TMS-CFFR FORAMINIFERA SPRING MEETING

COLOGNE, MAY 21-24, 2024

FORAMINIFERA & THE EVOLVING EARTH SYSTEM

The Micropalaeontological Society

Cushman Foundation for Foraminiferal Research

Est. 1950

Cumberland Bay (South Georgia) glacial evolution during the Holocene

Jack Wilkin [a, b], Erin McClymont [c], Claire Allen [b], Rowan Dejardin [d], Victoria Peck [b], Kate Littler [a], James Scourse [a], George Swann [e], Kerry Strong [c], Melanie Leng [e, f] and Sev Kender, [a, f].

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University of Exeter

British Antarctic Survey

Natural Environment Research Council

BGS British Geological Survey

University of Bristol

The University of Nottingham

Durham University

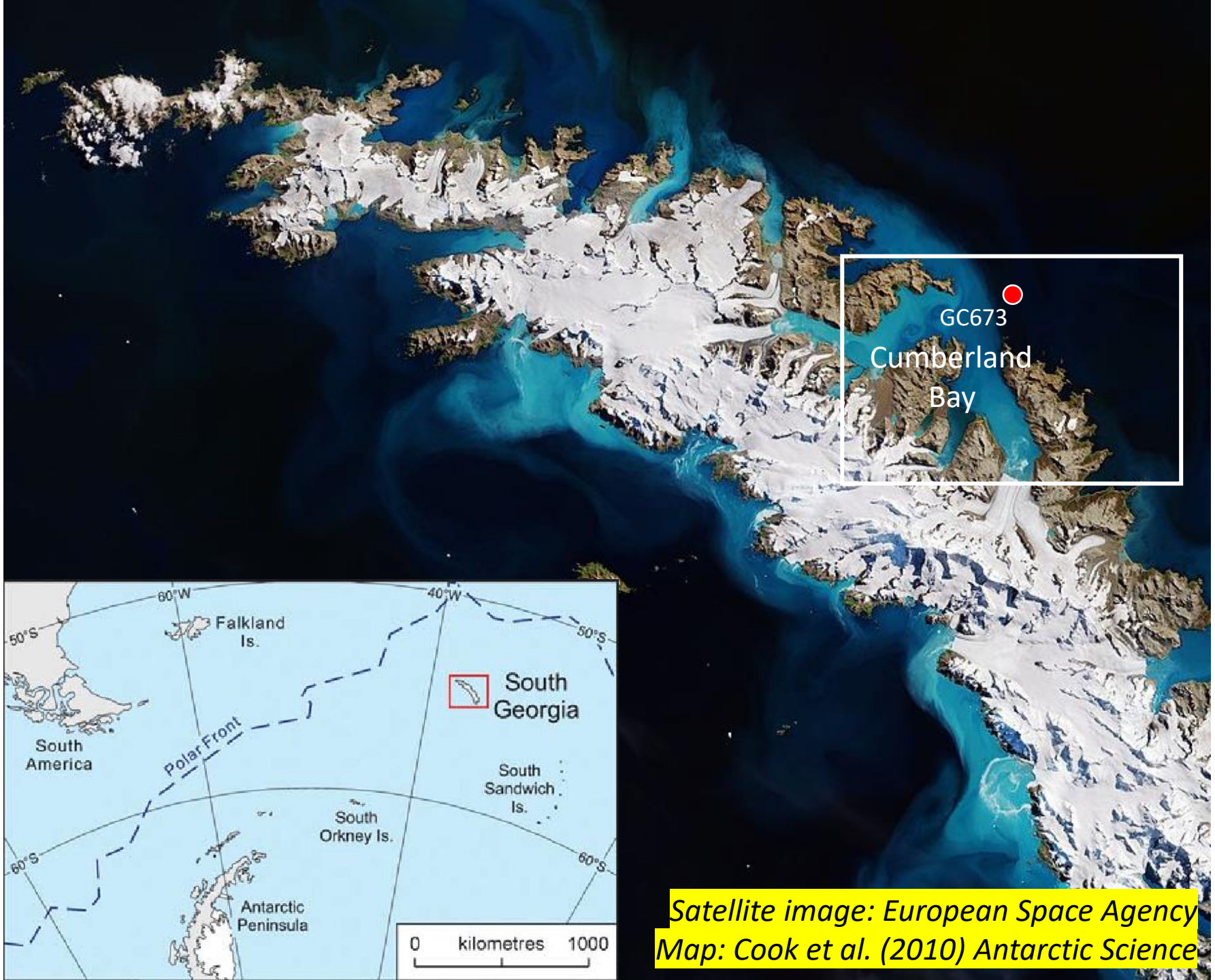
Aims and objectives

- Develop a multi-proxy record (foram and diatom assemblages, and pXRF).
- Reconstruct the glacial history of the northern South Georgia shelf during the Holocene.
- Test previous non-quantitative glacial models.

Encyclopaedia Britannica

Modern South Georgia

- Narrow, mountainous island. Largest island in the Scotia Arc.
- The South Georgia shelf is transversed by long and relatively deep cross-shelf glacial troughs.
- Cumberland Bay is one of the most dynamic glacial systems in the world with many tidewater (marine-terminating) glaciers.

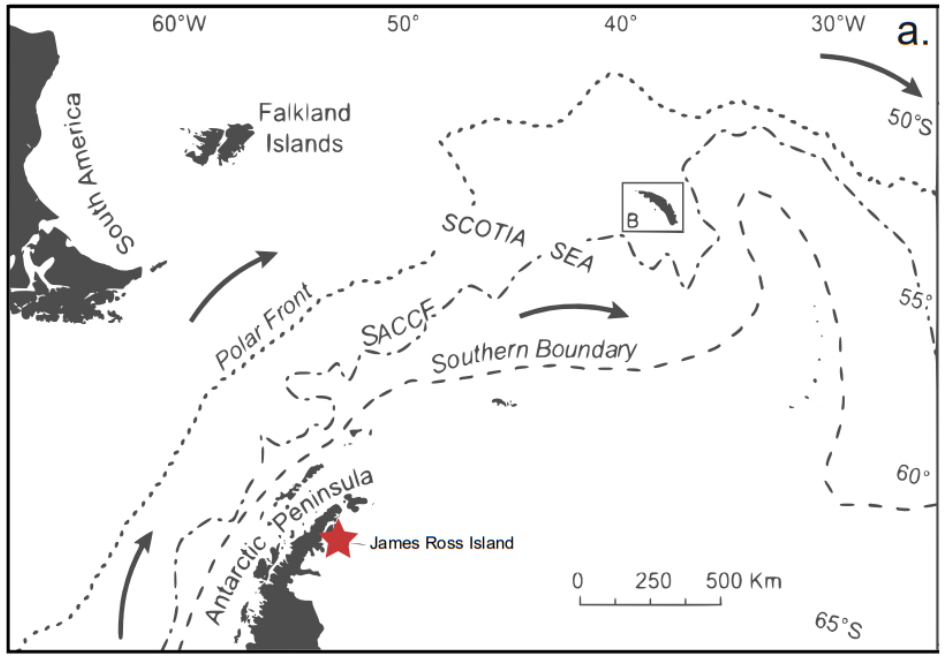


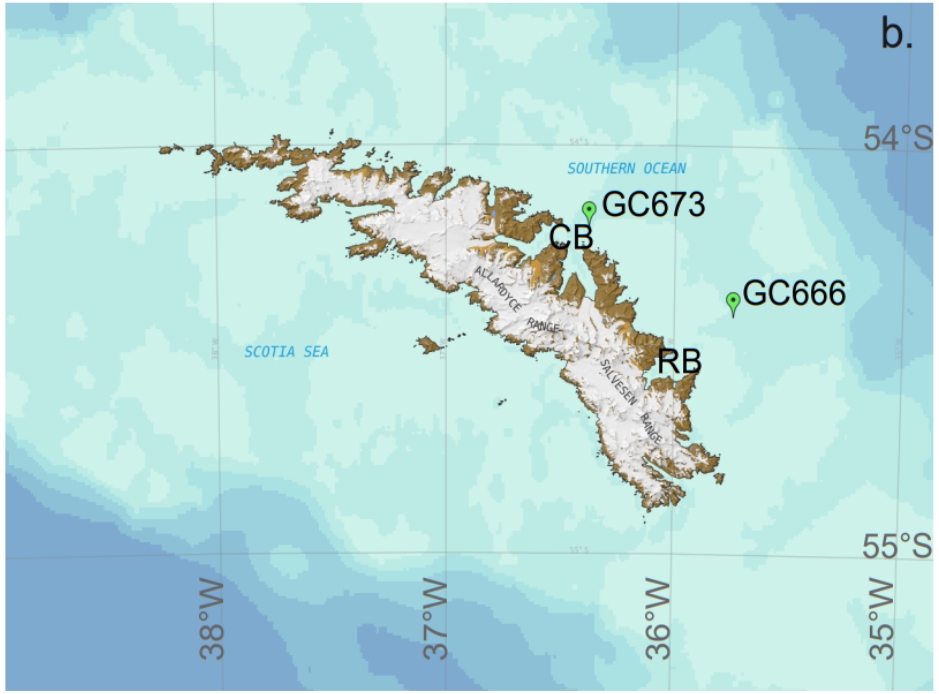
Satellite image: European Space Agency
Map: Cook et al. (2010) Antarctic Science

Materials

- GC673 – an 8.84 m long sediment core recovered from offshore Cumberland Bay.

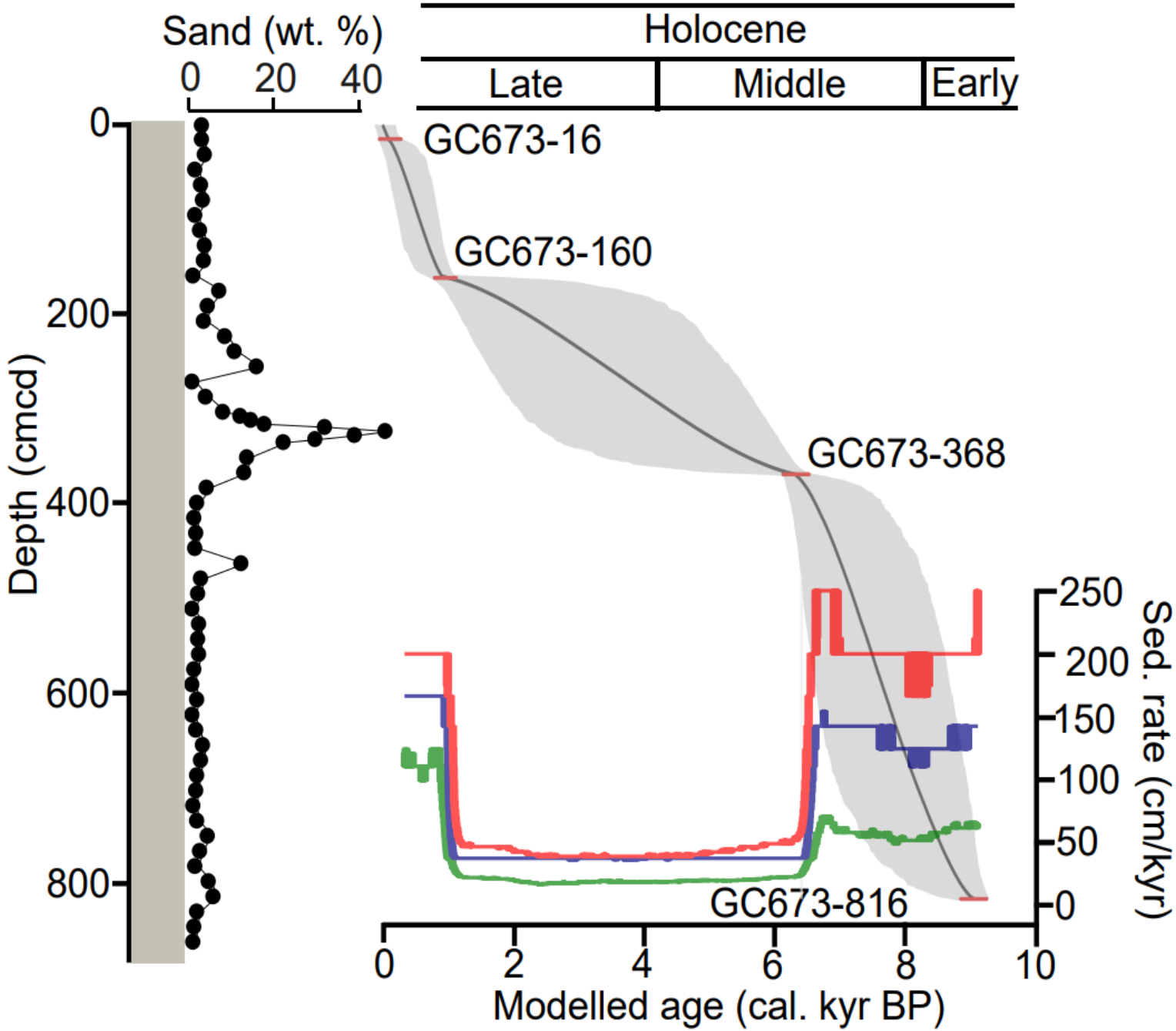
- Material was collected by the *RRS James Clark Ross* (JR-257) in 2012.





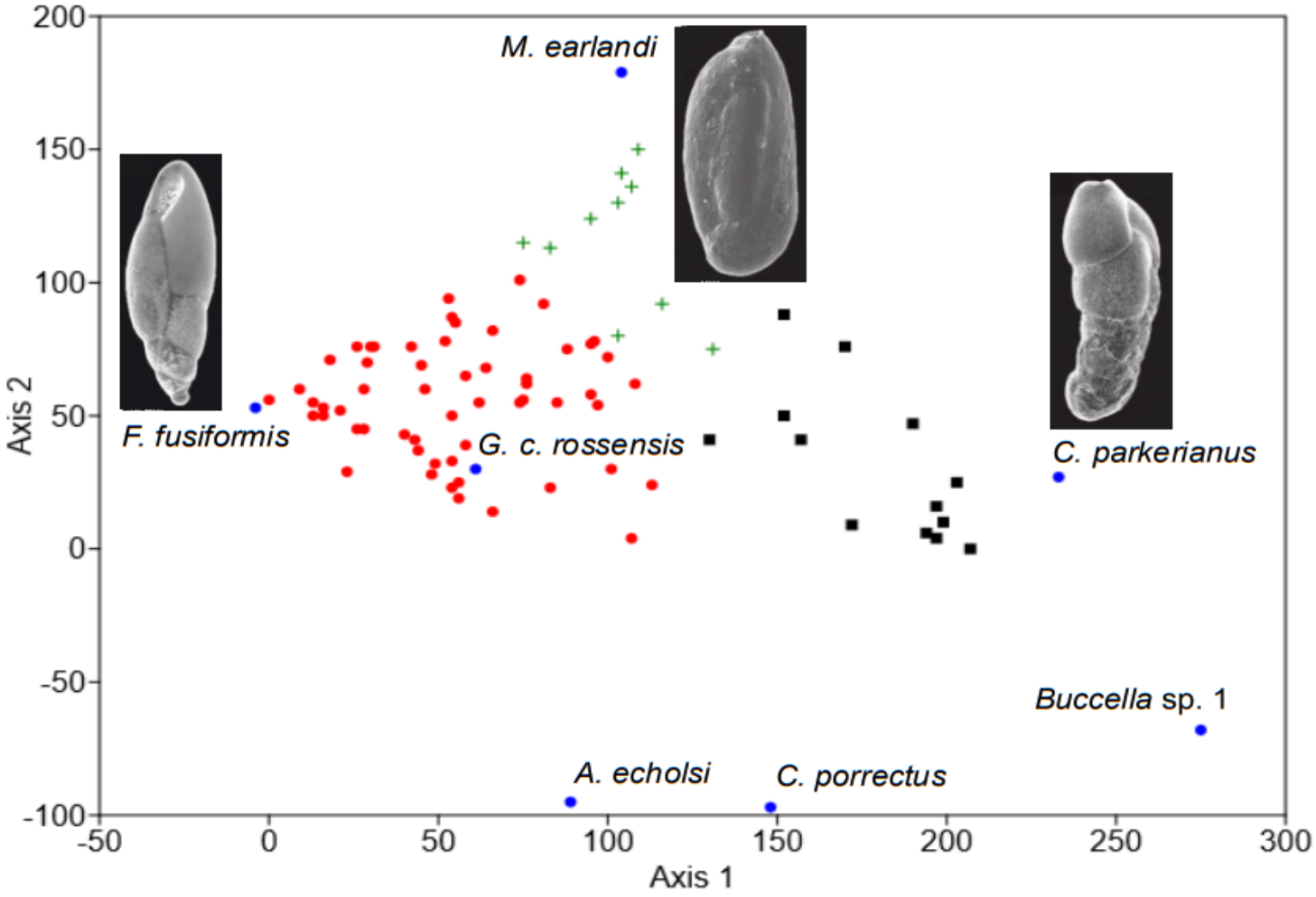
Materials

- GC673 – an 8.84 m long sediment core recovered from offshore Cumberland Bay.
- Material was collected by the *RRS James Clark Ross* (JR-257) in 2012.
- Diatomaceous mud, with rare sand.
- Radiocarbon dates show the core spans from ca. 9.7 cal. kyr BP to the Present.



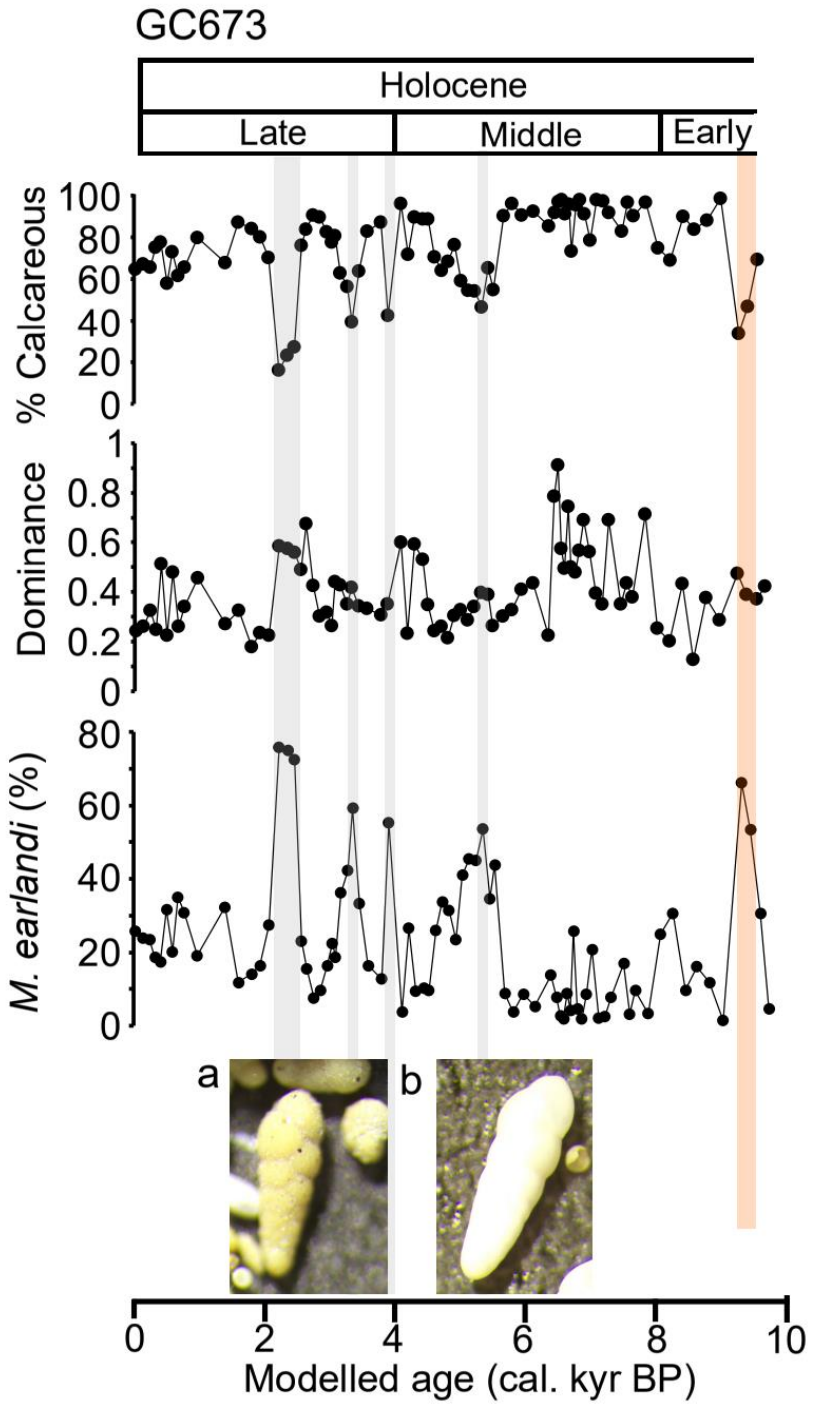
Foraminifera

- 3 benthic foram assemblages.



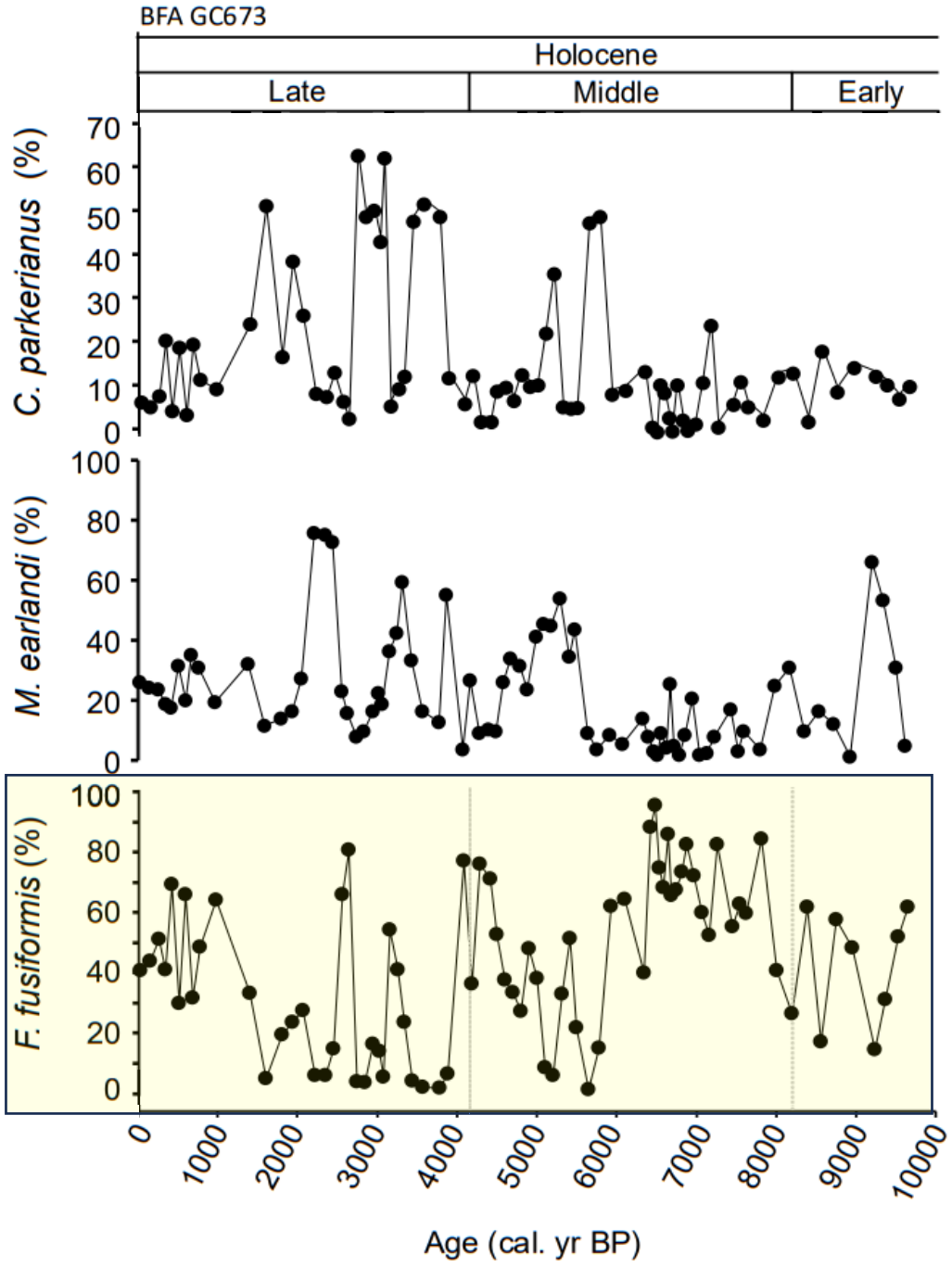
Foraminifera

- 3 benthic foram assemblages.
- Mostly well preserved but carbonate dissolution horizons are present.



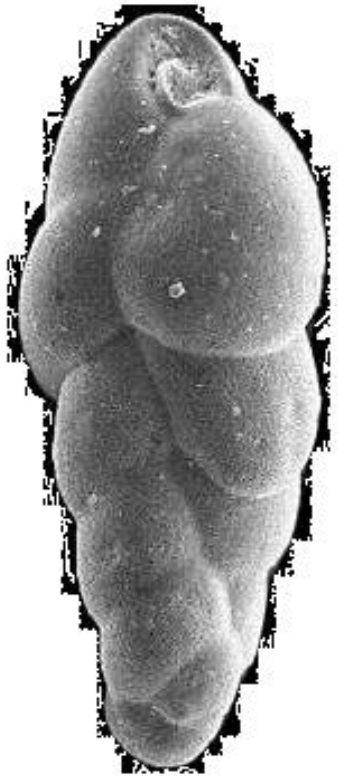
Foraminifera

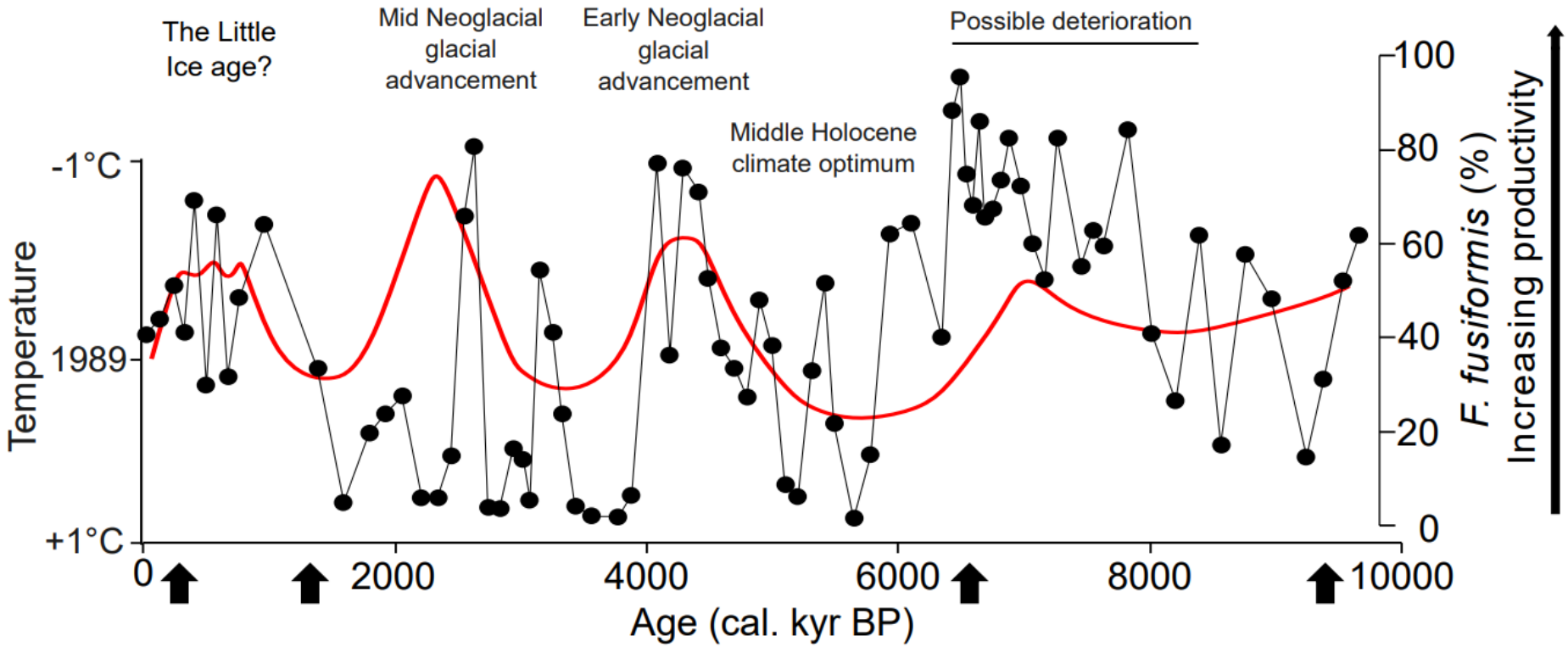
- 3 benthic foram assemblages.
- Mostly well preserved but carbonate dissolution horizons are present.
- Most important species is *F. fusiformis* – related to productivity.
- This species thrives in environments rich in organic matter associated with diatom blooms and influx of nutrient-rich waters.



F. fusiformis as a potential glacier advancement proxy

- Increases in *F. fusiformis* corresponds to short-term glacial advancements hypothesised by Clapperton *et al.* (1989).
- Some offset resulting from uncertainties in the age models used.
- Productivity proxies can be used as an indirect proxy for glacial activity.





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South Georgia marine productivity over the past 15 ka and implications for glacial evolution

Jack T. R. Wilkin, Sev Kender, Rowan Dejardin, Claire S. Allen, Victoria L. Peck, George E. A. Swann, Erin L. McClymont, James D. Scourse, Kate Littler, and Melanie J. Leng

Status: Waiting for Typesetting

South Georgia marine productivity over the past 15 ka and implications for glacial evolution

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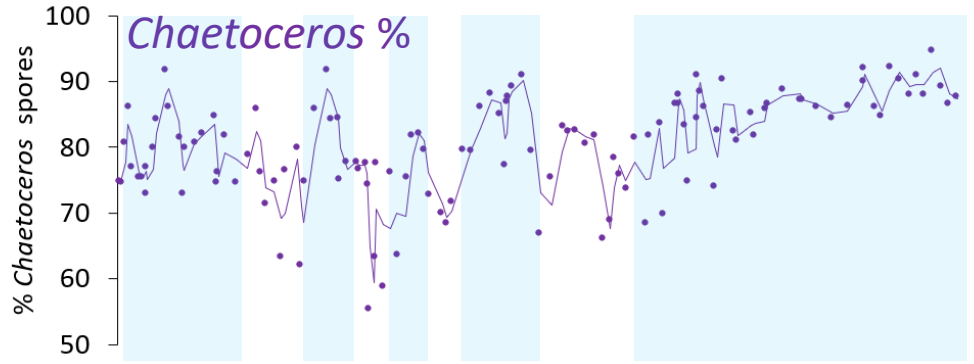
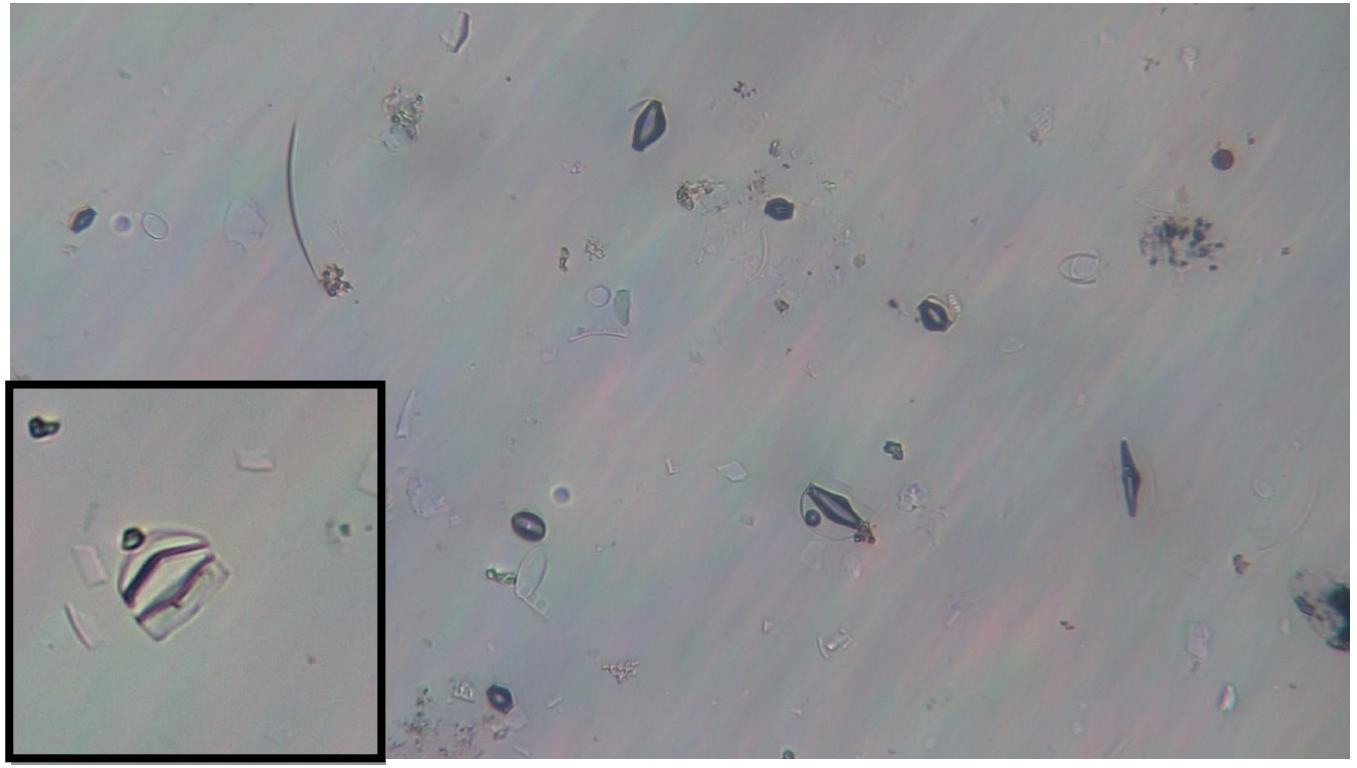
Diatoms

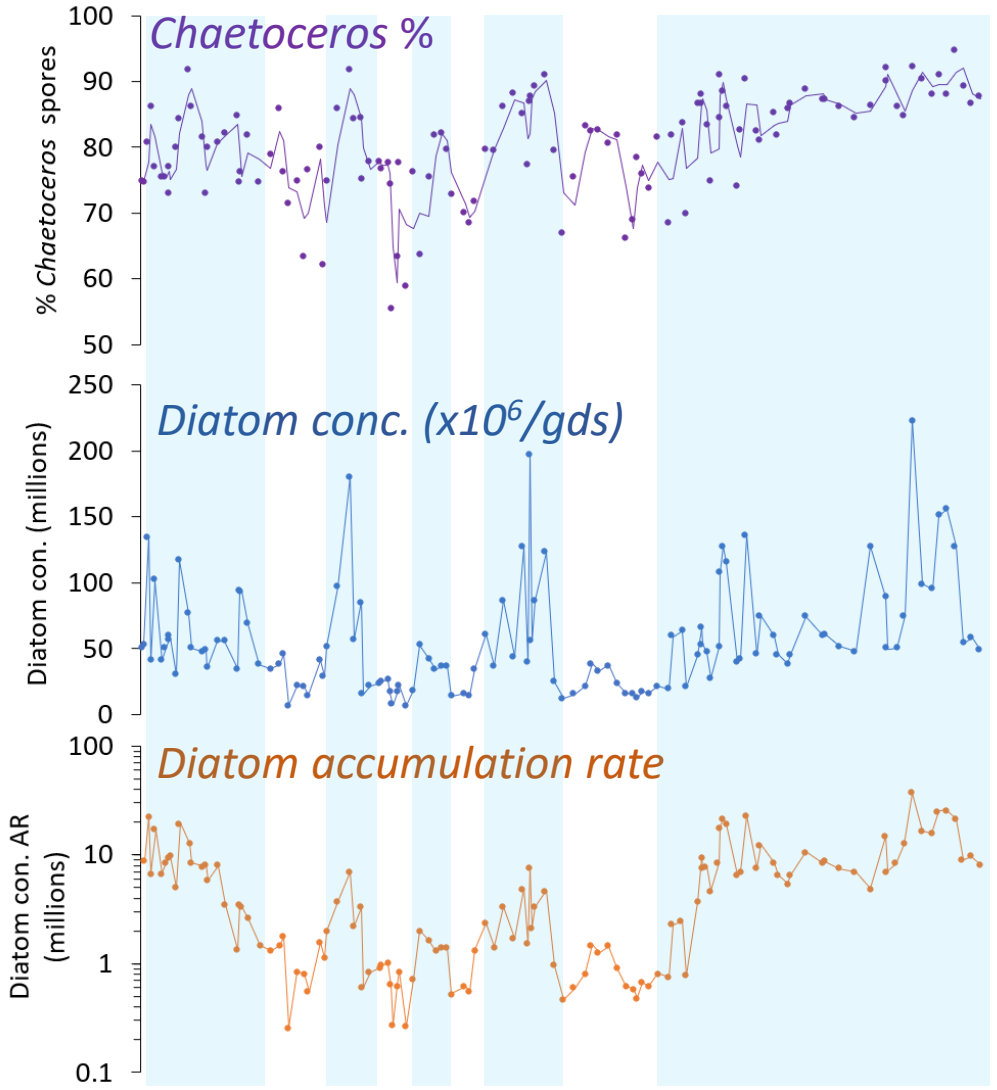
- *Chaetoceros* is the most abundant diatom.





Diatoms

- *Chaetoceros* is the most abundant diatom.
- *Chaetoceros* is commonly used as an indicator for past biogenic productivity in surface waters.
- Large proportions of *Chaetoceros* are commonly associated with the nutrients that are discharged from melting glaciers.



Diatoms

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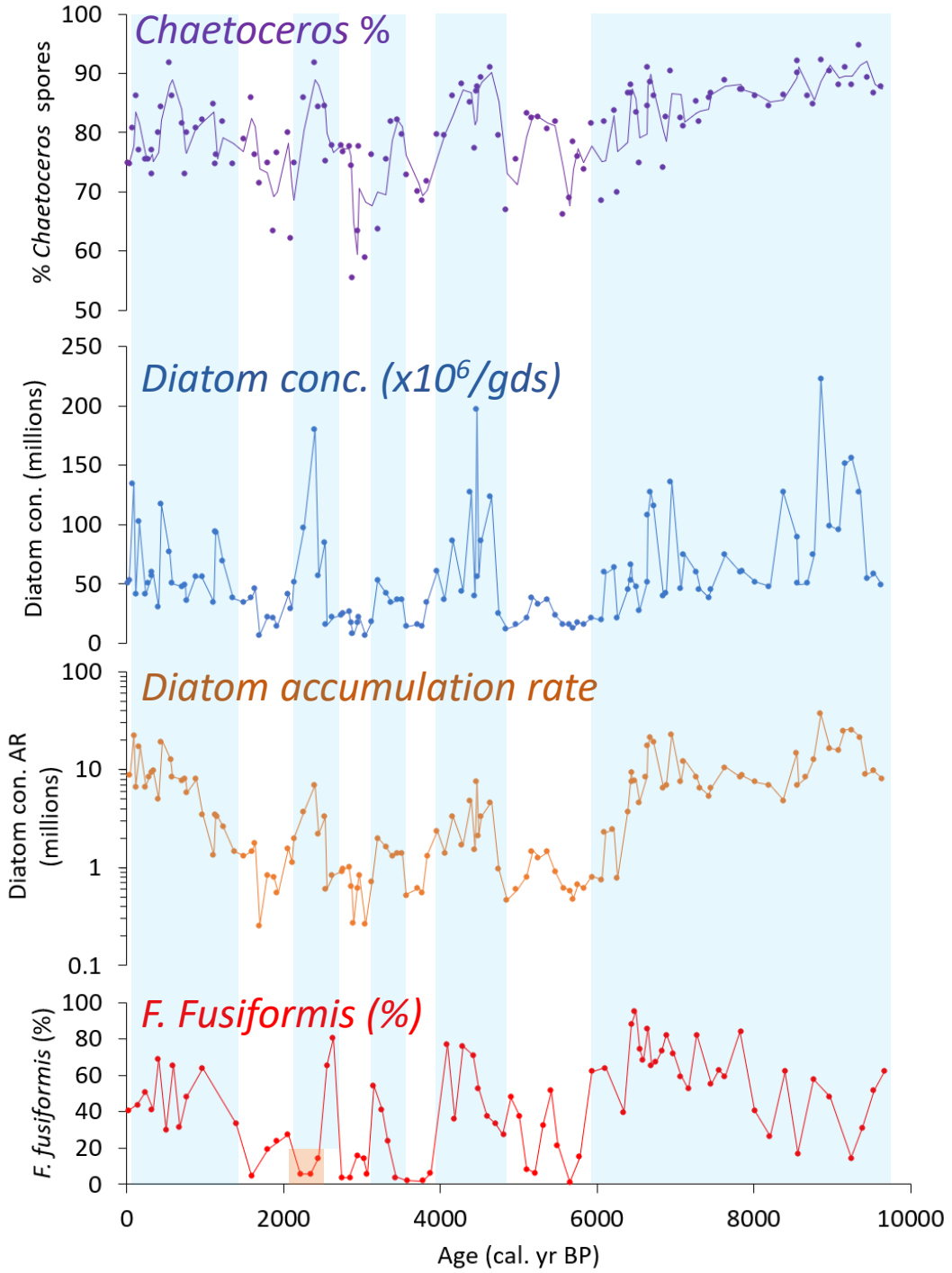
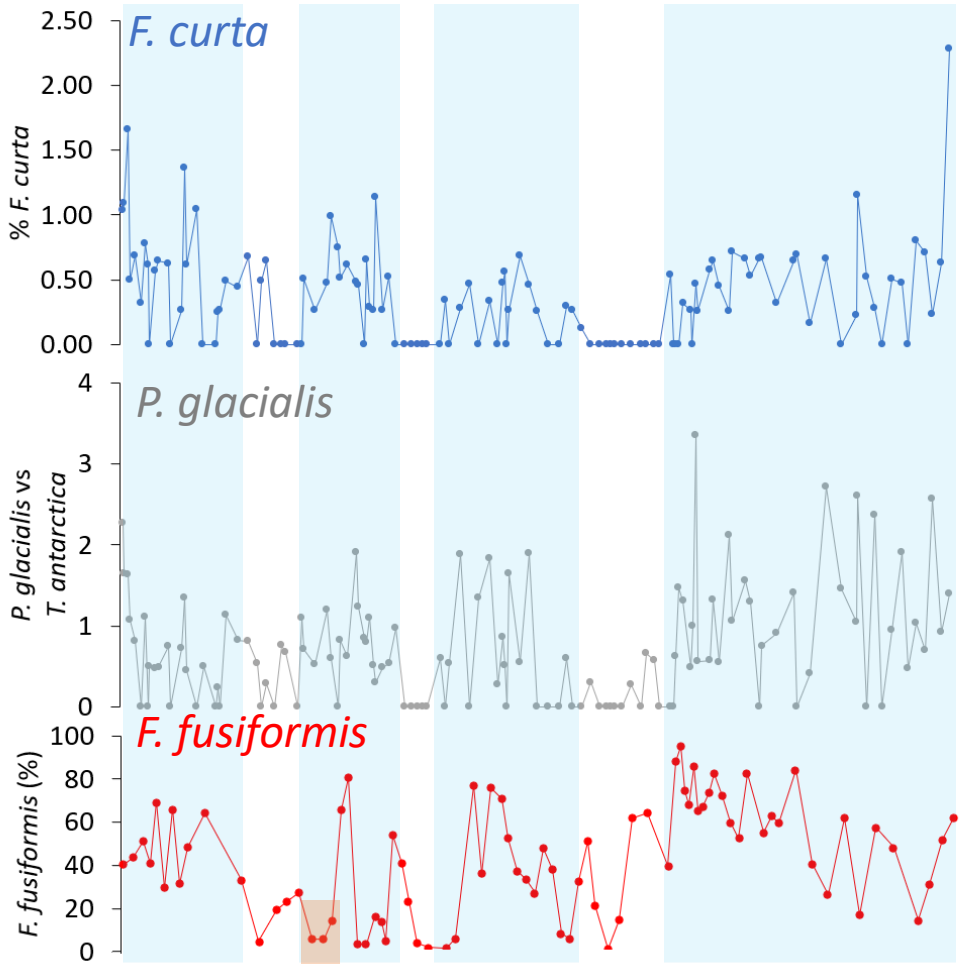
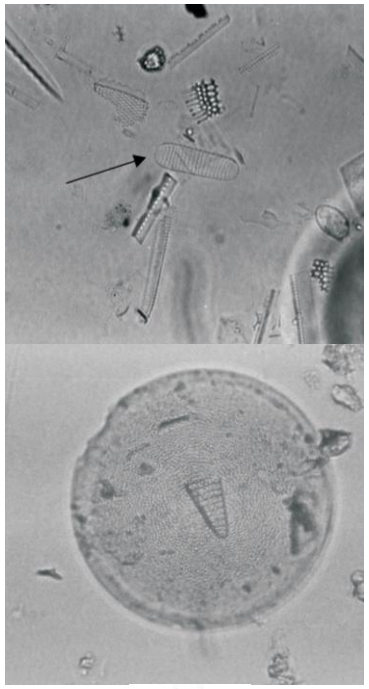
- *Chaetoceros* is commonly used as an indicator for past biogenic productivity in surface waters.
- Large proportions of *Chaetoceros* are commonly associated with the nutrients that are discharged from melting glaciers.
- The diatom concentrations and the % *Chaetoceros* spores peak at the same time as *F. fusiformis*.



Sea ice diatoms

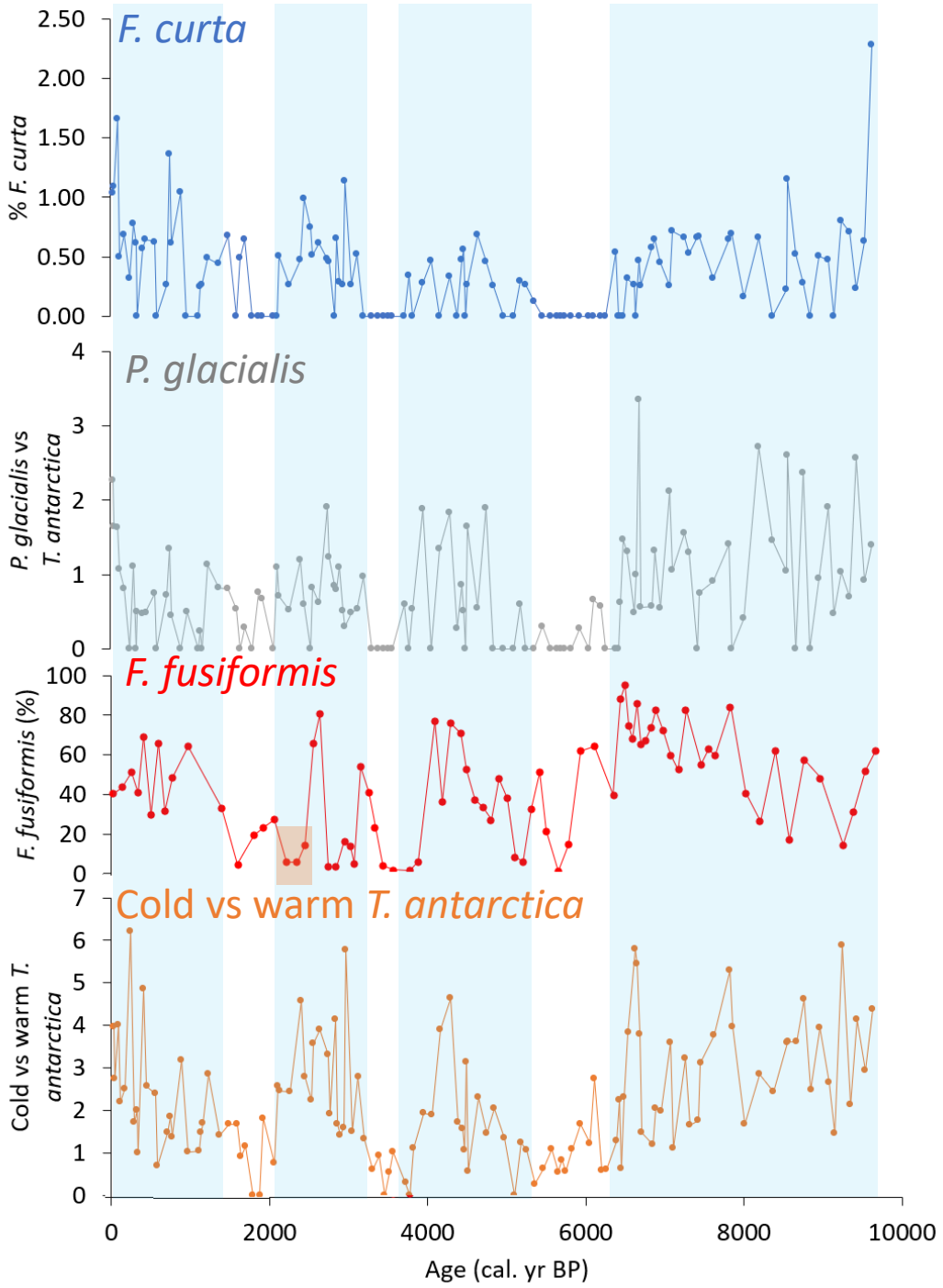
- Increase in sea ice diatoms = increase in *F. fusiformis*.

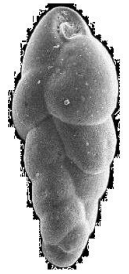


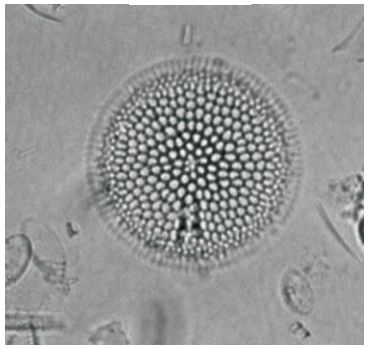


Sea ice diatoms

- Increase in sea ice diatoms = increase in *F. fusiformis*.
- Cold vs warm *Thalassiosira antarctica* = cold vs warm summers?
- Cold summers → not all snow melts → glacier grows.

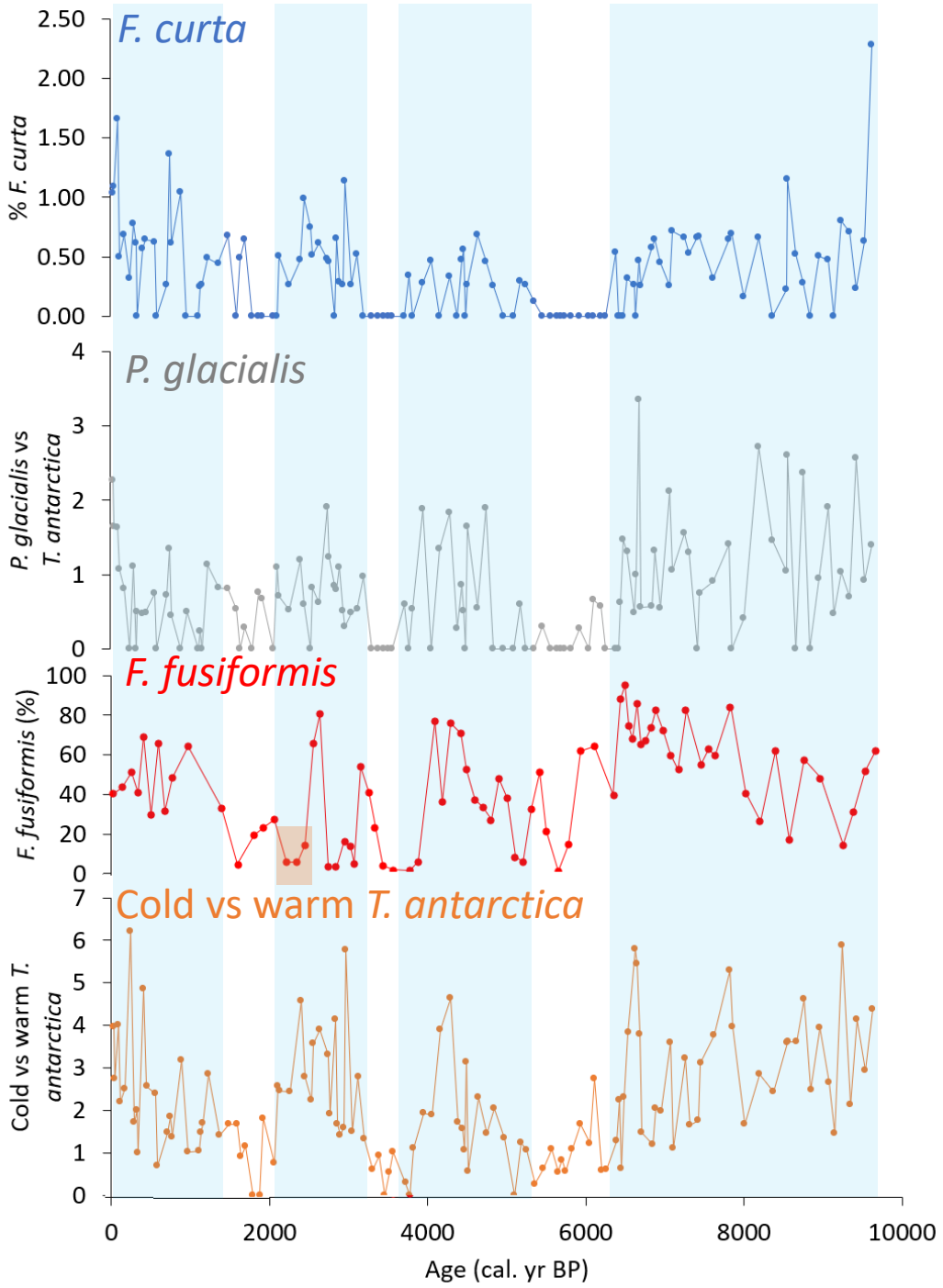


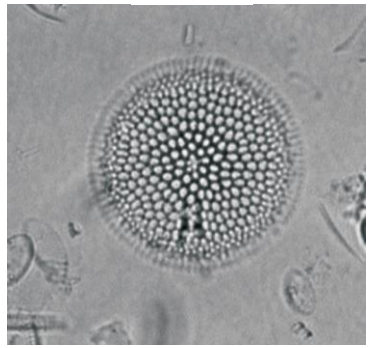




Sea ice diatoms

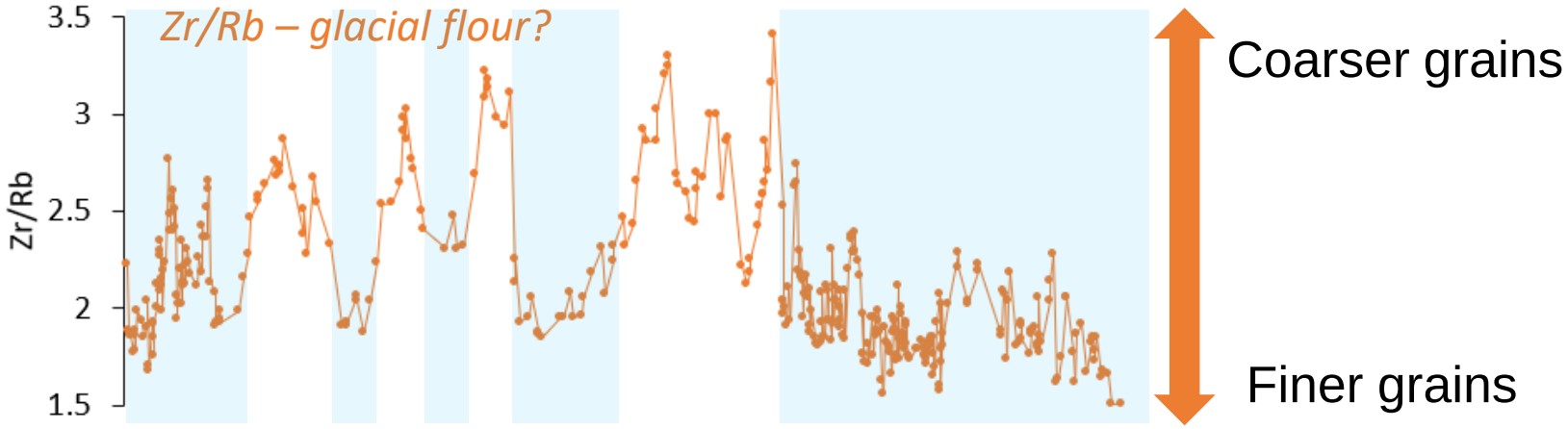
- Increase in sea ice diatoms = increase in *F. fusiformis*.
- Cold vs warm *Thalassiosira antarctica* = cold vs warm summers?
- Cold summers → not all snow melts → glacier grows.
- However …
- Even though small peaks are present the relative abundances are still low so further evidence for glacial activity is required.





XRF

- Portable XRF was used to determine the source of the sediment.
- Zr/Rb ratios are lower during cooler periods in other Southern Ocean records and have been associated with small grains.



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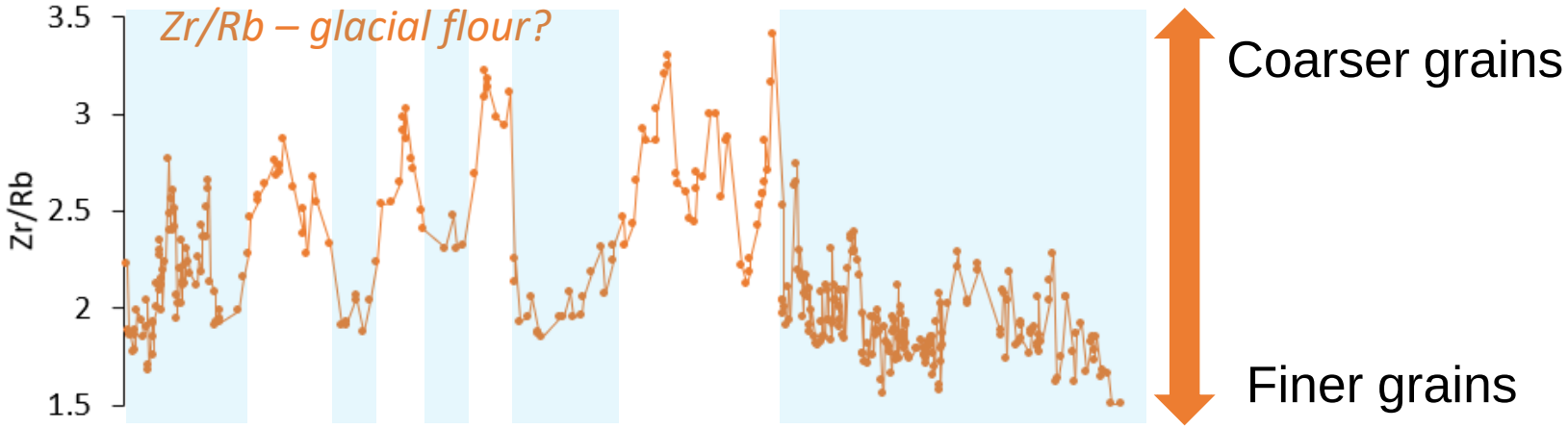
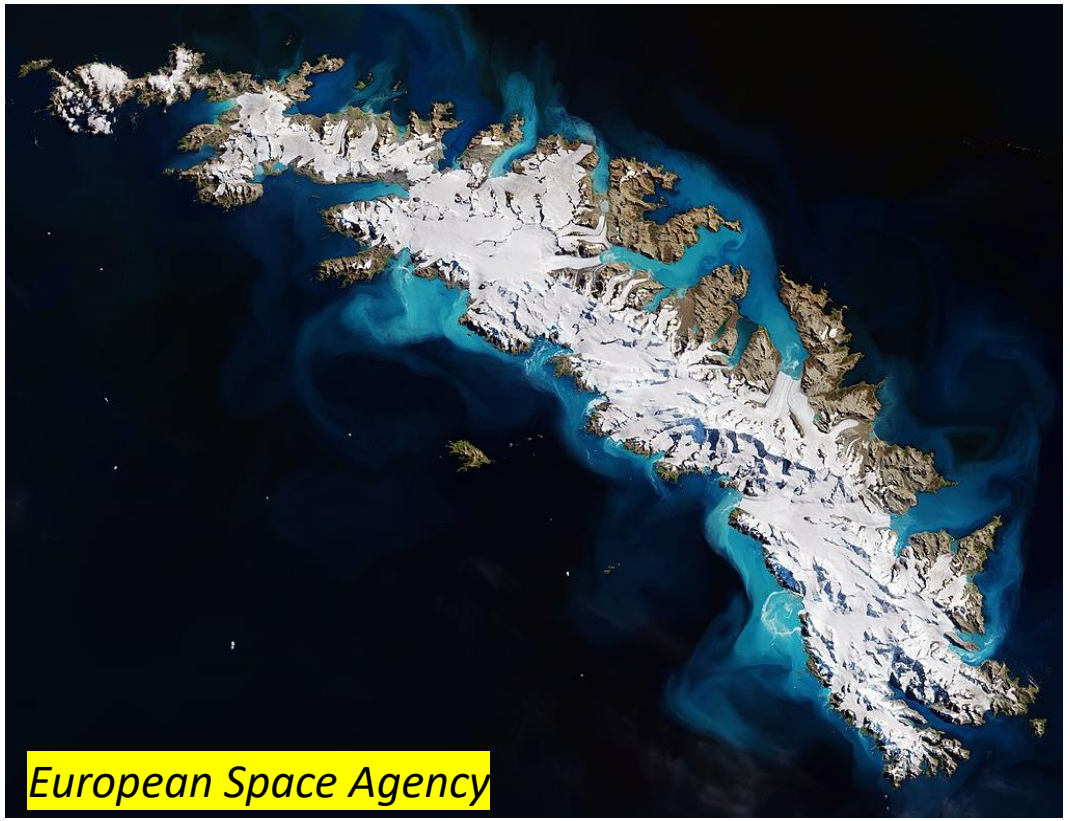
- Lower Zr/Rb ratios could be used as a proxy for glacial flour.





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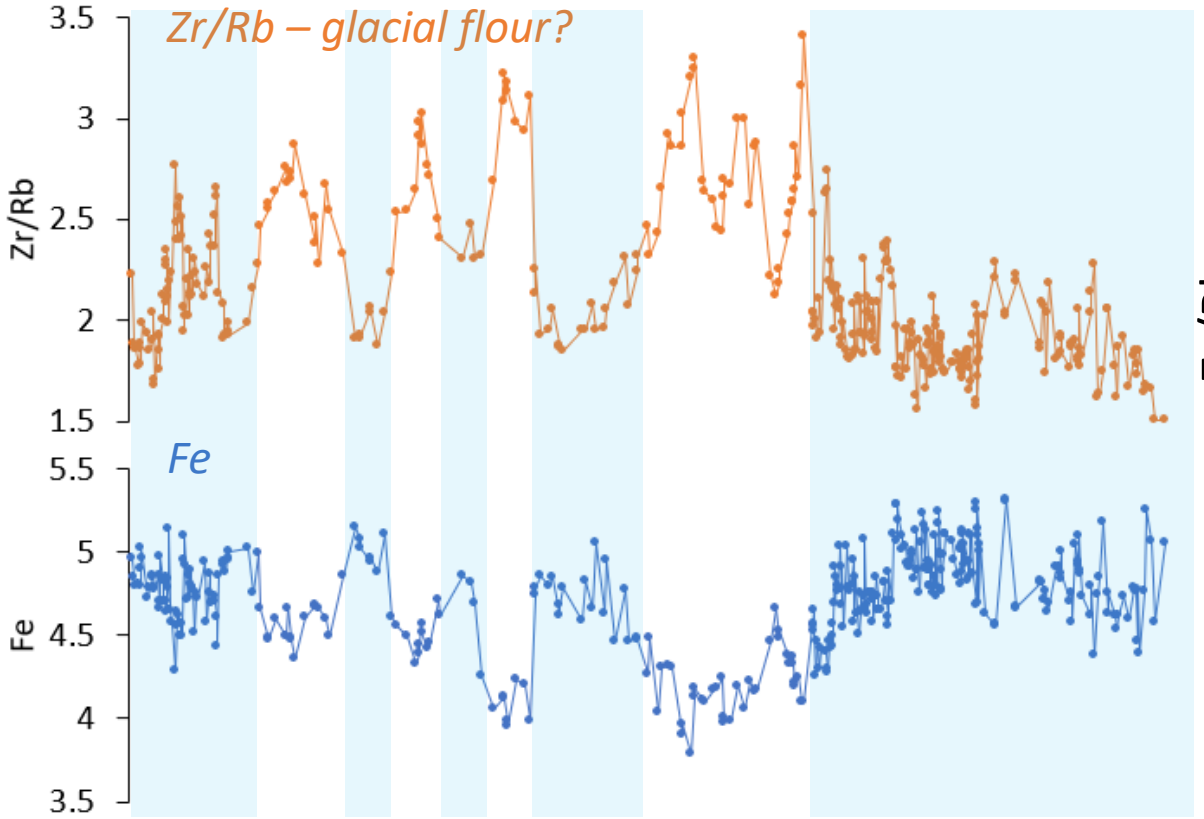
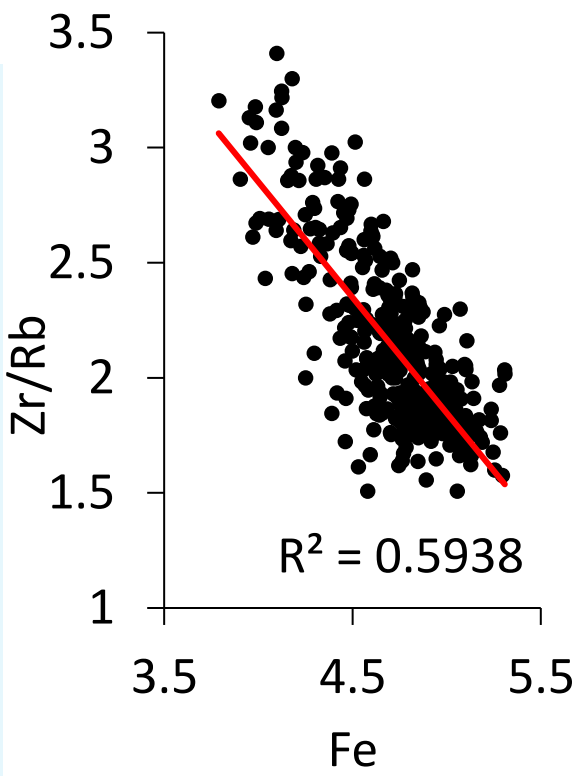
- Glacial flour is a good source of Fe.





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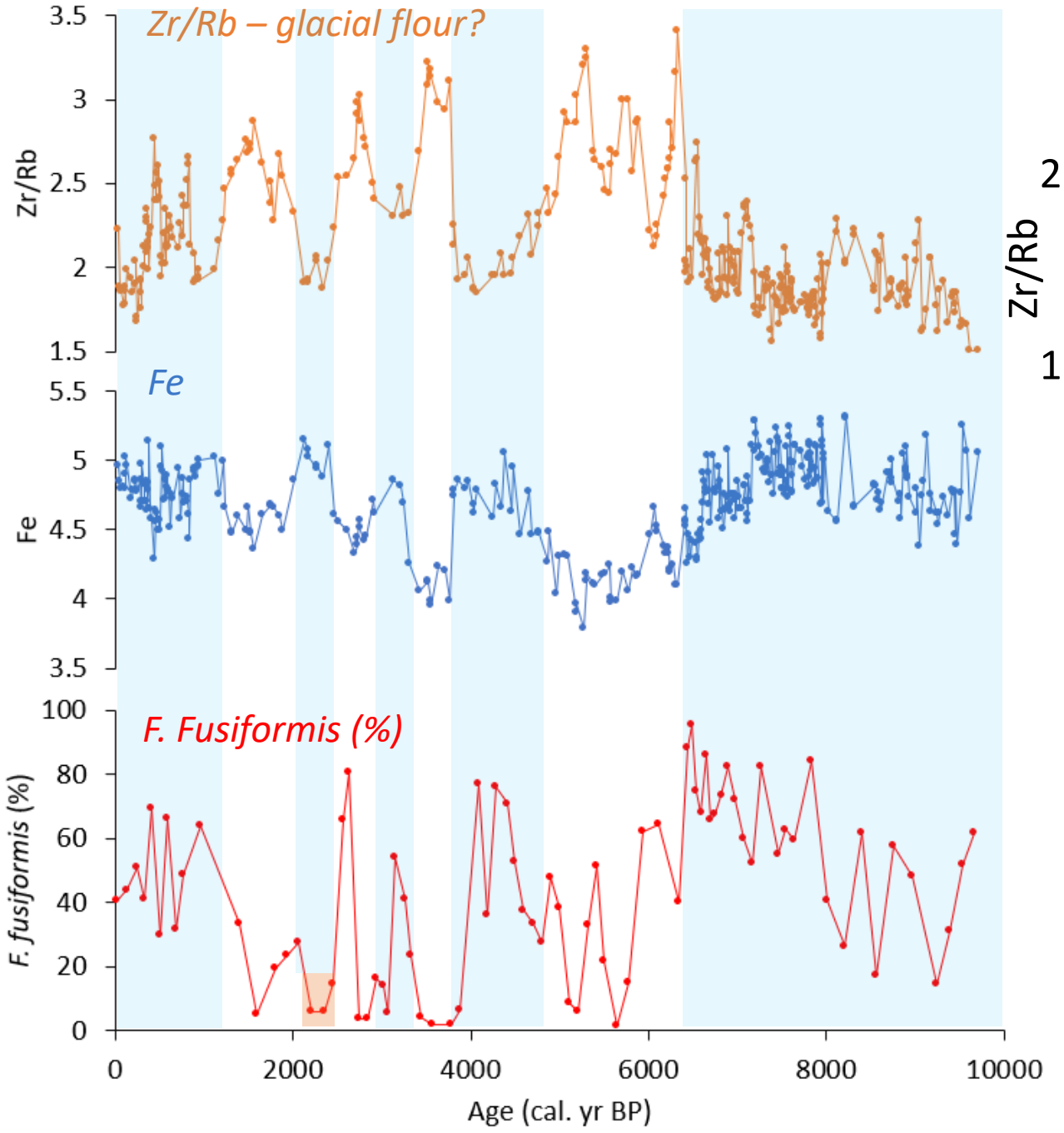
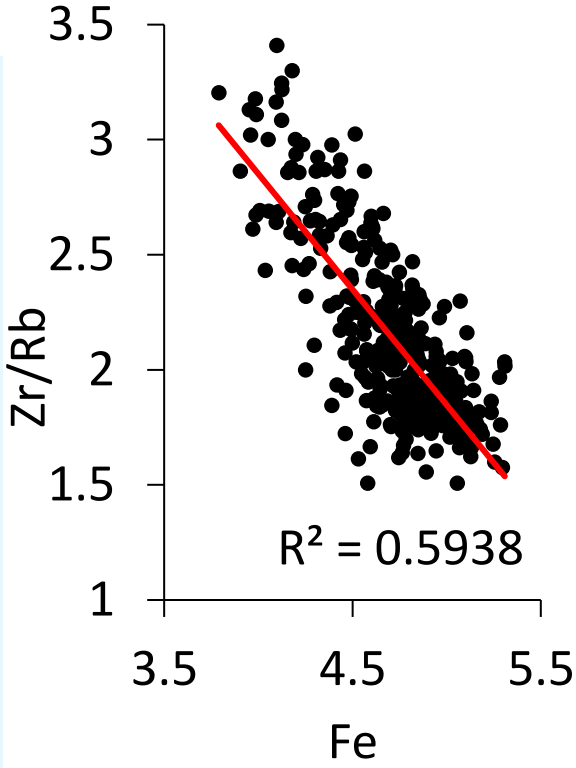
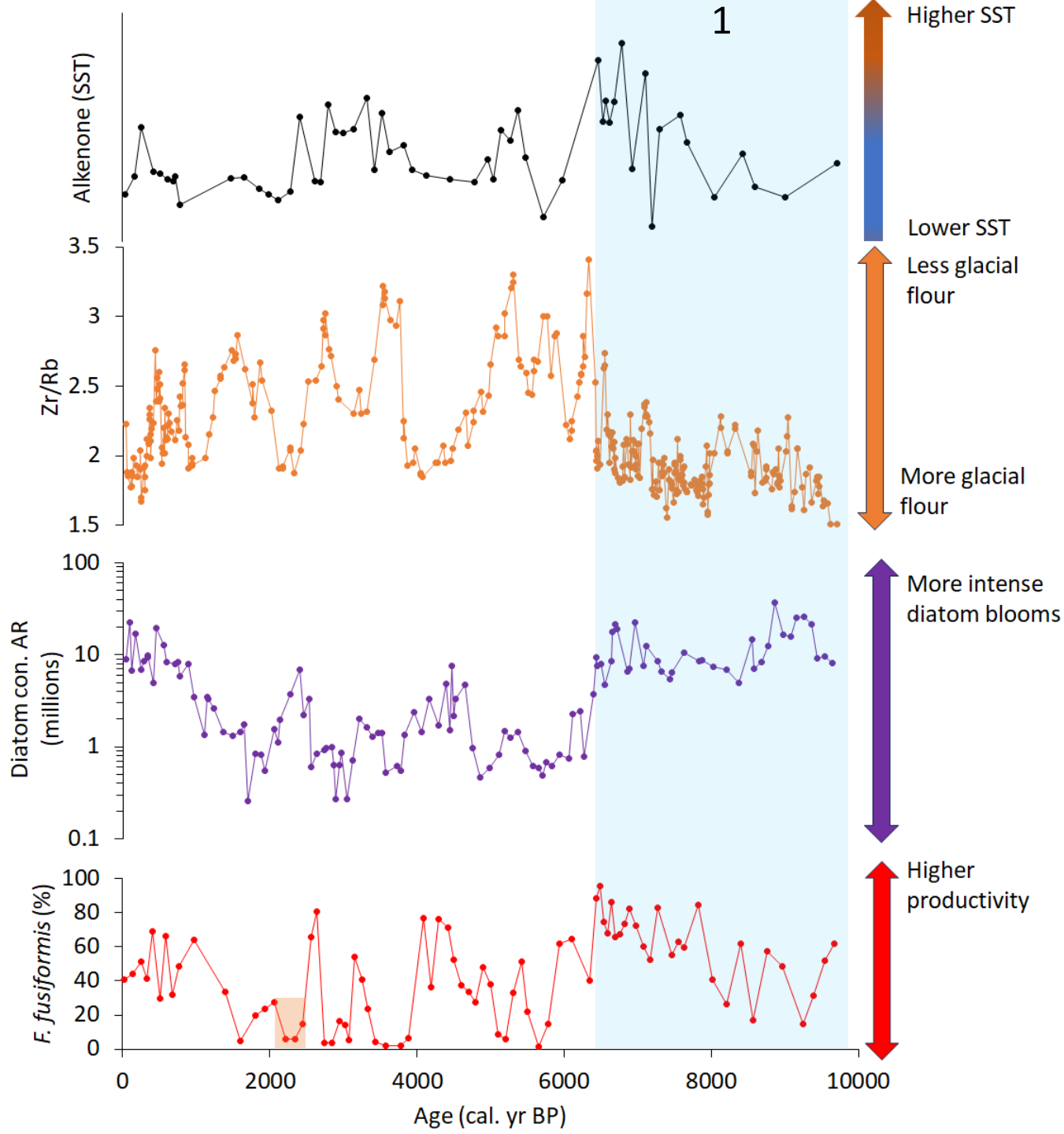
- Zr/Rb ratios are lower during cooler periods in other Southern Ocean records and have been associated with small grains.
- Lower Zr/Rb ratios could be used as a proxy for glacial flour.
- Glacial flour is a good source of Fe.
- Fe helps to fertilize the continental shelf = more diatoms = more *F. fusiformis.*





Glacial history

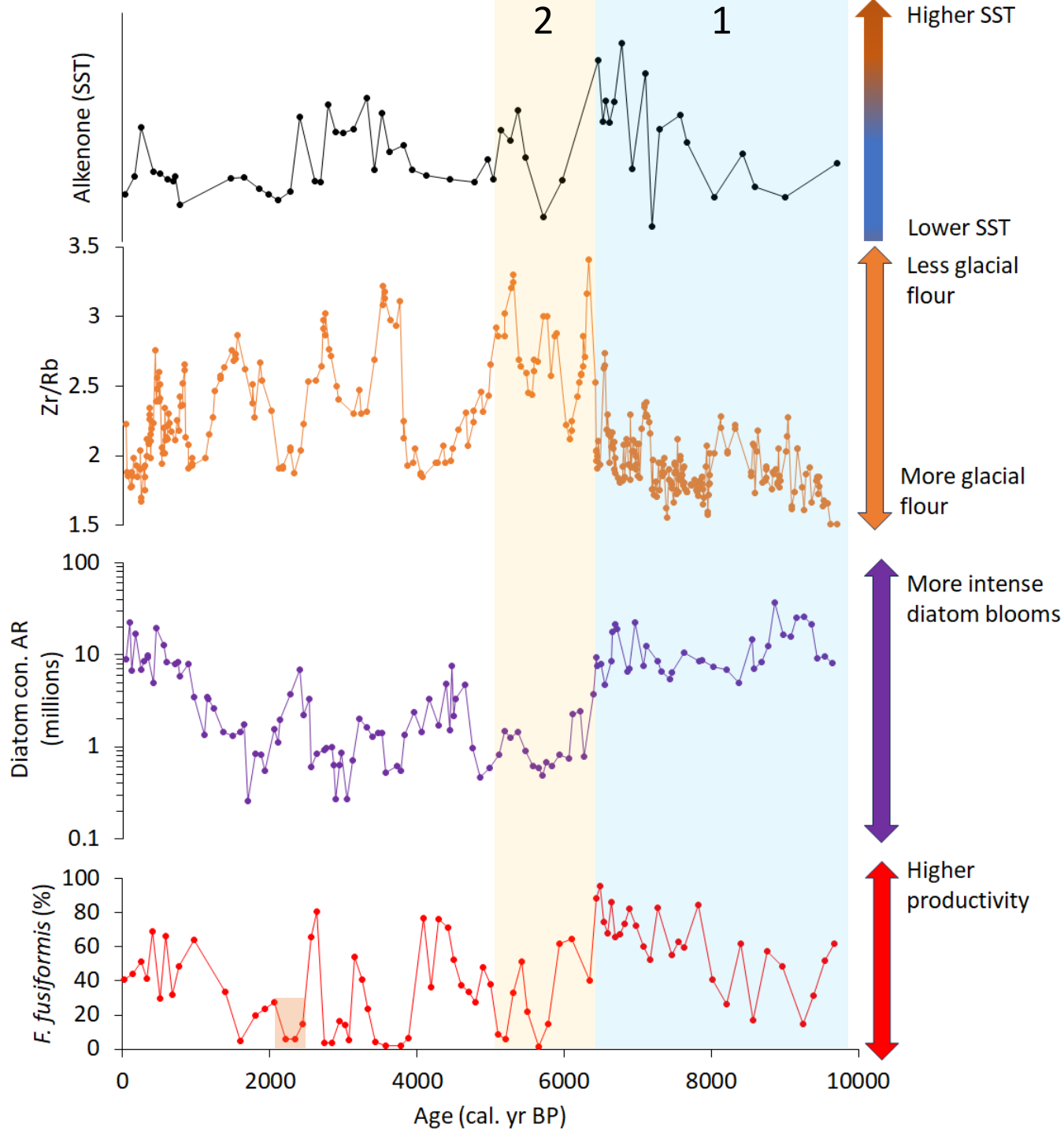
1. Early Holocene = glacial retreat



Glacial history

1. Early Holocene = glacial retreat

2. Tidewater glaciers have treated into the inner fjords = less productivity and sea ice diatoms.



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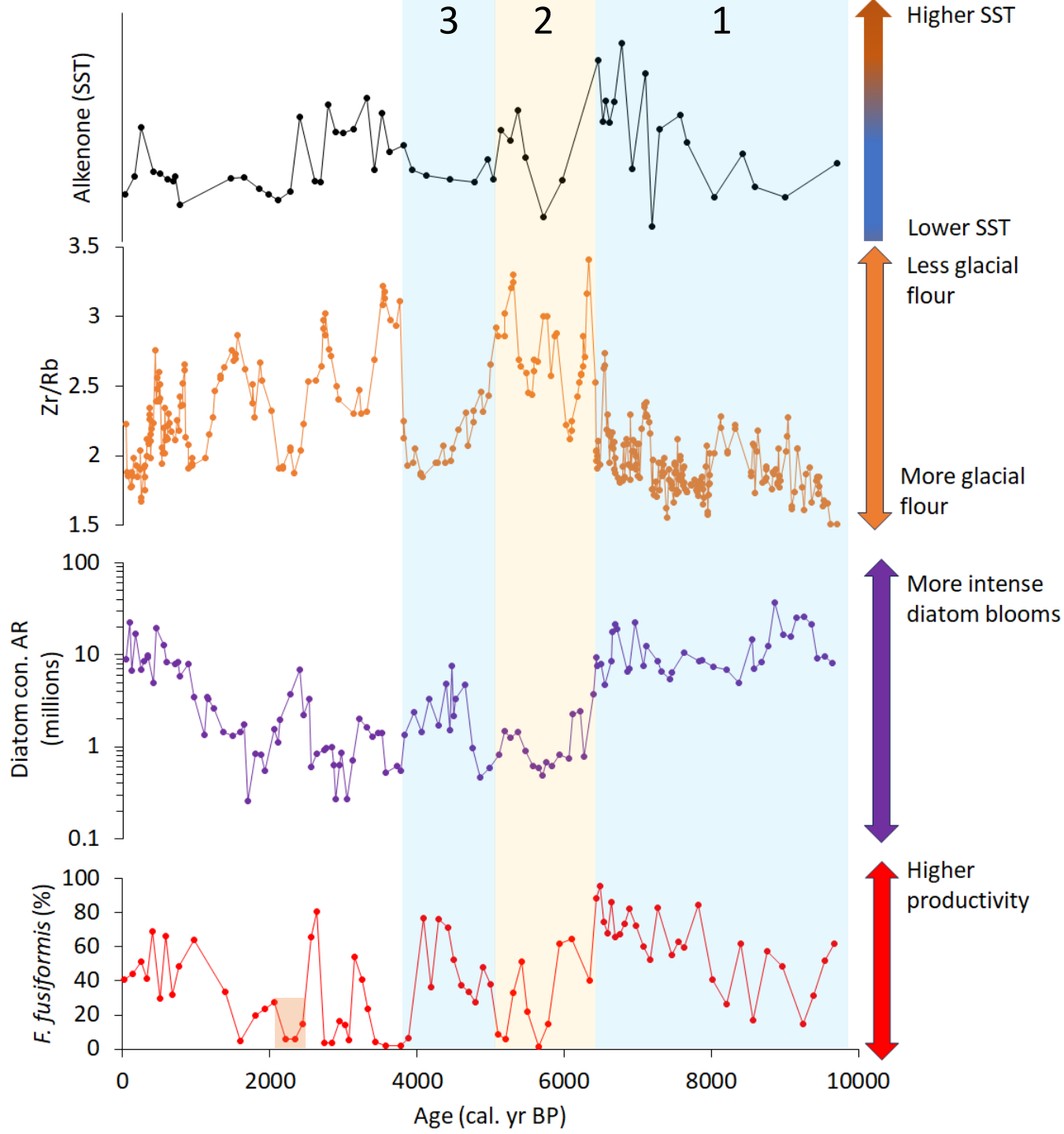
3. Early glacial advance = decreasing temperatures?



Glacial history

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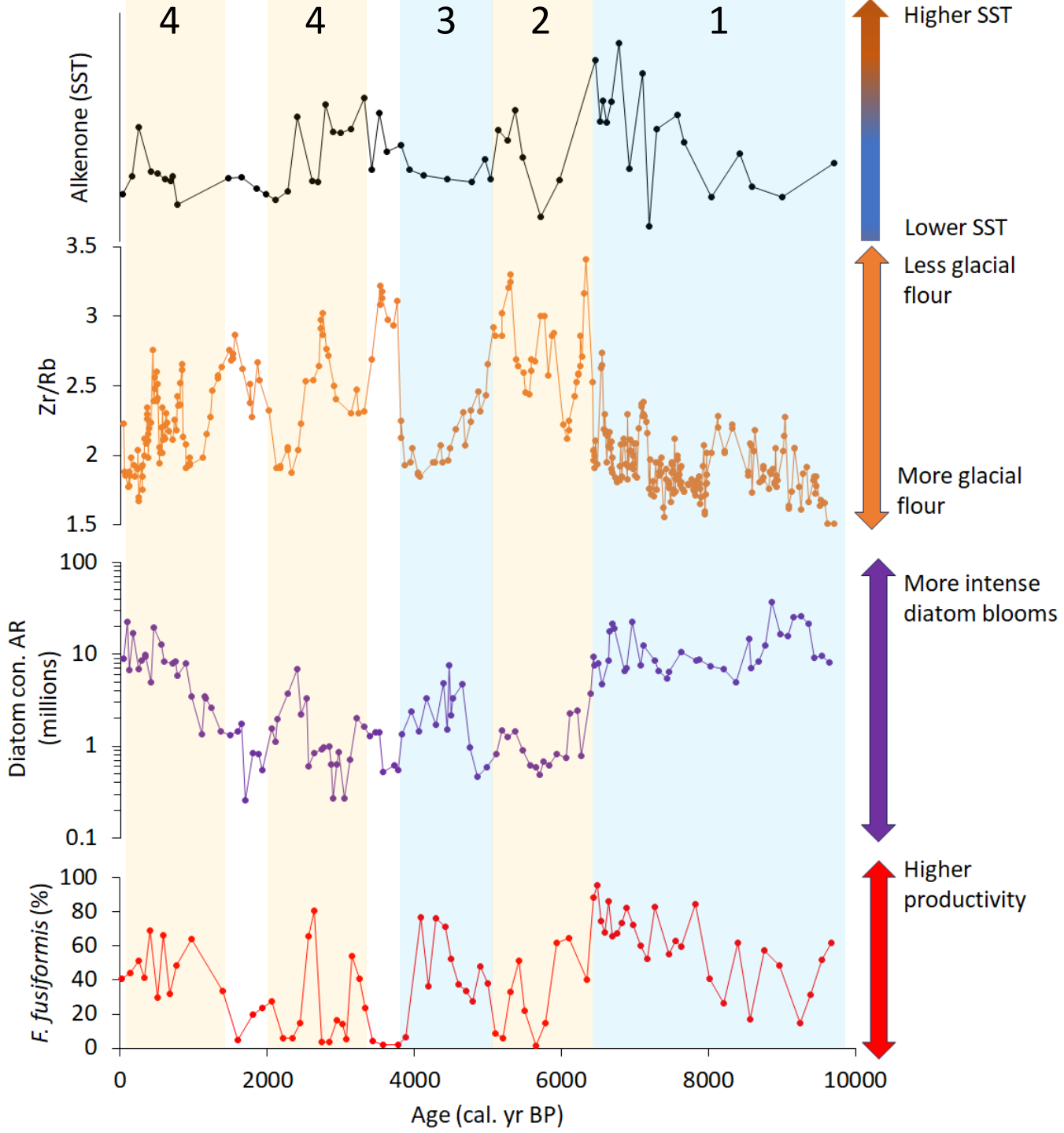
4. Two glacial advances during the Late Holocene. But why?



Glacial history

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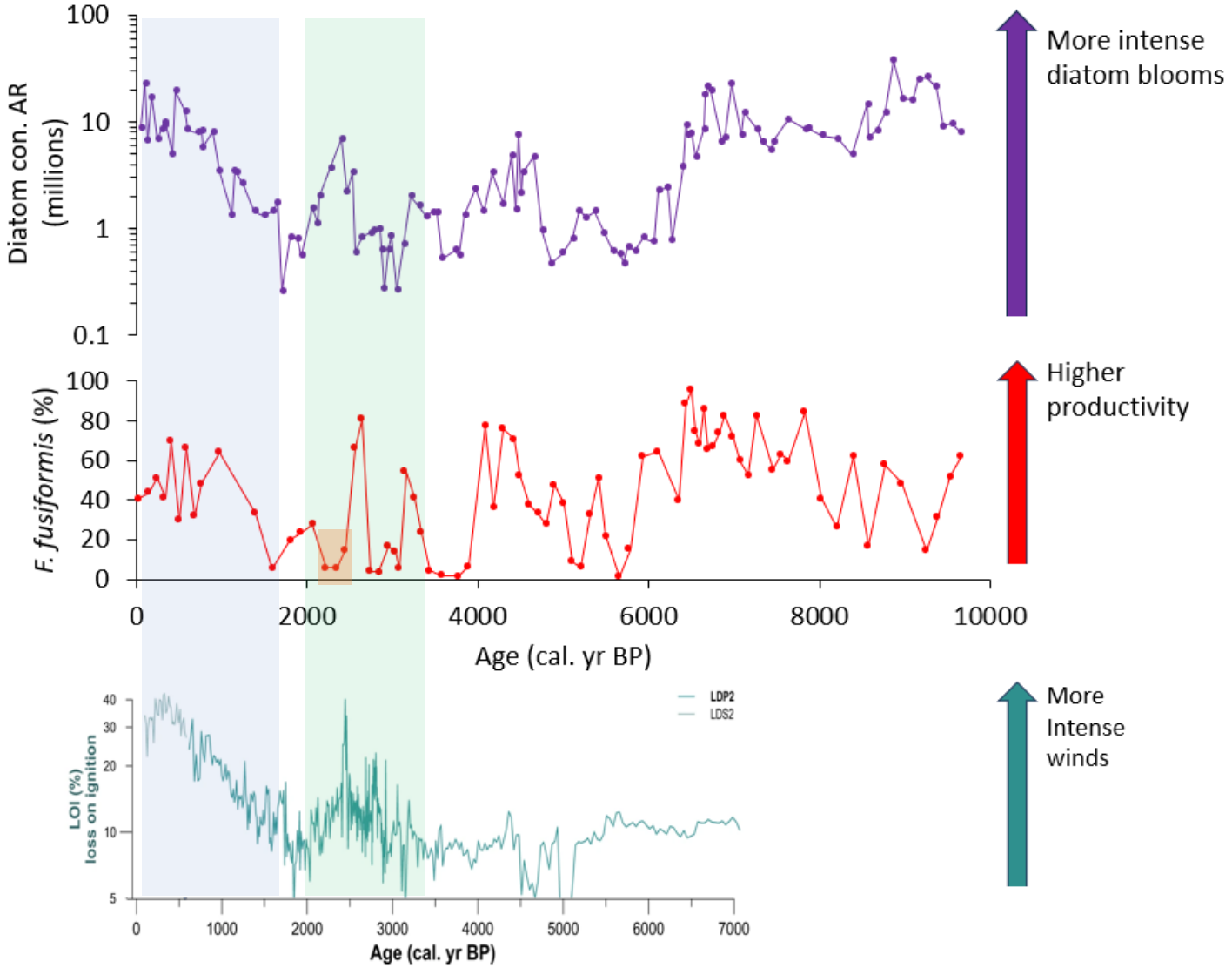
2. Tidewater glaciers have treated into the inner fjords = less productivity and sea ice diatoms.

3. Early glacial advance = decreasing temperatures?

4. Two glacial advances during the Late Holocene. But why?

- Advances correlate well with an increase in LOI data.

- Interpreted as an intensification of the SWW over South Georgia.



LoI data: van der Bilt. et al. 2022. Comm. Earth and Enviro.

Conclusions

- The palaeoclimatic and glacial history of South Georgia is dynamic as the island seems to be very sensitive to changes in climate.
- The benthic foraminifera *F. fusiformis* is associated with elevated diatom productivity = benthic-pelagic coupling.
- The principal driver of glacial advancement in sub-Antarctic latitudes is an intensification of the SWW.
- Zr/Rb is a reliable proxy for glacial flour that can also be used as a proxy for glacial melt.
- Shows the benefits and importance of multiproxy analysis in palaeoclimate research.