

## **Can changes in ocean properties off the coast of Madagascar be dated within the last 400 years?**

The ocean contains more than 95% of the water in the Earth's hydrological cycle. It is the largest reservoir of heat and stores a significant proportion of the Earth's carbon and nutrients. It plays an essential role in regulating the planet's climate. Therefore, understanding the ocean's physical properties is crucial for a full understanding of the Earth's processes (1). Information regarding processes that determine the ocean's status, and how its physical properties have changed over time are important when trying to model future projections of Earth's systems in a changing climate. However, ocean measurements currently only go back around 150 years. Thus, the current data is not sufficient to accurately predict the future status of the ocean.

During this project, I aim to extend ocean observation data back around 400 years in a key part of the pathway of the ocean conveyor belt, which is a constantly moving system of deep-ocean circulation, driven by temperature and salinity (7). My work will determine whether changes in the physical properties of the ocean can be observed and dated within this time frame. Once completed, I will determine whether changes are likely to have been human induced or natural by cross-referencing the changes observed to the industrial revolution, which marks when human activity began inputting increasing quantities of greenhouse gases into the atmosphere. I will also compare the data with climate records and determine whether parallels exist between the data sets. This will lead to greater understanding of ocean processes and its links to climate. In turn, this will allow us to better predict and model future changes to the Earth's systems.

To do this, I will use a sediment core collected from off the coast of Madagascar. The waters in this area are a key component of the Agulhas current, a critical component of the ocean conveyor belt. Part of this current, known as Agulhas leakage, flows into the Atlantic. It influences the variability of the meridional overturning circulation which is a circulation system of surface and deep water currents (2). This in turn, is thought to influence the formation of so-called deep water (3). Deep water is high in salt content, holds a low temperature, takes decades to form, and importantly, is hypothesised to play an important role in the planet's climate system. Knowledge of how the inputs to this system have changed over time is currently lacking.

To address this question, I will study Foraminifera present in the sediment core, which are microscopic shelled organisms that can record past ocean environmental conditions in their shells. The chemical makeup of the shells reflects the chemistry of the water at the time the shells were formed (4). Foraminifera shells are very well preserved and are considered among the best fossil records on Earth (5). Stable oxygen isotope ratios contained within the shells can be used to determine past water temperatures because in warmer waters the shells are enriched with heavier isotopes as the lighter isotopes evaporate first (4). Furthermore, magnesium/calcium (Mg/Ca) ratios can be used to reconstruct past sea surface temperatures as the substitution of the magnesium for calcium ions during the formation of calcium carbonate in Foraminifera is influenced by the temperature of the surrounding water. Thus, in increased water temperatures Mg/Ca ratios would likely be higher (6). Finally, the relative abundance as well as species composition in this area can be used to indicate environmental conditions. In warmer waters, organisms tend to rapidly increase in number, and because each species has an ideal set of growing conditions, species composition can also be used to indicate past environmental conditions (4).

To conclude, by the end of this project I aim to have reconstructed the past 400 years of ocean environmental conditions for the sediment core located off the coast of Madagascar by using the methods discussed above. From this, I hope to be able to determine whether changes currently being seen in the Agulhas current have an anthropogenic origin or are of natural causes. I also hope to be able to compare the data obtained from the sediment core with climate records to address whether patterns and similarities can provide evidence that improves our understanding of the

relationship between the oceans and our planet's climate. Such evidence is increasingly important as we enter a period of great change in our climate system.

## References

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