Proceedings of the Tenth Symposium on Antarctic Logistics and Operations

Shanghai,China July 15~18 2002

conducted by
Standing Committee on Antarctic Logistics and Operation(SCALOP)
of the
Council of Managers of National Antarctic Programs(COMNAP)
in conjunction with
XXVII Meetings of the Scientific Committee on Antarctic Research(SCAR)

China Ocean Press

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Overlook of Zhongshan Station at Larsemann Hills, Antarctica

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Preface

The X SCALOP Symposium was held in Shanghai Exhibition Center from July 15 – 18, 2002, together with XXVII SCAR and XIV COMNAP Meetings. These proceedings include 21 papers and 15 abstracts collected from the Symposium.

In the XIII COMNAP/SCALOP Meeting, Symposium Working Group decided that the X SCALOP Symposium would focus on the following 6 subjects:

1. Antarctic Medical Support and Standards ;
2. Selection and Recruitment Procedures ;
3. Proven Technologies and Equipment for Field Camps and Intra-continental Air Networks (including Waste Management) ;
4. Recent Advances in Solid and Liquid Waste Management ;
5. Alternative / Sustainable Energy ; and
6. Shipping in Antarctic Waters .

The X SCALOP Symposium Steering Committee was made up by Xu Shijie (China), Kim Pitt (Australia), Patricio Eberhard (Chile), Patrice Godon (France), Prem C Pandey (India), Kazuyuki Shiraishi (Japan), Arian Steenbruggen (Netherlands), Janerling Haugland (Norway), Julian Tangaere (New Zealand), Valery Klokov (Russia), John Pye (UK), Erick Chiang (USA). The Committee received 51 paper abstracts and held a reviewing meeting in Shanghai on April 29 – 30. 12 papers for oral presentation and 28 papers for poster presentation were selected at the reviewing meeting.

The X SCALOP Symposium Steering Committee wishes to acknowledge COMNAP and the Local Organizing Committee to provide financial assistance to the keynote speakers for attending the Symposium.

Finally, I would like to express my sincere thanks to all people involved from Chinese Arctic and Antarctic Administration and Polar Research Institute of China for their assistance and hard work on the preparations for the Symposium, special

gratitude to Mr. Kim Pitt, Mr. Qu Tanzhou, Dr. Zhang Zhanhai, for their help with the Symposium meeting and Mr. Liu Shunlin, Mr. Qin Weijia and Mr. Wu Jun for organizing of the reviewing meeting.

Xu Shijie
Chairman of the X SCALOP Symposium

Welcoming Speech

First of all, on behalf of the local organizing committee of the twenty-seventh SCAR and fourteenth COMNAP Meetings, I would like to extend my warm welcome to all of you to China.

SCALOP Symposium is one of key parts of COMNAP and SCALOP meetings which has played an important role since its establishment. It provides a forum for exchanging ideas and learning from each other. It is also a good chance to get to know the new progress in Antarctic logistic support and stimulate the cooperation among the members. The presentations here will be beneficial to prompting the safety of people working in Antarctica, the high-tech usage in the expedition and the environmental protection in Antarctica. All of these are highly accord to the principles of the Antarctic Treaty System.

I wish the X SCALOP Symposium successful and hope all of you enjoy your stay in China.

Qu Tanzhou

Director-general of Chinese Arctic and Antarctic Administration

CONTENTS

The Medical Support to China Antarctic Scientific Expedition

YU MAO (MD, MBA) Surgical Professor, Vice President
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Background

The Antarctic scientific expedition of China has been carring out for twenty years. All efforts of the logistic and medical supports play very important roles during expeditions. Strong effective and efficient work was provided to guarantee the Antarctic expedition. A complete system of screening candidates, setting up consulting room, and performing routin works in Antarctic has been set up. Some organizing issues are introduced as fellows.

How to make up Medical Support System

The medical support system, providing medical service in Antarctic, are consists of three componients. They are hospitals, doctors and consulting room of Antarctic. Each part has its clear function.

Hospitals (screening doctors): Some excellent general hospitals in Beijing are in charge of screening doctors who will work in Antarctica, such as Beijing Tongren Hospital, Beijing Union Hospital, Beijing Friendship Hospital and Beijing Tiantan Hospital. These hospitals have strict training plans and many excellent experts, so some well trained doctors can be selected as candidates each year.

Doctors working in antarctic Standards for

A qualified doctor Surgeon

Over 8 years working experience

With well personal predisposition (stable psychology, cooperation and team spirit)

With ability of foreign language

be interested in natural activities

has some knowledge in social science

For instance, Doctors coming from Tongren Hospital are coming from the department of surgery, all of them are male except one female. They are all attending doctors. The average age of them is 39.8.

Consulting Room:

There is a consulting room respectively in Zhongshan and Great Wall expedition station. They were built in Antarctic by the Chinese government. It can provide some medical equipments of first-aid for team members.

Besides that hospitals are also in charged of screening other crews except doctors. Usually all candidates will take Physical Examination in order to exclude congenital diseases, chronic diseases (especially cardiovascular disorders and pulmonary disorders), teeth problems, Mental disorders, some infectious diseases (hepatitis, TB etc).

All candidates are required to fill in the Psychological Questionnaire, which is designed by psychologists. The results will be evaluated by psychologists and governors. Combining the results with physical examination and psychological questionnaire, the qualified team members are recommended to the expedition.

Preparation for going to Antarctica

Training for doctors is one of the important issues. It is necessary to spend 3-6 months no training of strength basic skill on first-aid, internal medicine, dermatology and traditional Chinese medicine. The skills can enhance the abilities of dealing with varies disorders that doctors may face during the perio in Antarctica.

The doctor decides the quantities of medical supplement.

Another important event that doctor should do is spending several weeks with other team members. In this way, the doctor is able to communicate, understand, and adapt with others.

How to work in Antarctica

The features in summer time

The weather is nice and warm in summer time, and most scientific researches are usually done during this period. Personal emotion usually wrought up, exciting. However, some accidents could occur such as abrased wound, sprain, and frozen wound on hands and face because of longer outdoor work.

During winter-over period, people alevays After several months, works are almost finished in summer time, the team members face boring daily issues in wintertime, as they have to stay in doors in most of time. People could happen some psychological disorders (bad emotion, depression, anxiety, anger, suspicion, homesick, sleeplessness, fatigue and bad memory), and on the other side, some physical disorders can be seen on some persons, for instance, Hypertension, ST change in ECG, constipation, loss appetite, and stomatitis.

Countermeasures taken in Antarctica

To build good interpersonal relationship

To set up good relationship with each member

To set up trust among them

To communicate frequently

To participate activities

Check up individual's health condition frequently to find out some disorders in early stage and try to stop it as early as possible.

Multi-therapies for psychological problems

Music cassette and the videotapes of Chinese opera

Intellectual plays (Chinese ciess, bridge, table tennis and inves, etc.)

English learning workshop, computer and cooking workshop, etc.

Fitness training

All the measures taken are aimed at releasing or reducing bad emotions of the team members. The results are satisfactory. The approaches to symptoms:

Drugs and Chinese medicine(massage, acupuncture)

Hypertension

Sprain

Constipation

Loss appetite

Results (1989～2002)

All people received careful medical care. They have been given effective and timely treatment. No one had serious outcome. Some people with complex conditions have good outcome as taken the timely approaches and treatment. One person suffered from a mass in his parotid gland. He was suspected the diagnosis of neoplasm, therefore he was suggested to have surgical intervention. At last he got the procedure in Chili.

One person broke his left forearm while working outside. The wound limb was fixed immediately. He received advance treatment in Chili.

One person with stomach bleeding because of peptic ulcer received first-aid in station. Finally he was saved by the effective ways and after that, when his condition was stable, he was transferred to China quickly for advance therapy.

Two people had hematuria respectively in different period. The bleeding stopped after taking medicine. One person had mild diabetic symptoms . The symptoms were well controlled soon by diet therapy and medicines. The Future plan of medical support in Antarctica:

Set up internet in consulting room

To set up more closed medical relationship with other expedition in Antarctica

Unite the medical resource to share the medical serves in Antarctica.

To set up an entire software for medical file in Antarctica

Conclusions

Surgeons would be the best candidates.

Physical and mental check-up are very important for screening crews.

The main problems occurred in Antarctica were psychological disorders.

How to adjust people's emotional activities and adapt the change in Antarctica is still a main issue.

The Psychology of Antarctic Service

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RUNNING HEAD: Psychology of Antarctic Service

Abstract: This paper summarizes four decades of research on the psychology of Antarctic service. Results of multinational investigations conducted since the late 1950's are used to make the case that the process of psychosocial adaptation to isolation, confinement and extreme physical conditions exhibits four distinct characteristics. First, it is seasonal or cyclical in that variations in symptoms that comprise the "Winter-Over Syndrome" (depressed affect, insomnia, irritability or anger, and reductions in concentration and memory) appear to be associated with the altered diurnal cycle and psychological segmentation of the mission. For instance, some studies have documented a significant increase in the prevalence of subsyndromal seasonal affective disorder from late austral summer to mid-winter, but that this increase is more pronounced with an increase in station latitude. These findings suggest that behavior in Antarctica is influenced by patterns of exposure to daylight associated with time of year and latitude. The circannual patterns of change in total mood disturbance and serum TSH levels support an association between cold-related changes in thyroid function, referred to as the Polar T3 Syndrome, and the symptoms of the Winter-Over Syndrome. The increase in mood disturbance after the mid-point of winter isolation found in some studies suggest the existence of a "third quarter phenomenon" which is more psychosocial than environmental in nature and is independent of mission duration. Second, the psychology of Antarctic service is situational in that concurrent measures of personality, interpersonal needs, and coping styles are better predictors of depressed mood and peer-supervisor performance evaluations than pre-deployment measures. Moreover, many of the personality

characteristics that predict for successful performance in other occupational or social contexts (e.g., high achievement motivation, social extraversion), do not predict for successful performance in the Antarctic, or do predict for performance but in the opposite direction. This is because of the unique features of the station social and physical environments and the absence of resources typically used to cope with stress elsewhere. Third, it is social in that social relations within Antarctic crews and their relations with individual performance are influenced by several characteristics, including cultural differences and access to supportive networks. Social support is a more important predictor of individual mood in some cultures than in others. Support from family and friends are more strongly associated with individual performance during the winter than support from fellow crewmembers. Individuals belonging to crews with a clique structure report significantly more depression, anxiety, anger, fatigue, and confusion than individuals belonging to crews with a core-periphery structure. Finally, it is "salutogenic" in that depressed mood is inversely associated with the severity of station physical environment and the winter-over experience is associated with reduced subsequent rates of hospital admissions, both supporting the existence of a positive effect for individuals seeking challenging experiences in extreme environments.

Introduction

The psychology of Antarctic service has a long and distinguished history that extends back to the very first winter-over experience, the Belgica Expedition of 1898 – 1899. In his account of that expedition, the great polar explorer and expedition physician, Frederick A. Cook, described in vivid detail the melancholy and depression that affected the entire crew. Take, for instance, the following passage:

The curtain of blackness which has fallen over the outer world of icy desolation has descended upon the inner world of our souls. Around the tables, in the laboratory, and in the forecastle, men are sitting about sad and dejected, lost in dreams of melancholy from which, now and then, one arouses with an empty attempt at enthusiasm (1909:282).

Cook endeavored to treat these symptoms by having crewmembers sit in front of large, blazing fires. This treatment may be the first recorded attempt to use "light therapy" to treat symptoms of winter depression or Seasonal Affective disorder.

The field of Antarctic psychology, however, began as a scientific enterprise under the leadership of men such as Eric Gunderson of the United States, Jean Rivolier of France, and Tony Taylor of New Zealand, soon after the International Geophysical Year and the establishment of permanent research stations on the ice. Although these stations are designed to provide protection from the harsh environment, a measure of physical comfort, and insure a continuous year-round presence on the ice, the men and women who inhabit these stations are subjected to a number of stressors that may be grouped into three categories——Isolation, Confinement, and Environment (ICE). For varying periods of time, depending on their location, these stations are physically isolated from the outside world with darkness and weather conditions preventing travel to and from the continent. Station members are separated from family and friends back home and consequently experience varying degrees of emotional deprivation. Personal crises such as the death of a family member, financial difficulties, or deterioration of marital relations become magnified by the separation and distance between the individuals involved. Winter-over crews often experience some level of tension or conflict with external organizations and agencies, usually due to interference with established station routines, delays in the arrival of replacement personnel or supplies, or problems with communication which result from the disruption at times by environmental conditions and the frequent misinterpretation of the meaning or intent of certain messages.

The flip side of the isolation from the outside world is the confinement or lack of isolation within the station itself. During fieldwork conducted at McMurdo and South Pole stations in 1988 and 1989, informants complained that the lack of privacy and constant gossip that pervaded the community had a negative influence on social relations, especially relations between men and women. Consequently, as much as 60% of one's leisure time is spent alone in a dorm room (Evans et al., 1987). However, there is little separation between work and leisure because living and working spaces are in close proximity to one another, and one interacts with the same group of individuals in both sets of activities. This constant interaction also creates a potential for increased social conflict between workers and supervisors, co-workers, cliques, or people with conflicting personalities. Removing oneself from tense social situations during the winter is not a viable option. Travel outdoors for even brief periods in order to escape this confinement is restricted by the extreme cold, darkness, and policies de-signed to promote safety and reduce the risk of accidental injuries.

Finally, the environment itself poses a significant stressor despite the improvements in living conditions at either station. Residents of research stations must contend with high altitude (especially at the South Pole which is situated 2835 meters above sea level), extreme light-dark cycles, very low humidity, exposure to extreme cold when working outdoors, and the absence of viral and bacterial agents during the winter. Among the physiological responses to these environmental conditions are a complete absence of Stage IV sleep as well as sizable reductions in the amount of Stage III and REM sleep, a disruption of circadian rhythms, dyspnea, arterial hypoxia, headaches, hypocapnia, erythrocytosis, mild alkalosis, suppression of the immune system, and disruption of thyroid function (Guenter et al., 1970; Reed et al., 1986).

Screening and Selection

To minimize the risk of poor psychosocial adaptation, decrements in task performance and the need to treat and possibly evacuate individuals with psychiatric disorders resulting from long term-exposure to these stressors, most national Antarctic research programs have adopted some form of psychological screening and selection. These procedures vary from one country to the next. Some programs screen both summer and winter-over personnel, while other programs limit their screening to winter-over candidates. Some programs rely upon formal clinical evaluations and use of standardized psychometric tests, while others place their reliance on time-tested methods of personal interviews with program administrators, former expeditioners and station managers. In each of these instances, however, screening procedures are intended to accomplish two objectives. The first objective is to "select-out" or disqualify any candidate with a history of psychiatric disorder, current psychiatric symptoms, or other characteristics that place him or her at risk for a psychiatric disorder during his or her stay on the ice. The second objective is to "select-in" or identify and select candidates with characteristics that predict for optimum performance in Antarctica.

The importance of screening and selection procedures in accomplishing the first objective was recognized in the early days of the United States Antarctic Research Program. During the International Geophysical Year (1956 – 1957), psychological screening of the first two winter-over crews at the American stations resulted in correlations ranging between 0. 4 and 0. 6 between the pre-deployment clinician ratings of candidate suitability and post-deployment peer and supervisor evaluations of crewmember performance (Gunderson, 1974a). According to Gunderson (1974a), this degree of success was attributed to the wide range in quality among the persons screened and the fact that the psychiatrists' recommendations were entirely disregarded. In fact, at one Antarctic station in 1957, over one-half of the crewmembers had been recommended for disqualification due to emotional instability. That station had more conflict among members and between the crew and the station leader than any expedition since (Ronne, 1961).

Nowadays, the importance of select-out screening procedures is reflected in the relatively low burden on medical personnel in Antarctica resulting from psychiatric disorders. Data collected between 1957 and 2000 by the Human Biology and Medicine Working Group reveals that psychiatric disorders account for between 0.3 and 3.8% of all station sick call or outpatient visits. At the McMurdo clinic, psychiatric disorders represented 0% of all clinic visits during the austral winter of 1999, and 0.4% of visits during the austral summer of 1999 – 2000 (H. Mahar, personal communication).

Nevertheless, approximately 5% of winter-over personnel experience symptoms that fulfill DSM criteria (American Psychiatric Association, 1994) for a psychiatric disorder and are severe enough to warrant clinical intervention (Palinkas et al., 1995; Palinkas, Glogower, et al, 2001). Psychiatric debriefings conducted at McMurdo and South Pole between 1994 and 1997 revealed that 3.8% of personnel experienced mood disorders (depression), 3.8% experienced adjustment disorders, 2.6% experienced sleep disorders, 1.3% experienced alcohol or drug-related disorders, and 1.0% experienced personality disorders (Palinkas, Glogower et al., 2001). Although these rates are no higher than what might be experienced in the general population in the United States, they are noteworthy in that these men and women are required to undergo psychiatric screening prior to the austral winter.

Screening and selection procedures that involve predeployment psychiatric evaluations to select out potential cases of psychiatric disorder are but one element of the psychology of Antarctic service. Other elements include the use of psychiatrists and clinical psychologists to provide consultation via telecommunications networks to station physicians and crewmembers, both in response to disasters and emergencies involving the entire station as well as in response to individual experiences of symptoms; training of station personnel to provide psychological support to trauma victims; and post-deployment debriefings by clinicians that offer an opportunity to conduct crisis intervention and a measure of reassurance prior to the return home.

Although such resources and procedures are generally believed to be effective in minimizing the operational impact of severe psychiatric disorders in Antarctica, these disorders represent only a small part of the psychology of Antarctic service. The austral winter in Antarctica has long been associated with reports of depression, irritability, aggressive behavior, insomnia, difficulty in concentration and memory, absentmindedness, and the occurrence of mild fugue states known as "long-eye" or the "Antarctic stare" (Palmai 1963; Palinkas et al. 1995). During the 1989 winter season at McMurdo, for instance, 64.1% of the winter-over crew members interviewed reported some problem with sleep over the winter; 62.1% reported feeling depressed; 47.6% reported feeling more irritable than usual; and 51.5% reported difficulty with concentration or memory (Palinkas 1992). Mean depressive symptom scores increased significantly during this period (Palinkas et al., 1995). Collectively, these symptoms are referred to as the "winter-over syndrome" (Strange and Youngman 1971). Despite its name, the winter-over syndrome does not represent a clinical entity. However, the prevention of decrements in behavior and performance attributable to this syndrome is generally considered to be the domain of "select-in" procedures. For such procedures to be effective, however, a better understanding of the syndrome is required.

Characteristics of Behavior and Performance in Antarctica

Our efforts to understand the winter-over syndrome in particular and the human experience in Antarctica in general have revealed four characteristics of behavior and performance in isolated and confined environments. Under these conditions, behavior and performance is likely to be seasonal or cyclical, situational, social, and "salutogenic". Each of these principles is described in greater detail below.

1 Seasonal Characteristics

Longitudinal assessments of behavior and performance in the Antarctic reveal certain patterns that suggest an influence of various features of the physical and psycho-social environment. For instance, analyses of data collected between 1963 and 1974 revealed a significant increase in winter-over syndrome symptoms from early to late winter (Palinkas et al., 2000a). A review of data collected from personnel who spent the austral winter at Palmer, McMurdo and South Pole Stations in 1991 revealed a significant increase in the prevalence of subsyndromal seasonal affective disorder from late austral summer to mid-winter (Palinkas et al., 1996). A comparison of personnel at Palmer (64°45′S) and South Pole (90°S) Stations revealed significant differences in measures of seasonally-related depressive symptoms at mid-winter (July/ August) and late winter (October) (Palinkas et al., 1996). Cold temperatures that confine personnel indoors and restrict outdoor activity may account for differences in symptoms between stations, but not for differences between summer and winter symptoms observed at all three stations since these stations vary with respect to the degree of confinement and temperature during the winter. When viewed collectively, therefore, these results suggest that behavior in Antarctica is influenced by patterns of exposure to daylight associated with time of year and latitude.

A second pattern that appears to be circannual in nature was observed in a cohort of 22 men and women participating in a study of cold-related changes in thyroid function and its effect on mood. Profile of Mood States (POMS; McNair et al., 1992) Total Mood Disturbance scores showed an effect of time over the 12 months of Antarctic residence with a sine distribution and two peak values above the mesor, one in November and one in July, as well as a trough below the mesor in March (Palinkas, Reed et al., 2001). This circannual pattern is almost identical to the seasonal variation in serum TSH levels (Reed et al., 2001). Furthermore, the alteration of thyroid function has been demonstrated to be significantly correlated with performance on cognitive tests (Do et al., 1998) and mood symptoms (Palinkas, Reed et al., 2001). Such performance can be improved through the administration of low dosages of thyroid supplements (Reed et al., 2001).

A third pattern that appears to be seasonal in nature is related more to the experience of isolation and the seasonal round of activities than to the experience of cold and darkness. An analysis of deviations from the mean POMS Total Mood Disturbance scores at the South Pole during the austral winters of 1991 to 1994 based on a nonlinear iterative least squares model revealed a significant difference in the second half of the winter (July - October) compared to the first half (March - June) (Palinkas et al., 2000a). This pattern is also revealed in reports of positive and negative experiences found in the polar diaries of French Antarctic expeditioners by Stuster and colleagues (2000). These reports indicate more negative experiences during the third quarter of isolation and confinement in an Antarctic or subantarctic station, regardless of duration of the expedition.

The association between depressive symptoms and time of year and latitude are consistent with studies of individuals in the general population that suggest an increased risk of Seasonal Affective Disorder and subsyndromal seasonal affective disorder with increasing latitude and decreased exposure to bright light during the winter months (Kasper et al., 1989; Potkin et al., 1986). The circannual patterns of change in total mood disturbance and serum TSH levels support an association between cold-related changes in thyroid function in Antarctica, referred to as the Polar T3 Syndrome, and the mood symptoms of the Winter-Over Syndrome (Palinkas, Reed et al., 2001; Reed et al., 2001). These patterns are not confined to the winter months but occur during an entire year of exposure to an ICE environment. The increase in total mood disturbance scores and symptoms of confusion-bewilderment after the mid-point of winter isolation found at the South Pole suggest the existence of a "third quarter phenomenon" among personnel in isolated and confined environments (Bechtel and Berning, 1991). This phenomenon appears to be more psychosocial than environmental in nature and is independent of mission duration. It results from the realization that the mission is only half completed, and that a period of isolation and confinement equal in length to the first half remains. In this instance, the elevation in mood scores remains relatively constant throughout the second half (i.e., third and fourth quarters) of the austral winter.

2 Situational Characteristics

There is a long tradition of research on individual characteristics that predict for optimal performance and high adaptability in Antarctica (Gunderson, 1974b; Rivolier et al., 1983; Sandal et al., 2000; Taylor, 1987; Xue and Zhang, 1998). The object of these investigations has been to identify characteristics that might be used to "select-in" individuals most likely to adapt to such environments. However, our analyses of the human experience in Antarctica suggests that there are few, if any, traits that serve as useful predictors of performance during the austral winter. For instance, a previous study of 119 men and women who spent the 1989 austral winter in Antarctica found that while several features of personality characteristics, coping methods and resources, and social resources were associated with concurrent measures of depressive symptoms, the only baseline measures that were significantly associated with late winter depressive symptoms were pre-deployment depressive symptoms and satisfaction with social support (Palinkas and Browner, 1995). Furthermore, of these two predictors, pre-deployment level of depressive symptoms was the only significant independent predictor of late winter depressive symptoms. These results suggested that baseline measures of personality, stress and coping are weak prospective predictors of behavior and performance during the winter because such performance is influenced more by the conditions of isolation and confinement than by stable traits of individuals (Carver and Scheier, 1994; Holahan and Moos, 1987).

situation (Palinkas, 1991a). Adjustment of expectations to meet the reality of the situation may also account for the inverse association between a desire for efficiency in friends and emotional stability. Similarly, the ability to satisfy a desire for affection from others is limited by a perceived need among all crewmembers to create their own personal space in a confined setting. The willingness to display friendship and offer emotional support to other crewmembers is often counterbalanced by a perceived inability to offer effective support and a fear of being burdened by the problems of others that are similar in nature to one's own problems (Palinkas, 1992).

3 Social Characteristics

While situational characteristics of personnel may be used to predict individual performance, it is the performance of groups that appears to be of greater concern to Antarctic personnel. Research has consistently demonstrated that interpersonal conflict and tension is the greatest source of stress in the Antarctic (Natani and Shurley, 1974; Stuster et al., 2000; Taylor, 1987). Furthermore, our analysis of the role of interpersonal needs and social support in the behavior and performance of Antarctic winter-over crewmembers revealed a paradox. On the one hand, social support is important to these men and women. This was reflected in the significant inverse associations between satisfaction with support and concurrent and prospective measures of depressive symptoms (Palinkas and Browner, 1995). However, these measures include satisfaction with support received from individuals who are not fellow crewmembers, i. e., family and friends back home. With respect to other crewmembers, a repeated measures analysis of variance of personnel who spent the austral winter at the South Pole between 1992 and 1994 revealed a significant decline in the extent to which individuals asked others for advice or provided advice to others (Palinkas et al., 2000). Although this decline appears to be associated with a corresponding increase in mean POMS Total Mood Disturbance scores, this association is not significant.

However, this is not to say that social interaction is relatively unimportant in the Antarctic. Use of multidimensional scaling of data collected from the winter-over crews at the South Pole during the same three-year period revealed three distinct patterns (Johnson et al., in press). The first pattern was a clique structure in which crew members identified three distinct subgroups, based on areas of the station each subgroup usually spent most of their leisure time: 1) the "Biomed" group; 2) the "Library" group; and 3) the "Bar" group. Each group had a membership of five individuals. There were an additional six individuals who were not a part of any

These conditions include the stressors (e. g., isolation, confinement), and the limited availability of resources necessary to cope with these stressors. Likewise, methods and resources used to cope with stressful situations prior to deployment in Antarctica may not be effective in coping with isolation and confinement in Antarctica because they are situation-specific and not generalizable from one social environmental context to another, particularly when that context is an ICE environment.

A similar prospective study of the 657 men who overwintered at 8 different stations in Antarctica between 1963 and 1974 found that military crewmembers received significantly higher combined peer-supervisor evaluations of task ability, social compatibility, and overall performance than their civilian counterparts. Being married was a significant independent predictor of leadership. Many of the personality traits and interpersonal needs were significant predictors of predictors in the expected direction. For example, a high level of boredom expressed at screening was inversely associated with task ability, emotional stability, social compatibility, and overall performance. The desire for optimism in friends was a significant independent predictor of emotional stability and social compatibility. Peer-supervisor assessments of crewmember leadership were positively associated with the need to control others and inversely associated with self-reports of absentmindedness. However, other traits and characteristics were also associated with these performance measures, but not in the expected direction. For instance, the need for order was inversely associated with emotional stability and leadership, while the need for achievement was inversely associated with social compatibility. A desire for efficiency in friends was inversely associated with emotional stability. High levels of motivation were inversely associated with evaluations of leadership, and a desire for affection from others was inversely associated with task ability, emotional stability, social compatibility, and overall performance (Palinkas et al., 2000b).

The low need for achievement and orderliness, affection from others, and efficiency in friends may reflect characteristics uniquely suited to ICE environments. Under conditions of isolation and confinement, the ability to satisfy a need for achievement and order is often restricted by the environment itself. Individuals wishing to complete projects on schedule become frustrated at delays in communication with the outside, constant equipment failure, or absence of necessary supplies (Palinkas, 1992). Prior to the advent of computerized inventory control systems, it was often quite difficult to locate necessary equipment and supplies on station, even when such materiel was physically present. Crewmembers who adapt best to such situations are those who adjust their expectations to fit the reality of the group. The second pattern was a core-periphery structure. In this structure, most (n = 16) crewmembers strongly identified themselves as members of the same group (the core), followed by five additional members who maintained close ties with the core but were somewhat more independent (semiperiphery); and six individuals who were more independent in their social interactions (periphery). The third pattern was a clique-core/periphery hybrid in which a relatively unified group contains identifiable subgroups.

A comparison of mood scores over the course of the austral winter by means of a repeated measures analysis of variance revealed a significant difference among the three crew structures with respect to tension-anxiety, depression, and anger-hostility. The crew characterized by a clique structure exhibited significantly higher levels of tension-anxiety, depression and anger than the crew characterized by the core-periphery structure throughout the entire winter. The POMS scores of the crew characterized by the hybrid structure fell somewhat in between those of the other two crews. The three crews also differed significantly with respect to the amount of support given to fellow crewmembers over the course of the winter (Palinkas et al., 2000a).

These results suggest that individual behavior and performance is indeed influenced by crew dynamics and patterns of interaction, but not by the degree of support obtained from fellow crewmembers. A previous study of the 1989 winter-over crew of McMurdo (Palinkas and Johnson, 1990) revealed that station members who scored low on measures of emotional stabilty and supervisor/clinician evaluations of individual performance were not socially isolated. This finding was in contrast to the numerous studies that have documented an association between depression and a decrease in size of social networks and amount of received social support (Cohen and Wills, 1985; Lin and Ensel, 1984). The lack of an association may be interpreted as evidence of the tolerance of depressive symptoms on the one hand (Cravalho, 1996), and the limited use of other crewmembers to cope with stress on the other hand, largely because these crewmembers are facing the same stressors (Palinkas, 1992). Hence, an important distinction must be made between social dynamics as a stressor and social support as a mediator of the stress-performance relationship. Behavior and performance in ICE environments is social from the standpoint that impaired social interaction may be responsible for decrements, but that individuals adapt to such environments by refraining from a reliance upon their fellow crewmembers for support.

4 Salutogenic Characteristics

The fourth characteristic of behavior and performance in ICE environments is that it is "salutogenic." A term coined by Aaron Antonovsky (1979), salutogenic was intended to convey the idea that under certain conditions, stress could actually be beneficial and health-promoting, and not simply "pathogenic" or destructive to health and well-being. These conditions have been identified as "flow experiences" by Czikszentmihalyi (1975) in which individuals seek out challenges and obtain increased self-esteem and self-efficacy by successfully meeting these challenges.

The human experience in the Antarctic provides numerous instances of individuals who have had such flow experiences with salutogenic results. Our analysis of the data collected since 1963 uncovered two particular sources of evidence suggesting that some individuals, at least, exhibit improvements in performance and well-being during extended periods of isolation and confinement in extreme environments. The first source of evidence was obtained from an examination of mood disturbances during early and late winter among the 657 men who overwintered between 1963 and 1974. Symptoms of the winter-over syndrome (depression, irritability, insomnia, cognitive impairment) were inversely associated with the altitude, latitude, and mean annual temperature of the stations where individuals spent the austral winter. However, when these symptoms were separated into sleep related and non-sleep related categories, an interesting pattern emerged. Complaints of disturbed sleep (difficulty falling asleep or staying asleep, waking up at night, feeling tired during the day) were positively associated with the severity of the station physical environment in early winter, but not in late winter. In other words, the winter-over personnel in this cohort had somehow managed to adapt to the characteristics of the physical environment, thereby minimizing the impact of this environment on their sleep patterns. On the other hand, other symptoms (feeling blue, lonely, annoyed or irritated, critical of others, uneasy or worried, nervous or tense, and unable to concentrate) were inversely associated with severity of the station physical environment at both early and late winter. In other words, the more severe the physical environment, the fewer mood disturbances that were not sleep-related (Palinkas, 1991b; Palinkas et al., 2000a).

Further analysis of these individuals revealed three patterns of mood disturbance: 1) an increase in symptom scores from early to late winter (63.0%); 2) no change in symptom scores (8.5%); and 3) a decrease in symptom scores (28.4%). When compared with individuals who exhibited an increase in symptom scores, the only personality traits or interpersonal needs associated with a decline in symptom scores were a low need to include others, a low need to be included by others, and a low need to express affection to others (Palinkas et al., 2000a).

A second piece of evidence suggesting some form of positive adaptation to the characteristics of the physical environment is derived from a comparison of the seasonally-related depressive symptoms experienced among personnel who over-wintered at McMurdo and South Pole Stations in 1991. Although we noted earlier that S-SAD is positively associated with station latitude, mean Hamilton Depression Rating Scale (HDRS) scores and seasonally-related depressive symptom (SAD-SIGH) scores of personnel at McMurdo in 1991 were significantly higher than the respective scores of personnel at South Pole the same year (Palinkas et al., 1996).

Third, when viewed within the context of the stress-illness paradigm, the winter-over syndrome is interpreted as the inevitable consequence of the stress associated with the prolonged isolation and confinement, apparent absence of social support, and extreme environmental conditions of the Antarctic winter. However, despite the potential degradation to health and performance associated with more severe forms of the winter-over syndrome, the Antarctic winter-over experience does not appear to have any adverse long-term effects. In fact, exposure to such stress may actually confer some long-term health benefits. Using medical and service history records as well as screening data obtained from volunteers to the Operation Deep Freeze Program between 1963 and 1974, the subsequent first hospital admissions of 328 enlisted Navy men who actually wintered-over at six small Antarctic research stations were compared with those of a control group of 2,396 Navy winter-over volunteers who were assigned elsewhere because of the limited number of available winter-over assignments (Palinkas, 1986). All of these individuals were evaluated by screening teams, each consisting of a clinical psychologist and psychiatrist, and found to be medically and psychologically qualified for winter-over duty. Both groups were followed for a maximum of 15 years with an average follow-up of 5.4 years (6.1 years for the winter-over group, 5.3 years for the control group). The study found that the winter-over personnel experienced 20% fewer total first hospital admissions subsequent to their return from Antarctica than the control group during the same period. The winter-over group also displayed significantly fewer first admissions in selected International Classification of Disease Adapted for Use in the United States, Eight Revision (ICDA-8) diagnostic categories such as neoplasms (73% fewer admissions); endocrine, nutritional, and metabolic diseases (60% fewer admissions); diseases of the musculoskeletal system (44% fewer admissions); and nonsignificant de-clines in admissions for mental disorders (36% fewer admissions) and accidental injuries (27% fewer admissions) (Palinkas, 1986).

Taken altogether, these results suggest that Antarctic service can generate positive forms of adaptation in certain individuals, particularly those with a low need for social interaction. While not all individuals obtain such an experience, these results suggest prolonged exposure to an ICE environment does not necessarily produce pathogenic consequences. On the contrary, certain individuals are likely to acquire significant psychological benefits or flow experiences from such environments.

Conclusion

Research on the psychology of Antarctic service is important for two reasons. First, it helps us to better understand some of the underlying principles of behavior in any environment and behavior in isolated and confined environments in particular. This understanding is seen as especially important in situations like long-duration missions in space where the opportunities for conducting similar investigations is limited by logistic constraints and small samples of study subjects. Second, this research is increasingly important from an operations perspective. Improvement of select-out procedures can reduce the incidence and operational impact of psychiatric disorders, while improvement on select-in procedures can serve to improve quality of life and enhance task performance on the ice. Despite the past success of these procedures and programs, further improvements in psychological screening and support are recommended to compensate for the limitations in select-out procedures. Such improvements would include the development of guidelines for COMNAP in the screening and selection of personnel for various assignments and varying lengths of time in the Antarctic, in the assessment and classification of adaptive and maladaptive forms of behavior that are specific to the Antarctic, and in the protocols and resources necessary to respond to disasters and other forms of psychological trauma. Training of Antarctic personnel to cope with non-disaster related stressors is also recommended. Further improvements in psychological screening and support are also recommended to maximize the potential of select-in procedures. Such procedures should be designed to predict for the three essential components of the psychology of Antarctic service: task ability, emotional stability, and social compatibility.

References

Antonovsky, A. 1979. Health, *Stress, and Coping*. San Francisco: Jossey-Bass

Bechtel, R. B., and A. Berning. 1991. A. The third-quarter phenomenon: Do people experience discomfort after stress has passed? In A. A. Harrison, Y. A. Clearwater, and C. P. McKay (Eds). *From Antarctica to Outer Space: Life in Isolation and Confinement*. New York: Springer Verlag, pp. 261 – 266

Carver, C. S., and M. F. Scheier. 1994. Situational coping and coping dispositions in a stressful transaction. *Journal of Personality and Social Psychology*, 66, 184 – 195

Cohen, C. S., and T. A. Wills. 1985. Stress, social support, and the buffering hypothesis. *Psychological Bulletin*, 98, 310 – 357

Cook, F.A. 1909. *Through the First Antarctic Night* 1898 – 1899. New York: Doubleday, Page & Co., reprinted in 1998 Pittsburgh, PA: Polar Publishing Company

Do, N., M. Staudacher, J. Thomas, K. Reedy, S. Case, H. LeMar, N. Finney, L. Palinkas, and H.L. Reed. 1998. The effect of thyroxine supplementation on cognitive dysfunction encountered with extended Antarctic residence. Poster presented at the Annual Meetings of the Endocrine Society, New Orleans, LA, June 25, 1998

Cravalho, M.A. 1996. Toast on ice: The ethnopsychology of the winter-over experience in Antarctica. *Ethos*, 24, 628 – 656

Csikszentmilhayi, M. 1975. *Beyond Boredom and Anxiety*. San Francisco: Jossey-Bass

Evans, G. W., D. Stokols, and S. Carrere. 1987. *Human Adaptation to Isolated and Confined Environments*. NASA report. Irvine, CA: University of California, Irvine

Guenter, C.A., A.T. Joern, J.T. Shurley, and C.M. Pierce. 1970. Cardiorespiratory and metabolic effects in men on the south polar plateau. *Archives of Internal Medicine*, 125, 630 – 637

Gunderson, E.K.E. 1974a. Psychological studies in Antarctica: a review. In O. Enholm and E.K.E. Gunderson, (Eds). *Polar Human Biology: The Proceedings of the SCAR/IUPS/IUBS Symposium on Human Biology and Medicine in the Antarctic*. Chicago: Heinemann, pp. 352 – 361

Gunderson, E. K. E. 1974b. Psychological studies in Antarctica. In E. K. E Gunderson, (Ed). *Human Adaptability to Antarctic Conditions*. Washington, DC: American Geophysical Union, pp. 115 – 131

Holahan, C.J., and R.H. Moos. 1987. Personal and contextual determinants of coping strategies. *Journal of Personality and Social Psychology*, 52, 946 – 955

Johnson, J.C., J.S. Boster, and L.A. Palinkas. In press. The evolution of networks in extreme and isolated environments. *Journal of Mathematical Sociology*.

Kasper, S., T. A. Wehr, J. J. Bartko, P. A. Gaist, and N. E. Rosenthal. 1989. Epidemiologic findings of seasonal changes in mood and behavior. A telephone survey of Montgomery County, Maryland. *Archives of General Psychiatry*, 46, 823 – 833

Lin, N., and W.M. Ensel. 1984. Depression mobility and its social etiology: The role of life events and social support. *Journal of Health and Social Behavior*, 25, 176 – 189

McNair, D.M., M. Lorr, and L.F. Droppleman. 1992. *EdITS Manual for the Profile of Mood States, Revised*. San Diego: Educational and Industrial Testing Service

Natani, K., and J. T. Shurley. 1974. Sociopsychological aspects of a winter vigil at south polar station. In E.K.E Gunderson, (Ed). *Human Adaptability to Antarctic Conditions*. Washington, DC: American Geophysical Union, pp. 89 – 114

Palinkas, L. A. 1986. Health and performance of Antarctic winter – over personnel: A follow-up study. *Aviation, Space and Environmental Medicine*, 57, 954 – 959

Palinkas, L.A. 1991a. Group adaptation and individual adjustment in Antarctica: a summary of recent research. In A.A. Harrison, Y.A. Clearwater, and C.P. McKay, (Eds). *From Antarctica to Outer Space: Life in Isolation and Confinement*. New York: Springer-Verlag, pp. 239 – 251

Palinkas, L. A. 1991b. Effects of physical and social environment on the health and well-being of antarctic winter-over personnel. *Environment and Behavior*, 23, 782 – 99

Palinkas, L. A. 1992. Going to extremes: the cultural context of stress, illness and coping in Antarctica. *Social Science and Medicine*, 35, 651 – 64

Palinkas, L. A, and D. Browner. 1995. Effects of prolonged isolation in extreme environments on stress, coping, and depression. *Journal of Applied Social Psychology*, 25, 557 – 576

Palinkas, L.A., M. Cravalho, and D. Browner. 1995. Seasonal variation of depressive symptoms in Antarctica. *Acta Psychiatrica Scandinavia*, 91, 423 – 429

Palinkas, L. A, F. Glogower, M. Dembert, K. Hansen, K., and R. Smullen. 2001. Psychiatric morbidity after extended isolation and confinement in an extreme environment: the Antarctic Space Analog Program. Abstract No. 002. *Proceedings. Bioastronautics Investigators' Workshop*, January 17 – 19, 2001, Galveston, TX (CD-ROM)

Palinkas, L.A., M. Houseal, and N.E. Rosenthal. 1996. Subsyndromal seasonal affective disorder in Antarctica. *Journal of Nervous and Mental Disease*, 184, 530 – 534

Palinkas, L.A., and J.C. Johnson. 1990. Social relations and individual performance of winter-over personnel at McMurdo Station. *Antarctic Journal of the United States*, 25(5), 238 – 240

Palinkas, L. A., E. K. E. Gunderson, J. C. Johnson, and A. W. Holland. 2000a. Behavior and performance on long-duration spaceflights: Evidence from analogue environments. *Aviation, Space and Environmental Medicine*, 71 (Suppl 1), A29 – 36

Palinkas, L. A., E. K. E. Gunderson, A. W. Holland, C. Miller, and J. C. Johnson. 2000b. Predictors of behavior and performance in extreme environments: The Antarctic Space Analogue Program. *Aviation, Space and Environmental Medicine*, 71, 619 – 625

Palinkas, L. A., H. L. Reed, K. R. Reedy, N. V. Do, H. S. Case, and N. S. Finney. 2001. Circannual pattern of hypothalamic-pituitary-thyroid (HPT) function and mood during extended Antarctic residence. *Psychoneuroendocrinology*, 26, 421 – 431

Palmai, G. 1963. Psychological observations on an isolated group in Antarctica. *British Journal of Psychiatry*, 131, 651 – 654

Potkin, S. G., M. Zetin, V. Stamnekovic, D. Kripke, and W. E. Bunney, Jr. 1986. Seasonal affective disorder: prevalence varies with latitude and climate. *Clinical Neuropharmacology*, 9, 181

-183
Reed, H. L., K. D. Burman, K. M. M. Shakir, and J. T. O' Brian. 1986. Alterations in the hypothalamic-pituitary-thyroid axis after prolonged residence in Antarctica. *Clinical Endocrinology*, 25, 55-65
Reed, H. L., K. R. Reedy, L. A. Palinkas, N. V. Do, N. S. Finney, H. S. Case, H. S., H. J. LeMar, J. Wright, and J. Thomas. 2001. Impairment in cognitive and exercise performance during prolonged Antarctic residence: Effect of thyroxine supplementation in the Polar triiodothyronine syndrome. *Journal of Clinical Endocrinology and Metabolism*, 86, 110-116
Rivolier, J., G. Cazes, and C. Bachelard. 1983. *Summary of the French Research in Medicine and Psychology Conducted with Expeditions Polaires Francaises and Terres Australes et Antarctiques Francaises*. Paris, CNFRA
Ronne, F. 1961. *Antarctic Command*. New York: Bobbs-Merrill
Sandal, G. M., R. Vaernes, T. Bergan, M. Warncke, and H. Ursin. 1996. Psychological reactions during polar expeditions and isolation in hyperbaric chambers. *Aviation, Space and Environmental Medicine* 67:227-234
Strange, R. E., and S. A. Youngman 1971. Emotional aspects of wintering over. *Antarctic Journal of the United States*, 6, 255-257
Stuster, J. C. Bachelard, and P. Suedfeld. 2000. The relative importance of behavioral issues during long-duration ICE missions. *Aviation, Space, and Environmental Medicine*, 71, A17-A25
Taylor, A. J. W. 1987. *Antarctic Psychology*. Wellington, N. Z.: Department of Scientific and Industrial Research
Xue, Z., and Y. Zhang. 1998. Psychological selection methods for winter-over members of the Chinese National Antarctic Research Expedition. *Chinese Journal of Polar Science*, 9, 49-58

Antarctic Medical Support and Standards

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Foreword

The medical support to the Italian Antarctic Research Programme is performing an operational strategy that will be shortly shown and, possibly, shared with the other Antarctic Programmes to identify a common approach to Basic Standards in medical selection of personnel and to identify guidelines for Antarctic health management

Strategy

The main targets we want to reach are:

Sending only healthy personnel to Antarctica

Making a full assessment of risk to identify the "class" of medical clearance

1. How long does he have to stay there (from a few days to winter-overing)?
2. Does any possibility of evacuation exist(by helicopter, by plane to... where)?
3. Which kind of activity will he do in Antarctica (technician ... diver)?
4. Where (inside a full organized station or nearby, on the plateau, far from stations, etc.)?

5. What level of medical assistance will be available on the site (none, paramedic, surgeon, anaesthetist, hyper-baric)?

Asking a complete medical history application form

1. It is used with newcomers only (veterans must certify that did not have any medical problem since their last expedition).
2. Asking for symptoms instead of diagnosis is more useful to avoid incomplete declarations.
3. The limit of the applicant's medical history is the possibility of false or incomplete answers due to the fear of being disqualified.

A deep medical screening (following indications of the medical history)

1. Must identify (when possible):
   Diseases and malformations that are not compatible with Antarctic expeditions
   Hidden pathologies
2. Must avoid:
   Disqualification of important scientists whose medical problems would not affect their permanence or the safety of the whole personnel. To perform this target we follows the recommendation edited by Desmond Lugg when he was the chairman of the Working Group of Human Biology and Medicine of SCAR and Health Officer of ANARE. (An international common approach to medical screening for an easier interchanging of personnel coming from different countries would be a goal!).
   Invasive medical examinations
   Repetitive and expensive medical exams to those people who have recently been in Antarctica without problems

Maintaining the Antarctic personnel in good healthy conditions during his staying in Antarctica

Send expert physicians and, possibly, expert paramedics, trained about:

1. Life support and resuscitation (A training on first aid and emergency is made before departure. Maybe an international protocol as ACLS and/or ATLS should be required to the doctors. Many devices are available both at the Italian station and at the French/Italian station [Concordia] providing defibrillation, monitoring, blood values assessment).
2. Surgery in bleeding emergency (Life saving in case of a bleeding emergency requires a good surgeon and a good anaesthetist. No blood bags are available at the Italian Antarctic stations, but the doctors know the blood types of each participant and everybody learned that his blood could be helpful in case of an

emergency during the training courses).

3. Traumas (A lot of instruments have been supplied for managing traumas, including X-rays, external fixation and surgical orthopaedic bed. Since we cannot have both a surgeon and an orthopaedist at the antarctic stations so we look for applicants who are surgeons with a good knowledge of orthopaedics or orthopaedist with a good knowledge of surgery).

Medical and surgical supplies in Antarctica:

1. An operating theatre and surgical instruments must be available (We think that a surgeon + an anaesthetist is the minimal required medical team. We cannot forget that the doctor could become a patient too!).
2. A wide range of pharmaceuticals must be provided (Even if a big quantity of drugs is provided, each year there is a patient who needs a not available drug. An international common list of essential pharmaceuticals would be welcome!).
3. Telemedicine (In Antarctica the telemedicine is now present as "priority" of research and as "essential" supply of operational medicine. International standards of communicating medical information would be useful!).

Medical survey of the personnel (Doctors must visit the personnel many times during the expedition because consults on demand could not verify clinical or psychological abnormalities!)

Allowing exchange of personnel among Antarctic stations

Using similar procedures of medical screening

Using standard criteria of disqualifying applicants

Allowing medical clearance by the sending country

Using standard templates for clinical reports (in English)

Studying minimal standard requirements of medical facilities in an Antarctic station

Encouraging co-ordination among health officers

1. to define guidelines and strategies
2. to make a virtual permanent forum
3. to periodically meet themselves
4. to exchange between continuous information with the WGHBM (or Medical Branch of Antarctic Life Sciences):

(1) to increase the operational medicine knowledge with the scientific results of medical research

(2) to give operational support to Antarctic scientific medicine

Changes of Serum Thyroid Hormone and Plasma Catecholamine of Expedition Members in Antarctic Environment

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Abstract: The changes of serum thyroid hormone total thyroxine (TT4), triodothyronine (TT3), thyroid stimulating hormone (TSH) and plasma catecholamine, including norepinephrine (NE), epinephrine (E), dopamine (DA), were investigated in 10 male Antarctic expedition members (in Great Wall Station) under extreme environmental condition by Chemoluminescence Immunoassay (CLIA) and High Performance Liquid Chromatography with electrochemical detection (HPLC-ECD). Samples were taken in different time: (1) before leaving for Antarctica (2) returned to China after living for 1 year and 2 weeks in Antarctica. Comparing of before leaving and returned, results showed that there was a significant decrease in the contents of TT4 ($P<0.01$) with no significant change in the content of TT3. It was also found that the content of TSH increased significantly ($P<0.01$); No significant changes of plasma NE and DA were found but the content of E decreased significantly ($P<0.05$). The results indicated that the special Antarctic environment led to a restrain effect on the thyroid function and the level of plasma E in Antarctic expedition members. Both the thyroid and adrenal medulla system were associated in response to the Antarctic systemic stress human bodies and environments.

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Key words: Antarctic, expedition members, thyroid hormone, and catecholamine.

Introduction

Antarctica is the highest, driest, coldest and windiest continent on the earth. It also has no indigenous inhabitants. Due to the extreme and isolated environment, there are both physiological and psychological stressors in Antarctica. The expeditioners need to adapt to Antarctic extreme and isolated environment. This adaptation requires the changes of regulation enable to obtain new pyschophysiological homeostasis as stress reaction.

In 1984 China constructed the Greet Wall Station in the area of King George Island and dispatched the first Antarctic research expedition to conduct scientific investigation. Since then a series of human physiological and psychological changes were found during the expedition members staying and working in Antarctic Great Wall Station and Zhong Shan Station (Xue et al., 1989; 1998; Xue zhohong et al., 1990; Yu et al., 1991), for example, temporarily decline of cardiac and immune function and flexibility of higher nervous system activity (especially in winter) took place, and the desynchronization process on electroencephalogram increased suggesting stress on higher nervous system increased. Changes of endocrine were involved and might play important role. Our previous results showed that plasma cortical was increased and urinary adrenaline and noradrenaline were increased as well, but no data of plasma catecholamine were obtained.

Reed and Palinkas (Reed et al., 2001; 1995; 1990; 1986) found people who live and work in Antarctica longer than four to five months develop a characteristic constellation of symptoms and thyroid hormone changes called the Polar T3 syndrome. Elevated thyrotropin stimulating hormone (TSH) and decreased total triiodothyroronine (T3), thyroxine (T4), and free T3 were found and was associated with depressed mood. Considering physiological and physiological differences may exist between Chinese people and western people due to different race, society and cultural background. Present study is to observe the influence of pyschophysiological chronic stress on neuroendocrine in 16th winter-over Chinese expedition members. The changes of thyroid hormone and adrenal medulla hormone were examined and the relationships between them are expected to expose.

Methods

2.1 objects

Objects for the study were 10 male members of the 16th Chinese Antarctic Research Winter-over Expedition (the Great Wall Station) with average age of 35.6 (SD = 6.5). Everybody was required to be evaluated medically and psychologically and be qualified for winter-over duty. They departed and returned by airplane. Samples were taken in different times: (1) before departure for Antarctica (1999/12/09). (2) Returned to China after living for 1 year and 2 weeks in Antarctica (2000/12/25). Before venous blood was taken, each individual was required to be hollow, sedentary and had a rest for 30 min. The blood sample was divided into two parts, one part (test plasma catecholamine) was anti-coagulated by heparin, and then centrifuged for 15 min (3000r/min) in 4℃. Another part (test serum thyroid hormone) was allowed to clot at room temperature, and then separated and stored at −70℃. All samples remained at this temperature until co-assayed.

2.2 Measures

2.2.1 Serum thyroid hormone

The changes of serum thyroid hormone total thyroxine (TT4), triodothyronine (TT3) and thyroid stimulating hormone (TSH) were investigated by using Chemoluminescence Immunoassay (CLIA). TT3, TT4 and TSH were analyzed by using Automated Chemiluminescence's System (ACS: 180) CHIRON reagent box from Bayer company of Germany. The main ingredients are: (1) TT3: monoclonal mouse anti-T3 antibody (~300ng/vial) labeled with acridinium ester in buffered saline with sodium azide (0.1%), sodium barbital, and ANS. (2) TT4: monoclonal mouse anti-T4antibody (~5ug/vial) labeled with acridinium ester in sodium barbital buffer with protein stabilizers, ANS, EDTA, and sodium azide (0.1%). (3) TSH: monoclonal mouse anti-TSH antibody (~1.67ug/vial) labeled with acridinium ester in HEPES buffered saline with protein stabilizers, sodium azide (< 0.1%), and preservatives. The reference ranges for these assays are: TT4: 4.30 − 12.50 ug/dL, TT3: 0.66 − 1.92 ng/ml, TSH: 0.38 − 4.34 uIU/mL

2.2.2 *Plasma catecholamine*

The changes of plasma catecholamine, including norepinephrine (NE), epinephrine (E) and dopamine (DA) were tested by High Performance Liquid Chromatography with electrochemical detection (HPLC-ECD), according to the method of Chen Lanying (1990), using the catecholamine analytic instrument of Weters Company. The main ingredients (purchasing from Sigma company) are: norepinephrine (NE), epinephrine (E), normeta nephrine (NMN), 3, 4 – dihydroxyphenyacetic acid (DOPAC), dopamine (DA), metanephrine (MN), homovanillic acid (HVA), 3,4 – dihydroxybenzylamine (DHBA).

All tested data was indicated by X ± S, and dealt with statistically *t* examination. It indicated significant when $p<0.05$, and more significant when $p<0.01$.

Results

3.1 The changes of serum thyroid hormone TT3, TT4 and TSH

Results showed that after living for 1year and 2 weeks in Antarctica, serum TT4 decreased ($p<0.005$), and TSH increased ($p<0.01$). No significant change of serum TT3 ($p>0.5$) was found. (Table 1)

Table 1. Changes of Serum TT3, TT4 and TSH content in Antarctic Expedition members(X ± S)

	TT3 (ng/ml)	TT4(ug/dl)	TSH(uIU/ml)
(1) before departure for Antarctica	1.566 ± 0.316	8.047 ± 1.469	1.544 ± 0.592
(2) returned to China after living 1 year	1.577 ± 0.221	7.227 ± 1.152	2.099 ± 0.695
(1) compare with (2) (significance level)	**P** = 0.871	**P** = 0.004	**P** = 0.006

3.2 The changes of plasma catecholamine NE, E and DA

After living 1year and 2 weeks, Plasma E decreased ($p<0.05$), plasma DA decreased but no statistical significance, and plasma NE remained unchanged.

Table 2. Changes of Plasma catecholamine content(ng/ml)in Antarctic expedition members(X ± S)

	norepinephrine(NE)	epinephrine(E)	dopamine(DA)
(1) before departure for Antarctica	0.631 ± 0.188	0.119 ± 0.051	0.059 ± 0.084
(2) returned to China after living 1 year	0.684 ± 0.238	0.071 ± 0.025	0.031 ± 0.034
(1) compare with (2) (significance level)	**P** = 0.468	**P** = 0.026	**P** = 0.309

3.3 Comparison on TT4 and epinephrine (E)

Both TT4 and E significantly decreased after living for 1 year and 2 weeks in Antarctica.

Discussion

It is known that the changes of psychological behavior and physiological action were effected and restricted with each other. The changes of psychosocial distress always result from stress, then lead to changes of regulative net of society-psychology-nerve-endocrine-immunity. In order to research systematically the regulative factors of nerve-humor- endocrine, which involved change of psychophysiology and behavior, we selected factors such as NE, E, DA, TSH, TT3, and TT4 to observe.

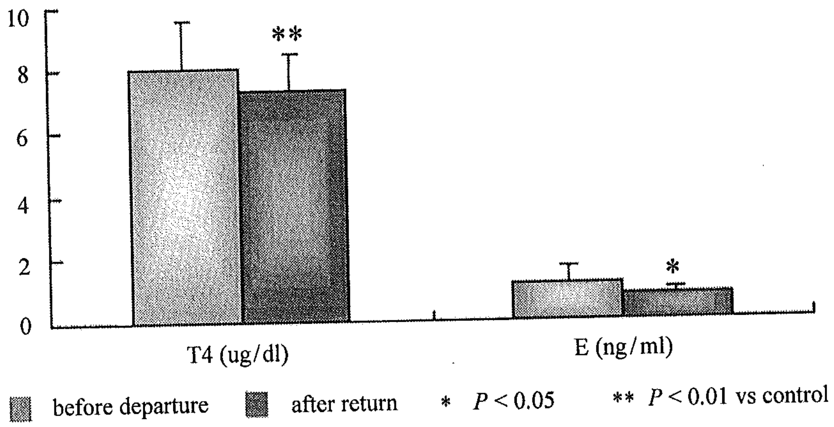

Fig. 1 Comparison on TT4 and epinephrine(E) of Antarctic expedition members before departure and after return

By comparing the content of thyroid hormone of the expeditioners(between before departure and returned after living 1 year and 2 weeks in Antarctica), the results showed that there was a significant decrease in the contents of TT4 ($P<0.01$) and with no significant change in the content of TT3. It was also found that the content of TSH increased significantly ($P<0.01$). The results are similar to the clinical finding: in the serum of client with hypothyroidism, the content of TT3 is normal; TT4 is decreased and TSH is increased. Among the adult, hypothyroidism is characterized by poor mentation, poor memory, and lack of initiative, and other psychological changes may also occur. It was known that TSH release is controlled mainly by the hypothalamic thyrotrophin releasing hormone (TRH), with small inhibitory effects exerted by somatostatin and dopamine. The other major controlling influence is from circulating factors, such as the thyroid iodothyronine hormones, which exert direct and indirect negative feedback effects at pituitary and hypothalamic levels. TRH nervous cells accept information from other part of nervous system, also to conform the influence of environment, and then release TRH, so makes feedback of the hypothalamic-pituitary-thyroid (HPT axis).

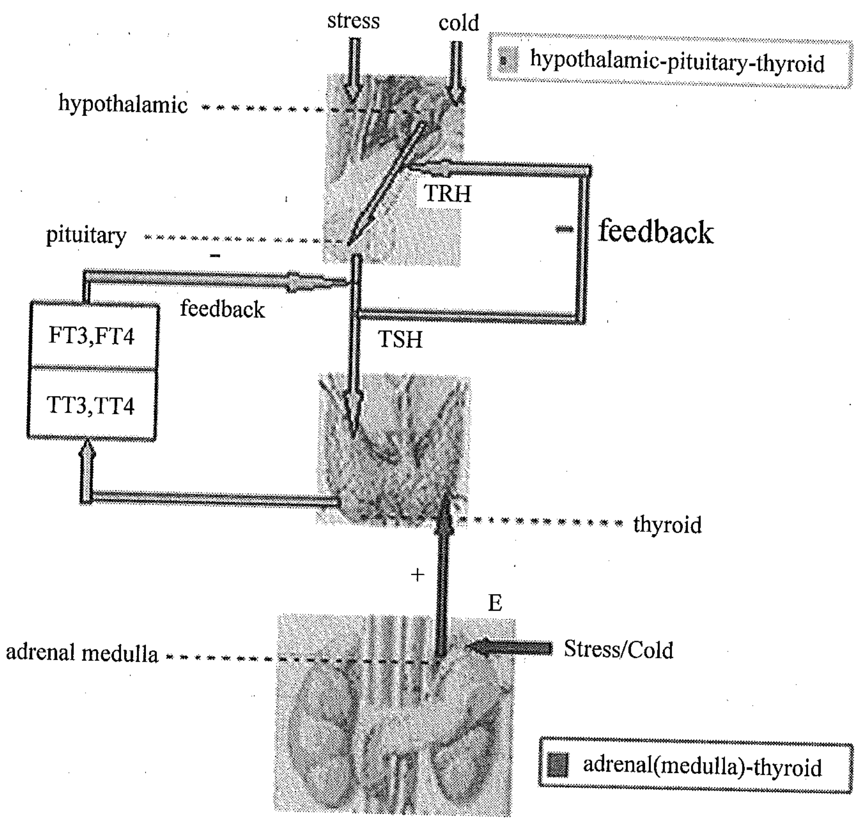

Fig. 2. The hypothalamic-pituitary-thyroid and the adrenal medulla - thyroid pathway

Groscoles (1989) found plasma T4 decreased to 1/3 of normal level in fasting emperor penguins after confinement, but free fasting emperor penguins had no changes. Reed (2001) reported that after 4 months Antarctic residents had taken L-thyroxine supplement to improve cognition, which seems to be related to circulating of T4. These results demonstrate the acute sensitivity of thyroid hormone balance to stress.

It is known that central never system controls endocrinal glands via hypothalamic-pituitary-target gland pathway, with exception of a few glands such as adrenal medulla and conarium. Recent research indicates that thyroid function may be regulated by sympathetic nerve-thyroid pathway, as well as the negative feedback pathway of the hypothalamic-pituitary-thyroid. E makes thyroid gland releasing thyroid hormone. The sympathetic nerve-thyroid pathway can be excited due to the different acute changes of inside and outside circumstance, which insures the releasing of thyroid hormone to adapt to environment either stillness or stress.

We found both TT4 and E deceased after living for 1year and two weeks in Antarctica. Clinic finds the levels of plasma catecholamine decreasing in patient with hypothyroidism; but increasing in patient with hyperthyroidism. It is obvious that psychological chronic stress is associated with development of behavioral symptoms or mood disorder; and also can activate both the hypothalamic-pituitary-thyroid and adrenal (medulla)-thyroid systems, leading to change of neuroendocrine hormones. The results indicate that the special Antarctic environment led to a restrain effect on the thyroid function and the level of plasma E in Antarctic expedition members. Both the thyroid and adrenal medulla system were associated in response to the Antarctic systemic stress to maintain the balance between human bodies and environments.

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References

Xue Quanfu, Deng Xixian, Cai Y N et al. 1989. Changes of cardiac and repiratory function in Antarctic research expedition members in the Antarctic. Proc. of Int. Sym. Of Antarctic Research, Beijing, China Ocean Press, 372

Xue Zuohong, Xue Quanfu, Xie Jianming. 1990. A primary investigation of personality and behavior among the expedition member in Great Wall Station in Antarctica. Acta Scientiarum Naturalium. Universitis Pekinensis (in Chinese), 26(3): 375

Yu Yongzhong, Wan Zonghui, Deng Xixian et al. 1991. Observation of immunoglobulins of Antarctic expeditioners. Chinese Jounal of Industrial Hygiene and Occupational disease (in Chinese), 9(4): 235

Reed HL., Reedy KR., Palinkas LA., et al .2001. Impairment in cognitive and exercise performance during prolonged antarctic residence: effect of thyroxine supplementation in the polar triiodothyronine syndrome.J Clin Endocrinol Metab, 86(1): 110

Reed HL 1995. Circannual changes in thyroid hormone physiology: the role of cold environmental temperatures, Arctic Med Res, 54 (12): 9

Reed HL., Silverman ED., Shakir KM., et al. 1990. Changes in Serum Triiodothyronine (T3) Kinetics after Prolonged Antarctic Residence: the Polar T3 Syndrome. J Clin Endocrinol Metab, 70 (4): 965

Reed HL., Burman Kd., Shakir., et al. 1986. Alterations in the hypothalamic--pituitary--thyroid axi after prolonged residence in Antarctica. Clin Endocrinal, 25(1): 55

Palinkas LA., Reed HL., Reedy KR., et al. 2001. Circannual pattern of hypothalamic-pituitary-thyroid (HPT) function and mood during extended Antarctic residence. Psychoneuroendocrinology, 26: 421

Groscolas R., Leloup J. 1989. The effect of severe starvation and captivity stress on plasma thyroxine and triiodothyronine concentrations in an antarctic bird (emperor penguin). General and Comparative Endocrinol, 73(1):108

Medical Events and Records Transfer

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All BAS staff and visitors are medically screened before deployment to the Antarctic. Initially, such medical data is recorded on paper at the point of contact with medical staff in the UK or abroad. The BASMU 3 form is an extensive questionnaire completed by the applicant and reviewed by the medical practitioner. The BASMU 4 form is completed by the medical practitioner on examination of the applicant. This data plus standard Blood Donor Screen results make up the core of an individuals medical record for Antarctic deployment purposes.

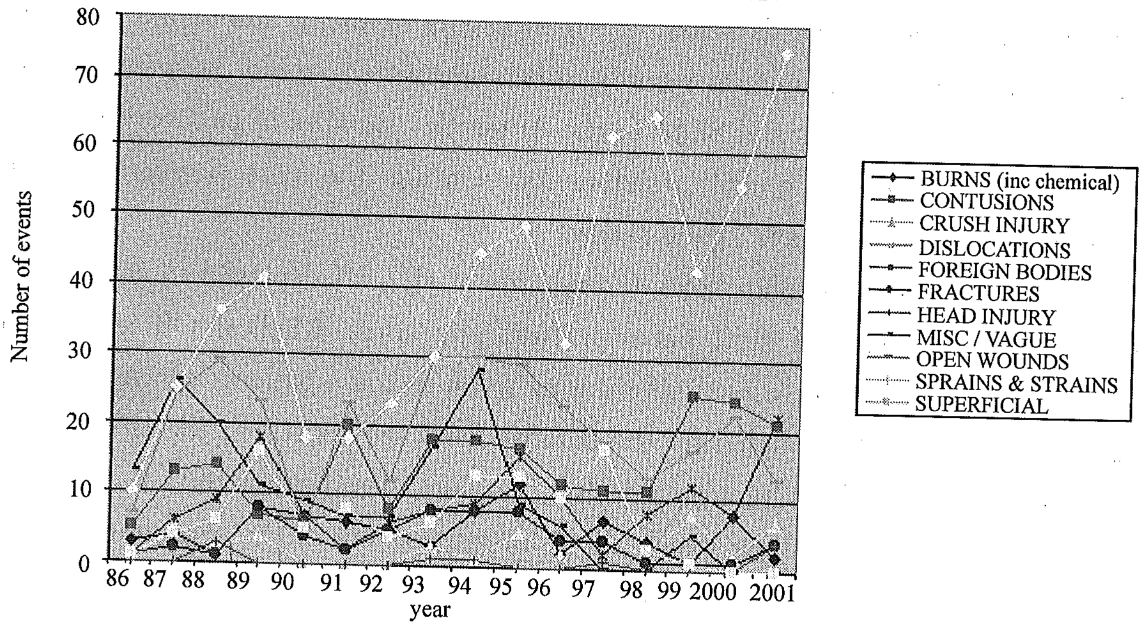
The above data is transferred to a custom built database which has identical electronic copies of the forms mentioned above. Using this Microsoft Access platform, a simple to use database which incorporates many automated one touch button functions; allows medical records to be transmitted rapidly between the BAS Medical Unit and Stations and Ships in the Antarctic. Bundles of password protected data tables are sent as e-mail attachments. During the past 5 years no such attachment is known to have 'gone astray'.

Each BAS Station and Ship holds the records of all staff deployed to cater for the complicated movement of staff between Antarctic sites. Medical Officers on site complete simple electronic consultation forms when seeing a patient. Once per month these are automatically collated by the database and sent north to the BAS Medical Unit. The World Health Organisation, International Classification of Diseases version 9; is held within the database which allows instant coding of the consultations. The analysis of such codes gives a valuable insight into medical trends and medication usage.

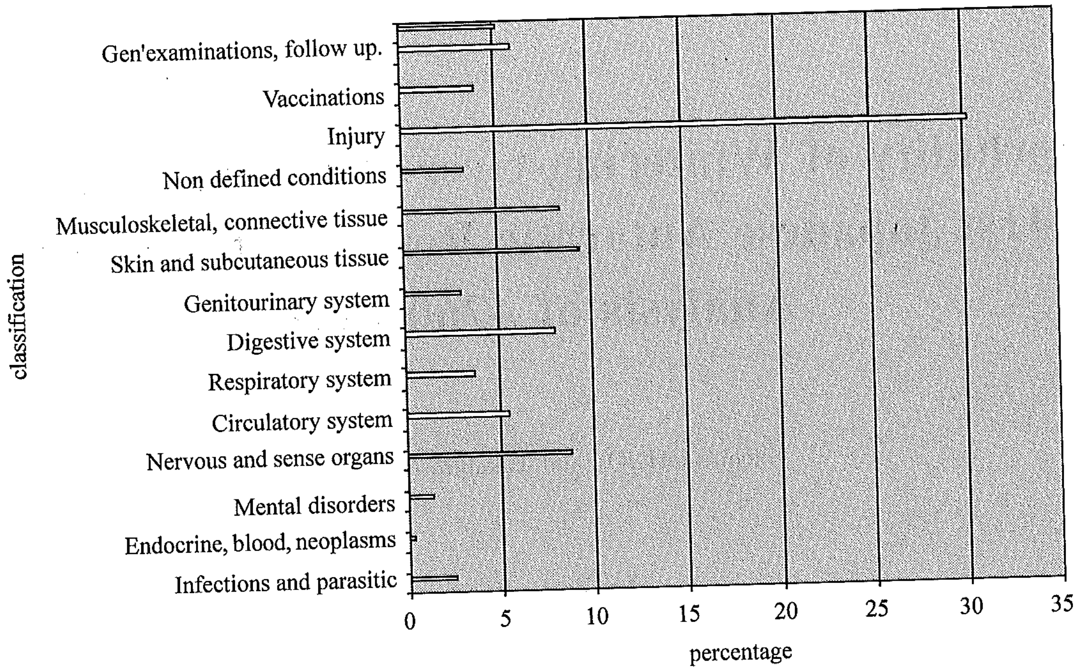
The size of the entire database is 4.2Mb. The average size of files being sent to and from the Antarctic holding medical data is 240Kb, however all such files are compressed to about 45Kb prior to transmission. An individual is able to use the database after a 30 minute introduction. A complete paper record can be entered into its electronic format within 10 minutes. Each remote site holds an independent database, which avoids problems caused by communication breakdowns. Medical summary sheets are automatically produced for quick reference to baseline data.

The analysis of annual consultations data via ICD codes has allowed medical trends to be viewed and acted upon. Data collected by an earlier system was incorporated into the present database. The updating of statistic presentations as shown below takes about 15 minutes annually. (It should be noted that staff numbers being deployed each season has risen by 40.6 % during the past 15 years). The review of such data has resulted in policy changes, medication stock updates and changes to working practise guidelines e.g.

- Provision of Slit Lamps due frequency of eye injuries.
- Physiotherapy training enhanced for Medical Officers.
- Increase in stock levels of certain drugs to cater for 'older' BAS population.
- Certain drugs included in stock to cater for cardiac and blood pressure related medical events.
- More widespread use of advice re Dehydration, CO poisoning, Diving related illness, Eye injuries and Dermatological problems.
- Health and Safety advice emphasised and strengthened re man handling.
- Changes to the contents of the Field Medical Boxes.



Medic Events 1986 onwards



Diesease, infection, injury in 2001(% of consultations)

Morbidity of Wintering-Over Participants In 1st to 41st Japanese Antarctic Research Expeditions: Analysis of 4760 cases

Giichiro OHNO* and Takahiro MIYATA**

Introduction

The aim of this research is to clarify the trend of diseases during Antarctic wintering, provide information useful to work out countermeasures and also for each member of the wintering team to control his health.

We have investigated 4760 cases of diseases in the wintering-over team of Japanese Antarctic Research Expedition (hereinafter referred to as JARE). This is a report on the characteristics of the diseases together with the experience of JARE 39. The result of the question airing conducted on the medical treatment system at the stations of various nations will also be reported.

Method

The tabulation this time was made from JARE 1 st to 41 st.

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The number of personnel is 1236 including 3 females. The number of members was 11 at first, but increased gradually to 40 at present, which is taken as the standard. The age of personnel is from 21 to 56 (average 33.1) and the oldest age and mean age are increasing gradually. Of them, JARE 2^{nd} and 6^{th} expeditions with no wintering carried out were excluded. The 1 st and 24^{th} expeditions without tabulation of disease/injury during wintering were excluded. So, the tabulation was made for 38 wintering teams. The total number of diseases was 4760. Analyses of monthly morbidity are made for the data of 1^{st} to 39^{th}.

Results

1 Proportion of diseases by medical department

The highest percentage was found in the surgical/orthopedic domain at 45%, followed by internal medicine at 23% and dentistry at 13%. The incidence of dental diseases was similar to that in the previous reports. Others included dermatology, ophthalmology and otorhinolaryngology, extending over almost all domains. According to yearly changes in the percentage of various departments, Surgery/ orthopedics, internal medicine and dentistry form 3 major domains. Other domains tend to increase, although with some differences, for example, ophthalmology in one occasion and psychiatry in another.

2 Number of disease /injury per member during wintering

According to the Chronological statistics of JARE, disease/ injury occurred 4.0 times per member per wintering. Difference in the action program and criteria for description by physicians preclude simple comparison, but it can be said that the number of diseases does not decrease. The incidence was 5.1 for the 39^{th} team. Department saw with not much difference with 5.1 times in researchers and 5.2 times in the logistic department. By age, the incidence was high in the younger generation of 20s at 6.1 against the mean of 5.1. It decreased in the 30s at 4.5 and 40s at 3.7 but increased sharply in the 50s at 7.0. This suggests that young men in their 20s overwork and that those in their 30s and 40s are good at controlling their health. Those past 50 find their work too hard to do physically. Health control in the 20s and 50s to be important.

3 The occurrence of disease by month

The graph shows the incidence of disease per month, with the number of cases occurring a year as 100% (Fig. 1).

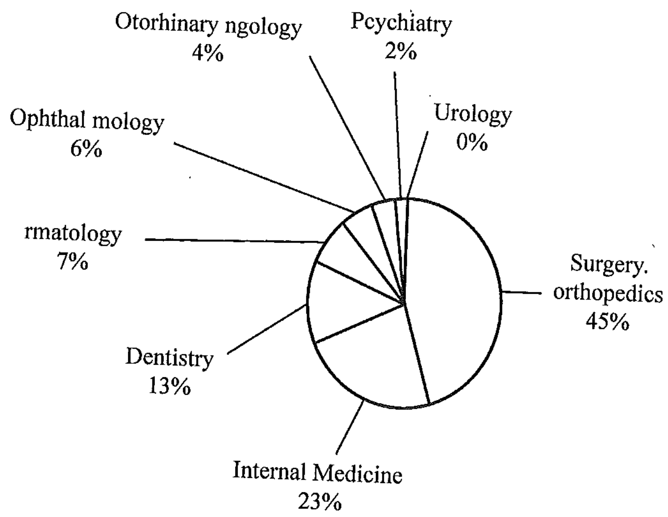

Fig. 1. Population of diseases of wintering personnel at Syowa Station (4744 cases): 1957 – 2001

On the whole, the incidence is decreasing gradually. In the domain of surgery/orthopedics, it tended to be low in the polar night period and high in the first half and second half of wintering, but decreases gradually when viewed throughout the year. In the domain of internal medicine, it remained almost the same throughout the year. In dentistry it was high in the second half, while in dermatology and ophthalmology it tended to be high in summer. In the domain of psychiatry, it was high during the polar night period.

3.1 Surgery/orthopedics

The incidence of injuries is high (Fig. 2). Acute injuries such as trauma and sprain occurred frequently at the beginning of wintering and decreased during the polar night period but increased slightly during the second half of wintering. Injuries considered accumulation of chronic fatigue such as impaired locomotors apparatus of the body, hernia with low back pain and fracture tended to occur frequently in the second half of wintering. Hemorrhoids occur frequently in winter as it is usually aggravated with coldness. However it was decreased during the polar night period because of the outdoor activities being restricted. Chilblains were bipolar. The temperature in April and May was around -20C whit is by no means classified as cold in the Antarctic.

However, this coldness is one, which we have not experienced in Japan, and it is a season in which the temperature drops rapidly. Frostbites are partly caused by Carelessness. The member become careful through such an experience and consequently the incidence of frostbite decrease. However, it becomes high again in September and October. Because these months fall on the coldest season and outdoor activities increase, the members cannot prevent frostbites even with utmost care. Therefore, it is important to regard frostbite as something unavoidable here and to prevent it from becoming severe.

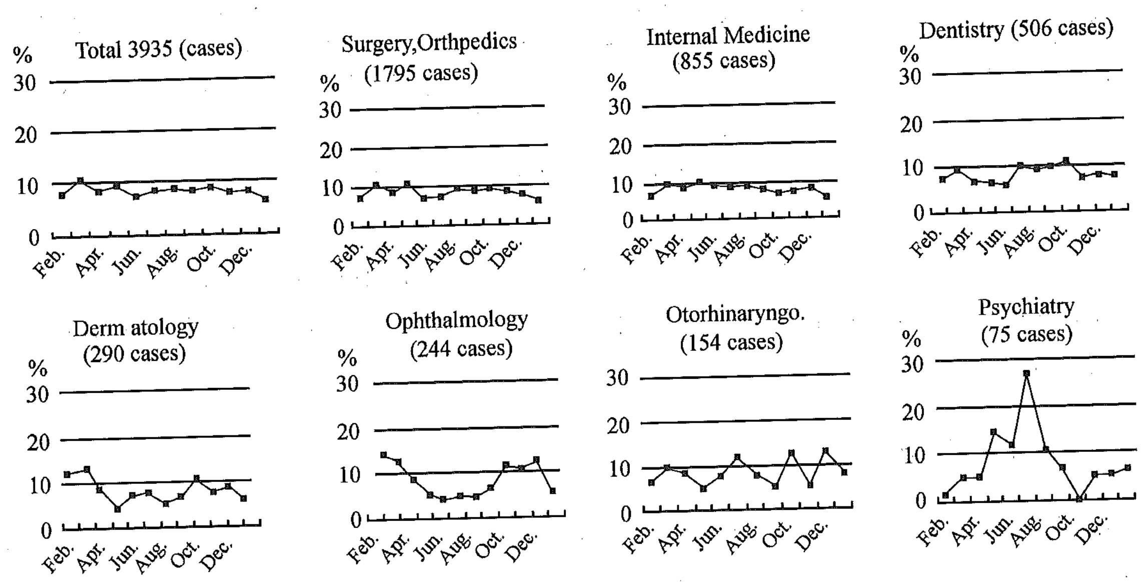

Fig. 2. The occurrence of diseases by month

3.2 *Internal diseases*

The incidence was high in the digestive system, the respiratory disease and the cardiovascular system (Fig. 3). Diseases of the digestive system and respiratory diseases decreased gradually. Of the cardiovascular diseases such as high blood pressure occurred frequently at the beginning of wintering but decreased gradually. Headache tended to develop in spring.

3.3 *Carbon mono oxide poisoning*

The Carbon mono oxide poisoning (CO poisoning) occurred frequently in the first half of wintering and decreased gradually. This is probably because the members of the team become accustomed to the use of headache and vehicles, which are related to this poisoning. The rate of monthly occurrence of carbon monoxide poisoning and the one at the right shows the number of yearly occurrence. Carbonmonooxide poisoning does not occur after JARE 21st. Particularly here snow tractors are switched from K

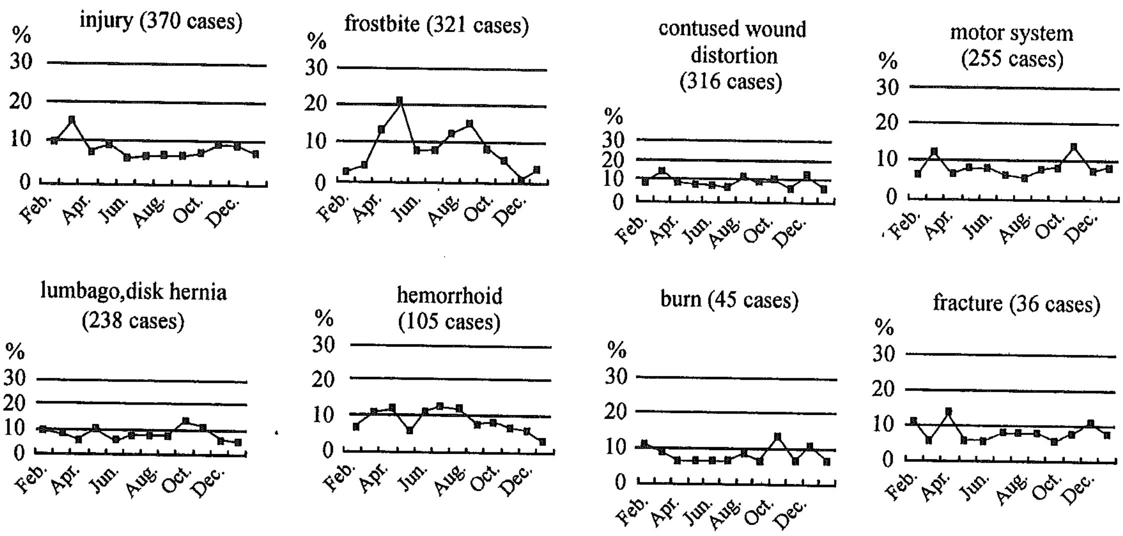

Fig. 3. The occurrence of surgical diseases by month

series to S series. With this as a turning point, gas poisoning ceased to occur. Improvement in the living foundation like this leads to prevention of occurrence of disease and injury.

3.4 *Dental diseases*

The incidence of infections was the highest, followed by falling off metal. The falling off metal is said to be caused by the difference in thermal expansivity between teeth and metal and also by inhaling of cold open air. It appears to occur frequently when the outdoor work is active. Broken teeth are due to injuries, but they are not consistent with the distribution of injuries. This shows the possibility that the problems of calcium metabolism and intake of nutriments during wintering presented.

3.5 *Dermatological diseases*

Photo dermatitis and angular stomatitis related to UV ray converge on spring.

3.6 *Otorhinolaryngolgy*

The occurrence of intrabuccal ahptha, laryngitis and rhinitis is seen.

3.7 *Ophthalmology*

The problem of foreign body is the most. It occurs frequently at the time when snow is decreased and dusts increase. Snow blindness occurs frequently in summer, but the incidence is higher in early spring.

3.8 *UV ray related diseases*

Are UV rays strong in the Antarctica? The graph (Fig. 4) shows the amount of UV rays in near the equator and at the Antarctic in December, March, April and November. It shows changes from sunrise to sunset as well as the direct direction to the sun, zenith and horizontal direction. At the equator UV rays direct from the sum were strong, and UV rays from the zenith were the same as those direct from the sun. However, UV ray in the horizontal direction decreased as the sunrise. In the Antarctic, the amount of UV rays changes with season. It was as large as that of the equator in November, the month of the ozone hole. Moreover, the angle of the sun is low, so the UV rays in the horizontal direction are strong throughout the day. This means that at the Antarctic under the influence of the ozone hole humans are exposed to UV rays stronger than those at the equator.

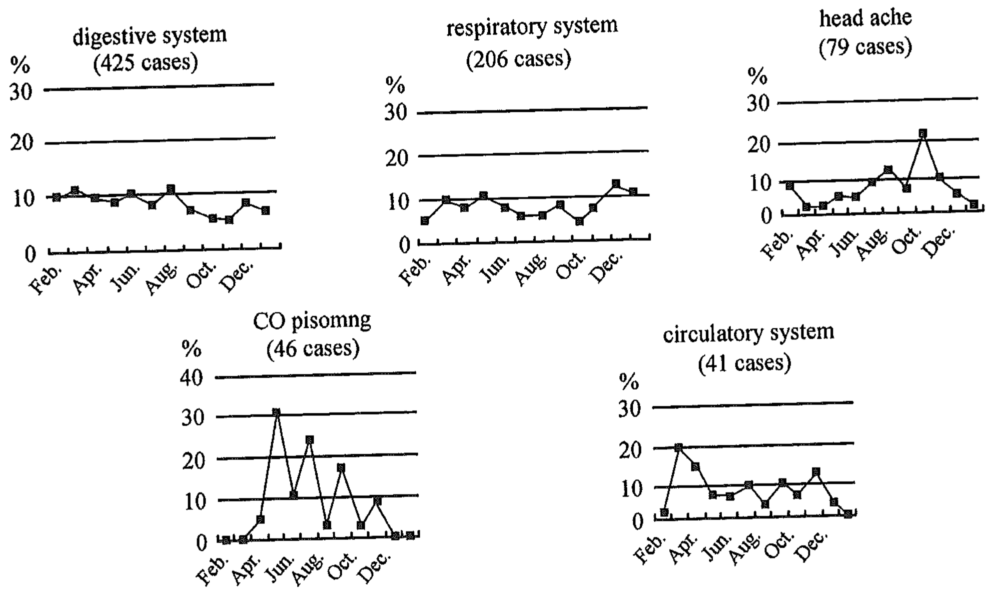

Fig. 4. The occurrence of internal medical diseases by month

4 The cause of diseases

We divided the cause of diseases in the 39th team into 3, namely climate, work and daily life (Fig. 5). Frostbite during work is calculated as both work and climate. Daily life related diseases were seen throughout the year. Climate-related diseases and work-related diseases increased in spring.

At the first period of wintering, works was concentrated mainly in and around the base because emphasis was placed mainly on the preparation for wintering. During the polar night, the outdoor activities are not suitable and asking help is absolutely impossible, so activities decrease. With the end of the polar night, outdoor activities

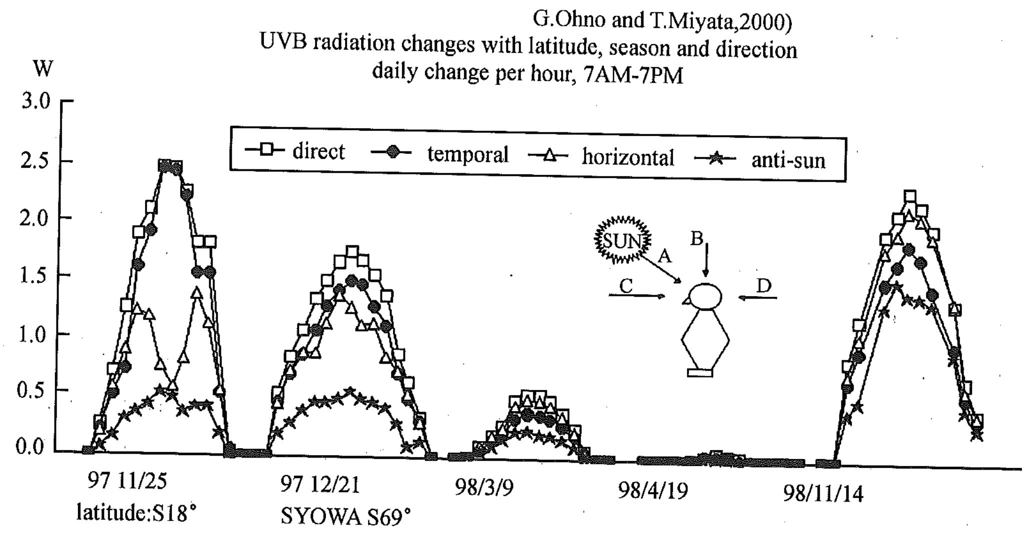

Fig. 5. Is ultraviolet B ray(UVB)in Antarctica so strong

begin on a full scale. This period coincides with the coldest season.

The sports event was far from serving the purpose of increasing the physical strength. Ten percent of the injuries during wintering were due to the sports events. However, this seems to have helpful for making the members actually feel the environment of Antarctic and also for preventing serious accidents.

5 Stress related diseases

Stresses can be said to increase at the time the incidence of these diseases is high. Insomnia had a peak in the polar night period, while headache peaked in around October. Cardiovascular diseases such as high blood pressure and digestive system decreased gradually. The peak varied with each disease. This suggests the diversity of stress.

The total of these stress-related diseases shows the intensity of stress (Fig. 6). Three peak, namely at the beginning of wintering, polar night period and second half were formed, which appeared to be consistent with member's actual feeling based on the individual experience.

We asked personnel a question: when did you become accustomed to the Antarctic? The question consisted of three items; interpersonal relations, mode of life and physical condition (Fig. 7). At the beginning of wintering, only 30% of the members assimilated with the interpersonal relations and mode of life. Growing familiar gradually, all members were accustomed to these two items at the end of the polar night. As for the physical condition, it was low at the beginning of wintering, and it was not until October that all the members felt accustomed physically to the

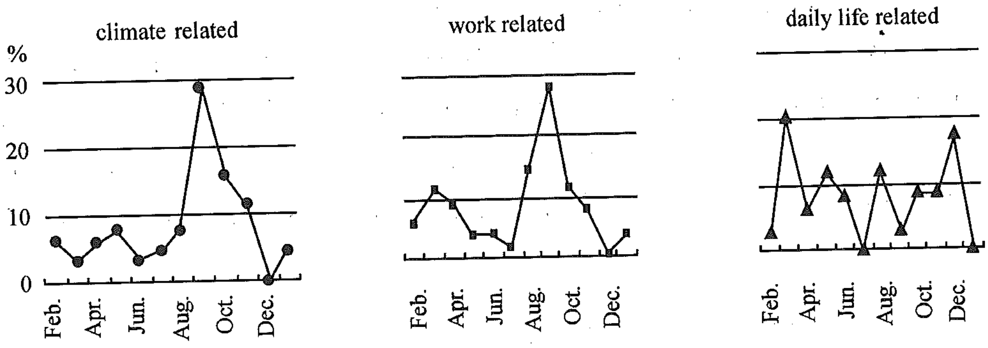

Fig. 6. The cause of diseases in JARE39(39 personnel, 199 cases)

Antarctic. This means that they did not become accustomed to the Antarctic until the coldest season was over.

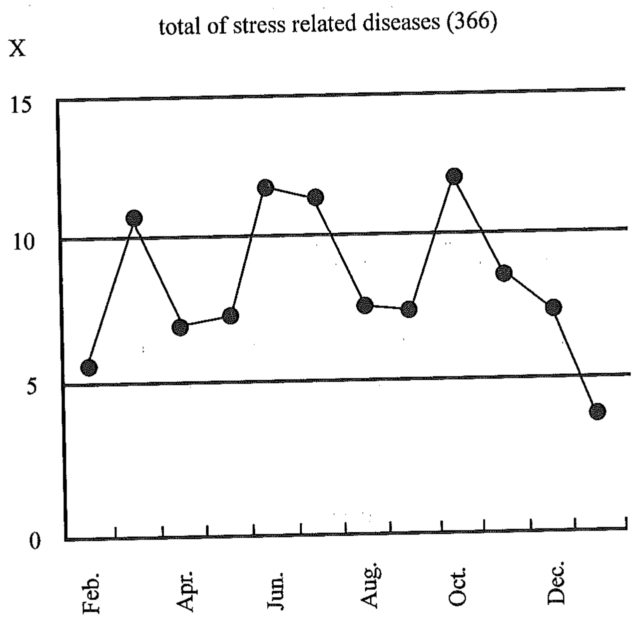

Fig. 7. Annual change of total of stress related diseases
n = 366, JARE 1 - 39

6 Medical systems comparing with other stations

The Japanese team has two doctors each year as a standard. Surgeons were the most 53%, followed internalist as 12%. They are a group of physicians good at treating diseases of which incidence in high. A psychiatrist is needed to resolve the problem of stress studied earlier. However, no psychiatrist has ever wintered.

The 39th team conducted a survey on the stations of various nations. We got information about 14 stations of 10 nations. As for the number of team, McMurdo station was conspicuous with 150. SYOWA station had 40. As for the number of wintering doctors, only Japan had two. As to the route of evacuation in emergency, many nations including Japan still rely on ships.

At the SYOWA station one death from blizzard is recorded. There have been 76 death cases in 14 stations in the past; 9% from diseases, 72 % from accidents (Fig. 8). Major fatal disease was heart attack, it may be difficult to save at any Antarctic station. Seventy-three percentages of fatal accidents involving airplanes and helicopters.

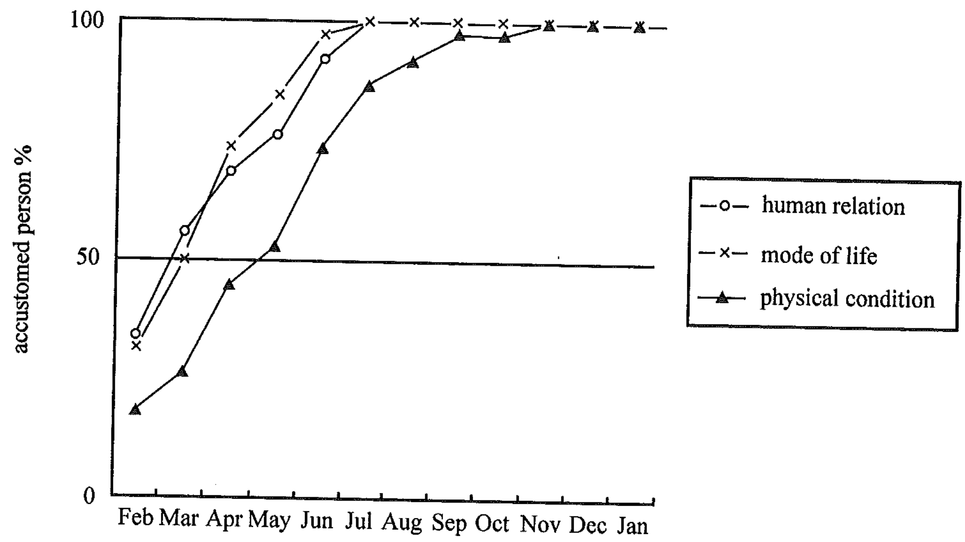

Fig. 8. Population of accustomed to Antarctica
n=38、Syowa station, 1998

Summary

Tendency of diseases in Antarctic is reported based on 4760 cases of JARE from 1st to 41st at Syowa station.

disease	heart attack	4
	myocardial in farction	2
	hem orrhagic peptic ulcer	1
accident	aircraft accident	40
	falling through sea ice/cre	6
	blizzard	2
	falling ice	1
	gas poisoning	1
	others	5
unknown		14

Fig 9. Analysis of deaths at Antarctic stations total of 14 stations of 10 nations, 1998
(G. Ohno and T. Miyata, 2000)

- Some diseases have characteristic tendencies. It may be useful for prevention against severe illnesses
- Syowa station has not superior medical equipment. The very low mortality of the station or JARE may be because effective personnel selection avoids severe diseases and there are no severe accidents by aircraft.
- The air evacuation system is indispensable but it must be established with thorough safety.

Reference

G. Ohno and T. Miyata: Morbidity of wintering-over participants in the First to the Thirty-ninth Japanese Antarctic Research Expeditions: Analysis of 4233 cases. Nankyoku Shiryo (Antarctic Record), vol. 44, No. 1, 1 – 13, 2000

G. Ohno and T. Miyata: Comparison of medical service systems at Syowa Station with other Antarctic stations: Medical staff, mortality and evacuation. Nankyoku Shiryo (Antarctic Record), vol. 44, No. 1, 42 – 50, 2000

G. Ohno and T. Miyata: Disease due to ultraviolet radiation in Antarctic wintering personnel: Analysis of geneses, seasonal change and annual variation. Nankyoku Shiryo (Antarctic Record), vol. 44, No. 3, 239 – 248, 2000

Telemedicine:
The Place of Simple Digital Medical Imaging

Chris Andrews, Iain Grant and Peter Marquis
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Plymouth, U.K.

Introduction

The medical philosophy of the British Antarctic Survey Medical Unit (BASMU) is to send well trained, but comparatively junior doctors to the Antarctic and support them with the advice of a large hospital (Derriford) with over 200 specialist Consultants. An important part of that support is gained by seeking opinions of those specialists of a variety of different digital images.

BASMU Doctors in Antarctica send good quality still digital images with a brief clinical history to the Accident and Emergency Department in Derriford. If necessary, advice is rapidly sought from Clinical Specialists throughout the hospital. This enhances the quality of diagnostic and therapeutic advice available.

Telecommunications from British Antarctic Survey (BAS) stations and ships are via the Inmarsat satellite system. The available bandwidth of 64 K and associated costs preclude the transmission of large digital files. BASMU have evolved methods to overcome these constraints and produce clinically acceptable material.

Digital photographic equipment

The Radiology Department at Derriford Hospital tested 12 off the shelf digital cameras for quality of image, ease of use and cost and selected the Nikon Coolpix 990 (cost £ 580/ $ 881, specification 3.34 million pixels, macro mode minimum shooting distance 2cm) for BASMU usage. Such cameras are now much cheaper to buy.

Typical clinical digital images are in the region of 350Kbytes, and are transmitted as anonymous e-mail attachments at a rate of 56Kbits/second, resulting in 50 second transmission times with a cost of £ 3.75 / $ 5.47 per image. On receipt the images are assessed in the Accident and Emergency Department and may be forwarded via the Hospitals Intranet to other clinical specialists. Past usage has concentrated on X-Rays, Opthalmology, Dermatology, and Genitourinary Medicine.

Case studies

Case studies from Antarctic locations help to confirm that Telemedicine does not need to be highly technical to be effective. A key factor is the need for training in digital photographic techniques for the doctors taking the original images. Doctors have also worked alongside the clinical specialists providing the telemedicine advice which helps to improve communication, trust and patient management. The following cases have been selected to show the range of advice that has been sought from the station doctor and for which it would not be possible to expect him or her to have sufficient training to cope without advice on their own in Antarctica. Some of those cases also affected individuals with an important role in the station and of whom quite understandably management required a likely prognosis.

1 Patient with Inflammation of eye lid

The image was sent to our Ophthalmic Surgeon for comment. Diagnosis was made of chalazion (cyst of a meibomian gland), which had become infected. Suitable management and antibiotic treatment was suggested and was successful.

Logistical implications

The doctor on site was very worried about what to do if the eye did not recover. The clarity of the image enabled our ophthalmic surgeon to offer exact advice. If it was to recur the advice was to surgically evacuate the cyst. A description of this procedure plus associated diagram was forwarded to the Doctor on site.

2 Patient with rash around the eye

An aircrew member of staff presented with a rash around the eye. The base Medical Officer was unclear as to aetiology and diagnosis. A clinical history and image was forwarded to Dermatology in Derriford Hospital. Advice from the Dermatologist was as follows:

"... this eczema is a consequent of the environment i. e. very low humidity. Patient needs to avoid soap on the involved areas and use moisturisers several times per day e. g. Diprobase, Unguentum Merck or 50% White Soft Paraffin and 50% Liquid Paraffin".

Logistical implications

The patient was one of the pilots and very important to the logistical functioning of the base. The use of this simple data transfer method enabled management to have the confidence that the pilot would recover very shortly and no replacement would be required.

3 Patient with Bloody Diarrhoea

The microscopy image, plated by the doctor from a faecal specimen, was forwarded to Microbiology for a diagnosis because of persistent symptoms of bloody diarrhoea. The image was reported as containing increased numbers of polymorphs but the small sample meant they were unable to comment on parasitic infection. The stool also showed neutophils. Gastroenerology were then asked for their for advice and reported that clinical history was a little long for infection and because of the recurrence, there was the possibility of underlying inflammatory bowel disease.

Logistical implications

Our confidence in this specialist information enabled BASMU to organise a routine medical evacuation to the medical services on the Falkland Islands, when it became possible, for sigmoidoscopy and rectal biopsy. The patient was successfully treated and managed for mild non-specific proctitis, returning to the base to complete his summer only tour of duty.

4 Patient with crush injury to a thumb

A Station support member received a crush injury to the thumb while attaching a trailer to a vehicle. The thumb was partly amputated 7mm distal from the tip. The nail bed also lacerated. Treatment consisted of sutures x 6 and the thumb was splinted.

Logistical implications

The particular problem faced by the Senior Medical Officer (SMO) in this case was to give permission for the individual to leave the service of the British Antarctic Survey (BAS) and undertake a recreational journey in South America. As a good employer it was important for BAS to ensure that the injury had completely healed. Repeat images were forwarded to the SMO who was therefore able to monitor progress, and eventually, give that permission.

5 Patient with significant allergic reaction

A Station support member at a base without a doctor, was stricken with a significant skin reaction. Images of the condition and a brief history were forwarded to the Senior Medical Officer at BASMU.

Logistical implications

The extent of the patient's rash caused great alarm on the base particularly as there was no doctor to offer expert advice. The paramedic had been trained in digital imaging and was able to seek advice rapidly from Plymouth. Diagnosis of an allergic reaction was made and appropriate treatment and management was undertaken. After investigation the cause of the reaction was traced to building insulation material the patient had been dealing with. He was instructed to avoid future contact with that material and made a good recovery.

6 Patient with leg fractures

A Station support member received fractures in a skiing accident. X-Rays performed by the Station Medical Officer and forwarded to the SMO at BASMU indicated that both bones in his lower right leg were fractured.

Logistical implications

This was a serious accident occurring in the austral summer and immediate plans were made to evacuate the patient by air. However after review of the digital images in the UK, the position and stability of the fractures, enabled the decision for evacuation by ship, rather than air, with a consequent reduction in both financial cost and field operational risk.

Conclusions

We believe that we have demonstrated that it is quite possible to provide an excellent medical service to the personnel in Antarctica with a well trained but fairly junior generalist using a good digital camera. The three essential factors in the successful implementation of this strategy are the recruitment of well motivated doctors, the training in photography and the backup of interested available specialists at the base hospital.

Medical Screening in the British Antarctic Survey

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Introduction

The British Antarctic Survey Medical Unit is based in the Accident & Emergency Department of Derriford Hospital in Plymouth which is one of the largest district general hospitals in the United Kingdom. The Medical Unit provides all aspects of medical support for the British Antarctic Survey including determination of fitness for service in Antarctica and regular medical screening.

These services are provided for all British Antarctic staff and any visitors who go to the Antarctic under the auspices of the British Antarctic Survey from other collaborating institutions. This means that the British Antarctic Medical Survey Unit undertakes up to approximately 450 such screening examinations per year.

There are problems with screening because of lack of evidence, and lack of international standards. Finding a balance between cost effectiveness, acceptability to subjects (ie non invasive screening) and efficacy is difficult.

Prospective Antarctic personnel range in age from 18 to 70, although the vast majority are in the first three decades of life and the mean age overall at the moment is about 28 years. This however is rising slowly as permanent staff become older and older people remain fit medically for a longer time.

The gradual increase in average age of people in the Antarctic particularly during summer is something which we must accept. This has however, considerable implications in that the older the personnel in the Antarctic the more likely they are to suffer from the diseases of older age and medical resources must take account of this.

The British Antarctic Survey Medical Unit in Plymouth has undertaken this service for BAS for the last five years. We believe that our policy in respect of screening is somewhat different from our predecessors with BAS and somewhat less intensive than that undertaken by some other nations. Our aim is to facilitate the persons capability during an Antarctic visit and to ensure that medical facilities are capable of meeting the needs of the population. Our aim is not to prevent people from going to the Antarctic if it is safe for them to do so, even if we need to enhance medical facilities to a limited extent for this to take place. Above all, however, we wish to promote safety for personnel while they are in the Antarctic.

This regime may seem to some people rather lax, but we have found that the biggest problems we have had were where personnel concealed medical problems which would not have been picked up by extensive investigation and some of which could easily have been solved had we known about them in advance. Our policy therefore is to encourage honesty as far as possible and we find that if people believe that we are there to help them rather than to prevent them from going that this is beneficial.

Pre-employment screening

All prospective employees for the British Antarctic Survey and the British Antarctic Survey Medical Unit are screened pre-deployment. This generally takes place after a successful interview where it is likely that a candidate will be selected for a particular post.

Prior to interview candidates are sent to an Antarctic Service application medical form together with some notes as to the procedure for medical certification and some information on conditions which generally preclude Antarctic service.

If it is clear from this documentation that the candidate is obviously medically unfit they will not be called forward for interview.

Following interview selection an extensive medical history questionnaire is filled in and the candidate is examined by one of our medical team. At the same time blood is taken for a blood donor screening and any other investigations which the doctor thinks are necessary and arrangements are made as indicated in the policy for chest x-ray and electro-cardiography to be undertaken. Any candidate who has a clinical cardiac murmur has echo-cardiography arranged and other investigations are undertaken as indicated, but are not done routinely.

Essentially we use the same screening procedure for employees whether they are likely to undertake a wintering or summer only post, but we allow a greater discretion in appointment to the latter.

Women who are going to over winter in the Antarctic have some well woman screening undertaken. In this we follow national guidelines for the population at large in terms of frequency and age for cervical smear, mammography and other investigations.

Visitors

Personnel from other Institutions who are making short research trips to the Antarctic in summer are dealt with somewhat differently. British Antarctic Survey Medical Unit forms are sent to the person and it is their task to give these to their general practitioner family physician and to arrange a medical examination. A comprehensive guide to fitness standards is also provided for the general practitioner.

The general practitioner will then undertake the examination on behalf of the British Antarctic Survey Medical Unit and doctors are encouraged to discuss any potential problems with us at BASMU.

The doctor then makes a recommendation to the BASMU, but the final decision rests with the Chief Medical Officer of this Unit who scrutinises all medical forms prior to giving the person a final medical category. It is essential that this mechanism is maintained.

Medical categories

All those going to the Antarctic, whether employees of BAS or visitors, will be given a medical category which gives some indication of their fitness for Antarctic service.

Category M1 is reserved for someone who is fully fit for all Antarctic service including over wintering and deep field work.

M2 is a category where someone is fit for summer service in Antarctica but is not, or may not be, fit for over wintering. This category is generally the one used for visitors as the screening has been less intense and we may not be certain whether they are fully fit for wintering service.

Category M3 is a restricted category in which the person is considered fit to undertake Antarctic service but under certain conditions only. The restriction has to be stated in the category and is usually straight forward. Someone for example with a condition which is usually easily treated by a doctor but which may cause problems otherwise may be restricted to service on a base where a doctor is present. Someone who requires a particular medication may have a restriction placed on them that they can only go to the Antarctic if they provide this medication in adequate amounts. Someone with a chronic back condition may be restricted in the amount of lifting they are allowed to do.

Category M4 gives a temporary agreement for service in Antarctica subject to regular review which is more frequent than the British Antarctic Survey Medical Unit review policy. This regular review will usually be annual but may be as frequent as every six months.

Medical category M5 is unfit for Antarctic service.

All of these medical categories may be suffixed with the letter T which indicates that this is temporary. This is most usually used for M4 and M5 where someone has a curable condition and the category will be changed after successful treatment.

In-service review

British Antarctic Survey employees are subject to regular review which is undertaken 5 yearly up to the age of 35, 3 yearly from 36 – 60 and annually thereafter.

Discussion

We arrived at undertaking this particular system of screening because we felt it achieved a good balance between cost and reliability. The evidence base for any screening system is very poor, the principal problem is there is little evidence. In the United Kingdom the National Institute for Clinical Excellence (NICE) publishes guidelines on some aspects of medical screening but by no means all. There is also an evidence based publication known as Bandolier which has published a black list of screening tests which are considered to be ineffective. This list was considered but has not been completely followed because there is clearly a difference between screening for Antarctic service and screening in general population.

What evidence there is however suggests that in excess of 90% of medical problems will be identified by an extensive questionnaire which is honestly answered and that medical examination will pick up another 3% – 5% of such problems.

There is little evidence that routine tests with the exception of urinalysis contribute much to detection of covert disease which could cause problems in the Antarctic. Further research is undoubtedly needed to try to gain the evidence about the effectiveness of potentially expensive medical screening. There is also a need for the Antarctic Medical Community to work together to promote health awareness in individuals, to agree standards for screening and service in Antarctica, while cooperating closely to cater for the individual not only the system.

We have been using the same system now for 5 years and during that time we have carried out examination on in excess of 2000 personnel and during that time we have had 3 medical problems which potentially we felt should have been discovered prior to deployment. All of these were due to lack of disclosure by the person and we do not believe that any of them would have been picked up by investigations. This was one of the principal reasons why we have attempted to encourage complete honesty.

During the 5 years we have had no unexpected deaths due to pre–existing medical problems.

When we initially started the system there was some discontent from a small proportion of BAS employees. This was largely because the previous provider had undertaken annual medicals for all staff. When the reasoning behind our decisions to stop this was explained the discontent disappeared.

Because we undertake the vast majority of screening ourselves we have the opportunity to undertake considerable amounts of health education during the screening process and much can be done to encourage healthy lifestyles and appropriate self care measures.

We have, inevitably, not been without problems. One of the common problems is Asthma. This is an increasingly common diagnosis which does require a certain amount of investigation. If anyone has a history of exercise or cold induced Asthma we will specifically test their respiratory function under those circumstances before agreeing on a fitness category.

The biggest problem however is when someone does not tell us that they have got Asthma and then ends up in the field in a situation where they cannot be treated when they develop an Asthma attack. It is much better to frankly discuss asthmatic problems with the person so that we can arrange for appropriate treatment to be available as and when necessary. We have over the years allowed many people with Asthma to go to the Antarctic and have not run in to any untoward problems as long as we were aware of the situation and their medical category was appropriate.

Patients who need long term medication can also be a problem. The Antarctic Survey medical indent is extremely comprehensive with drugs from the vast majority of classes available to the doctor. However, we could not possibly carry every variety of anti-hypertensive for example, which patients may be on and patients are therefore encouraged to make sure they have adequate supplies of their own medications.

It is often difficult to decide whether someone is fit to go to the Antarctic after treatment of certain conditions such as malignant disease or heart disease and we try to involve the patient in the decision making as far as this is concerned. The personnel have to be very clearly made aware of any additional risks that their condition may impose upon them and in our experience most people are very sensible in discussions about their fitness for the Antarctic.

We would admit that we have backed away from very prescriptive policies in respect of alcohol use, obesity and tobacco use. Alcohol in particular is associated with a very high percentage of medical events. BAS and BASMU encourage sensible drinking but with the Antarctic population this is not always rigidly enforceable.

Further work on the overall effects of alcohol on the Antarctic population may well be worthwhile.

Summary

The British Antarctic Survey Medical Unit uses a relatively low cost system which is based on what little evidence exists. Over the years we have been using it it has seemed to work. It encourages people to be honest in the declaration of their medical problem and so far we have not had too many in the way of unexpected problems.

Training of Medical Officers for Antarctic Service

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Introduction

British Antarctic Survey Medical Unit is based in the Accident & Emergency Department of Derriford Hospital in Plymouth, one of the largest district general hospitals in the United Kingdom. For five years we have had the contract to provide all aspects of medical support for the British Antarctic Survey including the recruitment and training of medical officers for Antarctic service.

This paper describes the system we use to train medical personnel.

The need for training

Doctors in the Antarctic need to be generalist in the widest sense of the word and one of the great difficulties with recruitment for Antarctica is that nowadays most doctors tend to specialise at an early stage in their career. Those who are junior enough still to be relatively generalist are too junior to take on the responsibility of Antarctic service without further training and those who are senior enough to take on the responsibility are often too specialised for the isolated practice in Antarctica.

It must also be appreciated that Antarctic medicine is somewhat unique in the spectrum of disease presented, the harsh nature of the environment and the facilities available to the doctor, both in terms of technology and paramedical support.

Doctors may therefore have to do things that they do not usually do and they may also have to rely much more heavily on their clinical experience and clinical examination rather than being able to obtain extensive investigations.

Several Antarctic programmes have indicated that there is some difficulty recruiting doctors for Antarctic service and it was felt that if we could provide a possibility of the doctor obtaining a higher degree whilst in the Antarctic this may help recruitment. Further, at the age and experience level of most of the doctors who wish to go to the Antarctic high quality training and support whilst in service is considered to be an important factor in improving recruitment. In Accident and Emergency medicine in the UK as a whole for example, it has been clearly shown that those departments which offer good training and support for senior house officers have a much better recruitment profile than those who do not.

Doctor selection

We recruit doctors by advertisement in the British Medical Journal on an annual basis. We have 4 posts available every year which are of various duration. We can have up to 14 medical officers in the system at any one time, either undertaking pre-deployment training, on deployment or post deployment research.

Most of the doctors we recruit are in the region of 4 to 5 years post qualification, have undertaken Senior House Officer time and are taking a career break prior to embarking on higher professional training.

Apart from expecting every doctor to have undertaken a post in an Emergency Department and at least 1 other year of post registration training we do not have any firm criteria and our recruitment is based to a large extent on whether we think the doctor will be a suitable medical officer for an Antarctic base.

In general we have somewhere in the region of 30 applications a year for the 4 posts, about 10 – 12 applicants will be brought forward for interview and to date we have had no difficulty in filling any of the posts.

Pre-deployment training

All doctors attend our Unit for at least 6 months before deployment and during that time they undergo a considerable amount of formal and informal training. The training is based at the University of Plymouth (soon to be the Peninsula Medical School) and there is a core of material both formal knowledge based teaching and practical skills teaching which all prospective Antarctic doctors undertake.

There is also time for hospital based practical training increasing the range of skills of the doctor and including paramedical skills such as radiology, nursing and laboratory skills which the doctor may not otherwise have undertaken.

The pre-deployment training together with formal assessment and their supervised deployment prepares the doctor for a Diploma in Remote Healthcare from the University of Plymouth.

The in-hospital training is tailored to the doctors' previous experience and will concentrate upon medical specialties to which they have not had a lot of exposure.

During deployment

We encourage continuing medical education by expecting the doctor to complete University assignments, by making a certain amount of literature available to them and we are gradually developing distance learning packages.

We support their clinical practice by telemedicine, by audited performance and by the availability of immediate medical specialist advice.

During deployment the doctors also collect specimens and data for research projects, which they will later undertake.

Post-deployment

Some, but not all of the medical officers, usually those who over winter at the main base, will undertake some on-going research in the laboratory, and will submit a dissertation for a Masters of Science in Remote Healthcare, again currently from Plymouth University.

Post deployment doctors are also invited to the Unit for de-briefing and careful consideration is given to their feedback in respect of the training as well as other matters.

The training is altered and tailored every year to try to meet the current needs of the doctors.

General staff training

Our Unit also undertakes training for all British Antarctic Survey staff in First Aid and for a proportion in advanced First Aid matters.

We have a purpose written first aid manual "Kurafid" which has emphasis on prevention as well as treatment and is issued to all personnel prior to the Antarctic briefing conference held on an annual basis. This serves as the course manual for the First Aid course, a compulsory part of the briefing conference which is an intensive $2^{1/2}$ day course.

The emphasis at this course is on small group teaching and on essential practical skills with much use of scenario based teaching. This allows students to become familiar with standardised field kits available in the Antarctic. The course is assessed in terms of competence and knowledge.

All personnel are encouraged to undertake regular updates to their first aid skills.

Selected personnel, who may be selected by the British Antarctic Survey, because of the nature of their deployment, or selected by the Medical Unit because they have shown particular expertise at the first aid course are invited to participate in a one week long advanced first aid course, which we call the Medical Assistant course. This is undertaken in groups of 8 – 10 with a lot of one to one teaching and teaches advanced skills that allow the person to be an assistant to the doctor or to undertake a more active role in medical treatment in bases where no doctor is deployed.

Future developments

We would like to see a web based distance learning course both for the doctors in Remote Healthcare and a web based first aid course so that personnel can update their skills whilst in the South. We also feel that some major incident management training would be of benefit and the current courses are not designed for Antarctic use, but rely heavily on resources which are not available in the Antarctic.

Conclusion

We believe that appropriate, intensive preparation of all personnel is the key to successful healthcare in the Antarctic.

Selection and Recruitment Procedures Chilean Antarctic Program

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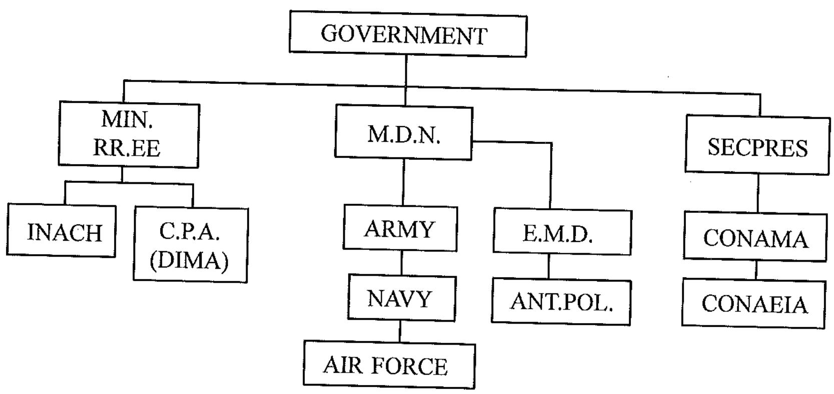
Chilean Antarctic Policy

The Chilean Antarctic Policy has been created according to the national geographical and historical vocation, defined according to the national capacities towards the new tendencies and coherent in its objectives.

This objectives mainly are related to full protect the natural environment and provide support to several activities, especially those concerning to scientific research and development and actually those related to have a controlled tourism.

To fulfill this objectives, the Chilean State developed its Antarctic activities trough the Ministry of Exterior Relations, Ministry of Defense and General Secretary of the Presidency.



The Chilean Antarctic Institute belongs to the Ministry of Exterior Relations responsible for implementing and developing the Chilean Antarctic Policy, the armed forces(army, navy and air force)are mainly responsible to provide logistical support to many scientific activities that are carried out in Antarctica.

On the other hand, the general secretary of the presidency is responsible for the control of the environmental protection programs.

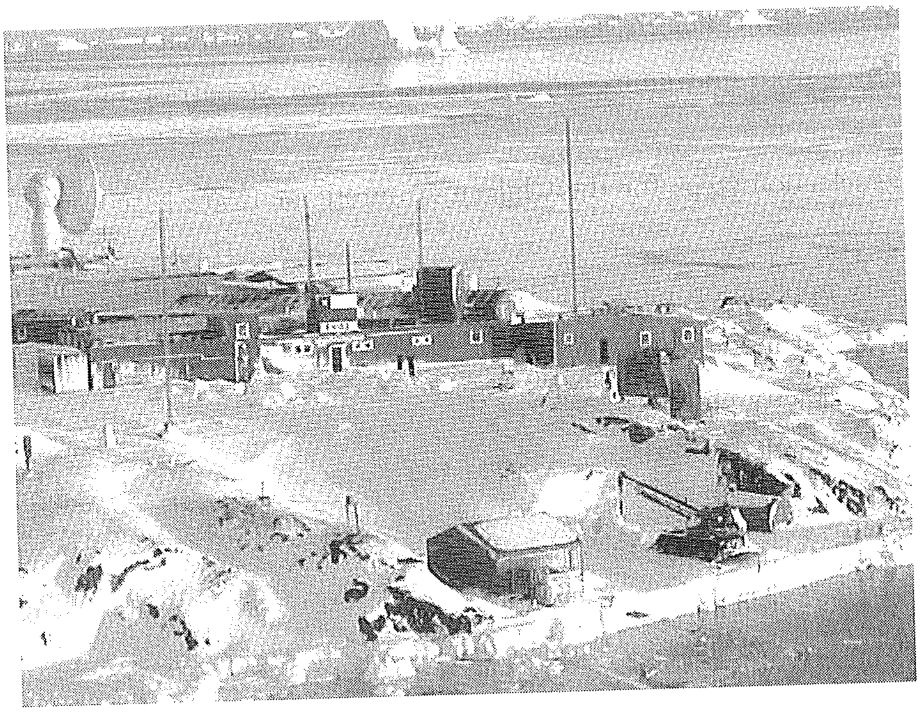
In summary, the four Chilean operators are:

- Chilean Antarctic Institute
- Chilean Army
- Chilean Navy
- Chilean Air-force

Selection steps for the Chilean Antarctic staff

The selection system focuses on the Chilean Antarctic Policy. This process has been very successful for 56 years.

In general, the Chilean personal must follow this selection procedure that women, men and children who would stay in the permanent and semi-permanent Chilean bases.



The Chilean Antarctic bases:

Base naval arturo prat navy base(1947)

Staff: 9 men

It is located in the Greenwich Island 62°10′S.

Gral. Bernardo Ohiggins army base(1948)

Staff: 20 men

Located in the Antarctic Peninsula 63°19′S.

Pdte. Eduardo Frei Montalva air force base(1969)

Staff: 83 peoples.

Located in King Jorge Island in the south Shetland 62°12′S.

Professor Julio Escudero Guzman base (1998)

Staff which varies due to the permanent or quasi-permenent activities or scientists

Located in King Jorge Island.

The scientific activities are developed in every base, by the selected staff during their one year or two years living there.

Furthermore, there are other Chilean Antarctic bases which are used for scientific purposes in a quasi-permanent status.

Air force base Lieutenant Luis Carvajal

The scientific staff varies

Located in Adelaida Island 67°45′lat. south inside the Antarctic pole.

Air force base"Pdte. Gabriel Gonzalez Videla"64°49″south lat.

Lieutenant Parodi and ambassador huneus, located at patriot hill camp 80° south latitude.

Then the selection steps for the Chilean Antarctic staff are based on the following main steps:

- voluntary application request
- psychologigal test
- physical capacity check op
- antarctic knowledge test
- personal interview
- medical check up

Psychological test

All the people, accepted to be part of the staff in the first step of the application, must take a psychological test.

This is a test to evaluate the personal characteristics of the applicant.

Taken by a specialized psychologlcal who, also, must interview every applicant who passed the psychologlcal test.

Scientists just take psychological test in case they have to live in the Antarctic for a whole year. At the same time, the family (spouses and children) must pass a psychological test which measures their capacity to become adapted to the Antarctic environment. People, who are not able to pass the psychologlcal test, fail.

Psychologists make an important work, because they give psychological attention not only to the staff selected to live in the Antarctica, but also to their families who live in the continent.

This attention is made by means of a permanent phone contact or personally whenit is possibie.

Test of Antarctic knowledge

The staff ' s antarctic knowledge varies, depending on the Chilean Antarctic operator, in general terms. People must know the following aspects:

- Antarctic treaty and Madrid Protocol formation and geographic structure of the continent
- flora and fauna
- discovery, exploration and consolidation of man in the Antarctica.
- Chile in Antarctica.
- Antarctic new material (Antarctic actuality)

The selection of the Antarctic staff takes 8 months, approximately every person from the selected staff will have specific tasks according to the activities of the operators:

- chief of staff or scientific activities.
- specialist in meteorology and scientific subjects.

- specialist in health and tooth health
- cook
- engine and telecommunications mechanics
- snow-cat drivers
- specialist in icy and snowy land exploration
- computer technician
- heavy machine operator
- physical education instructor
- planes and helicopters pilot and mechanic
- scientific of different investigations
- private bank employee
- civil service
- post office service
- others

Medical check up

Exhaustive medical check up is taken to every person of the Antarctic staff.

- electroencephalogram
- electrocardiograph
- blood test
- tooth test
- appendectomy

After the person is selected there is a per Antarctic period of adaptability, in that phase every person selected is operated on appendix, due to the reduced surgical capacity that prat and ohiggins bases have.

Pre Antarctic adaptation

The staff is trained in specific subject by the Antarctic operators for about 4 months even thinking, the staff has specialization and experience in its work or task

It is important that the selected person can adapt to his dnowledge and experience in the Antarctic life.

On the other hand, in the pre Antarctic adaptation period, it is very important for a better adaptability to the Antarctic continent that the staff shares professional and personal activities. In this way they can know their personal character, capabilities, weakness and limitations.

The training courses are done by every national operator nevertheless, there is a course called "introduction to the antarctic knowledge" which is done by the Chilean Antarctic Institute.

Courses are divided into two categories

The first categouy is the courses of general knowledge and all of the staff selected for the Antarctic national operator has to take them.

- fire courses
- snowy land environment
- Antarctic introduction
- risk prevention
- Antarctic environment protection
- procedures and security rules

The second kind of courses is specific and according to the personal taskd:

- methereological observers
- generator engine mechanics
- snow-cat drivers
- cooking
- welding, plumber, industrial electricity
- computer and communication equipment
- use
- environment control
- outboard motor course
- English course
- freight lift operator(carry machine)
- port captaincy
- air sea training(plane and helicopter)
- fuel quality control

• elementary diving course

Experiences and statistics

During 55 years of national Antarctic research and explorer presence, there hsa been 20.000 Chilean who have stayed in the Chilean Antarctic territory in different periods.

This large experience mades us assume an important role due to the achievement we have got.

Experiences related to operations and scientific aspects

The climatic conditions and topographic configuration affect most Chilean Antarctic activities seriously, some of them had become very dangerous. for that Chile has lost important human life.

Most of the accidents were caused by the bad weather conditions and due to the topographic configurations specially cracds, but, few of them, caused by the human mistakes.

The exhaustive process of selection has permitted that in general Chile has not negative effects about the specific functions of the person who has been selected.

Wth the use of satellite navigation equipment, the accidents and missing of exploration tesms were reduced.

There is a permanent evaluation of the cloth which is used by the Antarctic staff.

Based on daly reports, there is a permanent updating of the training process which improves the performance of the Chilean Antarctic activities and avoid negative aspects such as accidents.

Environmental aspects

Based on the madrid protocol, Chile gives a special importance of international cooperation for the full environmental protection.

Chilean bases have equipments to protect the environment as much as plssible.

Among other equipments there are sewage treatment, garbage comperssor, furnace desalinated machines.

Chie has a strong policy to protect the natural Antarctic environment perfectly, so in every selected process this is a main aspect that is included in the training programs.

Human relationships and psychological aspects

This is one of the most sensitive aspects that are considered in the continuous upgrading process.

Experience says the group must be together during 5 months before getting to the bases. the first period(first 3 months) is very difficult for the adaptation and to keep good personal relationships.

Some researches indicate that people change in personality such as:

- increase of a detailed thinding instead of a wide point of view of any normal situations at 26.6%
- decrease in planification and initiative 14.7%
- increase in spiritual aspects(art-meeting-reading)7%
- decrease in intellectual capacity 16%
- increase in emotional stability 9.3%
- increase in a dominating personality 12.3%
- increase in emotional sensitiveness 10%
- increase in self-sufficiency 13.3%
- increase in self control 4%
- increase anxiety 26.5%
- increase introversion 5.3%
- increase aggressiveness

These percentages ane related to the whole group, they mean that there could be people who increase their anxiety for instance at 50%.

In general, with the psychological researches, it is possible to determinate taat in a group, there are:

- permanent physical confort during the year
- a normal alcoholic comsuption

• adaptation capacity to the environment
• capacity to afford the family separation

This information was taken from permanent evaluation made at the end of a one year living in the Antarctic bases.

It is very inportant for the leadership of the chief staff to keep harmonical relationships between the members of the bases.

The "interpersonal relationships", were the lowest aspect evaluated with a 70.5%, while"dedication and performance"were the highest evaluated with an 82.3%.

Health aspects

The strict medical check up before Arrival to the Antarctic allowed 95% of the staff who hadn't any evacuation during one year period.

Evacuations are very difficult and riskful between March and November mainly due to the bad weather conditions. That is why the appendix surgery is relevant to prevent fatal consequences.

If a woman gets pregnant(base frei), she will be move to the continent two months before the childbirth. However, two boys and one girl were born between 1984 and 1985.

Neither drugs comsuption nor excessive alcohol is allowed. if it is necessary, the evacuation could be arranged for that person who did not follow this rule.

Smoking is not forbidden, there are special places for smokers. It is forbidden to smoke in bedrooms, living rooms, offices, wordshops, stores and laboratory.

Conclusion

During the past 55 years the Antarctic operators have provided logistical and technical support to many scientific research activities.

One of the most important achievements is that 20.000 Chilean people have lived in the Antarctic territory for a variable time.

People's performance has been evaluated as a 95% positively due to a serious and exhaustive personnel selection process.

The Chilean Antarctic operators work in a centralized way in a directive level according to our National Antarctic Policy. The operators give special emphasis to the environment protection and support to the scientific activities.

However the activities execution and the personnel selection for the Chilean Antarctic bases are developed independently for each operator.

There is a mutual corperation specially in logistic aspects like transportation, supplying, evacuation, etc.

Among different important achievements we can emphasize the scientific support at the south pole and more over the worldwide "endurance" rescue of Sir Ernest Shakleton, made by piloto Pardo in the "yelcho"ship in 1914.

This achievent was an important result of every logistic support of Antarctic.

The British Antarctic Survey Antarctic Employment Pool

J R W Hanson
British Antarctic Survey

Abstract: The British Antarctic Survey (BAS) is autonomous in sourcing and providing its own science, logistics and support staff. That BAS does not rely on staffing agencies or contract out to a provider of polar and / or trade experience, is seen as fundamental to successful operations over many years. Traditionally BAS employed the Antarctic summer only and over-wintering workforce on fixed term contracts of between 3 and 33 months in length, with a flexible end date which took into account variable staffing, operational and logistic needs. Development in European Union and UK employment law required BAS to introduce radical changes in the terms and conditions offered to Antarctic-based staff. Although the changes were necessary to remain compliant in law, opportunity was taken to establish an Antarctic Employment Pool (AEP). This has become a formal mechanism to assist and relieve pressure on the busy recruitment process and to develop a polar skills base to the benefit of both employee and employer.

Personnel now employed by BAS to work in the Antarctic are offered open ended appointments, with initial periods of employment ranging from 3 to 33 months as previously. After this initial posting they may remain on the staff complement (in the AEP) but will have no entitlement to pay. Staff interested in further employment with BAS, may then opt to be considered for a further period or periods of work with BAS in Antarctica.

The establishment of this pool of experienced and suitable staff ensures BAS has a good supply of trained and skilled personnel suited to achieve the planned science and technical programmes. This also meets the operational and logistic requirements deemed essential for the success of Antarctic seasons and subsequent winters. The

AEP has now been running successfully for 18 months and has already helped to reduce the recruitment process. The AEP is presented as a model of successful recruitment strategy for Antarctic operations.

There are many reasons which send men to the poles and the intellectual force uses them all. But the desire for knowledge for its own sake is the one which really counts and there is no field for the collection of knowledge which at the present time can be compared to the Antarctic. Exploration is the physical expression of the Intellectual Passion. And I tell you, if you have the desire for knowledge and the power to give it physical expression, go out and explore.

Introduction

The mission of the British Antarctic Survey (BAS) is to undertake a world-class programme of science in the Antarctic and related regions addressing key global and regional issues through research, survey and monitoring. In so doing BAS sustains for the UK an active and influential presence and a leading role in Antarctic affairs. BAS helps to discharge the UK's international responsibilities under the Antarctic Treaty System, especially concerning environmental protection and management.

The British Antarctic Survey operates from five research stations in the Antarctic and sub-Antarctic region. Signy on the South Orkney Islands is open and operational in the austral summer. Bird Island and King Edward Point on South Georgia, Rothera on Adelaide Island off the Antarctic Peninsula and Halley on the Brunt Ice Shelf in Coates Land are operational throughout the year.

The British Antarctic Survey has a total staff compliment averaging 457. Permanently employed scientists, administrators and ships personnel account for 373 while 84 are employed as open ended Antarctic complement appointees under the recently established Antarctic Employment Pool. During the austral winter of 2002 a total of 48 personnel are over wintering on the four stations. In addition to scientists, and depending on location, size, operational and logistic requirement, each station will require a combination of additional support professions and trades to accomplish austral summer season activities. These include; builders, communications staff, chefs, mechanical engineers, electricians, electronic engineers, field assistants and medical officers. BAS has to increase the Antarctic workforce by an average 71 people (an increase of 148% over winter complement) to meet this seasonal demand. This is the essential justification for the Antarctic Employment Pool. (Table 1)

Table 1. Real time need for Antarctic employment pool based on 2002 overwintering staff & 2002/03 austral season

position	Winter 2002 Posts	Summer 2002/03 Whole time epuivalents	Summer 2002/03 Actual Staff requirement
	A	B	C
Assistant Marine Biologist	3.00	4.50	6.00
Data Manager	1.00	1.50	2.00
Electronic Engineers(Science)	3.00	3.50	4.00
Marine Biologists	2.00	3.00	4.00
Meteorologists	5.00	6.50	7.00
Zoological Field Assistants	3.00	3.50	4.00
Field Assistants(Support)	7.00	12.00	16.00
Base Assistants	0.00	3.00	6.00
Fixed & Mobile Plant Technicians	5.00	7.25	9.00
Communications Staff	2.00	4.00	7.00
Electricians	3.00	5.00	9.00
Chefs	2.00	3.50	5.00
Mechanical Services Technicians	3.00	5.00	7.00
Boat Operators	2.00	3.00	4.00
Diving Officer	1.00	1.50	2.00
Steel Erectors	0.00	4.50	8.00
Carpenters	3.00	5.00	6.00
Ancillary Trades	0.00	4.00	7.00
Medical Officers*	3.00	4.50	6.00
Totals	48.00	84.75	119.00

Notes:

1) Difference of Column C against Column A = 148% increase for Austral summer programmes-a need for 71 more people.

2) Column B whole time equivalent posts represents the summer only cost increase to BAS. The actual personnel required to meet this allows for essential handover, operational and project planning. Summer employment periods may be from 2 to 7 months in duration.

* Medical Officers are not employed in the AEP but included here for completeness.

The Historical Perspective

Britain has been involved in Antarctic research and exploration for over 200 years and has had a permanent presence in the Antarctic since 1947. The British Antarctic Survey remains the only operator routinely overwintering populations of between 4 and 25 personnel for two consecutive winters. The rationale of consecutive winters (up to 30 months overseas) is based on safety and operational efficiency. An aim to achieve an exchange of about half a station's compliment each summer season allows for expertise and knowledge acquired in an individual's first winter to be handed down to the new peer intake. Valued continuity for long term scientific monitoring programmes is also achieved giving greater confidence in important historical data sets.

BAS has 45 years experience of selecting people to work in remote environments and the process of selection includes proactive advertising, a comprehensive application form, thorough interview (but not psychological testing), medical screening and post selection evaluation. This process, proven in its application and success over the years is nevertheless subject to gentle refinement and evaluation in the desire to attract, appoint and retain quality staff and the Antarctic Employment Pool is proving an important means of binding the whole selection process into a meaningful commitment between organisation and employee. Unlike some operators who contract out the demanding administrative function of Recruitment, the autonomy enjoyed by BAS in the selection and appointment of the scientific and supporting Antarctic workforce permits stability and understanding of need between all departments of the organisation. With the involvement of experienced personnel officers and station commanders in the interview process this hands on approach greatly assists selection, maintaining standards, determining training and preparation procedures and contributing significantly to the operational co-ordination of staff deployment and repatriation. Thus, the policy of maintaining the core recruitment facility in house remains fundamental to the strength and success of BAS.

AEP The Need for Change

In 2000, BAS faced a twofold need to meet changing employment legislation and create a better practical return on the annual investment in recruitment time and cost. The former requirement became the catalyst for the latter. The BAS Antarctic workforce, now the Antarctic Employment Pool represents 18% of the total BAS staff compliment and at any one time is never likely to be greater than 20%. (Table 2)

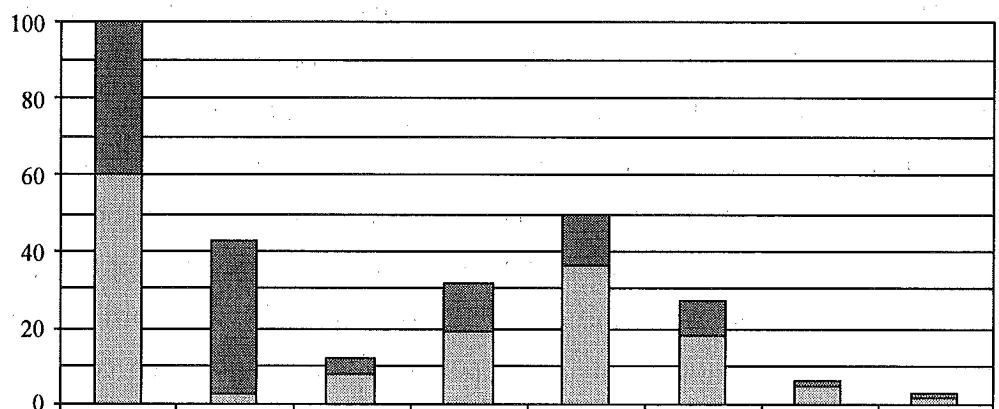
Table 2. % of AEP posts against overall staffing-2002/03

	%	No.
Fixed Term Appointments	9	40
Open ended	53	239
Ships Personnel	20	95
Antarctic Employment Pool	18	76
	100	449

Note:

AEP can only ever be about 17% of workforce, but need to retain operational level of staff from within this group

Prior to 2000, the average re-employment from within the 18% Antarctic workforce element was just 11.5% annually, representing a whole time equivalent of 9.5 posts. This figure is now increasing (Table 3) and BAS would like to achieve an ambitious 50% target for re-deployment of staff beyond an initial tour of duty, regardless of such initial duty being summer only or Aover-winter@ experience.



	Total AEP requirement	AEP on pay as at 31 May 02	Returners before AEP	Returners since AEP	Target for returners	New intake requirement 2002	Currently unavailable for selection	Not identified for re-employment within AEP
Winter	40.00	40.00	3.60	11.40	14.00	8.97	1.00	1.00
Summer only	60.00	2.50	7.90	19.20	36.00	17.93	4.80	1.50

The need to retain quality staff maximising the return for investment in people and the experiences gained is paramount. BAS has to develop the employment pool concept to attract key scientific and trade skills within an increasingly competitive employment market. Reducing natural wastage of talent is essential to future progress and the Survey is aware that in the past a lack of any real incentive to develop medium to longer term opportunity for loyal short term employees has discouraged some individuals from committing more time to BAS. While this has been disadvantageous it is not to suggest that BAS has ever been unable to sustain a quality and motivated Antarctic workforce. BAS also recognises that individuals with the ambition and commitment to work in Antarctica will not necessarily wish to do so over the length of a career. The realistic aim must be to hope interest might be retained over a 5 to 10 year period rather than the current and often less than 3 years.

The challenge of the Antarctic environment and opportunities for professional and personal development that the continent offers an individual are to a significant extent a polar operators best recruitment tool and an organisation to which people feel proud to be affiliated is a basic philosophy behind the employment pool. BAS aim to maintain and develop this profile, creating the opportunity to participate in and support the first class science programmes. The Antarctic Employment Pool allows for increased investment in people working on the principle that the strength of the organisation lies in the enthusiasm and expertise of the workforce.

Reference has been made to employment legislation as a need for change. For many years the Survey's Antarctic employees have been appointed on fixed term contracts appropriate to the duration of an individuals tour of duty. The UK Employment Regulation Act of 1999 and European Law on the use of fixed term appointments now make it impossible for BAS to employ a person for a limited time for a position that (through definition of need to keep Antarctic stations and infrastructures operative) is on-going. The conditions of the employment pool meet the statutory obligation on BAS to comply with current employment law in that individuals are offered open ended contracts but remunerated only for the time they are actually deployed to work in the south. Regardless of the practical and personal considerations of individuals, and the organisations duty of care in not keeping people in an isolated community beyond what might be deemed a sensible timescale (30 month maximum), the risk of an employee claiming unfair dismissal from a continuing position is negated. By complying with this legislation BAS, and perhaps other European operators, is applying fair and open conditions within what is increasingly a less employer friendly age.

The Antarctic Employment Pool in Practice
(Criteria for selection from the AEP)

The BAS Antarctic Employment Pool may include any person with an Antarctic employment contract who may from time to time be considered suitable to carry out the Survey's requirements and responsibilities in Antarctica. Each year BAS aims to select an Antarctic staff complement with the range of skills and expertise best suited to achieving the planned science and technical programmes and that best meet the operational and logistic priorities deemed essential for the success of the forthcoming and subsequent winters(s).

At the end of an Antarctic season in which an individual has concluded their duties and returned to the UK, and in each subsequent year while their contract of employment with BAS continues, the individual is asked to confirm in writing to the Recruitment Section of the Personnel department by the end of April, whether they are available to carry out further duties for BAS if required. Such duties are defined as being in the Antarctic for a period or periods up to but not exceeding 36 months and would normally commence in August or September to allow for refresher training before re-deployment. If an individual fails, for two consecutive years, to indicate availability for selection prior to the April deadline (i. e. at the beginning of the annual Recruitment Programme) that person's contract of employment with BAS will terminate and they are removed from the employment pool.

In considering selection from the Antarctic Employment Pool BAS takes into account attitude during training, motivation while South, and any disciplinary matters, should they have arisen. The benefit of staff appraisals on contribution and capability is a tested mechanism to assess suitability. Previous experience is only one factor that will be taken into consideration in deciding who is best suited to serve the overall requirements of BAS in any particular Antarctic season or winter.

BAS will consider preferences expressed by members of the Antarctic Employment Pool as to summer only and winter tours of duty and station or deep field location. In considering the options BAS will however always reserve the right to deploy selected people to the position and location that best meets the Survey's requirements at the time.

As the Antarctic Employment Pool develops it will be apparent that BAS cannot, in any one year, undertake to re-select all the people who, through their expression of continuing interest, wish to return to Antarctica. Eligible staff who are not successful are notified in writing and continue to be held on record for consideration in future years. Notwithstanding the ambition to expand and maximise the potential of the AEP, it remains good policy to introduce new talent into the organisation on a regular basis. BAS has no wish to deprive potential applicants of opportunity and there will be times, especially with scientific posts but also with trade and supporting positions, when the selection procedure identifies the external candidate as the preferred choice. This greatly assists in maintaining a high level of competition and upholds recruiting standards. The inevitable turnover of staff within an Antarctic workforce will ensure natural control because reselection from the AEP will realistically never meet all the Survey's Antarctic workforce requirements. It remains the responsibility of the recruitment team to ensure a fair, open system and to maintain a balance between proven and potential skills. In this respect the philosophy of recruitment within the British Antarctic Survey remains unchanged.

AEP Other Recruitment Factors

The concept of the Antarctic Employment Pool can only be successful if the Terms of Employment pertaining to the workforce remain attractive and concurrent with best personnel management practice. Such conditions constitute part of the employment contract between BAS and employee and are regularly reviewed and updated.

Salary must be realistic. Pay is no longer secondary to the opportunity and romance of Antarctica and achieving competitive remuneration in high-tech skills in all trades, but especially Information Technology and Electronics is a constant challenge. Quality and caring support to the remote workforce offers reassurance and high priority is placed on fair and positive management, medical care, welfare support, communication with home, health and safety and a commitment to training and self development.

Key issues to retaining a motivated quality workforce need to be addressed to meet the needs of the 21st century Antarctic employee. BAS is aware that it will have to review the length of the over-winter contract. Increasingly there is evidence that two winters, the 30 month overseas tour, is less ideal than in the past for the individual in terms of isolation, but also in respect of meeting career development and personal opportunities post tour. One winter contracts may be a factor that would increase the interest in remaining loyal to the needs of the Survey and help meet the target for employment pool availability. Work continues on issues like Equal Opportunities and work / life balance. A workforce of the highest calibre has to be sourced and maintained at a time when availability of the specialist population shows signs of becoming increasingly limited. In this respect BAS must review its own recruitment process and look for new ways to attract the best. In one such initiative the survey has embarked on the development of a high profile interactive web-site recruitment facility.

Summary

The British Antarctic Survey has confidence that the Antarctic Employment Pool model will underpin the continuing demand for a versatile, flexible, skilled and professional staff complement. BAS Management in conjunction with the Antarctic workforce remains vigilant to the recruitment challenges that lie ahead.

Selection of Antarctic Personnel

A Collaborative Project Between
Iain Grant, British Antarctic Survey Medical Unit, U.K.
Larry Palinkas, University of California, San Diego, USA
Peter Suedfeld, University of British Columbia, Canada
Hege Eriksen and Holger Ursin, University of Bergen, Norway

Aims & Objectives

SOAP aims to validate a concise battery of psychological tests, designed to assist the selection, both in and out, of personnel for service over winter in Antarctica.

Background

Many National Antarctic programmes already use psychological tests in selection. The British Antarctic Survey does not. Many different tests are in use (Rivolier presentation to Scientific Committee on Antarctic Research (SCAR) 1998). None of these batteries has been fully validated in this use. Individual tests have in some cases been used in other remote areas.

The British Antarctic Survey (BAS) contract Plymouth Hospitals NHS Trust to provide all medical services. This is undertaken by the British Antarctic Survey Medical Unit (BASMU) who are thus totally independent of BAS and any selection procedure. It was agreed following XXV SCAR that with the agreement of the British Antarctic Survey, this study would be undertaken to attempt to define the usefulness and validity of a concise battery of psychological tests foe Antarctic use.

Methods

Candidates selected for interview for potential over winter posts with BAS are asked to participate in the study. Those who agree, if selected for second stage selection procedures, complete the test battery. Some of these candidates will be selected for over winter positions, some for summer only posts and some will not be selected. The Test Battery comprises:

nPANAS (Positive affect Negative affect Scale)

nCES-D (Centre for Epidemiological Studies depression scale)

nBIC (Battery of Interpersonal Capabilities)

nLOT(Level of Optimism Test)

nASI (Anxiety Sensitivity Index)

nNEO-FFI

nCODE (DMI/Utrecht Coping List)

nHelmreich/PCI

The test battery is anonymised and forwarded to University of Bergen for analysis. The code list, a demographics form, and a scoring form completed by the interview panel are retained by BASMU in Plymouth Hospitals.

The first analysis compares the interview panel decision with the predictions from the tests. This will not be communicated to BAS/BASMU until the study is complete. The outcome of the service of those who go on to over winter in Antarctica will be predicted from the tests and compared with actual performance. For those spending more than one winter in Antarctica, the outcome measures are undertaken at the end of the first winter and repeated annually.

Outcome measures include a structured interview as soon as possible after the beginning of the summer season following a winter over, two short psychometric tests, (CES(D) and PANAS) a subjective health questionnaire, and a report from the base commander.

Analysis & Publication

Analysis of the results is being undertaken by the University of Bergen in collaboration with Professors Suedfeld and Palinkas. Grouped results will be made available in a report to SCAR.

Early results after the first pilot analysis (September 2001) suggest that

- The interview selects personnel with similar psychological profile to the general population
- The Helmreich Test may help to "rule in" candidates.

It is intended that results should be published in an appropriate peer reviewed journal in due course.

Proposal of Psychological Selection, Preparation and Monitoring of Concordia Station Winter Over Personnel

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Introduction

The suitable management of human resources is crucial to achieve the goals in every organization especially if it concerns complex enterprises in hostile environment, such as the Antarctic expeditions.

After the problems occurred during the International Geophysical Year (Rasmussen, 1973) the psychological selection of the personnel has been for many years the only preventive measure to decrease the risk of poor performance or of maladjustment manifestations.

The relevance of psychological selection, even though implemented through different procedures in different countries, has been understood by all the organizations operating in Antarctica, as it was demonstrated by the numerous papers on this subject presented in the SCALOP meetings (Gaum; Kawakubo, Umeki, Shiraisshi; Mulligan; Rajan; Rivolier; Sachdeva, Manju, Saxena, Priyamvada; 1994). The polar psychological literature identified the psychosocial characteristics required to adapt to the Antarctic psychosocial environment about 30 years ago and confirmed them in several studies performed by different authors (Gunderson, 1966, 1973, 1974; Rivolier, 1975;1992, 1997;Taylor, 1985, 1987). They are ability, stability, compatibility.

However the only psychological selection, as initial screening, has been considered insufficient to insure an optimal adjustment in analogous, isolated and confined, situations like the space (Nicholas, 1989; Manzey, Schiewe, 1992; Helmreich, Peri, et al. 1993) if it is not associated with other preventive measures such as the psychological preparation and support (Rivolier, 1997, Palinkas, 2001). The need of a multidimensional, integrated approach has been proposed and emphasised by several authors, coming from different countries (Rivolier, 1994; Peri, Barbarito, 1998), with experience in the selection area. This point of view produced a recommendation (no. XXIV-11) of the Human Biology and Medicine Working Group (HB&M WG) accepted by SCAR (SCAR bulletin n°126, 1997) where the importance of psychological selection, preparation and debriefing is reaffirmed for the personnel staying for several months in the Antarctic.

On the above base a discussion evolved between the French and Italian professionals in charge for the psychological selection, taking into account the different background (Crocq, Rivolier, Cazes, 1973; Peri, 1988) and operational conditions, the testing requirements, the theoretical frame, etc to develop a common protocol, here proposed, to cope with psychosocial issues arising in Concordia station.

The living conditions existing in Concordia station represent a stronger exacerbation of the well known harsh and extreme conditions being in the Antarctic coastal stations, due to the altitude (hypoxia) and to the more internal location.

The usual Antarctic stressors (cold, the alternation day/night, the exposure to the radiation, the environmental sameness, isolation, the confinement with the same persons) are all more marked (No flora and fauna) and make more difficult the process of human adaptation. In addition to that there is a multinational and multicultural context affecting strongly the individual and group adjustment process.

The situational stressors of the station can be grouped in the following main areas:

Physical hardship: Cold weather, darkness, altitude; hard work conditions outdoor; fresh food deprivation; minimal standards provided for health and safety

Isolation: Geographical, social and emotional remoteness.

Confinement: Absence of an opportunity to escape from the situation; forced, continuous proximity of others with lack of interpersonal choice; limited private space.

Tension control: Necessity of controlling and managing aggressive and emotional impulses; lack or shortage of heterosexual objects;

Boredom, Monotony: Sameness of physical surroundings: faces, work tasks, conversations; lack of stimulus variety.

Status limitations: Loss or reduction of status privileges, role overlap; lack of immediate status rewards.

Multicultural context: Coexistence of different values, goals, food preferences etc. on a national basis.

Psychosocial issues, according to our view, have to be managed carefully and effectively in this special environment, in which people cannot be replaced during the winter, to achieve successful outcomes.

Aims

The aim of this protocol is not only to prevent the maladjustment clinical manifestations arising during the stay (which could have devastating effects on the group) but also to decrease the negative impact of some possible psycho-socio-organizational and cultural problems on the performance.

A contribution to improve the understanding of human behaviour is a welcome side-effect of this type of activity which includes the monitoring of the personnel's conduct on the field.

Psychological selection criteria

Considering the above conditions, a winter-overer in Concordia station should have the following psychological characteristics:

Absence of psychiatric problems included in DSM-IV or ICD 10.

Enduring and mature motivation for the Antarctic service, ability to cope with personal isolation. Basic cognitive processes (Attention, Memory, Perception, etc.) sufficiently effective and accurate. High ability to establish and maintain good social relationships and to treat others with consideration, respect, sensitivity.

High emotional stability and self-control.

High ability to adapt to team work.

High resistance to stress and stress management skills.

High self-confidence and sufficient-high independence.

High interpersonal and cross-cultural tolerance.

Above average interpersonal conflicts management ability.

Above average discipline, acceptance and support to persons in authority.

Sufficient Problem Solving and Decision Making skills.
Sufficient communicational and assertiveness skills.
Sufficient planning ability and planning flexibility.

Leader

High planning ability and organizational flexibility
High interpersonal conflicts management ability
High interpersonal and cross-cultural tolerance.
High communicational and assertiveness skills
Remarkable Problem Solving and Decision Making skills

Psychological selection methods

2 stages are considered: I) Select-out and II) Select-in. These methods are used to select all the applicants (Antarctic newcomers and veterans) for staying in Concordia station.

I) Select-out. Psychological screening for every participant conducted in each country. Duration: usually 1 day/group of 4-6 candidates.

II) Select-in: Screening to be performed in a common place for all the candidates assessed fit after the select out, including individual and group test. Duration: 2 days/subgroup

SELECT OUT

Logistic organization

Professional personnel: 1 Psychologist and 1 Psychiatrist/Medical Officer
No more than 6 candidates every day, only 4 if they are leaders.
The test scoring will be performed in the following days.

Psychological tools

Interviews
Interview by the psychologist (duration: 1 h 15 min)

Areas to be explored: motivation for the Antarctic expedition, representation of the winter over, anamnesis, personal images of themselves, etc.

Interview by the psychiatrist/medical officer (duration: 30 – 45 min)

Areas to be explored: Personal and familial medical antecedents, life habits, Somatic concerns, Former experience of isolation and confinement, Motivation for his job during the expedition, level of information about life conditions in Concordia, etc.

Psychological Tests and questionnaires

The psychologist is necessary in this stage for providing instructions during the test administration.

MMPI 2 – Minnesota Multiphasic Personality Inventory (S. R. Hathaway and al., 1989)

Utilization of the base clinical scales and validity scales. Possible utilization of additional scales.

Duration of the test administration/completion: from 1h to 1h and 30 min. Questionnaire scoring 30 min.

GPP-I Gordon Personality Profile - Inventory (Gordon, 1993)

Duration of the test administration/completion: from 20 to 25 min. Questionnaire scoring 30 min.

EPI-Eysenck Personality Inventory (Eysenck, H. J. & Eysenck, S. B. G., 1963)

Duration of the test administration/completion: 10 min. Questionnaire scoring: 3 minutes

TSI-Structure Test of Intelligence of R. Amthauer or other equivalent test of intellectual functioning (Calonghi, Polacek, Ronco, 1974)

Duration of the test administration/completion: about 1h and 40 min. Questionnaire scoring 20 min.

Possible other psychological tests considered appropriate for investigating behavioural issues observed during the interview or for other particular reasons.

Complementary tests for the leaders

Rorschach test (Rorschach, H. 1981) or Wartegg Drawing Completion Form (Falcone, Grasso, Pinkus, 1977)

Rorschach. Administration time: from 20 to 40 min. Scoring time: from 30 to 60 min.

Wartegg. Duration of the test administration/completion: 30 min. Scoring time: from 40 to 60 min.

ITER (Peri, Ruffini, Mosticoni & Mosticoni, 1996)

Administration/Completion Time: from 20 to 30 min. Scoring time: 5 min.

Possible other psychological tests considered appropriate for investigating leadership skills or other useful abilities (communicating, negotiating, etc).

The candidates coming from other countries than France and Italy should be screened by the same psychological instruments but some changes could be accepted by the psychological selection body for special reasons to be represented preliminarily.

SELECT IN

The assessment includes individual and group tests.

The number of subjects to be included in each sub group has to be established and adapted according to the candidates who were assessed fit after the select out.

Examiners: 4 or 5 professional (psychiatrists, medical officers, psychologists). 2 or 3 observers in each group tests and 2 operators assigned to assess the candidates involved in the individual tests or to observe the candidates temporarily not involved in the trials.

Three of them could come from the country where the selection procedure is performed and 2 from the other country.

Language: English

Duration: 2 days

Group tests and behavioural assessment

Group discussion about various topics concerning the winter over

Two discussions: each of them with a different composition of the sub group

The duration of each discussion will be about 45 min

Group Problem Solving

One or two group problem solving trials concerning situations related to the real environment or cross cultural conflicts (cooking, leisure time, movies, etc.)

The duration of each trial will be about 45 min.

Other possible group tests

Work or activities to be performed in small groups

Behavioural observation of the candidates

During the meals, leisure and not structured time

Individual assessment

Interviews

Interview by the psychologist/psychiatrist/medical officer (duration: about 15 – 30 min) After the group tests. Areas to be explored: How was the candidates' experience about the group and the individual tests, their representation of the winter over, personal images of themselves, etc.

Psychological Tests and questionnaires

MIPG (Matrix of Intra- and Interpersonal Processes in the Group) (Abraham, 1994)Administration/Completion Time: from 20 to 30 min. Scoring time: from 10 to 15 min.

SIV (Survey of Interpersonal Values-Gordon) (Gordon, 1971)

Administration/Completion Time: from 20 to 30 min. Scoring time: from 15 to 20 min.

COPE (Carver, Scheier, Weintraub, 1989) or similar coping questionnaire

Administration/Completion Time: from 15 to 20 min. Scoring time: from 15 to 20 min.

Psychological preparation criteria

The psychosocial preparation methods should aim at improving further the individual skills and group ability to cope effectively with possible performance and maladjustment problems. The social support, the group cohesion, the team spirit, the cultural integration represent facilitating conditions of the individual and group performance in the Antarctic stations. In order to develop the above conditions and ascertain the compatibility a suitable setting where the members of the group can live together for a period before the departure for Antarctica should be considered.

Psychological preparation methods

During the preparation phase generally no additional selection is performed except for very particular risky psychosocial individual condition observed by the professionals.

Several methods and techniques can be applied in order to improve stress resistance, social skills, conflict management skills, to enhance group cohesion, social support etc during a period of 4 – 5 days in a possibly isolated place which could include:

Individual presentations on selected topics.

Group discussion about the psychosocial adjustment in the station. The discussion's aim is to reach a shared idea of the operational and behavioural manifestations of psychosocial adjustment, of their priority, their relationships, etc.

Intercultural management exercises.

Analysis and discussion of intercultural critical incidents.

Conflict management exercises.

Analysis and discussion of interpersonal conflicts.

Language: English

Psychosocial monitoring criteria

The behaviour of the participants in the field needs to be assessed as control of the selection and preparation methods used in the pre-departure phase. These evaluations represent essential data also for every research activity. They can be provided by the subjects themselves (subjective) and by the persons in charge of the station personnel or of the health service.

Psychosocial monitoring methods

Instruments

Medical Officer's recording of maladjustment manifestations (Rivolier, Gaud, Cazes, Bachelard, Rosnet, 2000)

Periodical self-assessment (once a day or a week) for very few personal parameters (mood, physical well being, nutrition satisfaction, sleep, performance, interpersonal relationships)(Peri, Barbarito, 1998)

Leader and Medical Officer periodical empirical evaluations of the conduct in the field (Rivolier, 1975).

References

Abraham, A. (1994). A Model for Exploring Intra-, Inter-, and Transpersonal Processes in Group. In A. L. Comunian, & U. P. Gielen (Eds.) *Adavancing Psychology and its Applications* (pp. 163–177). Milano: Angeli

American Psychiatric Associacion (1994): *Diagnostic and statistical manual of mental disorders*, Washington D.C., DSM IV Manuale diagnostico statistico dei disturbi mentali, Masson, Milano, 1996

Calonghi, L., Polacek, K., Ronco, A. (1974): *Test di struttura dell' intelligenza T S I* di R. Amthauer, Manuale, OS, Firenze

Carver C.S., Scheier M.F., Weintraub J.K., (1989): Assessing coping strategies: A theoretically based approach, *Journal of Personality and Social Psychology*, 56, 2, pp. 267-283

Crocq, L., Rivolier, J., Cazes. G. (1973) Selection and psychological adjustment of individuals living in small isolated groups in the French Antarctic stations in O. G. Edholm and E. KE. Gunderson (eds.). *Polar Human Biology*, Chigago, Heinemann, p. 362-368

Eysenck, H.J. & Eysenck, S. B. G. (1963) *Eysenck Personality Inventory*, Holder & Stoughton, London. It. Tr. EPI (Adult Form) Organizazioni Speciali, Firenze, 1976

Falcone, A, Grasso, M., Pinkus, L. (1977) *Presupposti teorici per l' uso del test di Wartegg*, Organizzazioni Speciali, Firenze

Gaum, B.: Development of a Standard Evaluation Procedure for Candidate Members of South African Expeditions to Antarctica, Proceedings of the Sixth Symposium on Antarctic Logistics and Operations, Rome, August 1994, p.213.

Gordon, L. V. (1960) Survey of Interpersonal Values, Science Research Associates, Chigago, It Adaptation of L. Meschieri, *Questionario SIV di L. V. Gordon*, Organizzazioni Speciali, Firenze 1971.

Gordon, L.V. (1999) *GPP-I Gordon Personal Profile Inventory*, Organizzazioni Speciali, Firenze. Italian adaptation from L. V. Gordon (1993) Gordon Personal Profile Inventory (rev. ed). The psychological corporation, San Antonio, TX

Gunderson, E. K. E. (1973). Individual behavior in confined or isolated groups. In J. Rasmussen (Ed.), *Man in isolation and confinement*, *Chigago*, Illinois: Aldine Publishing Company.

Gunderson, E.K.E (1966). Selection for Antarctic service, Naval Health Research Center, San Diego, Ca, Report N°66-15

Gunderson, E.K.E. (1974): Psychological studies in Antarctica in Gunderson, E. K. E. (Ed.), *Human adaptability to Antarctic conditions* (pp. 115 - 131), Washington D. C.: American Geophysical Union

Hathaway, S. R., Butcher, J. N., Dahlstrom, W.G., Graham, J.R., Tellegen, A., Kaemmer, B. (1989) *Minnesota Multiphasic Personality Inventory - 2*, University of Minnesota Press, Minneapolis

Helmreich, R. L., Peri, A., et al. (1993): Space Psychology Days 3 Selection, detection support in flight, Report ESA LTPO-SR-93-02 p.8-11, p.101

Kawakubo, M, Umeki, K. and Shiraishi K: Selection and Management of Japanese Antarctic Personnel, Proceedings of the Sixth Symposium on Antarctic Logistics and Operations, Rome, August 1994, p.191

Manzey, D., Schiewe, A. 1992) Psychological training of German science astronauts, *Acta Astronautica*, 27, 147-154

Mulligan, R.: Selection of ANARE station leaders, Proceedings of the Sixth Symposium on Antarctic Logistics and Operations, Rome, August 1994, p.157

Nicholas, J. M. (1989) Interpersonal and group behavior skills training of crews on space station, *Aviation, Space Environmental Medicine*, 60, 603 – 608

Palinkas, L. A. (2001) Psychological Issues in Long-Term Space Flights: Overview, *Gravitational and Space Biology Bulletin*, 14, 2, 25 – 33

Peri A., (1988): La selezione del personale per le spedizioni nazionali antartiche: metodologia, criteri adottati e risultati nell'accertamento dei requisiti psichici. *Annali di Medicina Navale*, 93, 4, 655 – 678

Peri, A., Barbarito, M. (1998): Dalla selezione alla psicoprofilassi: un approccio integrato alla trattazione delle problematiche psicologiche in ambiente antartico, *Giornale di Medicina Militare*, 148, 3 – 4, pp. 203 – 220

Peri, A., Ruffini, M.C., Mosticoni, R. & Mosticoni, S., (1996), Elaborazione di uno strumento psicometrico informatizzato (ITER) per la valutazione della capacità di risolvere problemi di gestione del tempo [Elaboration of a psychometric computerised test (ITER) to assess the skills of time management], *Giornale di Medicina Militare*, 146, 3, 351 – 359

Rajan, H. P.: Selection and Management of Antarctic Personnel-Indian Antarctic Programme, Proceedings of the Sixth Symposium on Antarctic Logistics and Operations, Rome, August 1994, p. 185

Rasmussen, J. (1973) *Man in isolation and confinement*, Chigago, Illinois: Aldine Publishing Company.

Rivolier, J. (1975): Selection et adaptation psychologiques des sujets vivant en groupes isolés en hivernage dans l'Antarctique, CNFRA, N°34

Rivolier, J. (1992): *Facteurs humains et situations extremes*, Masson, Paris

Rivolier, J. (1997): *l'homme dans l'espace*, Presses Universitaires de France, Paris

Rivolier, J.: Recent approaches on psychological selection of winter-overers, Proceedings of the Sixth Symposium on Antarctic Logistics and Operations, Rome, August 1994, p. 177

Rivolier, J., Gaud, R., Cazes, G., Bachelard, C., Rosnet, E. (2000) Preliminary study of the maladjustment manifestations during the polar winter-over. Proceedings of the First Workshop on Human Adaptation in Antarctica and Extreme Environments, Venice, May, 3 – 5, 1999. Italian Antarctic Research Programme

Rorschach, H. *Psychodiagnostik. metodik und Ergebnisse eines wahrnehmungsdiagnostischen Experiments (Deutenlasses von Zufallsformen)*, Huber, Bern, 1921. It. Tr. Psicodiagnostica. Metodologia e risultati di un esperimento diagnostico basato sulla percezione (interpretazione) di forme casuali. Kappa, Roma. 1981

Sachdeva, U., Manju Mehta, Saxena, S. and Priyamvada Jain: Psychological evaluation for the selection of members of the Indian Antarctic Expeditions, Proceedings of the Sixth Symposium on Antarctic Logistics and Operations, Rome, August 1994, p. 201

SCAR bulletin n°126, July 1997, p. 12

Taylor, A. J. W. (1985): The selection of people for work in polar regions: New Zealand and the Antarctic, *New Zealand Antarctic Record*, 6, 2 p. 26 – 38

Taylor, A. J. W. (1987): *Antarctic Psychology*, DSIR Bulletin N°244, SIPC, Wellington, NZ

An Unlined, Undersnow Utility Tunnel at the South Pole

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Abstract: The United States Antarctic Program (USAP), through its principal support contractor Raytheon Polar Services Company (RPSC), has recently completed a three-year project comprising nearly 1 kilometer (3, 071 feet) of undersnow utility tunnels at Amundsen-Scott Station, South Pole, Antarctica. The tunnel serves the new station facilities——currently under construction——by housing the piping which conveys fresh water from current and future water well sites, as well as waste water to repositories in abandoned wells. The undersnow tunnels permit year-round access for system operations and maintenance.

The network of tunnels is entirely unlined and unsupported, and for the most part maintains a rectangular cross section of 1.8-meters (6-feet) wide by 3-meters (10-feet) high. The tunnel runs from 6-meters (18-feet) to 14-meters (45-feet) below surface. Eight 1-meter diameter raises bored from surface serve the network as emergency escape ways.

The "ground" in which the tunnels are excavated is extremely hard snow (firn) of average density 0.5 g/cc. It is texturally uniform, well below any relict layering from annual snowfall, and free of fractures. When ambient tunnel temperatures equilibrate with tunnel wall temperatures in the closed tunnel, both measure −50℃. Structural safety guidelines provide that an excavation no more than 1.8-meters (6-feet) wide and maintaining cover of 6.5-meters (20-feet) in this material can support the weight of an over-passing or idling, fully loaded LC-130 aircraft without ground failure. Tunnel closure measuring stations show fairly consistent annual closure rates by "squeeze" between 1-cm to 5-cm center of span vertically, and 1-cm to 3-cm center of span horizontally. Significant tunnel course deflection has not yet been noted.

Tunnel excavation methods included both mechanical and manual advance. A prototype tunnel boring machine developed by the US Army Corps of Engineers, Cold Regions Research and Engineering Laboratories (CRREL) successfully excavated most of the tunnel segments. The CRREL technology represents the evolution of mechanical tunneling methods employed in Greenland in the late 1950's and early 1960's. In addition, primitive manual tunneling methods employing chainsaws, hand tools and man hauling were also successful on the South Pole tunnel project. Comparative performance of these methods is discussed in detail.

The safety performance for the entire project - from early testing through ultimate execution——maintained zero lost time accidents of any kind.

Introduction: Why a Tunnel at the South Pole?

The United States Antarctic Program (USAP), through its principal support contractor Raytheon Polar Services Company (RPSC), has recently completed a three-year project comprising nearly 1 kilometer (3,071 feet) of undersnow utility tunnels at Amundsen-Scott Station, South Pole, Antarctica.

Amundsen-Scott Station, located exactly at the geographic South Pole, sits on the broad, featureless polar plateau at an elevation 2.8 km (9,300 ft) above sea level. At this location, the top 2.7 km (9,000 ft) are ice, and of that column the top 92 m

(300 ft) is firn and snow. Surface temperatures at the South Pole range from ambient -83℃ to −14℃, and annual snow accumulation averages 20 cm (8 in). The South Pole is thus among the highest, driest, coldest places in the world.

Owing to its remote location, the South Pole also presents among the most difficult logistics and longest supply lines in the world. Supplies originating in the United States, for example, initially are shipped to New Zealand, thence to the US McMurdo Station - on Ross Island near the coast of Antarctica, and finally by air transport to the South Pole (Figure 1). Normally, supply procurements are made at least two years out.

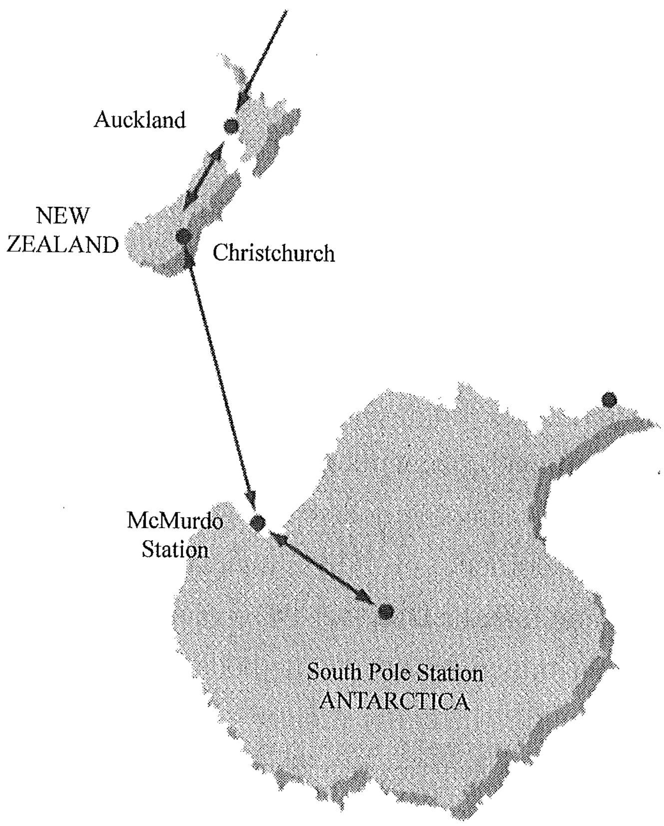

Fig. 1. Logistics Map

Because of the extreme climate and remote location, major construction activity at the South Pole is restricted to a short construction season running 3 − 1/2 months from November 01, to February 15. This period includes project mobilization and demobilization each year.

The United States has maintained - and is committed to maintaining -- continuous occupation at the South Pole since 1956, when it built the first permanent research station there during the International Geophysical Year. As that facility grew outmoded, an entirely new research facility was built in 1972, approximately 0.4 km

(1/4 mi) away and replacing the former one. This second facility has now itself become outmoded. Currently, the USAP, administered by the National Science Foundation (NSF), is engaged in building the third generation of station facilities at the South Pole. The new construction is adjacent to the current station as siting requirements and operations considerations call for shared use of current facilities during new station construction and for phased use of the new facilities.

In connection with this new station construction, RPSC has completed a network of undersnow tunnels which house fresh water and wastewater piping, tunnel lighting and some electrical utilities, and provide personnel access. Following a season of tunneling method testing, three construction seasons saw the completion of this tunnel excavation project in January 2002.

The fresh water piping conveys water from current and future water well sites to the new station. These wells are drilled from surface through the hard, dense snow layer of firn and into the ice at depths approximately 60 m (200 ft) below surface, where waste heat from the station's power generating facility is used to initiate, maintain, and grow a "bulb" of fresh water at the bottom of the well. With water consumption, that bulb may grow to 30 m (100 ft) in diameter and reach 120 m (400 ft) below surface or more. On reaching critical dimensions, all the liquid fresh water is pumped from the bulb. The resulting void becomes the repository for wastewater -- also conveyed by piping in the tunnel from the station to the abandoned well. At current water consumption levels and at an estimated life of seven years per water well, the tunnel network may provide for station requirements through year 2050.

The undersnow tunnels maximize surface utilization for other purposes, and minimize surface and near-surface obstacles. Further, they permit year-round sheltered access for system operations and maintenance, independent of outside temperature extremes, drifting snow, and long winter months of darkness. The new station siting requirements, the design life of the system, the required fall of grade, and the desire to avoid lift-station construction called for tunnel lengths and depths well in excess of those practical for cut-and-cover tunnels at South Pole. Over all, an unlined, undersnow utility tunnel system offers a promising solution for the new South Pole station.

The completed tunnel

The main tunnel course runs from a portal within the new station for 568m (1,864 ft) out to a face below a restricted access area, well away from normal station activity (Figure 2). From the portal to station 145 m (475 ft) the grade falls at 3%. At this point, the course turns 90° left and runs to the face at a grade of −1%. While the

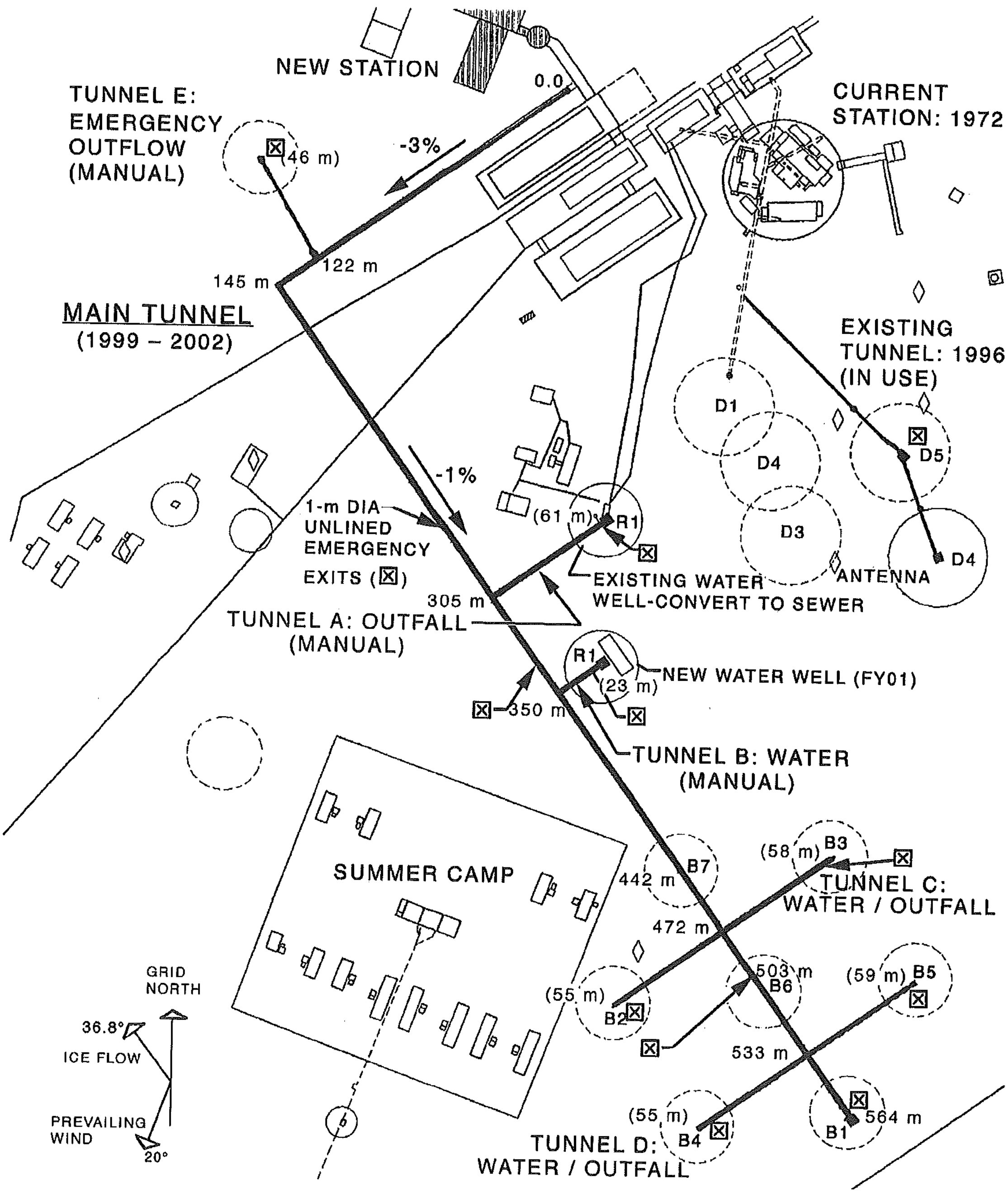

Fig. 2. South Pole Tunnel Site Plan

topography varies over the tunnel course due to manmade cuts and fills, the cover is shallowest above the portal at 6 m (18 ft) and deepest above the distal end at 14 m (45 ft). Seven side tunnels intersect the main tunnel course at right angles. Each of these, save one, runs on a flat grade. Side Tunnel "E"-an emergency wastewater outfall divert——falls away from the main tunnel at-1%.

All tunnels combined total a lineal 936 m (3,071 ft) for this project. They are unlined and unsupported, and for the most part maintain a rectangular cross section of 1.8 m (6 ft) wide by 3 m (10 ft) high. Eight 1 m (3 ft) diameter escape raises, and two utility raises bored from surface reach the tunnel below. The escape raises are fitted with timber ladders stulled into hitches cut into the snow, trap door landings, and topland tunnel shelters.

While the tunnel "begins" at a portal within the new station, tunneling actually began at the distal end -- Station 566 m (1,858 ft) -- and drove a straight course on +1% grade for 294 m (964 ft) during the first construction season. In the second season, dual entries made at Station 145 (475 ft) tied into the previous season's tunnel with a precise face-to-face hole through on line and grade (Figure 3), and then drove to what is now the "portal" on a +3% grade. The third season saw the completion of all the side tunnels, driven from separate entries to intersect the main tunnel. All headings maintained horizontal accuracy of 6 cm (0.2 ft) or better from prescribed line, and 95% of the headings maintained that same vertical accuracy with respect to design grade.

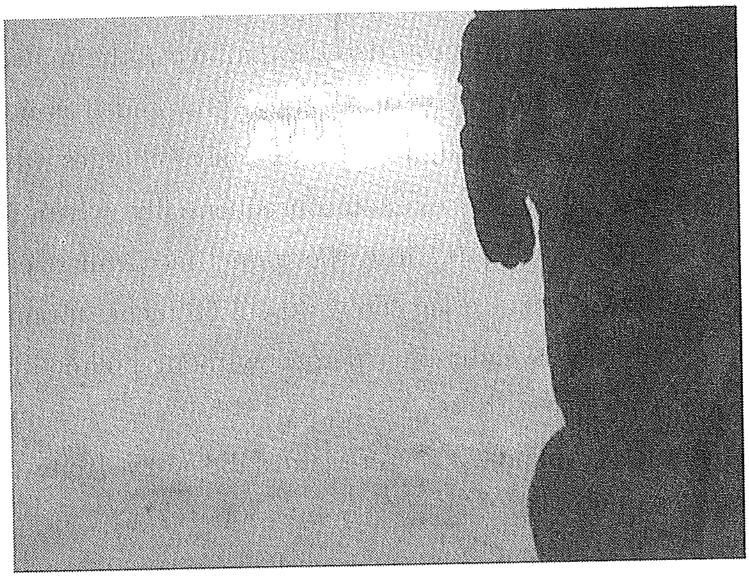

Fig. 3. Face-to-face hole through

Tunnel entries were made from the bottom of 15 m (50 ft) wide access trenches dozed from surface down to sill grade elevation. In all, five such trenches were required for the whole project. On the completion of a given tunnel segment, the entries were bulk-headed and the trenches backfilled to original grade.

Given the plan for current and future water well and wastewater bulbs to maintain a maximum diameter of 30m (100 ft), and a minimum separation of 30 m (100 ft) between bulbs, the side tunnels and main tunnel provide access for eight new water well sites. In general, these sites will become active commencing at the distal end of the network. Progressive abandonment of old facilities and tunnel segments in retreat will allow space for disposal of gob produced in tunnel maintenance activity.

"Ground" and tunnel conditions at the south pole

The "ground" in which the tunnels are excavated at South Pole is firn - a dense snow that has not yet compacted fully into solid ice. Its density at tunnel depths is 0.50 g/cc, whereas solid ice is 0.92 g/cc. The firn at the tunnel depths is texturally uniform, well below any relict layering from annual snowfall, and free of fractures.

This firn has some noteworthy qualities that make it rather unique as a tunneling medium. For example, it has high compression strength: around 14 kg/cm2 at 14 m depths (200 psi at 46 ft) (Gow, 1964). Practically speaking, a blunt object, such as a fist, striking a blow in the material will barely dimple the snow, and the tunnel walls stand reliably at the design overburden depths. Yet, the material yields readily to a cutting blade, such as a chain saw or an auger bit, and it is not abrasive in the least. It fractures cleanly with the lightest of explosive charges when sawn reliever cuts are first employed, yet compresses inconsequentially when they are not. A skillfully sawn block cut 0.6 m (2 ft) into the tunnel face will release from the face with a slight tap. A coarse threaded lag screw 20 cm (8 inches) long twisted into the tunnel back will suspend the weight of a person without pulling free. Indeed, the material is a pleasure to work with.

In a few places the "ground" characteristics did vary from those cited. For example, the tunnel course from Station 90 m (300 ft) to the portal ran up into backfilled snow from the previous season's surface excavation. This material had been track-packed by bulldozers, and had compacted and re-crystallized into dense firn, nearly "ice" at 0.84 g/cc. Furthermore, it was laced with bits and pieces of construction debris. On both accounts, the tunnel advance rate through this section was slower than usual. Solid debris otherwise was seldom encountered elsewhere in the tunnel as the tunnel ran mostly below the 1972 surface. The tunnel did, however, pass through a few 20- to 30-year old gasoline and diesel spills. Tunnel atmosphere contamination in these instances was found to be negligible.

The temperature of the firn at the tunnel depths measured at −50℃ after the tunnel had been sealed for a season. This coincidentally reflects the annual average surface mean temperature at South Pole (given by the "10 meter rule" which provides that at any point in Antarctica, the annual average surface mean may be found by the measuring the temperature 10 m below surface, which is constant). In a sealed tunnel, the ambient temperature equilibrates with the tunnel walls, and is also −50℃. When the tunnel is open to the surface, such as during summer tunneling operations, warmer outside ventilation air enters the tunnel, and ambient tunnel temperatures have been measured at −32℃ and the superficial firn temperatures at −37℃.

On a larger scale, the firn deforms by slow, plastic "squeeze" under the static overburden load. Tunnel closure measurement stations installed in the 1.8 m × 3 m rectangular tunnel cross section show fairly consistent annual closure rates to date of 1 cm to 5 cm center of span vertically, and 1 cm to 3 cm center of span horizontally. Unlike "squeezing ground" in rock tunnels, this "squeeze" is not attended by spalling, fracturing, or burst. On an even broader scale, while the entire ice sheet at South Pole moves at a rate of 9 m (30 ft) per year, significant deflection has not yet been noted over the long course of the tunnel.

Early material strength testing (Sodhi, Rand, Tobiasson; 1993) provided practical, structural safety guidelines for a tunnel in this material such that an excavation no more than 1.8 m (6 ft) wide, in firn of density 0.50 g/cc, under 6.5 m (20 ft) of cover can support the weight of an idling or over-passing fully loaded LC-130 aircraft or a 28-t (31-ton) D-7H Caterpillar bulldozer without ground failure.

Vertical variation in snow quality and density was not uniform in the project area. Whereas one might expect a gradational density change in the vertical section, such was not encountered. The several escape raises and access trenches mapped out two "regions" of different stratigraphy, neither one showing such gradational changes. In the distal portions of the project area - under a surface of historically restricted access——a 6 m (20 ft) thick layer of incompetent, "mealy" snow lay 2 m to 3 m above the top of the tunnel which was driven in "good" firn. The contact between the mealy snow and the firn was abrupt. Above the proximal portions of the tunnel - under a historically high traffic area——the mealy snow did not exist. In its place lay erratically compacted snow. In both areas, relict layering - often seen as lenticular partings thought to reflect annual snowfall——persisted to depths of 6 m (20 ft) below surface.

Tunnel method testing

Both mechanical and conventional tunneling alternatives were tested at South Pole prior to commencement of the actual tunneling project.

In the first instance, the US Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) had developed a continuous miner, tunnel-boring machine——loosely patterned after a "road header"——specifically for application at South Pole. Adapted onto a small, commercial track hoe, the prototype CRREL system employed crawler track locomotion, electro-hydraulic power, and a novel cutting drum and pneumatic chip disposal system. The system was deployed to South Pole and tested during the 1995 – 1996 and the 1996 – 1997 summer seasons. These tests successfully proved the concept for the prototype system in excavating a 120 m long tunnel. Following modifications made after these deployments, the system was once again deployed to South Pole for testing and demonstration in 1998 – 1999.

In the second instance, conventional - and actually rather primitive - tunneling methods were tested at South Pole in the 1998 – 1999 summer season to ensure that tunneling could proceed in the event the mechanical system could not. As the prototype CRREL system was still under continuous development, its application to a production assignment had yet to be proved, particularly in the system's durability and steer-ability. Given the difficulties of supply and logistics at South Pole, conventional method testing sought to use materials readily available there: electric chain saws, picks, shovels, sleds, and raw manpower. Even explosive methods for breaking out a tunnel face were tested. All these methods also proved successful at the South Pole.

The CRREL Tunneling System, Testing

The CRREL South Pole Tunneling System is the direct evolution of mechanical tunneling systems tested in Greenland during the late 1950's and early 1960's. While those systems were applied to ice, they did employ a Joy 3 continuous coal miner using shuttle cars for muck removal, and later a CRREL developed "Russell Miner". The Russell Miner employed a boom mounted cutting head and series of vane-axial booster fans in a string of ducting for pneumatic chip removal. There was sufficient residual moisture from the tunnel face cuttings in both instances to promote "crippling" muck freezing on the extensible belting in the Joy miner and in the shuttle cars, as well as on the in-line fans in the Russell Miner ducting system.

A significant advance in mechanical snow and ice mining technology presented by the CRREL South Pole Tunneling System lay in the negative pressure, telescoping, pneumatic ducting system powered by a single, surface-mounted 50 hp centrifugal fan.

CRREL system description

This CRREL system is comprised of five subsystems: the tunnel boring machine, the pneumatic chip disposal system, the drill rig, the generator module, and the workshop module. The whole system, when fully deployed, is shown diagrammatically in Figure 4.

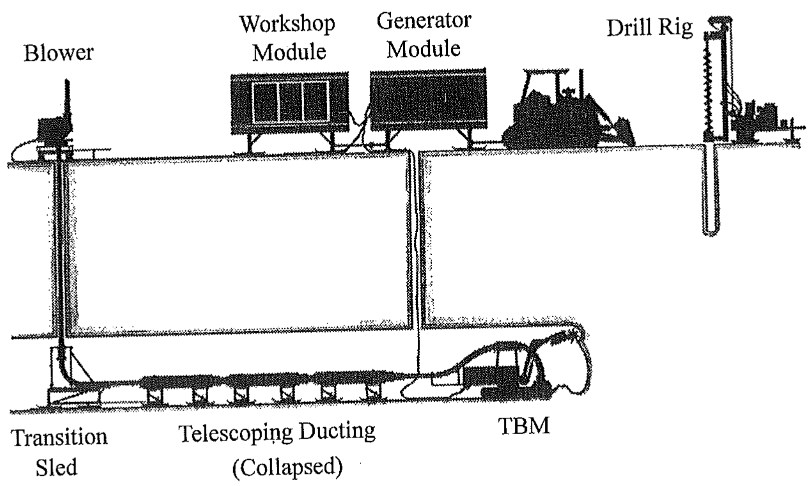

Fig. 4. CRREL tunneling System

The tunnel boring machine is loosely based on a transverse rotational "road header" model employing a 1.8 m (6 ft) wide by 0.6 m (2 ft) diameter cutting "drum" on the end of the boom (Figure 5). The drum consists of a series of 26 arms, in staggered orientation, each arm extending the full diameter of the drum, and fitted with specially designed cutters with 1.3 cm wide teeth. A hydraulic motor turns the cutting drum in overhand fashion. Face advance is initiated by sumping the rotating drum into the bottom of the face, advancing the whole machine on its tracks up to 20 cm (8 in) forward. Raising the boom with the rotating drum up to the top of the face cut produces a pile of cuttings on the tunnel floor and a 1.8 m (6 ft) wide by 3 m (10 ft) high rectangular excavation.

Fig. 5. CRREL funneler on surface

A spiral rake mounted on an extendable frame attached to the front of the machine then advances into the muck pile, gathers the chips, feeding them to an impeller that in turn injects the material into the airstreams of the pneumatic ducting system. The material travels through a horizontal, telescoping duct system trailing behind the machine, then up through a transition duct into vertical ducting fitted through a 0.3 m (12 in) hole bored from surface, and finally into a centrifugal fan on surface which expels the cuttings.

The skid-mounted drill rig, operating under its own diesel-hydraulic power, may bore 0.3m (12 in) diameter auger holes from the surface to the tunnel below for installing the vertical ducting, or to serve as a conduit passing power cables to the tunneling machine. These holes must be drilled to intersect the open tunnel, as the auger will not completely lift the cuttings from the hole, and residual cuttings will "bridge" and refreeze in the hole in a matter of minutes (Figure 6). In addition, using the 0.3 m auger hole as a pilot hole, the drill string may be fitted with a 1.0 m (3 ft) diameter back-boring bit to ream an escape raise hole or a larger utility hole.

The skid-mounted generator module contains a 205-kVA turbo-diesel generator set that powers the tunneling machine, the workshop module, the centrifugal surface blower fan, and a portable in-tunnel warming shelter.

In practice, the ducting system advances every 30m (100 ft) of tunnel advance, and the generator/workshop module assembly every 120 m (400 ft).

Testing

Following modifications made after the 1995 through 1997 deployments, the

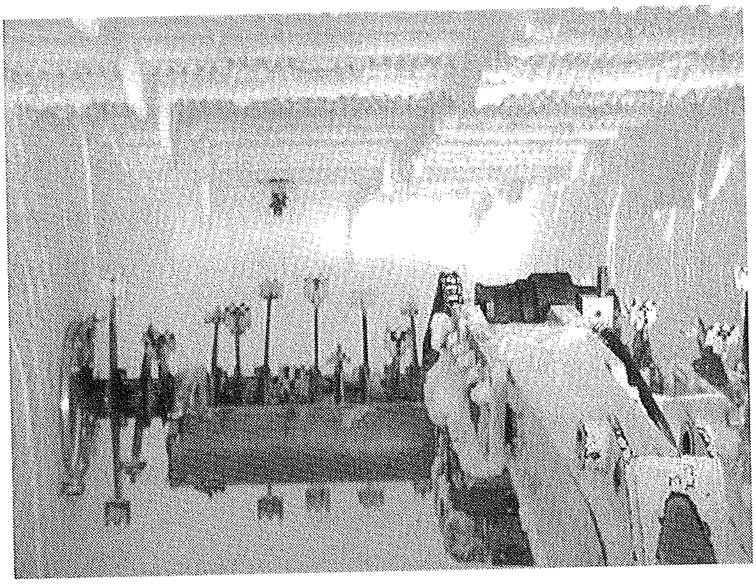

Fig. 6. The face, looking over cutting drum at auger hole through. Note laser spot on centerline

CRREL system was again deployed to South Pole in 1998 – 1999 for further testing and demonstration. In five days on station, which included system mobilization, mechanical repair, and demonstration, the tunneler drove an 11 m (36 ft) long tunnel. During this test, the system fairly demonstrated purely operational tunnel advance rates of 1.2 m to 1.8 m (4 ft to 6 ft) per hour. However, all the mechanical problems experienced during the 1995 – 1997 deployments were not resolved, and a guidance system for the tunneling machine had yet to be devised.

Conventional Tunneling Methods, Testing

Tunnel testing during the 1998 – 99 season demonstrated that all the planned utilities for the finished tunnel - namely, fresh water and waste water piping - could be installed cheaply and efficiently by tunnel rib-mounted hangers in a 1.2 m wide by 2.1 m high (4 ft by 7 ft) arched tunnel cross-section, and still provide ample space for pedestrian traffic. In fact, this configuration in the smaller tunnel provided more traffic area than in the floor-mounted utility supports subsequently installed in the 120 m long, 1. 8 m by 3 m proof-of-concept tunnel driven by CRREL in 1996. Conventional tunnel method testing during the 1998 season therefore concentrated on driving the smaller sized tunnel: the CRREL system could not drive a smaller tunnel.

Conventional tunnel method testing explored tunnel advance first by purely manual methods employing hand-tools, and second by using explosives for face breaking enhancements.

Manual advance methods

Tools for manual tunnel advance included: one 0.5m (20 in) bar electric chain saw, a portable light generator and extension cord, two mattock picks, two coal scoop shovels, two "banana" sleds, and one sheet of plywood serving as a muck sheet. All these tools and the personnel to use them were readily available at South Pole.

Face advance by conventional methods necessarily is dependent on a mining cycle. For these tests, the cycle proceeded as follows:

1. Set up line and grade strings, survey and mark the face.
2. Saw the face in a specified pattern of cuts.
3. Advance the muck sheet on floor grade, using the sawdust from step 2 to level the floor.
4. Pick down the face (1 miner), allowing the muck to fall onto the muck sheet.
5. As picking progresses, muck off the sheet into the sled, tram loaded sled out the portal and dump (1 or 2 miners).
6. After squaring the advanced face, set up line and grade sights, survey and mark face for next cycle.

In both of two methods tested, sawing commenced with cutting the entire outline of the face to the full depth of the saw bar. Thence, in one approach, the miner made three vertical relief cuts, looking straight ahead and running from top to bottom - one cut on center line, and two each splitting the width between the centerline and the ribs. Following that, the miner simply picked down the columns of firn between the relief cuts and squared the face.

In a second approach, after cutting the outline of the face, the miner made six evenly spaced vertical relief cuts, and five horizontal cuts from rib to rib evenly spaced from top to bottom. The resulting "blocks" were manually plucked or picked out of the face, and then the face picked square.

When the manual test tunnel approached 30m (100 ft) on a +1% grade, and the miners had become accustomed to the methods, the two approaches were pitted against each other in a time trial. Using two miners, the cycle time by the first approach clocked 31 minutes, compared to 27 minutes for the second approach. Using three miners, the cycle time by the first approach ran 26 minutes, and 25 minutes by the second. The muck produced from each face cut made between 8 to 11 sled loads to be hand-trammed out the portal.

The test tunnel eventually ran out to 32.3 m (106 ft) in seven 9-hour shifts.

Initially, one miner working alone took the tunnel to 11.6 m (38 ft) in three shifts. Thenceforth, as face surveying became time consuming, and the tramming distance longer, two additional miners joined to complete the test tunnel.

The tests showed that a single miner could comfortably break 3.6 m (12 feet) of tunnel in a single shift. The critical variable in advance rate became the manpower necessary for tramming the muck out of an ever-deepening tunnel.

Conclusions from this testing indicated that an average advance rate of 3.6 m (12 ft) per shift, given similar tools and conditions, was sustainable to tunnel depths of 152 m (500ft). A 152 m long tunnel, driven by a crew of three miners, could achieve 7.3 m (24 ft) per shift over the first 30 m (100 ft), and might make 1.8 m (6 ft) per shift over the interval 122 m to 152 m (400 ft to 500 ft). These predictions proved accurate in the ensuing tunneling seasons.

It happens that during the subsequent tunneling seasons, 0.6 m (24 in) bar chainsaws became available, and given a somewhat denser firn encountered in tunneling, a variation on the second face cutting approach evolved. The face-cutting pattern of choice used five vertical relief cuts, four horizontal relief cuts, and two small "burn" cuts to initiate block removal. Each cut was carefully made to facilitate sequential block removal and avoid blocks keying against one another. This face cutting pattern is depicted in Figure 7.

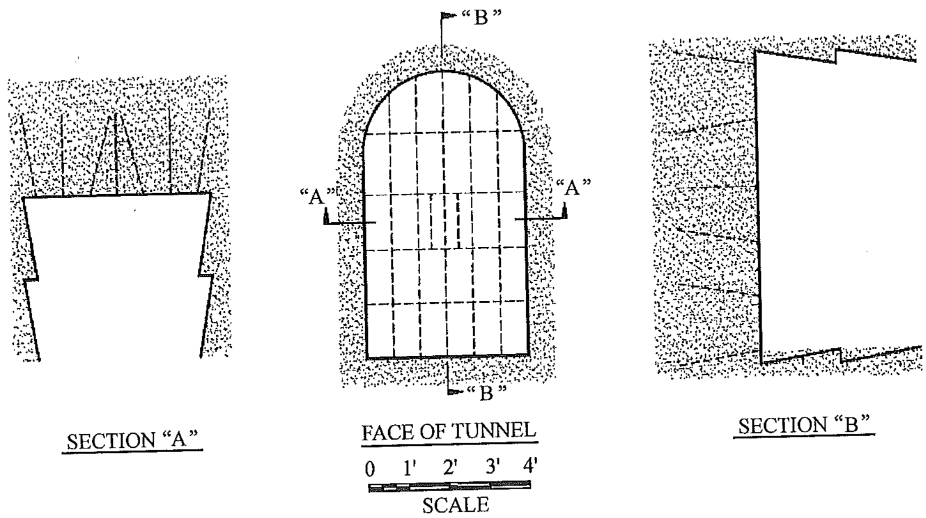

Fig. 7. Manual face cutting Pattern

Enhanced advance with explosives

Explosives methods testing sought a more labor efficient way of advancing the tunnel face in firn than by manually sawing and picking. Specifically, this testing sought a way to pull rounds respectively 0.6 m, 0.9 m, and 1.8 m deep (2, 3, and 6 ft). Explosives were readily available at the USAP's McMurdo Station and flown to South Pole for these purposes.

Following tests involving crater blasting, trim blasting, v-cuts, and combined v-cuts and trim blasting, the blasting solution that proved effective involved a combination of pre-sawing relief cuts and light explosives.

The successful explosive enhancement method began first with sawing the entire tunnel outline with a chainsaw as described above. Thence, two holes drilled with a 4 cm (1.625 in) diameter auger, each 0.6 m (2 ft) deep and both on centerline, received half a stick of dynamite each, or 0.1 kg (1/4 lb). These charges, timed to fire simultaneously, broke the entire round into coarse muck to the tunnel outline -- whose saw cuts acted as a pre-split relief cut - and no farther. The face broke fairly clean to an additional 0.3 m (1 ft) in advance of the saw cut depth. Given the short saw bar available, these tests suggested longer bars would improve the productivity of this already successful method.

General

Slabbing, or enlarging a pilot bore from 1.2 m by 2.1 m (4 ft by 7 ft) to 1.8 m by 3 m (6 ft by 10 ft) - the size of the CRREL system tunnel - was never tested. The volume of material to be moved in enlargement work was nearly identical to that produced by the pilot bore, thus tramming rates in enlargement work would be identical. It was merely observed that enlargement would proceed faster than face advance in the pilot bore, since the enlargement effort was not dependent on the mining cycle for advance. In practice, tunnel enlargement did take place in driving side Tunnel B. As expected, the enlargement work proceeded faster than pilot bore advance.

Tramming enhancements - such as better sled design than those simply available, or sled trains pulled by mechanical tuggers -- while proposed, were never explored nor provided. Adequate mechanical ventilation for using explosives was never available.

Production performance

The will of the program called for use of the CRREL machine to excavate the majority of the tunnel. Among other reasons, the larger cross-section it produced would defer tunnel maintenance requirements due to closure by "squeeze" for several years. Manual methods were employed when the mechanical system was 1) unavailable, 2) incapable of executing a desired course deflection, or 3) when time was of the essence for a comparatively short tunnel.

The ideal crew size for operating the CRREL tunneling system called for one tunneling machine operator, one in-tunnel duct tender, one permanent top lander, and one rover - a total of four people. The tunnel foreman acted as one of these four, and crewmembers rotated through all of the duties. Frequently, escape raise construction and other surface drilling took place simultaneously with face advance, thus involving all four crewmembers. Otherwise, the rover was involved in miscellaneous repair and supply duties, and ancillary tunnel construction work. Only three people per crew started each season. When operations were up and running, a fourth was added. The entire final season ran with only three members per crew, and production rate suffered for that during surface drilling and escape raise construction activity. In all cases, manual advance proceeded with three members per crew. Two crews operating on two 9-hour shifts per day, six days per week, ran the entire project.

Tunnel steering issues were solved for mechanical operation by using a laser and folding peep sights mounted on centerline in the tunnel "back" -- or "roof". The laser spot would strike the center of the cutting drum on up-cutting, thus centering the cut (Figure 6). That same spot, on striking a mark on the boom, gave the top of the cut. The bottom of the cut was manually checked every four feet of advance by measuring up from the sill to the laser beam. Guidance for manual advance, on the other hand, employed the ancient method of plumb-bobs and grade strings. No tunneling time or effort was wasted for having drifted off line and grade. This efficiency was particularly critical for the project in that all the tunnels driven originated at distant points and drove for precise intersections in existing workings.

In measuring production performance, "time" began when a given access trench had bottomed out, and surveyed line and grade had been established. In each of three production seasons, time started before the mechanical system was ready to be deployed. In these instances, manual advance initiated a pilot bore to guide the tunneling machine when it was ready. "Time" ended when either the season's production goals had been reached, or when the mechanical system broke down without hope of repair that season. "Time" did not count against machine performance when a single heading, manually driven tunnel was the sole intended activity, as in the case of side Tunnel E. "Time" also did not include project mobilization or de-mobilization - generally a week at either end of the season. In all cases, "time" applies only to 18-hours per working day.

Mechanical Advance

In analyzing the CRREL tunneling system performance, operational time applies to time the system was actively advancing the face. Down time refers to time the system was broken, or unavailable for use, including shortcomings in logistics and procurements. Standby time records time the system was available, but was not used, such as during meetings, drilling operations, or moving and re-staging the system set-up.

Mechanical tunneling performance in time, based on shift hours, for each of the three production seasons is given in Table 1. The down time fraction in all cases reflects mechanical down time and logistics/supply down time in roughly equal portions. Bad ground and ground support activity were never down time factors.

Mechanical tunneling performance in advance, expressed in meters (feet), is given in Table 2. Total mechanical advance includes overtaking the smaller, manually driven pilot bores. The fraction of mechanical advance involved in this activity may be inferred by comparing the reaming advance to the total. All other mechanical advance applies to full-face operations. It happens that the best weeks and best shift reported apply to full-face operations.

Although the CRREL tunneling system was a prototype system, by the second half of the last season, nearly all the major mechanical difficulties had been solved. The seasonal production statistics do not reflect this, but daily shift reports during this period show a minimum of down time for only small maintenance issues. The crew was well pleased with the CRREL tunneling system performance at the close of the last season.

Manual Advance

In addition to small pilot bores driven when the mechanical system was not available, two headings were specifically designated to be advanced by manual techniques Figure 8). Side Tunnel B, advanced initially by a pilot bore, then manually enlarged to 1.8 m by 2.7 m (6 ft by 9 ft), was accessed through the entry to Tunnel A, and driven to a short distance on a flat grade. The tram, however, ran uphill at +1% through the main tunnel, and around two 90° corners for over 91.5 m (300 ft). Side Tunnel E, commencing from its own, narrow access trench, drove 46 m (150 ft) on a 1% up grade to intersect the main tunnel.

Manual advance performance is given in Table 3. All manual tunneling was

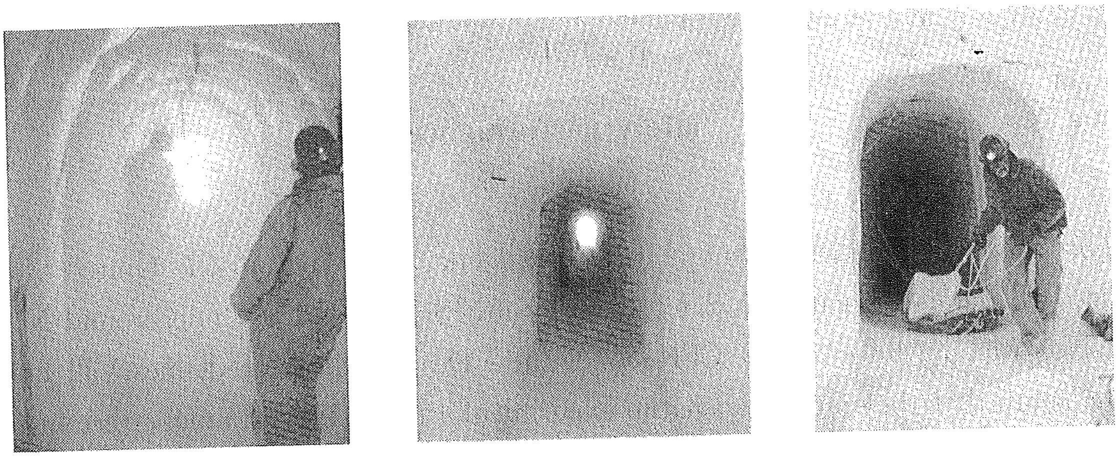

Fig. 8. Manual advance: sawing and hand-tramning

completed with 3-person crews. With the exception of Tunnel B, all of the manually driven tunnels began with a tramming distance of "zero".

The drive of the 2000-2001 season actually comprised three tunnel segments. Two commencing from the same access trench ran at 90° to one another: one 20.7 m (68 ft) long on a −1% grade, the other 61.3 m (201 ft) long on a +3% grade. The third segment, 4.3 m (14 ft) long at +3% began from within a fully machined tunnel when the face was nearing the final hole-through for the season and the mechanical system had broken down. Face muck was stored in the existing tunnel. Against expectations, spare parts arrived for the tunneling machine in time to effect repairs and resume mechanical advance.

Tunnel B was first advanced to 20.1 m (66 ft) by a pilot bore, and then enlarged to final dimension. Pilot bore advance consumed 5.5 shifts. Enlargement was completed in 3.1 shifts.

Comparative Performance

In comparing tunnel advance rates between mechanical and manual methods through similar ground mediums on this project, note: 1) the mechanical methods proved susceptible to down time, while manual methods experienced none, 2) manual advance rates fall off with the tramming distance, while mechanical rates do not, and 3) mechanical methods excavate roughly twice the volume per unit of advance than manual methods do on the first pass.

If the mechanical tunneling system experienced no down time on a 9-hour shift, then at 0.9 m (2.9 ft) per operating hour, that shift would produce 7.9 m (26.1 ft) of tunnel advance. By comparison, the smaller, manually driven tunnel demonstrated

7.3 m (24 ft) of advance at tram distances up to 61 m (200 ft).

Safety performance

Throughout the project, general safety guidelines derived from the United States Code of Federal Regulations: Safety and Health Standards for Underground Metal and Non-Metal Mines——30 CFR 56/57/58. Despite these guidelines, all crews were aware that they were engaged in experimental technology in unique terrain that called for developing some new guidelines. The first of these rules for tunneling at South Pole was: "Nobody gets cold!"

At the onset of cold, any crewmember was instructed to take immediate steps to restore body warmth, and to inform the crewmates of such. Cold focused one's attention on one's physical discomfort to the distraction from the work at hand, thus increasing the potential for dangerous mistakes. Heated spaces in the surface workshop module, the mobile in-tunnel shelter, and the cab of the tunneling machine itself were invaluable in maintaining warm, physical comfort.

A second rule was: "On encountering anything other than clean, white snow in the face, stop and investigate." Encountering buried junk was a certainty, but the size or type of junk was unpredictable. As it turned out, tunneling encountered little solid debris, but the rule proved its merit when the tunnel passed through an old gasoline spill - first smelled, and then seen as pinkish discoloration in the tunnel face. In this instance, a work stoppage was ordered until ground and atmospheric volatility and contamination were tested as "safe".

Three smoke-in-tunnel incidents occurred in the first season of operation and were considered "near misses." As no effective supplementary tunnel ventilation system was ever provided, the only mechanical tunnel ventilation derived from the CRREL ducting system. When "on", the ducting system drew over 2, 000 cubic feet of outside air per minute at a velocity somewhat over 40 feet per minute from the portal and through the tunnel, as measured at the rear of the tunneling machine. This was sufficient for miners working in uncontaminated air, but not sufficient in contaminated air. The rule, on encountering smoke-in-tunnel, became: evacuate immediately to a fresh air base first - before raising an alarm or attempting to suppress a fire.

While smoke-in-tunnel was the chief safety concern of the crew during the first tunneling season, such incidents never occurred in subsequent seasons. Instead, consensus on the chief safety concern following the second season was for personnel movement over and around the machine. The third season's chief concerns were for personnel movement around the machine as well, but also for "complacency". By the end of the last season, the work was going so well that the crew recognized the hazard of becoming "complacent" in good times!

In all tunneling seasons, the crews cultivated an attitude of 100% safety awareness, recognizing that "safety" was a shared and personal issue, not a statistical one. The fruits of this approach were a record of zero lost time accidents over the course of the entire project. Yet of all project statistics, the crews were most proud of this one (Figure 9).

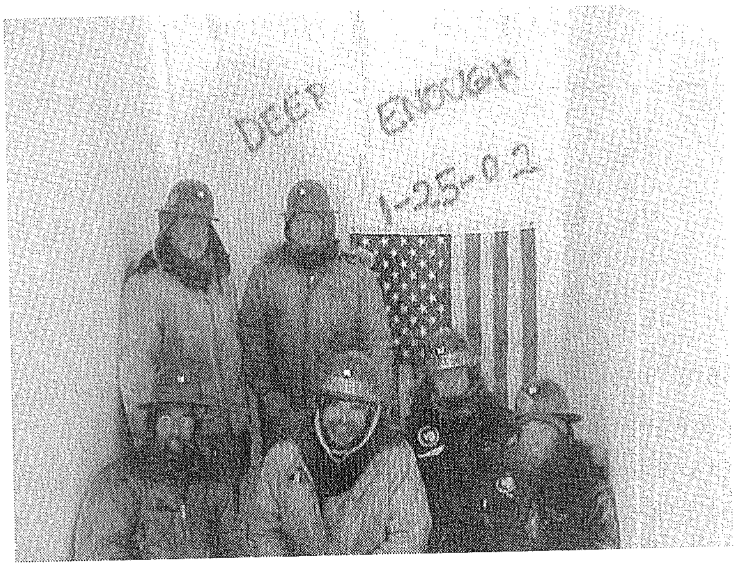

Fig. 9. "Deep Enough" The end of the tunnel

Table 1. Performance——Time

Season	Duration (weeks)	Operational Time, %	Down Time, %	Standby Time, %	Total Time on Machine
1999－2000	9	39	51	10	846 hr
2000－2001	9	35	57	8	926 hr
2001－2002	10	42	31	27	906 hr

Table 2. Performance——Advance, meters (feet)

Season	Total mechanical advance	Average weekly advance	Average advance per operating hour	Best Shift	Total reaming advance
1999－2000	294 (964)	32.6 (107)	0.9 (2.9)	10.4 (34)	24 (80)
2000－2001	287 (940)	31.7 (104)	0.9 (2.9)	7.9 (26)	86 (283)
2001－2002	290 (951)	28.4 (93)	0.8 (2.5)	9.4 (31)	7 (24)

Table 3. Manual Advance, meters (feet)

Season	Heading	Dimension	Length [Max tram length]	Shifts	Average advance /shift
1999 – 2000	Main Tunnel	1.2 × 2.1 (4 × 7)	24.4 (80) 24.4 (80)	3.3	7.3 (24)
2000 – 2001	Main Tunnel	1.2 × 2.1 (4 × 7)	86.3 (283) 61.3 (201)	14.7	5.9 (19.2)
2001 – 2002	Tunnel A	1.2 × 2.1 (4 × 7)	7.3 (24) 7.3 (24)	1.0	7.3 (24)
	Tunnel B	1.8 × 2.7 (6 × 9)	20.1 (66) 104.3 (342)	8.6	2.3 (7.7)
	Tunnel E	1.2 × 2.1 (4 × 7)	45.7 (150) 45.7 (150)	6.1	7.5(24.6)

References

Abel, J.F., Jr. (1961) "Under ice mining techniques." *CRREL Technical Report* 72, U.S. Army Snow, Ice, and Permafrost Establishment, Wilmette, Il

Gow, A.J., and R.O. Ramseier (1964) "Age hardening of snow at the South Pole." *Journal of Glaciology*, 4(35), 521 – 536

Sodhi, D.S., J.H. Rand, and W. Tobiasson (1993). "Stress analysis of a proposed tunnel under the South Pole Skiway." *Proc.*, 50th *Annual Eastern Snow Conference*, American Geophysical Union, Washington, D.C., 347 – 354

Walsh, M. R. (1999) "The CRREL South Pole Tunneling System"; *CRREL Report* 99 – 1; US Army Cold Regions Research and Engineering Laboratory, Hanover, NH

Walsh, M.R. (2001) "Tunneling system for the South Pole." *Journal of Cold Regions Engineering*, 15 (4), 231 – 236

Walsh, M.R., J.H. Wright, and E.B. Jensen (2001). "A tunnel boring machine at the South Pole." *Proc.*, *Rapid Excavation and Tunneling Conference*, Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Co., 687 – 698

Wright, J. H.; "Tunnel Tests, South Pole, 1998 – 99"; internal report, Antarctic Support Associates

Wright, J. H.; "South Pole Tunnel Project, 1990 – 2000 – After Action Report"; internal report, Antarctic Support Associates

Wright, J. H.; "South Pole Tunnel Project, 2000 – 2001 – After Action Report"; internal report, Raytheon Polar Services Company

Wright, J. H.; "South Pole Tunnel Project, 2001 – 2002 – After Action Report"; internal report, Raytheon Polar Services Company

Potential Use of IR Imaging for Search and Rescue and Crevasse Detection

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Abstract: Significant strides have been made in Infrared (IR) imaging in the past several years. Thermoelectrically-cooled back focal planes permit high resolution images from a compact, relatively inexpensive, commercial product. To test the utility of this technology in the Antarctic, the National Science Foundation is supporting a series of IR camera experiments. To date, these experiments have tested the utility of a vehicle-mounted IR camera for Search and Rescue operations and explored the potential of IR cameras for remotely detecting bridged crevasses. This presentation will outline the results to date of the IR camera experiments, provide some theoretical explanations, and describe future experiments to be performed this coming season.

Introduction

Safety in Antarctica depends upon having an effective Search and Rescue (SAR) capability at all stations. Provisions must be made for getting safely to the site of an accident or loss and locating the victim once there. The difficulties are exacerbated by winter darkness, blowing snow, or white-out conditions. The ability to see through inclement weather is critical to a rapid response. For this reason, some U.S. SAR vehicles have been equipped with Radar and GPS to aid in navigation. Recent marketing claims have suggested that IR cameras permit the means to see through fog and snow. Thus, a thorough investigation of IR technology is warranted to see if IR imaging can complement existing SAR technologies.

Another concern of those working in Antarctica is bridged crevasses. Under different weather conditions, bridged crevasses can be impossible to detect by eye. The cost of not recognizing them has led to loss of life, heavy equipment, and a LC-130. Careful probing by trained personnel can help to locate crevasses in known trouble spots. More recently, Ground Penetrating Radar (GPR) has been utilized to look down through the ice. The result is a profile which depicts both ice and underlying voids. Unfortunately, this Radar equipment is expensive, technically sophisticated and not readily available. Experimental observations, discussed below, suggest that IR may be an effective means to see the surface temperature expressions of bridged crevasses. Further work is needed to confirm the efficacy of this technique and, hopefully, turn it into an operational capability.

Due to the potential benefits, the U.S. Antarctic Program (USAP) is funding an investigation into applications of IR sensing. The two focus areas presented in this paper are the use of IR imaging for SAR and crevasse detection. Significant findings have been made in the 2001/2001 summer season and further studies are planned for the coming summer season.

IR Technology

In recent years, significant strides have been made in thermal imaging. This technology utilizes IR transmitting optics coupled with a thermal-electrically cooled back focal plane, which is sensitive to Infrared radiation. The result is a video camera which "sees" the IR emissions of objects rather than their visible light.. Warmer objects (or objects with high emissivity) appear brighter than cooler objects. See Figure 1.

Although developed originally for military applications, the technology has moved into the commercial sector. High resolution, high sensitivity imagers are now commercially available for costs as low as several thousand dollars (U.S.). To date, they have been used for:

- surveillance (e.g. seeing warm bodies at night),
- thermal engineering (for monitoring heat leaks and processing equipment)

Fig. 1. Typical IR Video Camera image showing a person entering a lighted room from outdoors. Note the cold nose and ears as well as the heat produced by the ouvrhead lights

- remote sensing (e.g. finding fire hot spots in forests and oil slicks at sea),
- Search and Rescue at Sea (where victims "glow" against the cold sea)

For the purposes of this research, the National Science Foundation purchased a Thermal Sentinel IR camera, manufactured by Aspect Technology. This video camera offers temperature sensitivity of 0.1 degree Celsius, a resolution of 256 pixels, and an operating temperature range of −40 to +70 degrees Celsius. Figure 2 shows the spectral response of the system. Note that the spectral response makes this a true thermal imager.

Field Tests for SAR Applications

The weight (3 kg) and size of the Sentinel camera make it particularly well suited for mounting on a vehicle. The initial experiments (January 2002) were conducted with the camera magnetically mounted to the top of a Spryte tracked vehicle. Figures 3a and 3b show the camera body atop the Spryte as well as the LCD video screen within the cockpit. Power is provided by connecting to the vehicle's 12 Volt electrical system.

In driving around the McMurdo area, the following observations were made with

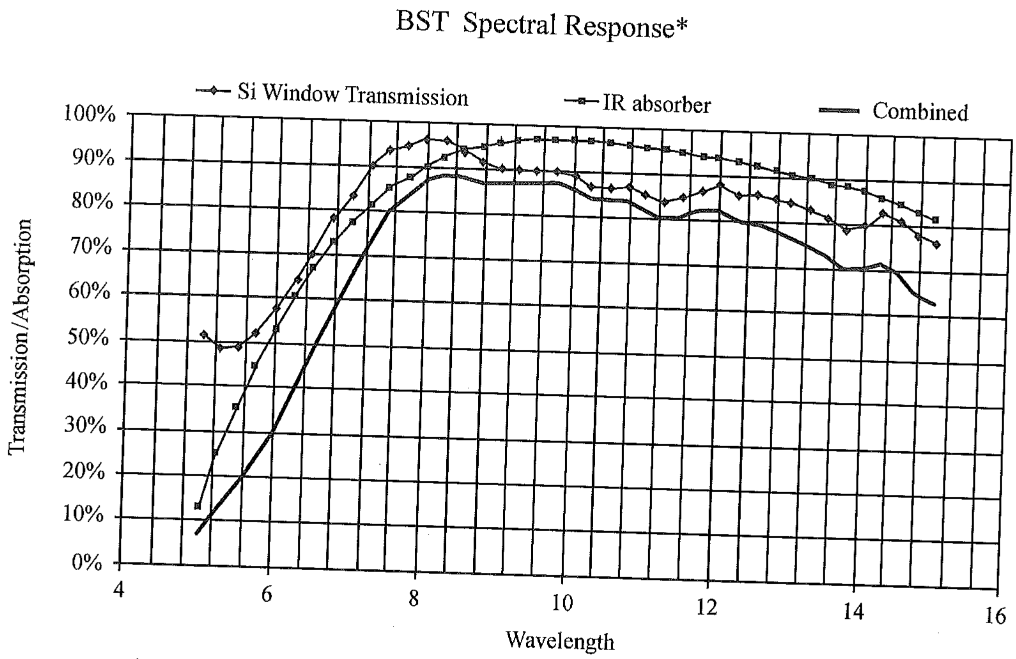


Fig. 2. Spectral respones curve for the Sentinel IR camera used in the experimnents. The"combined"curve shows that the camera sees only thermal energy in the range of 5 to 15 + microns

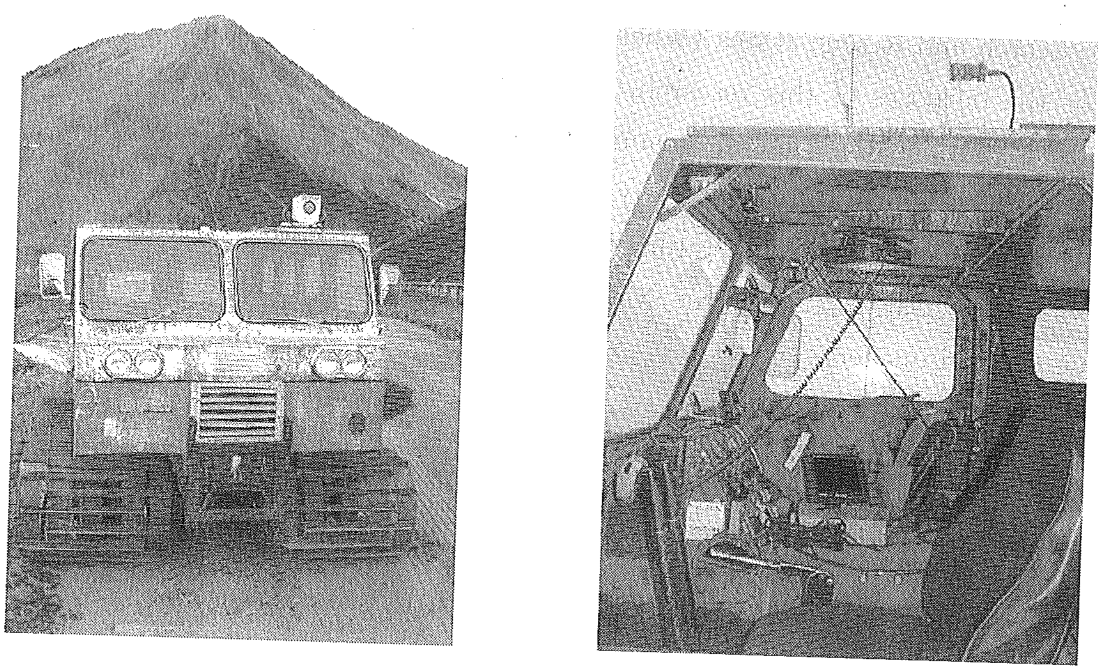


Fig. 3a and 3b. Figures depict the Sentinel camera mounted on a Spryte tracked vehicle. A magnetic mount secures it to the roof of the vehicle. An LCD flat panel screen can be seen next to the driver's seat

respect to the IR camera's capabilities:

- Topography is very evident. In fact the IR image was clearer than the visible image in the "flat white" lighting conditions.
- Hot vehicles could be clearly seen at a distance of 2 km.
- The driver could navigate from the LCD screen alone if it were mounted in a "Heads Up" manner.
- Roadway flags (red and green in color) could be clearly seen at 35 m.
- A person was visible at 500 m and discernible as a person at 300 m
- A prone body, lying in the snow, was very clear at 100 m. (See Figure 4)

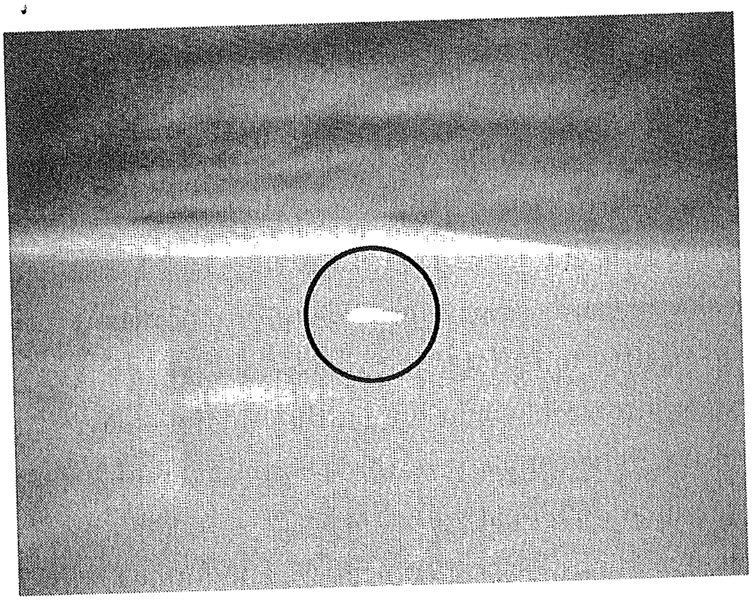


Fig. 4. Photograph taken from the LCD screen depicting a "victim" prostrate in the smow at a range of 100 meters. Note that the ECW clothing exhibits stark contrast relative to the background

- The visibility of a person is due to the clothing, not the heat of the body.

The last point requires some explanation. The brightness and contrast of the Sentinel camera are self-adjusting. Thermally bright object tend to saturate white in the image. Under these circumstances, a parka sitting atop the snow will produce the same image intensity as a person sitting next to it. This is seemingly good news for SAR; since it does not require that the victim be showing bare, warm skin to the camera in order to be seen. The thermal signature of the victim's Extreme Cold Weather (ECW) gear can be clearly seen by the camera (at least in the daylight conditions of the experiment)

IR Physics and Experimental Results

To understand the aforementioned comment that the image contrast was not a function of body heat but rather the material properties of the ECW clothing, one must recall some basic thermal physics. According to the Stefan Boltzmann equation, the thermal intensity emitted by an object scales as:

$$I = \varepsilon\sigma T^4$$

Where ε, the emissivity, depends on the material and σ is a physical constant. But it turns out that ice has an emissivity very close to 1 and higher than the emissivity of clothing. Hence, the ECW must have a higher temperature in order to glow against the darker background of the ice.

The reason for the temperature differential is the "Hot Pavement" effect. Objects that have a high albedo (such as pavement) absorb more energy from visible light. Thus they heat up relative to surfaces with lower albedo (such as grass). Similary, the ECW gear exposed to visible light during the Antarctic day, will heat up relative to the background ice. The corollary to this, however, is that during the Antarctic night, this temperature differential will disappear.

To confirm this hypothesis, an experiment was performed with ECW clothing on the snow. A Raytek RTK-ST80 non-contact IR thermometer was used to measure the temperature of snow, ECW wind pants, and an ECW parka under varying solar illumination. The results are summarized in Table 1. Under full sun, there is a significant difference in temperature between the ECW clothing and the snow. However, as the solar illumination diminishes into night, the differential disappears.

Table 1. Experimental data showing the temperature of smow, a USAP parka, and wind pants as a function of solar illumination. Note that as the illumination diminishes, so do the temperature differences. At might time, all three materials ane essentially at the same trmperature

LIGHT CONDITION	SNOW	WIND PANTS	USAP PARKA
Full Sun	35	78	74
Less Sun	35	66	60
Partial Sun	35	63	58
Slight Sun	35	46	48
Ful Shade	36	47	48
Night	36	36	38

Conclusions for Use of IR in SAR

Winter and bad weather will pose significant challenges to IR imaging. It is during the Austral night that one would most want to use IR to spot the body of a victim lost in the snow. Unfortunately, there will be minimal temperature differential during low- or no-light conditions, due to the "Hot Pavement" effect. The ECW gear of the victim will have equilibrated to the temperature of the snow, and thus will be indistinguishable from the background. So, when one needs the technology the most, it lacks the signal to locate victims.

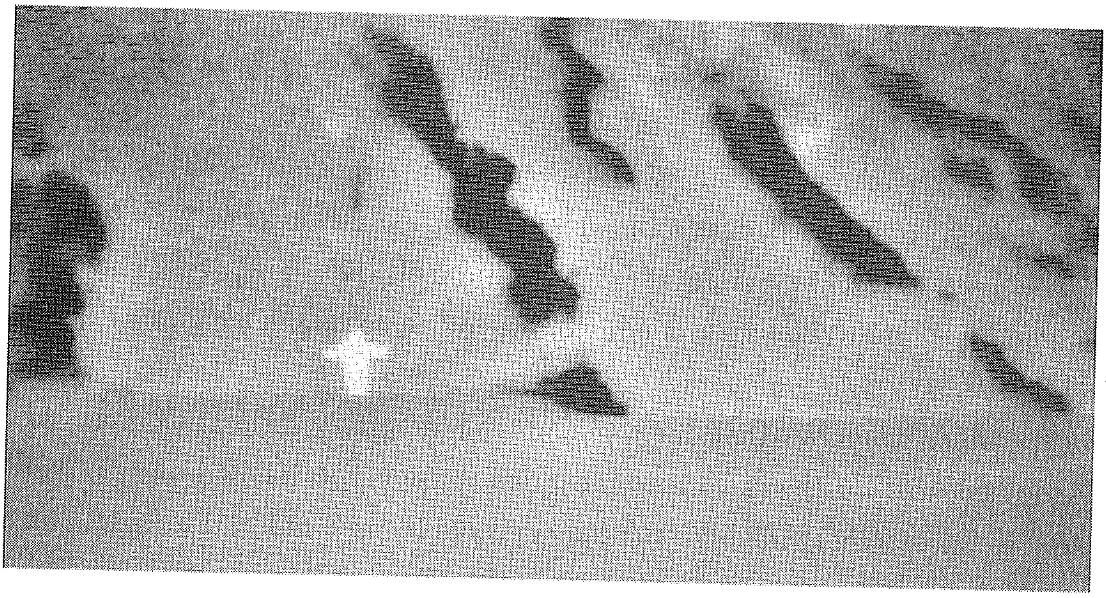
On the other hand, an IR camera mounted on a SAR vehicle can be viewed as a useful adjunct tool for the driver, who can use its signal to follow other hot vehicles engaged in the search. Similarly, the camera could be used to locate a flare lighted by the victim.

Field Tests for Crevasse Detection

In the course of testing the IR camera, it was observed that the camera yielded a very strong signal at nearby ice falls. Within the ice falls were bridged crevasses that appeared very dark relative to the background snow and ice. Figure 5 depicts the scene as observes by digital camera and IR Video. The bridged crevasses were barely visible to the naked eye. (In fact, the contrast has been heightened to make the crevasses more visible in the digital photograph.) On the other hand, the crevasses are starkly evident in the IR image.

The dark image of the crevasses presumably indicates colder temperatures. To confirm that it is temperature, not surface texture, a subsequent experiment was performed. Using a digital thermometer, a temperature profile was taken across several crevasses. Every meter, the thermometer probe was inserted 1 cm into the snow/ice until the reading stabilized. The result was a series of temperature profiles which depict the drop in temperature over the bridge.

Figure 6 shows one such temperature profile. The temperature over the bridged crevasse is seen to drop 10 degrees Celsius. Knowing that the IR camera can detect temperature differences as small as 0.1 degree, one observes that this is a remarkable signal. If normal crevasses exhibit a similar thermal signature, IR imaging provides a new and significant approach to detecting bridged crevasses.



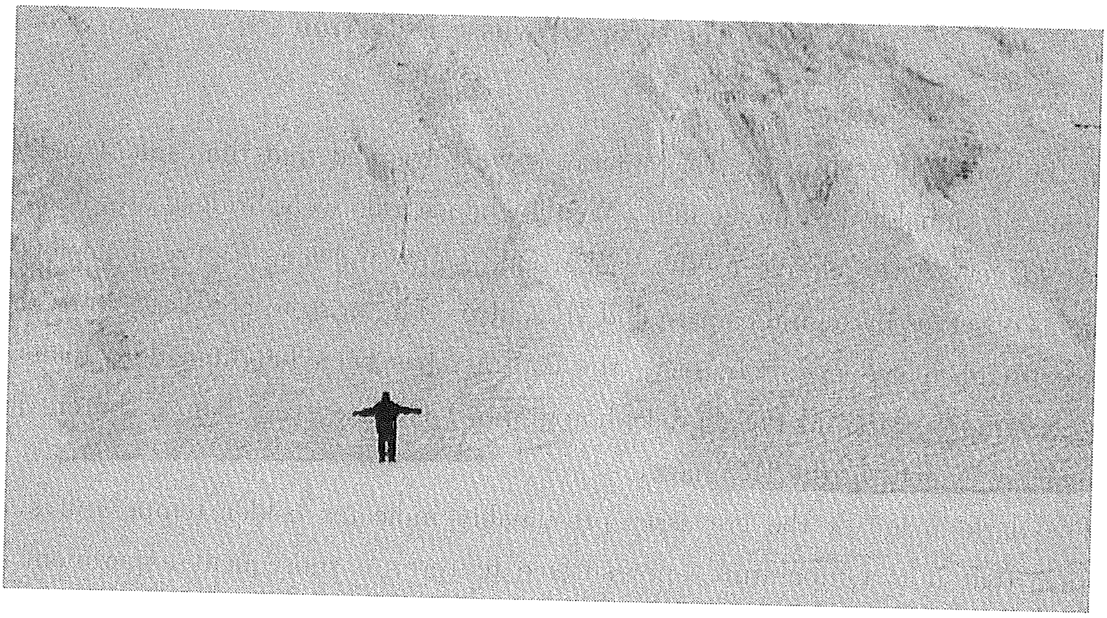


Fig. 5. Two photographs taken of the ice falls near McMurdo Station. The top one is an IR image and the bottom one is visible light. Note that as the illumination diminishes, so do the temperature differences. At night time, all three materials are essentially at the same temperature

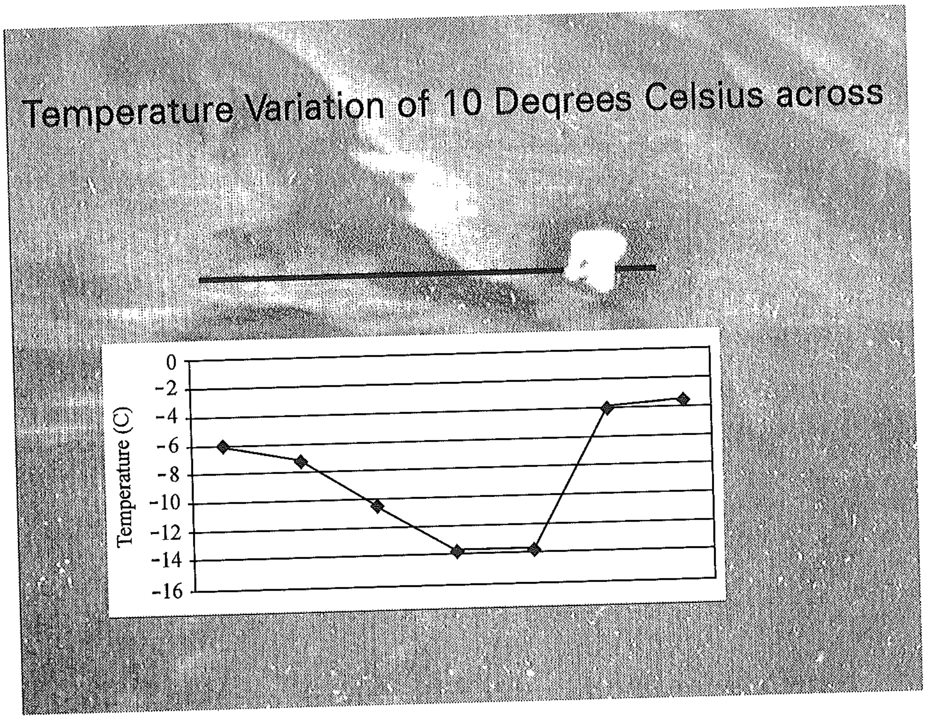


Fig. 6. Figure depicts multiple temperature measurements being taken across a bridged crevasse. The graph shows the temperature fluctuation as a function of position

Understanding Crevasse Detectability

A plausible explanation for the strong surface expression of bridged crevasses is that the cold temperatures characteristic of deep ice is conducted to the surface. Figure 7 shows data acquired by Gary Clow at Siple Dome. The temperature at 5 m depth is seen to be 11 degrees Celsius colder than the temperature at 1 meter depth, which corresponds to the peak summer temperature. If the bridge of the crevasse is seen as a "thermal short circuit", then we have a possible explanation for the cold surface temperatures.

The trouble with this explanation is that ice is a remarkably good thermal conductor. For the above explanation to hold, it must be demonstrated that the bridge ice is a fundamentally different from the adjacent ice. Experimentally, it was seen to be much more porous. This may be the key to the higher thermal conductivity. Proof is dependent upon further experiments.

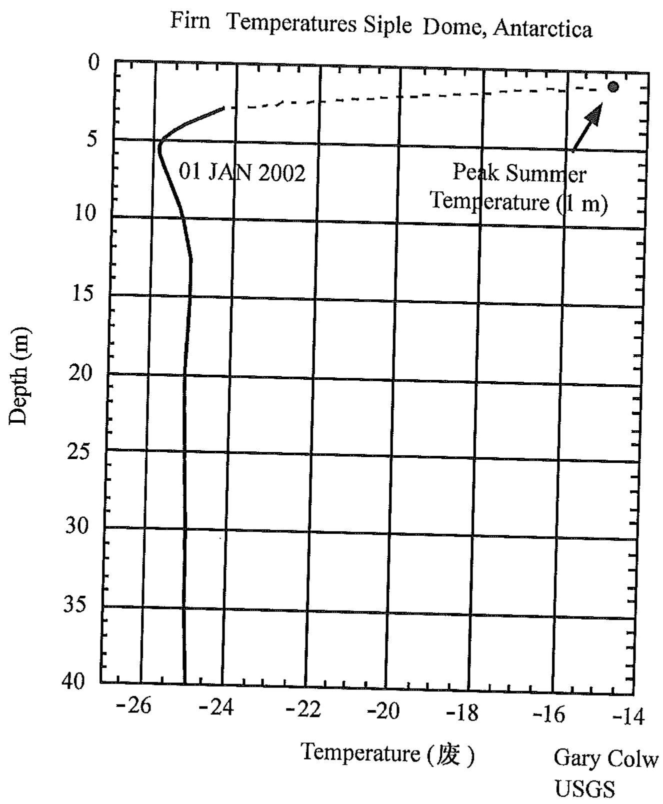


Fig. 7. Graph of ice temperature as a function of depth. Extrapolation at shallow depth shows the temperature drop that occurs as one bores down from the surface. (Data compliments of Gary Clow)

Proposed Crevasse Experiments for the 2002/2003 Season

The suggestive results of the crevasse experiment lead to a number of operational questions that must be answered before the technique becomes incorporated into the U.S. Antarctic Program:

- Can IR imaging (or IR temperature sensing) be used to reliably locate crevasses?
- Can one use the method to gauge the thickness of the crevasse bridge?

To answer these and other questions, the National Science Foundation is supporting further IR experiments in the coming season (FY03). Experiments at the Shear Zone near McMurdo Station will include:

- Recording IR imagery of crevasses from Helicopter, using GPS to ascertain accurate location
- Ground truthing the area to confirm the location and extent of observed crevasses
- Compare observations of IR camera with the results of Ground Penetrating Radar

- Acquire ice cores of ice bridges to determine their thickness and thermal characteristics
- Acquire vertical temperature profiles within a crevasse with thermister string and data logger
- Model experimental observations

The proposed experimental approach will serve to prove or disprove the efficacy of using IR as a means to detect bridged crevasses.

Potential Applications: The South Pole Traverse

An important potential application for the use of IR to detect crevasses is the U.S. Antarctic Program's South Pole Traverse. This project is intended to develop a safe over-ice traverse route from McMurdo Station to the South Pole. As shown in Figure 8, the route traverses the Ross Ice Shelf, crosses the Trans-Antarctic Mountains over

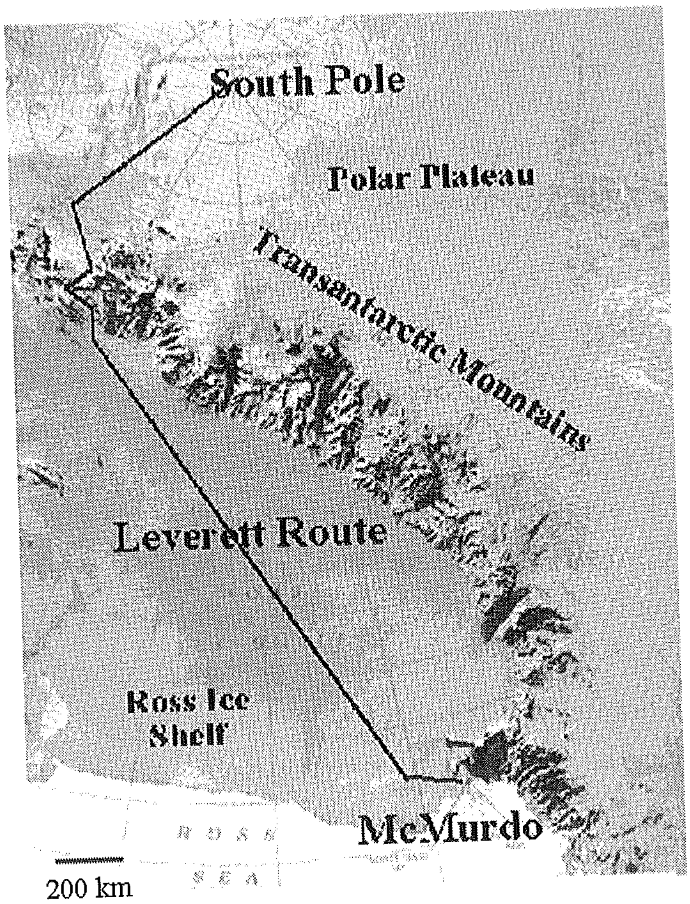


Fig. 8. Proposed route of the South Pole Traverse. Traverse will ascend the Leverett glacier in its approach to the Polat Plateau

the Leverett Glacier, then crosses the Polar Plateau to the South Pole. At numerous points along the traverse, there are known crevasse fields. Since safety will be paramount in this project, there will be a pressing need for technologies to detect and characterize crevasses.

If the experiments described in the above section are successful, then one can conceive of several applications for IR technology. The first is to use helicopter or Twin Otter to fly a IR camera over the traverse route, using the IR signal to see the surface expressions of crevasses. When coupled with GPS, this data will offer a geo-referenced image swath that can be used to identify possible trouble spots along the route.

A second application is to use IR technology to complement the data from a Ground Penetrating Radar (GPR). In this case one will utilize a non-contact IR thermometer mounted on a boom in front of a traverse vehicle. Temperature data from the probe will be relayed to a laptop computer which will display the ice temperature in a digital format and show temperature trends graphically. By setting a threshold, the vehicle operator will be alerted if the temperature drops below a set level; a possible indication of a crevasse in front of the vehicle.

The use of these methods may offer significant advantages to the Traverse Program, in that IR technology is relatively inexpensive, easy to operate, and significantly simpler than GPR methods.

Conclusions

Initial experiments performed last austral summer show that a vehicle-mounted IR camera can be used to spot a person at 500m distance in clear conditions. However, further examination proved that the albedo of a material (e.g. of an ECW parka) is critical in determining its thermal visibility. The visible energy absorbed by the ECW gear leads to increased temperature and an enhanced signal in the IR camera. Unfortunately, this negates the hoped for advantages of IR for Search and Rescue. "Victims" lost during the austral night will not have a strong IR signal. However, the IR camera may still prove useful for locating or following vehicles in the polar night.

Another preliminary result is that IR imaging provides a means for detecting bridged crevasses. Bridged crevasses at the ice falls near McMurdo Station presented extremely strong signatures in the IR camera. This observation presents an interesting challenge to future modeling and experiments: can IR imaging be used to determine the location, size, and degree of risk associated bridged crevasses? If this technique can be borne out, it has huge implications for Antarctic research. One can easily imagine applications, such as the South Pole Traverse Project, in which a plane or helicopter mounted IR camera could be used to assess safe routes. In addition, a boom-mounted non-contact IR thermometer could be used by traverse vehicles to confirm safe routes.

Acknowledgments

The author gratefully acknowledges the contributions of Ric Morris, Ph.D. for his insightful suggestions on the efficacy of IR in locating crevasses and Gary Clow for his on-going support in understanding the underlying physics of IR imaging.

Stores and Equipment

British Antarctic Survey Medical Unit
Accident and Emergency Department
Derriford Hospital
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U.K.

BASMU selects and supplies all medical equipment and pharmaceuticals to BAS Stations, Ships Aircraft and Field Parties. All supplies originate from the same location (Derriford Hospital, Plymouth, U. K.). Staff can therefore ensure that what is provided matches the requirement of Antarctic services in relation to environment, medical risk, envisaged level of care, skill levels of staff on site and logistic considerations.

Each BAS location in the Antarctic has a computerised Medical Indent (stock list) that has functions to allow usage, stock levels, ordering and review comments to be analysed. Re-stock orders are transmitted to BASMU from major Stations and Ships as Excell spreadsheet attachments within e-mails. Stations with no medical staff on site, summer only Stations and Field Medical Boxes are rotated back to BASMU at the end of each season for checking and re-stocking.

The following units within Derriford Hospital are involved in this supply chain:

BASMU - organisation, audit and control.

Pharmacy Department - supply of all drugs and medical accessories.

MEMS - servicing of major capital items e.g. Defibrillators.

Medical Nuclear Physics - servicing of Laser and X-ray equipment.

SDU - cleaning, sterilisation and packing of major surgical instrument sets.

Supply regimes are designed specifically for individual locations and staff involved. For example, the contents of the Field Medical Box takes into account the pre deployment training such staff undertake and the level of backup they can expect in a field situation. Supplies to Bird Island, a small wintering station with no Doctor, take into account that staff have undertaken an advanced medical assistants' course at Derriford Hospital.

Significant cost savings are generated through the buying power of our large organisation, Derriford Hospital being the largest District General Hospital in the UK. Examples of this are shown below:

Item	Cost
X-ray machine service.	nil
Defibrillator service and repair.	£35－00 / $53－20
Sterilisation of surgical instrument set.	£30－00 / $45－60
Paracetamol tablets × 1000.	£ 4－20 / $ 6－38
Yellow Fever vaccine 1 dose.	£ 8－10 / $12－31
IV Giving set (blood).	£ 1－30 / $ 1－98

Contents of BAS Field Medical Box

DRUGS

ANTACID tabs	Settlers' box of 36 tabs	1
LOPERAMIDE tabs 2mg	Box of 30	1
SENNA tabs 125mg	Box of 20	1
ANUSOL HC suppositories	Box of 12	1
PHT PHARMACY CLINIC SHOCK PACK	which contains: －	1
ADRENALINE inj 1/1000 1ml amp × 2		
CHLORPHENIRAMINE inj 10mg/ml 1ml amp × 2		
HYDROCORTISONE inj 100mg	×2	
(water inc in shock pack)		
SALBUTAMOL inhaler		1
CETIRIZINE 10mg tabs	Box of 7	1
METOCLOPPRAMIDE 10mg tabs	Box of 28	1
PROCHLORPERAZINE inj 12.5mg /ml 1ml amp	Box of 10	1
ASPIRIN 300mg soluble tabs	Box of 30	1
PARACETAMOL tabs box of 32, 2 for FMB, 2 for each IAP		4
WATER FOR INJECTION	5ml plastic vials	5
SODIUM CHLORIDE AND DEXTROSE	Box of 20 sachets	1

ORAL POWDER 22gm (Dioralyte)			
CO-DYDRAMOL tabs	Box of 30		2
NALBUPHINE (Nubain) Box of 10 amps			1
TRAMADOL 50mg caps	Box of 30		1
CEFUROXIME 750mg	Single vial		2
ERYTHROMYCIN 250mg tabs	Box of 28		1
AUGMENTIN 375mg tabs	Box of 21		2
METRONIDAZOLE 400mg tabs	Box of 21		2
ACYCLOVIR lip cream . Tube 2gm			1
IBUPROFEN 400mg tabs	Box of 24		2
ACYCLOVIR eye ointment 3%	4.5gm tube		1
FRAMYCETIN eye ointment	5gm tube		2
CYCLOPENTOLATE eye drops 1%	Single packet		5
PILOCARPINE eye drops 2% minims	Single packet		4
FLUORESCEIN eye drops	Single packet		2
AMETHOCAINE eye drops 1% 0.5ml	single packet		10
ADCORTYL in orobase	10gm tube		1
AQUEOUS SKIN CREAM	100gm		2
HYDROCORTISONE 1% cream, tube.			1
DELPH factor 30, sun block	200ml plastic bot		5
LIPSALVE STICK	sun block SP factor 15		8
SILVER SULPHADIAZINE cream	50gm tube	(Flamazine)	1
ZINC Undecenoate dusting powder,	70gm tube	(Mycota)	2
SAVLODIL sachets	Pack of 25		1
ZINC and CASTOR OIL	20gm tub		2
LIGNOCAINE Gel 2%	20gm tube		1
LIGNOCAINE inj 1% plain, 5ml plastic vial	Pack of 20		1
OIL of cloves	10ml bottle		1
FLUCONAZOLE 150mg tab	Pack of 1		2
LEVONELLE-2	Single pack		1
MICROGYNON 30	28 day pack		2

BANDAGES / ACCESSORIES

TUBIGRIP SIZE D 0.5M	1
TUBIGRIP SIZE E 0.5m	1
BANDAGE 7.5cm, cotton conforming (crinx)	4
BANDAGE 7.5cm, varicrepe	2
BANDAGE, triangular	6
BANDAGE 7.5cm × 4.5M elastoplast adhesive	1
ZINC OXIDE tape small	1
TAPE 2.5cm × 5m, anti allergic (Micropore)	1
ELASTOPLAST dressing, assorted pk of 20	3
STERISTRIPS 6 × 100mm pack of 10	2
WOUND DRESSING No14 medium	2
DRESSING BPC No 16, eye dressing	4
WOUND DRESSING No 15 large	2
GAUZE ABSORBANT 3 m box	1
GAUZE SWABS 7.5 × 7.5cm sterile, pack of 5.	5
PARAFFIN GAUZE 10 × 10 cm, sterile Box of 10	1
GYPSONA POP 10 cm role	2
GYPSONA POP 15cm roll	2
ORTHOPAEDIC PADDING 7.5cm, roll, Velband	3
SYRINGE 5ml plastic	20
NEEDLE 21g × 40mm, green	20
NEEDLE 23g × 25mm, blue	10
CANNULA 14g brown for chest decompression	2
MEDISWAB single packets	10
DENTAL ROLLS bundle of 12	1
AIRWAY NASOPHARYNGEAL SIZE 6	1
BLUE LINE RYLES tube with spigot	1
NYLON BAG with Zip, blue 'soft' plastic (immediate aid pack pouch)	2
POLYTHENE BAG for hand 15×30cm	6
POLYTHENE BAG for foot 30×50cm	6
GLOVES disposable latex large pairs	3
ADJUSTABLE STIFNECK extraction collar	1

GUEDAL AIRWAY No 2			1
GUEDAL AIRWAY No3 (1 for each immediate aid pack)			2
GUEDAL AIRWAY No 4			1
CATHETER 16FG urinary (Foley)			1
SUCTION TUBING	non sterile (30cm to link syringe and sucker)	*	1
SYRINGE, 50ml bladder, plastic		*	1
SUCKER, YANKAUER with finger control		*	1
Above three items used to construct hand suction or anal infusion device *			
POCKET MASK non return valve (Leardal)			1
TOURNIQUET, velcro			1
THERMOMETER, clinical, standard	(or 10 tempadot fabric indicators)		1
THERMOMETER, clinical, low reading			1
MEDICAL ASSESSMENT QUESTIONNAIRE (held on Base)			2
UNIVERSAL containers, plastic	(without spatula)		2
SUTURE, 3/0, mersilk, ethicon w328			4
SUTURE 4/0 Novafil			2
CAVIT 12gm tube			1
SAFETY PIN			12
EYE BATH			1
EYE PATCH, SILK COVERED			1
FLUCONAZOLE 150mg tab	Pack of 1		2
LEVONELLE - 2	Single pack		1
MICROGYNON 30	28 day pack		2
MOIST TISSUE WIPES small pkt			2
KURAFID manual	Immediate/First Aid manual		1
PERSONAL IMMEDIATE AID PACK 2 per Field Medical Box			
(taken from above stock)			
PARACETAMOL 500mg tabs	Pk of 32		1
NALBUPHINE (Nubain 2 mg/ml) amp			2
SYRINGE 5 ml plastic			2
NEEDLE blue 23g × 25mm			2
UNIVERSAL CONTAINER plastic, to carry Nubain amps			1

AMETHOCAINE eye drops 1% minims 0.5ml		2
BANDAGE triangular		1
ELASTOPLAST assorted	pk of 20	1
WOUND DRESSING No 14	medium	1
WOUND DRESSING No15	large	1
DRESSING BPC No16, eye dressing		1
GUEDAL AIRWAY No 3		1
SAFETY PIN		3
NYLON BAG with zip		1
INSTRUMENT ROLL		
SCALPEL HANDLE NO 3 BARD PARKER		1
FORCEPS 5" SPENCER WELLS CURVED ON FLAT		2
FORCEPS 5" TREVES TOOTHED DISSECTING		1
SCISSORS 6" LISTON BLUNT END		1
SCISSORS 5" DISSECTING STRAIGHT SHARP PT'		1
NEEDLE HOLDER 6" MAYO		1
SCALPEL BLADE NO 10		5
EXCAVATOR DENTAL SPOONSHAPED		1
DENTAL MIRROR		1
COLLEGE TWEEZERS		1
CANVAS POUCH		1

Collapsible Pier for O'Higgins Base

Hernán Solari, Paula Olguin
Engineers Command, Chilean Army
Santiago-Chile

Geometry and structure of the Pier

Objective

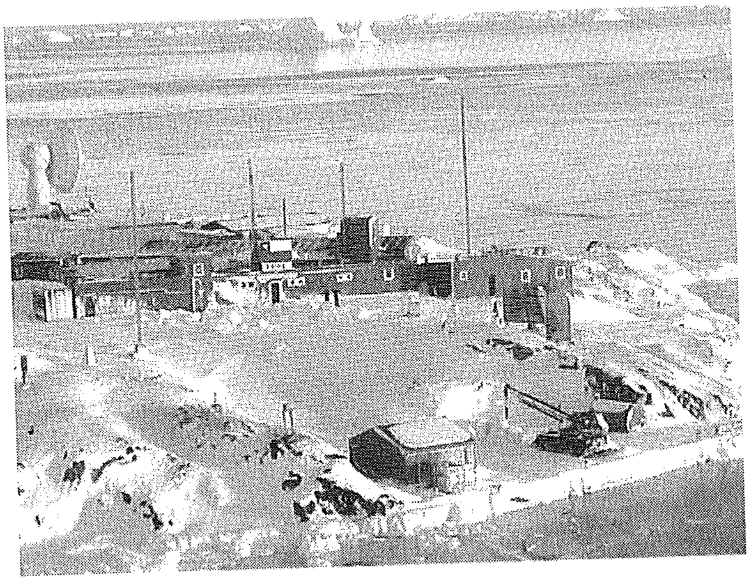
Improve the conditions for approaching and docking of a flat-bottomed self-propelled barge, of the "SKUA" type which gives transport between the re-supplying vessel to the Base mooring or docking point, carrying the supplies in a "TEU" type container.

Conditions of the Pier

Can be disassembled, stored, and kept safe when the mooring point is not in use. The jetty projects 8 meters out from the side of the mooring station, sloping downwards by 1 vertical meter and thus improving conditions for handling the barge.

Structure

- 4 rigid metal frames in "L" shape
- The longer side acts as supporting beam for an assembly of prefabricated reinforced concrete slabs on top.
- The shorter side is the column resting on the sea floor to support the rest.



Location

Rada Covadonga on Riquelme Islet (O'Higgins base)

Characteristics:

Collapsible Pier

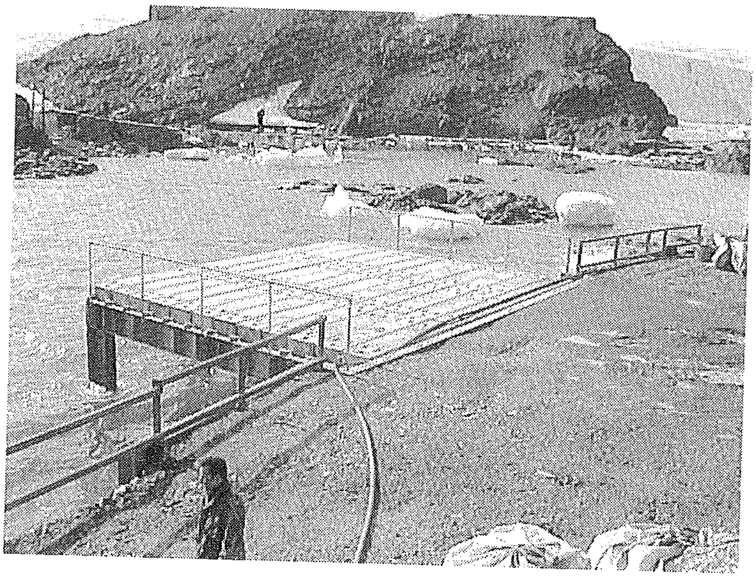
Scope

Detailed design illustration of the metallic collapsible platform, the anchoring posts for this platform and other structural elements.

Materials

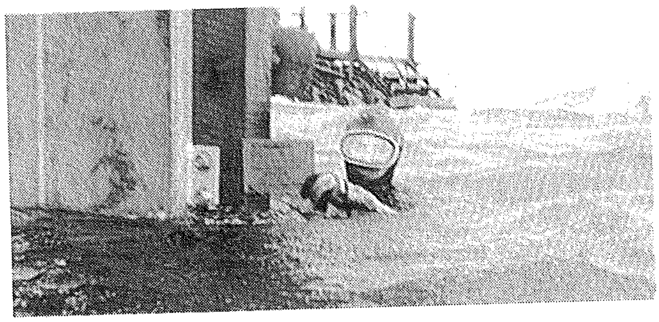
Structural Steel	:ASTM A36
Reinforced concrete	:H30
Reinforcing steel for concrete	:A6342-H
High-strength bolts	:ASTM A325

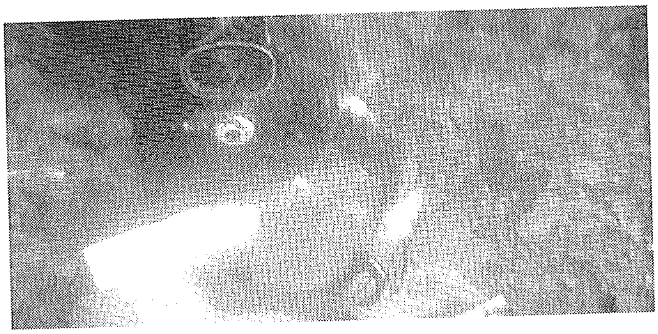
Standard Bolts :ASTM A36

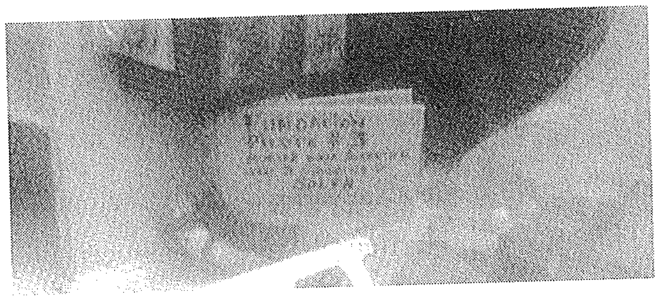


Equipment

- RIGO crane, RT200C model (with caterpillar tracks), for use in the antarctic
- KOMATSU digger vehicle, PC-200-5 model
- Container, TEU type (twenty feet length)







Preliminary Digital Geodesy and Cartography in Patriot Hills

Rodrigo Barriga and Jorge Perez, Carlos Iturrieta, Jose Badilla, Wendy Rubio, Juan Carlos Montero, Hector Parra, Edwin Hunt
Instituto Geográfico Militar, Nueva Santa Isabel 1640, Santiago, Chile.

Víctor Villanueva L. (Q.E.P.D.)
Instituto Antártico Chileno, Rómulo Correa 375, Punta Arenas, Chile.

Introduction

The project* titled "Satellite Geodesy and Digital Cartography in the Ellsworth Mountains, Patriot Hills Sector, Heritage Range", has been under way since 1998, within the general framework of the "Agreement for Technical and Technological Mutual Aid", signed in 1992, between the Chilean Antarctic Institute (INACH in Spanish initials) and the Military Geographic Institute (IGM), with the aim of creating digital cartography of Patriot Hills, in order to serve as an aid to such scientific explorations and research as may be performed now and in the future by Chilean bodies in that area.

The general background information for this project was presented at the meeting of the Scientific Assembly of the International Association for Geodesy held in Budapest, Hungary between the 2nd and the 7th of September 2001**.

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* Project N°162: Satellite Geodesy and Digital Cartography at Patriot Hills-Ellsworth Mountains, IGM-INACH.

** Proceedings, IAG 2001 Scientific Assembly, 2th-7th September, Budapest, Hungary.

The main objectives proposed for this project are the following :

1) Set up a Basic Geodesic Network in "Patriot Hills", by means of installing fixed and control points on solid rock, as part of a "Topographic and Geodesic Data Base" for the Ellsworth Mountains sector.
2) Create a "Gravimetric Base" in the Patriot Hills area, by means of transects linked to the gravimetric points referenced to the Absolute Gravimetric Station at Punta Arenas.
3) Capture Geodesic data using the GPS system for geo-referencing the images, in order to create digital cartography at 1:50 000 scale of the zone.
4) Create, edit and publish the preliminary cartography at 1 : 50 000 scale of the "Patriot Hills" area.

Tasks Performed

During the course of the project, two field campaigns were carried out in 1998 and 2000, with the participation of scientific staff from the IGM and the INACH, leading to the creation of a preliminary map at 1:50 000. In Figure 1, part of the task of moving around the area using special vehicles for the snow can be seen.

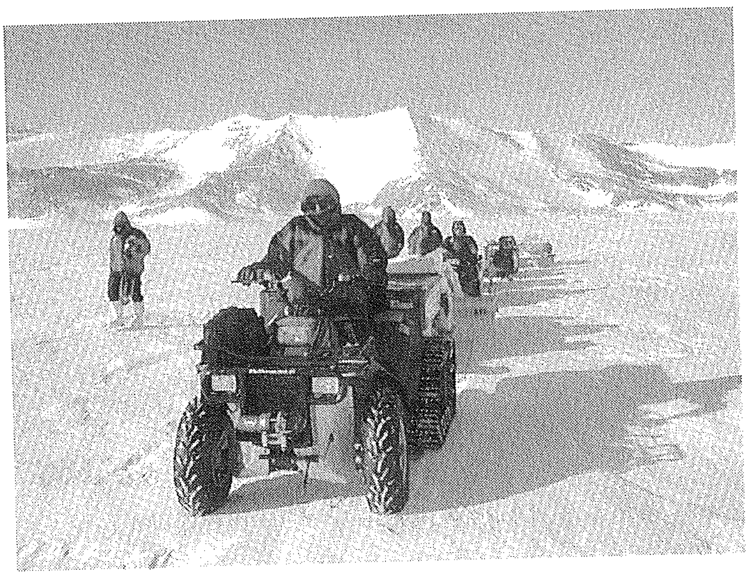

Fig. 1. Transport around the area (Source: IGM)

As a result of these field campaigns the following results were obtained :

GPS Measurements GPS[*] :

- "PH-001" station : Latitude 80° 18′ 00″ (S) Longitude 81°22′02″ (W)
- "PH-002" station : Latitude 80° 19′ 13″ (S) Longitude 81°25′59″ (W)
- "PH-003" station : Latitude 80° 09′ 37″ (S) Longitude 82°40′53″ (W)
- "PH-004" station : Latitude 80° 20′ 01″ (S) Longitude 81°15′02″ (W)
- "PH-005" station : Latitude 80° 18′44″ (S) Longitude 81°35′29″ (W)

Gravimetric Measurements[**] :

The gravimetric link beween the absolute gravity point at Punta Arenas called "PUQ-J7915" and the geodesic base point at Patriot Hills called 'GPS-PH -002" was set up, thus constituting a geodesic and gravimetric base for future tasks. The results of the gravimetric measurements are[***] :

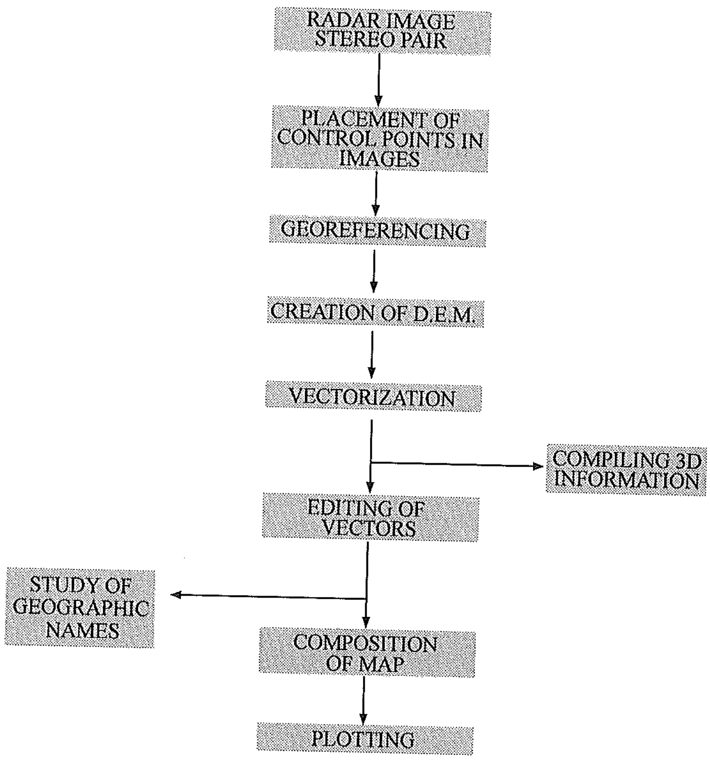

Fig. 2. Diagram of Cartographic Production for Patriot Hills

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* IGM Field Report for Geodesic Campaign at Patriot Hills: 1998 and 2000.

** IGM Field Report for Geodesic Campaign at Patriot Hills: 2000.

*** NIMA publication: GIGA-01-030 November 2000.

- Point "PH-002": Gravity Value (mgals.) 982890.963
- Point "PH-004": Gravity Value (mgals.) 982894.098
- Point "PH-005": Gravity Value (mgals.) 982884.982

Creation of preliminary digital cartography

In accordance with the objectives intended to be achieved and having carried out the first set of field work, a first version of the "preliminary" cartography was then created covering this important area. For this a consistent methodology was used throughout the performance of the preliminary study, the gathering of material, planning, terrain surveying and classification, geoprocessing of the images, vectorization, cartographic compilation and the publishing process. The production scheme for this cartography is seen in the following illustration :

Orthoimage Configuration

Satellite Image Characteristics

The first image was a RADARSAT image in standard 5 mode, ascending orbit, dated 20th September 1997 and a resolution of 12.5 meters.

The second image was a RADARSAT image in standard 2 mode, ascending orbit, date 2nd October 1997 and resolution of 12.5 meters.

Digital Elevation Model

The digital elevation model was set up by using the radargrammetry technique, with a stereoscopic pair of radar images.

Image Mosaic

In order to set up the mosaic, radar images were used, these being orthorectified using the digital elevation model obtained from the radargrammetric pair of images and postion-checked using GPS control points.

Cartographic Data

The first image was a RADARSAT image in standard 5 mode, ascending orbit, dated

20th September 1997 and a resolution of 12.5 meters.

The second image was a RADARSAT image in standard 2 mode, ascending orbit, date 2nd October 1997 and resolution of 12.5 meters.

Geographic Data

Reference System: WGS84
Datum: WGS84
Ellipsoid: WGS84

Sources of Information

Geodesic and Gravimetric Control Stations

These stations were measured and monumented on naked rock, during the field campaigns performed in 1998 and 2000, by means of GPS-satellite geodesic measurements and data captured with a Lacoste-Romberg gravimeter.

Control Points

These points were measured on the rock surface, as checks on planimetric data, obtained by means of GPS measurements.

Elevation

These elevation contours and altitude marks were taken from the LIBERTY HILLS map, created in the United States and published in 1967. This information was obtained by compiling photographs from the trimetrogon flights in 1961, 1962 and 1964.

Geographical Names

Geographic names in accordance with the Gazetteer of the Scientific Committee on Antarctic Research (SCAR).

Conclusions

Among the geodesic and gravimetric activities performed by the IGM and the INACH

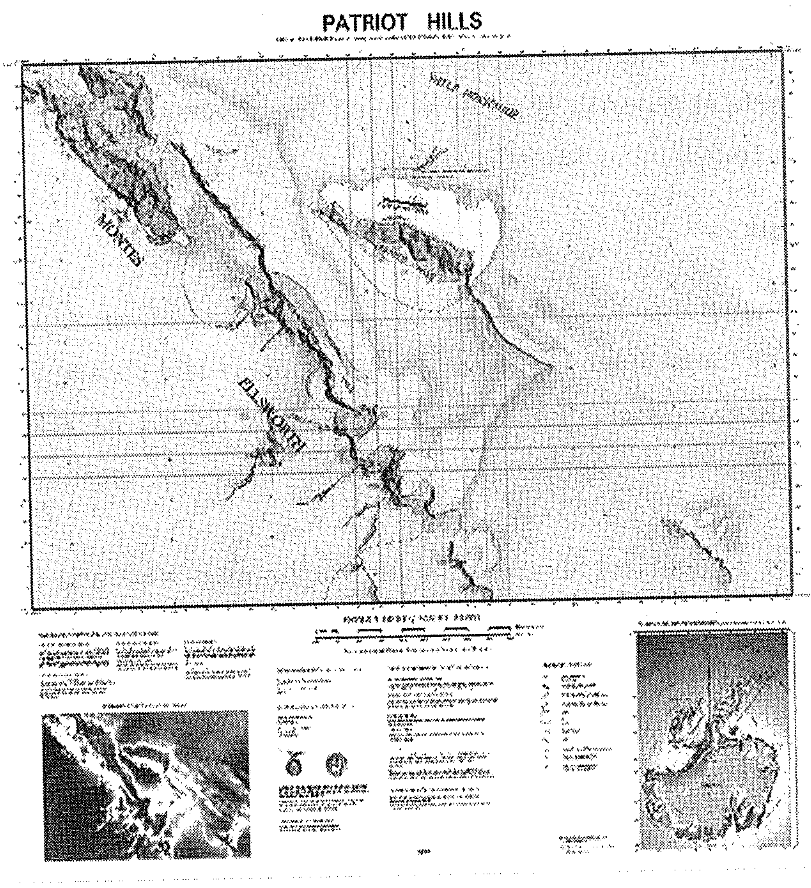


Fig. 3. Preliminary Cartography of Patriot Hills

in the Patriot Hills area, a major landmark has been achieved in its history, given that, for the first time, these organizations have established and monumented a network of Base and Fixed GPS stations on the Antarctic continental platform.

As a contribution to the Chilean and international scientific community, the campaigns of 1998 and 2000 of the IGM-INACH have made it possible to establish the first geodesic values for this zone.

With the gravimetric data captured, a new and interesting Gravity Network in Patriot Hills has been established, making it possible to project the Chilean Gravity network towards the South Pole. Three stations have been measured for this purpose. The adjustments to these measurements were made by means of cooperation with the cartographic agency of the United States (NIMA), and the values of this gravimetric data were released to the scientific community in the NIMA publication GIGA-01-030, November 2000.

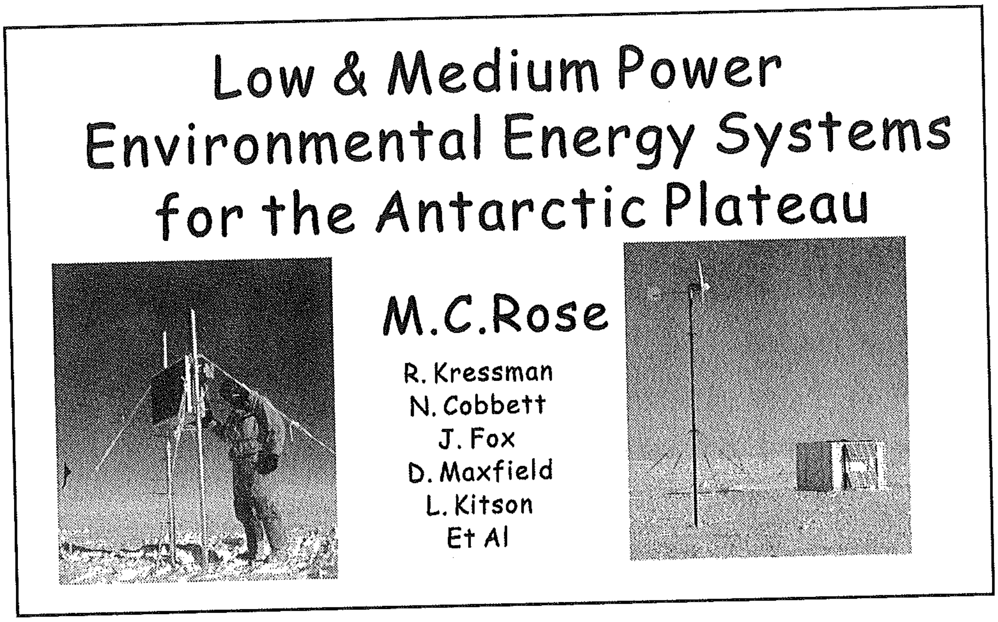
In the joint planning made between the IGM and the INACH it is intended to continue the various phases of work in the field and in the office in order to create a complete set of cartography for this area, which is initially intended to be at 1:50 000 scale, then subsequently being published at scales of greater detail.

Finally, the work in this area requires a very detailed planning process, for both technical and logistical aspects, bearing in mind the adverse weather conditions and the difficulties in travelling around the terrain.

Acknowledgements

Special thanks are expressed to the Army of Chile, to the Chilean Antarctic Institute and to the Military Geographic Institute for their support and constant backiing up of the execution of this project. The Chilean Air Force should be acknowledged for having made it possible to get to this important place by means of their aerial transport.

A sincerely felt recognition should be given to the man who was for many years head of the IGM-INACH project No. 162; Satellite Geodesy and Digital Cartography in the Ellsworth Mountains, Patriot Hills Sector, Heritage Range, the distinguished professor Mr Víctor Villanueva L. (R. I. P.), whose concern, effort and constant dedication have made possible the performance of this major cartographic and geodesic project.



Hello I am Mike Rose of the British Antarctic Survey, I am going to talk on Low and Medium power Environmental energy systems that British Antarctic Survey have developed for use on the Antarctic Plateau.

I would like to acknowledge my many co-workers at the British Antarctic Survey.

Outline of Talk

- Advantages of Environmental power
- What's the difference "Low" & "Medium" power?
- Descriptions of BAS's LPM's and AGO's
- A few important technical issues
- Costs of environmental power systems

This talk is about the powering autonomous unmanned experiments on the Antarctic plateau.

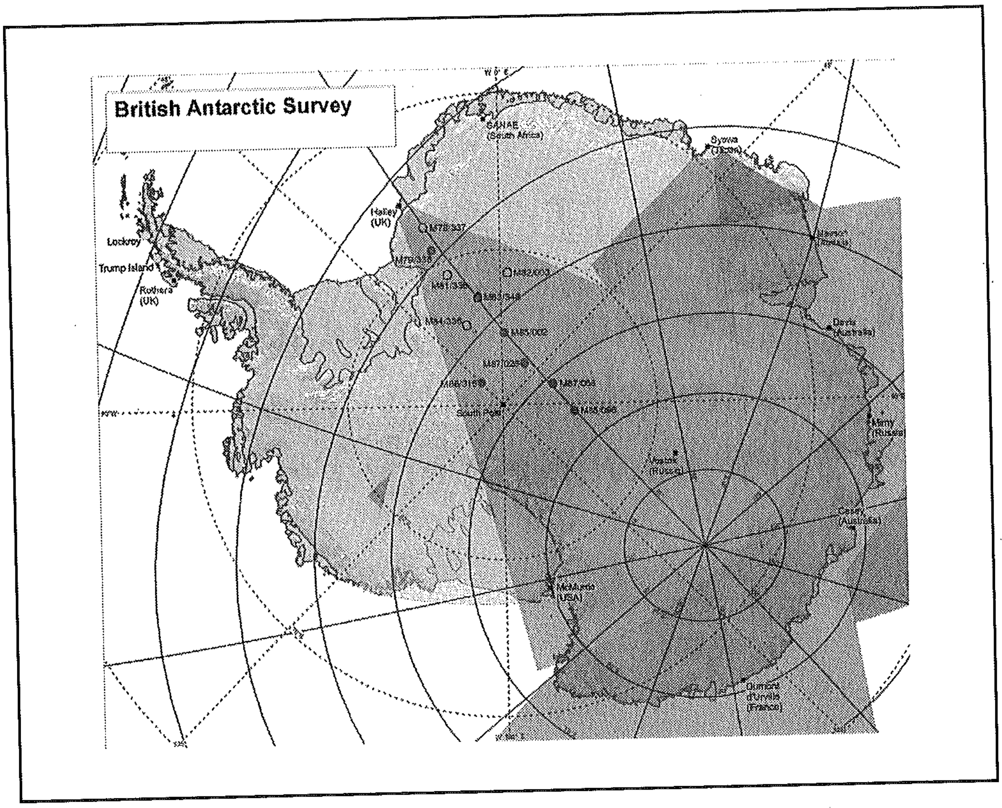
I am going to talk about the advantages of environmental power

I am going to explain the implications of the terms Low and Medium Power

I am going to describe two of our systems, a low power system-the Low Power Magnetometer or LPM and a medium power system-the Automatic Geophysical Observatory or AGO.

This is not a technical talk, but I will try and bring out a few important technical issues.

And finally I will talk about the cost of such systems.



But first, to get an idea of the scope of the systems that I will describe, here is a map of the Antarctic. The red dots are our LPM's, the green dots our AGOs (which also have an LPM at the same location), these coloured panels are the fields of view of the SHARE radars. The is Halley Station from where we fly to maintain these instruments, it is 1925 km from our station at Halley to the furthest LPM here. BAS also has LPM's on the peninsula and many other environmentally powered weather Stations and autonomous experiments ont shown on this map.

Environmental power

- LOGISTICALLY CHEAP
- Environmentally Friendly
- Technically relatively simple
- Solar power is <u>very</u> reliable

So why use environmental power.

First and main reason is because its logistically cheap, the energy is already onsite. In comparison 100W diesel generator would require about 400KG of fuel per year to each site every yeat.

Environmental power is of course environmentally friendly, not only is it easier to comply with environmental protective legisiation, but it can be used for powering experiments for pollution and atmospheric chemistry studies.

Although there ate many technical challenges with environmental power, they are relatively simple compared to other energy sources.

One source of environmental power-solar energy from Photovoltaic cells is probably the most reliable source of electric power known.

Power levels

- Low power (<1W) Ambient temperature, specialist electronics and instruments.

- Medium Power (>10W)-Room temperature, COTS

So why the terms low and medium power.

The key distinction of low power uwe and hence dissipation is that the systems will run very cold, it is not possible to insulate the electronics to such a degree that they will keep warm if they have very low power dissipation. If you go low power you not only have to develop low power electronics but this electronics must work at very low temperatures. The main advantage of low power is that you can use a power system of just a solat and battery which is extremely high reliability and low maintenance.

Once you get above a certain power level it is possible to keep the electronics warm, and hence with a more generous power budget you can use more normal electronics and many commercial off the shelf systens.

It's a fundamental choice, do you put your effrts into supplying lots of power or do you put your efforts into getting the electronics to run with low power and low temperatures.

I am not going to talk about High power systems, but a high power system would be defined as one where there was no optimisation of energy usage, and it you could for instance use normal mains powered equipment.

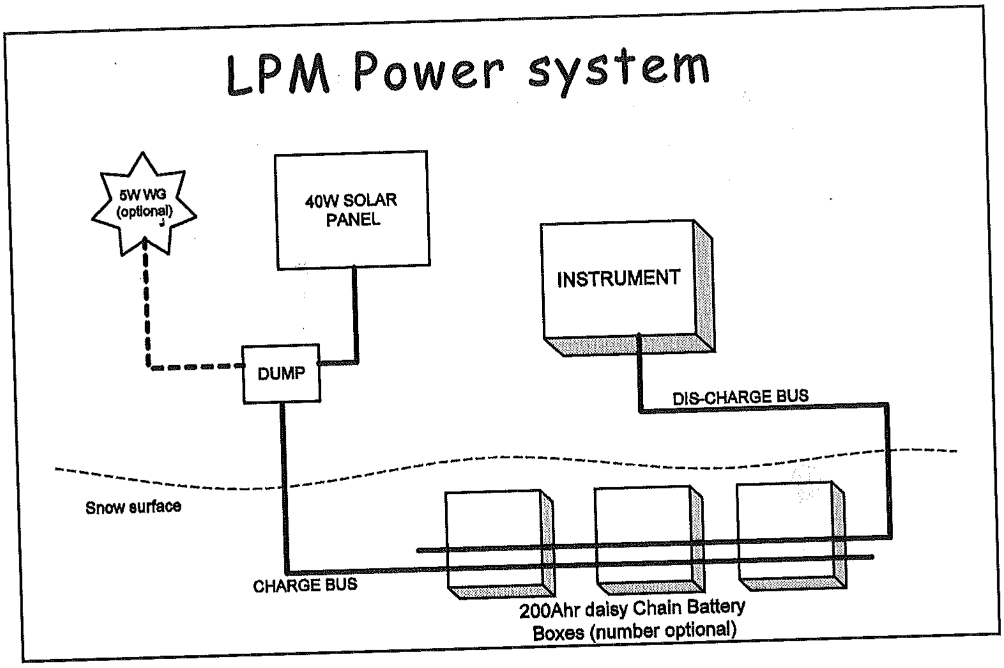
Low Power (e.gLPMs)

Solar + battery
Cold temperatures
Bespoke electronics
System weight 200kg
2 hour deployment, 1 hour annual
13 system years of operation

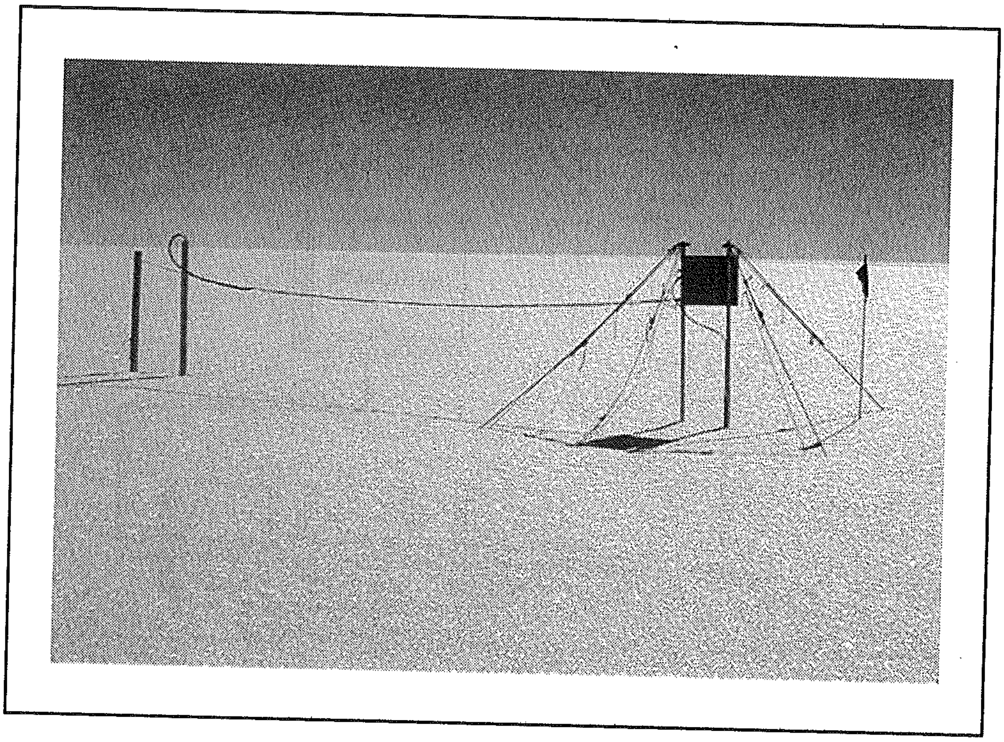
Our Low Power Magnetometer is an example of a low power system, Its average power use is just 0.5W, its main power source is a solat panel which means it has to rely on battery reserves during the polar winter.

It has been designed to be easy to deploy and maintain.

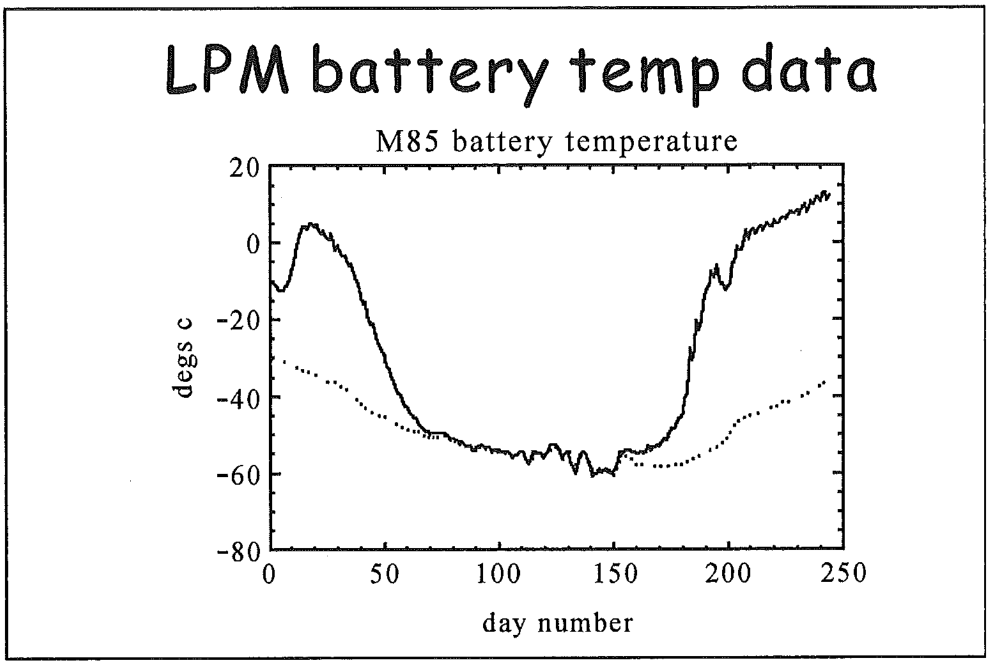
BAS has been operating these for two years, and we now have 13 system years of operation, This past season we expanded the network to 14 sites.



The power system is in principle quite simple, a solar panel charges a number of thermally insulated batteries that power the instrument.



This is a site in the Antarctic after its first year of operation. The solar panel is mounted on the far side of this enclosure which contains most of the electonics. The batteries are buried under the snow for thermal stability. The magnetic sensor is buried here for mechanical and thermal stability.



Here is a years worth of battery temperature data, the doted line is the temperature in the snow pack at the same depth as the batteries, whilst the solid line is the temperature of the batteries. In winter the batteries go very cold but during summer they are heated by the charging process to reasonable temperatures.

Medium Power (e.g. AGOs)

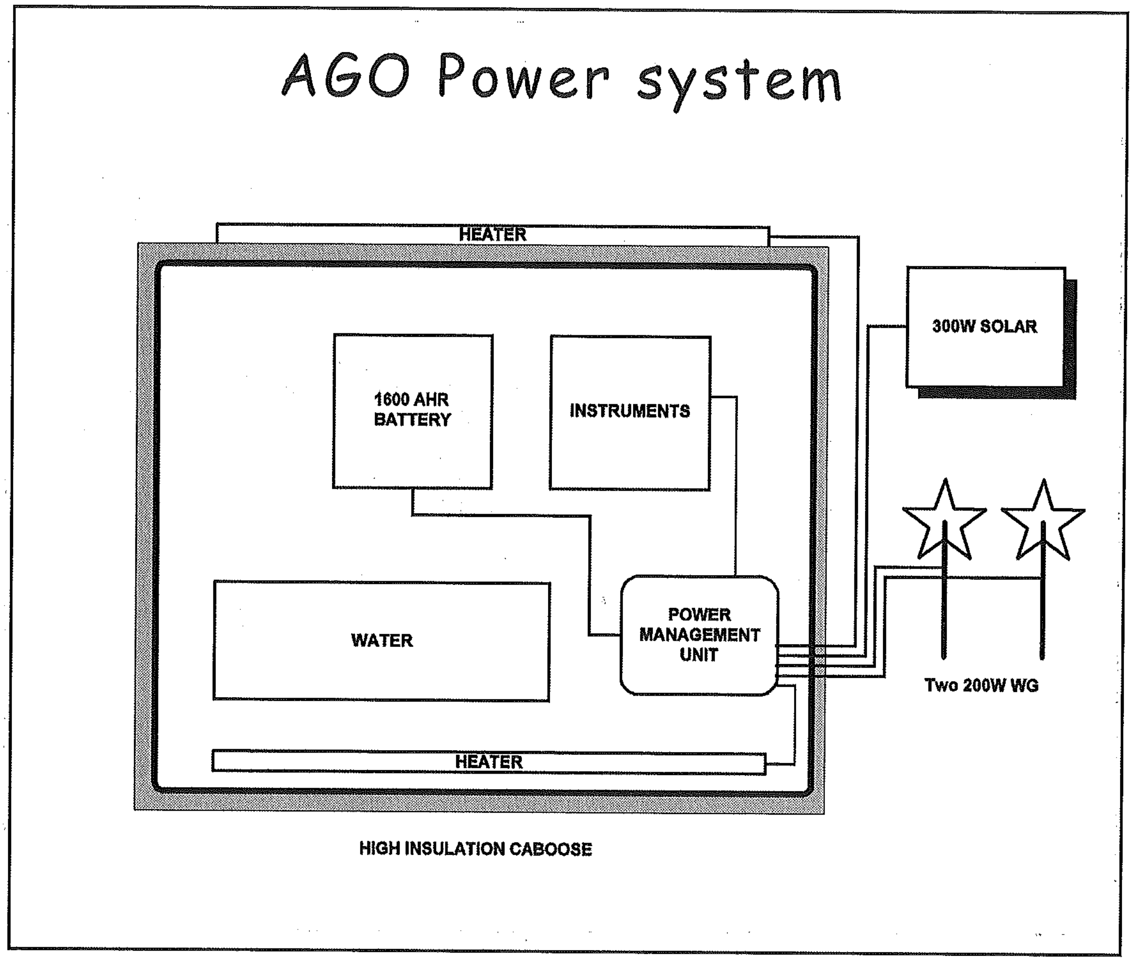
- **Wind**+ solar + battery + water
- Room temperature
- Much COT electronics
- System weight 4500kg
- 2 week deployment, 2 days annual
- 33 system years of operation

As an example of a medium power system our Automatic Geophysical Observatory has 100W of power available.

The main energy source is wind.

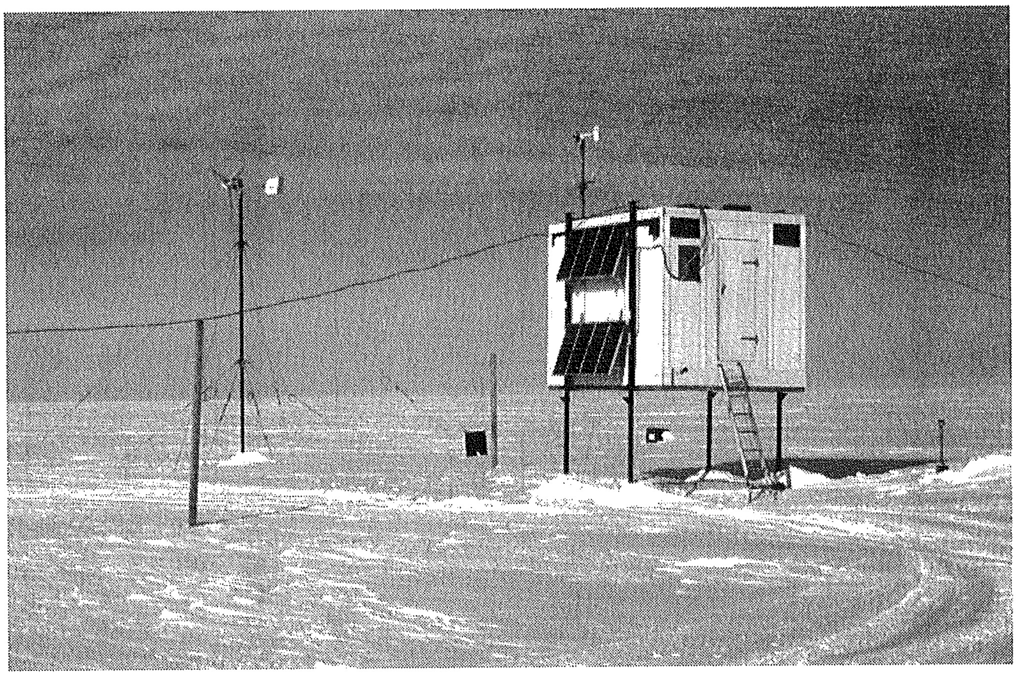
Its considerably bigger, heavier and takes more effort to deploy and maintain.

BAS has 4 AGOs which have accumulated 33 years system years of operation.



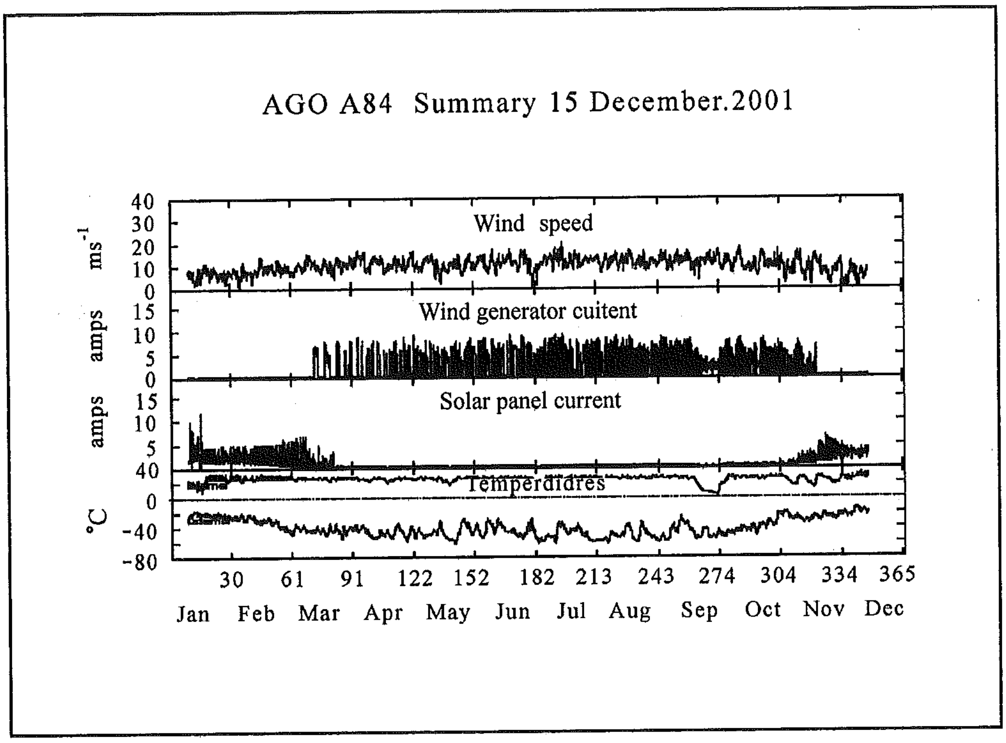
The power system is much more complex, and centres on a bespoke power management unit, that controls the power sources (in particulat the wind-generators) and manages where the power goes-batteries, or and internal heater or very occasionally an external dump heater. 300kg of water is an important part of the power system, it yields over 100MJ of energy by freezing-having the effect of delaying the temperature falling through 0℃.

336KJ/kg 300kg yields over 100W over the approx 1 week it takes to freeze.



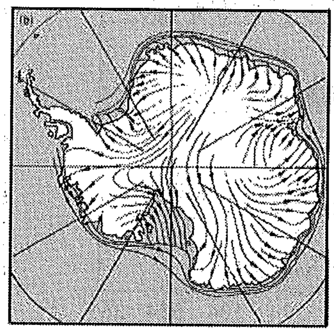
Here is an AGO system, one of the two wind gernerators, solar panels and the heavily insulated caboose containing the electronics.

These wires go to external aerials and sensors.



Here is a year's worth of data from an AGO. Wind speed, current into the batteries from the wind generator, current into the batteries from the solar panel and the internal temperature of the caboose and the external air temperature. There is an interesting feature on this graph, one wind generator froze for about two weeks here, resulting in a loss of temperature in the caboose, you can see how the rate of temperature loss slows as the water begins to freeze.

KatabaticWind



Model, but test with AWS

Harsh onwindgenerators

High Maintenance

Year round availability (but less in summer)

The environmental energy sources available on the plateau are wind or solar.

Good models exist of the strength and direction of the Katabatic or inversion wind, but local conditions and the V cubed sensitivity of the energy output to wind speed means that site testing with an automatic weather station is essential.

The Antarctic plateau is a harsh place for wind generators-some models do not make the grade, to use commercially available wind generators you need to test several models of the appropriate power rating.

What ever model you use it iis likely to require a high level of specialist maintenance.

But the benefit of wind is its year round availability.

Solar insolation

- Pre and post darkness period crucial
- Low solar angles (high airmass)
- Albedoof snow has significant effect
- BAS Developed solar model
- Oversize panels
- More vertical than usual (season dependant)

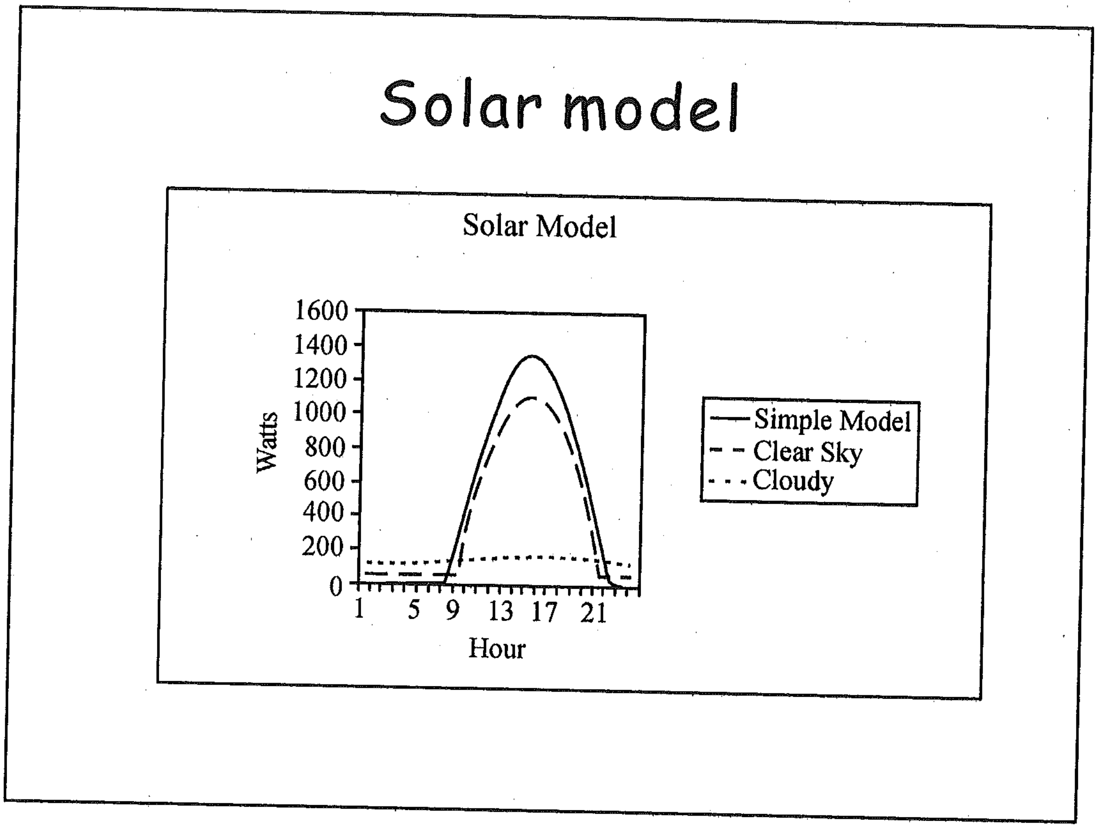
Solar energy is of course only available during sunlit hours, and a solar powered system must rely on battery reserves during darkness. For a system on the Antarctic plateau, the system performance in the periods just before and just after winter are crucial.

In those periods the sun is low on the horizon and the solar energy has to pass through a lot of atmosphere which attenuates the power.

Operating on the plateau means that you are operating over snow, and snow reflects a lot of solar energy which ahs a significant effect on the optimum solar panel angle.

Because the performance in the period just before and just after winter is crucial, Bas has developed its own solar modelling program which attempts to accurately model these effects.

which leads us to use oversized panels at a more vertical angle than normal.



This is the output of the model compared to a more simple model.
The blue line is the simple model, the red line is our model.

You can see that our model predicts less power and a faster drop off of power at High elevation angles because of attenuation in the atmosphere. It correctly predicts some power scattered from the snow even when the solar panel is not in direct sunlight. The model also gives panel output in overcast or cloudy conditions.

Overall Costs

	4 AGOs	10 LPMs
Development and purchase	£410K	£120K
Deployment	£410K	£60K
Annual maintenance	£50K	£30K

So what does it cost to run an environmentally powered energy system on the plateau

These figrues are the direct costs to BAS, in effect the extra money that BAS spent by running there projects, there is lot of overheads that I didn't include in these figures so they certainly aren't full economic costs.

This is the complete cost for 4 AGO's and this is the complete cost for 10 LPM's. It has cost us about 200K per AGO to put in the field, whereas the LPM has only cost about 18K, and in particular the deployment and maintenance costs of the low power systems are a lot less, particularly if you look at these costs on a per system basis.

Costs per system year

	AGO	LPM
System	£33K	£7K
Data Mega Byte	£11	£36
Watt	£330	£14K

For instance over a 10 year life time of an AGO and a 5 year expected lifetime of an LPM the cost per system year of the the LPM is only 1/4 of the ago.

However the cost picture is not simple, the costs per megabyte of data is cheaper for the mediun power system, and certainiy the cost of a watt of electrical power is much cheaper with the mediun power system.

Conclusions

- Environmental energy is cost effective and it works.
- Two distinctly different power regimes low and medium.
- Solar is high reliability but summer only
- Wind is high maintenance but year round availability

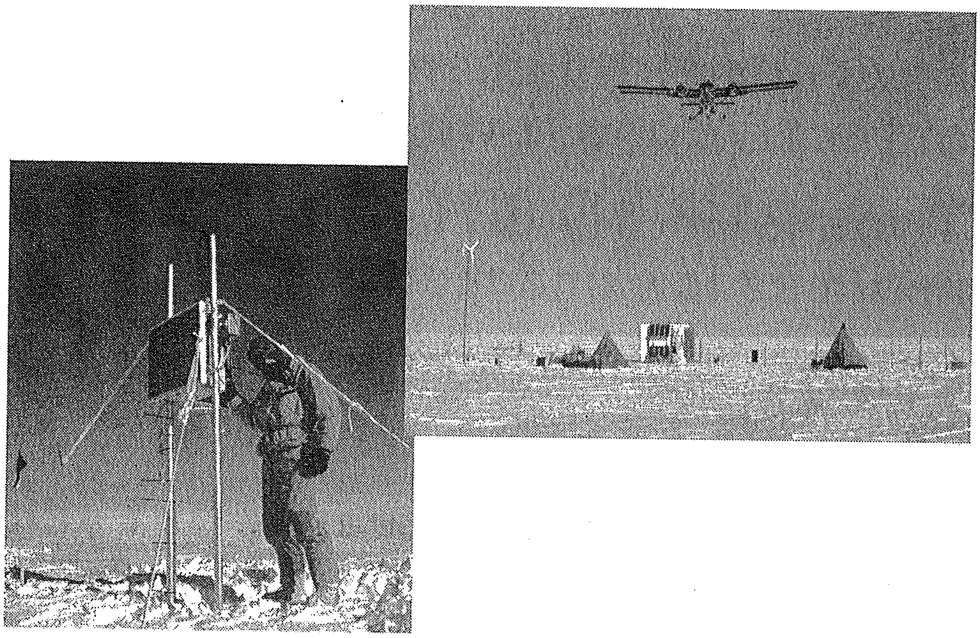
Conclusions

For autonomous experiments on the plateau environmental energy is cost effective and it works.

There are tow distinct regimes of operation, low power requiring specialist low temperature electronics and medium power which requires more onsite infrastucture and support.

Solar power is extremely high reliability but only available in summer, which means a system based only on solar panel will need to be low power to operate through winter on battery reserves, and low power means specialist electronics and low temperatures.

Wind power is high maintenance but has the benefit of year round availabiliaty which means its suitable for higher power sysyems.



Thankyou, any questions.

New Living Buildings at Zhongshan Station will have floor heating sourced by waste heat from the diesel generators

Cong Kat First Institute of Oceanography
State Oceanic Administration.
E-mail: kaibest@public.qd.sd.cn

Waste heat from the diesel generators has been utilized at Chinese Antarctic Stations for more than ten years.

The recovered energy is used to increase the temperature of lake water from 4 degrees below zero, to temperatures suitable for use around the station. Hot water is circulated in insulated piping, which prevents the water from freezing and provides a temperature of 25 – 30 degrees for washing and rse in the kitchen, and a temperature of 40 degrees for the showers.

In summer, due to the increased personnel at station and greater water use there is little excess energy availble from the generators.

But in winter, when station numbers and water ust decreases, additional energy can be recovered as waste heat from the diesel generators, and this will be used to facilitate floor heating.

Low-temperature hot water floor radiant heating is new technology.

Because of its energy savings and effectiveness, it is being applied in more and more residential buildings in China.

The materials for the Low-temperature hot water floor radiant heating were delivered to Zhong shan Station in February 2002 and will be installed in January 2003.

This will further economize energy use and increase the expeditioners' comfort.

Zhongshan Station

Days of heating period 365 Days

Outdoor mean air temperature during heating period −12℃

Degreedays of heating period 10250 D.℃

Outdoor design temperature for heating −29℃

Extreme minimum temperature −39℃

Maximum wind speed 46.2m/s

Mean wind speed 7.35m/s

The approximate size of the new living building is 35 meters(length)/16 meters (width)/7.5 meters(height)

Area of building envelope 1720m^2

Volume of building 3550 m^3

Shape coefficient of building 0.48

In summer

(Outdoor design temperature for heating −2℃)

Heat loss of building: 23KW

Heat load of floor heating: 11.KW

In winter

(Outdoor design temperature for heating −20℃)

Heat loss of building: 45KW

Heat load of floor heating: 22.5KW

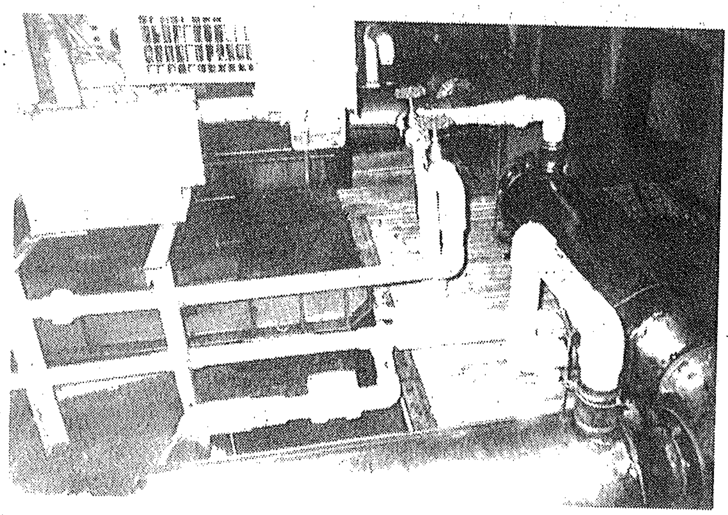


Fig.1. Diesel generator & exhaust/water heat exchanger

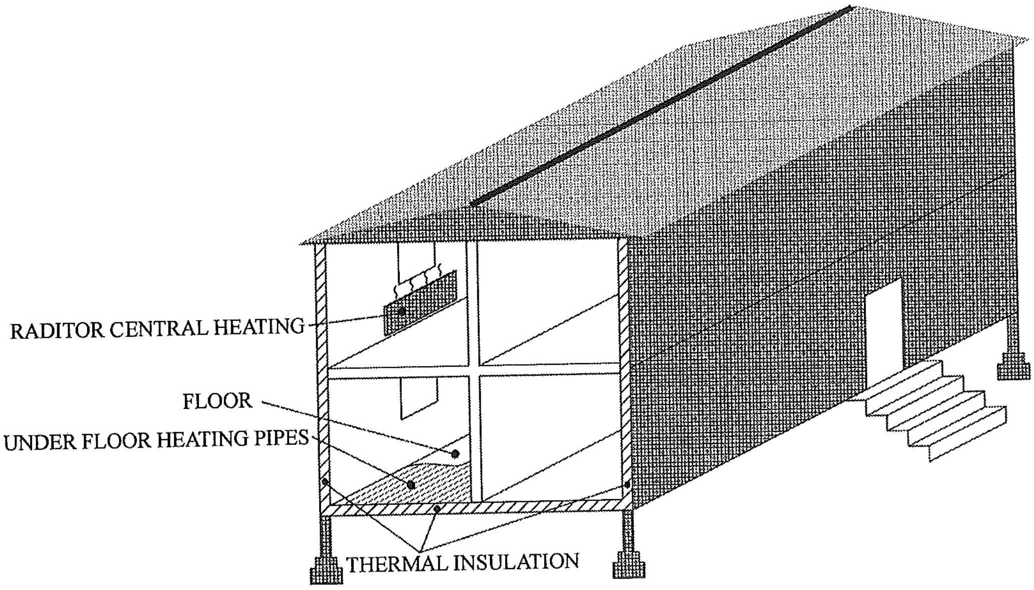


Fig. 2. New living building

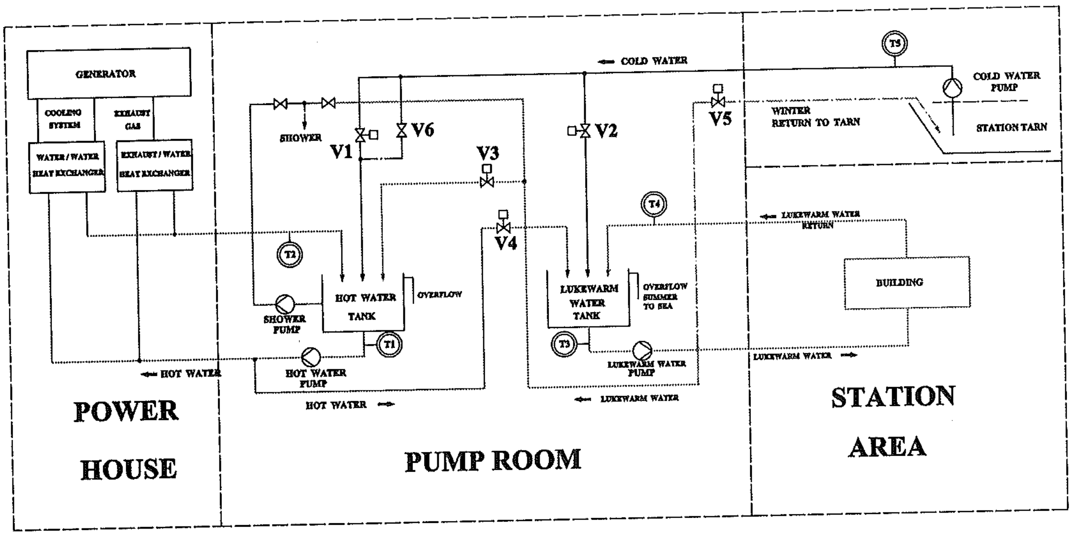


Fig. 3. Waste heat utilization & water supply system
basic flow scheme

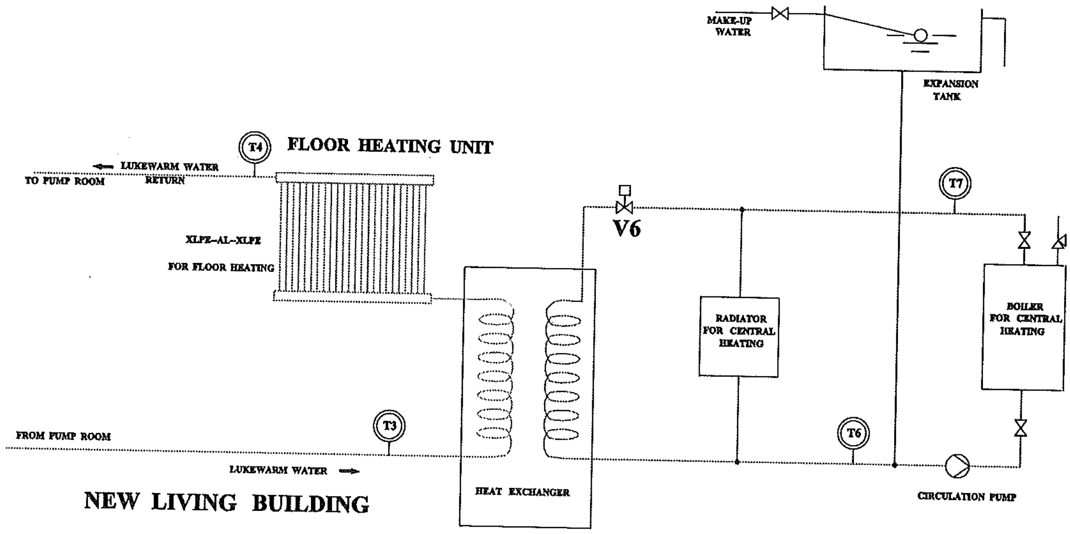


Fig. 4. Floor heating sourced by waste heat from the diesel generators flow sheet

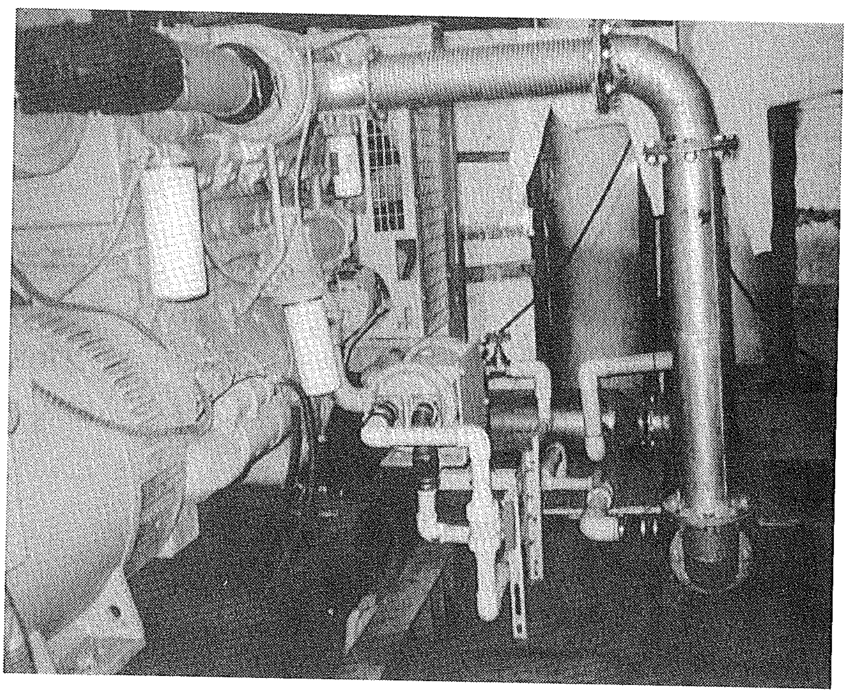


Fig. 5. Diesel generator & water/water heat exchanger

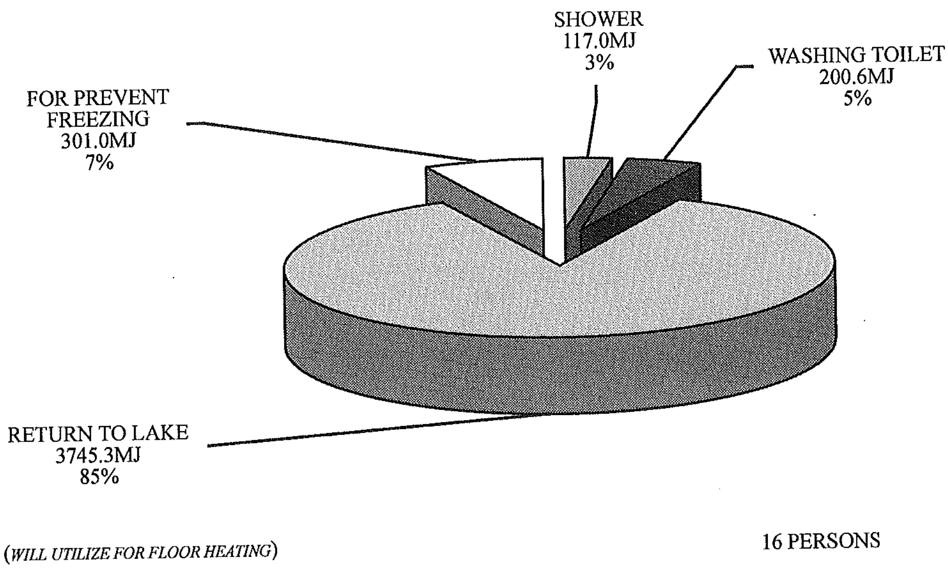


Fig. 6. In winter recovered energy balance per day
Total recovered energy 4363.9mj per day

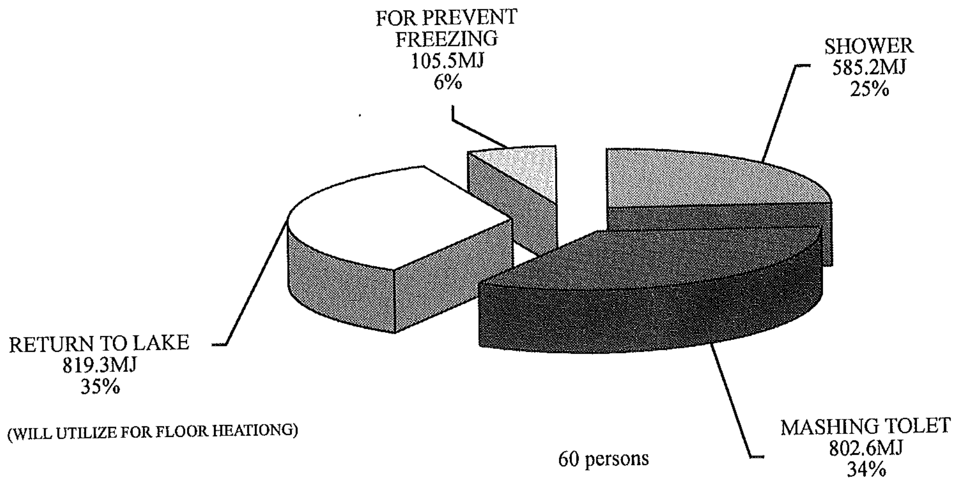


Fig. 7. In summer recovered energy balance per day
Total recovered energy 2357.5mj per day

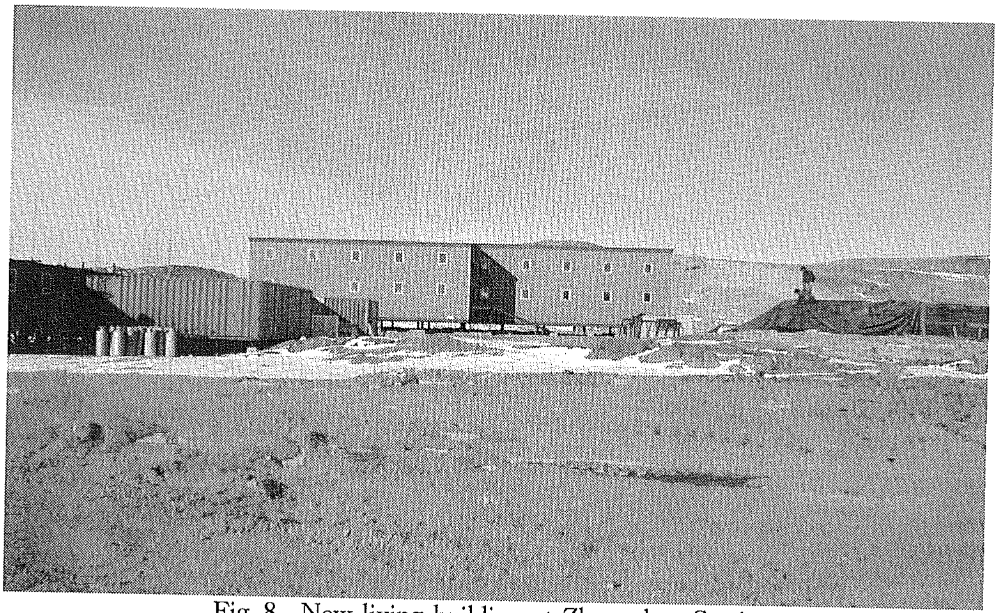


Fig. 8. New living building at Zhongshan Station

Management of Liquid and Solid Waste in the Chilean Antarctic Stations

Patricio Eberhard
Chilean Antarctic Institute

The Chilean Antarctic Program includes several bases and refuges in operation since 1947. In this poster, the evolution of the procedures applied to the management of liquid and solid waste is analysed. The study comprises the different stages with environmental requests according to the successive agreements and protocols on these matters.

Overwinter stations

NAME STATION	OPEN SINCE	PERSONNEL	
		SUMMER	WINTER
C'Higgins	1948	40	22
Prat	1947	35	11
Frei	1969	150	75

Summer stations and refuges

NAME STATION	OPEN SINCE	PERSONNEL	
		SUMMER	SPRING
Yelcho	1961	6-8	
Gonzalez Videla	1951	15	
Carvajal(ex UK Tbase)	1961	15	
Escudero(ex Fildes)	1975	30	
Risopatron	1957	8	
Ripamonti	1982	4	4
Patriot Hills	1995		25
Shirreff	1980	4	4

Solid waste planning

In the decades before the entry in force the Madrid Protocol(1998), all the waste and garbage from the Chilean winter and summer stations were leet near the stations. No waste procedure was used in the past. In some stations a waste compactor was used to reduce the waste to be removed from Antarctica. Also open incinerators were used to burn garbage in some summer stations.

No clean up activities for abandoned sites are planned. Nevertheless all these sites are now covered in order to avoid dispersion during strong winds or bad weather conditions.

After the Madrid Protocol aproval a waste management plan was developed (waste disposal plan from Inach. technical document, 1994), according to Annex Ⅲ from the protocol.

Currently, in our stations, waste is classified in four groups: sewage and domestic liquids; other liquid wastes and chemicals; combustible solids; and non-combustible solids.

We don't store radioactive waste in our stations. We don't accept discharge of radioactive waste from third parties in Chilean ports.

In most of our stations, food waste, glass, paper products, and metal cans are stored separately.

Two of our stations incinerate waste. Prohibited products like plastics, rubber, waste oil and hazardous materials are not burned. We don't monitor carbon monoxide and carbon particles. The incinerator operators are adequately trained.

Incinerator ashes are considerated "all other wastes" and removed away from Antarctica to Punta Arenas.

Also, we remove from the Antarctic treaty area all toxic waste materials, specifically electrical batteries; fuel (both solid and liquid); waste containing harmful levels of heavy metals; PVC; polyurethane foam; rubber and lubricating oils; all other plastic wastes; fuel drums and other solid and non-combustible waste.

Our ships en route to and from Antarctica are forbidden to discharge waste into the sea.

"Prhibited products" according to article 7 of annex Ⅲ, are not introduced in our stations. Such products are: Polychlorinated Biphenyl (PCB); nonsterile soil; polystyrene packaging beads or chips; and pesticides. In some opportunities we use nonsterile soil, according to appendix C of annex Ⅱ where importation of such products shall be"avoided to the maximum extent practicable".

Food waste containing animal parts, in particular poultry, are removed to Punta Arenas. Also, laboratory cultures and other dangerous products, according to annex Ⅱ and annex Ⅲ.

In all our stations we designate every year an appropriate individual to control, develop and monitor the waste management plans. According to article 10 of annex Ⅲ, we haven't designated a waste management official. Only Patricio Eberhard acts since 1996 as member of the Antarctic environmental officer network-aeon-from COMNAP/SCALOP.

Solid disposal

STATIONS	INCINERATOR	GARBAGE COMPACTOR	REMOVED TO PARENAS	DEPOSIT ON LAND OR ICE
O'Higgins		√	√	
Prat	√	√	√	
Frei	√		√	
Yelcho			√	
Gonzalezv.			√	
Carvajal			√	
Escudero		√	√	
Risopatron		√	√	
Ripamonti			√	
Patriot Hills			√	
Shirreff			√	

Sewage disposal

Before Madrid Protocol, all sevage from the Chilean winter and summer stations were drained directly to the sea. No sewage treatment plant was used. In some summer stations a primary tank were used before draining it into the sea or on the ground.

Now most of our stations have a sewage treatment plant including a raw water tank; primary sedimentation tank; secondary aeration tand and final discharge tand (including chlorinate and od-chlorinate)before discharge into the sea.

In our inland stations, at Patriot Hills, all sewage is frozen and removed to Punta Arenas by air in 200 litters drums.

We don't deposite sewage on ice.

Sewage disposal

STATIONS	SEWAGE TREATMENT PLANT	REMOVED TO PARENAS	DEPOSITED INTO SEA
O'Higgins	√		
Prat	√		
Frei			√
Yelcho	√		
Gonzalez Videla	√		
Carvajal			√
Escudero	√		
Risopatron	√		
Ripamonti	√		
Patriot Hills		√	
Shirreff			√

Solid waste removed to Punta Arenas (Chile)

Each year the Chilean Antarctic Program removes the solid waste from the main stations by ship. Most of them have been previously compacted and stored in 200 litter drums.

Solid waste produced in Chilean stations (average data)

	ANNUAL	SUMMER	ERMONT HS	ANNUAL	SUMMER	YEAR
O'Higgins	22	40	4	132	148	280
Prat	11	35	4	60	140	220
Frei	75	150	4	492	160	652
Gonzalez Videla		15	4		20	20
Carvajal		15	4		44	44
Patriot Hills		25	1		6	6
Escudero		30	2		20	20

Annual waste removed to Punta Arenas from Frei station(kilograms)

YEAR	WASTE	CONTAMINA TED FUEL	WOOD	METAL
1998~1999	29.400			
1999~2000	74.680			11.000
2000~2001	26.759	11.600	4.000	6.500
2001~2002	26.959	1.600		

Abstracts

Medical Capacities of the Chilean Antarctic Program

The Chilean Antarctic Program mobilises annually around 200 people, excluding crews of vessels and aeroplanes. The document shows different medical screenings and medical requirements that demand each national operators to their Antarctic applicants.

On the other hand, it describes the capacity of medical and dental support that available in Chilean bases, as well as, the aerial and marine capacity for medical evacuations. Analysis of medical attention statistic of personnel of Chilean and foreign bases is commented, showing 1203 medical attentions (175 to foreigners), 179 dental attentions occurs (45 to foreigners) and 12 medical evacuations (3 of foreign bases), during the last season.

Finally, the work describes the use of different telemedical procedures and services in use by national operators to support the medical aid, teleeducation and biomedical research. On-line Medical Health Record Database of INACH's Personnel deployed to Antarctica, created under ARGONAUTA Project, is investigated as a new standard for all the Chilean operators.

Miguel Figueroa
Antarctic Divicion, Chilean Air Foree

A Five-year Summary of USAP Medical Care Activities in Antarctica

Approximately 3500 people were deployed per year to Antarctica under the support of the United States Antarctic Program (USAP). Of that number, about 400 spend an entire twelve month period in Antarctica and the remainder spend from several weeks to six months on-continent during the austral summer season. Because the medical clinics at each of the U. S. research stations have limited capabilities, a pre-deployment medical screening program is utilized to identify individuals with existing medical conditions that would place the individual at increased health risk while in Antarctica, and the condition could not be diagnosed or treated effectively in the medical clinics there. Each person who is deployed must successfully complete this rigorous medical examination, with persons intending to spend the austral winter required to pass an additional psychological screening process. As part of our internal programmatic review, we have examined the USAP medical clinic activities over the last five years and itemized medical care delivery into several categories (e.g., types of care provided; emergent -vs- non-emergent care; accident/injuries -vs- illness or existing conditions) and in particular, examined those situations where the individual required evacuation or transport to advanced medical care facilities off-continent. This periodic review allows us to examine our pre-deployment medical screening program for effectiveness (in certain circumstances), to evaluate the level of care offered -vs- provided at each of our three medical clinics, to evaluate existing wellness or accident prevention programs, and to project the effectiveness of proposed changes in our medical screening or prevention programs and expansion of our on-continent medical care capabilities. The summary data provided will be specific to the United States Antarctic Program but because of the relatively large database, should be of interests to other national Antarctic programs.

Harry Mahar, Safety and Health Officer,
National Science Foundation

Induction Training

The British Antarctic Survey (BAS) hold an annual induction conference for new recruits and teams bound for Antarctica in the subsequent working season. The induction is in three modular parts, as follows:

Part one of the conference includes a 3-day introduction to Antarctic science, environmental issues, a glimpse of living and working in Antarctica and the logistics required to undertake a first class scientific programme. Various formats are used, including audiovisual presentations, talks by guest speakers, seminars, practical sessions, and social engagements.

The conference is followed by a 3.5-day first aid course run by the BAS Medical Unit, part of National Health Service Trust. The aim is to train all staff going to Antarctica in first aid care and immediate life support. This is part of a wider BAS medical support package including: medical screening, medical advice, doctor provision, remote medical diagnostics and medical pharmaceuticals.

The third part of the induction module is the Field Training Course, held in Derbyshire England. The aim of this module is to introduce staff to techniques of living safely in a harsh environment, Antarctic field living, crevasse rescue techniques and other ascossiated safety techniques. Within the constraints of open moorland and crags, simulations of Antarctic risk and difficulties are introduced to seed the learning of important personal survival techniques.

BAS has the advantage of many of its Antarctic staff being under one roof, providing the opportunity to undertake simultaneous induction of both support staff and scientists in many aspects of Antarctic life. Where projects include collaborators and scientists from Higher Education Institutes these staff are also obliged to undertake the induction training. This provides a wonderful opportunity for staff to get to know their peers, promote team building and raise an understanding of the science.

British Antarctic Survey(BAS)

Selection and Recruitment Procedures

The Personnel Selection, Training and Management Section, of the Italian Antarctic Program is interested in producing a poster, with a short text and some photos, on the following topics:

- survey of the requested professional requirements of candidates taking part in the Italian Antarctic expeditions (either for scientific or technical support purposes);
- more present professional profiles in the composition of the technical logistic support team needed for Antarctic operations;
- standards adopted for the assessment of fisio-phsychologic requisites, with explanation of discriminants that make such protocols different; discriminants that we can sintetize in:
  - scenarios where the candidate will operate;
  - age of candidate;
  - previous Antarctic experience;
- the aptitude test of candidates to be employed in Antarctica through their participation in the training (and formation) courses, that all personnel earmarked for taking part in the Italian Expeditions, without previous experience in Antarctica, is bound to attend. Location of such courses and description of teaching material (manuals and laws on Antarctica) distributed and explained.

B. Muggia
ENEA ANTARCTIC PROJECT-ITALY

The Baia Terra Nova Station Activities for Outdoor Operation

The present paper describes the methodologies used to perform the logistic activities of the Italian Programme for Antarctic Research during the 2001/2002 Austral Summer season. Marine research activities are not included.

During the XVII Italian Antarctic Campaign the outdoor activities were:

- logistic support to the Dome C base;
- logistic support to the ITASE scientific traverse;
- fitting out long term field camps;
- performing of short term field camps;
- air-link with the McMurdo, Scott and Dumont D'Urville stations.

The paper describes the camping gear used in the long term camps and the short term camps, the selection of a site for a camp and the ways to deliver personel and gear; the means used to enable the camp mobility; the waste management for remote camps; the gear and the methodologies to set a field measuring station.

Another chapter of the paper describes the logistic support to the short range research activities, carried out mainly by helicopters; the practice of the drop off/pick up and of the accompanied flights; the helicopters survival kit and the researcher team survival kit; the fuel depots network, carried out to perform the short range research activities, and their management.

The long range activities carried out by a light aircraft equipped with a ski landing gear are described, as well as the intracontinental air network carried out by means of this aircraft in the Ross Sea region. Most of the legs of this air network are longer than 1000 km so that, for safety and efficency reasons, refueling point in such long routes must be prepared. The refueling points, are generally equipped with a fuel cache, a meteo station and a tent with stove, power generator, radio, food, snow blower, ski-doo and groomer. The paper describes the refueling points in details. On the paper it also described the procedure to open, every new season, the Dome C base located on the Antarctic Plateau. This procedure is foreseen to open, at first, the refueling points.

During the Austral Spring of any new season in front of the Terra Nova Bay station an ice airstrip of 3000 m long is prepared. It allows intercontinental air links with New Zealand. The sum of both, the intercontinental link and the intracontinental network makes Terra Nova Bay station an hub. This air system is more widely described in the paper.

The Terra Nova Bay station is equipped with all basic means for aircraft handling and services as described in the paper. The most important of these services are the meteo and radio services. The reliability of meteo service is increasing rapidly yearly. It is based on the meteo forecast modelling downloaded, by means a satellite connections, twice per day.

The radio service is provided on the VHF marine, VHF avio and HF frequencies. To increase the operational range of the VHF systems two radio bridges are used.

This year a big increase of the comunications reliability was obtained by the use of the Iridium system.

G. De Rossi, U. Ponzo and P. Tuzi
ENEA ANTARCTIC PROJECT-ITALY

Solar Power Supplies

The mission of the British Antarctic Survey (BAS) is to undertake a world-class programme of science in the Antarctic and related regions, addressing key global and regional issues through research, survey and long term monitoring. To achieve the mission requires instrumentation and equipment to monitor processes and acquire scientific data. When instruments are deployed in the field for long term monitoring purposes, simple and robust renewable energy systems are needed. Solar power supplies are appropriate for many areas of Antarctica to power instrumentation systems.

Solar power supplies normally comprise solar panels to collect and convert solar radiation into electrical power. A battery system provides an efficient power storage device to balance the demand load against the available power being provided from the solar panels. To ensure the batteries are evenly charged and not subject to over-charging, a regulator is needed. The regulator and electronic control must be simple, reliable and able to operate in a polar environment.

The charging circuits for batteries can either be based on a constant current or constant voltage principle. Developments of these principles are possible including switching systems to accommodate different charging rates. This paper describes a solar power supply incorporating panels, batteries and a constant current charging circuit. The system has been deployed in Antarctica and operated reliably over several seasons. Performance and technical specifications are also presented to enable users to determine optimum characteristics for specific applications.

Vsevelod Afanasyev
Electronics Engineer
British Antarctic Survey
Email: v.afanasyev@bas.ac.uk

Integrating Solar Design in Antarctic Buildings

In 1999 ~ 2000, we started the development of a Solar Estimation, Modelling andAssessment Scheme (SEMAS) as a major strategic design tool for the effectiveutilisation of solar energy in Antarctic operations.

The first phase validated the modelling of solar radiations under actualcloud cover conditions and the modelling of power output from generic solarpower collection technologies. This included calibration using data sets fromin-situ pilot installations.

It was then used, as presented at SCALOP 2000, to assess the potential forusing solar energy at the Australian Antarctic stations and to identifyoptimum collection strategies.

The second phase is focusing on1) further calibration of the power output model for various types of solarenergy conversion systems (such as photovoltaics, solar hot water, glass-house or Trombe wall), and2) development of tools to effectively use model output to assess differentcombinations for integration into the overall building design.

This development work is done in parrallel with its application to theintegration of solar design in a new summer accommodation building at DavisStation.

The proposed poster will outline the SEMAS process and its applications usingas a case study the integration of solar design in the new Davisaccommodation building by the Australian Antarctic Division.

Guy Williams (1), Adrian Young (2), Peter Magill (2),
Antoine Guichard and Chris Paterson

(1) Latitude Technologies, Hobart, Tasmania, Australia - www.latitude.aq

(2) Australian Antarctic Division, Kingston, Tasmania, Australia -www.aad.gov.au Corresponding author: Guy Williams <guy.williams@latitude.aq>

Practical Uses of Solar Energy at Syowa

An installation of photovoltaic panels, whose capacity is 55 kW, was completed during the 2002 austral summer season. The project began in 1997 and the grid connection was completed in 1998. Some of the panels were damaged due to a strong wind and an electrical control circuit failed, but these early troubles were soon overcome. The average production in February 2002 was 8.2kW. The annual average power production is estimated at 5.2kW and this will account for approximately 3% of all electricity consumed at Syowa.

An air-type solar collector for warming the inside of rooms was installed on an internal wall of the living accommodation in 1999. It was proved to be effective and an improved type was installed in the workshop in 2001. The solar collector consists of an intake fan that is powered by a 22W photovoltaic panel and a collector panel of 1.1 sq m.

The collector panel is a black aluminum plate with multiple 1.5mm diameter holes. A small fan (3.2m3/min) is attached on the inside of the room wall to draw warm air into the room and the cool air return to the collector panel through a small hole opened under the panel. The temperature difference between the warm air and return air is up to 20℃ in the daytime of summer season, but a serious problem happened in the nighttime.

The cooled air falls to the bottom of the solar collector and this could then flow back to the room. To prevent this air flow a light, one-way air dumper was set to the lower outlet in 2002. Temperature observations are being undertaken to ensure the effectiveness of the dumper.

The solar energy obtained from the system is estimated at 86,318 MJ per year, so the collector will play a large part in heating the workshop.

Ishizawa Kenji, Yoshida Jiro and Endo Nobuhiko
National Institute of Polar Research

Testing Fuel Cell Technology in Polar Environment

All remote site experimental operations entail a logistic burden, of which power production normally constitutes a significant fraction. Within the U. S. Antarctic Program, Thermoelectric Generators (TEGs) have been used to power the remote Autonomous Geophysical Observatories for the last decade. Unfortunately, TEGs offer very low efficiency (< 5%) and require the support of LC-130s to deliver propane each austral summer. Alternative strategies utilizing wind and photovoltaic power have also been investigated for remote site experiments. While each achieves a degree of success, these technologies have inherent limitations. Solar power is inappropriate for austral winter and there is insufficient wind to power wind generators on much of the Antarctic Plateau. For these reasons, Fuel Cell technology is being investigated as an alternative source of power for low energy, remote site applications.

Fuel Cells are highly efficient (attaining efficiencies of 60% - 70%) and environmentally clean (producing only heat and water as byproducts). While fuel cells have been extensively investigated in temperate climates, there has been no thorough investigation of this technology for the cold, dry atmosphere of the polar environment. In response, the U. S. Office of Polar Programs is supporting the development of a Fuel Cell Test Station. This Test Station couples a 150 Watt, Proton Exchange Membrane fuel cell with a wide variety of instrumentation (temperature, humidity, current, voltage, and wind speed) enclosed in a thermally insulated box. The result is a self-monitoring power plant, able to log its power production at all times along with ambient and internal conditions. The acquired data is then sent via modem or Iridium telephone back to the United States for monitoring.

The goal of this project is to see how the Test Station performs in different environmental conditions: high wind, high altitude, extremely low temperature, blowing snow, etc. At the same time, it is an example of a remote site experimental station in that the anemometer is providing data on the local environment. The deployment schedule entails subjecting the fuel cell to a full year of operation in various sites: Colorado, then Raven, Greenland, then Barrow, Alaska, and lastly Antarctica, during the austral winter. The multiple environmental conditions will permit an assessment of the robustness of the power source. Moreover, it will permit engineering refinements so that the Test Station can be transitioned into the prototype for an actual experimental station.

This presentation will provide a description of fuel cell technology, explain the design and construction of the Fuel Cell Test Station, and cite the performance to date. Lastly, it will describe how the Test Station could be modified to become a remote site experimental station, if proven successful.

Don Atwood, Ph.D.
Raytheon Polar Services Company
Englewood, Colorado. USA

Utilization of Iridium Satellite Communications by the U.S. Antarctic Program

The USAP has utilized Iridium satellite communications since July, 1999, following the official inauguration of service by the former Iridium World Communications (IWC) on November 1, 1998. Following the August, 1999 Chapter 11 bankruptcy filling by IWC, a hiatus in USAP usage occurred during the interval of March-November, 2000. With the successful sale to Iridium Holdings LLC in November 2000, global Iridium communications services were officially re-launched in March, 2001. The USAP re-activated its utilization of Iridium services with dual services provided by commercial Iridium service providers and also by enrollment in the U.S. Department of Defense Enhanced Mobile Satellite Services (EMSS) program implemented in December, 2000. Enrollment in the EMSS program has enabled the USAP to address the cost barrier to wide-spread Iridium voice and data applications via the extremely low cost air time service available to US civilian government agencies and to select foreign governments. The USAP has deployed numerous Iridium Subscriber Unit (ISU) mobile telephones manufactured by Motorola in fixed base, field/portable, marine, and aeromobile applications. Applications within the USAP include base-base communications between Amundsen-Scott South Pole Station and McMurdo Station, deep field camp safety and operational communications with McMurdo, deep field educational outreach programs by the U.S. component of the International Trans-Antarctic Scientific Expedition (ITASE), and aeromobile safety and flight management communications for Kenn Borek Air Twin Otter and Air National Guard LC-130 aircraft. In parallel with the deployment of commercially available Motorola ISU equipment, NSF has supported the development of data modem and data related Iridium services via a Small Business Innovative Research (SBIR) grant to NAL Research Inc., Manassas, VA, USA. NAL, in close cooperation with Iridium Satellite LLC and a separate SBIR grant from the U.S.

Navy Office of Naval Research, has implemented a product development program designed to evolve Motorola produced original equipment manufacturer (OEM) ISU modules into dedicated data modems with reduced physical packaging, multi-channel capability, and more effective management of subscriber identify module (SIM) management. Iridium Satellite LLC announced the availability of dial-up data and gateway Internet services in June, 2001. The availability of network data services and data modem equipment has opened many new opportunities for exploitation in both Antarctic science research and supporting operations. This paper summaries USAP activities and provides an overview of the deployment of Iridium communications, the operational issues encountered, and the forthcoming plans by the USAP for future development of Iridium communications capability.

Patrick Smith,
Section, pdsmith @nsf.gov, USA
NSF/OPP Polar Research Support

Simple Biological-Processing Toilets Used in the Isolated Buildings at Syowa Station

There are presently 49 buildings at Syowa Station. Passageways connect the central building, generation house and two sleeping lodges to each other. Other station buildings are located apart to minimize problems of snowdrift and vulnerability in the event of fire. Sewage for main buildings is piped to a sewage treatment plant, but other buildings are not connected to the sewage system yet. Therefore, three kinds of simple toilets are installed in some buildings where people work.

Two of the toilets are combustion-type, one using an electric heater and the other a kerosene burner. The third, and newest, is a biological-processing toilet. This new design of toilet was installed in a heated room of a summer lodge at Syowa in 2000. An additional three of these toilets were installed in 2001. It has been proved that the toilets work well even in winter.

The toilets collect human wastes in a small tank (98 liter) containing wooden chips. The tank's contents are stirred by a blade at regular intervals. The temperature of the waste and chips in the tank is controlled between 30 − 45℃ by an electric heater. The intestinal bacteria are nourished by the waste and multiply in the tank. Finally the bacteria facilitate the decomposition of the waste into water and carbon dioxide. The gas bye-products are discharged from the tank to the outside atmosphere.

The maximum power requirement of one toilet is 650 W. The wooden chips need to be replaced every half a year based on a maximum frequency of use for 150 times per week. The toilet system has been proved to be effective because it is compact, does not use an open fire and is environmentally sound, as it does not require the introduction of special bacteria to Antarctica.

Ishizawa Kenji
National Institute of Polar Research

Scott Base Wastewater Treatment Plant

Following a comprehensive analysis of issues and options, the New Zealand Antarctic Institute determined that improved treatment of the wastewater discharge from Scott Base into McMurdo Sound was required because of:

- Unknown risk of potentially high environmental impacts (e.g. contamination of wildlife with human bacteria, viruses and genetic material)
- Lack of social acceptability (including non-compliance with New Zealand standards)

Effluent quality parameters were developed and several treatment technologies were considered from which a preferred process was selected.

A contractor was selected based upon the ability to deliver a compact, energy efficiently packaged plant, which could meet the effluent quality requirements, and be successfully operated by non-specialist staff.

The plant was delivered to Scott Base and installed in February 2002. It will be commissioned in August 2002.

Whilst the selected treatment technology is commonly used throughout the world including Antarctica, this plant is unusual because of its compact size and configuration as two 20 foot ISO containers. This proved to be very advantageous for transport and installation.

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A simple Method to Reduce Discharge of Sewage Microorganisms from an Antarctic Research Station

Abstract: The majority of coastal Antarctic stations release untreated sewage into the near-shore marine environment. This study assessed factors affecting microbial propagation within the temporary sewage-holding tanks of Rothera Research Station on the Antarctic Peninsula, and monitored pollution levels and extent in the local marine environment. We investigated a simple, practical method to reduce the number of non-native faecal microorganisms released into the sea. Microbial propagation within the station sewage-holding tanks occurred when the rate of sewage input was low and residence time in the tank was high. Continuous flushing of the tanks with unpolluted cold seawater decreased the temperature and residence time of the sewage. This inhibited microbial reproduction and decreased faecal coliform numbers subsequently released from the tank by at least 90%; as a result, bacterial densities in seawater around the sewage outfall were reduced. The widespread use of this simple method could significantly reduce the numbers of faecal coliform and other non-native microorganisms introduced into the Antarctic marine environment.

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A New Incinerator for Terra Nova Bay Station

The Italian Antarctic Program has decided to install a new thermodistruction plant for the disposal of solid organic waste produced at the station in Terra Nova Bay, and also for material coming from packaging (paper, wood).

Considering the difficulty to repatriate organic waste, the Italian Project studied the solution to incinerate such material at the station.

In order to identify the right type of incineration plant, the following targets have been taken in consideration:

- Minimum environmental impact from the fumes released in the atmosphere;
- Maximum efficiency of the fuel used at the station and heat recovery from thermodistruction process;
- Maximum simplicity to operate and mantain the plant;
- Maximum simplicity on the waste collecting and storing process.

The result of our analysis has taken us to select a plant with the following components:

- static pyrolitic, hot hearth, high volume furnace (primary combustion chamber);
- post-combustion chamber;
- heat recuperator;
- fume treatment line;
- analysis and control system for atmospheric emissions.

The chosen plant with the above characteristics permits to reach all the listed targets. In fact, the high volume furnace permits to store collected waste for few days avoiding to leave the stock material outside.

Primary combustion chamber and post-combustion chamber permit to realize the total Kiln in two separate sections: in the first one (primary chamber) the reaction starts and partially develops; in the second the gas flow encounters programmed and automatically controlled thermodynamic conditions that complete the reaction and therefore produce the perfect combustion, giving the highest guarantee of a low pollutant level in the exhaust gases (always complying with the most restrictive standards).

Maximum efficiency of the fuel use at the station and heat recovery from thermodistruction process is obtained by using a Heat recuperator capable to recover enthalpic heat from the smoke for the associates production of thermal energy, replacing the activity and function of the station's heating production system.

The dedusting of the fumes generated by the combustion process in the fume treatment line, performed by means of fabric deduster combined with an abatement system with a chemical reagent, assures a full observance with the fume emission levels set by the standard in force.

The control system constantly monitors every phase of the thermodistruction process, from the feeding of the waste into the furnace to the analysis and control of atmospheric emissions, allowing simplicity and versatility of operation, so that even without requiring specially operating skills for the operators it is possible to guarantee maximum respect of man and the environment.

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Lightweight Minimum Impact Infrastructure

1 Introduction

This presentation is a detailed description of the continuing research and development of lightweight minimum impact infrastructure being undertaken in the EPTAP station /Estacion Polar Teniente Arturo Parodi/ in the blue ice zone of Patriot Hills, Lat. 80° 19 south, Long. 81°18west.

2 National Antarctic political objectives

The EPTAP station is the product of the collaboration between the Antarctic Division of Chilean Air Force and the ARQZE unit / Extreme Zone Architecture / of the Santa Maria University of Valparaiso. EPTAP was concieved as a infrastructural support both for international scientific and technological investigation, and the logistics of polar zone flight paths that depend on the blue ice runways. The station was transported in two hercules C-130 planes and installed in November 1999, offering an initial capacity to accommodate 24 persons during the four months of summer. In its three successful seasons of operation the EPTAP station has become a model for the implementation of the principles of the Madrid Protocol, transforming itself into a technological laboritory for the testing of new prototypes of habitational systems that are transportable by plane, permiting the further exploration and investigation of the antarctic interior.

3 Sala Sastruggi

The EPTAP station incorporates the processes of snow acumulation particular to blue ice fields into its location and organization. Situated in the zone of superficial equilibrium to the north of the blue ice field, a membrane distribution tunnel of 200m^2 guarantees access to the seven insulated fibreglass living modules, and the snow acumulation that is provoked protects it from the extreme catabatic winds. In November 2000 the plug-in capacity of the tunel was exploited to add a new 60m^2

living and dining space called the Sala Sastruggi, fabricated from extruded aluminium profiles and double curvature membranes. The Sala Sastruggi is a prototype for an infrastructural system called the catabatic system that can provide small scale lightweight field stations deployable by plane and autonomously serviced.

4 Polar capsule

In november 2002 the existing capacity of EPTAP will be extended through the incorporation of two prototipical fibreglass living capsules of 16m^2 into the tunnel. The Polar Capsules conform highly insulated autonomous habitats, integrating support systems and transformable furniture that allows the reconfiguration of the interior space to accomidate a cycle of different activities. The deployment of these autonomous Polar Capsules by helicopter will potentiate the future exploration of the territory surrounding Patriot Hills.

5 shockwave

In November 2002 a prototipical membrane hangar of 200m^2, with a metallic geodesical structure will be installed at the edge of the blue ice field to provide shelter and support for the logistics of loading and unloading the C-130 Hercules planes and maintaining the blue ice runway. This hangar will become the first component of a future blue ice airport terminal.

6 water cycle systems

One of the polar capsules will be installed as the updated sanitary module of the EPTAP station through the integration of Water Cycle Systems. These prototipical systems minimize the production of waste water through the implementation of steam baths for personal hygene, and the recycling of grey water through a process of microfiltration. In environmentally sensitive areas such as blue ice fields these systems provide an acceptable and practical alternative to the current practice of deposition in snow holes, allowing the evacuation by air of minimal quantities of contaminated water. The system also integrates updated dry toilets in which separated urine and faeces are freeze dried by the snow, and subsequently evacuated by plane.

EPTAP Chilean Polar Station

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