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23 March 2015

To Whom it May Concern:

I would like to apply for an Antarctic Science Bursary to support field work on Deception Island with the Spanish Polar Programme in the coming summer season (2015-2016).

The following pages comprise, in order:

- Description of my current research project
- Description of my proposed research project (to be supported by the Bursary)
- Budget and budget justification
- Emails from the Spanish Polar Programme regarding my participation
- A brief *curriculum vitae*
- A copy of my collecting permit for the Deception Island work

The application form, with the relevant sections completed by my supervisor, is included separately.

Please note: I received my PhD in December 2009, and am therefore just over five years post-PhD. I recently asked Prof David Walton how 'early career' is defined for these Antarctic Science Bursaries. He told me that there are no strict limits, and that I would probably be considered early career by the Board.

Thank you in advance for considering my application.

Yours Sincerely,



Ceridwen Fraser

CURRENT PROJECT

Current Project:

Volcanoes as safe-havens for Antarctic species during ice ages

I currently have Australian Research Council (DECRA: Discovery Early Career Research Award) funding to research the role of volcanoes in maintaining biodiversity through past ice ages in Antarctica.

Description of existing project:

Antarctica was heavily glaciated at the peak of the last Ice Age (~18,000 years ago)¹, yet biological evidence indicates that most Antarctic terrestrial species have existed on the continent for millions of years²⁻⁴. How did Antarctic terrestrial species that require ice-free habitat, such as mites, springtails and mosses, survive ice ages on an ice-covered continent?

There are 17 Antarctic volcanoes that are known to have been active since the Last Glacial Maximum⁵. Ice-free terrain close to volcano summits, lower-altitude steam fields, and geothermal ice caves, could have existed throughout Pleistocene ice ages, and might have provided habitable environments ('refugia') that allowed Antarctic plants and invertebrate animals to survive on the continent.

Postglacial colonisation away from ice age refugia is typically marked by drastically lower genetic diversity in recolonised versus refugial regions^{4,6,7}. Under a hypothesis that

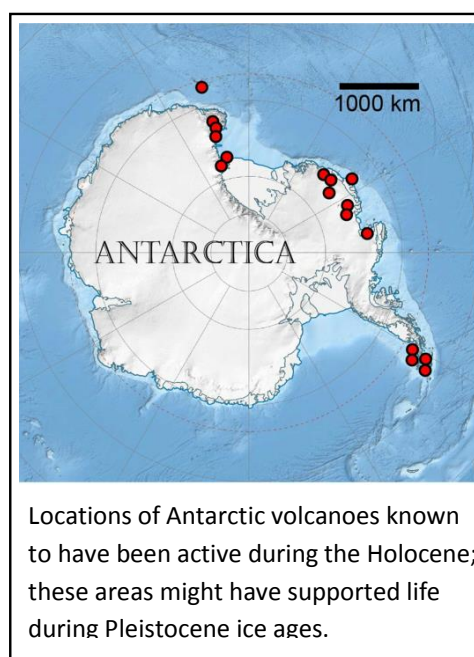
geothermal heat allowed localised persistence of Antarctic species throughout recent ice ages,

I predict that genetic diversity of a range of species will be highest close to volcanically-warmed areas, and lowest further away.

I am currently using genetic approaches to test this prediction on broad (continent-wide) scales for several species, with samples being sourced from existing collections, including those of the Australian Antarctic Division and the British Antarctic Survey. To do so, I am using both next-generation sequencing approaches (e.g. 'Genotyping by Sequencing' or GBS) and traditional methods such as microsatellite

mosses (where GBS is not possible due to degradation of herbarium specimen DNA). I am have also recently used GIS-based spatial analyses to test the hypotheses using existing species records and species richness patterns (see Fraser et al 2014, PNAS).

The DECRA funding that I have, however, is only for broad-scale phylogeographic research using existing samples from collections, whereas my proposed Antarctic Science Bursary-supported project is to undertake a fine-scale analysis of the local impacts of volcanic heat on



CURRENT PROJECT

biodiversity. I have recently been offered the opportunity to participate in a research voyage to Deception Island, at the tip of the Antarctic Peninsula, with the Spanish Polar Programme. This opportunity could enable me to address important questions on the role of volcanoes in structuring patterns of biodiversity by assessing diversity patterns within kilometres of heated soils, as opposed to the rougher, continent-wide analyses I will carry out for my DECRA. To participate, I will need funds to cover travel to South America for myself and a field assistant, as the DECRA budget does not include any field work costs. I can, however, use funds from the DECRA to carry out the genetic analyses necessary for this Deception Island project.

References:

1. Anderson, J.B., S.S. Shipp, A.L. Lowe, J.S. Wellner, and A.B. Mosola, The Antarctic Ice Sheet during the Last Glacial Maximum and its subsequent retreat history: a review. *Quaternary Science Reviews*, 2002. 21(1-3): p. 49-70.
2. Convey, P., J.A.E. Gibson, C.D. Hillenbrand, D.A. Hodgson, P.J.A. Pugh, J.L. Smellie, and M.I. Stevens, Antarctic terrestrial life - challenging the history of the frozen continent? *Biological Reviews*, 2008. 83(2): p. 103-117.
3. Convey, P., M.I. Stevens, D.A. Hodgson, J.L. Smellie, C.D. Hillenbrand, D.K.A. Barnes, A. Clarke, P.J.A. Pugh, K. Linse, and S.C. Cary, Exploring biological constraints on the glacial history of Antarctica. *Quaternary Science Reviews*, 2009. 28(27-28): p. 3035-3048.
4. Fraser, C.I., R. Nikula, D.E. Ruzzante, and J.M. Waters, Poleward bound: biological impacts of Southern Hemisphere glaciation. *Trends in Ecology & Evolution*, 2012. 27(8): p. 462-471.
5. LeMasurier, W.E. and J.W. Thomson, eds. *Volcanoes of the Antarctic Plate and Southern Oceans*. Antarctic Research Series. Vol. 48. 1990, American Geophysical Union: Washington, D.C. 487.
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7. Hewitt, G., The genetic legacy of the Quaternary ice ages. *Nature*, 2000. 405(6789): p. 907-913.

PROPOSED RESEARCH

How hot rocks help species survive in cold places:

using genetics to test whether small patches of volcanically-warmed earth can support high levels of biodiversity in Antarctica

General overview:

Antarctica contains many unique species that have evolved in almost total isolation for millions of years, despite repeated glacial periods. I hypothesise that many Antarctic terrestrial species could have survived recent ice ages in geothermal refugia. Species richness patterns provide some support for this hypothesis¹, but much more can be learned from higher-resolution studies of genetic diversity. This research will use next-generation DNA sequencing technologies to assess patterns of genetic diversity among several species on Deception Island.

Research plan:

Under a hypothesis that geothermal heat allowed localised persistence of Antarctic species throughout recent ice ages, I predict that genetic diversity of a range of species will be highest close to volcanically-warmed areas, and lowest further away. My broad-scale research using existing samples will provide only limited insight into how large geothermal refuges may have been and how much diversity each could host. On Deception Island, I will use spatial analyses of genetic diversity on fine scales (several kilometres) to assess how localised the impact of geothermal heat is on biodiversity patterns in Antarctica.

TARGET SPECIES and SAMPLING: I will target up to five key, broadly-distributed (not rare) species: the mosses *Bryum argenteum* and *Schistidium antarctici*, and the invertebrates *Cryptopygus antarcticus*, *Friesea grisea* (both Collembola) and *Halozetes belgicae* (Acari). These species show evidence of having survived in Antarctica throughout past ice ages²⁻⁵. I will aim to collect 30-50 samples of each species per site, e.g. using Tullgren Funnel extractions.

SITES: I will sample from eight sites on Deception Island (Figure 1). Three sites will be on volcanically heated ground that has not been disturbed by recent eruptions and hosts relatively old populations of biota; three will be on heated ground that was resurfaced by the volcanic eruptions of the 1960s, and two will be in non-ASPA areas: 1) westward of Fumarole Bay, over the ridge and to the west coast: allowing gradient analysis of the effects of geothermal heating on biodiversity; 2) Baily Head, on the south-eastern outer coast of the island. At each site, temperature probes will be used to determine the temperature of the soil, and in some cases transect designs will be used to stratify sampling across thermal gradients.

PROPOSED RESEARCH

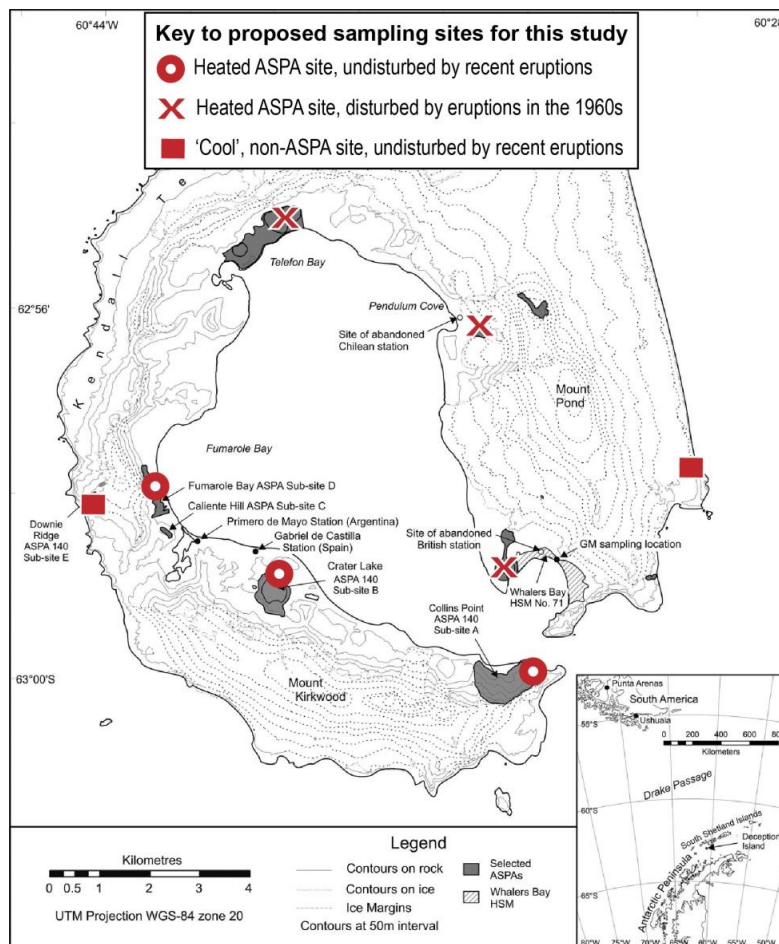


Figure 1: Proposed sampling sites for this study. Base map obtained from Greenslade et al (2012).⁶

GENETIC WORK: After collection, in my laboratory in Australia, DNA will be extracted from all samples, and 'genotyping by sequencing' (GBS)⁷ will be carried out to obtain SNP data to estimate genetic diversity within each species at each site.

Outputs:

I will prepare a publication based on the findings of this Deception Island study, and submit the manuscript to *Antarctic Science* for consideration. This research will also contribute to papers that I have already planned as part of my broader research on Antarctic geothermal refugia. I will also promote results to the media, and present results at international conferences.

Permits:

A permit for sampling from within the relevant ASPA sites on Deception Island has been obtained from the Australian Antarctic Division, and is valid until April 2017 (see attached).

PROPOSED RESEARCH

Scientific significance:

The results of this research will give valuable insights into how species have responded to past climate change in the Southern Hemisphere, the evolutionary history of southern polar terrestrial species, and the roles geothermal activity can play in structuring patterns of biodiversity. The importance of this research has already been recognised, with a recent paper in PNAS¹ that sparked a great deal of media interest and a commentary on its relevance and the importance of future work in this field⁸.

References

1. Fraser, C.I., A. Terauds, J. Smellie, P. Convey, and S.L. Chown, Geothermal activity helps life survive glacial cycles. *Proceedings of the National Academy of Sciences*, 2014. 111(15): p. 5634-5639.
2. McGaughran, A., M.I. Stevens, and B.R. Holland, Biogeography of circum-Antarctic springtails. *Molecular Phylogenetics and Evolution*, 2010. 57(1): p. 48-58.
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5. Mortimer, E., B.J. van Vuuren, J.E. Lee, D.J. Marshall, P. Convey, and S.L. Chown, Mite dispersal among the Southern Ocean Islands and Antarctica before the last glacial maximum. *Proceedings of the Royal Society Biological Sciences Series B*, 2011. 278(1709): p. 1247-1255.
6. Greenslade, P., M. Potapov, D. Russell, and P. Convey, Global Collembola on Deception Island. *Journal of Insect Science*, 2012. 12.
7. Lu, F., A.E. Lipka, J. Glaubitz, R. Elshire, J.H. Cherney, M.D. Casler, E.S. Buckler, and D.E. Costich, Switchgrass genomic diversity, ploidy, and evolution: novel insights from a network-based SNP discovery protocol. *PLoS Genetics*, 2013. 9: p. e1003215.
8. Pointing, S.B., B. Bollard-Breen, and L.N. Gillman, Diverse cryptic refuges for life during glaciation. *Proceedings of the National Academy of Sciences*, 2014. 111(15): p. 5452-5453.

BUDGET

Amount requested:

Airfares	£ 3,800
Living costs	£ 950
Total	£ 4,750

Budget justification:

- (i) **AIRFARES:** I request return airfares for myself and one field assistant from Canberra, Australia to Punta Arenas, Chile, to join the Spanish Polar Programme. The airline LAN Chile, the cheapest available quote, quotes economy fares for January 2016 at approximately GBP 1900 per person (**£3800** for two people).
- (ii) **LIVING COSTS:** I also request funds for living expenses for two days in Punta Arenas either side of the trip, to allow adequate time between ship and plane movements. Costs are based on the Australian Taxation Office 'reasonable travel' allowances for Chile, at AUD \$234.45 per person per day, coming to \$1875.60 for two people for four days, which is roughly GBP **£950** at current exchange rates.
- (iii) **TOTAL:** The total amount requested is thus GBP **£4750**.

Notes:

Need for funding to support this trip: The Australian Research Council (ARC) grant that I currently hold does not include any funds for travel for field work, as my original proposal was to use existing collections. All costs needed for this Deception Island project that are not included in the above budget (DNA analysis etc.) can, however, be supplied by my ARC grant.

Support from the Spanish Polar Programme: This project was formally offered logistical support from the Spanish Polar Programme in 2014 for the 2014-2015 summer season (see attached email). However, as I later discovered I was pregnant, with my baby due on 1 January 2015 (roughly the time the trip was planned for), I could not travel in the 2014-2015 season. I discussed this with Prof Antonio Quesada, head of the Spanish Polar Programme, via email as soon as possible (see attached), and he told me that I should be able to delay the trip until the 2015-2016 season. Formal confirmation of my participation in the coming summer season is anticipated, but cannot yet be supplied, as the Spanish Polar Programme makes decisions on the next season's logistics in April / May of each year.

Field assistant: The Spanish Polar Programme approved, in 2014, logistical support for myself and one field assistant, so that I do not need to work alone or infringe on the time of others working in the programme. I have found a willing assistant from among the PhD students in my department: Geoffrey Kay, who has extensive remote-area field work experience, including Antarctic field work. As an early-career researcher with strong interests in Antarctic research, he will be both an excellent assistant and an appropriate choice to share the funding from the Antarctic Science Bursary, which aims to support early career scientists.

Ceridwen Fraser

From: Comité Polar Español <cpe@mineco.es>
Sent: Tuesday, 27 May 2014 10:34 PM
To: Ceridwen Fraser; Comité Polar Español
Cc: Antonio Quesada; Miki
Subject: RE: Request to participate in the Spanish Antarctic Campaign
Attachments: Logistics_2014_2015.docx

Follow Up Flag: Flag for follow up
Flag Status: Completed

Dear Dr Fraser:

We are pleased to inform you that your request to participate in the Spanish Antarctic Base Gabriel de Castilla for the next Antarctic campaign 2014-2015 has been accepted in its scientific and logistics part.

We look forward to receiving the permits and certificates required in the application form, issued by the Australian Antarctic Authority, without which our support will be cancelled.

Please, fill in the attached document for cargo requirements. Meanwhile, we let you know that if you want to send material to Deception Island through our cargo procedures, the material should be in Cartagena (Murcia) on 6 October 2014.

Best regards,
Sonia

Secretaría Técnica del Comité Polar Español
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 Antes de imprimir este mensaje, asegúrese de que es necesario.

De: Ceridwen Fraser [ceridwen.fraser@anu.edu.au]
Enviado el: sábado, 19 de abril de 2014 5:31
Para: Comité Polar Español
Asunto: Request to participate in the Spanish Antarctic Campaign

To the Secretary of the Spanish Polar Committee:

Please find attached documents that comprise my application to participate in the Spanish Antarctic Campaign in the 2014/15 season. Please note the following points:

- I have not yet included medical certificates or environmental / sampling permits – these are in the process of being obtained through the Australian Antarctic Division, and will be forwarded to you as soon as they are available.
- I have attached the ‘Summary of Research Activities’ and my ‘brief CV’ as separate documents, as I could not write in those fields of the form.

Thank you in advance for considering this application, and I look forward to hearing from you once a decision has been made.

Best regards,
Ceridwen

Dr Ceridwen Fraser
Lecturer