RV SONNE

SO289 - South Pacific GEOTRACES

18th February - 8th April 2022

Valparaiso (Chile) - Noumea (New Caledonia)

2nd Weekly Report

(28th February - 6th March 2022)

Towards the East Pacific Rise assessing the efficiency of the biological carbon pump

Progress: After a delay of nearly 5 days, we were able to leave the port of Talcahuano on February 22, and start cruise SO289. We are now in international waters and will keep sailing west towards New Zealand and New Caledonia. We are 12 days into the cruise, and are sampling at station 17 (Fig. 1). The weather is very kind to us with very low winds and pleasant temperatures. Since 3 days, all the Corona restrictions have been lifted on board and we can go about our daily activities with no restrictions.

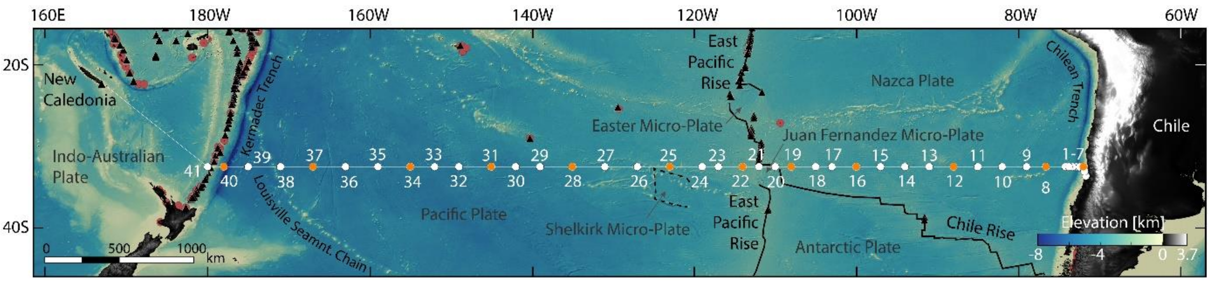

Fig. 1: Station plan for SO289. C Galley.

We have established a very efficient routine of equipment deployment and sampling. The team on board the SSONNE is very organised and effective. Each day we sample in detail the water column from the surface ocean to the seafloor, and collect waters and particles. We use a titanium CTD rosette frame (Fig. 2) for contamination prone elements, and also for sampling of microbial communities. The ships stainless steel CTD frame is used for non-contamination prone sampling of elements and isotopes like radium, thorium, uranium, rare earths and neodymium. At 120-180 nautical miles spacing, we occupy a station at which we spend ca. 6 hours with the deployments of the titanium and stainless steel CTDs. Every 3 days, at our superstations, we also add an additional stainless steel CTD cast, and deploy up to 11 in situ pumps to a depth of 1100 m for particle collection. At the superstations we spend up to 12 hours. Thorsten Schott, Dennis Köhler and Florian Evers are working hard every day in deploying the CTDs and in situ pumps.

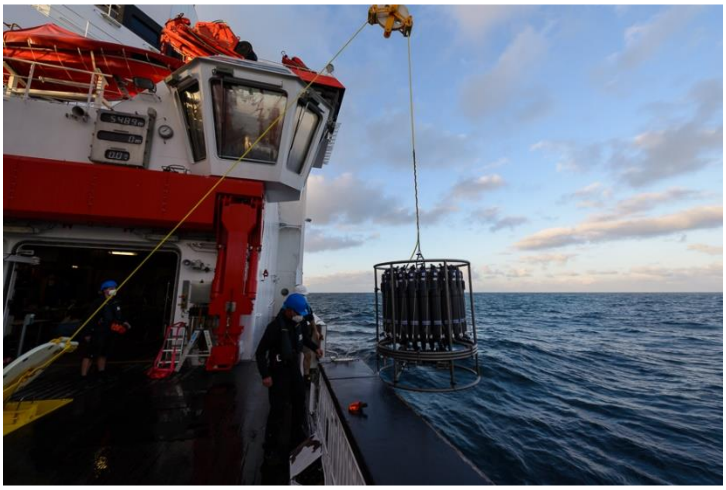

Fig. 2: Deployment of titanium CTD-frame. Photo N. Fröhberg.

East Pacific Rise: The South Pacific hosts large underwater volcanoes with hydrothermal vents, which emit hot fluids into the deep ocean at ca. 2500 m water depth along the East Pacific Rise (EPR) (Fig. 1). The East Pacific Rise is a fast spreading ridge system and there are reports of plumes travelling up to 4000 km from the vent sites. The hydrothermal plumes contain high concentrations of iron and other elements that are required by phytoplankton in the surface ocean for their growth. The plumes of iron in the South Pacific deep waters are thought to be transported southwards and to reach the surface waters in the Southern Ocean, which is the largest region in the world's ocean with phytoplankton growth limitation by iron. In the coming days we will assess the hydrothermal iron inputs and use tracers of helium isotopes and radium to assess hydrothermal plume fluxes and movements. We will employ biogeochemical modelling approaches after the cruise to determine their impact of plume derived iron on the phytoplankton productivity in the Southern Ocean.

We are now making a small detour north towards 31.5°S to have the highest chance of successfully sampling the hydrothermal plume systems of the East Pacific Rise. In case we would have remained on the 32.5°S latitude transect, then we would have crossed the Juan Fernandez microplate, with a lower chance of encountering hydrothermal plumes. We will now occupy a superstation in 2 days time at 31.5°S and 111.9°W, where we will sample in detail the characteristics of the non-buoyant plume system over the East Pacific Rise.

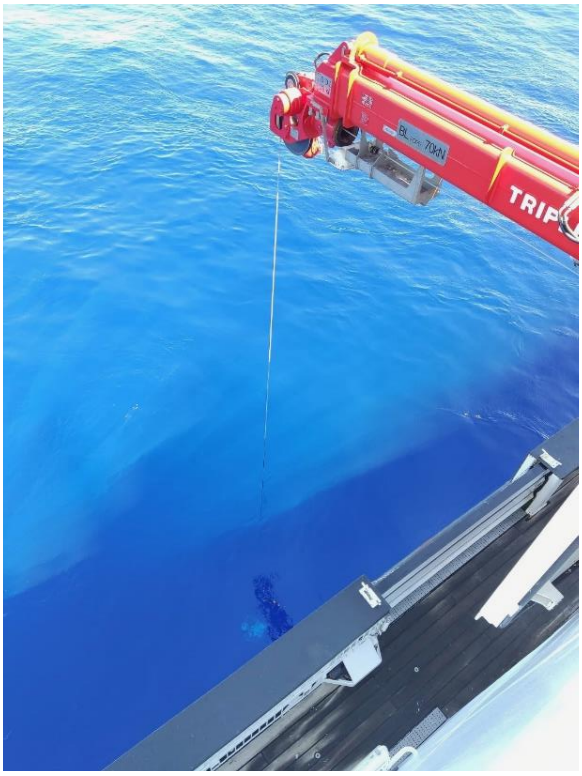

Figure 3: Sampling of particulate organic matter using in-situ pumps positioned at different depths. Photo by Stephan Hamisch

Biological Carbon Pump: The South Pacific Ocean is one of the most remote and least explored ocean regions of our planet. It also has the largest ocean area of ultra-low productivity, resulting in crystal clear blue waters with very few phytoplankton cells. The low productivity is thought to be caused by a low supply of nutrients like nitrate, and also of trace elements like iron and cobalt, which are all required for phytoplankton growth. The low productivity will likely result in a low uptake of atmospheric CO_2 by phytoplankton in this part of the world's ocean.

We are assessing the transfer of carbon (and trace elements) to the deep ocean, using the ^{234}Th (Thorium) disequilibrium technique. The debris of dead phytoplankton cells sinks from the surface ocean to greater depth. Typically, ocean regions with a high primary productivity will have a higher sinking flux of organic matter. The very low productivity in the South Pacific Ocean is expected to result in a low transfer of particles to the deep ocean, and therefore the uptake of atmospheric CO_2 by biological processes is low. The overall process of atmospheric CO_2 uptake by phytoplankton, and the transfer of this carbon to depth is called the biological carbon pump. We are assessing the efficiency of the biological carbon pump through the removal in the upper ocean of the ^{234}Th (thorium) isotope by adsorption onto sinking particles; ^{234}Th is produced in the ocean from ^{238}U (uranium) decay.

In all our oceans, ^{238}U is homogeneously distributed, and a naturally abundant isotope. Uranium does not interact with particles and is long-lived with a half-life of several million years, decaying to ^{234}Th. ^{234}Th is much less stable with a half-life of only 24.1 days and is highly particle reactive. This means, in contrast to ^{238}U, ^{234}Th readily adsorbs onto surfaces of particles and is removed by the sinking particles to the deep ocean.

We make use of a very simple physical rule: the activity (nuclear decays per minute) of the parent radionuclide (^{238}U) and that of the daughter nuclide (decay product ^{234}Th) is the same if both nuclides are still present within the system observed. In case we observe that the activity of ^{234}Th in the surface ocean is lower than that of ^{238}U, we know that some ^{234}Th has been transported from the surface waters. And that happens exclusively through sinking particles. We therefore determine how much ^{234}Th is transported to depth in association with sinking organic particles, and we can calculate our organic particle flux from the depletion ^{234}Th activity over depths up to 400 m. We use in situ pumps (Fig. 3) to collect particles for ^{234}Th and particulate carbon analysis, and in addition we sample waters for dissolved ^{234}Th analysis (and also ^{238}U). The sampling and counting of the ^{234}Th isotopes takes place at sea by our student helper Stephan Hamisch, and we will count the samples again once we are back at GEOMAR.

RV SONNE at sea 31.5°S/103.0°W

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