Chapter 1

INTRODUCTION

Calcium carbonate-precipitating organisms in the ocean are among the most successful and reliable substrates for paleochemical oceanographic studies. Paleooceanographers take advantage of isotopic and elemental substitution into the biogenic $CaCO_3$ lattice to monitor ocean history and learn about the role of the ocean in global climate. Measurements of these isotopic ratios and trace elements became possible with the advent of sensitive mass spectrometric techniques. Planktonic and benthic foraminifera (single cellular $CaCO_3$ precipitating organisms) preserved in sediments as well as surface corals in reef environments have proven invaluable recorders of their environment. Biological processes occasionally affect these records, and the accuracy of paleochemical proxies must be demonstrated in the modern environment before they may be trusted to reconstruct past ocean parameters. The deep ocean is especially important to global climate as the primary store and transporter of heat and CO_2 in the climate system. Deep-sea corals, largely forgotten by the oceanographic community for many years, have recently returned to prominence. Deep-sea corals offer unique advantages over benthic foraminifera because they are individually datable, they offer the capacity for high-resolution records within a given coral, and they are large enough to accommodate multiple tracers in a single coral. In this work, we are particularly interested in understanding the capacity of the ocean to influence rapid climate change, a timescale particularly suited to deep-sea corals. We approach this issue by monitoring and developing new tools to monitor deep-ocean chemistry recorded in deep-sea corals during times of rapid change.

The work presented here falls into two categories: (1) using an established tracer in deep-sea corals to draw inferences about the ocean system in the past and (2) developing a new tracer of nutrients in deep-sea corals to specifically quantify the relative mixing proportions that contribute to a given deep water parcel. Adkins et al. (2002) demonstrated that deep-sea corals are accurate recorders of the $\Delta^{14}C$ of dissolved inorganic carbon, and in chapters 2 and 3 we present two deep-sea coral records of North Atlantic $\Delta^{14}C$ from different time intervals.

In chapter 2, we measure radiocarbon in samples from a long-lived modern colonial deep-sea coral that was collected in 2001. Large quantities of ^{14}C were generated by the atmospheric detonation of nuclear weapons and subsequently incorporated into atmospheric CO_2. Our record monitors this pulse of ^{14}C-labeled CO_2 moving into the deep North Atlantic. This study illustrates the accuracy of deep-sea coral as recorders of seawater radiocarbon and is the first high-resolution record of bomb radiocarbon at a fixed location in the deep ocean. Our results impact the climate and ocean modeling community by observing the rate of CO_2 infiltration into the ocean, useful for calibrating the rate of CO_2 transfer to the deep ocean.

In chapter 3 we investigate radiocarbon in smaller solitary deep-sea corals from the Norrth Atlantic that have been U-series dated. This allows us to reconstruct deep-sea $\Delta^{14}C$ during the Younger Dryas cold interval. The atmospheric $\Delta^{14}C$ record during the Younger Dryas shows a rapid increase that cannot be accounted for by a corresponding increase in production rate. The $\Delta^{14}C$ increase has therefore been attributed to a sudden drop in the rate of North Atlantic Deep Water (NADW) formation, the major sink for atmospheric radiocarbon. Our deep-sea coral record tests this hypothesis and illustrates the increased influence of radiocarbon depleted southern source water in the intermediate/deep North Atlantic. Our data also show a transient return to enriched radiocarbon (well-ventilated) conditions during the middle of the Younger Dryas

In chapter 4, we present measurements of Cd/Ca in a suite of modern deep-sea corals to evaluate the tracer for deep-ocean reconstructions of nutrients. We found that the relation between Cd/Ca in the coral and Cd/Ca in the water is not simple. Based on the Cd/Ca signatures, we divided the corals into 3 utility groups and applied these structures to the Cd/Ca records that were generated in 2 fossil corals from the North Atlantic. We found our Cd/Ca record from the Younger Dryas to be unreliable, but a record from 15.4 ka probably reflects the average nutrient concentration at the coral growth site.

Bibliography

Adkins, J. F., S. Griffin, M. Kashgarian, H. Cheng, E. R. M. Druffel, E. A. Boyle, R. L. Edwards, and C. C. Shen. 2002. Radiocarbon dating of deep-sea corals. *Radiocarbon* 44 (2):567-580.