

Professor Thiede, SCAR delegates, fellow Antarctic scientists

Thank you for this enormous honour.

When I was first notified my first thoughts were of the many people who have encouraged me and with whom I have worked with over the years. Without them my own efforts would have had little effect, and I would like to reflect on these people briefly..

For a start, there's Vic McGregor, caving buddy and roommate at Auckland University in the early 60s, who got me my first trip to Antarctica in 1962 with the University of Wisconsin's Ellsworth Mountains project led by Cam Craddock. And 2 years later, Colin Bull, charismatic head of the Institute of Polar Studies at Ohio State University, who overlooked my undergraduate examination results in admitting me to the graduate programme.

I also had the good fortune to team up with another graduate student from Australia, John Lindsay, and Dave Elliot, then a young Postdoctoral Fellow from Cambridge, to be awarded a National Science Foundation grant to map the geology of the Beardmore glacier area, and we spent two great summers exploring the mountains by motor toboggan from 1966 to 1968 as part of the United States Antarctic Research Program. In the second season I had further good fortune in discovering a small bone fragment in a 200 my old river gravel. Dave followed this up by discovering more bones and the first dinosaur some years later. We also discovered the Sirius formation, and both dinosaur bones and the Sirius continue to attract attention even now 40 years later.

With the PhD completed I needed a job, and VUW was advertising a Postdoctoral Fellowship to run an Antarctic expedition. A happy coincidence. Twelve years earlier Bob Clark, Professor of Geology, had dispatched two third year students Barrie McKelvey and Peter Webb to Scott Base, the NZ base established for the Transantarctic Expedition and the NZ Government's IGY programme. Their job was to hitch a ride with anyone who would take them, and find a place to do some useful geology. They chose the then unexplored McMurdo Dry Valleys. By 1970 their fine lead had been followed by 13 further expeditions, and Bob was running out of staff to lead them. I was delighted to have both a job and the chance to work on the Beacon sandstone of the McMurdo Sound region, some 500 km north of the Beardmore.

My first awareness of SCAR came in 1969 just before taking up the PDF at VUW. I had read about the 2<sup>nd</sup> SCAR Symposium on Geology and Geophysics in August 1970 in Oslo, and my new University funded me to go. I was keen to present my restructured stratigraphy of the Beacon sandstone formations along the Transantarctic Mountains, and recall my revision not being too well received by the symposium organizer, Ray Adie, at the time the doyen of Antarctic geology. This led to a conversation with a young student of Ray's, Mike Thomson, who later took over from him to lead the SCAR Working Group in Geology for many years. Ray's comments and contacts at that meeting were also useful in developing the Beacon stratigraphy further, eventually forming a chapter in Bob Tingey's 1991 volume "Geology of Antarctica".

The PDF at VUW was for 2 years but Bob Clark managed to persuade the University Council that the University should keep me to run an Antarctic programme, so I was appointed to a half position for that and for the other half teaching geology. But in 1972 a new opportunity arose, again to work in a US-funded program, with an invitation to join Denny Hayes and Larry Frakes for the first deep-sea drilling cruise onto the Antarctic continental shelf – DSDP Leg 28. Peter Webb, at that stage working for the NZ Geological Survey, was also invited. It was a great team, fascinating core, and changed our view of Antarctic ice sheet history in an instant – like it was at least ten times older than anyone had thought. But when did the first ice sheet form?

Peter then moved to Northern Illinois University, which had just taken on the management of a project to core for the history of the Cenozoic era – the last 65 million years – in the McMurdo Dry Valleys. The Dry Valleys Drilling Project was maybe the first multinational science project on the continent, and the brainchild of Phil Smith, then operations manager of OPP, Bob Thomson, leader of the NZ Antarctic Research Programme and Tetsuya Torii, head of the Japan Polar Research Association, but mostly funded by the US.

Peter and I felt there was a much better chance of getting a history of the Antarctic ice sheet from drilling offshore, where there was likely to be a thick sedimentary record, so that became our mission. We pressed both

NZ and US Antarctic leaders of the time for permission to conclude the 3 years of DVDP drilling with a hole offshore – DVDP 15 in 1974. Permission was granted, but with many unexpected delays in this new venture, drilling began a month later than planned, and we had time to core only 50 m below the sea floor before Nov 20, when the sea ice started to crack, and we had to get off.

Of course we pleaded to try again, and after a couple of years reached an agreement whereby the US provided the rig and NZ ran the project. Four years later in 1979 we drilled MSSTS-1, reaching 230 m below the sea floor, but this time stopped by drilling problems. By that time I had a young graduate student working on Beacon coal measures, but with obvious practical and organisational skills. I had asked him to organize the MSSTS-1 core collection and boxing, and he did a really good job, as well as making a few shrewd observations about the drilling problems. I was also looking for help in running the University's annual expeditions, so despite some financial constraints at the time, the Vice-Chancellor was persuaded and Alex Pyne was appointed. Our success in drilling from that time is a tribute to that decision and of course to Alex.

With the next drill hole, CIROS-2 in 1984, we learned the final lessons required for sea-ice drilling, and with CIROS-1 in 1986 we drilled with amazing success - 98% recovery to 700 m below the sea floor, reaching the limit of the rig. We had reached back in time a little over 34 million years, but the strata still recorded icy conditions - not quite the warm green Antarctica we were seeking. Ten years after that we drilled the Cape Roberts series of holes with even more success (reported at this meeting) but this time coring into the floor of the basin at 34 million years, and still not quite getting back to the warm green Antarctica! Still time has proved us right in another respect – the sediments are providing a great story on the interplay between climate, ice sheets and sea level in the last 30 million years, being particularly useful in testing and constraining climate history inferred from the deep-sea isotope record. They also provide graphic evidence of a somewhat warmer world during higher CO<sub>2</sub> times when beech forests fringed the Antarctic coast.

These projects would have been virtually impossible to develop without the forum provided by the SCAR Working Groups in Geology and in Geophysics, which though separate still worked closely together for many years. This was particularly important for developing plans with German and Italian colleagues – Franz Tessonsohn and Carlo Alberto Ricci, both of which had programmes in the Ross Sea region, but also with the UK and Mike Thomson, whose normal domain was on the other side of the continent. But I also want to acknowledge a NZ colleague, geophysicist, Fred Davey, who has been a key figure in Antarctic science both in NZ and in SCAR, for his help in organizing the recent drilling and his chairing of the NZ component of the Cape Roberts Project.

In 1978 I was at Scott Polar Research Institute in Cambridge at morning coffee having just read John Mercer's article on "CO<sub>2</sub> and the West Antarctic Ice Sheet; threat of disaster." There John argued that the projected temperature rise from CO<sub>2</sub> could cause the ice shelves to collapse, leading to the rapid disintegration of WAIS itself in the next 50 to 100 years. SPRI Director Gordon Robin was cautiously dismissive, but much as I respected Gordon I did not feel quite the same way. I knew John from Ohio State days as quiet and thoughtful, and with a record of well-considered articles in glacial geology. Within a couple of years the first letters to the editor were appearing in NZ to dismiss the so-called threat of CO<sub>2</sub> induced warming, and I felt obliged to write a reply in defense of John's position. By 1990 with the first VOSTOK results showing the CO<sub>2</sub> and T trend for the last glacial cycle I had become convinced that rising CO<sub>2</sub> was a growing issue for the health of the Antarctic ice sheet and for the world in general.

Also in the 1970's oil shocks and rising prices caused some concern for Antarctic Treaty nations, especially with the oil industry speculating on huge deposits of oil and gas beneath the Antarctic margin. That led to a decade of Treaty negotiations towards a regime for managing mineral exploration, which, to everyone's amazement, turned into an Environmental Protocol almost overnight, signed in Madrid in 1991.

At the same time SCAR's Working Group in Biology, inspired by BAS biologist Nigel Bonner, had developed a sub-committee on environmental issues. In 1990 SCAR transformed it into GOSEAC - the Group of Specialists on Environmental Affairs and Conservation. The SCAR Delegates had decided that advice on conservation issues required scientists of all shades, and leavened the committee with a couple of non-biologists from other Working Groups – Geophysics produced Heinz Miller and Geology settled on me. Antarctic environmental

affairs and conservation – with remit to develop science-based advice for SCAR and the Antarctic Treaty System. Quite a challenge!

Nigel was very good at shaping the work of the committee into manageable tasks, but after 2 years he died unexpectedly, and SCAR appointed one of Nigel's younger BAS biologists, David Walton, in his place. David was the perfect choice, as SCAR today now recognizes, both as a leader and mentor for the other 9 committee members. SCAR's role in advising the Antarctic Treaty System on environmental affairs has now been largely taken over by the Committee on Environmental Protection, leading to the disbanding of GOSEAC in 2002. It is a tribute to the training we received in David's committee that several went on to take active roles in CEP.

But on the science side of SCAR, its meeting in 1986 was significant. It was held near Scripps Oceanographic Institution in San Diego, California, and the decade of drilling in McMurdo Sound that began with DVDP-15 was starting to produce results, with MSSTS-1 in 1979 and CIROS-2 in 1984. Also we were poised to drill CIROS-1, back to the warm green Eocene. At that meeting Peter Webb and I organized a workshop on Cenozoic climate history of the Southern High Latitudes, and sought support from both Geology and Geophysics Working Groups for a SCAR "Group of Specialists" on this topic. It was approved, with an unpronounceable acronym, along with Ian Dalziel's ANTALITH group for developing cross-sections through the Antarctic lithosphere.

Alan Cooper and Fred Davey had less than 2 years previously collected a comprehensive set of seismic data from on the Ross continental shelf, with a focus on the western Ross Sea. And Alan was there with the vision to see that CCHSHL should initially focus on mining the wealth of offshore seismic data from the entire Antarctic margin gathered by ships of many nations, who had positioned themselves just in case there was oil to be discovered. So to do this Alan was asked to head a small subcommittee set up to coordinate this, called ANTOSTRAT, short for Antarctic Offshore Acoustic Stratigraphy, with Peter Webb and me being the two geologists amongst 6 geophysicists. ANTOSTRAT ran from 1990 to 2002, generating several volumes synthesizing regional seismic data, as well as developing a seismic data library. It was also directly responsible for two further legs of the Ocean Drilling Program on the Antarctic shelf and rise (plus another to be drilled by IODP around 2009). It was a wonderful SCAR-sponsored forum in which to further develop drilling programs in McMurdo Sound.

By the mid-1990's the power of seismic stratigraphy of the world's continental margins was being widely interpreted in terms of cyclic coastal advance and retreat caused by growth and collapse of the Antarctic ice sheet, and ODP drilling in Prydz Bay, along the CIROS-1 drilling in the Ross Sea had shown there had been big ice sheets back to around 34 million years ago. But the CIROS record showed most clearly that these ice sheets were dynamic, coming and going on time scales of around a million years or less. Seismic data could not provide the resolution or the dating of these events and further drilling was needed – hence the Cape Roberts Project.

But by this time the growth of computing power was allowing the development of computer modeling of ice sheets growing them from a few simple parameters like topography, temperature and atmospheric gas composition. There were huge issues with the crude resolution of the models in space and time, but the idea of recreating past climate with guidance and testing from fragmentary and site-specific geological data was very appealing.

And so it was that ANTOSTRAT held a workshop here in Hobart in 1997 to review its achievements and consider its future. Keynote speaker, Bob Oglesby, convinced us all that this had to involve modeling. Over the next few years the ANTOSTRAT old guard, led by Alan Cooper and Peter Webb, with my encouragement, evolved into a new project as SCAR itself was restructuring. In 2004 this formally became a SCAR science research programme, entitled Antarctic Climate Evolution led by Martin Siegert, University of Edinburgh, and Rob Dunbar, Stanford University - integrating geological data and modeling over short and long time scales.

ACE work to date has made significant advances in linking variations in climate and ice sheet growth with the fall in atmospheric CO<sub>2</sub> levels from 3-4 times pre-industrial CO<sub>2</sub> levels in warm green Eocene times to pre-industrial levels over 20 million years ago. This new understanding is timely. In the almost 3 decades since John Mercer's paper, CO<sub>2</sub> levels have continued to rise. Unless checked they are projected to double before the end of

the century, with an even chance of a temperature rise that would take Antarctica back to a climate like that of the warm green Eocene we have been trying to find in our decades of drilling. Elsewhere I have observed that the melting ice and rising sea level now being reported could well be the start of second great climate event of the last 65 million years, the first being around 34 million years ago with the growth of the first big Antarctic ice sheet.

But that is a problem for us to address with our political leaders. The goal of the science community is to study, understand and appreciate the Antarctic region as a part of the Earth System, to report our findings openly, and in a way that the wider community can understand. My hope is that this understanding will lead to a greater appreciation and commitment for global climate stabilization, and with this a better chance for a sustained future for the Antarctic ice sheet and its dependent ecosystems.

I conclude with my thanks again to the SCAR president for recognizing in such a handsome manner our work and my role in it, and to my friends and colleagues here for sharing the occasion.