
  3) The earliest age of the DICE in Gondwana/Baltica could be due to a combination of asynchronous onset of the event and eastward migration of the fossil index taxa.

IV: Next steps

7 Data calibration & Cyclostratigraphy

A: Rock standards

- To get quantitative values for our cyclostratigraphic analysis, a total of 50 rock standards have been selected and analysed with both ICP-MS (ppm to %) and XRF (cps)
- To calibrate the XRF core scanner we plotted values obtained from the ICP-MS and XRF measurements and extracted the linear regression equation for each éléments we aim to calibrate.
- We aims at calibrating a total of 22 éléments to build a high-resolution dataset including detrial, redox and bioproductivity proxies.



B: Dataset

- We will initiate our cyclostratigraphic analysis of the entire core to build a robust floating ATS for the middle Stage 4-lower Guzhangian interval with a particular focus on the DICE isotopic excursion.
- The built ATS will be anchored to the one of Zhao *et al.* (2022) and will allow having a precise time frame to decipher the timing and duration of bio-geochemical events in the Miaolingian of Baltica.
- The integration of our study into the Cambrian geochemical framework will enable global correlation and enhance our understanding of geochemical variations in the ocean during the Miaolingian Series interval on a global scale.

V: Take home message

8 Conclusions

- The study provides a high-resolution picture of the DICE in Baltoscandia.
- The refinement of the biostratigraphic framework in the Albjära-1 core allowed for the precise location of the Wuliuan/Drumian Stage boundary.
- Cyclostratigraphy on the acquired XRF core scanning data will offer a chance to highly increase the temporal resolution of the Albjära-1 core, enabling to get an improved timing and duration for the bio-geochemical events in the Miaolingian Series.

VI: References

- Scotese (2014) - **PALEOMAP project**
- Zhao *et al.* (2022) - **Global and Planetary Change**
- Nielsen & Schovsbo (2015) - **Earth Science Reviews**
- Nielsen *et al.* (2018) - **Bulletin of the Geological Society of Denmark**
- Lauridsen (2000) - **Unpublished Cand. Scient. Thesis. University of Copenhagen**
- Li *et al.* (2020) - **Precambrian Research**
- Howley & Jiang (2010) - **Palaeogeography, Palaeoclimatology, Palaeocecology**
- Kouchinsky *et al.* (2022) - **Acta Palaeontologica Polonica**
- Baudin *et al.* (2015) - **Organic Geochemistry**