doi:10.1017/S095410202300007X

Editorial

What is the place of science in Antarctica?

The Antarctic Treaty System (ATS) is often paraphrased as providing the means by which Antarctica is protected as a 'continent for peace and science', on the face of it meaning that the primary purpose of humans being present in Antarctica is for the advancement of scientific knowledge. As is well known, some of the earliest expeditions to Antarctica placed scientific discovery and exploration amongst their highest priorities. Scientific research in Antarctica really took off with the International Geophysical Year of 1957/58, illustrating that even then the importance of Antarctica in the global system and for the advancement of science was starting to be appreciated. Even today, the lack of knowledge of parts of the continent and surrounding ocean, and/or within particular disciplines, means that 'discovery science' still has a major role to play. With today's emphasis and focus on the multifaceted field of 'global climate change', it is often easy to forget that little more than 30 years ago the concept was barely mentioned or its importance widely appreciated. So, what were the major drivers of the rapid development of Antarctic science in the mid- to late-20th Century, before 'climate fever' took over, and to what extent do these still apply? Perhaps more provocatively, does science itself really drive the actions and plans of those nations operating in Antarctica, or is it more accurate to see 'the tail wagging the dog', with scientific priorities and cooperation trailing behind geopolitical manoeuvring and the maximising of national prestige within the ATS?

Antarctica has always fascinated humans, whether scientists or not. From both scientific and personal perspectives, it provides some of the planet's extremes and superlatives. With most of the world's ice, lowest temperatures, importance as an upper atmospheric and space observatory and surrounded by the most powerful ocean current, it has long been central to glaciological, geological, tectonic, atmospheric and oceanographic studies. Its extreme environments quickly catalysed research into the evolution and exceptional survival abilities of its resident biota – remarkably diverse in the surrounding ocean and equally remarkably sparse on land, but both sharing very long-term histories in the region. There is still much to learn in all these fields, especially at the boundaries between traditionally distinct disciplines, in what used to be known as 'pure' research, or philosophical recognition of the value of knowledge itself.

In today's world, Antarctica and the Southern Ocean play key roles as 'sentinels' for change across the globe, not only relating to climate, but also areas like pollution, erosion of biogeography, space weather and the importance of wilderness values. Their roles as the 'engine' for the global ocean circulation system and a key driver of global climate now take prominence. However, it could be suggested that researchers who cannot connect what they do in some way to 'climate change' are effectively disadvantaged in the increasingly intense world of competition for funding. A widely used tenet of the ATS is that it prevents economic exploitation of Antarctica, but studies in the field of bioprospecting are now accelerating rapidly, while discussions regarding its regulation have stalled over many years in the ATCM and it is now probably too late to shut that stable door (Hughes & Bridge 2010; Joyner 2012). The still largely taboo question of what exploitable mineral resources there are in Antarctica and, if they are there, when and how might they be exploited, has not gone away and it is clear that some Treaty Parties have it actively in their sights (e.g. see https://oilprice.com/Energy/Crude-Oil/Russia-Makes-Move-On-Antarcticas-513-Billion-Barrels-Of-Oil.html; https://www.upstreamonline.com/politics/cold-war-russian-research-ship-at-centre-of-antarctic-oil-and-gas-prospecting-storm/2-1-1397780; Talalay & Zhang 2022)

As with the rest of both our personal lives and national economies, global realities in the early decades of the Twenty-first Century are already leading to important reconsideration of how science is achieved in Antarctica. This could be in terms of how we prioritise the science that is actually done (and who is given the privileged position to do so), how we assess and control our direct environmental impact, how we can develop and apply realistic and honest ways of assessing and controlling our carbon budgets and make our activities as 'green' as possible, or how and what we 'value' in the science generated from Antarctica. There is increasing pressure towards application, where possible, of remote sensing and related approaches to obtaining required data from Antarctica and thereby reducing the direct human footprint. However, seemingly paradoxically, multiple nations have recently, are now, or soon will be engaged in major station reconstruction and expansion programmes, or the construction of entirely new stations or logistic facilities (e.g. airstrips).

Cumulatively, such developments are seemingly inexorably increasing the size of the infrastructure footprint in Antarctica, even before consideration is given to the wider extent of human influence as operational footprints expand into ever more remote regions of the continent (Hughes *et al*. 2011; Brooks *et al*. 2019). A positive benefit is that the current round of developments do include significantly improved research facilities (e.g. well-equipped laboratories) across a wider range of different Parties' stations. Given the will for effective international engagement and cooperation, this is a prerequisite for allowing progress in response to calls for 'resource sharing' and more efficient use of available facilities on stations. In parallel, there has been a surge in the construction and operation of new, generally larger and arguably more environmentally damaging, research and logistic vessels. Accepting that any vessel has a practical lifespan, it seems highly desirable that these are the last generation of Antarctic research vessels that do not use alternative, more sustainable fuels.

These construction programmes typically last at least several years, imposing often severe practical limitations on researcher access to stations, facilities and ship-time. In combination with the direct operational impacts and delays associated with the COVID-19 pandemic (Hughes & Convey 2020), and the increasing realisation of just how many years are now required for operational planning to recover from this, this has led to a 'perfect' storm that has driven at least some Antarctic scientists onto the back foot. Some researchers and programmes have lost much or all of their planned field research for three full years now. It is starting to be admitted that some new facility construction programmes, however good we can hope the product will be in due course, as well as logistic practicalities such as the time required for re-establishment and restocking of remote field fuel depots, will impose significant access restrictions for the remainder of this decade. The Antarctic scientific community therefore faces considerable and ongoing challenges. This may be particularly the case for those near the start or end of their research careers, where 3–5 year delays in research and operational planning are not compatible with doctoral studentships, short (typically 1–3 year) fixed term post-doctoral contracts or grants, or with career-end retirement and succession planning (Figuerola *et al*. 2021).

In that much scientific research over the years in the region has required physical presence, and will continue to do so, it is reasonable to ask whether infrastructure construction has been primarily driven by scientific need. Or, conversely, by a combination of geopolitical (e.g. with the exception of Concordia station run jointly by France and Italy, all original claimant nations only operate stations within the area of their geographical claim, even though these are in abeyance under the ATS) and logistic access and cost considerations (often cited as the reason so many nations operate stations on the easily accessed South Shetland Islands). This infrastructure and its use, in turn, can lead to multiple negative direct or local impacts on the Antarctic environment, impacts that have correctly received increasing prominence and expressions of concern in recent years, despite being subject to the environmental impact assessment processes mandated through the ATS (e.g. Tin *et al*. 2009; Convey *et al*. 2012; Convey 2020; Lee *et al*. 2022).

In the sense that any form of human presence inevitably leads to impacts, can it be argued that science has negative impacts for Antarctica itself? These impacts then must be balanced against the wide-ranging benefits gained elsewhere in terms of things like pure knowledge, understanding of the global climate system, or the applied contributions of the findings made. The reality is perhaps more that 'science' first and foremost provides a convenient, lower environmental impact and (relative to other options) cheaper way of demonstrating 'presence', and this has the positive corollary of scientific knowledge generation and application. Conversely, the perception that all activity in Antarctica is science leads to a lack of differentiation between the researchers or research activity itself, and the far greater activity directly related to infrastructure. It is hard to argue against the proposition that, if science was not active in Antarctica, humans would still be there, and the geopolitical posturing would continue unabated. There could be less knowledge and awareness of, or will to do anything about, the impacts of humans in the continent than there is now, in the absence of environmental research and the pressure this leads to on the ATS governance system from the scientific community and the general population. In that sense, perhaps science is really doing something good for the Antarctic environment, even if that is because it is the lesser of multiple evils.

Acknowledgements

Thanks to colleagues for stimulating discussions around these issues, and comments on an initial draft. The views expressed here are solely those of the author.

References

Brooks, S.T, Jabour, J., van den Hoff, J. & Bergstrom, D.M. 2019. Our footprint on Antarctica competes with nature for rare ice-free land. *Nature Sustainability* **2**, 185–190. Doi: 10.1038/s41893-019-0237-y

Convey, P. 2020. The price of cumulative human activities in the Antarctic. *Antarctic Science* **32**, 425. Doi: 10.1017/S0954102020000577

Convey, P., Hughes, K.A. & Tin, T. 2012. Continental governance and environmental management mechanisms under the Antarctic Treaty System: sufficient for the biodiversity challenges of the next century? *Biodiversity* **13**, 234–248. Doi: 10.1080/14888386.2012.703551

Figuerola, B., Valiente, N., Barbosa, A., Brasier, M.J., Colominas-Ciuro, R., Convey, P., Liggett, D., Fernandez-Martinez, M.A., Gonzalez, S., Griffiths, H., Jawak, S.D., Merican, F., Noll, D., Prudencio, J., Quaglio, F. & Pertierra, L.R. 2021. Shifting perspectives in polar research: global lessons on the barriers and drivers for securing careers in natural sciences. *Frontiers in Ecology and Evolution – Biogeography and Macroecology* **9**, 777009. Doi: 10.3389/fevo.2021.777009

Hughes, K.A. & Bridge, P.D. 2010. Potential impacts of Antarctic bioprospecting and associated commercial activities upon Antarctic science and scientists. *Ethics in Science and Environmental Politics* **10**, 13–18.

Hughes, K.A. & Convey, P. 2020. Implications of the COVID-19 pandemic for Antarctica. *Antarctic Science* **32**, 426–439. Doi:10.1017/S095410202000053X

Hughes, K., Fretwell, P., Rae, J., Holmes, K. & Fleming, A. 2011. Untouched Antarctica: Mapping a finite and diminishing environmental resource. *Antarctic Science* **23**, 537–548. Doi: 10.1017/S095410201100037X

Joyner, C.C. 2012. Bioprospecting as a challenge to the Antarctic Treaty. In: Hemmings, A.D., Rothwell, D.R. & Scott, K.N. (eds.). *Antarctic Security in the Twenty-First Century.* Routledge, Abingdon, pp. 197–214.

Lee, J.R., Terauds, A., Carwardine, J., Shaw, J.D., Fuller, R.A., Possingham, H.P., Chown, S.L., Convey, P., Gilbert, N., Hughes, K.A., McIvor, E., Robinson, S., Ropert-Coudert, Y., Bergstrom, D., Biersma, E.M., Christian, C., Cowan, D., Frenot, Y., Jenouvrier, S., Kelley, L., Lee, M.J., Lynch, H., Njåstad, B., Ortuzar, P., Roura, R., Shaw, E.A., Stanwell-Smith, D., Tsujimoto, M., Quesada, A., Wall, D.H., Wilmotte, A. & Chadès, I. 2022. Threat management priorities for conserving Antarctic biodiversity. *PLoS Biology* **20**, e3001921. Doi: 10.1371/journal.pbio.3001921

Talalay, P.G. & Zhang, N. 2022. Antarctic mineral resources: Looking to the future of the Environmental Protocol. Earth-Science Reviews 232, 104142. *Earth-Science Reviews* **232**, 104142. Doi: 10.1016/j.earscirev.2022.104142

Tin, T., Fleming, Z., Hughes, K.A., Ainley, D., Convey, P., Moreno, C., Pfeiffer, S., Scott, J. & Snape, I. 2009. Impacts of local human activities on the Antarctic environment: a review. *Antarctic Science* **21**, 3–33. Doi:10.1017/S0954102009001722

Peter Convey
British Antarctic Survey, NERC, High Cross, Madingley Road,
Cambridge CB3 0ET, United Kingdom
pcon@bas.ac.uk