Changes in Atlantic Tropical Cyclones and the Bermuda High: Clues from the Last Millennium to Inform the Future

Emilia Pitchon

Current anthropogenic climate change is expected to increase hurricane intensity, with stronger winds, higher rainfall, and increased flooding, all of which pose a major threat to coastal communities. However, climate models vary in their predictions of how climate change will impact hurricane frequency and tracks, and 20th century data sources are limited given the brevity of the satellite era. To address this knowledge gap, we study the strength and position of the Bermuda High and how it has changed over the past millennium. The Bermuda High is a semipermanent high-pressure system over the Atlantic Ocean which impacts hurricane tracks and steering currents. To study its behavior, we evaluate two climate products with sea level pressure data spanning 1000 to 2000 C.E.: the Last Millennium Reanalysis and the Community Earth System Model. We compare various Bermuda High indices (BHI) as defined by previous studies, representing different measures of position and strength of the high-pressure system. Maps of sea level pressure anomalies and hurricane tracks are generated during years with high vs. low BHI values. This allows us to better understand the relationship between the Bermuda High and hurricane characteristics over the last 1000 years, providing important context for the future. This work is critical to better constrain hurricane risks under anthropogenic climate change and may help protect the people and environments at risk.

Understanding Phosphorus Mobility in Arclogites

Stella Potemkin

Phosphorus (P) is an essential nutrient for life. Throughout geologic time, availability of this element has limited primary productivity. Therefore, understanding how the phosphorus moves through Earth system has important implications for understanding life history. While surface fluxes of phosphorus are well studied, less attention has been given to understanding how P is recycled and moves through igneous systems. This thesis uses arclogites, a type of garnet pyroxene xenolith, as a tool to better understand P mobility in continental arc settings.

We collected quantitative mineral chemistry for four thin sections using wavelength-dispersive spectroscopy (WDS). Additionally, we analyzed existing whole-rock major element compositions for our four thin sections and additional arclogite samples with bulk rock P_2O_5 greater than 0.2 wt%. Mineral volumes were estimated using Image-J and existing point count data. The culmination of these data allowed us to investigate what contributions different mineral phases make towards bulk rock P_2O_5. Our research suggests that titanite and apatite are the main carriers of P in these rocks, however, questions remain about whether these minerals are primary features. This work expands our understanding of P mobility in arclogites and could have implications for our understanding of how the global P cycle has evolved throughout Earth history.

Oxygen Isotope Fractionation During Cyanobacterial Photosynthesis

Lingkun Guo

Marine primary productivity supports food webs and ecosystem health, driving large-scale animal distribution patterns in the ocean. Primary productivity is also a fundamental process in the biological pump, which sequesters inorganic carbon from the atmosphere through photosynthesis and transports it to the ocean interior where it is stored as organic carbon. Presently, different methods for quantifying productivity disagree with each other, presenting a major research challenge. To understand how climate change may impact the biosphere, it is necessary to continuously improve methods for quantifying primary productivity. The isotopic composition of dissolved oxygen in the ocean can be used as a constraint on oxygen production and therefore, be used to quantify marine primary productivity through the carbon-oxygen stoichiometry of photosynthesis. To distinguish newly produced O2 from O2 already present in the atmosphere, the 18O/16O and 17O/16O ratios of dissolved oxygen can be used. This approach is termed the "triple-oxygen isotope (TOI) method" and it relies on laboratory studies of the behavior of oxygen isotope ratios during photosynthesis to constrain field measurements. Despite the potential of the TOI method, major knowledge gaps remain. For example, nutrient availability affects the photosynthesis activity of microorganisms and is heterogeneous across global oceans. Therefore, understanding how oxygen isotope fractionation may vary under nutrient stress is crucial for correctly interpreting field measurements. To address this knowledge gap, this study examines the effect of nitrate availability on the isotopic composition of cyanobacterial photosynthetic oxygen. Freshwater cyanobacteria Synechocystis PCC 6803 are inoculated in media with different nitrate concentrations. The cyanobacterial photosynthetic oxygen is collected and its TOI composition is analyzed. Additionally, this study generates new data on the clumped isotope composition of photosynthetic oxygen, which is a parameter describing the degree of randomness in the distribution of rare oxygen isotopes (17O and 18O) in O2 molecules. Results suggest that there is larger oxygen isotope fractionation when cyanobacteria experience more nitrate limitation, and that the TOI and clumped isotope composition of photosynthetic oxygen can be utilized together to constrain gross oxygen production and provide information on the mechanism of cyanobacterial photosynthesis

Differences between modern and ancient Martian grain size distributions may reveal different paleoatmospheric conditions and provenance

Sarah Preston

Despite Mars's thin atmosphere, vast areas of its surface are covered in diverse active eolian bedforms. Of particular interest are the eolian systems in impact craters, which record small-scale and shifting wind patterns; such systems have been observed in Gale, Henry, Herschel, and Jezero craters. Significant evidence indicates that eolian processes also shaped the surface of ancient Mars.

Rover observations are particularly valuable in understanding both modern and ancient eolian processes. They enable observations of sediments, bedforms, and outcrops at scales from tens of microns to tens of meters and can collect weather data. Rovers, including Mars Exploration Rovers *Spirit* and *Opportunity* and Mars Science Laboratory *Curiosity*, have observed preserved eolian structures and strata across Mars's. The *Curiosity* rover has studied both a modern and an ancient dune field in Gale crater, Mars, providing the first in-situ observations of an ancient Martian environment and its modern analogue. The ancient Stimson sandstone appears to have a coarser grain size distribution than the modern Bagnold dunes. The apparent coarse grain size distribution in the Stimson may reflect a different atmospheric density when the Stimson was deposited or a different provenance than the Bagnold.

In this work, I aim to characterize the grain size distribution of the Stimson to determine whether it is coarser than the Bagnold dunes. I then aim to determine the implications of the Stimson's grain size distribution, addressing the hypotheses that

1. The Martian paleoatmosphere was denser, enabling it to transport grains of all sizes at lower wind speeds
2. The Martian paleoatmopshere was less dense, enabling larger grains to move via suspension and thus leaving larger grains to be preserved in lithified dune fields; or
3. The Stimson's source yielded coarser grains than the Bagnold's source.