The ANTARCTIC SCIENCE bursary

The ANTARCTIC SCIENCE Bursaries are awards of up to £5000, made annually to support promising young scientists, working in any field of Antarctic scientific research.

The purpose of the award is to broaden the scope of an existing research project through:

- funding extra field or laboratory work,
- purchasing/contributing towards the cost of a key piece of equipment,
- funding international collaboration

REQUIREMENTS:

- The title and a brief description of their existing research project, in no more than 500 words, plus references and no more than two supporting illustrations.
- A concise description of the extended research or visit for which the bursary will be used, in no more than 500 words, plus references and no more than two supporting illustrations. Applicants should make clear the relevance of the proposed research or visit to Antarctic research and indicate the aims and proposed deliverables.
- A budget justifying the money requested.
- A statement of endorsement by their supervisor or line manager, including a statement to the effect that the application is extra to work already approved or funded.
- **The applicants must attach a brief CV and a select bibliography of their publications**

CONDITIONS:

Applicants normally need to be enrolled in a PhD or normally employed as an early career researcher, with payment normally being to an institutional account.

Applications must be submitted on a standard Antarctic Science Bursary form, which may be downloaded from this website. Repeat applications will only be considered if a paper has already been submitted to Antarctic Science.

If Antarctic field work is proposed a letter of support from the National Operator is required. All field work must conform to the Protocol and follow, as a minimum, the SCAR Ethical Guidelines

Applications must be submitted to arrive at the Antarctic Science Office, **no later than midnight GMT on March 31st of each year.** Any applications received after the closing date will not be considered for an award in the stated year. Applicants will normally be notified of the outcome by June 1st of the award year.

Applications will be assessed by the Board of Directors, seeking advice as necessary. The Board will reach its decisions based on fit to the aims of the scheme, quality of science, likelihood of success, cost/benefit and timeliness within the relevant field of science.

A condition of acceptance of the ANTARCTIC SCIENCE Career Development Bursary is that the recipient must undertake to offer to ANTARCTIC SCIENCE a lead-author paper following on from the outcomes of the science activity for which the Bursary was awarded or from science activity associated with it. In addition the recipient must acknowledge the award in presentations and publications.

After completing the project the bursary holder must provide a short report on its success which will be posted on the Antarctic Science Ltd web site

If an applicant subsequently receives adequate grant funding from elsewhere they are required to return the ANTARCTIC SCIENCE Bursary.

The proposal will be judged on three principal criteria - science quality (including topicality and novelty), feasibility (incorporating both track record of the applicant and likelihood of success) and value for money.

The decision of the Antarctic Science Board is final and no correspondence will be entered into.

ANTARCTIC science

BURSARY APPLICATION FORM 2015

FIRST NAME

Christopher

MIDDLE NAME/S

Tyler

LAST/FAMILY NAME

Hayes

DATE OF BIRTH (DDMMYYYY)

EMAIL ADDRESS

FULL POSTAL ADDRESS

Department of Earth, Atmospheric and Planetary Sciences
Massachusetts Institute of Technology
45 Carleton St., E25-615
Cambridge, MA 02142
United States of America

POSTCODE

COUNTRY

United States of America

TELEPHONE NUMBER

FAX NUMBER

DEGREES/AWARDS HELD

PhD

Columbia University in the City of New York

2013

MA

Columbia University in the City of New York

2010

BSc

McGill University (Montreal, Canada)

2008

TITLE OF EXISTING RESEARCH PROJECT

Natural Fe Fertilization and Bioactive Metal Dynamics on the Western Antarctic Peninsula Shelf

SOURCE OF FUNDING FOR EXISTING PROJECT

U. S. National Science Foundation, Division of Polar Programs (Award #1142250). PI: Robert Sherrell (Rutgers University)

TITLE OF PROPOSED EXTENDED RESEARCH

Tracing continental input and organic matter export using the long-lived thorium isotopes

NAME OF SUPERVISOR AND AFFILIATION

David McGee (Massachusetts Institute of Technology)

I declare that the above information is correct and enclose the following documentation in support of my application

√ Endorsement by supervisor/line manager

√ A description of my existing research project

√ A description of the proposed extended research/visit

√ A budget justifying the money requested

√ A brief CV and Bibliography

By Typing your name below you agree that you are applying for the Antarctic Science Bursary. Please also enter the date you are signing this form.

Signed : Christopher Hayes
Date: 19 March, 2015

ANTARCTIC science

ENDORSEMENT BY SUPERVISOR or LINE MANAGER

FULL NAME OF APPLICANT

Christopher Tyler Hayes

TITLE OF PROPOSED EXTENDED RESEARCH/VISIT

Tracing continental input and organic matter export using the long-lived thorium isotopes

STATEMENT OF ENDORSEMENT :

FULL NAME OF SUPERVISOR/LINE MANAGER

David McGee

TELEPHONE NUMBER

NAME OF UNIVERSITY/INSTITUTE

Massachusetts Institute of Technology

EMAIL ADDRESS

STATEMENT :

Chris is a remarkable early-career chemical oceanographer whose work shows rigor, creativity, and an ability to connect datasets to the big picture. Chris is the ideal person to take on the proposed project, having used seawater thorium analyses to trace lithogenic inputs and particle fluxes in a series of high-quality studies in the North Atlantic and North Pacific. He has performed these analyses independently and mentored students in our lab in several projects for the past 18 months. He has also demonstrated an ability to efficiently and effectively communicate his results in publications. This project will aid in Chris' professional development beyond the projects undertaken in his postdoctoral fellowship and provide an additional opportunity for Chris to work with an undergraduate mentee in the laboratory.

This project is not funded by any other source. Please do not hesitate to contact me if you have any questions.

As the supervisor/line manager of the applicant, I declare that the applicant is already undertaking an approved programme of research and that this application is for funding to extend and improve that research; existing funds are not available to support this application.

To confirm that you endorse the applicant please fill in your name and the date you are completing this part of the form

Signed : **Date : 20 March 2015**

Description of Existing Project: **Natural Fe Fertilization and Bioactive Metal Dynamics on the Western Antarctic Peninsula Shelf (PI: Robert Sherrell, Rutgers University)**

The shelf waters off the Western Antarctic Peninsula (WAP) characteristically show high primary productivity, yet are bounded to the west and north by an apparently iron limited Antarctic Circumpolar Current. Natural sources of bioavailable iron (Fe) amendments are thought variously to arise from atmospheric deposition, upwelled Circumpolar Deep Water shoaling over the continental shelf, glacier and iceberg melting or even inputs from underlying shallow shelf sediments. As part of the ongoing Palmer LTER (Long-Term Ecological Research) program, a comprehensive study of the water column distribution, bio-uptake studies and the dynamics of various forms of Fe and other bioactive elements will be used to inform physical and biogeochemical models of the WAP.

The shelf waters off the WAP constitute a natural iron fertilization zone in which Fe inputs, ultimately of continental origin, relieve the micronutrient limitation characteristic of the broader Southern Ocean ACC waters just off the shelf break. However, despite 18 years of summertime cruises to this region by the Palmer Long Term Ecological Research (LTER) program, no comprehensive study of water column distributions and dynamics of iron (and other bioactive elements) has yet been carried out. We propose to build on our preliminary surface distribution data for dissolved Fe, Mn (manganese), Zn (zinc), Co (cobalt), Cu (copper), and Ni (nickel) in this region, obtained with seed money support over the last two years, to launch a **full scale two-field-season sampling program** for **dissolved and particulate trace metals**, to determine the **sources and mechanisms** for delivery of bioavailable Fe to the euphotic zone on the shelf, on one hand, and to test the hypothesis supported by our preliminary data that, counter-intuitively, low iron availability limits primary productivity on sub-regions of the shelf in the summertime (January).

Using a combination of surface underway high-resolution sampling, vertical profile sampling with the new USAP trace metal CTD/Rosette system, short-term drifting sediment trap deployments, and shipboard Fe addition incubation experiments, we will determine the source regions, water mass associations, euphotic zone concentrations, degree of iron limitation, phytoplankton assemblage Fe/C ratios, and particulate iron export fluxes for the LTER sampling grid covering the WAP shelf and adjacent pelagic ACC waters. Iron input mechanisms will be teased apart using a unique combination of multi-element seawater measurements (esp. Mn/Fe, a tracer of suboxic sedimentary fluxes), **Neodymium isotope ratios** that trace radiogenic continental inputs (as seen in our preliminary data), and **seawater oxygen isotope ratios** that can discern freshwater inputs derived from glacial melting vs. sea ice melting. Using these three tracers, we will interpret dissolved and particulate Fe distributions and determine which of the candidate iron sources (sediments, glaciers, icebergs, sea ice, Upper Circumpolar Deep Water (UCDW) intrusion, or atmospheric flux) are dominant for this region. In the context of LTER physical oceanographic measurements, we will determine mechanisms by which Fe and other bioactive metals are dispersed from source regions across the broader shelf water column, and especially the routes to the shelf-wide euphotic zone.

Description of Proposed Extended Research: **Tracing continental inputs and organic matter export using the long-lived thorium isotopes**

Two fundamental aspects of marine ecosystems are the uptake of limiting nutrients and the downward flux of organic matter. We propose to contribute to both of these 'unknowns' in the Palmer Long Term Ecological Research (LTER) sampling grid on the West Antarctic Peninsula (WAP, Fig. 1). By analyzing thorium isotopes (Th-232, half-life ~14 billion yrs and Th-230, half-life 76 thousand yrs) in seawater samples already collected during a 2014-2015 austral summer field campaign, we will: (1) use the distribution of the **continental tracer**, Th-232, as an indicator for biological uptake of Fe relative to its lithogenic sources (coastal sediments, ice-rafted debris or atmospheric dust); and (2) use the **radioactive clock**, Th-230, to provide a quantitative estimate of the export flux of organic matter. Both goals involve novel techniques and are complementary to the funded project by PI Sherrell, focused on the cycling of iron and other bioactive metals. We anticipate these goals will lead to 1-2 publications, to be submitted to *Antarctic Science*, and may provide supporting data for a larger-scale research proposal.

Thorium and iron are both added to the ocean via partial dissolution of lithogenic minerals. Fe, as an essential nutrient, is rapidly cycled into biological material, while the thorium cycle has no direct biological component [1]. Using a chemical kinetic view of the ocean, one can compare the Fe/Th-232 ratio found in seawater to that provided by crustal material and infer low ratios as due to the biological uptake of Fe. Surface waters at the northern extent of WAP shelf have a dissolved Fe/Th-232 molar ratio of 1000-2000 [2-3], while the average upper continental crust is 13,600 [4], indicating extensive relative Fe removal. Fe replete conditions closest to the WAP coast and Fe stress on the shelf break have been inferred indirectly using fluorescence (Fig. 1)[5]. We will test this inference using high spatial resolution Fe/Th-232 observations along the 200 and 600 lines (~90 Th-232 analyses at MIT).

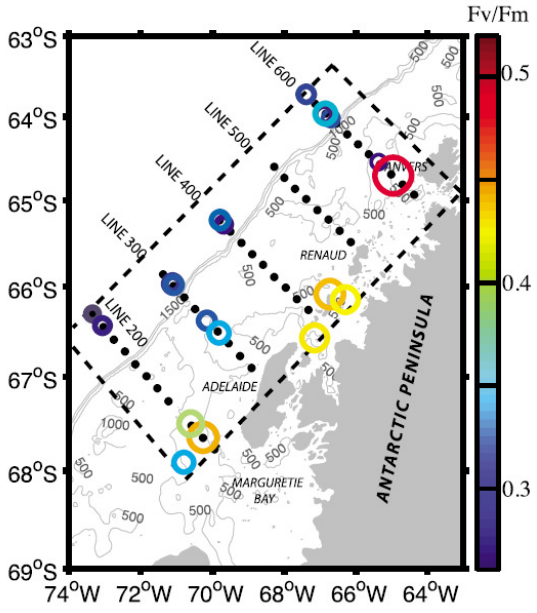

Figure 1. Palmer LTER sampling grid [5]. Plotted Fv/Fm values monitor the photosynthetic competency of photosystem II and are interpreted here as an indicator of nutrient limitation associated with Fe supply (low values indicating Fe stress and high values indicating Fe repletion).

Export flux, which can be regulated by nutrient limitation, has important implications for the air-sea partitioning of carbon dioxide and thus global climate. Reported export fluxes at Palmer LTER in January 2009, using drifting sediments traps and Th-234 fluxes (half-life 24 days) [6], were an order of magnitude larger than that based on the traditionally-used moored sediment trap. While under-collection by moored traps has been shown in other areas as well, this discrepancy is so large that more methods to estimate export flux are warranted. Analogous to the Th-234 method, export flux is calculated using the sinking flux of Th-230, quantified using its dissolved inventory, its known production due to uranium decay, and the particulate carbon-to-Th-230 ratio. Because of the much longer half-life of Th-230, it may record longer-term average fluxes (seasons to years) in complement to the weekly/monthly timescale captured by Th-234. We plan to estimate export flux using a high resolution depth profile (~20 Th-230 analyses at MIT) of dissolved and particulate Th-230 at the location of the moored sediment trap.

References

[1] Hayes, C.T., Anderson, R.F., Fleisher, M.Q., Serno, S., Winckler, G. and Gersonde, R. (2013) Quantifying lithogenic inputs to the North Pacific Ocean using the long-lived thorium isotopes. Earth Planet. Sci. Lett. 383, 16-25.

[2] Klunder, M.B., Laan, P., De Baar, H.J.W., Middag, R., Neven, I. and Van Ooijen, J. (2014) Dissolved Fe across the Weddell Sea and Drake Passage: impact of DFe on nutrient uptake. Biogeosciences 11, 651-669.
[3] Venchiarutti, C., van der Loeff, M.R. and Stimac, I. (2011) Scavenging of ^{231}Pa and thorium isotopes based on dissolved and size-fractionated particulate distributions at Drake Passage (ANTXXIV-3). Deep Sea Res. Pt. II 58, 2767-2784.
[4] Taylor, S.R. and McLennan, S.M. (1995) The geochemical evolution of the continental crust. Rev. Geophys. 33, 241-265.
[5] Huang, K., H. Ducklow, M. Vernet, N. Cassar, and M. L. Bender (2012), Export production and its regulating factors in the West Antarctica Peninsula region of the Southern Ocean, Global Biogeochem. Cycles, 26, GB2005, doi:10.1029/2010GB004028.
[6] Buesseler, K. O., A. M. P. McDonnell, O. M. E. Schofield, D. K. Steinberg, and H. W. Ducklow (2010), High particle export over the continental shelf of the west Antarctic Peninsula, Geophys. Res. Lett., 37, L22606, doi:10.1029/2010GL045448.

Budget & Justification

The majority of the cost in this project stems from analysis by Multi-collector Inductively-coupled Plasma Mass Spectrometry (MC-ICP-MS), using the Nu Plasma II, maintained by David McGee at MIT. The hourly rate for this instrument is $100 (USD)/hr. We plan on analyzing 109 seawater samples for ^{232}Th-^{230}Th and estimate 30 hours of instrument time will be required. The only other expense involved is $500 (USD) for reagents and materials in sample preparation, including nitric acid, hydrochloric acid, ammonium hydroxide and anion exchange resin (see report by Hayes et al., 2013, referenced above for details on our published methods). Salary for Christopher Hayes is already supported through a postdoctoral fellowship and an undergraduate assistant will participate in sample preparations, supported by internal MIT funds.

Line items:

30 hours instrument time (MC-ICP-MS) at $USD 100/hr	USD$ 3000 = £ 2040 (on 3/15/2015)
Reagents and materials	USD$ 500 = £ 340 (on 3/15/2015)

Total = £ 2380