Collaborative Research: An Autonomous Vertical Sampling Vehicle for Global Ocean Biogeochemical Mapping

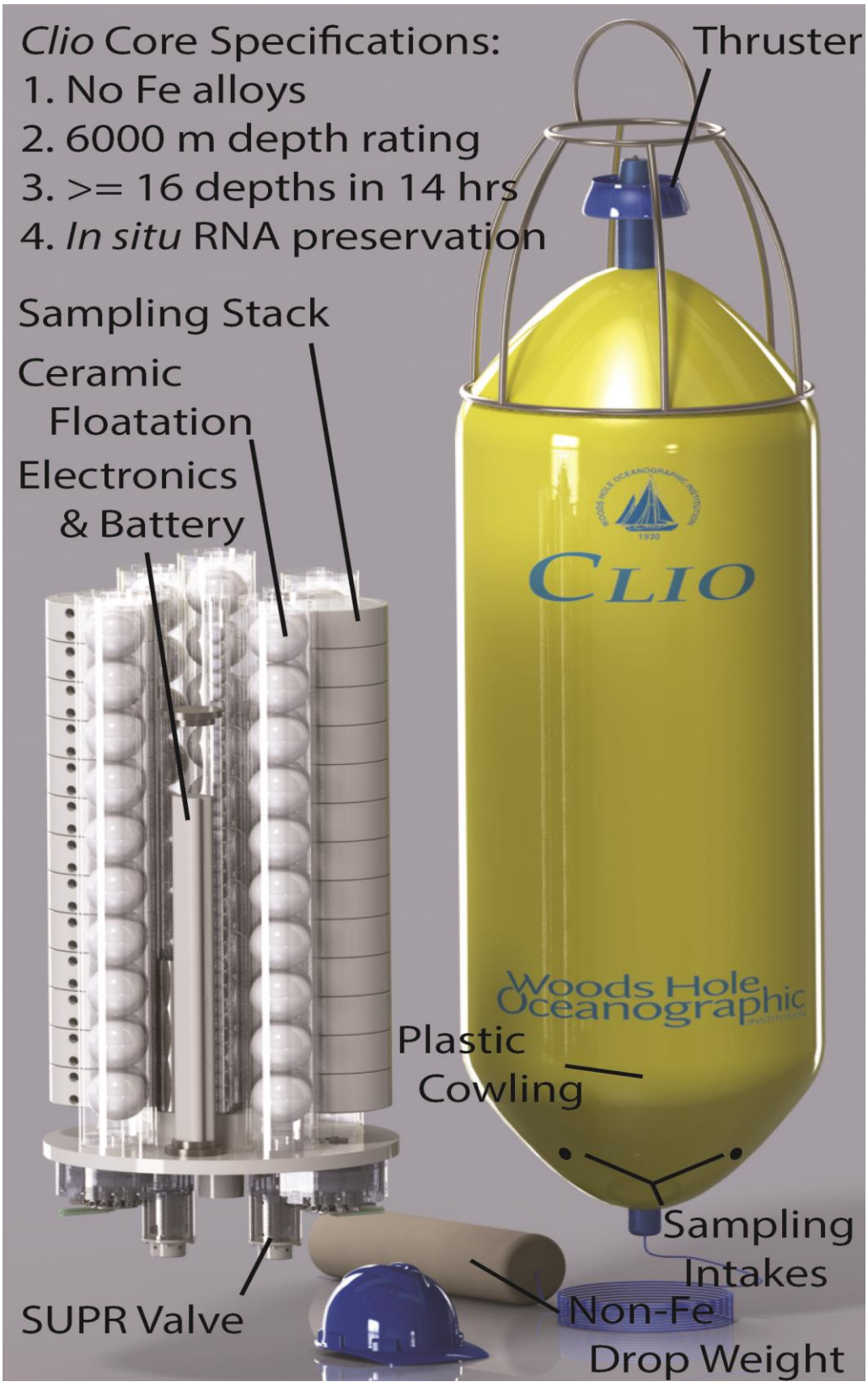
Breier, Jakuba, Saito, Woods Hole Oceanographic Institution; Dick, University of Michigan Ann Arbor

Overview: This project will develop a rapid vertical profiling autonomous underwater vehicle with biogeochemical sampling capabilities. This system will add a new, and much needed, biological dimension to the GEOTRACES program, and would most likely become the central instrument for a GENOTRACES microbial and enzymes research initiative – ultimately enabling the global marine mapping of microbial DNA, RNA and proteins, including key biogeochemical enzymes.

The instrumentation to collect and preserve biological material in the oceans is currently a major – if not the major – limiting factor in adding an "-omic" capability to planned GEOTRACES expeditions. For example, the large water volume sampling technologies currently available for GEOTRACES cannot preserve samples at the time of collection, kilometers below the surface, making RNA based transcriptome analyses impossible. Moreover, current samplers deployed by wire from the deck of the ship are simply too slow to allow the addition of high-resolution "-omic" sampling to planned GEOTRACES expeditions. GENOTRACES "-omic" sampling could be added to GEOTRACES cruises by expanding the sampling capacity of oceanographic research vessels. This project will do so by developing a wireless water-column sampling technology: a 6000 m rated autonomous *vertical* sampling vehicle with a high throughput sampling and sensing payload. At each sampling station, this profiling vehicle would be dropped from the ship, would free fall to the seafloor, and would then use a combination of variable ballast, vertical thrust, and drag control to ascend to, and stop at, 16 to 32 sampling depths, where it would collect filtered material, and aliquots of filtrate, from up to 150 L of seawater per sample – returning to the surface to be collected within as little as 14 hrs. The sampling system would be based on the Suspended Particulate Rosette Sampling system developed by Breier, which is used for deep-sea hydrothermal studies and is capable of *in situ* sample preservation of RNA. The vehicle would be a unique development based on a range of underwater vehicle technology. The combination of rapid vertical transport, the 6000 m depth range, and the need to stop at numerous target depths represents a novel and significant engineering challenge and developing a vehicle capable of this task with the sampling capacity needed for GENOTRACES "-omic" sampling is the objective of this proposal.

Intellectual Merit: Life processes and ocean chemistry are fundamentally linked. Ocean chemistry places constraints on the nature and extent of marine metabolic processes. Life processes alter the speciation, chemical associations, and water-column residence time of organic and inorganic seawater constituents. Microorganisms play a central role in these linkages due to their abundance, pervasiveness, and metabolic diversity. The potential insights to be gained from fully identifying the relationships between ocean life and chemistry have inspired great interest in conducting a first ever global mapping of ocean biochemistry. Such an endeavor would leverage recent advances in "-omic" analyses, which allow for the study of community genomes (DNA), transcriptomes (RNA), proteomes (proteins and enzymes), metabolomes (lipids and other metabolites), and metallomes (metals). Together these "-omic" measurements enable a comprehensive environmental "diagnosis" that describes the organisms present in a sample and what they are doing. Mapping the ocean using these techniques would describe the global extent and complexity of marine biogeochemical processes and the resulting data will be important in improving coupled global circulation and biogeochemical models.

Broader Impacts: This project will develop a new sampling platform that will make a GENOTRACES global marine survey scientifically and financially feasible. Wireless water column sampling will expand the sampling capacity of research vessels making more efficient use of their time. Without this engineering solution, the operational cost of stand-alone GENOTRACES cruises would be a challenge to realizing the GENOTRACES initiative. This project will also sponsor two consecutive teams of undergraduate female engineering students from Smith College's Picker Engineering Program during their senior engineering design course involving a total of 8 students directly in this project.


Clio Core Specifications:
1. No Fe alloys
2. 6000 m depth rating
3. >= 16 depths in 14 hrs
4. *In situ* RNA preservation
Thruster
Sampling Stack
Ceramic Floatation
Electronics & Battery
CLIO
Woods Hole Oceanographic
Plastic Cowling
Sampling Intakes
SUPR Valve
Non-Fe Drop Weight