Proglacial landscape evolution across the Antarctic Peninsula with Holocene climate change

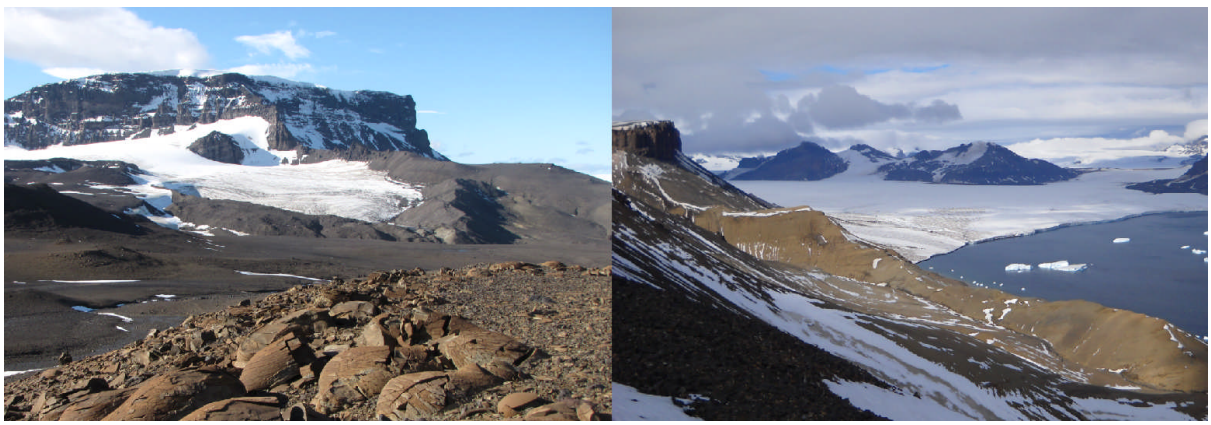
Supervisors: Dr Jonathan Carrivick (SoG, Leeds), Dr Duncan Quincey (SoG, Leeds), Dr Daniel Nývlt (Masaryk University)

Project Summary

The ice sheet margin around the Antarctic Peninsula receded rapidly from its Last Glacial Maximum (LGM) position on the continental shelf edge ~ 18 ka (Davies et al., 2012) to a position towards the head of fjords, and in some cases onto land. These former outlet glacier margins are marked by prominent (tens of km long) lateral moraine ridges along the major fjords. Coincidentally, sea level changes and isostasy created raised beaches, multiple shorelines and perched deltas (e.g. Fretwell et al., 2010). However, the rates and primary drivers of landscape evolution in NE Antarctic Peninsula in response to natural climate change are otherwise little known and are contentious, at least partly due to a lack of in situ observations, the variety of glaciation styles and complex paraglacial adjustments during and after the deglaciation.

The Pleistocene–Holocene transition along the northern tip of Antarctic Peninsula is connected with a significant and rapid climate warming between 13 and 12 ka BP and predominant early Holocene hypsythermal conditions continuing until 9.5 ka BP (Mulvaney et al., 2012) resulting in consequent ice shelf collapse and glacier retreat (e.g. Bentley et al., 2005). A number of mid and late-Holocene advances have been proposed from a handful of sites (Hjort et al., 1997; Bentley et al., 2009; Carrivick et al., 2012), but there is an absence of widespread evidence for a Little Ice Age across the Antarctic Peninsula (Mulvaney et al., 2012).

The opportunity to examine the composition, functioning and evolution of the ice-free proglacial parts of the Antarctic Peninsula is potentially extremely valuable, to yield new insights into the extent to which glaciers and their associated processes have shaped the landscape. These systems deliver vast volumes of meltwater and sediment to the bays and fjords of the Antarctic Peninsula (Griffith and Anderson, 1989; Kavan et al., 2017) and ultimately to the Southern Ocean. These water and sediment fluxes are controlled by glacier fluctuations (e.g. Diekmann et al., 2000; Evans et al., 2005) and in turn strongly influence mineral exports (e.g. Bown et al., 2018) and primary production and hence food webs in the Southern Ocean (e.g. Wefer and Fischer, 1991).



This project aims to assess landscape evolution across the Antarctic Peninsula during the Holocene by using a novel combination of high-resolution 3D geospatial analysis; most likely including datasets such as the recently released REMA DEM and Planet imagery, and field surveys of geomorphology, sedimentology and with geochronological ambitions. It will develop the methods and analysis of Carrivick et al. (2018) as applied to the proglacial areas of the central European Alps. Field surveys will be based on the Ulu Peninsula of James Ross Island, the second largest ice free area in the whole of Antarctica Peninsula, with the support and logistics of the Czech J.G.Mendel Station. Combining these skills and approaches will permit local process-based interpretations and a regional picture to be assembled of Holocene landscape development across the Antarctica Peninsula. Questions concerning sediment fluxes from glaciated versus deglaciated catchments, geomorphological structure-composition (landforms), geomorphological functioning (e.g. connectivity) and terrestrial-fjord linkages will be addressed.

Fit to NERC Science

This project is aligned with the NERC aim to understand the impact of climate change. It is aligned with the NERC societal challenge 'managing environmental change' by seeking understanding of how the processes of natural variability and human-influenced change work. This project will contributes to the UK's Antarctic research ambitions which are to contribute to our understanding of how the planet works and predict how it will change, and to manage our presence in Antarctica responsibly. This project will also foster international collaboration.

Student profile

The prospective student should have, or expect to receive, a first class BSc degree, or a distinction at Masters level, in an appropriate discipline. They should have interests and experience in most, if not all, of the following topics: geospatial analysis (raster and vector), remote sensing analysis, glacial geomorphology, sedimentology, fieldwork in remote and challenging environments. This experience together with other skills and interests that the applicant wishes to develop can be supported by the supervisors and developed during the project. A range of funding sources are available for the project which the candidate can apply to in collaboration with the supervisors.

Skills and training

Training in interdisciplinary research skills will include presenting your ongoing results and receiving constructive feedback from peers in a Research Support Group, from colleagues in the River Basins research cluster, in water@leeds, and at a university postgraduate research day. An additional important part of the research training will be to attend national and international conferences to present results and gain feedback. The student will be encouraged to write and submit papers for publication during the project. Discipline specific skills will be developed on reconstructing landscape evolution, on arctic alpine sediment sources, pathways and sinks, and process geomorphology. Full training in field and office-based techniques will be provided, although it is anticipated that the successful candidate will have a background in geospatial analysis (within GIS), remote sensing, dGPS and fieldwork experience. This project will preferably involve data collection in the field, based at J.G.Mendel Station on the Ulu Peninsula of James Ross Island in collaboration with the Czech Antarctic Research Programme, contingent on funding, permits and logistics.

Enquiries

Informal enquiries should be directed to Jonathan Carrivick at j.l.carrivick(at)leeds.ac.uk.

Enquiries relating to the application process and funding can be sent to Jacqui Manton (j.manton(at)leeds.ac.uk)

References

Bentley, M.J., Hodgson, D.A., Sugden, D.E., Roberts, S.J., Smith, J.A., Leng, M.J. and Bryant, C., 2005. Early Holocene retreat of the George VI ice shelf, Antarctic Peninsula. *Geology*, *33*(3), pp.173-176.

Bentley, M.J., Hodgson, D.A., Smith, J.A., Cofaigh, C.O., Domack, E.W., Larter, R.D., Roberts, S.J., Brachfeld, S., Leventer, A., Hjort, C. and Hillenbrand, C.D., 2009. Mechanisms of Holocene palaeoenvironmental change in the Antarctic Peninsula region. The Holocene, 19(1), pp.51-69.

Bown, J., van Haren, H., Meredith, M.P., Venables, H.J., Laan, P., Brearley, J.A. and de Baar, H.J., 2018. Evidences of strong sources of DFe and DMn in Ryder Bay, Western Antarctic Peninsula. Phil. Trans. R. Soc. A, 376(2122), p.20170172.

Carrivick, J.L., Davies, B.J., Glasser, N.F., Nývlt, D. and Hambrey, M.J., 2012. Late-Holocene changes in character and behaviour of land-terminating glaciers on James Ross Island, Antarctica. *Journal of Glaciology*, *58*(212), pp.1176-1190.

Carrivick, J.L., Heckmann, T., Turner, A. and Fischer, M., 2018. An assessment of landform composition and functioning with the first proglacial systems dataset of the central European Alps. *Geomorphology*.

Davies, B.J., Hambrey, M.J., Smellie, J.L., Carrivick, J.L. and Glasser, N.F., 2012. Antarctic Peninsula ice sheet evolution during the Cenozoic Era. *Quaternary Science Reviews*, *31*, pp.30-66.

Diekmann, B., Kuhn, G., Rachold, V., Abelmann, A., Brathauer, U., Fütterer, D.K., Gersonde, R. and Grobe, H., 2000. Terrigenous sediment supply in the Scotia Sea (Southern Ocean): response to Late Quaternary ice dynamics in Patagonia and on the Antarctic Peninsula. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *162*(3), pp.357-387.

Evans, J., Pudsey, C.J., ÓCofaigh, C., Morris, P. and Domack, E., 2005. Late Quaternary glacial history, flow dynamics and sedimentation along the eastern margin of the Antarctic Peninsula Ice Sheet. *Quaternary Science Reviews*, *24*(5-6), pp.741-774.

Fretwell, P.T., Hodgson, D.A., Watcham, E.P., Bentley, M.J. and Roberts, S.J., 2010. Holocene isostatic uplift of the South Shetland Islands, Antarctic Peninsula, modelled from raised beaches. *Quaternary Science Reviews*, *29*(15-16), pp.1880-1893.

Griffith, T.W. and Anderson, J.B., 1989. Climatic control of sedimentation in bays and fjords of the northern Antarctic Peninsula. *Marine Geology*, *85*(2-4), pp.181-204.

Hjort, C., Ingólfsson, Ó., Möller, P. and Lirio, J.M., 1997. Holocene glacial history and sea-level changes on James Ross Island, Antarctic Peninsula. *Journal of Quaternary Science*, 12, pp. 259-273.

Kavan, J., Ondruch, J., Nývlt, D., Hrbáček, F., Carrivick, J.L. and Láska, K., 2017. Seasonal hydrological and suspended sediment transport dynamics in proglacial streams, James Ross Island, Antarctica. *Geografiska Annaler*, A 97(1), pp. 38-55.

Mulvaney, R., Abram, N.J., Hindmarsh, R.C., Arrowsmith, C., Fleet, L., Triest, J., Sime, L.C., Alemany, O. and Foord, S., 2012. Recent Antarctic Peninsula warming relative to Holocene climate and ice-shelf history. *Nature*, *489*(7414), p.141.

Wefer, G. and Fischer, G., 1991. Annual primary production and export flux in the Southern Ocean from sediment trap data. *Marine Chemistry*, *35*(1), pp.597-613.