Middle Miocene paleoenvironmental changes in the South Atlantic region – a multiproxy reconstruction

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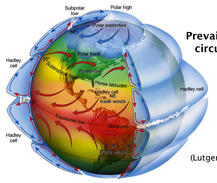
INTRODUCTION & OBJECTIVES

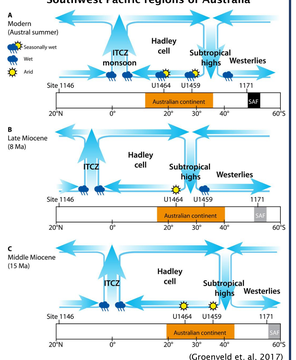
The Miocene Climate Optimum (MCO; ~17–15.1Ma) was a time of warming and elevated atmospheric CO_2 concentrations, whereas the mid-Miocene Climate transition (MMCT, ~15–13Ma) was a time of cooling and expansion of Antarctic ice sheets.



Prevailing atmospheric circulation patterns

(Lutgens et. al, 2007)

The International Ocean Discovery Program South Atlantic Transect (SAT) Expeditions 390/393 recovered Cenozoic successions and ~150–350 m of the underlying oceanic crust from six sites along a slow/intermediate spreading Mid-Atlantic Ridge crustal flow line at ~31°S. Recovered records span key intervals of climate shifts including MCO and MMCT.

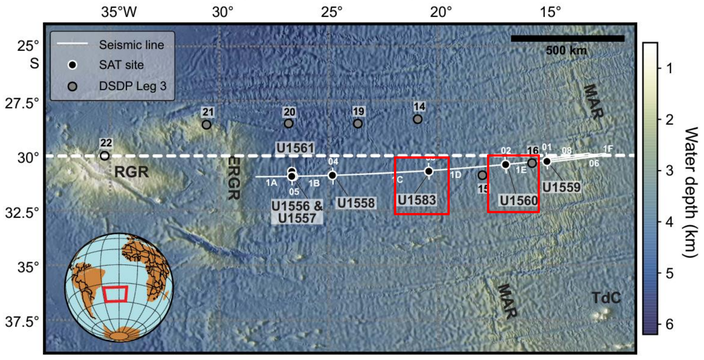


(Groenveld et. al, 2017)

- Investigate Hadley cell response across the Middle Miocene epoch from the perspective of the South Atlantic Gyre.
- Test whether/how the East Antarctic sea-ice was affected by latitudinal migrations of the westerlies during MCO and MMCT.

MATERIALS AND METHODS

We carried out analysis of shipboard Natural Gamma Radiation (NGR) and X-ray fluorescence (XRF, collected at 2cm intervals at 10, 30, 50 kV) data from sediments of Holes U1583C (30°43′S, 20°26′W, water depth 4214.6 m, 30 Ma crust) and U1560A (30°24′S, 16°55′W, water depth 3724.4 mbsl, 15 Ma crust).



Site locations highlighted by red boxes. From Teagle et al. (2023).

Sediment cores from sites

X-Ray Fluorescence Scanner at the College Station Core Repository

XRF data

XRF Data

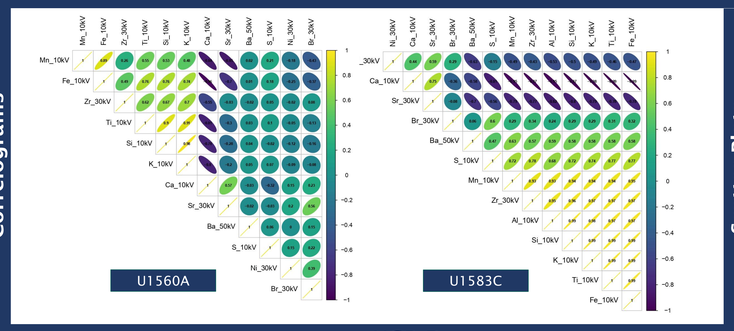
NGR Data

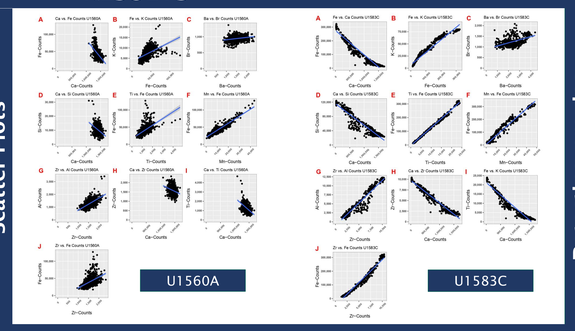
Quality Control of data, normalization and Standardization

RStudio

Data Analysis

RESULTS



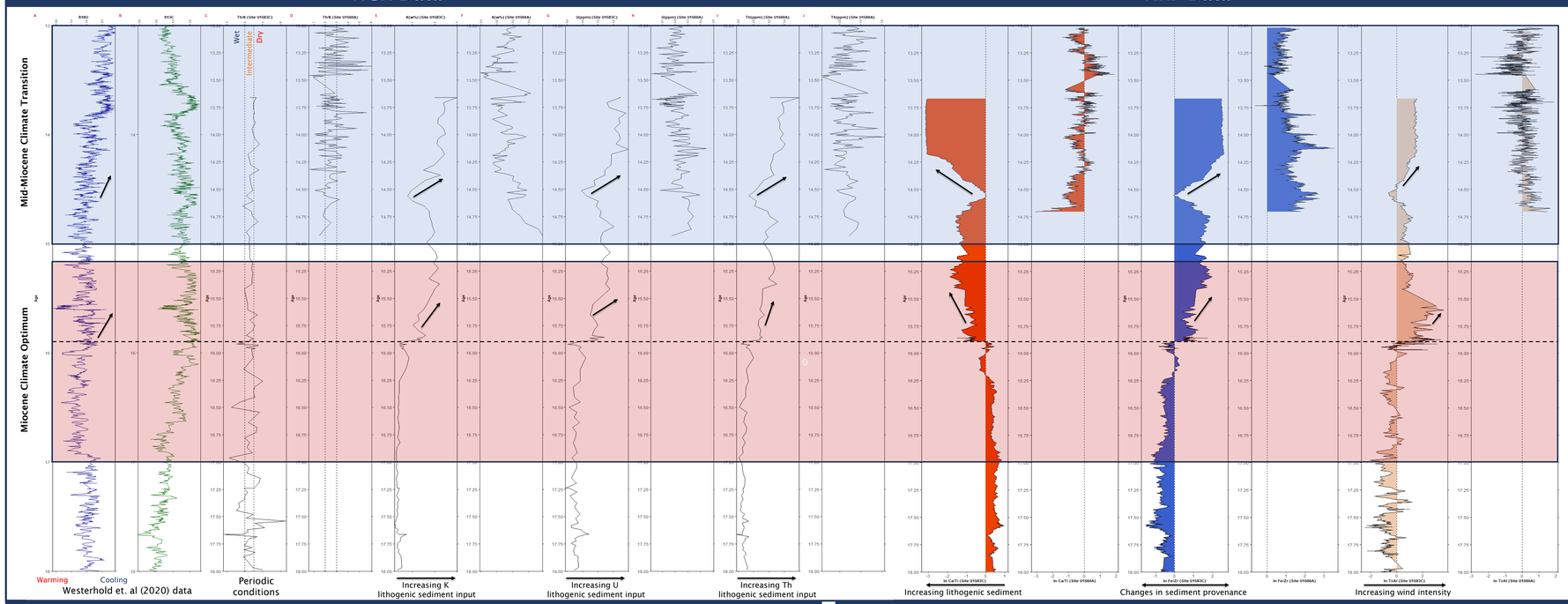


Detecting proxies

- Main aim is to look for stronger correlations among normalized elemental values from both sites and use the strongly correlated elemental ratios.
- Elemental ratios can/will be used as paleoenvironmental proxies to qualitatively assess then prevailing environments.

NGR Data

XRF Data



DISCUSSION

- Correlation plots from both holes indicate a strong negative correlation with calcium and elements that are indicative of terrigenous input (e.g., Zr, Al, Ti, Fe). Silica also has a strong negative correlation with Ca but a strong positive correlation with other terrigenous elements, indicating in this dataset, Si is a terrigenous rather than productivity indicator.
- Although the NGR trends from Holes U1560A and U1583C are similar across the MMCT, the amplitude of values at U1560A seem to be much lower in comparison to those from Hole U1583C.

Onset of paleoenvironmental changes in the regions seems to be synchronous with changes in global $\delta^{13}C$, with $\delta^{18}O$ variations driving further changes in environmental depositions.

- In Hole U1583C, the variations in %K and Th seem to have a two-step increase related to cooling out of the MCO into the MMCT, suggesting periods of increased windiness at ~16 Ma and ~14.5 Ma.
- XRF data also indicates a two-step increase in windiness and deposition of terrigenous sediments at ~16 Ma and ~14.5 Ma.

Both NGR and XRF data show increased windiness (albeit differing intensities) over the South Atlantic mid-latitudes, possibly indicating the contraction of the Hadley Cell and position of the Westerlies closer to Holes U1583C and U1560A. These contractions may be related to phases of cooling during MCO and MMCT.

FUTURE WORK

- Quantitative geochemical analysis (stable isotopes, trace metals) will be conducted on surface and thermocline dwelling planktic foraminifera species to characterize sea surface temperature and salinity changes at both holes across the MCO and MMCT.
- Biostratigraphy and microfossil assemblage analysis to determine the biotic responses to environmental variations in the South Atlantic regions across the Middle Miocene epochs.
- Correlate South Atlantic surface ocean dynamics to Antarctic records to further characterize the influence of Hadley Cell dynamics on sea ice.

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