RV SONNE

Cruise SO308 South Indian Ocean GEOTRACES GI07

31st October – 22nd December 2024

Durban (South Africa) – Fremantle (Australia)

5. Weekly Report

Reporting Period: 25th November - 1st December - 2024

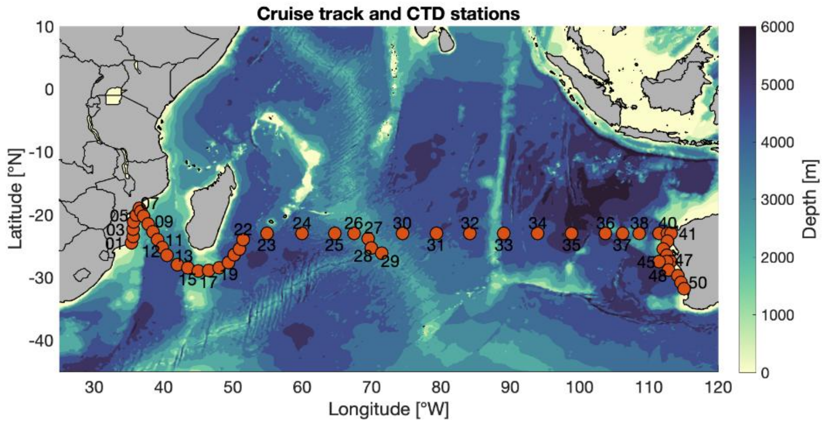

Fig. 1. The planned cruise track with 51 stations (red dots).

The GEOTRACES research cruise SO308 is 4 weeks underway, and we are just about to start sampling at station 33 (Fig. 1).

Over the last seven days we have sampled 3 hydrothermal sites which are part of the Central Indian Ridge: the Edmond Kairei and Pelagia systems. We then headed northeast to our track along 23°S on the way to Australia. The sampling of the vents provided strong plume signals from particles in the neutrally buoyant plume (observed by the turbidity sensor on the CTD frame). In addition, we observed enhanced methane concentrations from measurements by Ingeborg Bussmann (AWI). Methane is emitted as a reduced carbon compound by hydrothermal vent system, and then is swiftly oxidized in the water column by bacteria. The methane signal was most pronounced at station 27, over the Edmond vent system, with concentrations up to 10 nM. Ingeborg analyses water column samples at every depth and at every station along the transect, and has observed typically very low methane concentrations in the remote Indian Ocean with higher levels in the coastal waters off Mozambique.

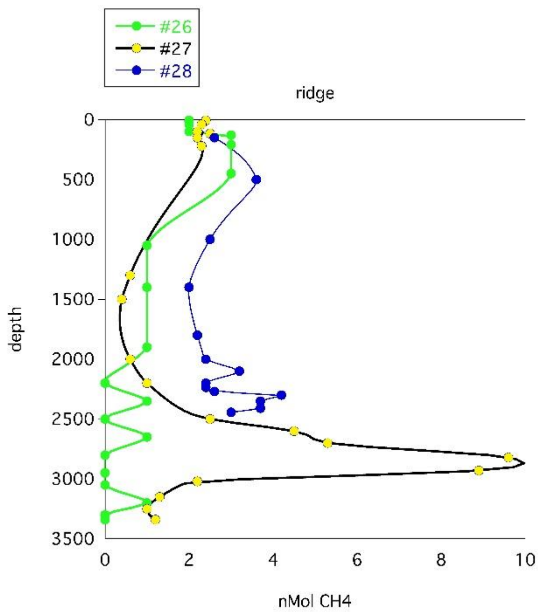

Fig. 2. Depth profile of methane at the hydrothermal vent systems on Central Indian Ridge (stations 26-28). Data by Ingeborg Bussmann (AWI).

Since leaving the Central Indian Ridge, we have sampled the waters along 23°S, which was all successful. The wind and wave conditions have worsened over the last few days, which resulted in lower speed of the SONNE, and also the cancellations of some of the MUC sediment sampling activities. Today, the wind has decreased somewhat (Force 5 to 6 with 3 m waves) and we hope to have smooth sampling tonight.

In the coming days the stations will be further apart (ca. 250 nm), which will allow us to organize our data, check our sample bottle availability and write our cruise reports. By next weekend we will be close to the EEZ of Australia, and start preparing for sampling the Australian slope and shelf and its Leeuwin current.

Observations of the Biological Carbon Pump

Ocean carbon sequestration

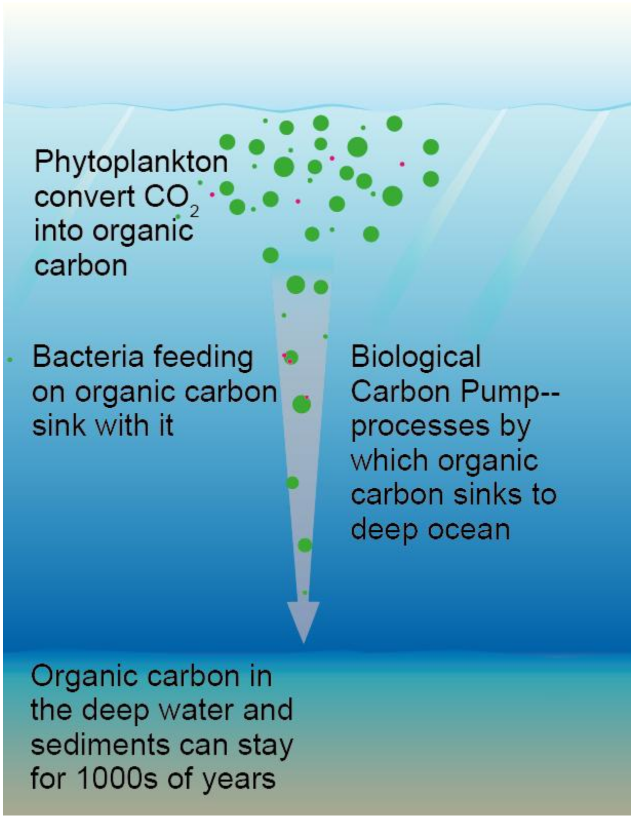

Figure 3: Simplified schematic of the BCP. Image by Charlotte Eckmann.

Marine phytoplankton convert atmospheric carbon dioxide (CO_2) into organic carbon. Upon death, their tiny carbon-based bodies sink from the surface ocean to the deep sea and sediments, and the CO_2 is then removed from the atmosphere for hundreds to thousands of years. The remains of phytoplankton and other detritus sinking through the water column are referred to as marine snow, as they look like falling snowflakes. The processes by which marine snow sinks from the surface to be sequestered in the deep are collectively called the biological carbon pump (BCP; Fig. 3), and how well the pump works depends on the types of phytoplankton and the complex web of biological interactions they are a part of.

The sinking phytoplankton remains are a food source for bacteria. Thus, by virtue of hitching a ride, bacteria also contribute to the BCP. Since many of the carbon building blocks that make up bacteria are particularly resistant to being converted into CO_2, their contribution to the BCP is an important aspect of long-term oceanic carbon sequestration.

One of our research questions is to assess the efficiency of the BCP across the Indian Ocean transect. And also how much do bacteria contribute to the BCP's sinking carbon. To answer these questions, Wan Zhang and Jinqiang Guo (scientists from GEOMAR Helmholtz Centre for Ocean Research) will make good use of the thousands of liters of water that pass through the in-situ pumps (Fig 4).

The case of the missing thorium

Wan will use thorium isotopes to measure the rate of particle sinking (in other words the export flux). Like radium, thorium is part of a radioactive decay system used to answer oceanographic questions. Uranium-238 is also measured by Wan, as a naturally occurring isotope in seawater. It does not react much with anything, so it has constant activity across depths of a

Figure 4. Wan Zhang and Jinqiang Guo pose with Xuegang Chen and their in-situ pumps. Photos by Wan Zhang and Jinqiang Guo.

water column. Uranium-238 decays into thorium-234, and, in an ocean system with no BCP or other biological activity, the ratio of activities of uranium-238 to thorium-234 is constant. However, unlike its parent isotope Uranium-238, thorium-234 is attracted to particles. When a thorium isotope hitches a ride from the surface ocean on a sinking particle, it is removed to a greater depth. Therefore, at the surface, there will be a deficit of thorium-234 to uranium-238, and the deficit relates directly to the strength of the BCP at that location (Fig. 5).

Wan is using an instrument called a beta counter on-board ship to measure thorium activity in the particles collected by the pumps. The beta counter was not happy for a few weeks, but thanks to tireless efforts of André Mutzberg (GEOMAR), it is now in working order. Once she measures the activities, Wan can then use the activity ratios of uranium-238 and thorium-234 to estimate the export flux of the BCP with the help of particulate carbon concentrations obtained from in situ pump filtration.

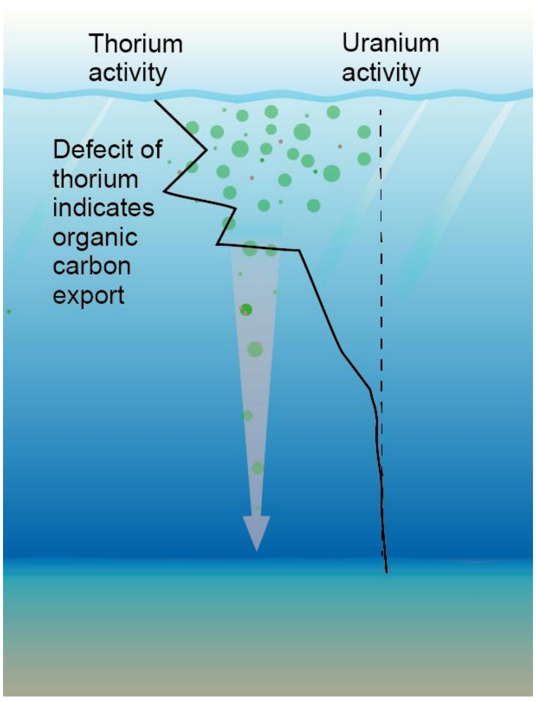

Figure 5. Simplified schematic of a plot of thorium and uranium activities across depth. Image by Charlotte Eckmann.

Bacterial remineralization of sinking material

Jinqiang is investigating the particles collected by the in situ pumps for signs of bacterial origin. One "fingerprint" he's on the lookout for is muramic acid, which is a component of the cell wall in bacteria. Since phytoplankton do not use this particular carbon building block, it is a good bacterial biomarker. He will use the amount of muramic acid and other biomarkers as a proxy for the amount of bacterial material is in the particles of the BCP. Combined with Wan's BPC flux estimations, this can tell us how important bacterial carbon is to the BPC and if that is tied to the strength of the BCP.

Adding it all together

It is important to know both the strength of the BCP and the types of organic matter that contribute to it so that we get a better understanding of how much carbon is shuttled to the deep sea and how likely it is to stay there. The ability to sequester carbon from the atmosphere in the current and future ocean is critical for the control of atmospheric CO_2 levels.

RV SONNE at sea 23°0 S/89°0 E

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