Human Impact
on the
Antarctic Environment:

Minimising the Risk
to the
Unique Environment
of
Sub-glacial Lakes

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Human impact on the Antarctic environment: minimising risk to the unique environment of sub-glacial lakes

The Representatives,

Recalling Article II of the Antarctic Treaty and Recommendations VIII-13, IX-5, X-7, XII-3 and XIV-3;

Recognizing the knowledge of the tectonic, geochemical, climatic, glacial and biological evolution of the Antarctic region that can be obtained from exploration of sub-glacial lakes;

Bearing in mind the potential irreparable risk to the unique environment of these lakes should biological or other contaminants be introduced through or as an unintended result of such exploration;

Conscious of the need for wider international and interdisciplinary discussion and adequate prior research, preparation and planning of such exploration to ensure the best possible scientific results and to minimise any associated risks to the sub-glacial environment;

Conscious also that planning such exploration will, in most cases, require preparation of a Comprehensive Environmental Impact Evaluation as provided for in Recommendation XIV-2

Recommend to their Governments as follows:

1. That a moratorium be declared on any attempt at direct intrusion into sub-glacial lakes

2. That during the moratorium, they promote further research into: understanding sub-glacial lakes systems, technologies for researching the lakes without intrusion, intrusion methods which minimise real and potential risks of contamination, and investigation of alternative sites which provide information about sub-glacial lake systems and methods for their exploration

3. That during the moratorium, they encourage public education and debate on the issue

4. That SCAR annually reviews progress and plans related to clause (2) above and compile a report to be presented to the next ATCM

5. That at the end of five years an international conference of interested parties be held to pool and share knowledge and viewpoints on the issue; and that, at any subsequent ATCM, if any of the Antarctic Treaty Consultative Parties so requests, a vote then be held on whether to terminate or otherwise amend the moratorium, a successful vote requiring the support of a majority of the Parties, including a majority of the States which are Antarctic Treaty Consultative Parties at the time of adoption of the moratorium.
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Abstract

Lake Vostok, the largest of the recently discovered sub-glacial lakes in Antarctica, has been isolated for millions of years. Exploration may yield considerable scientific knowledge in areas which include glaciology, the climatic and geological history of the Antarctic and, particularly since the discovery of bacteria in accreted ice from the lake, biology. Any exploration must endeavour to preserve the pristine nature of the lake, as contamination will invalidate data and future research. Increasing pressure to drill into the lake in the near future have been countered by strong arguments that insufficient research has been done to ensure the risks of drilling are minor and transitory in nature, and that the benefits derived are both interdisciplinary and international. Thus, a moratorium and period of directed research is proposed, during which time more can be learned about sub-glacial lake systems, risks can be accurately assessed and quantified, and the scientific benefits of any future lake intrusion maximised.

Introduction

The goal of this report is to recommend measures, in accordance with the principals and objectives of the Antarctic Treaty, to address the issue of the exploration of Antarctic sub-glacial lakes, specifically Lake Vostok.

There are instruments within the Antarctic Treaty System (ATS), such as the Environmental Impact Assessment process, which require that any exploration is conducted in such a way so as to minimise and environmental impact on the lake system.

However, for a number of reasons outlined in greater detail below, there is concern that the current scientific and political pressure regarding the penetration of Lake Vostok may lead to undesirable outcomes. Such outcomes could include the unintended and unnecessary contamination of the lake and/or a lack of scientific co-ordination on the issue.

This report outlines a course of action which aims to minimise any harmful effects to Lake Vostok and its environs (including other sub-glacial lakes to which it may be connected) while allowing for a wide-ranging international and interdisciplinary scientific programme. A background to the relevant scientific and political issues is given in the first section, while the subsequent sections describe and justify the recommendation.

Lake Vostok

Lake Vostok is the largest of nearly 70 lakes beneath the East Antarctic Ice Sheet that may have existed for millions of years (see map, Figure 1). The very high pressures beneath the ice sheet allow the melting point of water to be lowered and liquid water to be present. Lake Vostok extends 280km north-south and 50-60km east-west. The East Antarctic Ice Sheet that seals the lake ranges in thickness from 3750 to 4100m. The ice surface is 10 times flatter over the surface of the lake than in surrounding regions (Siegert, 2000).
The existence of sub-glacial lakes was hypothesised in the late 1950s after observations of unusually flat areas atop the ice sheet (Siegert, 1999). During the 9th Soviet Antarctic Survey (1963-64), seismic traces were collected which ultimately led to the confirmation of the existence of these water bodies in the 1970s. The discovery of Lake Vostok was first reported at the 23rd session of the Scientific Committee on Antarctic Research (SCAR) in 1994 (Kapitsa et al. 1996).

The large ancient and unexplored water bodies have sparked significant scientific and media interest. The scientific objectives for any lake exploration focus on characterising life in this extreme environment, deciphering the sedimentary and ice records with regard to the climatic evolution of the continent and any links between the origins of the lakes and the evolution of life there. Another thread of interest is in the development of technologies which may be used for the exploration of other planets.

An international drilling team aiming to recover a record of global climate changes from the ice at depth came within a few hundred metres of the liquid surface of Lake Vostok in 1990. They encountered what appeared to be accreted water from the lake itself at this depth (see cross-section, Figure 3) (Petit et al., 1997; Jouzel et al., 1999).

Primitive bacteria have been found in the lake ice at the bottom of the core, which holds promise for identifying adaptations that could support extraterrestrial life (Abyzov, 1998; Ellis-Evans, 1998).

**Background**

Existing knowledge as to the nature of Antarctica’s sub-glacial lakes has come from a wide variety of sources. As mentioned above, the main source of information about Lake Vostok has come from analysis of the accreted ice above Lake Vostok. In addition to this, knowledge of earth history and continental drift contributes to the development of hypotheses about the origins of the lake. Predictive modelling has also been used to develop theories as to the nature and origins of and the hydrographical, geological and glaciological processes operating in the sub-glacial lakes.

**Life under the Ice**

The sub-glacial environment is an extremely oligotrophic (nutrient-poor) environment under high pressure and it contains fresh water. This extreme environment is unique due both to the extreme conditions prevailing and its isolation, which ice core dating indicates has lasted at least half a million years and potentially much longer. The lakes are suspected of having very low levels of nutrients, thus, any organisms in the lakes are likely to have unique adaptations.

Interest in the lake environment has been heightened because it is an analogue for the conditions which are thought to exist under solid ice deposits on Mars, Europa and possibly the Moon and other planets. Therefore it
presents opportunities to aid an understanding of extraterrestrial life. The primitive bacteria (see photos, Figure 2) found in the lake ice at the bottom of the core could allow biologists and exo-biologists to identify adaptations that could support extraterrestrial life.

There is concern that any penetration of the lake may contaminate what is otherwise a pristine environment, therefore there has been a recent push for clean drilling technology. Also, the biota are likely to be so small that broad-spectrum assays will be required for detection. The sub-glacial environment is anaerobic and oligotrophic and any penetration may rapidly alter this unique environment (Ellis-Evans, 1998, Karl et al., 1999).

**Climatic and Tectonic Evolution of the Antarctic**

The sub-glacial lakes will provide insights into the evolution of the Antarctic continent. The existing Vostok ice core has yielded much information about the past climates of Earth over a timescale of nearly half a million years.

It is likely that beneath the lake there is a tectonic rift and a unique sedimentary record of the Earth’s climate. The sediment is also likely to yield information about the initiation of glaciations and may also act as a deposit of any extraterrestrial material from the glacial ice. The sub-glacial water is geo-chemically unique as a result of its isolation (Priscu, 1999). A combination of this information is likely to provide insights to Antarctica’s role in global climate, now and in the past (Malaize, 1999, Yiou, 1997).

Similar concerns exist regarding accessibility of the sub-glacial sediments as exist for the biological arena. Access to the sub-glacial environment is fraught with technical difficulty if the pristine nature of the environment is to be preserved.

**Physiography of the Lake**

The knowledge of the exact nature of the lake system remains unknown, including crucial issues such as the possible interconnection between neighbouring sub-glacial lakes.

It is hoped that the bed topography, sediment thickness, water depth and aerial extent will be mapped, and that this evidence will help gain an understanding of the origin, evolution and age of the lake system (Siegert, 2000).

Much of this information gathering is amenable to remote mapping, but penetration of the lake will permit more precise mapping to be carried out.

**Glaciology and Ice Dynamics**

Lake Vostok also presents an opportunity to gain information about ice dynamics, particularly flow over water. The lake significantly alters the velocity and direction of ice flow due to the change in resistance at the base of the ice.
(Kwok et al., 2000). The processes of melt and re-freeze at the ice-lake interface are also of interest for understanding the dynamics of both the ice sheet and the lake. This information may help to explain glacial fluctuations (Siegert et al., 2000).

**Exploration Technology**

The wide range of scientific objectives to be addressed is driving a push for innovative technologies to enable exploration of sub-glacial lake systems. The aim is to develop and refine methods of sample retrieval, lake monitoring and in situ measurement that will not have a significant impact on any aspect of the lake system. The challenge is to find ways of testing such technology and methodology (Clow, 2000).

In addition to this, there is a desire to use the opportunity of developing clean technologies for drilling into water bodies to develop similar technology for drilling through ice on other planets.

**ATS policy and Sub-Glacial Lake Exploration**

Any action regarding the penetration of Lake Vostok will require an Environmental Impact Assessment (EIA). Under the Protocol on Environmental Protection to the Antarctic Treaty (The Protocol), three categories of EIA are provided for depending on the level of expected environmental impact: less than, equal to or more than minor or transitory.

Construction of any bases or airstrips, or the commencement of any scientific drilling generally requires the use of a Comprehensive Environmental Evaluation (CEE), i.e. the impact is likely to be more than minor or transitory. ATS recommendation XIV-3 makes this requirement explicit in the case of scientific drilling.

The situation with respect to Lake Vostok is more complex, because drilling of the Vostok core commenced in 1990, prior to the adoption of the protocol. However, there is recognition by the Antarctic Treaty Consultative Meeting (ATCM) that there is a need for a CEE. Russia has stated that it will present a CEE for penetration into Lake Vostok at the 2002 ATCM and has made public its plans to drill 50m further down towards Lake Vostok.

When a National Antarctic Programme (NAP) wishes to undertake an activity which may have a significant impact, they prepare their own CEE and submit it to the Committee for Environmental Protection. At this point, it is open to comment from international scientists and NGOs. While such comments often provide the basis for modifications to the activity, there is no obligation on the part of those proposing the activity to take these comments into account, and a final decision on whether the activity proceeds rests in the hands of the proposing national programme.
Thus, ultimately the decision as to what constitutes a minor or transitory impact rests in the hands of the national programme proposing a CEE. Since the term “minor”, in particular, is capable of such wide interpretation, there may be no consistency in assessing whether a given activity, such as actual penetration of the lake, will lead to an impact which is no more than minor.

There is concern resulting from the ongoing discussion of research programmes and plans for further drilling that there is a developing sense of inevitability about drilling into Lake Vostok, even before any environmental evaluation has been produced.

“This would be a most serious failure of the State Parties and the international science community in regard to the obligations under the protocol – and a dreadful precedent for subsequent EIA practice in Antarctica” (ASOC, 2001)

The Problem
A challenge has arisen to ensure that the necessary substantial scientific research precedes any penetration of Lake Vostok and the risk of irreversible contamination which that implies. There is a strong desire and enthusiasm to explore the lake for the scientific and technological reasons outlined above.

But there is also considerable resistance to such action at this time, in order to ensure that the unique nature of the Lake Vostok system, and the knowledge it may yield, is preserved. Because decisions on crucial matters such as the interpretation of “minor” impacts lie in the hands of those proposing any CEE for lake exploration, the current political framework is insufficient to ensure that such concerns are fully explored and countered through adequate and convincing science.

There are no clear mechanisms under the protocol to address the restrictions required for the nature and scale of the proposed activity, i.e. the penetration of Lake Vostok. The following recommendation aims to delay such a course of action until there is an international and interdisciplinary agreement that any lake penetration method is sufficiently advanced and its risks sufficiently quantified to avoid significant impact on the lake system.
Description of the Recommendation

This section describes the recommendation in greater detail, and the following section provides the justification for this recommendation.

The recommendation is as follows:

1. *That a moratorium be declared on any attempt at direct intrusion into sub-glacial lakes*

This moratorium, declared by the Antarctic Treaty Consultative Parties (ATCPs), includes any activity that could conceivably lead to penetration of sub-glacial lakes, and covers all Antarctic sub-glacial lakes.

2. *That during the moratorium, they promote further research into: understanding sub-glacial lakes systems, technologies for researching the lakes without intrusion, intrusion methods which minimise real and potential risks of contamination, and investigation of alternative sites which provide information about sub-glacial lake systems and methods for their exploration*

This is to be a period of active, directed research to further our understanding of sub-glacial lake systems. It is intended that ATCPs will encourage their NAPs to prioritise research activities that will assist in meeting the objectives outlined above. This period will not only improve our understanding of the lakes themselves, but also provide time to improve the technology required for any subsequent lake and sediment penetration so that the nature and level of contamination is measurable, and deemed to be insignificant. This research will also address any existing risks of lake contamination, such as that posed by the drilling fluid in the Vostok ice core.

3. *That during the moratorium, they encourage public education and debate on the issue*

It is intended that, during the moratorium, the NAPs will facilitate public education, access to information and debate on the issue to promote wider public awareness. This will increase the potential to build a buffer of opinion and political influence on the issue.

4. *That SCAR annually reviews progress and plans related to clause (2) above and compile a report to be presented to the next ATCM.*

It is intended that the Scientific Committee on Antarctic Research (SCAR) be responsible for reviewing annually the progress made towards the objectives of the research programme. The purpose of these reviews will be to ensure full international and interdisciplinary information-sharing to drive co-operation and efficiency amongst research groups. Following each review, SCAR will compile
a report for presentation to each ATCM detailing progress in the past year’s research, direction and priorities for future research and a summary of issues that remain to be addressed within the scope of the moratorium.

5. That at the end of five years an international conference of interested parties be held to pool and share knowledge and viewpoints on the issue; and that at any subsequent ATCM, if any of the Antarctic Treaty Consultative Parties so requests, a vote then be held on whether to terminate or otherwise amend the moratorium, a successful vote requiring the support of a majority of the Parties, including a majority of the States which are Antarctic Treaty Consultative Parties at the time of adoption of the moratorium.

It is intended that at the end of the five-year period, a conference will be convened immediately before the ATCM for that year. The conference will bring together all interested parties, including governmental, scientific, environmental and other stakeholder groups with the purpose of providing a forum for debate on the issue of Antarctic sub-glacial lakes.

At the following ATCM, if any ATCP wishes to call for a vote on the future of the moratorium then a vote will be held. If no party calls for a vote then the moratorium will continue. If the vote takes place it will be carried out as is depicted in Figure 6. If the motion is not passed, then by default the moratorium remains in place. If the moratorium is not ended, then the opportunity to call for a vote will recur at subsequent ATCMs.
Justification for the Recommendation

The justification of the recommendation is structured in two main parts. The first part considers the alternative courses of action available to the ATCPs and the perceived consequences of each of those. This leads to the reasons for the working party recommending that a moratorium is the best course of action available. The following section provides justification for the details of the recommendation itself, including the logic and reasoning behind each clause.

Alternatives considered

The working party considered a number of different options to deal with the growing pressure for exploration of Antarctic sub-glacial lakes. The options were then examined in terms of their feasibility, the time-scale of the protection they offered, the ease with which the decision could be modified in the future, the level of protection of the lakes each option generated, and the time required to bring the option into effect.

**Option 1: Take no action**

As was explained in the Background, the current control on intrusion of Antarctic sub-glacial lakes is that any drilling activity should require a Comprehensive Environmental Evaluation (CEE). As has been mentioned previously, the increasing pressure on the current system, the possibility of widely varying interpretation of what constitutes a “minor” impact, and the importance of this issue means that this self-regulating procedure may not be sufficient to protect the lakes and the information they might yield from the risks associated with a near-term drilling programme.

The current level of interest and enthusiasm has resulted in a race to be the first to penetrate the lakes, specifically Lake Vostok. However not all states and scientific disciplines agree that we are ready for such exploration to commence, or how any future drilling programme should be conducted. In order to protect the interests of all countries and disciplines it is better to encourage greater cooperation and a greater understanding of all risks before drilling commences.

The option to take no action is ruled out as it does not adequately protect these interests, and allows exploration to occur before sufficient international understanding has been developed of the consequences and risks.

**Option 2: Devise a new Antarctic Treaty instrument**

The working party considered the option of devising a new Antarctic Treaty instrument, such as a sub-glacial lakes protocol, a treaty, or adding a 6th annex to the Environmental Protocol. The sub-glacial lakes are sufficiently unique to demand a new treaty instrument alongside marine resources and mineral exploration.
However, any kind of a new treaty instrument would need to be fully ratified by all ATCPs and this would take too long considering the pressures noted above. The costs associated would also be substantial. Therefore although this option may be appropriate, it is not feasible.

**Option 3: Make all Antarctic sub-glacial lakes Specially Protected Areas (SPAs)**

This option was considered as it recognises that the Antarctic sub-glacial lakes are unique environments and that the current state of knowledge is inadequate to determine the best way to explore them further. This option is essentially the extreme application of the precautionary principle, whereby the lakes are protected from any activity because it is not known what to do with them.

There are a number of problems with this option, including that the concept of an SPA does not legally exist because Annex 5 of the Madrid Protocol has not been ratified by India. This option is also considered to be unrealistic, and it is unlikely that it would be agreed to at an ATCM because of its lack of flexibility, since SPAs are permanent measures which cannot be readily amended.

**Option 4: Set up a committee to oversee any CEE applications related to Antarctic sub-glacial lakes**

This option is essentially placing an additional level of control on the current system. Presently, any NAP can publish a CEE involving drilling into sub-glacial lakes, and this receives comments from the other ATCPs. Option 4 would involve a committee agreed to by all of the ATCPs who would have the explicit task of approving any CEEs involving intrusion into sub-glacial lakes, thereby providing an additional check on activities at these sites.

This option was ruled out, however, as it is a mechanism which is inconsistent with the other instruments of the Antarctic Treaty System, which does not generally admit the concept of governing or policing bodies such as the one envisaged. It also does not effectively put an end to the race that is currently building, and it is perceived that there would be great difficulties electing a non-biased committee to control the future of these lakes. This option is also ruled out as it explicitly assumes that there will be drilling, which is not necessarily desirable.

**Option 5: Set up an international, interdisciplinary group to proactively carry out a drilling programme**

This option acknowledges that intrusive exploration will happen sooner rather than later, and so attempts to at least manage the way in which it happens. The group would ensure that everyone's interests are taken into consideration and compile the appropriate CEE.

However, this option is unrealistic as it is based on the assumption that current knowledge supports the start of such exploration, whereas many believe that
this is not the case, and that more substantial scientific research is required before any such decision is made. It is clear that the goal of meeting everyone’s needs is unattainable today, and that more work needs to be done to develop an understanding of the sub-glacial lakes system, therefore this option is ruled out.

**The option chosen: A five year moratorium and directed research period**

The concept of a moratorium was chosen as the best option as it allows a period of active, directed research around the subject (co-ordinated by SCAR) while ensuring inactivity with regards to intrusive exploration. The moratorium is devised to place a “pressure valve” on the building situation, and to allow all the different disciplines and nations to synchronise their efforts.

The objective is that by the time the moratorium is ended, any activity involving intrusive exploration of the sub-glacial lake system will be undertaken as a truly collaborative, international, multi-disciplinary effort. This option is favoured because it is feasible in principle, and therefore could be accepted at the ATCM.

It provides an acceptable temporary pause for those who are keen to proceed, but does not put a permanent ban on intrusive exploration. On the other hand, the recommendation is still for a ban, which is intrinsically acceptable to those prefer to wait, or to potentially never drill.

This recommendation only requires agreement at the ATCM to be brought into force, which is beneficial as the process is a relatively fast mechanism for dealing with the immediate political pressure to drill, compared with other ATS instruments.

**Detailed Justification**

The earlier sections of this report have outlined the motivation for investigating the Antarctic sub-glacial lake system and the drilling or robotic exploration of Lake Vostok in particular, as well as the reasons for being concerned about the level of readiness of all stakeholders with respect to immediate intrusive investigation.

The recommendation therefore has a specific objective of setting aside a minimum (five-year) period of time during which we can be sure that:

- no irreversible action is taken that may damage the scientific or wilderness value of the Antarctic sub-glacial lake environment
- investigation and collaboration on a more complete understanding and awareness of the Antarctic sub-glacial lake environment and techniques for its exploration are positively motivated

To achieve this objective the recommendation has incorporated the following detailed considerations:

- The moratorium will apply for a minimum period of five years.
This is enough time for measurable progress to be made in those areas of investigation that are currently lagging but also a short enough period that there is no significant risk regarding the momentum of investigations that are further advanced. It should be noted that there is no explicit maximum period for the moratorium – there is no compulsion to end the moratorium or to embark upon intrusive exploration unless the ACTPs have an explicit wish to proceed in this direction.

- The ending (or changing) of the moratorium will require one (or more) of the ATCPs to call for a vote on that motion.

This is entirely in line with the precedent set by the protocol on environmental protection (Madrid Protocol). It also recognises that calling for the vote may be seen as a significant gesture in its own right, i.e. a positive and deliberate action towards change rather than an encouragement of complacency and biding of time.

On voting, a simple majority of ATCPs in favour is again consistent with the Madrid Protocol and ensures that it mitigates against growing levels of dissent on the subject. It is also seen as being a realistic level of agreement to ensure that the recommendation is accepted in the first place and that it does not outlast its usefulness through any technical difficulty connected with changing it.

It should be noted that the ending (or changing) of the moratorium based on a majority vote does not imply an end to consensus based decision making – all existing ATS instruments and procedures remain and will apply (as appropriate) to activities concerning the exploration of Antarctic sub-glacial lakes beyond the end of moratorium.

- The period of the moratorium must positively motivate progress towards a more complete understanding of the Antarctic sub-glacial lake environment and a measurably safe basis for the exploration of these and analogous environments.

This is based on a belief that faster, better overall progress can be achieved by slowing down in certain areas (intrusive exploration) in the short term. The moratorium will achieve this by:

(i) putting the onus of proof on safe exploration with the parties that can see benefit in pursuing that exploration
(ii) insisting that risks associated with intrusive techniques are quantifiable and that technologies to be used for this exploration (or that have already been used for ice coring above Antarctic sub-glacial lakes) are measurably minimising that risk to the point that it can be safely ignored
(iii) placing an expectation that for the moratorium to be ended, all scientific and otherwise concerned disciplines be at a compatible level of readiness to embark upon intrusive investigation, to the
extent that interdisciplinary collaboration during the moratorium should be fuelled in the interests of anyone achieving the goal of encouraging those with an urgent need to understand certain aspects of sub-glacial lakes (or the technology for their investigation) to seek other sources of this understanding.

- The period of the moratorium will further provide for a level of public debate on the topic that is appropriate to the unique status of the Antarctic sub-glacial lakes.

It is recognised that these are indeed a very special environment, possibly the last remaining distinct environment on the "surface" of the Earth that has not yet been entered into and irrevocably altered by human activity. It is inconceivable that such an environment should be violated without the widest possible consideration being given to potential objections and consequences from scientific, moral, religious and political perspectives. This is due diligence for the scientific community that would propose and proceed with the exploration and a necessary context for any governmental involvement such that both remain suitably aligned with wider, informed public opinion.

- The recommendation refers explicitly to intrusive exploration.

A significant distinction is being made here between possible remote measurement of certain properties of the lakes and the physical introduction of anything into the waters of the lakes. In other words, the sensitive environment is that where the waters of the lake system circulate or permeate, and the adjacent physical environments that can been seen to affect the behaviour of the lake system waters.

For the time being, the ice above the lake is considered to remain isolated from the essentially "sealed system" within which fluids circulate, though there is most certainly some boundary zone that requires definition and protection. The investigations referred to above will be expected to confirm these assumptions as part of the work to quantify risks.

Although there is a conceivable risk that some forms of remote measurement may introduce harmful effects, e.g. involving exposure of the lake contents to unaccustomed levels of electromagnetic radiation, it is considered that sufficient experience has been gained of these techniques to make valid judgements concerning their safety.

- The moratorium will apply to all Antarctic sub-glacial lakes, i.e. not just Lake Vostok where existing activities are located.

There can be no certainty that these lakes are not connected (SCAR, 2000). An action on one lake cannot therefore be considered in isolation of another. Neither can any one lake be singled out as ‘most appropriate’ for intrusive exploration, because prior to now, little research has been conducted on other lakes.
The management and monitoring of activities and knowledge during the period of the moratorium is in the hands of SCAR.

SCAR is well positioned, and motivated, to perform this role because it:

(i) Coordinates ongoing research activities and can best summarise what has been done in order to identify gaps and opportunities
(ii) Has already established the necessary connections and discussions forums with scientific groups and national bodies
(iii) Represents an essential peer group for moderating the activities of any individual NAP that may wish to proceed at an inappropriate rate or using an inappropriate method

In addition to the explicit annual review of Antarctic sub-glacial lakes research, SCAR is charged with convening a special conference open to all stakeholders after five years, i.e. to coincide with the first opportunity for any ATCP to call for a vote that might change or end the moratorium.

This conference is the only forum in which non-ATCP/NAP bodies have an equal right to contribute. It is not intended that the conference be charged with any specific, actionable goals, but it will be minuted and will form part of the briefing to ATCPs before the ATCM that year.

Expected Outcomes and Consequences of the Recommendation

The introduction of this moratorium will in no way dampen the motivation and interest in the investigation of Antarctic sub-glacial lakes such as Lake Vostok. Indeed, an anticipated heightening of interest should be motivated by the rising public awareness and the requirement to close gaps in our understanding before considering a change in status of the moratorium.

Those parties with most to gain will recognize that they will benefit most if they proactively assist less-advanced or less-interested parties to reach similar levels of awareness and engagement. At the end of initial five-year period, the Antarctic science community will undoubtedly be much better informed about the likely nature, significance and vulnerability of the Antarctic sub-glacial lakes environment and this understanding will have incorporated all concerns raised from non-scientific stakeholders.

There is no clear expectation that this would or should lead to an immediate call to end or change the moratorium. However, it is to be expected that once sufficient feeling of benefit and safety are evident amongst the NAPs and ATCPs then some call for change will be accompanied by a successful vote to end the moratorium and to begin a well co-ordinated international and multi-disciplinary investigation of the Antarctic sub-glacial lake environment.
Expected Consequences if the Recommendation is not adopted

Given the current level of activity and enthusiasm surrounding proposals to drill into Lake Vostok, there is a certain air of inevitability that such drilling will take place, and sooner rather than later.

A national programme such as those of Russia or the US will put forward a CEE based on the current level of knowledge of the lake system and the risks intrusion into it. While this CEE may attract adverse comment from some quarters concerning the lack of prior and substantial scientific research on such issues, there is no effective obstacle to prevent the drilling programme from proceeding.

As a consequence, one or more lakes may be irreversibly contaminated, and all data gathered as a result of the drilling programme will be called into question, thus calling into question the entire investment made in it. Furthermore, no act of mitigation will be able to restore a lake to its pristine state and thus the value of any future research will have been irreparably damaged.
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Figures

**Figure One:** The location of numerous subglacial lakes (*blue dots*) in Antarctica have been identified by analysis of various radar surveys of the continent. Many of these bodies may be linked by subglacial channels, but groupings of (presumably) interconnected lakes (*red outlines*) should be completely isolated from other clusters. *Source: American Scientist, Nov-Dec 1999*

**Figure Two:** Two research teams, led by David M. Karl from the University of Hawaii and John C. Priscu of Montana State University, examined fragments of ice taken from roughly 3,600 meters below the surface -- about 120 meters above the interface of ice and suspected water. Both teams found bacteria in ice believed to be refrozen lake water. The teams conclude that a potentially large and diverse population of bacteria may be present in the lake. *Source: David M. Karl, et al*
Figure Three: Diagram of Lake Vostok indicating the ice flow over the lake near Vostok Station. The melting and accreting processes are indicated at the base of the ice sheet. Arrows also indicate the potential circulation within the lake. The accretion ice is the layered material at the base of the ice sheet. The sediments (lined pattern) and hypothesized gas hydrates (pebble pattern) on the lake floor are shown. Source: Final Report, Lake Vostok Workshop, Washington, 1998, National Science Foundation

Figure Four: Leading strategy being considered for the exploration of Lake Vostok (panel a) would use hot water to bore through most of the ice sheet (1). The drilling apparatus would then be removed and a probe lowered to a position perhaps 200 meters above the lake (2). Heaters in the tip of this "thermal probe" would allow it to melt its way to the lake, all the while spooling out a cable, which would freeze into the ice (3). An alternative approach (panel b) would require launching a more capable thermal probe directly from the surface (1). This probe would penetrate the entire ice sheet (2), stopping when it detected that it had reached the lake (3). Both schemes would then call for the probe to release a swimming robotic vehicle and to deploy sensors that could measure properties of the lake water (panel c). Source: American Scientist, Nov-Dec 1999
Figure Five: Relief map of Antarctic geology underlying the ice sheet, with Lake Vostok indicated. Source: Final Report, Lake Vostok Workshop, Washington, 1998, National Science Foundation.
Figure Six: The voting procedure to be carried out at the ATCM after the initial five-year period, which may or may not bring an end to the moratorium.