Dissolved Rare Earth Elements Along Oxygen Gradient

Graduate Student-Faculty Collaborative Initiative in Research and Scholarship

By

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Description:

Oxygen Minimum Zones (OMZs) are large volumes of water within the ocean that have low dissolved oxygen and typically with concentrations lower than five micromoles. Oxygen levels are essential to the world's oceans as they sustain many biological as well as geochemical processes. Based on many conservative climate model outputs, it is clear that global temperature will rise in the near future, which will lead to more oxygen-deficient environments in the oceans (Breitburg et al., 2018; and references therein). Intensification of OMZs is already being observed in the Gulf of Mexico and off the coast of California. These OMZs negatively affect seafloor environments and the availability of economically important species. Dissolved oxygen can ultimately determine the accumulation of organic matter on the seafloor and therefore is of interest to those assessing paleoenvironment, carbon cycling, and oil and gas industry. In this project I will be studying the behavior of Rare Earth Elements (REEs) under different dissolved oxygen environments in the ocean. REEs represent a series of 14 elements with similar chemical behavior. All have valences of +3 in earth conditions (with the exceptions of Ce which can be +4 and Eu which can be +2). The present day ocean has very little dissolved REEs (REEs prefer to form chemical complexes under oxygenated conditions) but how that would change as the oceanic oxygen decreases is relatively understudied. The oxygen gradient off the coast of San Diego provides us a perfect natural laboratory where the oxygen content of the seawater is the lowest closest to the shore and gradually increases towards the open ocean. The hypothesis to be tested is: *Rare Earth Elements in the oceans prefer to remain in a dissolved phase in a low ambient oxygen condition.*

Furthermore, the application of REEs in modern technology and improper disposal has increased its abundance in the environment (including oceans). Through the proposed research we will be studying the behavior of REEs in seawater under different levels of oxygen. The samples for this proposed research project are already being collected off the coast of San Diego.

Expected Outcomes:

Off the coast of San-Diego, oxygen levels are a minimum closest to the coastline and increase towards the open ocean, thereby establishing an oxygen gradient that is ideal for studying dissolved REE behavior in relation to surrounding oxygen concentrations in seawater. More specifically these samples will help us address the following questions:

(1) In what ways does REE behavior vary with changing ambient oxygen levels?

(2) What differences in behavior do light and heavy REEs show under the same or similar ambient oxygen levels?

(3) If they do behave differently, is the behavior consistent across oxygen gradients. In case they do behave in a different manner, does the behavior vary over oxic to anoxic conditions?

Based on existing literature we expect to observe increased concentration of REE in the seawater with the lowest amount of dissolved oxygen. If our results indeed show a gradual decrease in REE concentration moving from the coastal region towards open ocean, then it will validate our hypothesis. However, if we observe different results, that will indicate more complex biogeochemical processes in the water column.

Importance:

One part of the proposed research will look into how varying oxygen concentrations can influence the concentration of dissolved REEs in near shore water off San Diego. The results of this study can have far reaching implications for both marine ecosystems and the human population living along the coast. Samples collected for this project can produce enough data that an empirical relationship may be established between REE abundance and dissolved oxygen in OMZs. A thorough understanding guided by an empirical relationship such as this one will allow for the development of predictive models which can be used to project future changes in ocean chemistry as the oceans continue to warm.

Initiative Requirements:

In order to maintain regular contact with the Graduate Student Center I will put reminders on my calendar to attend all relevant workshops. Currently I am working on acquiring as much background knowledge on my topic of study as possible, the upcoming term (Spring 2019) I will be processing and analyzing my samples. Finally, I should be ready to present and submit my findings in the Fall of 2019. I have weekly meetings with my advisor to help with the progress of my research and I will begin keeping track of the significance of those meetings using the log sheet provided by the GSC. Lastly my faculty advisor is normally very cooperative and flexible, with that said to get him to attend the required workshop I will simply let him know ahead of time so that he can make time for it.

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Faculty Input:

1. Description of the collaborative and your role in making it successful, including how it fits within the student's professional development.

Mr. Salvador Vargas is a graduate student in the Department of Geological Sciences at California State University, Bakersfield (CSUB). As part of his Master's thesis, he is working on understanding Rare Earth Element (REE) behavior along a redox gradient off the coast of San Diego. I am his thesis advisor. While I am and will teach him the complex chemistry that is involved in measuring REEs in seawater, my overarching goal is to train Mr. Vargas on how to ask research questions, frame hypothesis, devise experiments to test hypothesis, interpret data, and disseminate results to both the scientific community and general audience. To learn how to approach a problem and solve it would be a life skill that Mr. Vargas can then apply to any future career path he chooses to take.

2. Describe the steps you will take to prepare your student for the completion and submission of the project.

Mr. Vargas is working on an important and timely research topic. He has expanded on the importance of the proposed research in his proposal. Last summer, he participated in a 4-day research cruise off San Diego, where we collected water samples necessary for his thesis project. While he had limited experience in collecting real oceanographic samples, he learned very quickly and could operate independently in a short duration of time. Currently, Mr. Vargas is in the process of doing extensive literature survey so that he can gain a wholistic idea about the large body of work that already exists and put his own project in that context. Since the beginning of the fall semester we have had multiple meetings where we discussed sample analysis plans at length. We plan to start analyzing samples by early Spring. Measuring REEs in seawater is a tedious process and needs a lot of careful training. I am responsible to teach him the technique and help him collect the necessary data. He and I have a good rapport and it appears that he is eager to learn and invested in the project. So, I do not see any immediate obstacle in successful completion of the project.