The history and development of protective clothing in Antarctica

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1 Introduction

1.1 Antarctica — an extreme environment

Antarctica is the only continent with no native human population — it is simply too extreme an environment. No human set foot on Antarctica until, perhaps, John Davis in 1821, and there has been continuous human habitation only since the second world war.

1.2 Human survival in Antarctica

Humans can only exist in this environment by sheltering from it in warmed, insulated stations. Survival outside of buildings and vehicles requires clothing that protects the wearer from the elements while allowing the wearer to operate efficiently whatever the task — see Figure 1.

Philosophies and technologies in clothing have seen less change than other fields such as transport, although these changes have resulted in a dramatic improvement in the comfort of the wearer. Many thousands of tourists now visit Antarctica each year, including children and the elderly, and do so in comfort and safety. Major scientific and construction efforts such as the Cape Roberts Project and the South Pole Station upgrade are undertaken with the workers not only surviving and completing their tasks, but doing so in comfort that would have amazed the explorers of a century ago.
1.3 This review

This review considers the philosophies and technologies applied to Antarctic clothing over the history of human endeavour on the continent. Three eras have been identified and are considered: the Heroic Era of discovery and exploration (taken from the time of the first long sledging journeys at the turn of the last century, to 1917), the Scientific Era of the expansion of occupation and scientific discovery (from the mid-20th century to an arbitrary cutoff of 1990), and the Contemporary Era of today.
2 The heroic era

2.1 Period considered

The Heroic Era covers the period of early discovery and exploration of Antarctica. This report considers the time period from the first long sledge journeys at the beginning of the 20th century, as this was the first time that clothing was tested in other than ship and hut environments. The era is generally considered to end with the departure of Shackleton’s Ross Sea Party in 1917.

2.2 Human activity

This era, as its name suggests, was a time of exploration under conditions of extreme difficulty. Feats of achievement and endurance such as Shackleton’s ‘Endurance’ and ‘James Caird’ journeys, Mawson’s lone trek and Scott’s fatal pole attempt have captured the imagination since that time.

Antarctic activities were a mixture of indoor work on ships or ashore in huts, outdoor work in the same areas, and sledge journeys on the continent. These sledge journeys were the most challenging, with limited supplies, little opportunity to clean or repair clothing, and alternating hard physical labour and rest in extreme cold. It was under these conditions that the men’s clothing (for there were no women on the expeditions of the time) suffered the most, as did the men in them.

2.3 Clothing

Much of the material written in English available from the period comes from diaries and expedition reports of the expedition leaders, with some material produced by other members of the expeditions. There is therefore a likelihood of problems in planning and logistics (such as clothing selection) being ‘glossed over’ in an effort (conscious or otherwise) to paint the author in a good light. Shackleton, for example, while mentioning the terribly worn state of the Endurance personnel’s clothing by the time that rescue was effected (Shackleton 1919), makes no mention of the discomfort that must have been suffered by men performing heavy labour in clothing that, judging by experience on other expeditions (Cherry-Garrard 1937, King 1982), would have become soaked in frozen sweat.
Many expeditions modified clothing for warmer climates (see Figure 2, for example) rather than use clothing especially designed for Antarctic conditions. Amundsen commented on Scott’s “fine woolen clothing ... specially designed (in England) ...” (Huntford 1979), seen in Figure 3(a). This clothing contrasted with his own Eskimo-styled wolf skin outers over Reindeer fur garments (see Figure 3(b)), right down to fur underwear chosen because it would not stretch or hold moisture (Huntford 1979). Englishmen seem to have had difficulty adopting these forms of dress: Bertram (1939) for example, while noting claims that “Caribou skin is without comparison the best material for clothing in extreme cold” felt that for a number of reasons, including the need to have womenfolk available to effect repairs on Eskimo clothing, Western clothing (such as the items seen in Figure 4) weighing between 16 and 21 pounds in total, was more appropriate.

It appears that the only difficulties Amundsen had with his clothing were at times being too hot on the move (solved by sledding in his fur underwear), and ongoing difficulties with boot design. The initial leather and canvas designs proved inadequate, and the boots underwent several redesigns while in Antarctica preparing for the trek to the pole. He eventually had success with very large boots with two pairs of Eskimo Reindeer fur socks, plenty of sennegrass, and thick woolen socks (Huntford 1979).

Feet were often difficult to keep warm and dry. Sennegrass was used suc-
(a) Shackleton, Scott and Wilson just before the start of the southern journey, November 2, 1902.

(b) Dr Frederick A. Cook and Roald Amundsen trial Eskimo fur garments, Greenland, winter 1898.

Figure 3: A comparison of the clothing worn by Scott’s party, and that worn by Amundsen. *From Huntford (1979).*
Figure 4: A number of items worn by early explorers on the continent. From Bertram (1939).
Figure 5: Madigan returns to Mawson’s hut during a blizzard, his face iced up with moisture from his breath combining with wind-blown snow. *From Laseron (1947).*

cessfully by Amundsen (Huntford 1979) but was disparaged as “primitive” by Englishmen such as Bertram (1939). Mawson’s feet were so badly damaged on his solo return trek that the soles literally fell off, and had to be bound back on with scraps of cloth (*Laseron* 1947). Woolen socks were popular, but other materials such as squares of blanket (Bertram 1939), Amundsen’s Reindeer fur, and even goat and human hair (*Mossman et al.* 1906) were used with some success.

Many early sledge expeditions encountered difficulties with moisture causing clothing to become damp on the move, and then frozen solid at night. Figure 5 shows the effect of moisture on the breath in freezing conditions. In those days the ‘layering’ principle that became popular later in the 20th century was not used, and a few layers of heavy clothing were worn (*Bertram* 1939, King 1982). Sweating was unavoidable with the man-hauling of heavy sleds — the problem was exacerbated by the heavy nature of the clothing causing extra work (*Young* 1979).

The problem of damp clothing extended to sleeping bags. These were constructed of Reindeer hide, and could be used fur-in or fur-out, depending on the conditions and the user (*King* 1982). Down-filled liners were used, and
were found to freeze solid once they had a little moisture in them, rendering them quite useless (King 1982). On sledging journeys such as the winter ‘worst journey in the world’ trek from Cape Evans to Cape Crozier, several difficulties with sleeping bags were encountered. Once moisture had accumulated in them they would freeze solid as soon as they were vacated, and couldn’t be rolled up for fear of breaking them (King 1982). They couldn’t be dried in the field, rapidly wore out when manipulated when frozen, and once one had spent up to two hours fighting one’s way into a frozen bag (Cherry-Garrard 1937) it was often too cold to sleep. Indeed, the frozen bags were so uncomfortable that expedition members had difficulty staying awake once out of them, and risked falling asleep as they heated breakfast (King 1982).

Few problems were reported with hand-wear. On many expeditions fingerless gloves or mitts were worn under thick mitts (Mossman et al. 1906, King 1982) and proved popular with the wearers for both their warmth, and the ease they afforded the wearer when performing manual tasks.

The need for protection from the wind was well recognised, and was often effected with gabardine over-suits and windproof-covered balaclavas (Mossman et al. 1906, King 1982). Often anoraks were used, as the absence of a front closure meant that less wind could enter.

Snow-blindness was encountered even when tinted glass goggles were worn (Laseron 1947, King 1982), implying that either the glass was not tinted enough, or blocked more visible than ultra-violet radiation. Leather goggles were also used with some success, sometimes in combination with the tinted glass goggles (King 1982).
3 Further exploration

3.1 Period considered

There has been continuous occupation of Antarctica from the early 1940s, when bases were established in secret on the peninsula. The period around the International Geophysical Year (IGY) of 1956–1957 saw an explosion of exploration and occupation of the continent, including the establishment of New Zealand’s Scott Base and several stations on the plateau (Army 1958). While many of the bases established for IGY have been decommissioned there are still many that have been constantly occupied since that time. Clothing and equipment has been iteratively developed as technologies improve and experience provides lessons.

3.2 Human activity

Over this period of both physical and scientific exploration a wide variety of activities have been performed, including the construction of bases, making of scientific observations, and overland journeys by dog-sled and vehicle. A wide variety of clothing styles has been adapted and developed to meet the wide-ranging requirements of these activities.

3.3 Clothing

Much of the clothing worn in the early years of this period were military issue (Army 1958), reflecting both the strong military presence on the continent and the military’s experience in cold weather operations. At times the extreme nature of the Antarctic environment made it obvious that this clothing had been developed for the milder conditions often found in the northern hemisphere and were unsuitable for use in the Antarctic (Canada 1944).

By this time the importance of preventing sweating had been recognised (Bertram 1939, NSF 1966?). The layering principle had been developed to prevent sweating and was being used with success (Remington 1959).

Much of the information available from this time comes from military or government reports, and focuses on the functionality and utility of clothing. Several of these authors comment on difficulties with bulky or ill-fitting clothing. These garments not only make work uncomfortable (Remington 1959,
Young 1979) but pose a hazard as they tire out their wearers, impair visibility and can catch on equipment (Canada 1944, Army 1958, Barclay 1986). This was a time of experimentation and rapid development. Some clothing tested was clearly unsuitable, and in fact was so poorly designed (Figure 6, for example) that military personnel risked disciplinary action and refused to wear it (Canada 1944).

Vapour impermeable boots were introduced by the United States, and ‘fish-net’ undergarments like the one in Figure 10(a) were used successfully by several nations (Remington 1959), demonstrating the discovery that a trapped layer of warm air next to the skin provides excellent insulation.

The need for windproof outer clothing noted by early explorers (Section 2.3) was recognised as vital. Many improvements over the early explorers’ gabardine or boxcloth were tested. Nations were experimenting with various forms of insulation and wind-proofing, such as the Russian’s use of rubberised fabric with eider down lining (Army 1958) seen in Figure 7. Some original items of clothing were still finding favour, such as knitted wool jerseys.
Figure 7: Russian Antarctic suit used in IGY, consisting of a rubberised outer with eider down lining. From *Army* (1958).
4 Contemporary times

4.1 Period considered

For the purposes of this review, a period from 1990 to the present day is considered to represent 'present day' activities.

4.2 Human activity

Human activities have become more sedentary since IGY. Dog teams are no longer used for journeys across the ice — vehicles, often heated, now take their place. Tents, vehicles and buildings keep humans warm and protected from the environment for much of the time. If the weather gets too rough workers can generally get inside and wait for it to improve. The intent of clothing has moved from pure survival towards task accomplishment, comfort and ease: softer, lighter fabrics with more pockets are now worn.

Perhaps the only people who still have the need for 'extreme conditions' protection are the tourist-adventurers who aspire towards reaching the pole or crossing the continent on foot, and search and rescue teams who may have to rescue other personnel in extreme conditions.

4.3 Clothing

The problems of bulky clothing are noted on page 11 in Section 3.3. Effort has therefore gone into developing clothing that is less bulky. Denner (1990) notes that the long-held belief that all good insulators (such as down or steel wool) give similar warmth for a similar bulk has been disproved with the development of 'thin insulator' technology. Figure 8 shows that thin insulators give nearly twice the warmth for similar thickness; this discovery has led to the popularity of fabrics such as Thinsulate™ for gloves and other items.

Undergarments, too, have changed. Fur is not used, and even wool is going out of favour as newer fabrics such as polypropylene (see Figure 9) show their advantages.

Mesh or 'brynje' undergarments have also proved popular as a means of trapping warm air near the skin, and preventing undergarments from picking moisture up from sweaty skin during heavy labour. Figure 10(a) shows a garment from the IGY era, and its contemporary is seen in Figure 10(b).
Figure 8: The relative warmth of several insulating fabrics. From Denner (1990).

Figure 9: The thermal conductance of some popular fabrics for undergarments. The danger of wearing cotton is apparent, as is the thermal advantage provided by polypropylene. From Denner (1990).
(a) An early 'coat of mail' design. 
*From Canadian (1944).*
(b) A modern British Antarctic Survey undergarment. *From BAS (1985).*

Figure 10: Mesh or 'brynje' undergarments have proved popular, although early knotted designs were uncomfortable. Modern garments are constructed of polypropylene.
Specialised garments have been developed for particular working conditions. Search and rescue teams are issued high-alpine boots and thick down jackets, and scientific teams collecting ‘pristine’ samples wear oversuits to protect the environment (see Figure 11).

The design of many items has changed little in the last half century — note the similarity between Figures 12(a), 12(b) and 13. The differences not visible in these pictures is in the fabrics — polypropylene has replaced wool at the skin contact layer, and waterproof/breathable fabrics are increasingly used for outer shells (Denner 1990).
(a) An American in the mid-1960s. *From NSF (1966).*

(b) Contemporary U.S. issue clothing. *From NSF (1990).*

Figure 12: Minor changes in clothing design can be seen in this comparison from two editions of the same survival manual.
Figure 13: Contemporary New Zealand issue clothing. *From Spratt (1995).*
5 Conclusion

Early explorers generally used one of two approaches in the design of their Antarctic clothing. A few, like Amundsen, adapted Eskimo-style fur clothing to their needs, while most explorers wore heavier, warmer versions of clothing used in Europe. These garments suffered from difficulty in regulating body temperature during exercise, and tended to become saturated with ice as a result.

By the time of the International Geophysical Year (1956 – 1957) the layering concept was developed. This enabled the wearer to modify the thickness and warmth of his or her clothing to suit the environmental conditions and type of work being performed, and thus avoid heavy sweating and the associated problems.

Today Antarctic workers and adventurers still follow the layering principle, but with an increasing trend towards artificial rather than natural fabrics. The emphasis has moved from one of survival to one of wearer comfort and the ability to perform the work required.
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