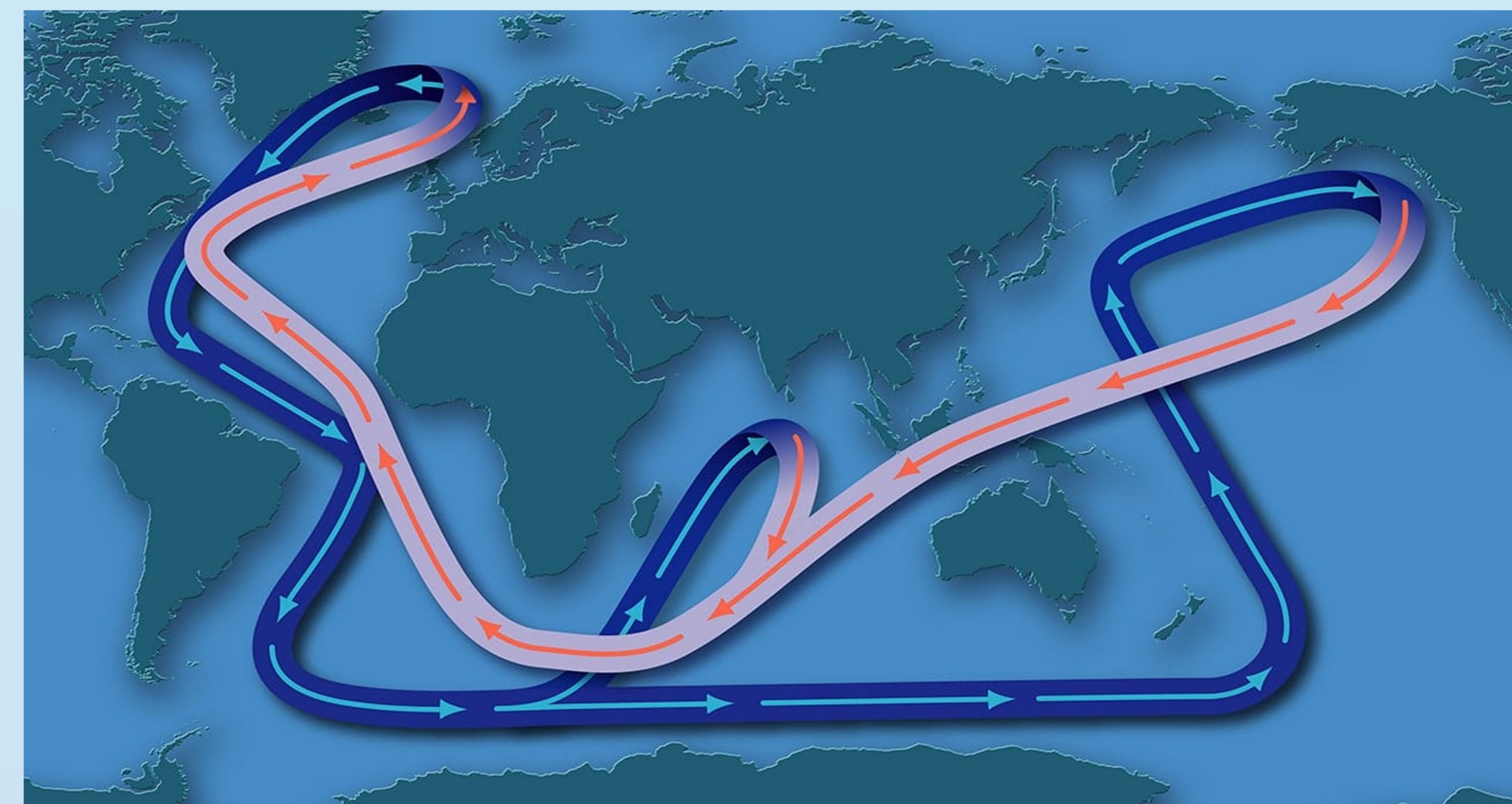


# The opening of Drake's passage and its contribution to climate

Kristen Anastopoulos & Tiarra Love  
[k\\_anastopolous@salemstate.edu](mailto:k_anastopolous@salemstate.edu), [T\\_love@salemstate.edu](mailto:T_love@salemstate.edu)

## INTRODUCTION

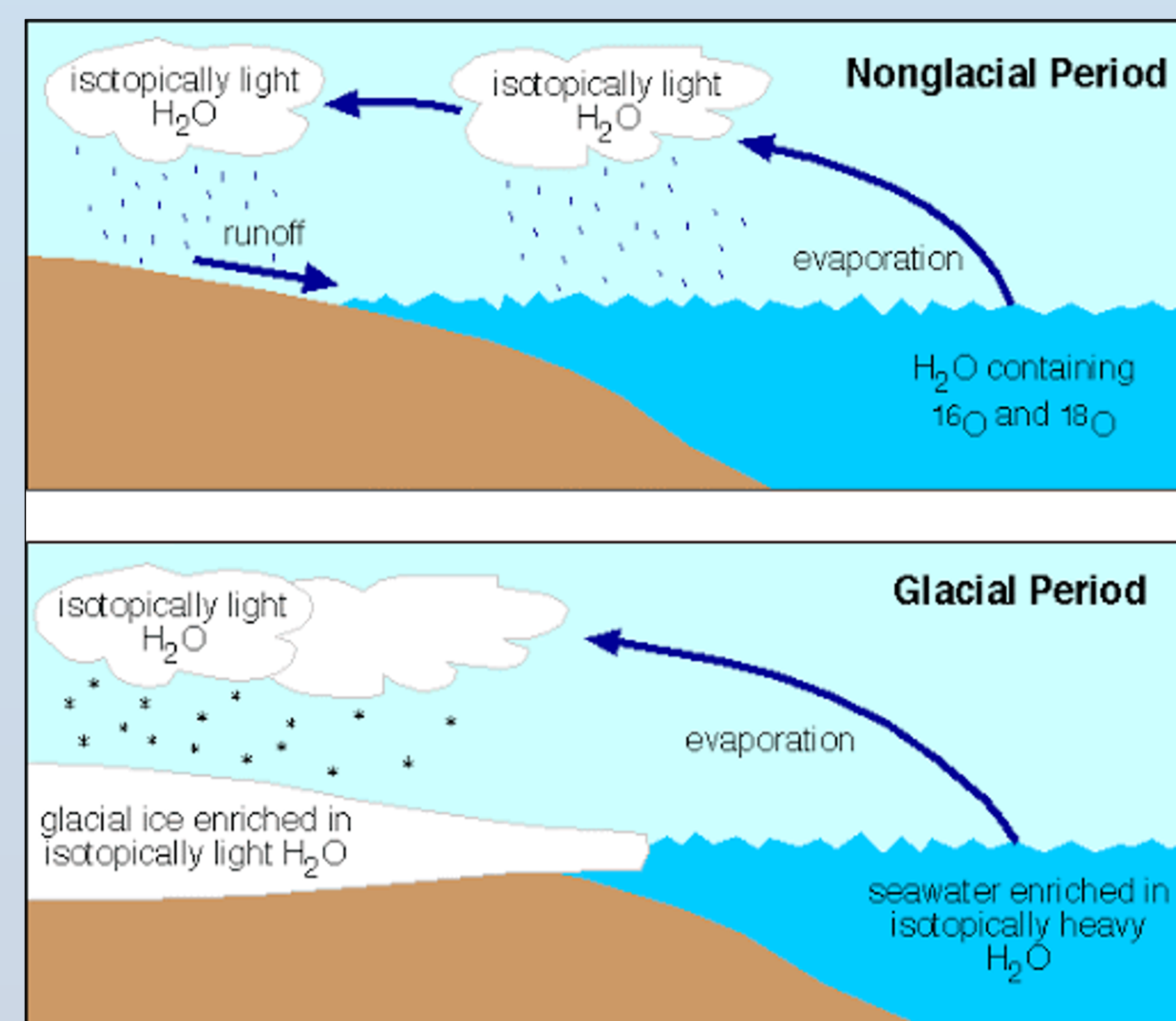
Plate tectonics controls changes in continental geography, topography, oceanic gateways, oceanic bathymetry, and concentrations in atmospheric gases throughout Earth's history. These changes directly affect Earth's ocean circulation patterns causing changes in climate and therefore sea level. Modern Ocean circulation patterns (the Ocean Conveyor Belt) are driven by a combination of thermohaline currents in the deep ocean and surface waters. The general circulation model of cold, dense water sinking to the ocean's bottom where warmer, less dense water remains on the surface is controlled by position of landmasses, salinity, and freshwater input (rainfall or melting of glacial ice). These circulation patterns are crucial in ocean conditions, a disruption in these patterns could cause a severe change in the climate. Understanding the thermohaline circulation patterns today allows us to interpret Earth's conditions in the past.



**Figure 1:** Illustration of the Global Ocean Conveyor belt driven by thermohaline circulation. Warm water (red) on the Indian and Pacific ocean surface flows westwards and northwards through the Atlantic. Evaporation is occurring along the way, which makes the water saltier. As the water approaches the colder Northern Latitudes, it becomes cold, salty, and dense enough to sink to the ocean's bottom and travels south (blue line). It eventually re-emerges with the warm water in the western Indian and Pacific oceans.

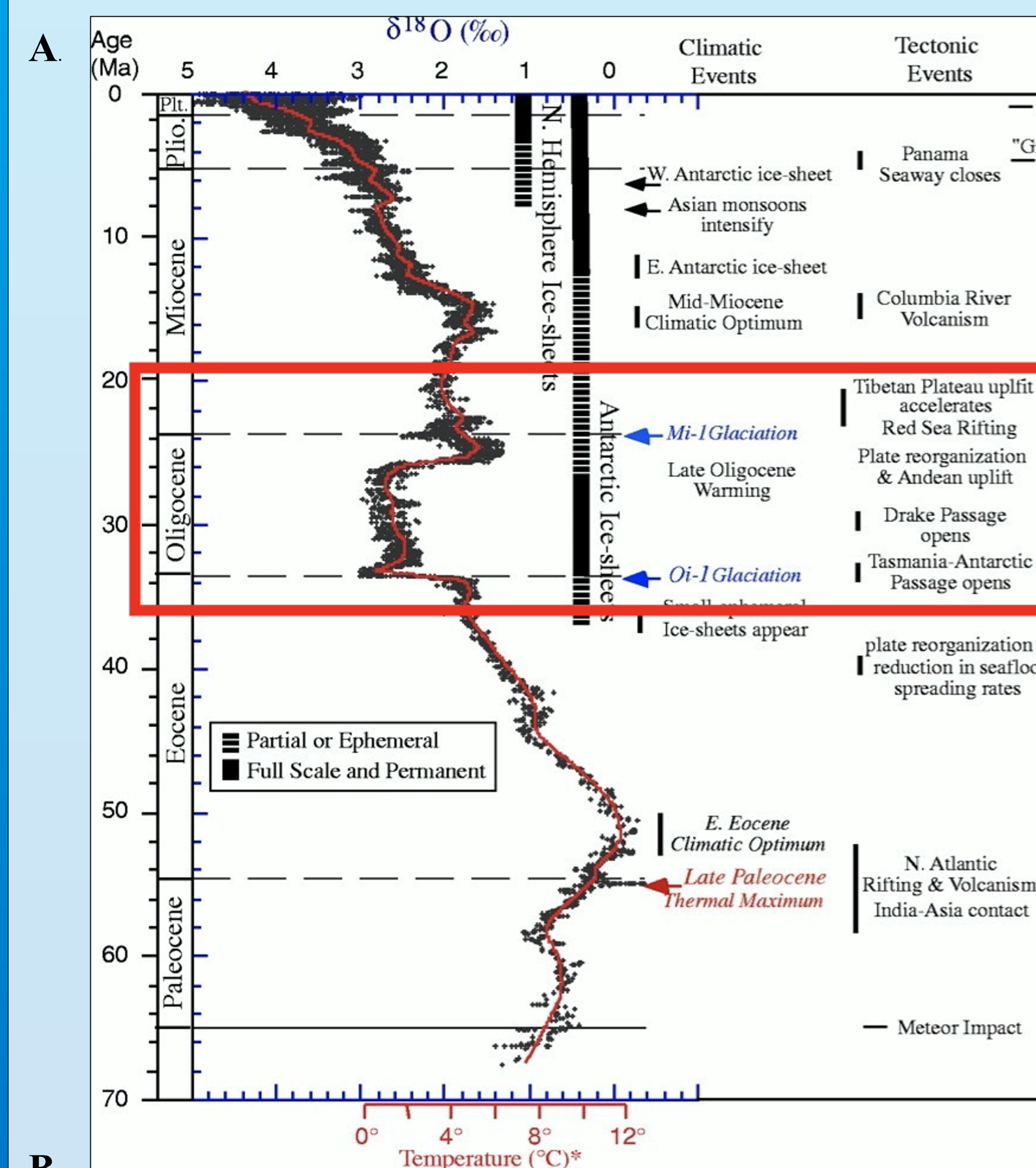
## METHODOLOGY

- Multiple proxies are used to study the interplay of climate and tectonics
- One proxy is looking at dO18 isotope records in deep sea sediments. This is important because of the fractionation of heavy oxygen in the hydrologic cycle;
- Benthic Foraminifera are protists that live in the ocean that use oxygen to make their shells and record the ratio of dO18/dO16 in the ocean water at the time of their shell formation.
- Different species of forams use different ratios of dO18/dO16 in their shells.
- A record of the %dO18 is produced which allows us insight on the ocean conditions at the time of their formation.



**Figure 2:** Illustration showing how oxygen behaves during a non-glacial and glacial period. when H<sub>2</sub>O evaporates from the ocean, heavier water (containing O<sup>18</sup>) will be left behind and lighter O<sup>16</sup> will preferentially evaporate.

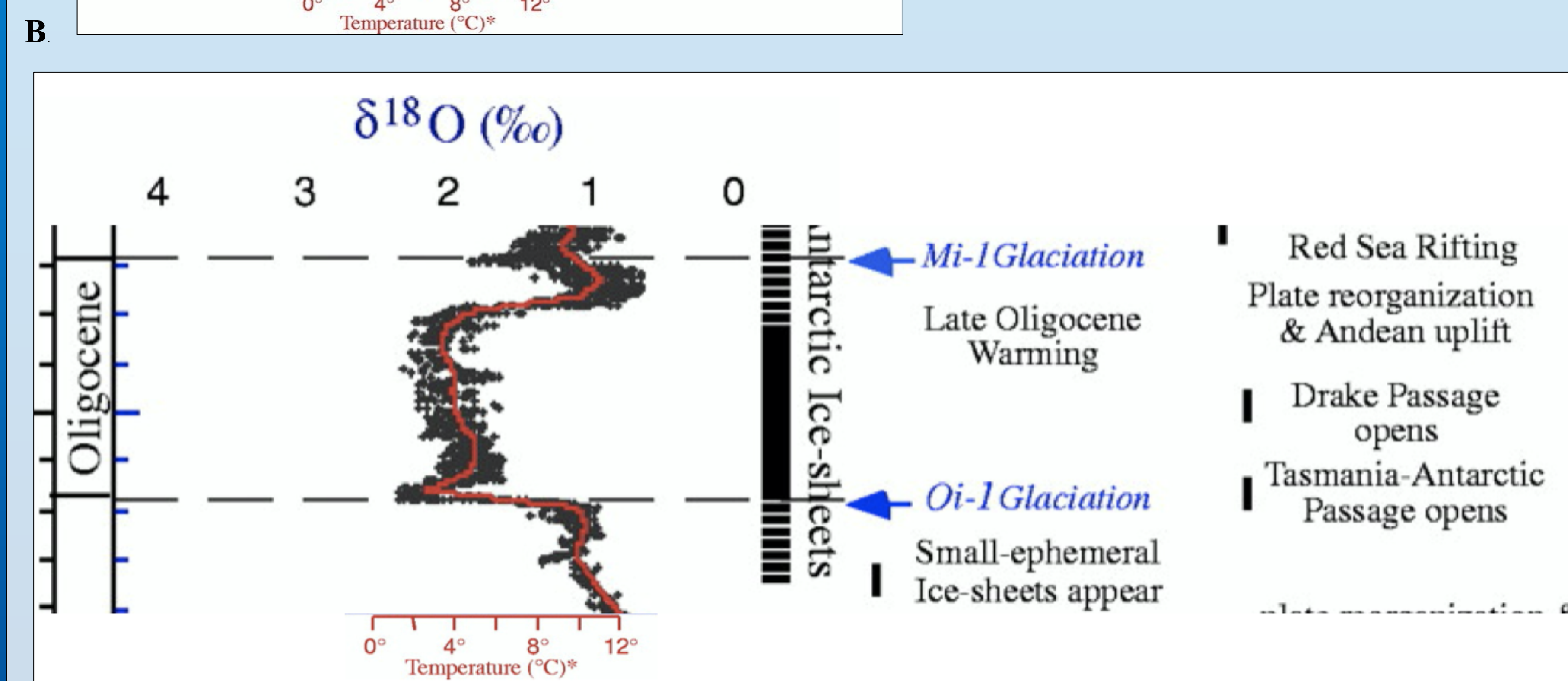
## RESULTS



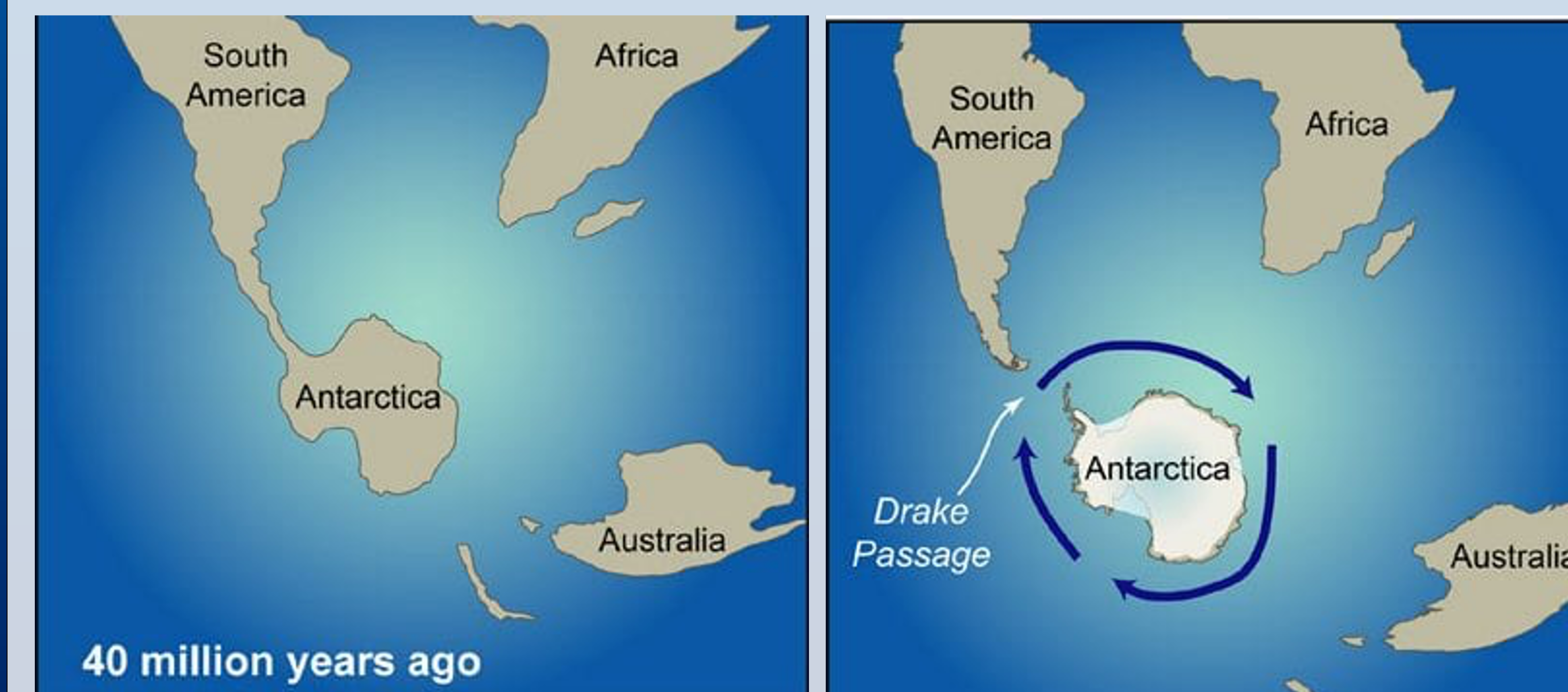
**Figure 3:**

**A:** Zachos' Curve highlighting the dO18 records throughout Earth's history and how those compare to different tectonic events. The red box represents the zoomed in section (3A).

**B:** Zoomed in section of Zachos' curve showing area of interest, the opening of Drake's passage. There is a pattern of low dO18 to high dO18 corresponding to the opening of Drakes passage and when there was strong presence of Antarctic Ice Sheets.



**Figure 4:** Map of Antarctica and surrounding continents before and after the opening of Drake's Passage. The blue arrows represent the Antarctic Circumpolar Current



## DISCUSSION

- Figure 3 shows the dO18 record of Benthic foraminifera, compared to tectonic and climatic events throughout Earth's history, focusing in on the tectonic event opening of Tasmania-Antarctic passage and Drake's passage.
- Around 34 million years ago seafloor spreading opened Drake's passage and Antarctica was no longer connected to the tip of South America.
- Antarctica was now completely surrounded by the Southern Ocean allowing the Antarctic Circumpolar current to form and flow around Antarctica (figure 4).
- This isolates the warm waters from circulating trapping the cold waters causing a large-scale cooling event causing the buildup of the Antarctic Ice sheets today.
- At the same time there are these tectonic events, there is a spike in the dO18 record from lower to higher dO18 values.
- This acts as evidence that there were changes occurring in Earth's Oceans.
- This period of time can be correlated to when the Antarctic ice sheets were forming, trapping the dO16 which is why it is more depleted in the record.
- During a glacial period, the sea level will drop on average 100m due to the water stored in growing glaciers and ice sheets.
- During an interglacial, these ice sheets will begin to melt with an increase in temperature, which causes an expansion of the volume of ocean water.
- Ice Albedo Feedback simply states that ice is more reflective than the ocean or land, which will help cool the earth faster creating a positive feedback loop. Oceans are more effective in holding heat energy (absorbing) due to the darker color, and glaciers/ice sheets reflecting this energy due to the light color.

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