Guest editorial

Unravelling the History of Climate Change

The spatial configuration of the Antarctic ice sheet has fluctuated widely during the Late Quaternary, primarily in response to climate and sea-level forcings. Ice core time-series have long been used as proxy climate records for the Antarctic ice sheet surface and polar atmosphere, and there has been a major multinational effort to drill ice cores on or near the summit of ice domes to retrieve the longest possible records. The annual layering of ice accumulation has afforded high resolution proxy climate records on annual to decadal intervals, spanning a few hundred to hundreds of thousands of years. These time-series have also detailed the changes in the ice sheet surface elevation and dynamics, particularly since the transition from glacial to Holocene climate. However, ice sheet sensitivity to external forcings and the associated fluctuations in ice volume are probably best researched around the ice sheet's margins. The sedimentary record in these circumAntarctic margins holds the key to our unravelling of past and future responses of the Antarctic ice sheet and circumpolar oceans to climate and environmental change, including: fluctuations in ice volume; the distribution of ice shelves; the production of Antarctic bottom water; the variability in the fast ice and pack ice characteristics; biogeochemical cycling and marine productivity; and the evolutionary response of marine and terrestrial species and ecosystems.

Clearly, detailed analyses of the sedimentary record will increasingly provide us with the necessary insight into past processes and events, an understanding of which will remain crucial despite the sophistication of numerical modelling. However, one challenge for Antarctic palaeoscience is the discrimination of palaeoclimatic events from the record of palaeoenvironmental change. The interpretation of changes in Antarctic geography is complex, largely because the response time of the ice sheet, outlet glaciers and mountain glaciers, ranges from ~40 000 years to 1000 years respectively. Antarctica is nourished by high precipitation rates during anomalously warm climates such as the Holocene, whilst the lagging ice dynamics is principally determined by the previous cold glacial conditions. Climatic and environmental feedback processes are many in the circumAntarctic. Outlet glacier tongues and ice shelves can expand during cool periods, not because of increased ice mass transport, but instead through the reduction in surface and basal melting. Biological productivity on the continental shelf can respond to a number of factors, ice melt discharge, changes in ocean circulation, sea ice concentration and recovery of the benthic environment after ice front retreat. Lake hydrological and coastal process histories are linked to the rates of post-glacial isostasy in addition to climatic factors. Rigorous discrimination of palaeoclimatic events thus requires a wide variety of skills and a broad basis for collaborations. Only if scientists working on the modern processes and palaeo records are motivated to combine their efforts and are encouraged by funding agencies to do so, will it be possible to fully understand the relationship between the oceanic and atmospheric circulation patterns and the climatic, ice, sedimentological and biological regimes in the circumAntarctic.

Antarctic palaeoscience offers far more than data for the validation of numerical models, or a simple regional interpretation of events. Palaeoscience cannot be justified if it only provides analogues for future change as the predicted greenhouse gas levels may not been experienced for hundreds of millions of years. Its full value lies in unravelling the causes of and responses to non-linear climate and environmental change, the feedback and self-regulatory controls in the earth system, and the onset, sensitivity and history of modern climatic regimes such as ENSO related phenomena.

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