7

The continent's imprint

Circled by these columns hoary,
All the field of fame is ours;
Here to carve a name in story,
Or a tomb beneath these towers.
Southward still our way we trace,
Winding through an icy maze.
Luff her to– there she goes through!
Glory leads, and we pursue

James Croxall Palmer, 'Antarctic Mariner's Song',
Thulia; a Tale of the Antarctic, 1843

I have ventured this many summers in a sea of glory but far beyond my depth.

Shakespeare, *Henry VIII*

The diary

Tuesday 9 January 1973

There was a 'Pale brown swill' party in the palaeo lab last night—it was pretty terrible. On this officially dry ship it was the duty of the ship's chemist to make home brew. This was passable when canned grape juice was used as a base—it was less successful with canned tomato juice. When I asked the brewer how old the vintage was, he looked at his watch!

A single pair of spectacularly patterned black and white Cape petrels has joined us today.

8pm. The weather is deteriorating; the sea is steely grey and rough and visibility is poor. I have been standing out on the fantail having a bird watch—but even through gloves my hands were too cold to hold the binoculars for long. It was worth the chill though, as we have been joined by several individuals of 'light mantled' sooty albatross—very graceful flyers, smaller and more slender than the Wanderers, with dark heads and wings grading into an ash-grey body. The numbers of Cape petrels have increased, and there is also a small, awkwardly flying, chunkily built little black and white chap that I can't identify. Strange that we always have more birds when the weather is poor—perhaps it's harder to get food, or the wind currents generated by our passage are attractive.

There are not many bergs today, although we had 39 at once on the radar screen last night, which is a record, and involved a lot of course changes.

Wednesday 10 January

Site 268 Site 5 (63°56.99′S; 105°09.34′E) Water depth 3,529 m.

Occupied 10–12 January 1973

We came on site around noon after a very rough night. Just now I stood on deck for nearly half an hour but again my hands froze through my gloves and it became too cold to focus the binoculars. The sea is rough and grey and it's snowing intermittently. Appropriately, today's bird tally includes a single lovely snow petrel, very white and graceful, with the faintest grey shading under its wings. A good performer, flying low and close to the fantail, so we had a clear view.

The Cape petrels have aggregated into a small duck-like flock of a dozen or so, sitting on the rough seas and assiduously bathing! Earlier there were what might be Antarctic fulmars, plus a pair of Wilson's storm petrels, but these are so tiny and fly so close to the water that they are hard to identify. Also one common or garden seagull.

Thursday 18 January

Such a lackadaisical diarist! Site 5 was busy, with me playing lead smear-slide expert, which is a full-time operation, especially with ginger-haired David calling the tune! Chert stopped that hole dead in its tracks, and with it went all my chances of getting a look at the Lower Tertiary of East Antarctica—pity![1]

1 Chert is a very hard grey rock composed of microcrystalline quartz. Siliceous sediments on the sea floor may be converted to chert. In the deep sea they form very hard beds, and were then very difficult to drill through; later improvements in drilling technology have made drilling through such chert beds easier.

We then had the luxury of nearly five whole days just sailing—no broken hours or immediate problems to cope with. However, there's now plenty of work to do putting some sense into what we have to date, so I have begun a compilation of where all the diatom oozes are—to try and tie them into when the glaciation started. It has been exciting—the major outcome of the whole venture so far has been to find out just how old the icecap must be—somewhere in the 15 to 20 million-year mark at least! When we left no-one expected the evidence of ice to be more than 3 or 5 millions of years old … now here we are with diatom oozes—the hallmark of cold waters, seeming to be so much older. Wonder why it was so long before the northern hemisphere felt the effects? And there are pebbles in the cores—down into the bottom cores—these are ice-rafted—the debris dropped by the melting of icebergs … we are here closest to the Antarctic coast and the record shows the diverse scrapings from the land by early ice.

Strangely, there has been no birdlife in these past few days—we have come a little bit north again, and lost the icebergs a day or two after the last site, so it is strange that the seas seem so barren. We did see one pack (?) of killer whales; about a dozen or so one evening—one had surfaced and rolled right beside us, but I missed it. When I came on deck they were a hundred yards or so astern, blowing hard and with their pointed, porpoise-like dorsal fins breaking the surface.

Site 269 Site 6 (61°40.57′S; 140°04.21′E) Water depth 4,282 m.

Occupied 17–21 January 1973

And there are still no icebergs. The sea is choppy but not really rough, and it's been foggy all day. The drilling is bad—its hard chert again, and trouble with the ship's positioning system made us lose the hole once and redrill. The water is deep and the cores are slow in coming.

For a recreational break we enjoyed a trip aloft. Going nearly to the top of the rig in the elevator this afternoon was both exhilarating and daunting. For the first time I had the impression of what a tiny refuge this is in an enormous cold ocean. The sea was very green, although white fog closed us in at a couple of hundred yards. The wind was so cold it seemed to go right through even the Antarctic parkas—though these are pretty antique.

From a great height the ship below was dramatic, with its red deck and the mass of rust-red core barrels stacked on a rack forward—beyond that the reassuring sight and the steady feel of the bow slicing ahead.

There was much hilarity at the different styles shown by the novices in riding the belt line up to the platform!

I had better go and see what's happening in the core lab…

Closer to the continent—abyssal plain to continental rise

Site 268 is located on the lower continental rise—where the sea floor begins to rise gently from the abyssal plain that lies to the south of the South East Indian Ridge. It is the most southern of our transect of drill sites lying between the crest of the ridge and the Antarctic continent.

The Operations Resumé for this site is vivid, reading:

> Site 268, of all of the 11 sites drilled on Leg 28, gave us the feeling that the Challenger had arrived in another world. All forms of communication were very poor at this location which was approximately 120 miles north of the continent of Antarctica. The temperatures would drop to the lower 20s during the one to two hours of darkness each day, and during midday would reach a high of only 28–30 (–1 to –2°C). At times fog reduced visibility to almost zero, yet on the radar scope there were usually 15 to 40 icebergs present. The radar proved invaluable but would not always pick up the oval or rounded top icebergs. (Hayes 1974, p.37)

The presence of the nearby landmass of Antarctica is very evident in the sediments drilled at this site. There are clays and silts eroded from the continent, and the organic oozes are more rare than in the more northerly drill sites. But most significantly, ice-rafted debris is common down into some of the oldest sediments—pebbles or clasts that are the deposits of ice melting out from floating icebergs. Just a few of these show sharply faceted faces, with scrape marks or striae. This shows clearly that they were dragged along at the base of a glacier.

From this site we voyaged parallel to Antarctica's Wilkes Land coast, but headed a little to the northeast. Site 269 was thus drilled further from the Antarctic margin in the southeastern corner of the South Indian Abyssal Plain. Here there was much less sediment coming from the continent, little from floating icebergs, and, as is typical for an abyssal plain, there was a settling out of fine debris from ocean currents, including the turbidity currents described earlier.

Boundaries in the ocean; drill logs on a cabin wall

At this stage I had taped paper copies of the preliminary drill logs to the wall of my cabin. It was soon obvious by lying back on my bunk staring at these and a superimposed time scale provided by the fossil record, that the boundary between the warmer, calcareous oozes and the diatom oozes—these reflecting cooler waters to the south—had migrated northwards from the Miocene, and showed a sudden spurt in that track about 5 million years ago. Was this the beginning of the Polar Front or Antarctic Convergence, or some other ocean boundary? Today this boundary reflects the zone where cooler waters from the south meet warmer waters from the subantarctic. The zone is related to the Antarctic Circumpolar Current, which flows from west to east around Antarctica, linking all the major oceans. Whatever the boundary was on these logs, it was exciting to see some kind of shift—possibly from warmer to colder waters—clearly evident on these scrappy, much scribbled on strips of paper.

The paper logs on the cabin wall were prone to move with the ship's roll and needed constant refixing. But their constant movement didn't diminish the sense that the patterns they showed were significant.

Today, the Antarctic Circumpolar Current is the dominant feature of oceanic circulation. This, the world's largest ocean current, is driven by westerly winds. Its flow is deep, extending from the surface to the sea floor. The current is truly circumpolar; there is no land to impede its flow at these latitudes. It has been estimated that it might carry up to 150 times the volume of water in all the world's rivers. Imagine all the water in Sydney Harbour flowing through Drake Passage, between South America and the Antarctic Peninsula, every three seconds. The passage of the current is not straightforward. Through Drake Passage it splits, with a warmer branch flowing north to the Falklands. In the Indian Ocean it is split by the Kerguelen Plateau.

Oceanic circulation around Antarctica is critically important in affecting global climate. Because the Antarctic Circumpolar Current connects the world's major oceans, it redistributes heat and so influences patterns of rainfall and temperature. The vertical flow of water from the surface to the deep ocean is important too. Freezing around the Antarctic continent generates cold salty water—Antarctic Bottom Water—that flows in the deep parts of the world oceans, ranging as far as the North Atlantic and forming part of a conveyor belt that distributes heat around the globe. It is relevant also to the exchange of gases at the sea surface, with the oceans containing as much as 50 times the CO_2 of the atmosphere, and the rate of absorption of CO_2 being higher in the high latitude seas.

Other boundaries in the ocean, defined by changes in water temperature and salinity, are closely linked with the Antarctic Circumpolar Current. Prominent among these is the Antarctic Convergence—the zone where cold, dense waters surrounding Antarctica sink beneath the warmer Subantarctic waters to the north. This is a boundary of enormous biological richness. Upwelling within the ocean creates high levels of nutrients. It gives rise to what Alan Gurney in his *Below the Convergence* describes as the 'pasture of the ocean', referring to the phytoplankton, mainly diatoms, being browsed on by the zooplankton, notably the shrimp-like krill. The zooplankton in turn supports seabirds, penguins, seals and whales.

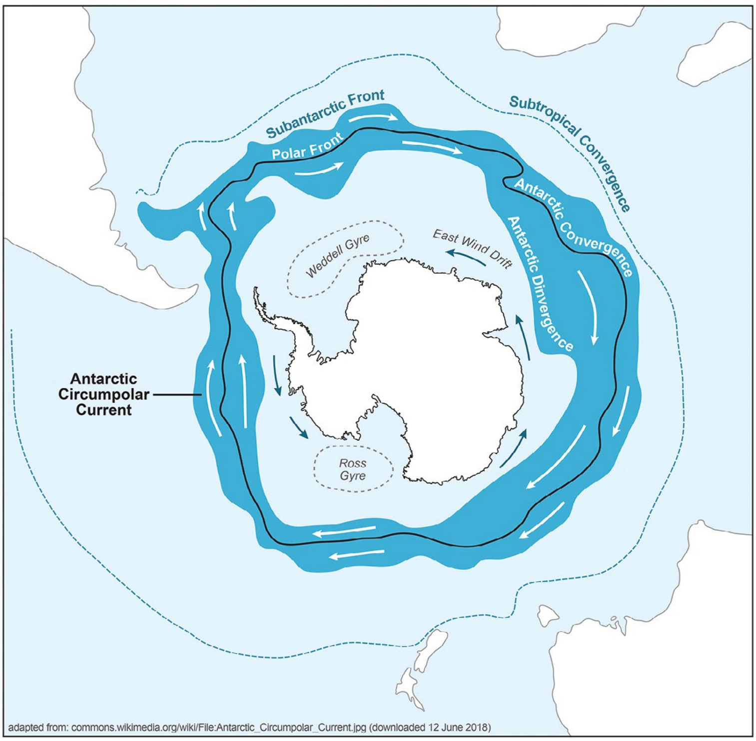

Figure 7.1. Circum-Antarctic circulation, showing Antarctic Convergence and Antarctic Circumpolar Current.

Source: Compiled from various sources, including Wikipedia (accessed 22 June 2018). Drafting by Clive Hilliker.

Early mariners felt the presence of the Antarctic Circumpolar Current and its internal boundaries. Edmond Halley, in his small pink ship, the *Paramore*, sailing south in the Atlantic in January 1700, encountered extreme cold when just north of 51°S, between the Falkland Islands and South Georgia, and reported that it was 'scarce tollerable to us used to the warm climates' (Halley in Dalrymple 1775, p.30). James Cook on his second voyage was made aware of the intensity of the current in the southern Indian Ocean; James Clark Ross with the *Erebus* and *Terror*, sailing east from Kerguelen in that same ocean, noted in his journal that the vessels were sailing well ahead of the distances calculated by dead reckoning, which were based on expectations from their previously determined positions.

The origins of the Antarctic Circumpolar Current are presently the subject of intense debate. In simple terms, the issue is—was it a cause, or was it a result of the full-blown glaciation of Antarctica? Did it precipitate the descent from a greenhouse-like world into the current icehouse?

The development of a circumpolar current would have isolated Antarctica from any warm currents coming from the north, a situation that would have precipitated the cooling of that continent. For Antarctica to become isolated, landmasses formerly joined to Antarctica would need to move away to create a clear passage. There is now evidence that there was ice at sea level around Antarctica some 34 million years ago. A circumpolar current would have been made possible at this time by the opening of a deep-water gap south of Tasmania as the South Tasman Rise separated from Antarctica's Victoria Land. The timing of the opening of a deep-water channel south of Drake Passage at the southern tip of South America is less clear, but when that happened Antarctica could have been surrounded by a ring of cold water that would have prevented the penetration of warmer waters from the north, thermally isolating the polar continent and allowing the rapid development of an icecap.

The signature of the current and its contained fronts, especially the Polar Front, in the sediments of the sea floor was thought to be the presence of a zone of silica-rich organisms to the south, separated by a zone of erosion from limy deposits to the north. This was how we interpreted the patterns in the logs taped to my cabin wall in January 1973. Our tentative interpretation was accepted, along with other data, for a long while.

But inevitably, time has brought a much better understanding of the sequence of events. The nature of the Antarctic Circumpolar Current itself is better understood—whether the main part of its flow is at the surface or occurs in deep jets close to the ocean floor, where small continental blocks, the tectonic history of which is as yet poorly understood, could interrupt continuous flow. And the history of glaciation itself has become better understood. The development of an icecap may not have been essentially linear—it may have progressed in fits and starts—and factors other than oceanic circulation are likely to have been influential. Among these, the levels of atmospheric CO_2 may be important, and modelling has supported the idea that declines in CO_2 were significant in icecap development. Scientists Rob DeConto and David Pollard in 2003 modelled Eocene conditions and suggested that declining CO_2 levels may have been more important than the opening of ocean gateways around Antarctica in the development of a major icecap. Their research suggested small icecaps might have formed initially as CO_2 levels declined then and subsequently coalesced into a continent wide formation.

Just why levels of CO_2 might have become lower at this point in time is not clear, but one suggestion is that collisions of continents on a global scale may have produced patterns of deep weathering that affected CO_2 in the atmosphere.

What is probable is that, after the development of an icecap at a continental scale, a number of feedbacks, including for example the effects of albedo—the proportion of the sun's light reflected from a given surface; high in the case of ice, which is linked with cooling—would have come into play, and influenced the dynamics of the icecap and the circulation of the surrounding oceans. Indeed, such feedbacks may have exerted control on polar ice development on a global scale, since we know that ice in some form was present in the northern hemisphere from as early as 40 million years ago (see Chapter 6).

Even the extent and nature of vegetation on Antarctica may have produced a feedback that influenced the form and extent of glaciation on that continent—the darkness of widespread vegetation could have had a warming effect.

The United States Exploring Expedition

Drill site 268 lies to the north of the Knox Coast, which is part of Wilkes Land. Researching the name of this part of the Antarctic coast, I discovered that it was named for a member of the US Exploring Expedition of 1838–42 led by Lieutenant Charles Wilkes. Samuel R. Knox was a 'Passed Midshipman' on that expedition—one who has passed his lieutenant's exam, and who is eligible for promotion should there be a suitable vacancy. Young Knox was the first to command the tiny schooner *Flying Fish*, one of six vessels that set out from Norfolk Virginia on 19 August 1838. The genesis of the expedition, and the prolonged and hazardous voyage, has been described in vivid detail by Nathaniel Philbrick in 2003 as *Sea of Glory*. From this I have drawn much of the following account. But for the story of James Croxall Palmer, surgeon to that expedition and amateur poet, I have relied on my own account in *Antarctica: Music, Sounds and Cultural Connections*, published in 2015.

The United States Exploring Expedition was America's attempt to catch up with expeditions to the south launched from Europe—expeditions such as that of the British under the command of James Clark Ross in *Erebus* and *Terror*, and the French under Dumont d'Urville in the *Astrolabe* and *Zélée.*

The US Exploring Expedition (often referred to—without affection—as the Ex.Ex. or the Wilkes Expedition) had a long and difficult birth, but was eventually approved by President John Adams, and Lieutenant Charles Wilkes was selected as Commander. The expedition's aims were many and diverse: to seek new territories in the South Seas, to protect US sealing and whaling industries, to look for new opportunities for commerce, to assert American power and to undertake scientific research in a wide range of disciplines.

Wilkes was certainly not the first choice of commander and probably not the best, as subsequent events were to prove. The large size of the expedition that he was appointed to lead tested his leadership skills and the fact that he was a mere lieutenant rather than a captain rankled with him and was a continuing source of his bitterness, as was his abiding conviction that cabals were developing among the crews of the expedition's vessels. These personality traits, unfortunate in one who was the leader of a large party sailing under perilous circumstances, set an uneasy tone for the expedition that was felt by all who served under him.

The expedition consisted of six vessels, aptly described as 'oddly assorted'. The flagship was the USS *Vincennes*, a sloop-of-war of the US Navy. Other large vessels were the *Peacock*, also a sloop-of-war; the brigantine *Porpoise*; and the clumsy sailer *Relief*, which served as a supply ship. Bringing up the rear of the squadron were two tiny vessels, the *Flying Fish* and the *Sea Gull*, both former New York pilot boats. These last were certainly small and ill equipped for dealing with the rigours of Antarctic waters. The *Flying Fish* was a sloop of a mere 96 tons, often with a crew of less than 10.

None of the vessels of the expedition had been modified to deal with the expected conditions. There were none of the double-planked hulls, the sturdy oaken keels and waterproof decking that had been fitted, for example, to the vessels of the British expedition under James Clark Ross.

Nine scientists were appointed to the expedition. Wilkes had significantly reduced this number from a larger contingent originally proposed. This civilian scientific corps eventually consisted of naturalists, a botanist, a mineralogist-geologist, taxidermists and a philologist or linguist. Wilkes elected to undertake the surveying and hydrography himself, disciplines in which he was eminently capable. The one member of this party who eventually enjoyed scientific fame was the geologist James Dwight Dana, who was to become one of the most prominent geological thinkers of the nineteenth century. At the age of 24 he had already published what was to become a classic text on mineralogy. He was to make substantial contributions to Australian geology; perhaps surprisingly, he undertook much of the zoology reporting for the expedition including the formal description of the krill species *Euphausia superba*, the tiny crustacean that forms the basis of the food chain in the Southern Ocean.

Dana's involvement in the expedition was, in a sense, the making of him as a scientist, much like Darwin in his *Beagle* voyage. Although, like other scientists in the voyage, he was forbidden by Wilkes to take part in the Antarctic sector, Dana had had ample opportunity to study and report on the geology of islands in the Pacific. In his treatise on the origin of coral reefs he expanded on Darwin's understanding of them, showing that the volcanic islands with which reefs are associated occur in long chains, reflecting the progressive ages of the islands. Much of his knowledge of these was based on what he had learnt in the islands of Hawaii. In his scientific life Dana was a master of grand syntheses. He established the way in which the nature of the continental crust differed from that of the ocean basins and the ways in which mountain belts—particularly those of North America—are formed about the ancient core of a continent.

In later life he was the recipient of major scientific awards, including the prestigious Copley Medal of the Royal Society and the Wollaston Medal of the Geological Society of London. Darwin was particularly impressed by his work on Crustacea, as well as that on coral reefs and geology, and wrote to him thus: 'I am really lost in astonishment at what you have done in mental labour. And then, beside the labour, so much originality in all your works' (see Pirsson 1919, p.75).

However, the scientists—the 'scientifics'—didn't rate very highly with Wilkes. None of them were actually included in the Antarctic parts of the venture—they were kept apart and allowed to work only in the Pacific.

The expedition sailed from Virginia across the Atlantic to Madeira and the Cape Verde Islands, then recrossed that ocean to voyage down the coast of South America, eventually to shelter in Orange Bay on the southern coast of Tierra del Fuego. From there, with the assemblage of ships divided into two, they were to make the first attempt into the Antarctic. Their timing for this venture was poor, as the brief summer season was nearing its end. The aim was to achieve 'furthest South'—to venture further than either James Cook in 1774 or the sealing captain James Weddell in 1823. The *Peacock* and the tiny *Flying Fish* took the route in search of Cook's record—Cook's *ne plus ultra*, which lay to the west of the Antarctic Peninsula. The *Porpoise* and the *Sea Gull* followed Weddell's route to the east but were driven back by impenetrable ice.

The *Flying Fish* almost reached Cook's most southerly point but, reaching 70°S latitude, fell just a degree short. The *Peacock* and the *Flying Fish* were separated, and the *Flying Fish* crew in particular faced a battle against ice and storms—with huge seas, giant icebergs and ice floes—losing most of the sails and masts in the tumultuous conditions. Eventually they struggled back to Orange Bay. The other small sloop, the *Sea Gull*, was lost forever in severe storms when the vessels of the expedition were leaving that refuge on the next leg of their voyage.

The remaining ships of the Ex.Ex. sailed into the Pacific and carried out surveying, scientific and ethnographic studies of a multitude of oceanic islands. Then, from a base in colonial Sydney, they made another attempt on the Antarctic, sailing south on 26 December 1840 at the height of the southern summer but, significantly, leaving the scientists behind in Sydney. After encountering the ice-bound margin of East Antarctica, the vessels turned westwards and traversed some 2,400 kilometres of that hazardous coast.

The sighting of land was reported on several occasions—some of the sightings were controversial, poorly recorded in the ship's log and subsequently contested—but no landings were made, so there were no ceremonies to plant the American flag and claim the land for the United States. At one point members of the expedition encountered the *Astrolabe*, part of the French expedition led by Dumont d'Urville, although neither vessel acknowledged the other. Wilkes himself did, however, make the effort to communicate with the British expedition led by James Clark Ross, leaving copies of his charts along with suggestions for the route to be explored, for Ross to collect when he arrived in Hobart. Ross, it appears, was somewhat scornful of both the charts and the proffered advice, although his reasons no doubt had more to do with national pride than documenting the geography of Antarctica.

Later explorers, including Douglas Mawson, were dismayed to find that in places Wilkes's calculations had been in error by over 100 kilometres in latitude, due probably to the phenomenon of 'looming', where the refraction of light makes it possible to see objects lying far below the horizon. Nevertheless, where Wilkes had been able to get closer to the coast, his sightings were accurate, his measurements of longitude remarkably sound.

The expedition finally retreated northwards at the long glacier they called 'Termination Tongue'. This was the point at which HMS *Challenger* also retreated northwards in 1874. In spite of some doubtful sightings, Wilkes felt justified in claiming to be the first to establish Antarctica as a major continent, rather than isolated and disconnected islands. The legacy of the voyage was long-lasting; mariners around the world used many of Wilkes's charts for more than a century.

The magnitude of the achievements of the Ex.Ex., however, was for some years overshadowed by the court martial brought against Wilkes by his subordinates, on the grounds of ill-treatment of his junior officers. While these accusations were not upheld—he received a light slap on the wrist—and the claims of the officers were eventually dismissed, the doubts raised by the court martial lingered, and explorers such as Ross refused to accept the findings of Wilkes's survey.

The expedition returned to the United States, in fulfilment of its commission to map part of the northwestern coast of North America, the region around the mouth of the Columbia River. There, the large ship *Peacock* foundered on a sand bar at the mouth of the river and was lost, broken up by the waves. The crew, miraculously, was saved.

Figure 7.2. James Croxall Palmer.
Source: Photograph reproduced courtesy of US Bureau of Medicine and Surgery.

A poet in the mix

On board the *Peacock* at this stage was James Croxall Palmer (1811–1883), appointed as Assistant Surgeon to the expedition. Palmer was a thoroughgoing medical man. He later served in a variety of vessels and was involved in naval battles of the American Civil War. Subsequently, he enjoyed a distinguished career as head of a number of naval hospitals, eventually becoming Surgeon General of the US Navy. Along with other officers, and as instructed by his 'captain', Palmer kept a meticulous record of the events of the voyage in his journal. That journal was lost in the shipwreck, but Palmer was able to recall in fine detail the events, not only of the *Peacock*, but also many of the struggles that had beset the other vessels.

Palmer was also a poet. In 1843, just a year after the completion of the Ex.Ex., he published the epic poem that he had begun during the Antarctic venture—this he called *Thulia: A Tale of the Antarctic*. In the poem, the tiny vessel *Flying Fish* becomes *Thulia*—a reference to Thule, an island in antiquity—or any far-off region beyond the borders of the known world, though the term has historically had a northern or Arctic connotation. The verse reproduced at the beginning of this chapter shows the style of the poem. Its language is vernacular, but above all it is heavy with a sense of the national glory with which the expedition was imbued. Icebergs become towers, dominating the field they claim in glory, should they survive the battle against these fearful odds. The poem is in ballad form—four-line stanzas with a simple rhyme pattern. It forms the major part of a book-length epic that includes other verse poems, some deeply melancholy and filled with yearnings for home, but most threaded through with the sense that hardships were to be endured, and sacrifices made, all in the name of glory for the United States.

Some verses, however, include references that show Palmer's awareness of the scientific aspects of the voyage—he notes seabirds and their habits, particular cloud formations and even the tiny, violet coloured marine snail *Janthina*, which floats on the open seas. Clearly, Palmer was aware of the natural world around them. It is highly likely that as ship's surgeon, he would have enjoyed friendly relationships with members of the scientific contingent, and these features would have been part of the regular discussion.

The volume of poetry is lavishly illustrated with engravings by the expedition's young artist, Alfred Agate. Although only in his late twenties when he joined the expedition, Agate was already well established as an artist and had exhibited work at the National Academy of Design in New York. During the Ex.Ex., he produced images of landscape and of peoples in the Pacific and in the North and South American sectors of the voyage. He often used a camera lucida as a drawing aid to project landscape images on to paper. It is his work that illustrates the formal report of the expedition, although Wilkes himself was a competent artist.

It seems probable that James Dwight Dana, geologist and sometime zoologist to the expedition, was close to Palmer. Among his many talents, Dana was an able musician, played both guitar and flute, and later set parts of the poem to music. This may well be the earliest Antarctic music.

The illustrated volume of poems that Palmer published in 1843 was, some said, produced in time to catch the Christmas market. It was in fact the first narrative of the voyage to appear in print after the return of the expedition. The notes and appendix to the poem support the verses with a remarkably detailed description of the quest for furthest south.

As Commander, Wilkes's role was to write the official account of the expedition. In this he drew both on his own journals and on those of his officers, which were compulsorily surrendered to him. His five-volume narrative of the voyage was published with funding by the US Congress in 1844, two years after the end of the expedition and just one year after the publication of *Thulia.* Palmer's epic poem thus neatly preempted his commander's effort; its quick publication suggests that it slipped under his radar. It may be that Wilkes did not recognise it for what it was, and thought it to be just a romantic poem rather than a revealing story describing significant parts of the US Exploring Expedition's voyage.

Douglas Mawson and the 1911–14 Australasian Antarctic Expedition

Three of the sites drilled on Leg 28 fell within the broad area of the Southern Ocean that was investigated by the Australian geologist Douglas Mawson during the 1911–14 Australasian Antarctic Expedition. While sampling and dredging activities were carried out from the steam yacht *Aurora* within that broad region, Mawson's prime area of focus was the coastal margin of East Antarctica, extending from 91°E to 146°E. Leg 28 Sites 267 and 268 lie offshore from this coastal region, broadly interpreted; Site 269 lies further to the northeast, but still within the broad sampling zone of Mawson's expedition. The aim of Mawson's dredging within the coastal seas was to relate geological interpretations obtained from the dredges to observations made on the adjacent land area, that is, from the bases near Commonwealth Bay in the east and near the edge of the Shackleton Ice Shelf in the west. Figure 7.3 shows Mawson's map of the East Antarctic coastal region, the site of the bases and part of the tracks of the *Aurora*; it also shows the position of Site 268 and its close proximity to the Antarctic coast—insofar as this can be determined under its ice cover.

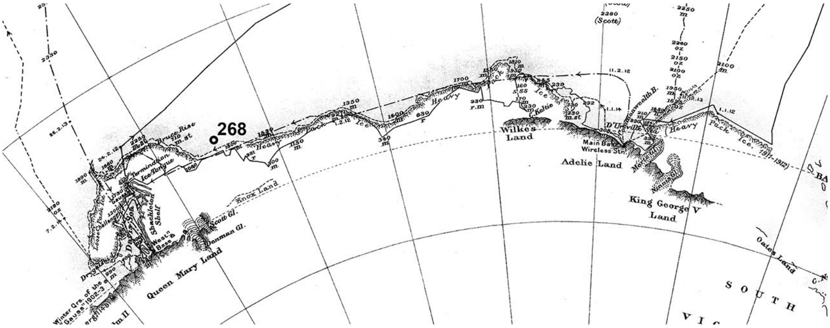

Figure 7.3. Extract from Mawson's 1914 map of the East Antarctic coastal region, showing bases at Commonwealth Bay and near Shackleton Ice Shelf, as well as part of the routes of the *Aurora* cruises. The position of Site 268, drilled on Leg 28, has been added.

Source: Map from Wikipedia Commons.

Douglas Mawson's interest in Antarctica was sparked by ancient glacial sediments near Adelaide, where he was lecturing. In 1907 he approached Ernest Shackleton, leader of the British Antarctic Expedition, and asked if he could join that expedition on the vessel *Nimrod.* Mawson was inspired by the thought of being able to observe modern glaciers and their effects on geological processes. His request was granted by Shackleton, and thus began Mawson's long involvement with Antarctica. He was subsequently successful in organising and leading the Australasian Expedition, which was supported by the SY *Aurora*, a sturdy former sealing vessel from Dundee. Funding was provided by state and Commonwealth governments after intense lobbying. The first of the three summer cruises of the *Aurora* left Hobart in December 1911, prepared not only to establish bases on Macquarie Island and on the Antarctic continent, but also to undertake a program of extensive soundings and dredgings in the Southern Ocean and along the coastal margin of Antarctica. Further dredging programs were carried out in the summers of 1912/13 and 1913/14, when the *Aurora* acted as a resupply vessel to the two shore bases. There was an awareness that very little information existed on the floor of the Southern Ocean and that the efforts of HMS *Challenger* more than 40 years previously had yielded only sparse data that was limited to a narrow geographical area.

The deep sea work of depth sounding and bottom sampling was carried out under the direction of John King Davis, captain of the *Aurora.* Two types of machines were used in these activities, as Captain Davis detailed in his reports—a Lucas machine for depths up to 6,000 fathoms and a Kelvin sounder for depths up to 200 fathoms. A steam winding machine was used to retrieve the measuring wire in the former, hand power in the latter. Samples of the sea floor were retrieved by use of hollow tubes spliced on to the end of the sounding wire, similar, in a general way, to sample retrieval in HMS *Challenger*.

Trawling, mostly to recover samples of the bottom fauna, was a more complex and time-consuming operation than sounding and dredging. A wide-mouthed net was dragged across the sea bottom, aided by a steam windlass attached to a wooden derrick. The results of this activity were not always expected. In the *Home of the Blizzard* in 1915, Mawson wrote:

> Unfortunately for biological considerations, our catches often partook too much of a geological character; stones great and small, several of which hauled on board actually weighed half a ton each, were most unwelcome items, for they tore the net and crushed the contents. It was thus ascertained that the oozy floor of the sea in those waters is abundantly sprinkled with rocks which arrived at their present resting place on release from icebergs, embedded in which they floated out from the land. Each stone showed just how far it had been sunk in the mud, for the upper protruding part was blackened with a curious deposit of manganese oxide. (Mawson 2010, p.407)

It is notable that Mawson, always the geologist, doesn't seem to have kept these stones, nor made a detailed record of them. He must surely have been aware that they could have provided valuable information on the geology of both coastal and inland regions of Antarctica. Modern studies, using geochemical information from rocks 'sprinkled on the sea floor' have been a source of data from nearby, or even more distant coastal regions.

The Australasian Antarctic Expedition was more strongly focused on science than most of the others in the early twentieth century—those of the 'heroic era' of Antarctic exploration. This may have been because it was driven and led by a scientist in Mawson, who was later to become Professor of Geology at Adelaide University. Support for the science, and an eagerness to join the expedition, came from a range of specialists—other geologists, biologists, magnetic specialists and medical men—largely young graduates from universities in Australia and New Zealand. The expedition was also funded by the Australasian Association for the Advancement of Science, and from public subscription.

The expedition generated extensive records from expedition members and from specialists co-opted later. Recently there has been criticism of Mawson's 'ownership' of much of the expedition's research—a sense that the achievements of many of the specialist scientists and other workers were downplayed, or even forgotten, when the final reports were written. This issue forms the basis of Heather Rossiter's 2011 book, *Mawson's Forgotten Men*. This is based on the 1911–13 Antarctic diary of Charles Turnbull Harrison, a biologist and artist on the expedition. In the preface to the book, Rossiter pays tribute to the largely unremembered men who carried out the scientific work of the expedition, and those who supported them. The process of forgetting she attributes to the 'emotional need for a hero' but cites this response as essentially unfair. Stephen Martin, author of *A History of Antarctica*, offers in explanation the fact that very little went wrong in the shore-based parties, so there was nothing dramatic to report. A more convincing reason might lie with an overpowering sense of a leader's entitlement. Certainly in the case of Mawson, such a sense, coupled with his evident ambition, may be the root cause. This could explain how the names of active young scientists were dropped from some of the reports, for example that of Lesley Blake, who largely mapped the geology and topography of Subantarctic Macquarie Island, but who died in the trenches of World War I. While Blake's name appeared on the early reports of this survey, a later report was produced under the sole name of Mawson.

A photographic record of the Mawson expedition: Frank Hurley

Apart from some very competent sketches by Charles Harrison, the making of visual records of the expedition fell largely to the photographer Frank Hurley. His artistry, along with that of Herbert Ponting, the brilliantly professional photographer on Scott's *Terra Nova* Expedition of 1910–13, marked the beginning of a shift away from painting and drawing as the primary ways of recording the events of Antarctic expeditions, although for a period both were retained, sometimes in combination.

The small number of iceberg photographs taken on HMS *Challenger* were probably the first of their kind, but we lack information on possible photographers, although the images were clearly popular items among the crew. Photography was important in the national expeditions of the heroic age at the beginning of the twentieth century, although they did not carry specialist photographers. Unforgettable images include the aerial view of the *Gauss*, taken by Erich von Drygalski, leader of the German National Expedition of 1901–03, who ascended some 490 metres in a hydrogen-filled balloon to capture the image of their vessel trapped in ice; and the picture of a kilted bagpiper and an apparently engrossed penguin, taken on the Scottish expedition of 1902–4.

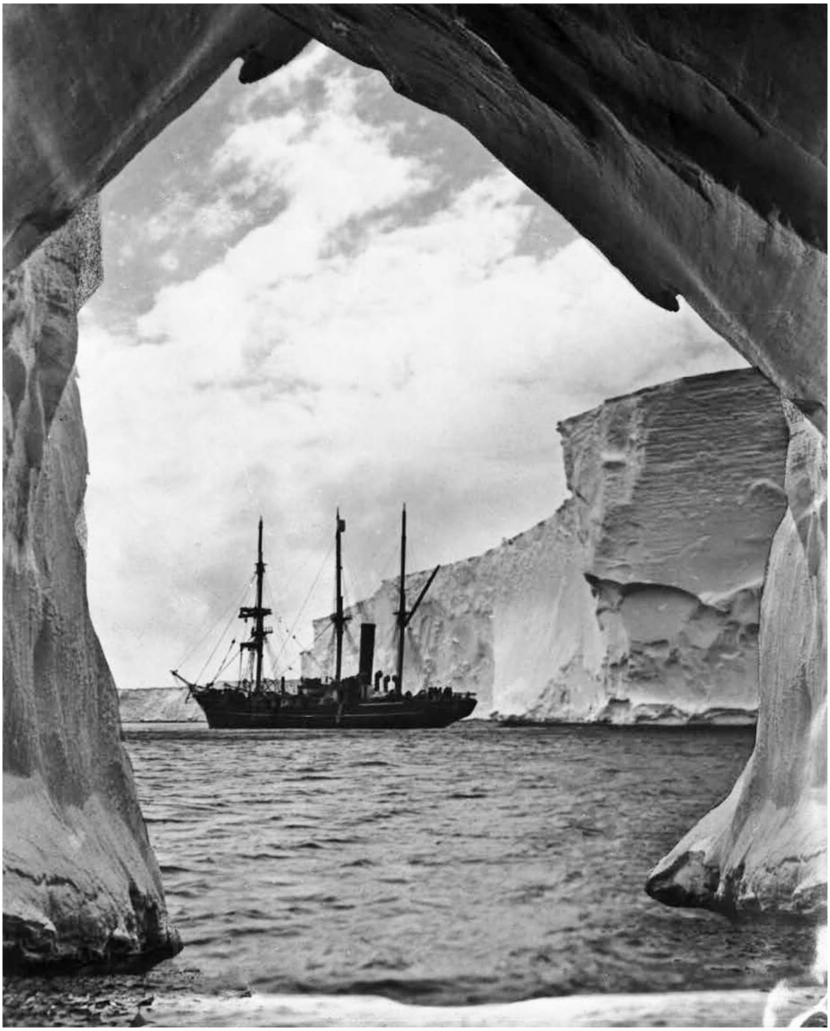

Figure 7.4. *A glimpse of the Aurora from within a cavern in the Merz Glacier, Adelie Land. Australasian Antarctic Expedition*. Frank Hurley.

Source: Courtesy of National Library of Australia.

Frank Hurley later professed to be a great admirer of Ponting's work but had not seen his photographs when he joined Mawson's expedition. He was part of that expedition from 1911 to 1913 and was involved in five more Antarctic ventures after that. He was prominent in Shackleton's Imperial Trans-Antarctic Expedition from 1914 to 1916, then in another to South Georgia in 1917 and finally was twice present on Mawson's British Australian New Zealand Antarctic Research Expeditions (BANZARE) of 1929–31.

Always an adventurous spirit, Hurley was prepared to take extreme physical risks for his photographs. He took experimental risks with the photographic process itself, too, and viewed photography as a 'malleable' medium. Helen Ennis, in *Frank Hurley's Antarctica* (2010), reports that Hurley was 'not constrained by the notion that the exposure of the negative was the single, defining moment, the moment of truth' that could not be elaborated in any way. Rather, he saw that manipulation of negatives and the combining of prints could forge a stronger sense of the external—of a heightened reality; of being 'in the moment'. Figure 7.4 is one example of using multiple negatives to achieve a desired effect. In this view of the *Aurora* it is probable that the details of the framing cave, the sky and the overall image are provided by combining three negatives.

Hurley was a showman. He was active in promoting his work, both his Antarctic experience and his depictions of the battlefields of World War I. His reputation rested not only on his still photographs but also on his cinematography; the widely shown movie *South* (1919) was based on a compilation of photographs from Shackleton's *Endurance* expedition. He made many documentaries on Australian subjects, too, as well as a number of books—all of these have something of an air of proclaiming and advertising that country's virtues. He has been described as the most celebrated Australian documentary film-maker of his time. In terms of Antarctica, however, his total of four years in and around that continent produced a number of narrative images of human struggle and endurance, and others that celebrated icy forms of both land and sea. Many from this body of work have become icons, coming to define Antarctica in the eyes and thoughts of a wide public.

An unexpected pollen record?

For me, the sea floor samples retrieved by dredging during the cruises of the Australasian Antarctic Expedition proved to be an unexpected source of information on the former land vegetation of Antarctica, although the picture they provided was a confused one. It was almost a gift to discover that most of the geologically recent muds brought up from the sea floor by Mawson's expedition, especially those from close to the continent, were rich in pollen. The source of this was undoubtedly the continent itself with the pollen and spores coming from sequences of sedimentary rocks on shore when these were eroded by the action of ice.

In 1982, the centenary of the birth of Douglas Mawson, I was able to obtain 53 dredge samples recovered from the hollow tubes attached to the sounding apparatus of the *Aurora.* These were stored in well-stoppered, old-fashioned test tubes at the Australian Museum in Sydney, labelled in a neat hand that I assumed to be Mawson's. The samples come from a wide area of the Antarctic coast from Commonwealth Bay in the east, where the expedition's main base was established, to the vicinity of the Shackleton Ice Shelf in the west. Most yielded a great deal of well-preserved pollen, recycled from older rocks.

Ultimately the pollen had come from plants that once grew on Antarctica and had been swept into lakes and swamps in a world before the present icecap formed. The sediments in these sites became consolidated—cemented into sedimentary rock—before being picked up by glaciers and dropped out at sea, shedding their pollen load on to the sea floor in the process. The pollen within these sedimentary rocks is usually deposited close to shore, often near the grounding line of the transporting glaciers.

As noted in Chapter 1, the pollen and spores in these recent sea floor muds represent a jumble of geological ages. This limits their value in reconstructing the vegetation of any particular geological period; they do, however, give us a list of the plants that once grew there—we just don't know precisely when. They can, however, be a useful tool in suggesting the position and age of sedimentary rock sequences that might lie beneath the ice.

Given that the topography of the Antarctic continent beneath its ice cover is increasingly well understood through direct studies of ice thickness, using techniques such as ice-penetrating radar, magnetic and gravity data and modelling, it has been exciting to see how well the simple data of recycled fossil pollen in the modern muds of the sea floor relates to these new views of what lies beneath the ice. One example shows how these sources of data can come together in understanding the foundations of Antarctica. Glaciers flowing out via the Shackleton Ice Shelf probably drain the deep Aurora sub-basin of East Antarctica; this sedimentary basin beneath the ice may once—before the split between Australia and Antarctica—have been joined to the southern end of Australia's Perth Basin. Sedimentary sequences of Permian and Triassic age are common there. On the sea floor close to the Shackleton Ice Shelf, well-preserved pollen of Permian age—the winged pollen of the early seed ferns—is particularly abundant. Could this pollen demonstrate that there are sediments of Permian age eroding in the Aurora sub-ice basin beneath its present thick ice cover? I discussed the possible origins for the sea floor pollen suites in a paper published after the Mawson Symposium of 2011 (Truswell 2012).

This is a specifically geological application of the recycled pollen on the sea floor. But the presence in these assemblages of pollen known from southern temperate rainforests such as those growing now in Tasmania provides more information on vegetation history. It is just one line of evidence that these forests once grew in Antarctica although we do not know just when or for how long they persisted. That information must come from pollen assemblies in place in well-dated boreholes (see Chapter 9).

This text is taken from *A Memory of Ice: The Antarctic Voyage of the Glomar Challenger*, by Elizabeth Truswell, published 2019 by ANU Press, The Australian National University, Canberra, Australia.